Sent: 10/09/2021 11:32:28 AM
Subject: DA2020\0393 - 28 Lockwood Avenue Belrose 2085 - A-30753
Attachments: Minimum-Requirements for Building Site Groundwater Investigations and Reporting.pdf;

Hi Council,

With respect to the above DA-

WaterNSW has reviewed the accompanying DA documents and is unclear as to whether the basement construction will be water-tight (i.e. tanked).

WaterNSW and the Department of Planning, Industry & Environment (DPIE) require the perimeter walls and floor of the basement being constructed using a 'tanked' (waterproof) construction method. This would need clarification in the respective report (i.e. Geotechnical Report).

Notwithstanding the above, DPIE have prepared the Minimum Requirements for Building Site Groundwater Investigations and Reporting (2021) guide which I have attached for your reference.

Further information can also be found at Aquifer interference activities - Water in New South Wales (nsw.gov.au)

We request that the geotechnical report be updated accordingly as the hydrogeological assessment cannot be completed without it.

WaterNSW awaits the above requested clarification and information.

Kind Regards,
Stacey

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WaterNSW acknowledges the Traditional Custodians of the land and water on which we work and recognises the continuing cultural and spiritual connections that Aboriginal and Torres Strait Islander People have to Country. We pay our respects to Elders past, present and emerging.

Minimum requirements for building site groundwater investigations and reporting

Information for developers and consultants

January 2021

NSW Department of Planning, Industry and Environment | dpie.nsw.gov.au

Published by the NSW Department of Planning, Industry and Environment

dpie.nsw.gov.au

Title: Minimum requirements for building site groundwater investigations and reporting

Subtitle: Information for developers and consultants

First published: January 2021

ISBN: 978-1-76058-419-1

Department reference number: PUB20/940

More information

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Cover image: Greg Russell

Preamble

Constructing buildings with basements that require excavation is aquifer interference activity. Therefore, it is subject to the *Water Management Act 2000*, relevant water sharing plans and the *NSW Aquifer Interference Policy*. These apply even if the excavation is unlikely to intersect groundwater at the time of construction. For example, a building basement constructed under prevailing drought conditions—when groundwater levels are low—can receive substantial seepage inflows after completion if it is not entirely sealed and if prolonged wet weather causes the groundwater levels to rise.

The Department of Planning, Industry and Environment asserts that permanent building dewatering (ongoing continuous or frequent pumping of groundwater seepage) is inconsistent with the principles of ecologically sustainable development. This dewatering places energy, water, maintenance and administrative demands on the future occupants of a development. That approach also permanently impacts groundwater systems and reduces the availability of groundwater for all users (including the environment).

In some groundwater systems, there is the potential to induce the compaction of unconsolidated layers beneath neighbouring land. This may result in damage to other properties and permanently reduce the capacity of the aquifer. The department also believes that developers must include engineered drainage around and beneath a tanked basement to restore natural groundwater flow conditions following construction completion.

Applicants must seek appropriate licences and approvals for a building project before construction starts. Applying for a licence before construction allows the department to conduct appropriate hydrogeological assessment. Informed groundwater assessments can help prevent delays that could occur if construction work would need to stop if otherwise unforeseen inflows occurred during excavation.

The department strongly recommends that developers communicate with the relevant agency early in the process to identify whether a lack of available authorisations for a water source could delay or prevent a building project from proceeding. As a guide, the department recommends that enquiries relating to licences and approvals should begin between the developer and the relevant agency no later than straight after (if not before) the lodgement of a development application. That maximises the time available to get the necessary authorisation before the planned starting date for construction.

Evidence from past projects shows that dewatering can critically impact nearby buildings, structures and infrastructures when the magnitude and duration of induced drawdown exceeds what has naturally occurred in the past. Engineering measures—such as using interlocking or sealed perimeter support walls with the external reinjection of pumped groundwater—can mitigate drawdown effects to some degree. However, difficult ground conditions or poorly managed construction practices can affect the integrity of the barrier walls and result in unplanned inflows to the excavation.

Reinjecting pumped groundwater may be desirable from a ground-stability perspective; however, be cautious if the extracted groundwater is polluted in any way. Proper treatment of the extracted water is necessary before reinjection to prevent ongoing pollution of the aquifer. If a development is considering reinjection, this should be managed in the same way as discharge to a surface water system—that is, development must protect the receiving water source. The *NSW Aquifer Interference Policy* provides more guidance on managing the effects of a development on groundwater quality.

Definitions for the purposes of this document only

Term	Definition
Aquifer	A geological structure or formation—or an artificial landfill—that is permeated with water or can be permeated with water, including low-yielding and saline groundwater systems that might not otherwise fall within the conventionally accepted hydrogeological definition.
Aquifer interference activity	An enterprise that penetrates an aquifer, generally interferes with an aquifer, changes or obstructs groundwater flow within an aquifer, or takes and disposes water from an aquifer as defined in the *Water Management Act 2000* and the *NSW Aquifer Interference Policy*.
Building	Refers to residential, commercial and industrial structures—including mixed-use developments—but does not refer to extractive industries, such as mines or quarries, or to infrastructure projects, such as road or rail tunnels.
Department	Refers to the NSW Department of Planning, Industry and Environment, as it manages water resources in the state in accordance with the *Water Management Act 2000*. Where relevant, it may also refer to predecessor organisations and agencies that were previously responsible for water management in NSW.
Determination	Refers to interpretation by a suitably qualified consultant of the water-quality results from field or laboratory tests compared with the thresholds or criteria for an individual development and national, state or local guideline values.
Developer and consultant	Refers to development companies, development applicants, development proponents, legal representatives, and licence or approval holders as well as consulting technical specialists providing engineering, environmental, architectural or design advice for a project.
Dewatering	Generally the removal of water from an aquifer as part of a building development to maintain access, serviceability and safe operating conditions.
Dewatering completion report	A document prepared in the specified form that sets out the necessary information to enable the relevant agency to assess the actual volumes and impacts of the dewatering.
Dewatering management plan	A document prepared for one of two reasons: (1) in support of a water supply works approval application that sets out the necessary information to enable WaterNSW to issue a works approval (2) as part of a state significant development application.
Drained basement	A substructure beneath a building that is designed and constructed to minimise as much as possible the take of groundwater to: (1) a flow that can be authorised under a water access licence and that the future building manager maintains (2) meet the monitoring and reporting requirements of a regulated exemption; the department does not recommend this as sustainable development.
Exemption	Refers to an allowance specified within the *Water Management (General) Regulation 2018* as amended or updated from time to time. Conditions may be applied to regulated exemptions where ongoing compliance needs to be demonstrated.
Hydraulic conductivity	Refers to the rate of horizontal groundwater flow through an aquifer. This document uses ‘hydraulic conductivity’ and ‘permeability’ interchangeably to simplify discussion—permeability being a slightly different geotechnical term. A suitably qualified person is to conduct hydraulic conductivity or permeability testing following conventionally accepted testing and analysis procedures.

Term	Definition
Hydrogeological assessment	In accordance with the requirements and criteria of the *NSW Aquifer Interference Policy*, this refers to: (1) a review of the proposed dewatering activity (2) an analysis of the amount of groundwater take that the developer and consultant have calculated (3) an examination of the areal impacts that the developer and consultant predict.
Integrated development	A building project that requires development consent from council as well as a use, work or activity authorisation under Section 91 of the *Water Management Act 2000* to be carried out.
Licences and approvals	Refer to one or a combination of the following: a water access licence, water supply works approval, water use approval, combined approval or aquifer interference activity approval. The development may also require licences, permits or approvals relating to other regulatory jurisdictions.
Minimal harm	Is assumed where the following are within the minimal impact criteria in the *NSW Aquifer Interference Policy*: (1) the effects of the pumping of groundwater by a dewatering activity in terms of (a) water level drawdown (as a factor in the occurrence of ground surface settlement and aquifer compaction) (b) water quality (as a potentially degrading influence on beneficial use) (c) impact on the surrounding environment (including loss, decline or deterioration of groundwater supply to other nearby users and groundwater-dependent ecosystems) (2) the volume (as a take of water that needs to be accounted for) can be authorised by a water access licence (unless an exemption applies) that has been obtained through a controlled allocation process or from a water market through trading.
Regulatory body	One or more of the entities that have separate jurisdictional oversight of some or all aspects of a development, such as councils, the NSW Environment Protection Authority (EPA) or the department.
Relevant agency	Either WaterNSW or the Natural Resources Access Regulator (NRAR). WaterNSW (www.waternsw.com.au/) is responsible for licensing and approvals, water trades and water resource information for its customers. NRAR (www.industry.nsw.gov.au/natural-resources-access-regulator) is responsible for compliance with and enforcement of water management rules and approval conditions and also carries out licensing for entities that are not customers of WaterNSW.
Site hydrogeology report	A document that supports an integrated development application or state significant development application and sets out the information necessary to enable the department to carry out a robust hydrogeological assessment.
State significant development	A building project of a scale or importance that meets the specific requirements, class or description within a state environmental planning policy.
Suitably qualified person	Someone who is a member of a recognised professional organisation and has the appropriate experience, education and qualifications to competently conduct the required work.
Take of water	Comprises the pumping of water by a building development from a water source, irrespective of whether it is derived from a perched groundwater system, is of a quality that would otherwise limit its consumptive use or occurs as seepage from within low-permeability soil or rock material.
Tanked basement	A watertight substructure beneath a building that is designed and constructed to avoid taking any groundwater in the future.

Term	Definition
Water source	Within the *Water Management Act 2000*, refers to the whole or any part of (1) rivers, lakes or estuaries (2) places where water occurs on or below the surface of the ground.

Contributors

This document was developed with significant contributions from water management agencies through an interagency working group. The author acknowledges and is grateful for the valuable contributions from the following staff of the water management agencies:

- The Department of Planning, Industry and Environment—Fabienne d'Hautefeuille, Cate Barrett, Faye Williamson, Jess Thompson, Caitlan Deeth, Ann Smithson, Boyd Dent.
- WaterNSW—Kim Garside, Amanda Fuller, Krystle Moore, Wayne Conners, Angie Castro, Lycia Hayes, Sally Bock.
- Natural Resources Access Regulator—Elise Trask, Richard Nevill, Tim Baker, Rachel Daly.

Contents

1 Introduction

1.1 Legislation and policy

Aquifer interference activities are defined within the *Water Management Act 2000* and the *NSW Aquifer Interference Policy* (NSW Office of Water, 2012). The Act identifies that an aquifer interference activity involves:

- the penetration of an aquifer
- the interference with water in an aquifer
- the obstruction of water flow in an aquifer
- the taking of water from an aquifer when carrying out mining or any other activity the regulations prescribe
- the disposal of water taken from an aquifer when mining or carrying out another prescribed activity

The *NSW Aquifer Interference Policy* further details the scope of aquifer interference activities to include the following high-risk projects:

- mining activities (open-cut and underground mines)
- extractive industries (sand and gravel pits, dredging operations or quarries)
- coal seam gas exploration and production
- construction dewatering (buildings, transport projects or civil works)
- injection works
- potentially contaminating activities or those that can damage the structural integrity of an aquifer.

The *NSW Aquifer Interference Policy* provides specific guidance on the licensing and approval requirements for activities that interfere with aquifers (or groundwater systems).

1.2 Required authorisations

Applicants must seek the appropriate authorisations before construction starts. The licensing process is independent of the planning process, and developers should be aware that getting development consent does not automatically include permission to take groundwater. Appropriate authorisation will comprise one or more of a water access licence, water supply works approval or aquifer interference activity approval, depending on the circumstances. Applicants must get authorisations before water is taken. Therefore, these authorisations are generally required before excavation can start. Granting development consent does not guarantee that that the applicant will be able to secure the required shares from the affected water source.

The department strongly recommends that developers communicate early in the process with the relevant agency—WaterNSW or the Natural Resources Access Regulator (NRAR)—to identify the level of commitment in the relevant water source. The inability of a developer to get the necessary entitlement can delay or prevent a building project from proceeding. Clearly identifying the pathway to getting the required shares should happen as soon as possible after receiving development consent (if not beforehand) to prevent such delays.

1.3 Applicability of this guideline

This document sets out the requirements applying to commercial, residential and mixed-use building developments that incorporate basement levels and that require excavation. The technical

requirements in this document apply to the following reports at the appropriate steps in the licensing process:

- the **site hydrogeology report**, a technically robust report to support lodgement of a development application with council
- the **dewatering management plan**, a comprehensive and detailed plan to support a water supply works approval application
- the **dewatering completion report**, a thorough and accurate report to support the surrendering of the water supply works approval.

The developer and consultant must present the described information so the department can carry out a hydrogeological assessment of the effects of the proposed building dewatering activity. That assessment will consider the minimal impact criteria established within the *NSW Aquifer Interference Policy* and will help the department decide on whether a water access licence will be required. The department will then advise the relevant agency of the outcomes of the assessment so the agency can determine the application.

If the developer and consultant propose to modify the building design after the department has already provided advice to the relevant agency, then another referral to the department may be required. The modification might have a different effect on the groundwater system beneath the property, which would mean the department must conduct a new hydrogeological assessment.

The requirements in this document do not specifically apply to transport engineering (such as road and rail cuttings, embankments or bridges), underground projects (tunnels or underground mines) or other extractive industries (quarries, sand mining or open-cut mines). Those activities have different impacts and time frames, and are often dealt with through different processes. However, if specific requirements are unavailable for those types of projects, the information in this document may define a broad and consistent scope for the types of investigations and reporting that apply to those other activities.

1.4 Recommended basement design

The department asserts that basements should be watertight (fully tanked) for the life of the building (typically 100 years) to:

- avoid the energy demand from the continual operation of the pump-out system
- reduce the required maintenance demand to keep the pumps operating and drainage lines free of clogging from the aeration of mineral-rich groundwater
- eliminate the water demand on the surrounding groundwater system and optimise the availability of groundwater for all users
- prevent an additional administrative demand to retain records and maintain valid approvals, licences, or both, that would otherwise be imposed on the future managers of the property.

Adopting the tanked basement position limits groundwater system impacts to the short-term (that is, transitory drawdown and take) compared with the long-term (permanent and progressive) consequences from continual pumping.

If the developer adopts the recommended tanked basement design, then the developer and consultant must ensure that the completed structure causes no obstruction to predevelopment groundwater flow. The department expects that incorporating appropriate engineering design methods, techniques and materials into the development at the time of construction will help avoid such an obstruction.

If a drained basement design is impossible, then the developer and consultant must ensure that the substructure minimises the take of groundwater as much as possible. Any take of water after the basement has been completed—including during periods of high groundwater elevations—

must meet relevant impact assessment criteria. It must also either be authorised under a water access licence or be low enough to meet a regulated exemption threshold. Claiming an exemption does not exempt the applicant from specific monitoring and reporting requirements.

1.5 Guiding principles

The guiding principles for building site dewatering activity are to:

- meet regulatory obligations under the *Water Management Act 2000*, relevant water sharing plans and the *NSW Aquifer Interference Policy*
- correctly characterise the existing groundwater regime, including authorised users and dependent ecosystems
- appropriately predict the likely effects from dewatering and capture enough data during construction to demonstrate that the actual effects are consistent with the predictions
- minimise the impact of the construction activity and the completed development on the groundwater regime
- properly account for the take of groundwater during construction
- demonstrate that unavoidable ongoing take from the completed development is either minimal (that is, low enough to be conditionally exempt) or properly accounted for under a water access licence.

1.6 Scope of investigations and planning

Investigations into the groundwater systems beneath a property and planning for a proposed building development must include but not be limited to:

- enough site-specific information before excavation to reasonably calculate the amount of groundwater likely to be taken
- an accurate conceptual hydrogeological model for the project site
- a preliminary estimate of take based on accurate building dimensions, knowledge of the ground conditions and expected duration of construction
- identification of the potential for adverse effects based on the preliminary estimate of take and the type of aquifer being interfered with
- comprehensive site-specific investigations to refine the anticipated amount of take and the potential for adverse effects
- the required licences and approvals for the amount of water and dewatering activity, respectively, considering the level of commitment within the relevant groundwater source
- a documented building management system for the completed development that includes routine monitoring and reporting of any groundwater inflow to below-ground areas (if unavoidable) throughout occupation.

1.7 Variations to these requirements

Developers and consultants may obtain variations to these minimum requirements through written agreement with the department. The department will need adequate time to properly assess the nature of each variation request and how the proposed changes might impact the aquifer, other users and the environment before considering whether to make an agreement. Developers and consultants must therefore submit the request for a variation at least six months before lodgement of each development or licence application. If the department receives many variation requests at once, this may unavoidably delay assessment of individual proposals.

The department will consider variations only where the proposed design has thorough documentation and evidence to justify the need for a different approach to environmental protection.

The site-specific data to support a requested variation must include:

- comprehensive water level monitoring across the site that demonstrates the practical range of natural water level variation under wet and dry conditions
- hydraulic conductivity test results for each of the lithological units identified in the subsurface beneath the property
- details of the groundwater quality that is to be pumped
- an accurate calculation of the amount of groundwater to be taken using site-specific data only
- results of analytical or numerical hydrogeological computer modelling (depending on the amount of groundwater intercepted) of the potential impacts of dewatering at the site in question.

Where the department has not received a fully documented variation and provided written agreement, the investigations and reporting arrangements must comply with these minimum requirements.

2 Measurement standards

Measurements taken throughout the dewatering activity must be accurate and precise enough to enable a robust hydrogeological assessment. Table 1 lists the minimum standards for measurements that developers must take at the site.

Table 1. Measurements and required accuracy

Measurement	Units	Required accuracy	Comment
Time and date	12 hour or 24 hour (specify)	Record time entries to the nearest minute	Record date entries in day/month/year format (dd/mm/yyyy)
Discharge	Litres (L)	Discharge volume to nearest litre	Meters must be the same type and accuracy specified by the department for other purposes
Discharge	Kilolitres (kL)	Discharge volume to nearest 100 litres (0.1 kL)	Meters must be the same type and accuracy specified by the department for other purposes
Discharge	Megalitres (ML)	Discharge volume to nearest 1,000 litres (0.1 ML)	Meters must be the same type and accuracy specified by the department for other purposes
Elevation	Metres relative to Australian Height Datum (m AHD)	Report elevation information an accuracy of ±0.03 m (30 mm) or better	Surveying of monitoring bore measurement points by a registered surveyor to required accuracy necessary for hydrogeological assessment
Location	Metres	Report position information to an accuracy of ±0.03 m (30 mm) or better	Surveying of monitoring bore location to required accuracy necessary for hydrogeological assessment

Measurement	Units	Required accuracy	Comment
Water level	Metres	Report water level measurements to an accuracy of ±0.01 m (10 mm) or better	Water level measurements to required accuracy necessary for hydrogeological assessment. We recommend using electric water level sensors with continuous recorders.
Field pH	pH units	Report measurements to an accuracy of ±0.1 pH unit	We recommend using regularly calibrated instruments or continuous monitoring devices with the required accuracy or better
Field electrical conductivity	Microsiemens per centimetre (µS/cm)	Report measurements to an accuracy of ±10 µS/cm	We recommend using regularly calibrated instruments or continuous monitoring devices with the required accuracy or better
Field temperature	Degrees Celsius (°C)	Report measurements to an accuracy of ±1°C	We recommend using regularly calibrated instruments or continuous monitoring devices with the required accuracy or better
Field reduction-oxidation (redox) potential	Millivolts (mV)	Report measurements to an accuracy of ±10 mV	We recommend using regularly calibrated instruments or continuous monitoring devices with the required accuracy or better

3 Groundwater monitoring arrangements

3.1 Monitoring point locations and depths

Subject properties require a minimum of three monitoring bore locations at or around them—appropriately licensed if required and documented in driller's logs. The department requires these monitoring locations to be situated to avoid any damage or destruction to them during construction. Potentially, they need to be available for periodic future measurements of groundwater levels and quality throughout the occupational phase of the building. If a monitoring bore location becomes damaged at any time during construction, an appropriately positioned replacement must be installed within one week of the damage having occurred.

Configurations for monitoring bore locations must allow the triangulation of groundwater elevations; the locations must accurately determine an unambiguous hydraulic-flow direction and gradient. Where appropriate, monitoring locations may achieve more than one purpose—that is, the department understands that the duplication of effort necessary to separately install bores for environmental investigations, acid-sulfate soils sampling and geotechnical testing can be minimised. Comprehensive planning before intrusive site investigations allows for the construction of multipurpose monitoring bores, achieving cost efficiency for the project. Groundwater monitoring bores must be installed according to the current edition of the *Minimum Construction Requirements for Water Bores in Australia*.

To adequately document the subsurface conditions at a project site, drilling investigations must extend to depths greater than the proposed lowermost basement level. Table 2 identifies the required depths of investigation and the required depths of monitoring bores to properly

characterise the groundwater system and assist the engineering design of the basement structures. The screened intervals of monitoring bores have been specified to be set across the lowermost basement level to identify groundwater conditions at the bulk excavation level, assuming uniform ground conditions.

Table 2. Required depths of investigation and monitoring

Number of basement levels	Assumed depth of substructure	Minimum depth of intrusive investigation	Nominated monitoring-bore requirement	Comment
One level	3 m below ground level	At least one investigation hole drilled to 10 m below ground level	Monitoring bores to be screened from 2 to 5 m below ground level	Assuming uniform ground conditions
Two levels	6 m below ground level	At least one investigation hole drilled to 15 m below ground level	Monitoring bores to be screened from 5 to 8 m below ground level	Assuming uniform ground conditions
Three levels	9 m below ground level	At least one investigation hole drilled to 20 m below ground level	Monitoring bores to be screened from 6 to 12 m below ground level	Assuming uniform ground conditions
Four levels	12 m below ground level	At least one investigation hole drilled to 25 m below ground level	Monitoring bores to be screened from 9 to 15 m below ground level	Assuming uniform ground conditions
Five levels	15 m below ground level	At least one investigation hole drilled to 30 m below ground level	Monitoring bores to be screened from 12 to 18 m below ground level	Assuming uniform ground conditions

3.1.1 Uniform ground conditions

Properties where drilling results indicate that uniform ground exists require three monitoring locations around the periphery of the site outside the basement footprint. These must be spaced to achieve a spread of points that can serve to triangulate hydraulic gradients and groundwater flow directions from water level measurements. Linear arrangements are unacceptable.

Each monitoring bore must be screened across the depth of the proposed bulk excavation level (see Table 2) to identify that no semiconfined conditions exist in the groundwater system being intersected. If measured data identifies potentiometric pressure effects, then the monitoring program should include additional shallower monitoring points—such as those used for initial site environmental investigations.

The documented borehole logs for each monitoring bore must clearly demonstrate the following:

- the subsurface between the ground surface and the bulk excavation level is effectively uniform
- the water levels measured in each of the monitoring bores are within a range that would be expected of an unconfined groundwater system given the site setting
- the position of the monitoring bores and the measured water levels identify an appropriate hydraulic gradient and flow direction given the site setting.

Where site-specific drilling results cannot demonstrate these requirements, additional monitoring bores must be installed and included in the monitoring program.

Developers must provide all data relating to the design, construction, relative placement and absolute positioning of each monitoring point (including replacement works where necessary) to the required standard (see Table 1) to the relevant agency (WaterNSW or NRAR).

3.1.2 Cut-off layer situations

Properties where the drilling results identify a discrete cut-off layer and the intention is to use the lower permeability of that unit to limit groundwater inflow to the base of the excavation require additional monitoring points. They require three monitoring locations around the periphery of the site outside the basement footprint, spaced to achieve a spread of points that can serve to triangulate hydraulic gradients and groundwater flow directions from water level measurements. Linear arrangements are unacceptable.

Each monitoring location must have a twinned bore arrangement to permit measurements of water levels from above and below the unit that will serve as a cut-off layer. The deeper monitoring bores at each of the three locations are to be screened across the depth of the proposed bulk excavation level (see Table 2) to identify that no semiconfined conditions exist in the groundwater system being intersected. The shallow monitoring bores at each of the three locations are to be screened just above the identified cut-off layer.

The documented borehole logs for each monitoring bore must clearly demonstrate the following:

- the subsurface above the cut-off layer is effectively uniform
- the subsurface below the cut-off layer to the bulk excavation level is effectively uniform
- the water levels measured in each of the monitoring bores above the cut-off layer are within a range that would be expected of an unconfined groundwater system given the site setting
- the water levels measured in each of the monitoring bores below the cut-off layer are within a range that would be expected of an unconfined or semiconfined groundwater system given the site setting
- the position of the monitoring bores and the measured water levels identify an appropriate hydraulic gradient and flow direction above and below the cut-off layer given the site setting.

Where site-specific drilling results cannot demonstrate these requirements, additional monitoring bores must be installed and included in the monitoring program.

Developers must provide all data relating to the design, construction, relative placement and absolute positioning of each monitoring point (including replacement works where necessary) to the required standard (see Table 1) to the relevant agency (WaterNSW or NRAR).

3.1.3 Excavation intersecting a base layer

Properties where drilling results indicate that the building excavation will intersect unconsolidated layers above a less permeable base layer will require additional monitoring. If the overlying unconsolidated layer is less than three metres total thickness from the ground surface to the base of the unit across the entire site, then monitoring bores can be established as if the subsurface were uniform. If the overlying unconsolidated material is greater than three metres total thickness from the ground surface to the base of the unit across the entire site, then monitoring locations with twinned bores are required. There must be three monitoring locations around the periphery of the site outside the basement footprint, spaced to achieve a spread of points that serve to triangulate hydraulic gradients and groundwater flow directions from water level measurements. Linear arrangements are unacceptable.

Each monitoring location must have a twinned bore arrangement to permit separate measurements of water levels from the overlying unconsolidated unit and from the underlying base layer. The deep monitoring bores at each of the three locations are to be screened across the depth of the proposed bulk excavation level (see Table 2). The shallow monitoring bores at each of the three locations are to be screened just above the top of the base layer.

The documented borehole logs for each monitoring bore must clearly demonstrate the following:

- the subsurface above the base layer is effectively uniform
- the subsurface within the base layer to the bulk excavation level is effectively uniform
- the water levels measured in each of the monitoring bores above the base layer are within a range that would be expected of an unconfined groundwater system given the site setting
- the water levels measured in each of the monitoring bores within the base layer are within a range that would be expected of an unconfined or semiconfined groundwater system given the site setting
- the position of the monitoring bores and the measured water levels identify an appropriate hydraulic gradient and flow direction above and within the base layer given the site setting.

Where site-specific drilling results cannot demonstrate these requirements, additional monitoring bores must be installed and included in the monitoring program.

Developers must provide all data relating to the design, construction, relative placement and absolute positioning of each monitoring point (including replacement works where necessary) to the required standard (see Table 1) to the relevant agency (WaterNSW or NRAR).

3.2 Monitoring schedules

3.2.1 Temporary construction dewatering

The following monitoring schedules apply for the period that the proposed development will be taking groundwater as part of the temporary construction dewatering activity:

- daily groundwater levels measured over a minimum three-month period within the six months immediately before each application lodgement (the preference is for continuous monitoring using data loggers for the full six-month period), continuing throughout the dewatering period and for one month after dewatering finishes
- weekly in situ water quality measurements and determinations using a calibrated handheld water quality meter of groundwater, discharge water and any water for reinjection; this must include, at a minimum, electrical conductivity (specific conductance at 25°C), temperature, pH and reduction-oxidation (redox) potential
- monthly sampling, laboratory testing and determinations of both groundwater and discharge water quality, together with any water for reinjection
- more frequent grab samples where there are analytes, especially contaminants of concern, or return concentrations found to be elevated above trigger values, adopted criteria or guideline values; more frequent sampling may also be required to demonstrate compliance with discharge limits, and in situ field water quality measurements should happen with each grab sample for confirmation
- weekly meter readings with dates and times of water measurement (to monitor cumulative discharge volumes and the range of flow rates and confirm ongoing correct functioning of the installed meter); daily meter readings are necessary where the duration of dewatering is only a few weeks long.

3.2.2 Permanent dewatering

If for some reason the development is not watertight enough to prevent groundwater inflow, the following monitoring schedules apply for the period that the proposed development will be taking groundwater:

- monthly in situ field water quality measurements and determinations using a calibrated handheld water quality meter of both groundwater and discharge water; this must include a

minimum of electrical conductivity (specific conductance at 25°C), temperature, pH and redox potential

- monthly meter readings with dates and times of measurement (to monitor annual discharge volumes and average flow rates and confirm ongoing correct functioning of the installed meter).

The department requires developers and consultants to incorporate these schedules and specific annual reporting arrangements to the relevant agency (WaterNSW or NRAR) into a documented building management system for the property. This way, the actual take can be determined at any time during the life of the building (typically 100 years).

3.3 Hydraulic conductivity testing

Accurate site-specific aquifer testing is required. Calculating potential impacts from the take of groundwater relies on the properties of the aquifer. The departmental assessment of the project will reference site-specific aquifer parameters.

Each permeability test must happen at least three times to demonstrate repeatability, and the departmental hydrogeological assessment will consider the highest value result. Selecting the highest value is necessary to reduce the potential for the actual take of groundwater to exceed the amount authorised by a water access licence or the threshold of any available exemption.

In layered ground, permeability testing must take place for each lithology to be intersected by the excavation and the material up to three metres below the deepest point to be excavated. These unit-specific measurements are necessary because groundwater inflows to an excavation will typically occur through preferential pathways formed by higher permeability layers or conduits. It is therefore essential to identify whether particular layers contribute the majority of groundwater inflows to an excavation. This is because they can target specialised engineering treatments to reduce or prevent seepage, particularly if those units are relatively thin (compared with the full depth of excavation).

All permeability test results are to be provided graphically for each of the individual lithologies tested. Graphics of the test results are to be grouped based on the lithology to which they refer. All measurements and results must be reported to the relevant agency (WaterNSW or NRAR) at the required time.

3.4 Volumes and flow rates

Metering of the pumping and discharge volume and the duration over which it occurs must determine the take of groundwater for every building dewatering activity. Meters must meet department standards and must be installed, maintained and used in accordance with relevant national standards.

Developers are to record meter readings at intervals the department sets (see Section 3.2 Monitoring schedules). They must report all measurements to the relevant agency (WaterNSW or NRAR) at the required time.

3.5 Groundwater quality

Monitoring groundwater quality must take place to demonstrate the effects of a building dewatering activity and to identify any changes to receiving waters due to discharge. Field measurements, sampling and laboratory testing must include groundwater, discharge water and receiving water at every monitoring event scheduled for the duration of the activity.

Field measurements are to take place for the typical parameters appropriate for groundwater systems (see Table A1, Appendix A) at a minimum. Other parameters can be added to field testing as necessary to meet the requirements of another regulatory body. Developers must use regularly

calibrated water quality meters for taking field measurements and must provide evidence of their most recent calibration.

A suitably qualified person must conduct sampling in accordance with documented protocols developed for that purpose. Sample transport to the laboratory must follow documented chain-of-custody procedures and occur within prescribed holding times.

National Association of Testing Authorities-accredited laboratories or an ISO/AS and NZ standard-accredited laboratory must carry out sample testing for at least the routine analyte list the department requires (see Table A2, Appendix A). Laboratory testing must include quality-assurance and quality-control checks and reporting to demonstrate the validity of results.

The department recognises that specific sampling and analysis for contaminated sites are common approaches for many projects, and developers and consultants can use the requirements of another regulatory body in those instances as a baseline suite. Rather than having duplicated tests where overlaps could occur, the department expects developers to add any additional analytes required by another regulatory body to the routine tests listed in Appendix A.

Similarly, any acid sulfate soils management testing program (such as that outlined in Stone, Ahern and Blunden, 1998) can serve as a baseline suite, with the routine analytes the department requires added to the analyte list to avoid duplication.

Water quality sampling and field measurements must take place at the intervals the department requires (see Section 3.2 Monitoring schedules). Developers must report all measurements and results to the relevant agency (WaterNSW or NRAR) at the required time.

4 Reporting

Developers and consultants must report the information listed in Table 3 to the relevant agency (WaterNSW or NRAR) to support a development application and a water supply works approval application. Some of the report contents in Table 3 also apply to filling out a dewatering completion report on the appropriate form. A suitably qualified person is to prepare and sign off all reports.

The identified document contents apply to the required reports, but there is a caveat. The department expects developers and consultants to demonstrate refinements of the hydrogeological understanding and improvements in the prediction of the effects of dewatering (including take volumes) between the site hydrogeology report and the dewatering management plan. Reproducing the same report for both the site hydrogeology report and the dewatering management plan does not demonstrate the refinement that the department expects to occur from the ongoing monitoring and testing data that the developer and consultant collect and consider.

Table 3. Required report contents

Section	Requirement	Minimum information	Comment
Introduction	General description of the site	• Property address and lot and deposited plan (DP) numbers • Description of the proposed building development • Timing details of the building dewatering schedule and the broader construction schedule	Include these elements in all documents
Site geology	Conceptualisation based on results of comprehensive intrusive investigations at the site	• General discussion of ground surface elevation across the site • Tabulation of the subsurface layers identified from intrusive investigations at the site, including depths and thicknesses	Include these elements in: • site hydrogeology report

Section	Requirement	Minimum information	Comment
		• Detailed material descriptions of each layer encountered during intrusive investigations • Determinations of potential acid sulfate soils (PASS) and actual acid sulfate soils (ASS) from multiple site-specific samples and laboratory analysis	• dewatering management plan
Site hydrogeology	Conceptualisation and aquifer conceptualisation based on results of comprehensive intrusive investigations at the site	• Depth to groundwater based on at least daily measurements from within a six-month period before lodgement of the application • Basic statistics (minimum, average, median, maximum) of groundwater measurements in metres depth below ground level and metres elevation referenced to AHD • Prediction of the highest groundwater level in metres depth below ground level and metres elevation referenced to AHD under wet weather conditions (where the predevelopment monitoring does not, or is unlikely to, extend beyond two years) • Hydraulic conductivity test results for every substantial lithological layer to be intersected by the excavation (tested at least three times each to demonstrate repeatability) • Tabulated details and included to-scale plan diagram of at least three groundwater monitoring locations distributed across the site positioned to allow triangulation of groundwater flow directions • Like-for-like replacement protocols for monitoring bores that may be damaged or destroyed by the proposed construction activity	Include these elements in: • site hydrogeology report • dewatering management plan
Analytical or numerical groundwater flow modelling	Groundwater take and impact predictions based on appropriate modelling	• Description of the groundwater flow model used (cannot be a geotechnical pore pressure or seepage inflow model) • Demonstration that conceptualisation represents site conditions • Details of the site-specific information used to conceptualise, construct, calibrate and validate the model • All assumptions made and those inherent in the modelling approach • Details of the adopted model parameters • Predictions of the maximum extent of the cone of depression resulting from the full duration of the proposed dewatering pumping • Comprehensive impact assessment in accordance with the *NSW Aquifer*	Include these elements in: • site hydrogeology report • dewatering management plan

Section	Requirement	Minimum information	Comment
		Interference Policy requirements and criteria • Nomination of groundwater trigger levels to activate contingency measures should unforeseen impacts occur	
Building design	Accurate dimensions for the basement footprint in three dimensions and extent of the required drawdown	• Clearly documented basement dimensions on all subsurface floor plans (to outside the design walls for the entire basement footprint) • Clearly documented excavation design on two section diagrams (oriented approximately perpendicular to each other and extending across the site) • Identification of critical levels associated with the excavation and building design in metres elevation referenced to AHD on the sections as follows: ○ ground surface level ○ highest predicted groundwater level ○ lowermost basement finished floor level ○ substructure floor level for lift pits or stormwater tanks extending beneath lowermost basement ○ bulk excavation level ○ required pumping water level ○ base of aquifer • Proposed excavation support method and the degree of watertightness expected from the completed wall system • Waterproofing methodology to be used to reduce the permeability of the wall and floor system to complete a watertight basement • Drainage system to be installed around and beneath the watertight basement to prevent obstruction of groundwater flow and consequent adverse effects (for example, waterlogging or increased discharge on neighbouring properties)	Include these elements in: • site hydrogeology report • dewatering management plan
Water take	Calculation of take volume and identification of any licensing requirements	• Weekly and total water take requirements based on the groundwater flow modelling • Discussion of the licensing requirements, including availability of shares in the groundwater source • Need for a water access licence to authorise the volume of groundwater predicted to be taken during dewatering pumping • Need for an approval to authorise the bores or structure used to take groundwater	Include these elements in all documents

Section	Requirement	Minimum information	Comment
Monitoring and reporting	Details of the groundwater management actions for the project	• Establishment of trigger levels (based on monitoring data gathered since project commencement and supplemented by measurements following development consent, as well as trends analysis if necessary) that are to be applied once construction commences to identify whether adverse impacts are occurring • Description of the response actions if groundwater reaches or exceeds the trigger levels or points • Scheduling and content of the frequent regular recording of the monitoring measurements, data-handling protocols and reporting processes • Notification plan to the relevant agency (WaterNSW or NRAR) should unforeseen impacts occur or if groundwater exceeds triggers • Nomination of the due date for submitting the dewatering completion report	Include these elements in all documents
Figures	Illustrations and diagrams showing relevant information	• Diagram illustrating location of property • Site survey illustrating spot elevations and contours • Detailed design plan for each basement level footprint with major axis dimensions (to outside each basement wall) clearly documented • Revised hydrogeological section diagrams based on detailed design plans (to scale and with critical levels clearly identified) oriented approximately perpendicular to each other • Plan diagram of the three monitoring locations used for groundwater measurements and sampling relative to basement footprint • A plan illustration of the extent of the cone of depression and capture zone that will be developed from the pumping required to dewater the site using the predicted highest groundwater level elevation	Include these elements in: • site hydrogeology report • dewatering management plan
Attachments	Supporting documentation	• Site borehole logs • All raw measurement data in electronic format • All field and laboratory test result data in electronic format • Copies of written agreements for variations • Signed statement of compliance with these requirements by the author (a suitably qualified person)	Include these elements in all documents

5 More information

Additional information and helpful resources are available from:

- WaterNSW construction dewatering and metering webpages (www.waternsw.com.au/customer-service/water-licensing/dewatering, www.waternsw.com.au/customer-service/water-licensing/metering)
- NRAR 'Groundwater WAL exemptions for 3ML and Botany Sands' and 'Fact sheets' webpages (www.industry.nsw.gov.au/natural-resources-access-regulator/licensing-and-approvals/groundwater-wal, www.industry.nsw.gov.au/natural-resources-access-regulator/resources/Factsheets)
- Department of Planning, Industry and Environment—Water internet portal (www.industry.nsw.gov.au/water).

6 References

NSW Office of Water (2012) *NSW Aquifer Interference Policy*, NSW Government policy for the licensing and assessment of aquifer interference activities, NSW Department of Primary Industries, NSW Department of Trade and Investment, Regional Infrastructure and Services, publication number 11445, September, ISBN 978 1 74256 338 1.

Stone, Y, Ahern, C, and Blunden, B (1998) *Acid Sulfate Soil Manual*, New South Wales Acid Sulfate Soil Management Advisory Committee, Wollongbar, August, ISBN 0 7347 0000 8.

Appendix A—Routine water quality monitoring lists

Field measurements

Table A1 lists required field tests. Developers are to record all measurements with detailed date, time and location entries for inclusion in a report to the relevant agency.

Table A1. List of required field water quality tests and schedule

Type	Field measurements	Testing requirement
Physical parameters	Electrical conductivity, temperature, pH, redox potential	Mandatory
Water level	Standing water level at time of field parameter measurement	Mandatory

Laboratory tests

Table A2 lists required laboratory tests. Analytes with an asterisk (*) are most relevant to surface water systems and have been included to provide a testing suite appropriate for both groundwater and receiving waters.

Where Table A2 indicates, parameters that are 'mandatory for baseline thereafter negotiable' will be considered for a discontinuation or reduction in frequency as the program continues only if developers meet certain conditions. They must demonstrate that a minimum of 12 consecutive sampling events have exhibited concentrations below water quality guideline criteria. The requirement for 12 consecutive sampling events may be tailored to suit each project on a case-by-case basis to align with the development schedule. Examples would be sampling once per month for 12 months if detailed design studies will be prolonged, sampling once per fortnight for six months for typical durations or sampling once a week for 12 weeks if there are time constraints.

Table A2. List of required laboratory water quality tests and schedule

Type	Corresponding laboratory analyses	Testing requirement
Physical parameters	Alkalinity (bicarbonate, carbonate, hydroxide and total), electrical conductivity (EC), pH, redox potential (Eh), total dissolved solids (TDS), total hardness, temperature, dissolved oxygen (DO)	Mandatory
Other physical parameters	Turbidity* (NTU), total suspended solids* (TSS), total organic carbon* (TOC), sodium absorption ratio* (SAR)	Mandatory for discharge to any receiving waters
Major anions	Sulfate (SO_4), chloride (Cl), carbonates (CO_3), bromide (Br), fluoride (F)	Mandatory
Major cations	Calcium (Ca), magnesium (Mg), sodium (Na), potassium (K)	Mandatory
Ionic balance	Cation/anion balance (as a percentage)	Mandatory
Dissolved inorganics and dissolved heavy metals	Aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), lithium (Li), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), silica (dissolved SiO_2), silver (Ag), strontium (Sr), uranium (U), vanadium (V), zinc (Zn)	Mandatory for baseline thereafter negotiable, depending on site setting unless otherwise required by another regulatory body

Type	Corresponding laboratory analyses	Testing requirement
Nutrients	Ammonia (NH_3), nitrate (NO_3), total nitrogen (N), oxidised nitrogen (N), total phosphorus (P), reactive phosphorus (P)	Mandatory for baseline thereafter negotiable, depending on site setting unless otherwise required by another regulatory body
Microbiological organisms	Faecal coliforms, faecal streptococci, *Escherichia coli*	Mandatory for baseline thereafter negotiable, depending on site setting unless otherwise required by another regulatory body
Organics	Benzene toluene ethylbenzene xylene (BTEX), polycyclic aromatic hydrocarbons (PAHs), total recoverable hydrocarbons (TRHs)	Mandatory for baseline thereafter negotiable, depending on site contamination status unless otherwise required by another regulatory body
Other	Range of analytes relevant to site-specific contaminants of environmental concern—for example: • pesticides (OCPS, OPPs) • polychlorinated biphenyls (PCBs) • semivolatile chlorinated hydrocarbons (SVOCs) • volatile chlorinated hydrocarbons (VOCs) • chlorinated aliphatics • phenols • perfluoroalkyl and polyfluoroalkyl substances (PFAS)	As required by the NSW EPA or accredited site auditor (for properties regulated under the *Contaminated Land Management Act 1997*), on the advice of a specialist environmental consultant or as required by another regulatory body