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AND DEVELOPMENT PLANNING 

GUIDELINE FOR INVOLVING 
HYDROGEOLOGISTS IN EIA PROCESSES 

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EDITION 1 

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GUIDELINE FOR INVOLVING HYDROGEOLOGISTS IN EIA PROCESSES

Edition 1

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PREFACE

For Environmental Impact Assessment (EIA) processes to retain their role and usefulness in supporting decision-making, the involvement of specialists in EIA needs to be improved in order to:

- Add value to project planning and design;
- Accurately predict and assess potential project benefits and negative impacts;
- Provide practical recommendations for avoiding or adequately managing negative impacts and enhancing benefits;
- Supply adequate and appropriate information that addresses key issues and concerns to effectively inform decision-making in support of sustainable development.

The purpose of this series of guidelines is to improve the efficiency, effectiveness and quality of specialist involvement in EIA processes. They aim to improve the capacity of roleplayers to anticipate, request, plan, review and discuss specialist involvement in EIA processes. Specifically, they aim to improve the capacity of EIA practitioners to draft appropriate terms of reference for specialist input and assist all roleplayers in evaluating whether or not specialist input to the EIA process was appropriate for the type of development and environmental context.

The guidelines draw on best practice in EIA in general, and within specialist fields of expertise in particular, to address the following issues related to the timing, scope and quality of specialist input. Although the guidelines have been developed with specific reference to the Western Cape province of South Africa, their core elements are more widely applicable.

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<td>- When should specialists be involved in the EIA process; i.e. at what stage in the EIA process should specialists be involved (if at all) and what triggers the need for their input?</td>
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<td>- Which aspects must be addressed through specialist involvement; i.e. what is the purpose and scope of specialist involvement?</td>
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<td>- What are appropriate approaches that specialists can employ?</td>
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<td>- What triggers the review of specialist studies by different roleplayers?</td>
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<td>- What are the review criteria against which specialist inputs can be evaluated to ensure that they meet minimum requirements, are reasonable, objective and professionally sound?</td>
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The following guidelines form part of this series:

- Guideline for determining the scope of specialist involvement in EIA processes
- Guideline for the review of specialist input into the EIA process
• Guideline for involving biodiversity specialists in EIA processes
• Guideline for involving hydrogeologists in EIA processes
• Guideline for involving visual and aesthetic specialists in EIA processes
• Guideline for involving heritage specialists in EIA processes
• Guideline for involving economists in EIA processes

The Guideline for determining the scope of specialist involvement and the Guideline for the review of specialist input provide generic guidance applicable to any specialist input to the EIA process and clarify the roles and responsibilities of the different roleplayers involved in the scoping and review of specialist input. It is recommended that these two guidelines are read first to introduce the generic concepts underpinning the guidelines which are focussed on specific specialist disciplines.

It is widely recognized that no amount of theoretical information on how best to plan and coordinate specialist inputs as an EIA practitioner, or to provide or review specialist input, can replace the value of practical experience of co-ordinating, being responsible for and/or reviewing specialist studies. Only with such experience can the EIA practitioner and specialist develop sound judgment on such issues as the level of detail needed or expected in specialist input to inform decision-makers adequately. For this reason, the guidelines should not be viewed as prescriptive and inflexible documents; their intention is to provide best practice guidance only.

Who is the target audience for these guidelines?

The guidelines are directed at authorities, EIA practitioners, specialists, proponents, financing institutions and other interested and affected parties involved in EIA processes.

What type of environmental assessment processes and developments are these guidelines applicable to?

The guidelines have been developed to support project-level EIA processes regardless of whether this is undertaken during the early project planning phase to inform planning and design decisions (i.e. during pre-application planning/screening) or as part of a legally defined EIA process to obtain statutory approval for a proposed project (i.e. during screening, scoping and/or impact assessment). The guidelines promote early, focussed and appropriate involvement of specialists in EIA processes in order to encourage proactive consideration of potentially significant impacts, so that they may be avoided through due consideration of alternatives and changes to the project.

The guidelines aim to be applicable to a range of types and scales of development, as well as different biophysical, social, economic and governance contexts.
**What will these guidelines not do?**

In order to retain their relevance in the context of changing legislation, the guidelines promote the principles of EIA best practice without being tied to specific legislated national or provincial EIA requirements. They therefore do not clarify the specific administrative, procedural or reporting requirements and timeframes for applications to obtain statutory approval. They should, therefore, be read in conjunction with the applicable legislation, regulations and procedural guidelines to ensure that mandatory requirements are met.

The guidelines do not intend to create experts out of non-specialists. Although the guidelines outline broad approaches that are available to the specialist discipline (e.g. field survey, desktop review, consultation, modelling), specific methods (e.g. the type of model or sampling technique to be used) cannot be prescribed. The guidelines should therefore not be used indiscriminately without due consideration of the particular context and circumstances within which an EIA is undertaken as this influences both the approach and the methods available and used by specialists.

The specialist guidelines have been structured to make them user-friendly. They are divided into six parts, as follows:

- **Part A**: Background;
- **Part B**: Triggers and key issues;
- **Part C**: Planning and co-ordination of specialist inputs (drawing up Terms of Reference);
- **Part D**: Providing specialist input;
- **Part E**: Review of specialist input; and
- **Part F**: References.

Part A provides grounding in the specialist subject matter for all users. It is expected that authorities and peer reviewers will make most use of Parts B and E; EIA practitioners and project proponents Parts B, C and E; specialists Part C and D; and other stakeholders Parts B, D and E. Part F gives useful sources of information for those who wish to explore the specialist topic.
Specialist hydrogeological input to the EIA process must be sought if the development may:

- Discharge or leak effluent or chemicals with the potential to change groundwater quality.
- Change the volume of groundwater in storage or entering groundwater storage beyond what is allowed by the DWAF General Authorisations.
- Change the groundwater flow regime.

An assessment then needs to be made, with the involvement of the hydrogeologist, of whether a specialist hydrogeological assessment is required. This is based on environmental triggers:

- The degree of separation between the base of the development and the water table.
- The character of the overlying soil and rock material
- Separation between the development and boreholes
- Separation between the development and wetlands or sensitive ecological features
- The vulnerability status of the aquifer
- The Management Class status of the resource and its Resource Quality Objectives (RQOs)
- Exploitation potential of the aquifer
- Abstraction in the coastal zone
- Where groundwater could release of toxic vapours
- The aquifer is the only, or a significant, water supply source

The hydrogeological assessment should address the baseline characteristics of the system, responses to key issues and concerns, comparisons of alternative approaches, recommendations for management actions and for monitoring programmes. Components of a well executed hydrogeological assessment include:

- Summary impact assessment table using the defined impact assessment and significance rating criteria;
- Clear indication of whether impacts are irreversible or result in an irreplaceable loss to the ecosystem and/or society.
- Statement of impact significance for each issue specifying whether level of acceptable change has been exceeded and whether the impact presents a potential fatal flaw;
- Identification of beneficiaries and losers from the proposed development.
- Specification of key risks and uncertainties that may influence the impact assessment findings
- Degree of confidence in the impact assessment prediction.
- Summary of key management actions that fundamentally affect impact significance.
- Identification of the best practicable environmental option, providing reasons.
▪ Identification of viable development alternatives not previously considered.

Review of the specialist input should:

▪ Consider whether or not the conclusions are logical (i.e. they can be substantiated), and if the conceptual model is appropriate.
▪ Test that the conceptual model is clear and logical and not flawed in the assumptions that it makes.
SYNOPSIS

May be included in final guideline.
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1. INTRODUCTION

The promulgation of the National Water Act in 1998 (Act 36 of 1998) changed the status of groundwater from a private resource to a public resource. This coincided with a greater recognition of the importance and role of groundwater as a water supply source and in sustaining ecosystem functioning. Authorities, EIA practitioners (EAPs) and project proponents have realised that a need exists for guidance on when specialist hydrogeological assessments are required and how they should be undertaken.

This guideline encourages project proponents and EAPs to seek specialist hydrogeological input at the earliest appropriate stage and to the appropriate extent of a project development. It gives hydrogeologists guidance on the type and level of information required from specialist input to the EIA process. It should also increase the administrative capacity to process applications, while improving the competence of EAPs. This should improve the credibility and effectiveness of EIA process by:

1) Adding value to project planning and design decisions
2) Identifying potential impacts and ensuring these are avoided or adequately managed
3) Supplying adequate information to address key issues and concerns
4) Informing decision-making to support sustainable development

2. COMMON EIA TERMINOLOGY

There are concepts and terminology that are specific to the Environmental Impact Assessment process. Some of the more common ones are described in Box 1.
Box 1: Defining common impact assessment terminology

The following definitions aim to clarify common EIA terms and concepts:

- **Environmental impact assessment:** A public process that is used to identify, predict and assess the potential positive and negative environmental impacts of a proposed project on the biophysical, social and economic environment and to propose appropriate management actions and monitoring programmes. The EIA process is used to inform decision-making by the project proponent, relevant authorities and financing institutions. The process includes the following components: pre-application and mandatory screening, scoping, impact assessment (including the identification of management actions and monitoring requirements), integration and decision-making.

- **Screening:** A decision-making process to determine whether or not a development proposal requires environmental assessment, and if so, what level of assessment is appropriate. Screening is initiated during the early stages of the development of a proposal. *Pre-application screening* is typically undertaken at the initiative of a development proponent prior to submitting an application to the lead authority to authorize an activity, or deciding to abandon a proposed project. *Mandatory screening* is typically administered by an environmental authority or financing institution. The outcome of the screening process is typically a Screening Report/Checklist.

- **Scoping:** The process of determining the spatial and temporal boundaries (i.e. extent) and key issues to be addressed in an environmental assessment. The main purpose is to focus the environmental assessment on a manageable number of important questions on which decision-making is expected to focus and to ensure that only key issues and reasonable alternatives are examined. The outcome of the scoping process is a Scoping Report that includes issues raised during the scoping process, appropriate responses and, where required, terms of reference for specialist involvement.

- **Impact assessment:** Issues that cannot be resolved during scoping and that require further investigation are taken forward into the impact assessment. Depending on the amount of available information, specialists may be required to assess the nature, extent, duration, intensity or magnitude, probability and significance of the potential impacts; define the level of confidence in the assessment; and propose management actions and monitoring programmes. Specialist studies/reports form the basis of the integrated Environmental Impact Report which is compiled by the EIA practitioner.

- **Root cause/source of impact:** A description of the aspect of the development that will result in an impact on the biophysical, social or economic environment (e.g. atmospheric emissions from industrial stacks);

- **Issue:** A context-specific question that asks “what will the impact of some activity/aspect of the development be on some element of the biophysical, social or economic environment?” (e.g. what is the impact of atmospheric emissions on the health of surrounding communities?);

- **Impact:** A description of the effect of an aspect of the development on a specified component of the biophysical, social or economic environment within a defined time and space (e.g. an increased risk of respiratory disease amongst people living within a 10km radius from the industry, for the duration of the life of the project, due to sulphur dioxide emissions from the industry);

- **Scenarios:** A description of plausible future environmental or operating conditions that could influence the nature, extent, duration, magnitude/intensity, probability and significance of the impact occurring (e.g. concentration of sulphur dioxide emissions during normal operations vs during upset conditions; dispersion of atmospheric pollutants during normal wind conditions vs during presence of an inversion layer).

- **Alternatives:** A possible course of action, in place of another, that would generally meet the same purpose and need defined by the development proposal (e.g. alternative project site away from residential areas; alternative fuel source that minimizes sulphur dioxide emissions).

- **Precautionary Principle:** Applied when an activity raises the risk of harm to human health or the environment, even though the cause and effect relationships are not fully established scientifically.
3. PRINCIPLES AND CONCEPTS UNDERPINNING HYDROGEOLOGICAL INPUT

3.1 USE OF THE TERM “HYDROGEOLOGY”

For a long time in South Africa the term geohydrology has been used to describe the science that investigates the occurrence of water in subsurface settings. This differs from standard international practice where the term hydrogeology is used. In this guideline these two terms are assumed to be interchangeable, with similar meanings. In the interest of simplification and in light of efforts in South Africa to conform to international terminology, hydrogeology is the preferred term and used throughout this document.

3.2 TYPES OF SUB-SURFACE WATER

Hydrogeologists recognise different types of sub-surface water. So, for example, soil water is seen as distinct and different from inter-flow (water moving through the unsaturated part of the aquifer), which is viewed as distinct and different from groundwater that occurs in an aquifer. Most hydrogeological research studies concentrate on understanding the character and behaviour of water occurring in aquifers. For the purposes of this guidelines however, the term ‘hydrogeological input’ will refer to studies that deal with all types of sub-surface water. This is in recognition of the fact that hydrogeologists appointed to EIA studies are usually required to give input on and to investigate all components of the groundwater flow path. Certain specialist fields, such as hydrogeochemistry, geomicrobiology, hydrogeophysics are considered components of hydrogeological input. As such this guideline document is assumed to also apply to all the sub-component studies that constitute a hydrogeological assessment.

3.3 IMPORTANCE OF A CONCEPTUAL MODEL

Groundwater studies are by definition complicated by the largely hidden nature of the resource and its host media. Heterogeneities in the subsurface environment usually complicate the application of standard models of groundwater behaviour. Hydrogeological descriptions, should, nonetheless include a simplified conceptual description/model of the groundwater system. This should ideally include a three-dimensional or a box model sketch that illustrates the volume and direction of water flux through the system (i.e. the system dynamics). Components that are typically included in such a model include information on the areas and volume of groundwater recharge, groundwater flow directions and areas and volumes of groundwater discharge. The amount of detail to be included in such a conceptual model and its scale should be determined by the focus and scale of the development and its possible impacts.
3.4 CATEGORIES OF GROUNDWATER RELATED IMPACTS

The focus of a hydrogeological assessment is a function of the types of possible impacts associated with the development. Three broad categories of groundwater related impacts are recognised:

1) Where effluent or chemicals with the potential to change groundwater quality is handled as part of the project, or discharged into the environment due to the project;

2) Where the volume of groundwater in storage or entering groundwater storage is changed; and

3) Where the groundwater flow regime is changed.

The guideline will highlight that there are issues of concern that are unique – the result of the interaction of the ‘impact category’ and the specific characteristics of the development (see Table 4) - which will direct the focus of the hydrogeological assessment.

For example; for a development that falls in the first of the categories, where the concern is around the impact on groundwater quality, the focus of the input (and hence the conceptual model) would be on understanding groundwater recharge volume and pathways, chemical character of the effluent or chemicals, and on geochemical processes that could alter the chemical character of the infiltrating pollutant. If the concern is that the groundwater resource may be exhausted by over abstraction (included under the second of the category classes), the focus of the input would be on understanding groundwater recharge, storage volume, and the volume and timing of groundwater abstraction and discharge. Similarly, where the project may result in the lowering of the water table due to an excavation (the third of the category classes), such as an open pit mine, the assessment would need to focus on understanding the groundwater flow regime.

Some of the basic hydrogeological principles and concepts are explained in Box 2.
Box 2: Basic principles and concepts in hydrogeology.*

When rain falls to the ground, some water flows along the land surface, draining into streams or lakes, some is used by plants, some evaporates and returns to the atmosphere, and some seeps into the ground. Water seeping down from the land surface adds to the groundwater and is called recharge water. Scientists estimate that about 5% of South Africa’s rainfall percolates through the soil and dry rock to replenish aquifers. Although this is a relatively small fraction of our annual rainfall, it contributes to a huge underground resource that accounts for an estimated 90% of all water stored at any one time in our catchments.

Aquifer is the name given to underground soil or rock through which groundwater can easily move. Aquifers typically consist of gravel, sand, sandstone, or fractured rock like the Table Mountain quartzites, or in dissolution cavities in rock like limestone. Clay and shale formations generally restrict the flow of groundwater.

Water leaving an aquifer is called discharge water. Besides being pumped from a well, groundwater might also discharge naturally as springs or into wetlands, lakes, or rivers. Groundwater moves slowly. Periods of flow from recharge to its point of discharge may be many decades or centuries. This means that aquifers are buffered from drought. Large quantities of water are stored in aquifers, which allow these systems to sustain constant flow to, for example, rivers and lakes.

In many parts of the world groundwater is the main source of water for day to day use. Groundwater resources can, however, be over exploited, resulting in a declining water table and dry wells. The resource may also become unfit for use because of pollution.

Groundwater also plays an important role in sustaining the functioning of ecosystems. A groundwater dependent ecosystem, or component of an ecosystem, can be defined as: ‘An ecosystem, or component of an ecosystem, that would be significantly altered by a change in the volume and/or temporal distribution of its groundwater supply’ (Brown, et al., 2003).

* Figures were sourced from the website of the USGS: www.usgs.gov
4. CONTEXTUALISING THE HYDROGEOLOGICAL INPUT

4.1 LEGAL, POLICY AND PLANNING CONTEXT FOR HYDROGEOLOGICAL INPUT

The Bill of Rights (Constitution of South Africa) gives all South Africans the right to an environment that is "not harmful to their health or well-being", as well as the right to have the environment protected for the benefit of present and future generations. This must be balanced against the need to promote and sustain “justifiable economic and social development”. The constitution further requires co-operative governance between the different spheres of government.

The framework for the sustainable management and protection of the environment is provided by the National Environmental Management Act (NEMA) (Act No. 108 of 1998), while the framework for the protection of water resources is provided by the National Water Policy White Paper (DWAF, 1997) and the National Water Act (NWA) (Act 36 of 1998). These statutory instruments are guided by a recognised need to protect natural resources for current and future generations, protect human health and well being, and promote economic and social development.

To achieve the sustainable use and protection of water resources, the NWA requires the implementation of:

- Resource directed measures (RDM), which define the desired level of protection for a water resource and its ecological reserve. Based on this, goals (RQOs) are specified for management of the resource. (See Box 3 for detail on what is meant by these concepts.)
- Source directed controls (SDCs), which control impacts on water resources through the use of regulatory measures such as registration, permits, directives and prosecution, and economic incentives such as levies and fees, in order to ensure that the RQOs are met.

These measures define the limits and constraints that must be imposed on the use of water resources, and must be considered in EIA processes. The management of water resources (including the discharge of effluent and waste) is in part effected through an allocation system, which requires, depending on the type and level of use, the registration or licensing of that water use.

Functions such as the environment and pollution control are concurrent national and provincial functions. Provincial government is also responsible for assessing and considering development applications in terms of the requirements of the Environmental Impact Assessment Regulations issued in terms of the Environment Conservation Act (Act 73 of 1989)\(^1\).

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\(^1\) Soon to be replaced by EIA regulations to be issued in terms of Section 24 of the NEMA.
Box 3: Description of the Resource Directed Measures

Three components constitute the Resource Directed Measures: the Classification, the Reserve and Resource Quality Objectives (RQOs). Two components constitute the Reserve: (1) The quantity and quality of water required to satisfy basic human needs; and (2) The quantity and quality of water required to protect aquatic ecosystems. The level at which the ecological Reserve is set will depend on the agreed upon management class of that resource.

The classification system groups water resources into classes representing different levels of protection. It provides a framework for the protection and use of water resources, as both the ecological Reserve and the RQOs are functions of a resource’s management class. In order to maintain a water resource within an agreed upon management class, objectives are defined, which constitute the RQOs for that resource. These may be seen as goals to aim for, if the management class represents an improvement on an impacted resource, or thresholds or safety nets which represent the limit of acceptable impact. They may be numeric or descriptive.

In determining RQOs, a balance must be sought between the need to protect and sustain water resources on the one hand, and the need to develop and use them on the other. Once the class of a water resource and the resource quality objectives have been determined they are binding on all authorities and institutions when exercising any power or performing any duty under the NWA. (Act No. 36 of 1998) RQOs could include any requirements or conditions that may need to be met to ensure that the water resource is maintained in a desired and sustainable state or condition.

RQOs for groundwater could include:
1. Water levels, groundwater gradients, storage volumes and quality parameters required to sustain groundwater reserves for basic human needs and baseflow to springs, wetlands, rivers and estuaries.
2. Groundwater gradients and levels required to maintain the integrity of the aquifer and the aquifer’s broader functions.
3. The water table or piezometric levels.
4. The presence (or not) of dissolved and suspended substances (naturally occurring hydrogeochemicals and contaminants).
5. Aquifer parameters such as permeability, storativity and recharge; landscape features such as springs, sinkholes and caverns characteristic of the aquifer type; subsurface and surface ecosystems in which groundwater fulfils any vital function.
6. Aquatic biota in features dependent on groundwater baseflow, such as rivers, wetlands, and caves, or biota living in the aquifer itself.
4.2 ENVIRONMENTAL CONTEXT FOR HYDROGEOLOGICAL INPUT TO ENVIRONMENTAL IMPACT ASSESSMENTS

Specialist input to EIAs need to take into account the specific nature of the biophysical, social and economic environment within which they are undertaken. Box 4 provides an overview of the hydrogeology of the Western Cape province.

**Box 4: Hydrogeological overview and context for the Western Cape province**

The climate of the Western Cape is strongly seasonal, with almost all its rainfall occurring during winter (May to August). A number of large surface water reservoirs have been built to store water to meet demand, particularly during the dry summer months. Farmers and smaller municipalities have also come to rely on groundwater as a source of water during summer and to overcome periods of drought. The City of Cape Town is currently looking at the development of groundwater resources (such as the Table Mountain Group Aquifer System and the Cape Flats Aquifer) to satisfy future bulk water supply needs.

The basement complex of the Western Cape consists of the metamorphic Malmesbury Group rocks and the granites of the Cape Granite Suite. These are overlain by sedimentary rocks of the Cape Supergroup (which include the Table Mountain Group rocks) and Tertiary-Quaternary age alluvial deposits that cover coastal plain areas, like the Cape Flats. Within these the most significant groundwater resources occur in the Pakhuis, Nardouw and Peninsula formations of the Table Mountain Group, and some of the Tertiary-Quaternary deposits (like the Cape Flats and Atlantis Aquifers). Their occurrence and distribution in the Western Cape are shown in the following figure.

The substantial thickness of the TMG in places, its high permeability in faulted areas, the generally good water quality (especially in the Peninsula Formation) and its exposure in high rainfall areas means that this aquifer may be able to provide significant volumes of useable water on a sustainable basis. Large scale abstraction for agricultural purposes already occur in places like the Hex River valley.

Less prominent, but also important as a water supply source, especially in the more arid parts of the province are fractures in the Malmesbury Group rocks and the aquifers associated with Karoo dolerite intrusions.
The vulnerability of each of these aquifer systems varies, depending on factors such as depth to water table, aquifer media, recharge (related to climate), and slope. Due to its shallow water table, moderate slope and association with human settlement, aquifers associated with Tertiary-Quaternary deposits in the Western Cape are particularly vulnerable to point source pollution.

A concern with large-scale groundwater abstraction is its impact on ecosystems. Due to the Western Cape’s strongly seasonal rainfall, almost all summer streamflow is the result of groundwater discharge. Groundwater discharge plays an important role in sustaining the functioning of wetland plant communities. These occur within a region that is blessed with the richly diverse and largely endemic Cape Floral Kingdom, or Fynbos (one of six plant kingdoms in the world). As such, groundwater development in the Western Cape needs to occur with due regard for its impact on the environment.
PART B: TRIGGERS AND KEY ISSUES

5. TRIGGERS FOR SPECIALIST INPUT

Specialists can be involved for different purposes and at different intensities during various stages of the EIA process, regardless of whether the process is initiated before or upon submission of an application for environmental authorization. Depending on the nature of the project and the environmental context, specialist involvement may take the form of any or all of the following: specialist opinion, archival research, literature review, detailed baseline survey (including site visit/s), consultation and interviews, mapping and modelling. Terms of reference for specialist involvement should, therefore, be appropriate to the purpose and intensity/scale of involvement and should be discussed and agreed between the EIA practitioner and the specialist.

5.1 TIMING OF SPECIALIST INPUT TO THE EIA PROCESS

A specialist hydrogeological input will be required as part of a project EIA process where the proposed development and the environmental setting combine to present the risk of a significant impact on the groundwater environment or the users of groundwater resources (incl. ecosystems and groundwater abstractors). The following steps are suggested to determine this:

STEP 1. The proponent and/or the EAP determines that the proposed development falls within the activity types listed in Table 1. Where a development does fall within any of the activity groupings, there is a need to consult a hydrogeologist. This determination should be done with consideration of project upset conditions (failure scenarios) that could result in groundwater resources being exposed to risk. Developments that do not fall within these activity classes are unlikely to have a significant impact on the groundwater or groundwater-linked environments. In such an instance there is no need for a specialist hydrogeological assessment.

STEP 2. Where a development is found to fall in one of the activity classes listed in Table 1 a hydrogeologist should be involved in the EIA process. In conjunction with the project proponent and the EAP, the hydrogeologist should conduct a screening exercise to assess whether the environmental conditions prompt the need for a specialist hydrogeological assessment. Guidance on when environmental conditions or settings would prompt the need for a specialist hydrogeological assessment is provided in Table 2. Where none of the listed conditions exist or are likely to exist, there is no need for a specialist hydrogeological assessment, unless special circumstances exist at the site in question. These circumstances may be highlighted by the hydrogeologist conducting the screening investigation, interested and affected parties, a regulatory authority, or by another specialist assessment being undertaken as part of the proposed, or any other, development.
STEP 3. Once it has been established that an activity listed in Table 1 coincides with an environmental condition that makes environmental impact likely (Table 2), the specialist, with the EAP, the project proponent and the regulatory authorities must determine the level of environmental impact assessment (i.e. whether a screening study is adequate, or whether an EIA is required). Criteria to be used when making this determination include: project scale, sensitivity of the proposed location and expectation of adverse environmental impacts. Regulations published under the NEMA (Act No. 107 of 1998) lists activities that require a screening study and activities that require an environmental impact assessment.

### Table 1: Activity types that call for hydrogeological specialist involvement

<table>
<thead>
<tr>
<th>Groundwater related impact types</th>
<th>Examples of activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where effluent or chemicals with the potential to change groundwater quality is handled as part of the project, or discharged into the environment due to the project.</td>
<td>Storage and handling of hazardous materials, cemeteries, waste disposal sites, waste water treatment works, use of nitrogen and phosphate fertilizers, piggeries, irrigation with polluted water, etc.</td>
</tr>
<tr>
<td>The volume of groundwater in storage or entering groundwater storage is changed beyond what is allowed by the DWAF General Authorisations.</td>
<td>Starting or ending a groundwater abstraction scheme, surface water impoundments, drainage of wetlands, surface hardening that changes natural rainwater infiltration and groundwater recharge, significant changes in vegetation cover, agricultural irrigation, streamflow reduction activities such as those identified in the National Water Act, etc.</td>
</tr>
<tr>
<td>The groundwater flow regime is changed.</td>
<td>Excavations and cuttings, developments on floodplains that restrain/restrict subsurface flow and the connectivity between groundwater and surface water systems, open pit mines or mine shafts, tunnels, etc.</td>
</tr>
</tbody>
</table>

### Table 2: Screening for specialist input: Environmental settings that require specialist hydrogeological assessments

- There is insufficient separation between the base of the development and the water table to prevent pollutant entry to the groundwater resource or effect adequate effluent degradation. Guidelines and recommendations are available on safe separation distances between the water table and activities such as petrol stations (SABS, 1999), cemeteries (Fisher, 2001) and waste disposal sites (DWAF, 1994). For more general guidelines on groundwater protection, also see: Foster, et al., date unknown; Morris, et al., 2003; and Zaporozec, et al., 2002.
- The character of the soil and rock material allows the rapid infiltration of polluted water.
- A borehole used for any abstractive purpose occurs within the area of influence of the proposed development. This area of influence will vary, depending on the hydrogeological setting and the nature of the development. It is suggested that a radius of 1 kilometre be used as an initial guideline of whether groundwater abstraction occurs near the proposed
## Environmental Context

- A wetland or sensitive ecological setting that is probably sustained by groundwater, occurs within the area of influence of the proposed development. This area of influence will vary, depending on the hydrogeological setting and the nature of the development. It is suggested that a radius of 1 kilometre be used as an initial guideline of whether such ecosystems occur near the proposed development.

- The underlying aquifer is recognised as particularly vulnerable to pollution. National scale maps that delineate the distribution of vulnerable aquifers are available (e.g. Lynch, *et al.*, 1994; and Conrad and van der Voort, 1998). The classification of groundwater resource units (required by the NWA (Act No. 36 of 1998)) will provide additional information on the vulnerability status of aquifers.

- Abstraction occurs from a carbonate deposit or an aquifer associated with a carbonate deposit, where the development of dolines and sinkholes are possible.

- Abstraction occurs from an aquifer where a reduction in pore space may occur in the aquifer or in an associated deposit. (Typical of thick silt and clay deposits.)

- Groundwater in the aquifer is to be managed to a 'good' or 'pristine' state. This will be defined by the National Classification system that is being developed by the Department of Water Affairs and Forestry (DWAF) and will be set by the Minister.

- The development utilises or will occur where it may impact an aquifer that is known (or suspected) of have significant exploitation potential. Significance depends on factors such as water availability, water demand, and water quality.

- The development utilises or will occur where it may impact an aquifer that is the only (i.e. sole source aquifer) or a significant water supply source (or may become a significant water supply source) for an area utilised by a nearby community.

- Groundwater is abstracted from an aquifer that occurs in the coastal zone, where there is the potential for saline intrusion as a result of abstraction.

- Development will occur over an area where the release of toxic vapours (e.g. volatile organic compounds) from polluted groundwater is likely. This type of pollution is usually associated with the release of petroleum products such as petrol and solvents used in dry cleaning and industrial processes.

## 6. KEY ISSUES REQUIRING SPECIALIST HYDROGEOLOGICAL INPUT

In order to focus the EIA process and avoid the generation of excessive amounts of irrelevant information, “issues-focused scoping” is commonly used in South Africa to determine the scope of the EIA and focus the input on a manageable number of important issues. Issues are concerns related to the proposed development, generally phrased as questions, taking the form “what will the *impact of some activity be on some element of the biophysical, social or economic environment?*” (Weaver *et al.*, 1999). Issues that cannot be addressed during the scoping process are taken forward into the impact assessment and are addressed through the input of various specialists.
Some of the hydrogeology related issues that typically arise for different types of development, and for different types of environmental contexts are listed in Table 3. This table can be used to guide EAPs and stakeholders to anticipate issues that could be relevant for particular development types in certain environmental contexts. The table should, however, not be regarded as a definitive list of issues and it does not replace the need for a comprehensive, systematic scoping process to identify the range of issues pertinent to a particular development.

### Table 3: Categorisation of issues to be addressed by the Hydrogeological input

<table>
<thead>
<tr>
<th>Type of environment</th>
<th>Type of development (small – large scale)</th>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Development category 1:</strong> Change in groundwater quality, e.g. Petrol station.</td>
<td><strong>Development category 2a:</strong> Change in quantity of groundwater in storage, e.g. wellfield development.</td>
<td><strong>Development category 2b:</strong> Change in groundwater recharge</td>
<td><strong>Development category 3:</strong> Change groundwater flow regime, e.g. deep excavations.</td>
</tr>
<tr>
<td><strong>A) Shallow water table</strong></td>
<td>Pollution of the water resource.</td>
<td>Impact on groundwater dependent ecosystems.</td>
<td>Decline in water level and discharge, with impact on ecosystems and ecosystem services.</td>
</tr>
<tr>
<td><strong>B) Rapid water infiltration and flow</strong></td>
<td>Pollution of the water resource.</td>
<td>n/a</td>
<td>Increased discharge.</td>
</tr>
<tr>
<td><strong>C) Groundwater abstraction within 1 km of development</strong></td>
<td>Health, aesthetic and/or use versatility impact on resource users.</td>
<td>Reduced yield and increased abstraction costs.</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>D) Wetland or GDE occurs within 1 km of development</strong></td>
<td>Loss of ecological functioning and associated ecosystem services.</td>
<td>Drying out of wetland and diminished ecosystem services.</td>
<td>Decline in water level and discharge, with impact on ecosystems and ecosystem services.</td>
</tr>
<tr>
<td>Type of environment</td>
<td>Type of development (small – large scale)</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------</td>
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<td>-----------</td>
</tr>
<tr>
<td></td>
<td>Development category 1: Change in groundwater quality, e.g. Petrol station.</td>
<td>Development category 2a: Change in quantity of groundwater in storage, e.g. wellfield development.</td>
<td>Development category 2b: Change in groundwater recharge</td>
</tr>
<tr>
<td>(E) Aquifer is particularly vulnerable to pollution</td>
<td>Pollution of the water resource.</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>(F) Karstic terrain</td>
<td>Pollution of the water resource.</td>
<td>Lowering of water table, resulting in sinkhole or doline development and reduced flow and habitat for ecosystems</td>
<td>Lowering of water table, resulting in sinkhole or doline development and reduced flow and habitat for ecosystems</td>
</tr>
<tr>
<td>(G) Aquifer Classification requires high management to high level</td>
<td>Ecosystem degradation and economic cost.</td>
<td>Lowering of water levels and decreased groundwater discharge.</td>
<td>Declining water levels and decreased groundwater discharge.</td>
</tr>
<tr>
<td>(H) Aquifer occur in association with deposits susceptible to subsidence</td>
<td>n/a</td>
<td>Lowered water table, resulting in formation subsidence with damage to infrastructure</td>
<td>Lowered water table, resulting in formation subsidence with damage to infrastructure</td>
</tr>
<tr>
<td>(I) Aquifer has a high exploitation potential</td>
<td>Pollution of the water resource.</td>
<td>Over-exploitation of the resource.</td>
<td>Reduction in sustainable yield of aquifer.</td>
</tr>
</tbody>
</table>
### Type of development (small – large scale)

<table>
<thead>
<tr>
<th>Type of environment</th>
<th>Development category 1: Change in groundwater quality, e.g. Petrol station.</th>
<th>Development category 2a: Change in quantity of groundwater in storage, e.g. wellfield development.</th>
<th>Development category 2b: Change in groundwater recharge</th>
<th>Development category 3: Change groundwater flow regime, e.g. deep excavations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(J) Development located near coast</td>
<td>Polluted surf zone with ecological and human health impacts</td>
<td>Saltwater intrusion resulting in poor water quality. Reduced discharge to marine environment</td>
<td>Increased likelihood of saline intrusion.</td>
<td>Decreased likelihood of saline intrusion.</td>
</tr>
<tr>
<td>(J) Groundwater is polluted with toxic vapour releasing substances</td>
<td>n/a</td>
<td>Health impact of using polluted water.</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>(L) Aquifer is the only significant water source</td>
<td>Pollution of the water resource.</td>
<td>Over exploitation of the resource.</td>
<td>Decrease in the sustainable yield of the aquifer.</td>
<td>Introduction of contaminants and change in chemistry, which may result in deterioration (incl. yield) of water resource.</td>
</tr>
</tbody>
</table>
PART C: PLANNING AND COORDINATION OF SPECIALIST INPUTS (TOR)

7. QUALIFICATIONS AND SKILLS REQUIRED TO PROVIDE HYDROGEOLOGICAL INPUT

The anticipated impacts of the proposed development will dictate the kind of hydrogeology and related skills that will be required during the EIA process. A description of the kind of skills that will be required for each of the three main impact types are given in Table 4. It is expected that at least one hydrogeologist in the specialist study team will have an M.Sc. degree, with at least 3 years of relevant work experience. Additional considerations may relate to the specialist’s knowledge of the study area, familiarity with the requirements of the EIA process, and familiarity with the type of project.

Table 4: Range of skills associated with different groundwater impact types.

<table>
<thead>
<tr>
<th>Impact Types</th>
<th>Range of possible skills/qualifications required</th>
</tr>
</thead>
</table>
| Contamination | Chemist or materials handling specialist – To identify and quantify contamination risk  
Soil scientist – To evaluate contamination in unsaturated zone (i.e. soils)  
Hydrogeologist – To describe and assess impacts relating to physical flow path/migration pathway  
Hydrogeochemist – To describe and assess impacts relating to chemical migration processes  
Microbiologist – To describe and assess impacts relating to bacteriological processes  
Ecologist – To assess the degree of ecosystem dependence on groundwater |
| Abstraction or recharge | Hydrogeologist – To describe and assess impacts relating to aquifer  
Groundwater Modeller – To assess the extent of the cone of depression or recharge mound, and its effect of groundwater discharge  
Ecologist – To assess the degree of ecosystem dependence on groundwater |
| Change in flow path/migration pathway | Hydrogeologist – To describe and assess impacts relating to physical flow path/migration pathway  
Groundwater Modeller – To assess the extent of the cone of depression or recharge mound, and its effect of groundwater discharge  
Ecologist – To assess the degree of ecosystem dependence on groundwater |
8. DETERMINING THE EXTENT/SCOPE OF THE HYDROGEOLOGICAL INPUT

Once the need for specialist input has been determined (see Section 6), the extent/scope of the specialist input needs to be defined through consultation between the EAP, the specialist, the project proponent and the relevant authorities. General guidance on the extent to involve specialists are provided in one of the guideline documents of this series (Guideline for determining the scope of specialist involvement in EIA processes).

8.1 ESTABLISHING THE TIME AND SPACE BOUNDARY TO THE INPUT

The size and nature of the proposed development influences the time and space boundaries of the specialist's involvement. Boundaries primarily need to be agreed upon between the EIA practitioner, the specialist, the proponent and the decision-making authority, however, should also be accepted by other I&APs.

The time and space boundary of the specialist studies will be a function of factors such as the scale of impact associated with the development and the value and sensitivity of the groundwater resource, groundwater dependent ecosystems and the discharge environment. Factors to consider when defining the time and space boundary of the input are:

- The aquifer flow regime and boundary effects.
- Seasonal variation and dependence.
- The ecological status, value and complexity of the receiving environment.
- The area over which a change in water quality or water levels could occur.
- The need to assess users and uses of the aquifer and/or the impacted environment.

As a first level screening a census of groundwater abstracting boreholes and ecosystems that are potentially dependent on groundwater within a 1 kilometre radius of the proposed development is recommended. During the screening and (if required) the EIA phases of the process the likelihood of impacts on these uses will be assessed.

8.2 CLARIFYING APPROPRIATE DEVELOPMENT ALTERNATIVES

Alternatives considered in the EIA process can include location and/or routing alternatives, layout alternatives, process and/or design alternatives, scheduling alternatives or input alternatives. Any development proposal may include a range of possible alternatives from some or all of these various categories of alternatives. When dealing with the issue of alternatives, the focus should rather be on ensuring that the alternatives that are generated address the significant issue at hand. It would therefore not be reasonable to expect the same developer to consider alternative water supply options if there is adequate water of good quality available. In
other words, the issue is not the level of alternative, but the significance of the impact on the receiving environment.

The hydrogeologist should ideally be involved in assisting the project proponent to identify the range of viable alternatives that should be assessed in the specialist assessment. In water supply assessments alternatives could include different wellfield locations, wellfield design, abstraction scheduling, augmentation of recharge options and water demand management measures.

Protecting aquifers against pollution usually involves the balancing of the cost of protective measures against the risks associated with pollution. The benefits, and risks associated with each alternative should be clearly spelt out by the specialist. Where possible an estimate should be provided of the costs associated with each alternative. Attention should be drawn to the extent of scientific uncertainty associated with the impact scenarios identified in the study. The discussion on protective measures and alternatives should be guided with due consideration of the precautionary principle (see Box 1).

Alternatives are best considered in the screening and scoping phase of the EIA where the proposal has the most flexibility and opportunity to make amendments to the project description to avoid or prevent significant impacts and enhance benefits.

8.3 ESTABLISHING ENVIRONMENTAL AND OPERATING SCENARIOS

Two types of scenarios should be considered for all types of development. These are scenarios that consider events and circumstances that are external to the project (e.g. influence of drought on groundwater impacts associated with development / earthquake rupturing tank at petrol station leading to pollution) and scenarios that consider events and circumstances that are internal to the project (e.g. spillage of oil from offloading tanker vehicle, leading to groundwater contamination, i.e. potential operational upset situations).

As part of hydrogeological input, possible environmental and operating scenarios that could influence the nature, extent, duration, magnitude/intensity, probability and significance of anticipated impacts should be assessed. Parameters that could be varied to generate different scenarios are listed in Table 5.
Table 5: Parameters to be considered when developing scenarios

<table>
<thead>
<tr>
<th>Scenario Type:</th>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario Examples</td>
<td>Spillage or leakage of hazardous material</td>
<td>Effluent Disposal</td>
</tr>
<tr>
<td></td>
<td>Effluent Disposal</td>
<td>Groundwater abstraction</td>
</tr>
<tr>
<td></td>
<td>Artificial groundwater recharge</td>
<td>Artificial recharge volume and abstraction rates</td>
</tr>
<tr>
<td>Parameters</td>
<td>Volume likely to be spilled/leaked</td>
<td>Volume discharged effluent quality</td>
</tr>
<tr>
<td></td>
<td>Toxicity of material</td>
<td>Depth to the water table</td>
</tr>
<tr>
<td></td>
<td>Seasonal variation in depth to water table</td>
<td>Volume abstracted</td>
</tr>
<tr>
<td></td>
<td>Weather conditions</td>
<td>Abstraction period and scheduling</td>
</tr>
<tr>
<td></td>
<td>Mitigation measures</td>
<td>Change in recharge</td>
</tr>
<tr>
<td></td>
<td>Mitigation measure</td>
<td>Level of the ecological reserve</td>
</tr>
<tr>
<td></td>
<td>response time</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.4 INCORPORATING THE ASSESSMENT OF CUMULATIVE EFFECTS

Groundwater is particularly susceptible to the cumulative effect of small impacts. Due regard must be given to this during the assessment, and should be thoroughly considered in a designated section of the assessment report. Where Resource Quality Objectives (RQOs) exist, the impact of the proposed development on these should be discussed within the context of its contribution to the cumulative effect. Box 5 provides a definition of the different interpretations and components of cumulative effects.
### Box 5: Differing interpretations and components of direct, indirect and cumulative effects

<table>
<thead>
<tr>
<th>Direct (or primary) effects</th>
<th>Indirect (or secondary) effects</th>
<th>Cumulative effects can be:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct (or primary) effects</td>
<td>Indirect (or secondary) effects</td>
<td>Additive: the simple sum of all the effects (e.g. the combined effect on an aquifer of small scale abstraction by many users);</td>
</tr>
<tr>
<td>Direct (or primary) effects</td>
<td>Indirect (or secondary) effects</td>
<td>Synergistic: effects interact to produce a total effect greater than the sum of individual effects. These effects often happen as habitats or resources approach capacity (e.g. Water levels are drawn down to a point where salt water intrusion occurs);</td>
</tr>
<tr>
<td>Direct (or primary) effects</td>
<td>Indirect (or secondary) effects</td>
<td>Time crowding: frequent, repetitive impacts on a particular resource at the same time (e.g. reduced groundwater discharge to an ecosystem during the dry season, because of groundwater abstraction during these months).</td>
</tr>
<tr>
<td>Direct (or primary) effects</td>
<td>Indirect (or secondary) effects</td>
<td>Neutralizing: where effects may counteract each other to reduce the overall effect (e.g. artificially induced recharge reducing the effect of abstraction on aquifer water levels).</td>
</tr>
<tr>
<td>Direct (or primary) effects</td>
<td>Indirect (or secondary) effects</td>
<td>Space crowding: high spatial density of impacts on an ecosystem (e.g. the concentration of boreholes over a small area, resulting in accentuated local drawdown).</td>
</tr>
</tbody>
</table>

*Source: Cooper, 2004.*

### 9. SELECTING THE APPROPRIATE APPROACH TO THE HYDROGEOLOGICAL ASSESSMENT

The issues that are typically associated with hydrogeological input as part of EIAs are listed in Section 6. Although a range of diverse issues is listed, the basic approach to understanding the associated hydrogeological implications would be fairly similar. Key elements of an approach to a hydrogeological assessment are presented in Box 6.
### Box 6: Key elements of an approach to a hydrogeological assessment

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial/Conceptual Planning</strong></td>
<td>All hydrogeological studies require a conceptual model that captures the specialist's understanding of the hydrological system. Existing knowledge is used to develop a conceptual understanding of the groundwater system. The design of the information gathering is based on the conceptual model, and information gathered during the assessment is used to refine the conceptual model.</td>
</tr>
<tr>
<td><strong>Reconnaissance and information review</strong></td>
<td>All information relevant to the assessment is identified and key texts reviewed. Central to the study is the identification of boreholes in the study area and all users and uses that could be impacted. The National Groundwater Database of DWAF is a good starting point to identify boreholes, but it is not enough. Databases may not be up to date or may contain incorrect information. A hydrocensus is the most appropriate way of collection information of groundwater occurrence, quality and use in an area.</td>
</tr>
<tr>
<td><strong>Field studies</strong></td>
<td>Field studies are used to characterise the subsurface environment. The conceptual model of the study area will help to identify issues that require improved understanding, while the conceptual understanding of the mechanism by which impact occurs will help to prioritise issues to be clarified. Approaches include water quality testing, borehole drilling, pumping tests, geophysics or tracer tests.</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td>The information gathered during the field study phase will be analysed, and the results of that used to refine the initial conceptual model. The validity of the analysis results may be tested through numerical flow or transport modelling. Results of the data gathering and hydrocensus will serve to calibrate these models.</td>
</tr>
<tr>
<td><strong>Refined model</strong></td>
<td>Based on the information gathered during the previous steps a refined model of the system (and its linkages) is generated. This may take the form of a calibrated numerical model.</td>
</tr>
</tbody>
</table>

Further details on the approaches that are typical of the three types of groundwater impacting activities are given in Table 6. The table highlights the tools that are typically employed during the field-study and analysis phases of the assessment. However, it should not be regarded as a comprehensive summary of approaches and does not replace the need for a discussion,
between the EAP, the specialist, the project proponent and relevant authorities, to determine the best approach for the specific circumstances. Not all of the steps listed will be required in all instances, especially where the significance and likelihood of impact on the groundwater environment is small or where there is a good understanding of the groundwater system.

**Table 6: Categorisation of various approaches and methods used for hydrogeology assessments**

<table>
<thead>
<tr>
<th>Type of approach used to assess impacts</th>
<th>Description</th>
<th>When is it used?</th>
<th>Notes</th>
<th>Impact types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrocensus</strong> (Level of detail depends on project and receiving environment)</td>
<td>Typically involves the location and gathering of information on boreholes, users, uses and sensitive ecological receptors within a defined radius of the development.</td>
<td>Necessary to understand the receiving environment and who/what may potentially be affected, prior to the development of a conceptual flow model. May not be necessary for low contamination risk projects that can be effectively managed through application of the SABS guidelines (e.g. SABS, 1999 for petrol stations). A review of the DWAF database is not considered to suffice as a hydrocensus.</td>
<td></td>
<td>Always</td>
</tr>
<tr>
<td><strong>Qualitative conceptual model</strong></td>
<td>This may take the form of a box model or map on which the direction and volume of water flux is shown. Subsequent assessments will test the validity of the assumptions that underlie the conceptual model.</td>
<td>Always applied to understand flow pathways and discharge areas (with associated ecosystems), and to communicate results to non-specialists.</td>
<td></td>
<td>Always</td>
</tr>
<tr>
<td><strong>Quantitative</strong></td>
<td>The use of an</td>
<td>Used to understand</td>
<td>Often used:</td>
<td>Often used:</td>
</tr>
<tr>
<td>Type of approach used to assess impacts</td>
<td>Description</td>
<td>When is it used?</td>
<td>Impact types</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Notes</td>
<td>Contamination of groundwater</td>
<td>Change in Groundwater storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>groundwater flows in cases where projects may be high risk, highly controversial, in a highly sensitive environment or where a high degree of confidence in the results is required.</td>
<td>Then in conjunction with transport model</td>
<td>In large scale abstraction or where associated with sensitive environment.</td>
</tr>
<tr>
<td>flow model</td>
<td>appropriate software package to test assumptions and scenarios of groundwater flow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative transport model</td>
<td>The use of an appropriate software package to calculate the rates of contaminant transport in the subsurface environment.</td>
<td>Used to understand contaminant flows in cases where projects may be high risk, highly controversial, in a highly sensitive environment or where a high degree of confidence in the results is required.</td>
<td>Often used</td>
<td>Rarely used: Where concern relates to contaminant migration from pollution sources.</td>
</tr>
<tr>
<td>Drill test boreholes</td>
<td>Boreholes are drilled to enable testing and/or monitoring of aquifer characteristics.</td>
<td>Undertaken to verify and test conceptual or quantitative models, where existing data is limited.</td>
<td></td>
<td>Rarely used: In large scale developments or where associated with sensitive environment.</td>
</tr>
<tr>
<td>Pumptest existing or drilled boreholes</td>
<td>The pumping of boreholes at various rates and periods to determine aquifer parameters.</td>
<td>To check whether there is an impact on neighbouring boreholes (or vice versa) and to understand borehole hydraulics.</td>
<td></td>
<td>Rarely used: In large scale developments or where associated with sensitive environment.</td>
</tr>
<tr>
<td>Recharge study</td>
<td>Determination of recharge to the aquifer through direct measurement, water balance, Darcyan or tracer methods. Usually requires long-term data for a number of parameters.</td>
<td>Only undertaken for large-scale abstraction projects in sensitive environments, in order to understand the regional context, the long-term sustainability of the abstraction scheme, and the recharge potential.</td>
<td></td>
<td>Never</td>
</tr>
<tr>
<td>Type of approach used to assess impacts</td>
<td>Description</td>
<td>When is it used?</td>
<td>Impact types</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Notes</td>
<td>Contamination of groundwater</td>
<td>Change in Groundwater storage</td>
</tr>
<tr>
<td>Rapid reserve determination</td>
<td>A low confidence determination of the amount and quality of water that must be set aside to protect ecological functioning and basic human needs</td>
<td>Only undertaken if project invokes a licence application (i.e. water use exceeds the DWAF General Authorisation) and there is a need to determine the limits to abstraction/groundwater use.</td>
<td>Rarely.</td>
<td>Rarely: Except where waste discharge to a receiving environment is planned</td>
</tr>
<tr>
<td>Comprehensive reserve determination</td>
<td>A high confidence determination of the amount and quality of water that must be set aside to protect ecological functioning and basic human needs</td>
<td>Only undertaken where the rapid reserve determination doesn’t provide sufficient information to enable the issuing of a water use license by DWAF.</td>
<td>Never</td>
<td></td>
</tr>
</tbody>
</table>

10. **THE TIMING OF THE SPECIALIST INPUT IN RELATION TO OTHER SPECIALIST ASSESSMENTS**

One of the ways in which early specialist involvement can benefit projects is that information requirements can be identified early on, which allows for better planning and coordination of the different specialist outputs. This should ensure that time delays due to specialist assessment over-runs are reduced. Section 9.5 lists some of the information from other specialists fields that are commonly used in hydrogeological assessments.

11. **DEALING WITH CONFIDENTIALITY REQUIREMENTS**

In developing TORs issues of confidentiality need to be discussed and agreed upon. These may relate to how commercially confidential information is treated and communicated, or information about the receiving environment. Information on the receiving environment may be kept confidential in order to protect sensitive resources i.e. where information may precipitate additional impacts, e.g. public interest in a rare and endangered species may result in increased visitation of an area. It should be noted that respect for confidentiality (where there are good reasons for this) does not imply a “lack of transparency” in the EIA.
12. ENSURING ADEQUATE STAKEHOLDER CONSULTATION

Specialists have a responsibility to engage with stakeholders over and above the EIA stakeholder engagement process. They should identify the types of stakeholders that should typically be consulted with during the specialist study - and for what purpose. Consultation with stakeholders should however be done in line with the overall stakeholder engagement process and principles established for the EIA i.e. ideally working through the appointed stakeholder engagement practitioner.
PART D: PROVIDING SPECIALIST INPUT

13. RELEVANT HYDROGEOLOGICAL PROJECT INFORMATION

Before a detailed assessment can commence, the specialist should be provided with the following information:

- The location of the proposed development and its associated activities (i.e. aspects of construction, operation and decommissioning);
- Development site plan with associated activities;
- The expected time frames associated with each of the phases of the development, including the initiation, construction, production and decommissioning phases.
- The site history and its current use
- Adjacent land use.

With this information in hand the hydrogeologist will be able to gather information on the biophysical environment, conduct an informed site visit and participate in and raise issues during the scoping process. Thereafter information required for the assessment will depend on the specialists' understanding of the issues (upon which the assessment will focus) identified during the initial site visit, issues meetings held with the proponent and the EAP, or raised during public scoping meetings.

Some of the information that will be required in order to develop an initial hydrogeological conceptual model and field study plan include:

- Site geology and hydrogeology (including groundwater quality)
- Borehole data (incl. construction, geological logs and water strike detail)
- Topography
- Surface water features and characteristics
- Users and uses of the resource
- Site zoning
- Particulars of any previous studies of relevance conducted in the area

Testing the validity of the conceptual model and the modelling of impacts may include:

- Water levels, with historical data if available
- Water chemistry, with historical data if available
- Character and history of springs, seepage points and wetlands
- Composition, structure and function of terrestrial vegetation
- Rainfall chemistry and pattern over space and time.
14. ISSUES RAISED IN THE SCOPING PROCESS

The scoping process generates issues and concerns. These are responded to by the EIA team. The hydrogeological specialist may be required to respond to groundwater issues that can be resolved (“closed off”) in the scoping phase, or to provide responses as to how issues could be resolved through more detailed groundwater assessment in the “Impact Assessment” phase.

Hydrogeological specialists must participate, or at least make reference to the project scoping report when designing their inputs. This should help to ensure that the issues raised during the scoping process are addressed during the assessment. When addressing issues, the hydrogeologist must ensure that findings are communicated and illustrated in a manner that is accessible to the general public. This may require the simplification of text and the use of illustrations and figures. The hydrogeologist also has a responsibility to make a clear distinction between findings based on observation (data) and those that result from conceptual reasoning.

15. THE LEGAL, POLICY AND PLANNING CONSIDERATIONS

The responsibility and authority for granting approval of groundwater development and use fall with the Department of Water Affairs and Forestry (DWAF) and the Department of Environmental Affairs and Tourism (DEAT) and their delegated regional authorities. Legislation that guides the permitting process is provided by the National Water Act (Act 36 of 1998), the Environment Conservation Act (Act 73 of 1989) and the National Environmental Management Act (Act 107 of 1998). Some of the legislative and regulatory requirements that are associated with groundwater impacting activities include:

- The submission of a water use license application to DWAF
- A pre-application meeting with regulatory authorities (including DWAF and DEAT)
- The compilation of a draft screening report, which may include a draft hydrogeological assessment report
- Public consultation
- A final screening report, which usually includes the comments received during the consultation process, and an Environmental Management Plan (EMP)

16. INFORMATION GENERATED BY OTHER SPECIALISTS

The hydrogeological assessment will be informed and in some cases guided by other specialist reviews and assessments, for example, on the terrestrial ecosystems, surface water hydrology, rainfall chemistry, and the socio-economy. The hydrogeological assessment will, in turn, also inform and guide these specialist reviews and assessments.
Some of the information that could typically be obtained from these related assessments includes:

- The level and extent of dependence of ecosystems on groundwater;
- The contribution that groundwater discharge makes to streamflow;
- Parameters for input to the determination of recharge (e.g. rainfall intensity, duration and chemistry);
- Dispersion and deposition rates and concentrations of atmospheric pollutants; and
- Regional water sources, water use and projected growth in water demand.
- Storage, use and potential spillage of hazardous materials on site (or associated with the project), which could impact groundwater.

Guidance on how to approach assessments in data poor circumstances is given in Box 7.

### Box 7: What to do in data poor circumstances

Groundwater and its connection to rest of the water cycle and the broader environment is poorly understood in most settings. The task of unravelling these linkages is especially difficult in data poor circumstances. It is only through testing, or sampling, and monitoring that an improved understanding can be developed.

A conceptual model of the groundwater system and its linkages will usually serve to highlight the areas and degree of uncertainty. Often these gaps in knowledge and understanding can be filled in through the review of existing reports, maps and data sets. However, where these are lacking, a need exists to gather data. The scale and complexity of such a programme should be a function of potential risk presented by the development, the sensitivity and value of the potentially affected environment, and the long term risk associated with a limited understanding.

Where a catchment-wide data gathering or monitoring system is implemented, it will, depending on its design, focus on collecting data on part or all of the following:

- The quantity of water in the various water resources;
- The quality of the water resources;
- The use of the water resources;
- The rehabilitation of water resources;
- The health of aquatic ecosystems; and
- Atmospheric conditions that may influence water resources.

Discussions on the principles that underpin monitoring programmes are presented in Section 19.

### 17. INPUT ON IMPACTS AND MANAGEMENT ACTIONS

Anticipated impacts should be assessed for the different alternatives, both normal and upset conditions, both with and without impact mitigation actions.
17.1 INTERPRETING IMPACT ASSESSMENT CRITERIA

The assessment of possible impacts, its reporting and decision making requires consistency in the interpretation of impact assessment criteria. Criteria that could be used to describe impacts are listed in Box 8.

Local stakeholders and communities may attach specific direct or indirect values water resource uses that could be affected by a proposed development. These values may be different from the values of society as a whole. In determining the significance of impacts, it is important therefore that the hydrogeological specialist works closely with other specialists (e.g. in the social and economic fields), to ensure that these values are incorporated in the EIA.

<table>
<thead>
<tr>
<th>Box 8: Criteria used for the assessment of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>The assessment of impacts should be done according to a synthesis of the assessment criteria listed below. Wherever possible, the specialist must refine and customize these criteria to their particular study.</td>
</tr>
<tr>
<td><strong>Nature of the impact</strong> - This is an appraisal of the type of effect the activity would have on the affected environment. This description should include what is being affected and how.</td>
</tr>
<tr>
<td><strong>Extent</strong> - Here it should be indicated whether the impact will be:</td>
</tr>
<tr>
<td>- local extending only as far as the activity;</td>
</tr>
<tr>
<td>- will be limited to the site and its immediate surroundings;</td>
</tr>
<tr>
<td>- will have an impact on the region;</td>
</tr>
<tr>
<td>- will have an impact on a national scale;</td>
</tr>
<tr>
<td>- will have an impact across international borders.</td>
</tr>
<tr>
<td><strong>Duration</strong> - Here it should be indicated whether the lifetime of the impact will be:</td>
</tr>
<tr>
<td>- short term (e.g. 0 – 5 years);</td>
</tr>
<tr>
<td>- medium term (e.g. 5 – 15 years);</td>
</tr>
<tr>
<td>- long term where the impact will cease after the operational life of the activity, either because of natural process or by human intervention; or</td>
</tr>
<tr>
<td>- permanent where mitigation either by natural process or by human intervention will not occur in such a way or in such a time span that the impact can be considered transient.</td>
</tr>
<tr>
<td><strong>Intensity</strong> – Here it should be established whether the impact is destructive or benign and should be indicated as:</td>
</tr>
<tr>
<td>- low, where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected;</td>
</tr>
<tr>
<td>- medium, where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and</td>
</tr>
<tr>
<td>- high, where natural, cultural or social functions or processes are altered to the extent that it will temporarily or permanently cease.</td>
</tr>
<tr>
<td><strong>Probability</strong> – This should describe the likelihood of the impact actually occurring indicated as:</td>
</tr>
<tr>
<td>- improbable, where the possibility of the impact to materialize is very low either because of design or historic experience;</td>
</tr>
<tr>
<td>- probable, where there is a distinct possibility that the impact will occur;</td>
</tr>
</tbody>
</table>
highly probable, where it is most likely that the impact will occur; or
- definite, where the impact will occur regardless of any prevention measures.

Significance – The significance of impacts can be determined through a synthesis of the aspects produced in terms of their nature, duration, intensity, extent and probability and be described as:
- low, where it will not have an influence on the decision;
- medium, where it should have an influence on the decision unless it is mitigated; or
- high, where it would influence the decision regardless of any possible mitigation.

Adapted from: Department of Environmental Affairs and Tourism, 1998

17.2 ESTABLISHING THRESHOLDS OF SIGNIFICANCE AND LEVELS OF ACCEPTABLE CHANGE

Clear objectives on the state of all significant water resources are being developed by DWAF. These are known as the Resource Quality Objectives (RQOs) and are set according to the Management Class of the resource. The development of RQOs is mandated by the National Water Act (Act no. 36 of 1998), which requires the development of a national resource Classification system. The management class of each water resource unit is developed through a broad consultation process and with due consideration of the basic human needs and ecological reserves. Conditions stipulated as part of the RQO may include water levels and permissible degree of fluctuation, water quality with seasonal and inter-annual variation, and aquifer structure. (See Box 3)

The specialist input should be clear on the extent to which the proposed development could impact the meeting of the water resource’s RQOs and the Reserve. Changes in the state of impacted water resources should be reported using the parameters that are stipulated in the RQOs for that resource. This will help regulating authorities to assess the significance of the impacts (relative to threshold exceedance – i.e. RQOs) and to consider the implications of any anticipated change from the current environmental state.

17.3 IDENTIFYING POTENTIALLY SIGNIFICANT FLAWS

One of the aims of hydrogeological input is to establish whether a proposed development exceeds legislative guidelines regarding, for example, discharge water quality. Where a development impacts the sustainability of the resource and its ability to meet legislated criteria for that resource (e.g. RQOs, Basic Human Needs Reserve and Ecological Reserve), such a development would be considered significantly flawed. Box 9 provides a definition of a potential significant flaw.
Box 9: Definition of a potential significant flaw

A potential significant flaw is an impact that could have a "no-go" implication for the project. For the purposes of this study, it is considered that a "no-go" situation could arise if the proposed project were to lead to:

a) Degradation of the resource to the point where it is unable to meet its basic needs reserve or its ecological reserve.

b) Exceedance of legislated standards or guidelines (e.g. DWAF water quality guidelines), resulting in the necessary licences/approvals not being issued by the authorities.

c) Non-compliance with conditions of existing Records of Decision.

d) Impacts that may be evaluated to be of high significance and that are considered by stakeholders and decision-makers to be unacceptable.

e) Technically unfeasible.

f) Financially unfeasible.

17.4 IDENTIFYING BENEFICIARIES AND THE LOSERS

Once all the uses of the groundwater resource and its receiving environment are identified and listed, the hydrogeological assessment must determine the effect of the development in terms of beneficiaries and losers. Inevitably trade-offs are made in decision-making and the assessment must, therefore, inform this process. Important in this regard are criteria such as societal value, vulnerability, relative importance, equity and fairness. An example of such criteria could be defined as given in Box 10.

Box 10: Description of community vulnerability

Vulnerable or risk-prone communities can be described as:

- Communities whose reliance on water resource goods and/or services is particularly high. For example, in subsistence communities, in communities where livelihoods are based on the harvest or extraction of natural resources, and/or in communities who rely solely on that component of the receiving environment likely to be most affected by the proposed project.

- Communities in dynamic, sensitive or harsh ecosystems, where extreme conditions (e.g. drought, floods, earthquakes, landslides) make them particularly vulnerable to additional negative impacts.

Adapted from: Brownlie, 2005, this guideline series.

The identification of beneficiaries and losers requires consideration of downstream benefits (e.g. job creation, economic growth and skills transfer) and costs (e.g. loss of ecosystem goods and services). This requires consideration of the extent to which there is a conversion of natural capital to other forms of capital (social, economic, infrastructure). The assessment of the impact of a development, and hence the identification of losers, are, in the groundwater environment, complicated by the fact that the groundwater resource and its uses are often poorly understood. So for example, it is almost impossible to be certain about the extent and degree of to which an ecosystem is reliant on the rate, timing and quality of groundwater discharge. It is similarly also difficult to quantify the value to society of the goods and services offered by such ecosystems.
17.5 MANAGEMENT ACTIONS

Through management actions (mitigation measures) the likelihood of impact on the receiving environment and users and/or impact significance can be reduced. Consensus on management actions should be secured through participation by all specialists contributing to the EIA in related fields; i.e. the proposed hydrogeological management actions should not compromise the recommendations proposed for other spheres of management. Management actions may take the form of avoidance, mitigation, compensation, rehabilitation or enhancement. Pre-requisites for successful mitigation should be explicit.

Due to the hidden nature and slow travel rates of groundwater, its rehabilitation is usually an extremely expensive exercise. It is therefore advisable to implement groundwater impact avoidance or mitigation measures at the earliest possible stage of developments. Management actions for “worst case” operating scenarios should be considered.

Where impacts relate to the abstraction of groundwater, management actions should include approaches that:
- Reduce water use;
- Improve water resource management;
- Minimise quality impacts.

As part of the EIA process the project proponent should include a written comment (preferably in the form of a firm commitment) on their ability and willingness to implement the management actions recommended by the hydrogeological assessment. Preferably this management action will have been agreed to by the project proponent in the course of formulating the management action.

17.6 IDENTIFYING THE BEST PRACTICABLE ENVIRONMENTAL OPTION

Where possible approaches followed during the assessment and recommendations made should refer to the Best Practicable Environmental Option (BPEO). The selection of the Best Practicable Environmental Option (BPEO) should be guided by the objective of maintaining (as far as possible) the integrity of the resource and its ability to sustainably provide goods and services.

Each specialist assessment will identify the BPEO from a range of given options, or even add to the set of options. It is the responsibility of the EAP to evaluate the BPEO recommendations within the various specialist assessments and provide an overall recommendation for the BPEO, which takes into account the outcomes of the various specialist assessments. In the event that there have been differences in opinion between specialist assessments regarding the BPEO, the Environmental Impact Report should highlight these reasons and explain why these have arisen (e.g. the pursuance of different management or environmental objectives).
18. COMMUNICATING THE FINDINGS OF THE IMPACT ASSESSMENT

Specialist assessment reports should be concise and, as far as possible, avoid the use of technical jargon. Where this is unavoidable, brief explanations should be provided in order to ensure that the reader is able to understand the approach to, and findings of, the specialist assessment.

The specialist should compile a detailed report(s). As a minimum it should contain the following:
- Summary impact assessment table using the defined impact assessment and significance rating criteria;
- Clear indication of whether impacts are irreversible or result in an irrereplaceable loss to the ecosystem and/or society.
- Statement of impact significance for each issue specifying whether level of acceptable change has been exceeded and whether the impact presents a potential fatal flaw;
- Identification of beneficiaries and losers from the proposed development.
- Specification of key risks and uncertainties that may influence the impact assessment findings
- Degree of confidence in the impact assessment prediction.
- Summary of key management actions that fundamentally affect impact significance.
- Identification of the best practicable environmental option, providing reasons.
- Identification of viable development alternatives not previously considered.

19. MONITORING PROGRAMMES

Monitoring is undertaken in order to comply with permits and to understand the functioning of hydrogeological systems, in order to determine current and predict future trends. Monitoring can be defined as the measurement of one or more variables on a once-off or repeat basis.

Guiding principles for effective monitoring are that (DWAF, 2004b):
- Each component of a monitoring strategy should have a clearly defined purpose.
- Data collected should be relevant to the decisions that need to be taken.
- Monitoring should be physically and financially feasible.
- Data collected should be compatible with the models that use them.
- Monitoring should make use of the best available technologies and resources, without entailing unnecessary costs.
- The components of monitoring programmes should be updated periodically to take into account changing management problems, resource availability and decision-making models.
The installation of groundwater monitoring systems requires specialized knowledge, and consultation with an appropriately qualified hydrogeologist is essential.

The development type will determine the data monitored. These could include 24 hour rainfall, continuous run-off quantities and quality. Samples must be collected, preserved and analyzed according to specifications in the permit. Borehole data is also required, and would typically include: geological log, water intersections (depth and quantity), construction information (depth of hole and casing, borehole diameter, method drilled, date drilled), use of the borehole water, if not solely for monitoring; frequency of abstraction; abstraction rate and whether other water sources are readily available; water quality; borehole type; hole diameter; hole depth, casing, screens and filters; location of piezometer tubes; borehole protection; groundwater levels; results of pumping and/or packer tests; distribution, quality and yield of fountains, wells, dams, pans, streams and rivers.

Groundwater monitoring strategies should aim to make the best use of available resources. This requires proactive efforts to (DWAF, 2004b):

- Prioritise monitoring activities which provide the most critical information;
- Promote cooperation and coordination with other monitoring activities, e.g. surface water and meteorology;
- Align and refine existing programmes to avoid unnecessary effort or duplication of effort;
- Streamline monitoring procedures to reduce man-hours and travel times wherever possible;
- Make the best use of existing infrastructure, especially boreholes;
- Make use of local water users for financial and/or logistical support;
- Make use of appropriate technologies;
- Conduct cost-benefit analyses for the monitoring network design.
PART E: EVALUATION OF THE SPECIALIST HYDROGEOLOGICAL INPUT

20. EVALUATION OF THE SPECIALIST INPUT

When reviewing specialist hydrogeological reports it must be judged whether the assessment methods are sound, the results are plausible and whether the conclusions are logical and substantiated by the results. Importantly, the conceptual model must be tested for appropriateness. Under certain conditions it may be necessary to obtain the services of an independent specialist to act as reviewer. Further information on the role of the independent peer review is given in Guideline 7 of this series (Guideline for the review of specialist input to the EIA process).

The conceptual model needs to be logical, since if it is not, the entire assessment will be flawed. The conceptual model usually involves simplification and generalisation, and it should be checked to establish if these are based on plausible/valid assumptions.

Other criteria to consider during the peer review:

- The specialist study have included inputs from a qualified, experienced hydrogeologist and/or a geochemist (and/or specialists in related fields, if necessary).
- If a hydrocensus is not included in the assessment, reasons for this should be clearly motivated.
- Any specialist assessment should include a conceptual model that describes recharge, flow, discharge and the type of aquifer (e.g. confined or semi-confined).
- The conceptual model should be substantiated by well referenced, supporting information.
- Assumptions, limitations and confidence levels underpinning the conceptual model must be made explicit.
- For large projects in sensitive areas, the assessment must include and describe the field work undertaken and indicate linkages with other specialists.
- Where modelling is used assumptions and parameters must be specified.
- Key groundwater references should be cited.
PART F: REFERENCES


Department of Water Affairs and Forestry (DWAF), 1997, National Water Policy, Pretoria.


Foster, S., Garduño, H., Kemper, K., Tuinhof, A., Nanni, M., and Dumars, C., date unknown, Groundwater Quality Protection - defining strategy and setting priorities, GW•MATE Briefing Note Series, Briefing Note 8, World Bank, Washington D.C.


21. USEFUL RESOURCES

**General Texts**


**Groundwater sampling:**


**Pumptesting:**


**Numerical Modelling:**


**Groundwater Vulnerability mapping**


**Installation of Monitoring networks:**

resources evaluation and management. WRC report No. 835/1/00


Recharge estimation:

Establishment and management of Waste Disposal Sites


Establishment of Cemeteries

Specifications for petrol storage tanks at service stations

Assessing the dependence of ecosystems on groundwater

# APPENDIX A: DEFINITIONS AND ACRONYMS

## DEFINITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternatives</td>
<td>A possible course of action, in place of another, that would meet the same purpose and need defined by the development proposal. Alternatives considered in the EIA process can include location and/or routing alternatives, layout alternatives, process and/or design alternatives, scheduling alternatives or input alternatives.</td>
</tr>
<tr>
<td>Alluvial</td>
<td>Recent unconsolidated sediments, resulting from the operations of modern rivers, thus including the sediments laid down in the river beds, flood plains, lakes, fans at the foot of mountain slopes, and estuaries.</td>
</tr>
<tr>
<td>Aquifer</td>
<td>A saturated permeable geological unit that can transmit significant (economically useful) quantities of water under ordinary hydraulic gradients. Specific geologic materials are not innately defined as aquifers and aquitards, but within the context of the stratigraphic sequence in the subsurface area of interest.</td>
</tr>
<tr>
<td>Best practicable environmental option</td>
<td>This is the option that provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term.</td>
</tr>
<tr>
<td>Discharge area</td>
<td>The area or zone where ground water emerges from the aquifer naturally or artificially. Natural outflow may be into a stream, lake, spring, wetland, etc. Artificial outflow may occur via pump wells.</td>
</tr>
<tr>
<td>Environmental impact assessment</td>
<td>An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting and assessing the potential positive and negative social, economic and biophysical impacts of a proposed development. The EIA includes an evaluation of alternatives; recommendations for appropriate management actions for minimising or avoiding negative impacts and for enhancing positive impacts; as well as proposed monitoring measures.</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Water in the subsurface, which is beneath the water table, and thus present within the saturated zone. In contrast, to water present in the unsaturated or vadose zone which is referred to as soil moisture.</td>
</tr>
<tr>
<td>Groundwater dependent Ecosystem</td>
<td>An ecosystem, or component of an ecosystem, that would be significantly altered by a change in the volume and/or temporal distribution of its groundwater supply' (Brown, et al., 2003).</td>
</tr>
<tr>
<td>Impact</td>
<td>A description of the effect of an aspect of the development on a specified component of the biophysical, social or economic environment within a defined time and space.</td>
</tr>
<tr>
<td>Issue</td>
<td>Issues are concerns related to the proposed development, generally be phrased as questions, taking the form “what will the impact of some activity be on some element of the biophysical, social or economic environment?”</td>
</tr>
</tbody>
</table>
### Key issue
An issue raised during the scoping process that has not received an adequate response and which requires further investigation before it can be resolved.

### Recharge areas
Areas of land that allow groundwater to be replenished through infiltration or seepage from precipitation or surface runoff.

### Scenarios
A description of plausible future environmental states that could influence the nature, extent, duration, magnitude/intensity, probability and significance of the impact occurring.

### Stakeholders
A subgroup of the public whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. The term includes the proponent, authorities and all interested and affected parties.

### Thresholds of significance
The level or limit at which point an impact changes from low to medium significance, or medium to high significance.

### Water table
The top of an unconfined aquifer where water pressure is equal to atmospheric pressure. The water table depth fluctuates with climate conditions on the land surface above and is usually gently curved and follows a subdued version of the land surface topography.

### ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAT</td>
<td>Best available technology</td>
</tr>
<tr>
<td>BPEO</td>
<td>Best Practicable Environmental Option</td>
</tr>
<tr>
<td>DEA&amp;DP</td>
<td>Department of Environmental Affairs and Development Planning</td>
</tr>
<tr>
<td>DEAT</td>
<td>Department of Environmental Affairs and Tourism</td>
</tr>
<tr>
<td>DWAF</td>
<td>Department of Water Affairs and Forestry</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
</tbody>
</table>

### UNITS

<table>
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<tr>
<th>Unit</th>
<th>Description</th>
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<tbody>
<tr>
<td>µg/L</td>
<td>Micrograms per liter</td>
</tr>
<tr>
<td>g/s</td>
<td>Grams per second</td>
</tr>
<tr>
<td>kg/s</td>
<td>Kilograms per second</td>
</tr>
<tr>
<td>m/s</td>
<td>Metres per second</td>
</tr>
<tr>
<td>L/s</td>
<td>Litres per second</td>
</tr>
<tr>
<td>m/day</td>
<td>Metres per day</td>
</tr>
</tbody>
</table>
APPENDIX B: EXAMPLE HYDROCENSUS DATA SHEET

<table>
<thead>
<tr>
<th>HYDROCENSUS DATA SHEET</th>
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</thead>
<tbody>
<tr>
<td>SITE IDENTIFICATION</td>
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<tr>
<td>POINT ID</td>
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<tr>
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</tr>
<tr>
<td>SITE OWNER PARTICULARS</td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Address</td>
</tr>
<tr>
<td>Contact Tel. Numbers</td>
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<td></td>
</tr>
<tr>
<td>WELL TYPE</td>
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<tr>
<td></td>
</tr>
<tr>
<td>WELL USE (&amp; volume)</td>
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<tr>
<td>WELL DIMENSIONS</td>
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<tr>
<td>Inside Diameter</td>
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<td>Total Depth</td>
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<tr>
<td>Screen</td>
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<tr>
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</tr>
<tr>
<td>REST WATER LEVEL</td>
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</tr>
<tr>
<td>APPROXIMATE DISTANCES TO</td>
</tr>
<tr>
<td>Polluting Activities</td>
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<tr>
<td>Septic Tank</td>
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<tr>
<td>Waste Dumps</td>
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<tr>
<td>Domestic Waste</td>
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<tr>
<td>Animal Waste</td>
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<tr>
<td>Vehicle sites</td>
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<tr>
<td>Burial Sites</td>
</tr>
<tr>
<td>Other</td>
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<tr>
<td></td>
</tr>
<tr>
<td>DATE</td>
</tr>
<tr>
<td>TIME</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Data Collected By</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>