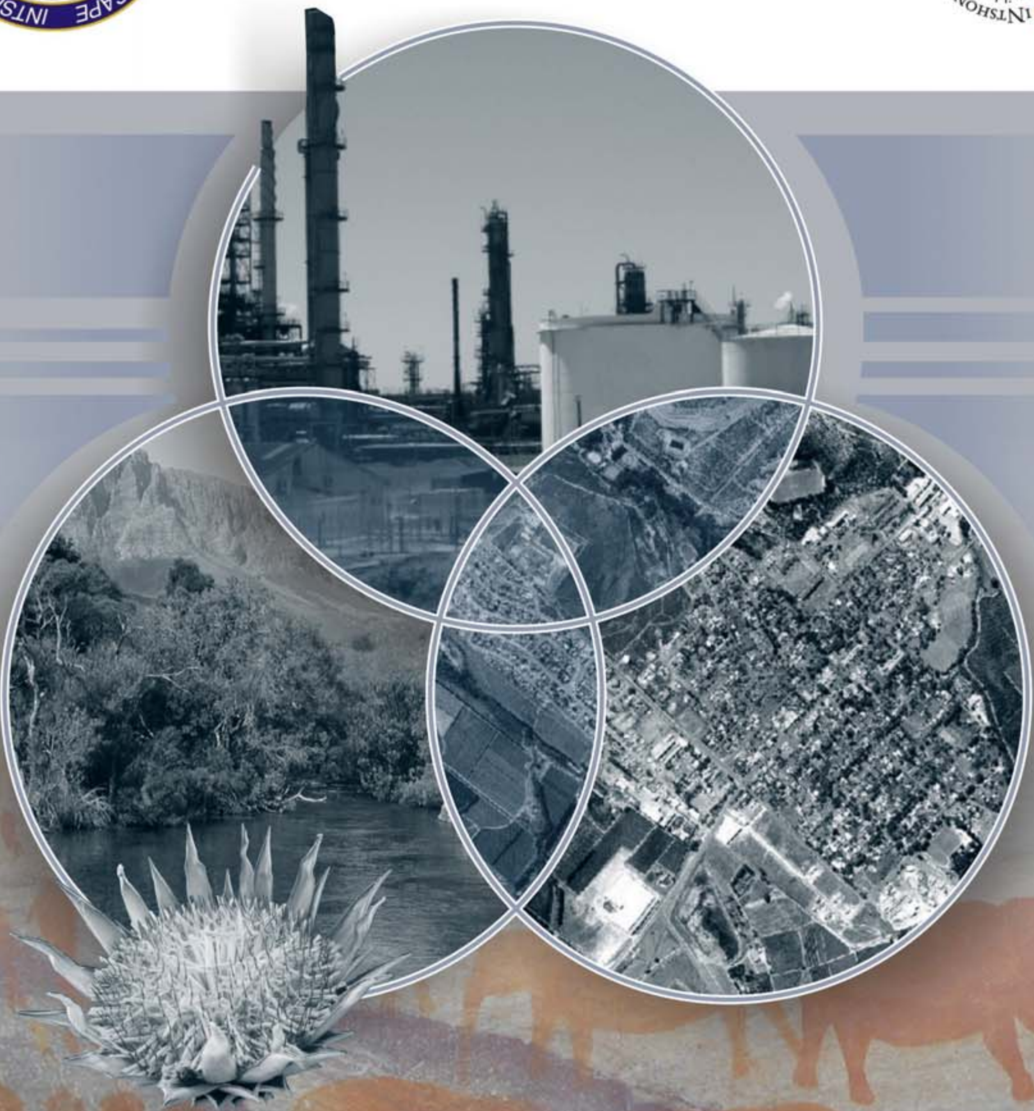
GUIDELINE FOR INVOLVING HYDROGEOLOGISTS IN EIA PROCESSES

**PROVINCIAL GOVERNMENT OF THE WESTERN CAPE:
DEPARTMENT OF ENVIRONMENTAL AFFAIRS
AND DEVELOPMENT PLANNING**



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Edition 1

Issued by:
Provincial Government of the Western Cape:
Department of Environmental Affairs and Development Planning
Utilitas Building, 1 Dorp Street
Private Bag X9086
Cape Town 8000
South Africa

Prepared by:
Irené Saayman
CSIR Environmentek
P O Box 320
Stellenbosch 7599
South Africa

Coordinated by:
CSIR Environmentek
P O Box 320
Stellenbosch 7599
South Africa

Contact person:
Frauke Münster
Tel: +27 21 888-2538
(fmunster@csir.co.za)

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ACKNOWLEDGEMENTS

Steering committee:

Paul Hardcastle - DEA&DP
Ayub Mohammed - DEA&DP
Susie Brownlie - deVilliers Brownlie Associates
Keith Wiseman - City of Cape Town
Mike Burns - CSIR Environmentek
Paul Lochner - CSIR Environmentek
Pete Ashton - CSIR Environmentek

Focus group participants:

Paul Hardcastle - DEA&DP
Adri La Meyer - DEA&DP
Melanie Webber - DEA&DP
Mike Smart - DWAF
Wietsche Roets - Cape Nature
Ricky Murray - Groundwater Africa
Julian Conrad - GEOSS
Richie Morris - MEGA
Irené Saayman - CSIR Environmentek
Christine Colvin - CSIR Environmentek
John Weaver - CSIR Environmentek
David Le Maitre - CSIR Environmentek
Paul Lochner - CSIR Environmentek
Frauke Münster - CSIR Environmentek

Internal review:

Mike Burns - CSIR Environmentek
John Weaver - CSIR Environmentek
Christine Colvin - CSIR Environmentek
Ross Campbell - CSIR Environmentek
Paul Lochner - CSIR Environmentek
Yakeen Atwaru - DEA&DP
Adri La Meyer - DEA&DP

Stakeholders engaged in the guideline development process:

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Finalisation of report figures and formatting:

Magdel van der Merwe and Elna Logie, DTP Solutions

PREFACE

The purpose of an Environmental Impact Assessment (EIA) process is to provide decision-makers (be they government authorities, the project proponent or financial institutions) with adequate and appropriate information about the potential positive and negative impacts of a proposed development and associated management actions in order to make an informed decision whether or not to approve, proceed with or finance the development.

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

- Add greater value to project planning and design;
- Adequately evaluate reasonable alternatives;
- Accurately predict and assess potential project benefits and negative impacts;
- Provide practical recommendations for avoiding or adequately managing negative impacts and enhancing benefits;
- Supply enough relevant information at the most appropriate stage of the EIA process to address adequately the key issues and concerns, and effectively inform decision-making in support of sustainable development.

It is important to note that not all EIA processes require specialist input; broadly speaking, specialist involvement is needed when the environment could be significantly affected by the proposed activity, where that environment is valued by or important to society, and/or where there is insufficient information to determine whether or not unavoidable impacts would be significant.

The purpose of this series of guidelines is to improve the efficiency, effectiveness and quality of specialist involvement in EIA processes. The guidelines 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. Furthermore, they aim to ensure that specialist inputs support the development of effective, practical Environmental Management Plans where projects are authorised to proceed (refer to *Guideline for Environmental Management Plans*).

The guidelines draw on best practice in EIA processes 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. The terms “specialist involvement” and “input” have been used in preference to “specialist assessment” and “studies” to indicate that the scope of specialists’ contribution (if required) depends on the nature of the project, the environmental context and the amount of available information and does not always entail detailed studies or assessment of impacts.

	ISSUES
TIMING	▪ 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?
SCOPE	▪ Which aspects must be addressed through specialist involvement; i.e. what is the purpose and scope of specialist involvement? ▪ What are appropriate approaches that specialists can employ? ▪ What qualifications, skills and experience are required?
QUALITY	▪ What triggers the review of specialist studies by different roleplayers? ▪ 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?

The following guidelines form part of this first series of guidelines for involving specialists in EIA processes:

- Guideline for determining the scope of specialist involvement in EIA processes
- Guideline for the review of specialist input in EIA processes
- 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 in EIA processes* and the *Guideline for the review of specialist input in EIA processes* 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 focused on specific specialist disciplines.

Who is the target audience for these guidelines?

The guidelines are directed at authorities, EIA practitioners, specialists, proponents, financial institutions and other interested and affected parties involved in EIA processes. Although the guidelines have been developed with specific reference to the Western Cape province of South Africa, their core elements are more widely applicable.

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 they are used during the early project planning phase to inform planning and design decisions (i.e. during pre-application planning) 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). Where specialist input may be required, the guidelines promote early, focused and appropriate involvement of specialists in EIA processes in order to encourage proactive consideration of potentially significant impacts, so that negative impacts may be avoided or effectively managed and benefits enhanced 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 terms and 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.

It is widely recognized that no amount of theoretical information on how best to plan and coordinate specialist inputs, or to provide or review specialist input, can replace the value of practical experience of coordinating, being responsible for and/or reviewing specialist inputs. Only such experience can develop sound judgment on such issues as the level of detail needed or expected from specialists 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 to improve the quality of specialist input.

Furthermore, 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, modeling), 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 process is undertaken as this influences both the approach and the methods available and used by specialists.

How are these guidelines structured?
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 potentially requiring specialist input;
- **Part C**: Planning and coordination 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.

SUMMARY

This guideline deals with the specialist hydrogeological input to the EIA process. It is applicable to related specialist disciplines such as hydrogeochemistry, geomicrobiology and hydrogeophysics.

The guideline gives an introductory background to the key concepts underpinning the consideration of groundwater impacts in EIA processes and identifies the main triggers and key issues that require the involvement of hydrogeological specialist(s).

Triggers and Key Issues Potentially Requiring Specialist Input

In order to determine whether hydrogeological specialist input to the EIA process is required it is suggested that:

1. The proponent and/or the EIA practitioner determines whether the proposed development falls within one of the following activity types:

    - 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.
    - The volume of groundwater in storage or entering groundwater storage is changed beyond what is allowed by the DWAF General Authorisations.
    - The groundwater flow regime is changed.

2. Where a development is found to fall in one of these activity classes, the hydrogeologist, in conjunction with the project proponent and the EIA practitioner, should be involved to determine whether the environmental conditions prompt the need for more detailed specialist hydrogeological input (see Table 2 for examples of such settings). Where none of the listed conditions exist or are likely to exist, there is no need for a specialist, unless special circumstances exist at the site in question.

3. Once it has been established that an activity coincides with an environmental condition that makes environmental impact likely, the specialist, with the EIA practitioner, the project proponent and the regulatory authorities must determine the level of environmental assessment required. Criteria to be used when making this determination include: project scale, sensitivity of the proposed location and expectation of adverse environmental impacts.

    Hydrogeology related issues that typically arise during the EIA process include:

    - Concern about the pollution or degradation in quality of water resources and the health and economic implications thereof;
    - Concern about over utilisation of the water resource and the consequences that the loss thereof may have;
    - Concern about the impact that a declining water table may have on the environment / ecosystems (e.g. wetlands, springs or river systems);
    - Concern about the impact of a rising water table on infrastructure and

land-use;

- Concern about the impacts related to land subsidence and sinkhole development;

Planning and Coordination of Specialist Inputs (Drawing Up the Terms of Reference)

Once the need for specialist input has been determined, the scope of the specialist input needs to be defined through consultation between the EIA practitioner, the specialist, the project proponent and the relevant authorities. In drawing up terms of reference for hydrogeological specialists, the following needs to be taken into account:

- 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 of the EIA process.
- The size and nature of the proposed development influences the time and space boundaries of the specialist's involvement.
- The hydrogeologist should ideally be involved in assisting the project proponent to identify the range of viable alternatives that should be considered.
- 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 specialist report.
- Specialists have a responsibility to engage with stakeholders over and above the EIA stakeholder engagement process, where this is necessary. They should identify the types of stakeholders that should typically be consulted with during the specialist study - and for what purpose.
- Issues of confidentiality need to be discussed and agreed upon.

Specialist Input and Management Actions

The following need to be considered when providing specialist input to the EIA process:

- Specialists need to trace likely cause-effect pathways to determine all potentially significant direct, indirect and cumulative impacts.
- One of the aims of hydrogeological input is to establish whether a proposed development exceeds legislative guidelines (e.g. RQOs or the Reserve).
- The determination of impact significance needs to consider the predicted impact of the proposed development in light of the vision for the area, including its water resources, rather than in terms of the impact on the current baseline conditions.
- 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).
- Where conclusions are formulated based on assumptions, these must be clearly outlined, and where necessary scenarios must be generated which illustrate their effect on study conclusions.

Through management actions the likelihood of negative impacts on the receiving environment and users and/or impact significance can be reduced. As far as possible, consensus on management actions should be secured between all specialists contributing to the EIA process in related fields. Management actions may take the form of avoidance, mitigation, compensation and offsets, rehabilitation or enhancement.

Review of Specialist Input

When reviewing specialist hydrogeological inputs it must be judged whether the approach and methods used were appropriate and 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.

The following should also be considered during the review:

- The specialist study should 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, 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.
- 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.

CONTENTS

Appendices

List of figures

List of tables

List of boxes

HYDROGEOLOGIST SPECIALIST GUIDELINE

PART A: BACKGROUND

This part of the guideline introduces the field of hydrogeology, gives principles and concepts underpinning specialist input on hydrogeological issues, impact assessment and management, contextualizes specialist input and looks at the role and timing of specialist input in the EIA process.

1. INTRODUCTION

The promulgation of the National Water Act in 1998 (Act No. 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. For these reasons, the potential impact of developments on groundwater resources need to be considered in Environmental Impact Assessment (EIA) processes and taken into account by decision-makers. However, little guidance currently exists to determine when specialist hydrogeological input is required or what the scope of this input should be. For these reasons, the Western Cape Department of Environmental Affairs and Development Planning (DEA&DP) embarked on the process of developing guidelines for the involvement of hydrogeological specialists in EIA processes.

This guideline encourages project proponents and EIA practitioners to seek specialist hydrogeological input at the earliest appropriate stage and to the appropriate extent of a project development where this is called for based on the nature of the project and the receiving environment. 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 development applications, while improving the competence of authorities, EIA practitioners, proponents and other stakeholders to review and comment on specialist inputs.

2. PRINCIPLES AND CONCEPTS UNDERPINNING HYDROGEOLOGISTS' INVOLVEMENT IN EIA PROCESSES

2.1 PRINCIPLES FOR INVOLVING SPECIALISTS IN THE EIA PROCESS

The following generic principles apply to the involvement of specialists in EIA processes and underpin this series of guidelines:

- Eliminate unnecessary specialist involvement through proactive project planning and design to avoid or sufficiently reduce negative impacts that may otherwise require specialist assessment;

- Maximise use of existing relevant information prior to involving a specialist;
- Where appropriate and necessary, involve specialists early in the EIA process to increase efficiency and effectiveness of their involvement.
- Maintain continuity of specialist involvement throughout the process (specialist involvement should add value to project planning and design);
- Support flexible, focused and appropriate involvement of specialists to provide adequate, relevant information to make informed decisions (i.e. the correct level of information should be supplied at the right time in the EIA process);
- Allow for greater involvement of specialists in the identification of key issues, over and above those identified through stakeholder engagement processes;
- Allow for efficient and effective interaction between specialists and the EIA practitioner, the project proponent, the authorities, other specialists on the EIA team and other interested and affected parties (I&APs) to improve the quality of the EIA process and outcomes and ensure that findings are informed by local and indigenous knowledge and experience.

2.2 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 term used throughout this document.

2.3 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 these sub-component specialist disciplines.

2.4 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. Values such as groundwater recharge and discharge may be presented as a range of values, accompanied by an indication of its associated level of uncertainty (see Section 10.5 on dealing with uncertainty).

2.5 CATEGORIES OF GROUNDWATER RELATED IMPACTS

The focus of hydrogeological input 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.

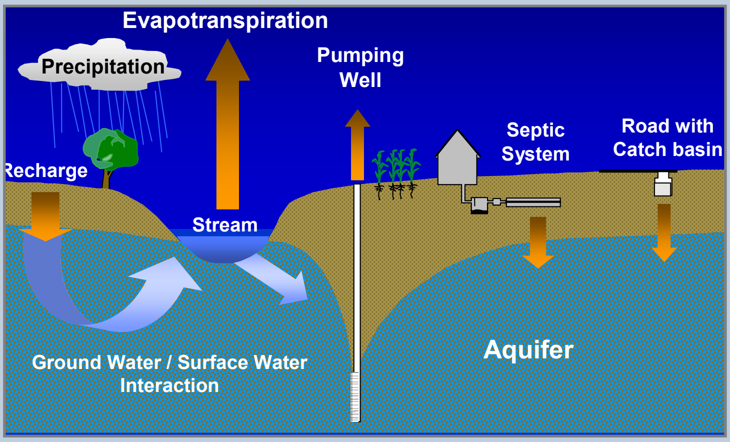
The guideline will highlight that there are issues of concern that are unique – the result of the interaction of the 'impact category' and the specific characteristics of the development (see Table 3) - which will direct the focus of the hydrogeological input.

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, the 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 input would need to focus on understanding the groundwater flow regime.

Some of the basic hydrogeological principles and concepts are explained in Box 1.

Box 1: 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.

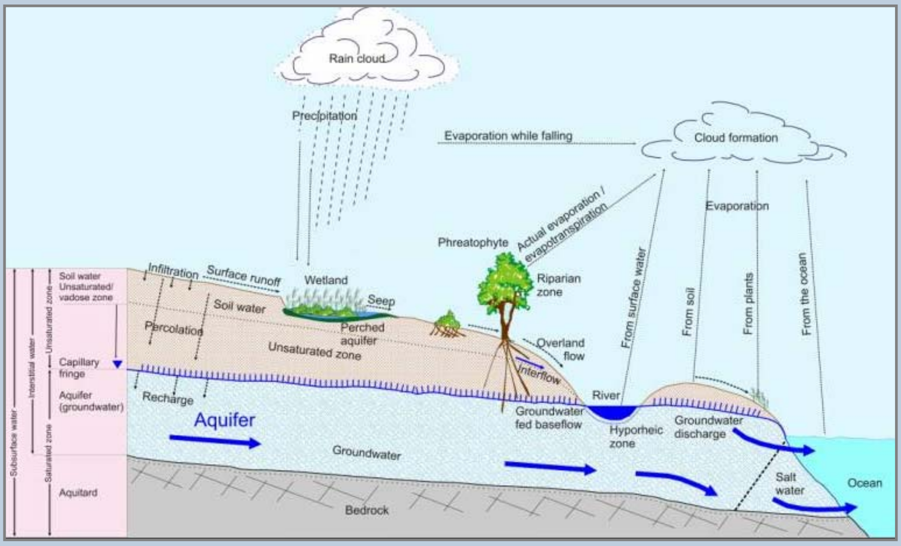


Aquifer is the name given to underground soil or rock through which groundwater can easily move. Aquifers typically consist of gravel, sand, sandstone, or fractured rock like the Table Mountain quartzites, or dissolution cavities in rock like limestone. Clay and shale formations generally restrict the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



2.6 COMMON EIA TERMS AND CONCEPTS

Common EIA terms and concepts used throughout this series of guidelines are summarised in Box 2.

Box 2: Common EIA terms and concepts

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

- ***Environmental impact assessment:*** A process that is used to identify, predict and assess the potential positive and negative impacts of a proposed project (including reasonable alternatives) 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 financial institutions. The process includes some or all of the following components: pre-application planning, screening, scoping, impact assessment (including the identification of management actions and monitoring requirements), integration and decision-making. Suitably qualified and experienced specialists may be required to provide input at various stages of the EIA process.
- ***Pre-application planning:*** The process of identifying and incorporating environmental opportunities and constraints into the early stages of project planning and design, prior to the submission of an application for statutory approval. This includes the identification of potential fatal flaws and negative impacts of potentially high significance, as well as the identification of alternatives and management actions that could prevent, avoid or reduce significant impacts or enhance and secure benefits. This process is sometimes referred to as "pre-application screening", "positive planning" or "fatal flaw assessment".
- ***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 usually administered by an environmental authority or financial 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 impact assessment. The main purpose is to focus the impact 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.
- ***Trigger:*** A particular characteristic of either the receiving environment or the proposed project which indicates that there is likely to be an *issue* and/or potentially significant *impact* associated with that proposed development that may require specialist input. Legal requirements of existing and future legislation may also trigger the need for specialist involvement but are not discussed in this guideline.
- ***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).

- ***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).
- ***Risk situation:*** A description of the environmental or operating circumstances that could influence the probability of a significant impact occurring.
- ***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 meet the same purpose and need but which would avoid or minimize negative impacts or enhance project benefits. These can include alternative locations/sites, routes, layouts, processes, designs, schedules and/or inputs. The "no-go" alternative constitutes the 'without project' option and provides a benchmark against which to evaluate changes; development should result in net benefit to society and should avoid undesirable negative impacts.
- ***Best practicable environmental option:*** This is the alternative/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.
- ***Impact significance:*** A term used to evaluate how severe an impact would be, taking into account objective or scientific data as well as human values. A specific significance rating should not be confused with the acceptability of the impact (i.e. an impact of low significance is not automatically "acceptable").
- ***Thresholds of significance:*** The level or limit at which point an impact changes from low to medium significance, or medium to high significance.
- ***Management actions:*** Actions – including planning and design changes - that enhance benefits associated with a proposed development, or that avoid, mitigate, restore, rehabilitate or compensate for the negative impacts.
- ***Monitoring programmes:*** Programmes established to observe, take samples or measure specific variables in order to track changes, measure performance of compliance, and/or detect problems.
- ***Review:*** The process of determining whether specialist input meets minimum requirements, is reasonable, objective and professionally sound.

3. CONTEXTUALISING THE HYDROGEOLOGICAL INPUT

This section provides a brief overview of the legal, policy and planning context for involving a hydrogeology specialist, and gives the specific Western Cape context within which that specialist would be working. Readers need to be aware that legislation, policies and plans are reviewed periodically. The guidelines therefore do not replace the need to consult the currently applicable legislation, policies and plans.

3.1 LEGAL, POLICY AND PLANNING CONTEXT FOR INVOLVING A HYDROGEOLOGY SPECIALIST

The Bill of Rights (Constitution of South Africa, Act No. 108 of 1996) 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 No. 36 of 1998). The EIA process is currently guided by the regulations promulgated in terms of the Environment Conservation Act (Act No. 73 of 1989). These regulations are currently being revised and will be replaced by regulations promulgated in terms of the NEMA. 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 these, resource quality objectives (RQOs) are specified for management of the resource. (See Box 3 for detail on what is meant by these concepts.); and
- Source directed controls (SDCs), which control impacts on water resources through the use of regulatory measures such as registration, permits, directives, prosecution, and economic incentives such as levies and fees, in order to ensure that the RQOs are met.

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 (Colvin, *et al.,* 2004):

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.

These measures define the limits and constraints that must be imposed on the use of water resources, and must be considered in EIA processes (see Box 4 for the statutory definition of what constitutes a "water use").

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. Guidelines on the procedures required for licensing an abstractive groundwater use have been developed by Parsons, et al. (2005). Among its outputs is a decision-support system that "will allow users to ascertain [what] information officials require to assess applications to develop and use groundwater".

Box 4: Statutory definition of "Water use"

For the purposes of this Act, water use includes -
(a) taking water from a water resource;
(b) storing water;
(c) impeding or diverting the flow of water in a watercourse;
(d) engaging in a stream flow reduction activity contemplated in section 36;
(e) engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);
(f) discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
(g) disposing of waste in a manner which may detrimentally impact on a water resource;
(h) disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
(i) altering the bed, banks, course or characteristics of a watercourse;
(j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
(k) using water for recreational purposes.

Source: Section 21, National Water Act (Act No. 36 of 1998)

Functions such as environmental management 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 No. 73 of 1989)[1], and for

[1] Soon to be replaced by EIA regulations to be issued in terms of Section 24 of the NEMA.

giving input to spatial and development framework planning (e.g. through formulation of the Provincial Spatial Development Framework (PSDF)) [2].

In terms of the Municipal Systems Act (Act No. 32 of 2000), it is compulsory for all municipalities to go through an Integrated Development Planning (IDP) process to prepare a five-year strategic development plan for the area under their control. The IDP process, specifically the spatial component (Spatial Development Framework), in the Western Cape Province, is based on a bioregional planning approach[3], which is meant to achieve continuity in the landscape and to maintain important natural areas and ecological processes. The duty of municipal officials to prevent pollution and ecological degradation, to promote conservation and secure ecologically sustainable development and use of natural resources, originates from the Constitution and NEMA and have again been confirmed in the Local Government: Municipal Systems Act of 2000 (Act No. 32 of 2000).

3.2 ENVIRONMENTAL CONTEXT FOR HYDROGEOLOGICAL INPUT

Specialist input to EIA processes need to take into account the specific nature of the biophysical, social and economic environment within which they are undertaken. Box 5 provides an overview of the hydrogeology of the Western Cape province as an example.

Box 5: 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 (TMG) 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 unconsolidated Tertiary-Quaternary age 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 Figure 1.

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.

[2] The provincial government information dissemination website (www.capegateway.gov.za) should keep those interested informed of the latest regional development strategies.

[3] Bioregional planning, as promoted and supported by the Western Cape Department of Environmental Affairs and Development Planning, is not a planning process on its own, but an approach that supplements the statutory spatial planning process by providing a spatial and theoretical framework for the integration of social, environmental and economic criteria in local planning initiatives. Bioregional planning involves the identification of priority areas for conservation and their placement within a supportive planning framework of buffer and transition areas (i.e. creating integrated landscapes).

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.

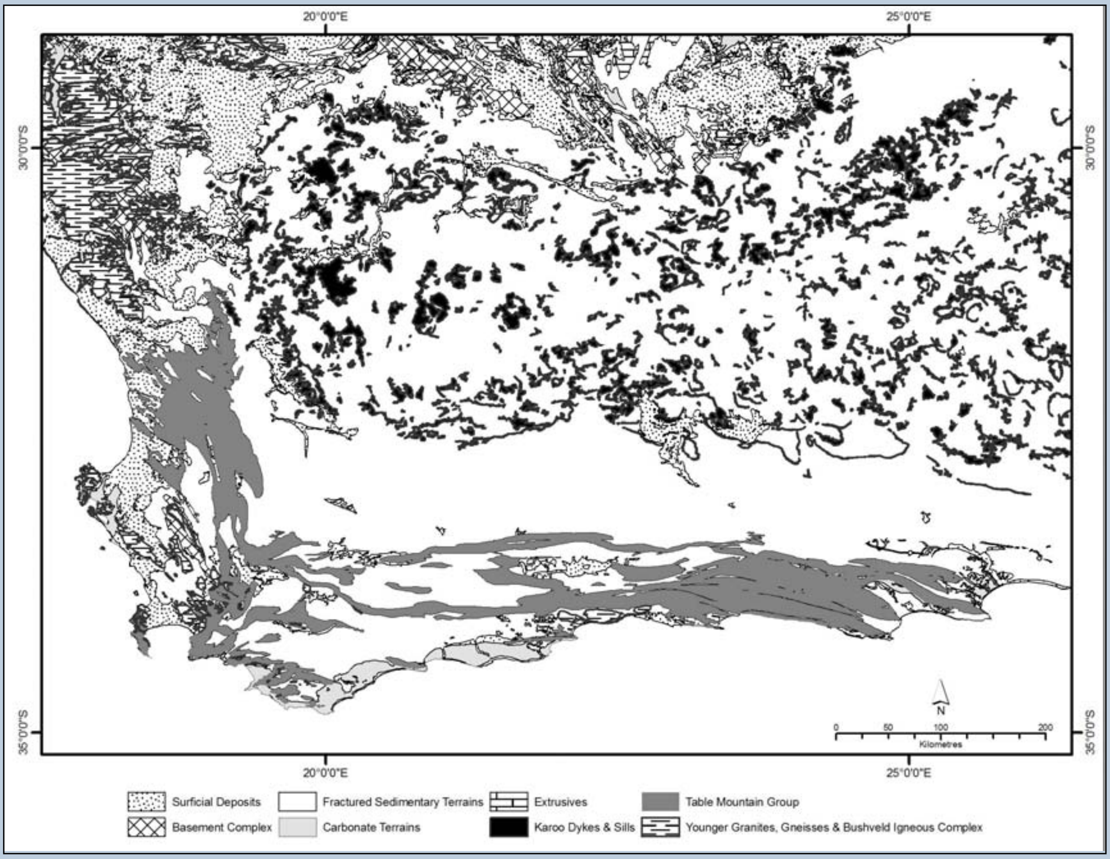


Figure 1: The distribution of geological formations associated with significant groundwater resources.

The vulnerability of each if these aquifer systems varies, depending on factors such as depth to water table, aquifer media, recharge (related to climate) and slope. Due to their 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 (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.

4. THE ROLE AND TIMING OF SPECIALIST INPUT WITHIN THE EIA PROCESS

The role and timing of specialist input within the broader EIA process involves a number of aspects that need to be considered, i.e.:

- Whether, when and why specialist input is required – see Sections 5 and 6 and the *Guideline for determining the scope of specialist involvement in EIA processes;*
- What the scope of specialist input should be - see Section 8, 10 and 11;
- What level/intensity of specialist input is required – see Section 8.

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 statutory approval. Specialists can therefore provide input during pre-application planning or following the submission of an application for statutory approval of the proposed development (i.e. during screening, scoping and/or impact assessment).

- **Pre-application planning stage,** to identify environmental opportunities and constraints (e.g. vulnerable groundwater resources), alternatives and potential fatal flaws to the proposed project that should be incorporated into early project planning and design.
- **Screening stage,** to assist decision-makers determine whether or not a proposed project requires environmental assessment and, if so, what level of assessment is required.
- **Scoping stage,** to identify key issues and alternatives associated with the proposed project, to respond to issues raised by other stakeholders and, where further specialist input is required, to assist in drafting and reviewing specialist terms of reference.
- **Impact assessment stage,** to predict and assess potential impacts of the proposed development and recommend management actions and monitoring programmes.

The involvement of specialists should not be seen as an obstacle in the approval process. Specialist input, especially at the early stages of project planning, can play an important role in helping to identify potential “fatal flaws” and formulate practical design alternatives that enhance project benefits, as well as minimise negative impacts, and possibly even project costs.

Depending on the nature of the project, the stage of project planning and the EIA process, the environmental context and the amount of available information, specialist involvement will vary in intensity (i.e. level of detail) and may include **any or all** of the following approaches:

- Provision of a specialist opinion or comment;
- Archival research and literature review;
- Detailed baseline survey (including site visit/s);
- Consultation and interviews;
- Mapping and simulation modeling;
- Assessment of impacts and their significance.

A specialist's role in the EIA process could be to assist with any or all of the following:

- Describing the affected environment
- Describing the legal, policy and planning context
- Identifying and responding to issues
- Identifying alternatives
- Identifying opportunities and constraints
- Developing specialist terms of reference (TOR)
- Predicting and assessing impacts
- Recommending management actions and monitoring programmes
- Undertaking an independent peer review of specialist input

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 (and the authorities where relevant).

The *Guideline for determining the scope of specialist involvement in EIA processes* provides more detailed guidance on the role and timing of specialist input and provides a generic approach that can be used to determine the need for specialist involvement. Clarification of responsibilities amongst the different roleplayers, as well as prerequisites for specialists to provide effective, efficient and quality input, is included.

PART B: TRIGGERS AND KEY ISSUES POTENTIALLY REQUIRING SPECIALIST INPUT

This part of the guideline looks at the triggers and key issues potentially requiring hydrogeologist's input to the EIA process.

5. TRIGGERS FOR SPECIALIST INPUT

A 'trigger' means a characteristic of either the proposed project or the receiving environment which indicates that hydrogeology is likely to be a 'key issue' and may require the involvement of an appropriately qualified and experienced specialist. Legal requirements of existing and future legislation may also trigger the need for specialist involvement, but are not discussed in this guideline (see Parsons, et al., 2005 for a discussion on the legal triggers associated with groundwater abstraction). The following steps are suggested to determine this:

Step 1.

The proponent and/or the EIA practitioner determines whether 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 specialist hydrogeological input.

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 EIA practitioner, the hydrogeologist should provide appropriate input to determine whether the environmental conditions prompt the need for more detailed specialist hydrogeological input. Guidance on when environmental conditions or settings would prompt the need for specialist hydrogeological input is provided in Table 2. Where none of the listed conditions exist or are likely to exist, there is no need for a specialist, unless special circumstances exist at the site in question. Special circumstances may be highlighted by the hydrogeologist conducting the investigation, interested and affected parties, a regulatory authority, or by other specialist input being provided 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 EIA practitioner, the project proponent and the regulatory authorities must determine the level of environmental assessment required (i.e. whether a screening study is adequate, or whether a full impact assessment is required). Criteria to be used when making this determination include: project scale, sensitivity of the proposed location and expectation of adverse environmental impacts.

Table 1: Activity types that call for hydrogeological specialist involvement

Groundwater related impact types	Examples of activities
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.	▪ 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.
The volume of groundwater in storage or entering groundwater storage is changed beyond what is allowed by the DWAF General Authorisations.	▪ 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.
The groundwater flow regime is changed by the proposed project.	▪ 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 ▪ Operations that result in the draining of wetlands etc.

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

Environmental Context
▪ **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: Zaporozec, *et al*., 2002; Morris, *et al*., 2003; and Foster, *et al*., date unknown.
▪ **The character of the soil and rock material allows the rapid infiltration of polluted water. This is a function of the nature of the rock and soil material.** Descriptions of the characteristics of most rock and soil types are available in all hydrogeology and soil textbooks (e.g. Freeze and Cherry, 1979).

Environmental Context
▪ **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 development.
▪ **Abstraction occurs from an aquifer that sustains or contributes to river baseflow or any other surface water feature where it is likely to contribute to ecosystem functioning.** Under the National Water Act (Act No. 36 of 1998) a component of all significant water resources is set aside for use by ecosystems, and may not be impacted upon by abstraction (Box 3).
▪ **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. Groundwater discharge to groundwater dependent ecosystems may be protected as part of the ecological reserve (see Box 3).
▪ **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 & van der Voort, 1998). The classification of groundwater resource units (required by the NWA) 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.** Maps showing area that are susceptible to the development of dolines and sinkholes are available from the Council for Geoscience and affected municipalities.
▪ **Abstraction occurs from an aquifer where a reduction in pore space may occur in the aquifer or in an associated deposit, leading to consolidation of the deposit giving rise to ground subsidence.** This is 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.** See Box 11 for a description of community vulnerability.
▪ **Groundwater abstraction could result in the ingress of poor quality water.** This is most likely in coastal areas, where seawater intrusion may result, but could occur in any setting where the pumped aquifer is linked to a system with poor quality water.
▪ **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 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 process 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. Where stakeholders have no interest in or may be poorly informed about groundwater issues, such issues may be overlooked. The involvement of a hydrogeologist in scoping is therefore important, especially where there are triggers indicating that groundwater impacts may be significant.

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 authorities, EIA practitioners, project proponents 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 hydrogeologist

Type of environment	Development category 1: Change in groundwater quality, e.g. Petrol station.	Development category 2a: Change in quantity of groundwater in storage, e.g. wellfield development.	Development category 2b: Change in groundwater recharge		Development category 3: Change groundwater flow regime, e.g. deep excavations.
			Decreased	**Increased**	
(A) Shallow water table	Pollution of the water resource.	Impact on groundwater dependent ecosystems.	Decline in water level and discharge, with impact on ecosystems and ecosystem services.	Inundation of low-lying areas.	Lowering of the water table.
(B) Rapid water infiltration and flow	Pollution of the water resource.	n/a	n/a	Increased discharge.	Lowering of the water table.
(C) Groundwater abstraction within 1 km of development	Health, aesthetic and/or use versatility impact on resource users.	Reduced yield and increased abstraction costs.	n/a	Use recharged water; possible health, aesthetic and/or use impacts.	Lowering of the water table.
(D) Wetland or groundwater dependent ecosystem occurs within 1 km of development	Loss of ecological functioning and associated ecosystem services.	Drying out of wetland and diminished ecosystem services.	Decline in water level and discharge, with impact on ecosystems and ecosystem services.	Increased discharge and change in character of the discharge environment, with possible impacts on ecosystems and ecosystem services.	Change in discharge and impact on ecosystems and ecosystem services.
(E) Aquifer is particularly vulnerable to	Pollution of the water resource.	n/a	n/a	Introduction of contaminants into the	n/a

Type of environment	Development category 1: Change in groundwater quality, e.g. Petrol station.	Development category 2a: Change in quantity of groundwater in storage, e.g. wellfield development.	Development category 2b: Change in groundwater recharge		Development category 3: Change groundwater flow regime, e.g. deep excavations.
			Decreased	Increased	
pollution				water resource.	
(F) Abstraction from an aquifer in Karstic terrain	Pollution of the water resource.	Lowering of water table, resulting in sinkhole or doline development and reduced flow and habitat for ecosystems	Lowering of water table, resulting in sinkhole or doline development and reduced flow and habitat for ecosystems	Rising water levels and increased spring discharge	Lowering of water table, resulting in sinkhole or doline development and reduced flow and habitat for ecosystems
(G) Aquifer occurs in material susceptible to consolidation or subsidence	n/a	Lowered water table, resulting in land subsidence with damage to infrastructure	Lowered water table, resulting in land subsidence with damage to infrastructure	n/a	Lowered water table, resulting in land subsidence with damage to infrastructure
(H) Aquifer Classification requires management to a pristine level	Ecosystem degradation and economic cost of rehabilitation.	Lowering of water levels and decreased groundwater discharge.	Declining water levels and decreased groundwater discharge.	Change in water quality of the receiving water resource.	Lowering the water table.
(I) Aquifer has a high exploitation potential	Pollution of the water resource.	Over-exploitation of the resource.	Reduction in sustainable yield of aquifer.	Introduction of contaminants and change in chemistry, which may result in deterioration (incl. yield) of water resource.	Introduction of pathways that allow pollutant entry.
(J) Development located near coast	Polluted surf zone with ecological and human	Saltwater intrusion resulting in poor water	Increased likelihood of saline intrusion.	Decreased likelihood of saline intrusion	Increased likelihood of saline intrusion.

Type of environment	Development category 1: Change in groundwater quality, e.g. Petrol station.	Development category 2a: Change in quantity of groundwater in storage, e.g. wellfield development.	Development category 2b: Change in groundwater recharge		Development category 3: Change groundwater flow regime, e.g. deep excavations.
			Decreased	Increased	
	health impacts	quality. Reduced discharge to marine environment			
(J) Groundwater is polluted with toxic vapour releasing substances	n/a	Health impact of using polluted water.	n/a	n/a	Introduction of pathways for release of vapour into human environment, with possible health impact.
(L) Aquifer is the only significant water source	Pollution of the water resource.	Over exploitation of the resource.	Decrease in the sustainable yield of the aquifer.	Introduction of contaminants and change in chemistry, which may result in deterioration (incl. yield) of water resource.	Lowering the water table with loss of storage, with possible impact on ecosystems.

PART C: PLANNING AND COORDINATION OF SPECIALIST INPUTS (DRAWING UP THE TERMS OF REFERENCE)

Once the need for input from a hydrogeologist has been determined, the scope of specialist input needs to be clarified through discussions between the EIA practitioner, the specialist, the proponent and the decision-making authority. This part of the guideline covers the choice of an appropriate specialist, and the negotiation process leading to sound terms of reference (TOR) for that specialist. Appendix B gives generic TOR for specialist input.

7. QUALIFICATIONS AND SKILLS REQUIRED

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 a 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/…

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

Impact Types	Range of possible skills/qualifications required
Contamination Contaminant transport in the environment is controlled by physical and (bio)chemical factors and processes. The importance of any one factor or process depends on the characteristics of the environment (physical, chemical and biological) and the nature of the contaminant. Thus different specialists may need to be involved to come to an understanding of the various processes and factors.	*Chemist or materials handling specialist* – To identify and quantify contamination risk. *Soil scientist* – To evaluate contamination in unsaturated zone (i.e. soils). *Hydrogeologist* – To identify, describe and/or assess impacts relating to physical flow path/migration pathway. *Hydrogeochemist* – To identify, describe and/or assess impacts relating to chemical migration processes. *Microbiologist* – To identify, describe and/or assess impacts relating to bacteriological processes. *Ecologist* – To describe and assess the degree of ecosystem dependence on groundwater.
Abstraction or recharge Requires an understanding of aquifer properties, and how the proposed activity will influence recharge, discharge and groundwater flow in the aquifer.	*Hydrogeologist* – To identify, describe and/or assess impacts relating to the 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 Requires an understanding of aquifer properties, and how the proposed activity will influence recharge, discharge and groundwater flow in the aquifer.	*Hydrogeologist* – To identify, describe and/or 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

In addition to the above, the specialist should:

- Be competent at interpreting and evaluating information and answering the "so what" and “to whom” questions, not simply providing descriptive information;
- Have sufficient practical experience working in the specific ecosystems of the affected region (or similar environments), and preferably local area, to make him/her respected by peers;
- Be able to think beyond his/her immediate discipline, able to trace impact pathways and identify indirect or cumulative impacts, and think of biodiversity/human wellbeing/economic interfaces;
- Have good knowledge relating to assessment techniques and to relevant legislation, policies and guidelines; and
- Be independent i.e. the specialist should not benefit financially from the outcome of the project decision-making.

8. DETERMINING THE SCOPE OF SPECIALIST INPUT

Once the need for specialist input has been determined (see Section 5), the scope of the specialist input needs to be defined through consultation between the EIA practitioner, the specialist, the project proponent and the relevant authorities. For this it is important that the participants in this discussion have a common understanding of the commonly used (and confused) EIA terms (Box 2). Sections 8.1 – 8.9 provide a brief overview of elements that should be discussed and agreed upon at the outset of the specialist's involvement in the EIA process and in drafting TOR[4]. General guidance on the prerequisites for involving specialists are provided in the *Guideline for determining the scope of specialist involvement in EIA processes*.

In complex and/or controversial projects, the draft TOR for specialists should preferably be reviewed by key stakeholders before they are finalized. Alternatively, the TOR for specialists should be evaluated by an independent reviewer.

8.1 IDENTIFYING OR RESPONDING TO ISSUES

The visual specialist could be asked *either* to identify issues, *and/or* to respond to, *and/or* to investigate issues raised through the scoping process. The Scoping Report should be consulted by the specialist in order to ensure that any visual issues raised are considered appropriately. The visual specialist should therefore determine:

- Whether the issues raised through the scoping process are valid in the context of the proposed project, and need to be addressed further. The specialist is not necessarily required to assess each issue raised during scoping; a response or a comment on why the issue is not relevant or is not assessed further may suffice in some cases. The specialist must give sound reasons to support his/her conclusions.
- Whether there is enough information to predict reliably the likely significance of key issues and associated impacts. If not, additional information should be gathered.
- Whether or not additional key issues need to be considered (i.e. issues that were not raised by stakeholders through the scoping process). The specialist must provide clear reasons for including any additional issues in the EIA process.
- Where there is sufficient reliable information, the specialist must determine:
    - Whether or not it can be reliably concluded that impacts could be avoided either by amending the project proposal, pursuing alternatives, and/or by appropriate management actions. *In this instance the specialist should provide sound motivation and justification for his/her conclusions. There would then not be a need to assess these issues further in the impact assessment phase and the further involvement of the economic specialist/s would be unnecessary.*
    - Whether or not the issue is potentially significant, and/or the issue and associated impacts cannot be avoided. *In this instance the specialist should indicate the type of visual expertise need to address the issue and help draw up sound terms of reference for specialist inputs during the impact assessment phase.*

[4] Recommended reading: DEAT, 2002

If appointed to provide specialist input during the impact assessment phase, the specialist should respond to and/or address all those visual issues raised during scoping which were deemed to lead to potentially significant impacts, were unavoidable and/or about which there was insufficient information to reach conclusions at the scoping stage about their potential impact significance. 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.

8.2 ESTABLISHING APPROPRIATE TIME AND SPACE BOUNDARIES0

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 impact assessment phase of the EIA process the likelihood of impacts on these uses will be assessed. In some settings, particularly where regional aquifer systems (like the TMG aquifer or Karst aquifers) are impacted, it may be necessary for the study to become a regional one.

8.3 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[5]. Any development proposal may include a range of possible alternatives from some or all of these various categories of alternatives. The *"no-go"* alternative in EIA provides a benchmark against which to evaluate potential impacts of the proposed project alternatives. When dealing with the issue of alternatives, the focus should rather be on ensuring that the

[5] Recommended reading: DEAT, 2004a

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 EIA practitioner and the project proponent to identify the range of viable alternatives that should be considered by the hydrogeologist in the EIA process. For proposed water supply projects 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.

Alternatives are best considered in the screening and scoping phase of the EIA process, 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.

8.4 ESTABLISHING ENVIRONMENTAL AND OPERATING SCENARIOS

Two types of scenarios should be considered for all types of development. These are environmental 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 operating scenarios that consider events and circumstances that are internal to the project, including potential operational upset situations (e.g. spillage of oil from offloading tanker vehicle leading to groundwater contamination).

The specialist should consider and assess possible environmental and operating scenarios that could influence the nature, extent, duration, magnitude/intensity, probability and significance of anticipated impacts. Parameters that could be varied to generate different scenarios are listed in Table 5.

Table 5: Parameters to be considered when developing scenarios

SCENARIO TYPE:	**OPERATING**					**ENVIRONMENTAL**
Scenario Examples	**Spillage or leakage of hazardous material**	**Effluent Disposal**	**Groundwater abstraction**	**Artificial groundwater recharge**	**Excavation to below water table**	**Drought Conditions**
Parameters	▪ Type of contaminant and volume likely to be spilled/leaked ▪ Toxicity of material ▪ Seasonal variation in depth to water table ▪ Weather conditions ▪ Mitigation measures ▪ Mitigation measure response time	▪ Volume discharged ▪ Discharge effluent quality ▪ Depth to the water table ▪ Chemical make-up	▪ Volume abstracted ▪ Abstraction period and scheduling ▪ Change in recharge ▪ Level of the ecological reserve	▪ Recharge water quality ▪ Pore clogging risk ▪ Artificial recharge volume and abstraction rates	▪ Depth to water table ▪ Depth of excavation ▪ Change in recharge ▪ Aquifer permeability ▪ Volumes to be dewatered	▪ Degree of recharge reduction ▪ Increased groundwater abstraction ▪ Declining water levels

8.5 ADDRESSING DIRECT, INDIRECT AND CUMULATIVE IMPACTS

The specialist must consider potentially significant direct, indirect and cumulative impacts of a proposed activity (see Box 6)[6]. This requires the following:

- Conceptualisation of possible cause-effect pathways resulting from the proposed development;
- An understanding of current and future plans, projects and activities in the same area;
- An awareness of other threats or trends that could affect the groundwater resources in the area in which the development is proposed;
- An understanding of the likely resilience and status of the affected resource;
- An understanding of broader strategic goals or targets for the area that would be affected by the proposed project.

The level of detail to which these should be considered will be influenced by the nature of the proposed project and issues raised through the scoping process. Where potentially significant cumulative effects are likely and cannot be addressed in the EIA, the specialist should alert the EIA practitioner and decision-maker/s to these effects and make explicit recommendations as to ways of addressing them (e.g. through a strategic environmental assessment or systems-based approach).

Groundwater is particularly susceptible to the cumulative effect of numerous small impacts. Due regard must be given to this by the hydrogeologist 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 6 provides a definition of the different interpretations and components of direct, indirect and cumulative effects.

[6] Recommended reading: DEAT, 2004b

Box 6: Differing interpretations and components of direct, indirect and cumulative effects

Direct (or primary) effects occur at the same time and in the same space as the activity. For example, the pollution of groundwater resulting from onsite spillages of hazardous materials.

Indirect (or secondary) effects occur later in time, or at a different place, from the causal activity, or as a result of a complex pathway. For example, abstraction of groundwater leading to changes in the water table and affecting a distant groundwater dependent wetland.

Cumulative effects can be:

- Additive: the simple sum of all the effects (e.g. the combined effect on an aquifer of small scale abstraction by many users);
- 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);
- 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).
- 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).
- 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).

Source: Adapted from Cooper, 2004.

8.6 SELECTING THE APPROPRIATE APPROACH

The issues that are typically associated with hydrogeological input as part of EIA processes 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 hydrogeological inputs to EIA processes are presented in Box 7.

Box 7: Key elements of an approach to a hydrogeological investigation

Initial/Conceptual Planning	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 subsequent information gathering is based on the conceptual model, and information gathered during further investigation is used to refine the conceptual model.
Reconnaissance and information review	All relevant, existing information is identified and key texts reviewed. Central to the hydrogeological study is the identification of boreholes in the area and all users and uses that could be impacted. The National Groundwater Database and the National Groundwater Archive 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 (see Appendix C for an example of a hydrocesus data sheet).
Field studies	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.
Analysis	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 modeling. Results of the data gathering and hydrocensus will serve to calibrate these models.
Refined model	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. This updated model is then used to assess the potential impacts of groundwater associated with the proposed project.

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 EIA practitioner, 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.

8.7 CLARIFYING THE TIMING, SEQUENCING AND INTEGRATION OF SPECIALIST INPUT

Effective interaction with other specialists should be facilitated by the EIA practitioner to ensure that an integrated approach is adopted to ensure that the various components of the environment are seen as a whole.

One of the ways in which early specialist involvement can benefit the EIA process 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 specialist fields that are commonly used by hydrogeologists.

8.8 ENSURING APPROPRIATE STAKEHOLDER ENGAGEMENT

Where necessary, 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 process i.e. ideally working through the appointed stakeholder engagement practitioner.

8.9 CLARIFYING CONFIDENTIALITY REQUIREMENTS

In developing TORs issues of confidentiality need to be discussed and agreed upon. This may relate to how commercially confidential information, or sensitive information about the receiving environment, is treated and communicated. Information on the receiving environment may be kept confidential in order to protect sensitive resources i.e. where information may precipitate additional impacts. 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 process.

Table 6: Categorisation of various approaches used for hydrogeology assessments

Type of approach used to assess impacts	Description	When is it used?			
		Notes	Impact types		
			Change in groundwater quality (i.e. Contamination of groundwater)	Change in Groundwater storage	Change in flow /migration pathway
Hydrocensus (Level of detail depends on project and receiving environment)	Typically involves locating and gathering of information on boreholes, users, uses and sensitive ecological receptors within a defined radius of the development.	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, as it may contain errors and omissions and may be out-of-date.	Always	Always	Always
Qualitative conceptual model	This may take the form of a box model or map on which the direction and volume of water flux is shown. Subsequent steps will test the validity of the assumptions that underlie the conceptual model.	Always applied to understand flow pathways and discharge areas (with associated ecosystems), and to communicate results to non-specialists.	Always	Always	Always
Quantitative flow model	The use of an appropriate software package to test	Used to understand groundwater flows in cases where projects may	Often used: Then in conjunction	Often used: In large scale	Rarely used: In large scale

Type of approach used to assess impacts	Description	When is it used?			
		Notes	Impact types		
			Change in groundwater quality (i.e. Contamination of groundwater)	**Change in Groundwater storage**	**Change in flow /migration pathway**
	assumptions and scenarios of groundwater flow.	be high risk, highly controversial, in a highly sensitive environment or where a high degree of confidence in the results is required.	with transport model	abstraction or where associated with sensitive environment.	developments or where associated with sensitive environment.
Quantitative transport model	The use of an appropriate software package to calculate the rates of contaminant transport in the subsurface environment.	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.	Often used	Rarely used: Where concern relates to contaminant migration from pollution sources.	Almost never used
Drill test boreholes	Boreholes are drilled to enable testing and/or monitoring of aquifer characteristics.	Undertaken to verify and test conceptual or quantitative models, where existing data is limited.	Rarely used: In large scale developments or where associated with sensitive environment.		
Pumptest existing or drilled boreholes	The pumping of boreholes at various rates and periods to determine aquifer parameters.	To check whether there is an impact on neighbouring boreholes (or *vice versa*) and to understand borehole hydraulics.	Rarely used: In large scale developments or where associated with sensitive environment.		
Recharge study	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.	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.	Never	Almost never: In large scale developments or where associated with sensitive environment.	

Type of approach used to assess impacts	Description	When is it used?			
		Notes	Impact types		
			Change in groundwater quality (i.e. Contamination of groundwater)	Change in Groundwater storage	Change in flow /migration pathway
Determination of dependency of ecosystems on groundwater flows.	Iterative process to establish the role of groundwater in sustaining ecosystems. Culminates in a trans-disciplinary assessment of the component of groundwater that feeds baseflow to aquatic systems or sustains terrestrial ecosystems.	Undertaken where concern exists about impacts on groundwater dependent ecosystems. This determination may be required as part reserve determinations.	Rarely. Depends on the receiving environment.	Rarely. Depends on the receiving environment.	
Rapid reserve determination	A low confidence determination of the amount and quality of water that must be set aside to protect ecological functioning and basic human needs	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.	Rarely. Need is determined through consultation with the appropriate water management authority.	Rarely: Rapid reserve determinations have been completed by DWAF for most significant water resources.	
Comprehensive reserve determination	A high confidence determination of the amount and quality of water that must be set aside to protect ecological functioning and basic human needs.	Only undertaken where the rapid reserve determination doesn't provide sufficient information to enable the issuing of a water use license by DWAF.	Never	Rarely: Only for large scale developments or where associated with sensitive environment.	

PART D: PROVIDING SPECIALIST INPUT

This part of the guideline provides guidance for providing specialist input, as well as identifying the information required by specialists.

9. INFORMATION REQUIRED TO PROVIDE SPECIALIST INPUT

9.1 RELEVANT PROJECT AND SITE RELATED INFORMATION

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

- The location of the proposed development and its associated activities (i.e. aspects of construction, operation and decommissioning that may potentially impact on groundwater);
- Specific information on hazardous substances that may be handled or produced through the course of the development (incl. during 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;
- Company policy commitments that may be relevant;
- Details of mitigation measures that form part of the project plan or design.

In addition, it might be necessary, where appropriate, to provide the specialist with info on the site's and adjacent lands' current use and use history. Relevant information should be sourced by the specialist as needed.

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 impact assessment phase (where this is required) will depend on the specialists' understanding of the issues (upon which the assessment will focus) identified during the initial site visit, discussions with the proponent and the EIA practitioner, or raised during public scoping meetings.

9.2 INFORMATION DESCRIBING THE AFFECTED ENVIRONMENT

Site related 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 and groundwater levels)
- Borehole data (incl. construction, geological logs and water strike detail)
- Topography, borehole and groundwater dependent ecosystem surveys
- Surface water features and characteristics

- Users and uses of the resource
- Site zoning
- Particulars of any previous studies of relevance conducted in the area

The specialist should also be provided with relevant information from any pre-application screening studies for the proposed project or site.

Information required for testing the validity of the conceptual model and numerical models 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.

The involvement of specialists should be based on the need to supply information relevant to the assessment of impacts associated with the development proposal. Gaps in scientific information for geographical areas/ ecosystems or habitats, especially where the information is not readily linked to development impacts, or where impacts can be avoided/mitigated without specialist input, should not be used to motivate for specialist involvement.

9.3 THE LEGAL, POLICY AND PLANNING CONTEXT

The following information of a legal, policy or planning nature is needed to identify and assess potential groundwater impacts resulting from the project and to determine whether the proposed development conflicts with current and planned legislation, policies and plans:

Essential information:
- Policies, plans or objectives that provide a vision of the desired future state and use of water resources in order to evaluate whether or not the proposed development contributes to, or conflicts with the achievement of this vision.
- The Provincial Spatial Development Framework (PSDF), local Integrated Development Plans (IDP) and Spatial Development Frameworks (SDF) and zoning schemes of provincial or local authorities, which give an indication of planning policy for the area, and whether the proposed project will be compatible with these policies, with particular reference to groundwater aspects.
- Legislation and by-laws governing water use.

9.4 INFORMATION GENERATED BY OTHER SPECIALISTS IN THE EIA PROCESS

The hydrogeological input will be informed and in some cases guided by other specialist inputs, for example, on the terrestrial ecosystems, surface water hydrology, rainfall chemistry and soci-economic context. The hydrogeological input may, in turn, also inform and guide these specialist inputs.

Some of the information that could typically be obtained from these specialists 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;
- Regional water sources, water use and projected growth in water demand; and
- 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 11.

10. SPECIALIST INPUT FOR IMPACT ASSESSMENT AND RECOMMENDING MANAGEMENT ACTIONS

A hydrogeologist could provide input at different stages of the EIA process (Section 4). This input could be relatively minor, in the form of a brief professional opinion, or a detailed hydrogeological assessment with an associated written report, depending on the nature of the proposed project and the sensitivity and complexity of the receiving environment. In most instances, regardless of the final product and its level of detail, the conceptual thinking followed by any specialist should be similar.

As a general guide the specialist should:

- Consider the **full project cycle**;
- Answer the **"so what" and "to whom"** questions of probable impacts, i.e. what are the likely consequences of impacts, how severe would they be, and who would be affected by these impacts;
- Predict, assess and evaluate potentially significant **direct, indirect and cumulative impacts**, both with and without management actions. The evaluation of significance should be linked to **thresholds of significance**;
- Assess and evaluate impacts for the **different alternatives** and for **different environmental and operating scenarios**, where appropriate;
- Consider not only impacts on the **affected site**, but also impacts **beyond the site boundaries**;
- Assess and evaluate any **opportunities and constraints** posed by the receiving environment/operating context on the proposed development.

10.1 PREDICTING POTENTIAL IMPACTS

Specialists need to trace likely cause-effect pathways[7] to determine all potentially significant direct, indirect and cumulative impacts. The impact/s will depend on the nature of the project (e.g. type and nature of associated infrastructure, project inputs and/or outputs), as well as on the properties of the receiving environment, both human and natural, and on their probable response and linkages.

For example, the abstraction of groundwater could result in a change in the water table. Changes to the water table could affect discharge to rivers and wetlands, availability of water to terrestrial groundwater dependent ecosystems, etc. These impacts may interact with each other to result in additional impacts (e.g. reduced groundwater discharge may result in reduced dry-season river flow and could cause near-stream vegetation die-off that results in increased erosion and stream sediment levels during the wet-season), which in turn could impact on local economies and employment (e.g. by resulting in the die-off of commercial fish species or the silting-up of dams).

One of the aims of the provision 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. The term '**fatal flaw**' is used in the pre-application planning and screening phases of a project to evaluate whether or not an impact would have a 'no-go' implication for the project (Box 8). In the scoping and impact assessment stages, this term is not used; rather, impacts are described in terms of their potential **significance** (Section 10.2).

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[7] Münster and Davies, 2005.

Box 8: Potential fatal flaws from a hydrogeological perspective

A potential fatal flaw is an impact that could have a "no-go" implication for the project. A ‘no-go’ situation could arise if residual negative impacts (i.e. those impacts that still remain after implementation of all practical mitigatory procedures/actions) associated with 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 (eg. 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) Negative impacts that may be evaluated to be of high significance and that are considered by stakeholders and decision-makers to be unacceptable and for which management actions that would effectively reduce the significance of the impact are technically and/or financially unfeasible.

10.2 INTERPRETING IMPACT ASSESSMENT CRITERIA

The assessment of possible impacts, their reporting and the subsequent decision-making process requires consistency in the interpretation of impact assessment criteria. Criteria that could be used to describe impacts are listed in Box 9.

Local stakeholders and communities may attach specific direct or indirect values to 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 process.

The determination of impact significance needs to consider the predicted impact of the proposed development in light of the vision for the area, including its water resources, rather than in terms of the impact on the current baseline conditions. For example, abstraction from an aquifer that has been designated a management class that allows significant impact will be less significant than abstraction from an aquifer that needs to be managed to a relatively unimpacted state.

Box 9: Criteria used for the assessment of impacts

The assessment of impacts should be done according to a synthesis of the general assessment criteria listed below. Wherever possible, the specialist must refine and customize these criteria to their particular study.

Nature of the impact - 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.

Extent - Here it should be indicated whether the impact will be:
- *local* extending only as far as the activity;
- will be limited to the *site and its immediate surroundings*;
- will have an impact on the *region*;
- will have an impact on a *national* scale;
- will have an impact across *international* borders.

Duration - Here it should be indicated whether the lifetime of the impact will be:
- *short term* (e.g. 0 – 5 years);
- *medium term* (e.g. 5 – 15 years);
- *long term* where the impact will cease after the operational life of the activity, either because of natural process or by human intervention; or
- *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.

Intensity – Here it should be established whether the impact is destructive or benign and should be indicated as:
- *low,* where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected;
- *medium,* where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and
- *high,* where natural, cultural or social functions or processes are altered to the extent that it will temporarily or permanently cease.

Probability – This should describe the likelihood of the impact actually occurring indicated as:
- *improbable,* where the possibility of the impact to materialize is very low either because of design or historic experience;
- *probable,* where there is a distinct possibility that the impact will occur;
- *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.

Wherever possible, the specialist must refine and customise these criteria for the purpose of the particular hydrogeological assessment. (For example: “high” significance in a groundwater context could be defined as abstraction resulting in drawdown that exceeds the applicable Resource Quality Objectives; or may refer to discharge of effluent that exceed the appropriate Water Quality guidelines of DWAF.)

Adapted from: Department of Environmental Affairs and Tourism, 1998

10.3 ESTABLISHING THRESHOLDS OF SIGNIFICANCE

Thresholds of significance define the level or limit at which point an impact changes from low to medium significance, or medium to high significance. These thresholds are often determined by current societal values which define what would be acceptable or unacceptable to society and may be expressed in the form of legislated standards, guidelines or objectives.

Clear objectives for 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 (refer to 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 affected water resources should be reported using the parameters that are stipulated in the RQOs for that resource. This should be used as the basis for determining and communicating 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.

10.4 DESCRIBING THE DISTRIBUTION OF IMPACTS – BENEFICIARIES AND LOSERS

Once all the uses of the groundwater resource and its receiving environment are identified and listed, the hydrogeologist must determine the effect of the development in terms of beneficiaries and losers. Inevitably trade-offs are made in decision-making and the hydrogeological input 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 are 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, communities who rely solely on groundwater for their water supplies;
- 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.

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.

10.5 IDENTIFYING KEY UNCERTAINTIES, ASSUMPTIONS AND RISKS

Most groundwater studies focus on understanding the impact of development on the sustainability of groundwater resources and on groundwater dependent ecosystems. This requires that hydrogeologists understand the areas and magnitude of groundwater recharge and discharge, and the way and extent to which groundwater and surface water systems are linked to each other. Unfortunately these components are difficult to conceptualise, and can only be quantified through elaborate, usually expensive, often multi-year research studies. In data scarce areas hydrogeologists are forced to make assumptions about these components, despite high uncertainty. This practice may be acceptable (if founded on scientific knowledge and logic) where the risks are small.

Where conclusions are formulated based on assumptions, these must be clearly outlined and, where necessary, scenarios must be generated which illustrate their effect on study conclusions.

The specialist should clearly communicate any major risks and uncertainties associated with the assessment of groundwater-related impacts. The hydrogeologist must be explicit about:

- Any assumptions made in the assessment methodology;
- Any gaps in information that may affect the accuracy or reliability of predictions and/or confidence levels;
- Any inherent uncertainties with regard to the behaviour or resilience of the receiving environment, including the influence of environmental trends and/or operating conditions;
- The risk implications associated with any of the above; and
- The associated consequences, highlighting significant or irreversible impacts.

10.6 DEFINING CONFIDENCE LEVELS AND CONSTRAINTS TO INPUT

The specialist must inform the EIA practitioenr as to the time and resources necessary for their involvement to ensure that their input is not undermined by low levels of confidence. Where little is known about the affected environment, and it is not possible to assign a significance rating to potential impacts *with high levels of confidence* from initial site visits and synthesis of available information, field surveys and/or seasonal studies may be needed. Where these studies cannot be carried out, the resultant decline in confidence in evaluating significance of impact must be clearly stated in the specialist report.

The level of confidence in predicting the impact can be described as:

- low, where there is little confidence in the prediction, due to inherent uncertainty about the likely response of the receiving ecosystem, or inadequate information;
- medium, where there is a moderate level of confidence in the prediction; or
- high, where the impact can be predicted with a high level of confidence.

10.7 RECOMMENDING MANAGEMENT ACTIONS

Through management actions the likelihood of negative impacts on the receiving environment and users and/or impact significance can be reduced. In some instances opportunities may exist to beneficially enhance a groundwater resource, for example through the increase of recharge to a stressed aquifer. Consensus on management actions should be secured through participation by all specialists contributing to the EIA process in related fields; i.e. the proposed management actions to address hydrogeological impacts should not compromise the recommendations proposed for other spheres of impact management. Management actions may take the form of avoidance, mitigation, compensation and offsets, rehabilitation or enhancement. Pre-requisites for successful management 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, a water resource and aquifer management plan should be developed, with approaches that:

- Structure abstraction within safe temporal and quantity ranges;
- Reduce water use;
- Minimise quality impacts; and
- Monitor impact indicators.

Such a water resource or aquifer specific management plan needs to comply with existing management plans. As part of the national approach to the management of water resources a water management framework is in place nationally (National Water Resources Strategy) and will be developed for each of the Water Management Areas (Catchment Management Strategies). A local management plan (e.g. aquifer management plan) may be in place for certain groundwater resources, where the need for such a plan has been identified by a national, regional or local management authority.

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 hydrogeologist. Preferably these management actions will have been agreed to by the project proponent in the course of formulating the management action.

10.8 IDENTIFYING THE BEST PRACTICABLE ENVIRONMENTAL OPTION

The selection of the Best Practicable Environmental Option (BPEO) from a groundwater perspective 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 EIA practitioner 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).

10.9 COMMUNICATING THE FINDINGS OF THE SPECIALIST INPUT

Specialist assessment reports should be concise and, as far as possible, avoid the use of technical terminology. 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.

In order to answer the “so what” question, specialist assessments provided during the impact assessment stage of the EIA process must include the following:

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 irreplaceable loss to the environment and/or society.
- A statement as to whether or not the proposed project would comply or be consistent with international conventions, treaties or protocols and with national, provincial and local legislation, policies and plans as applicable;
- The need, where relevant, for higher order assessment to address potentially significant cumulative effects, or issues which fall outside the scope of the EIA process;
- Statement of impact significance for each issue and alternative, before and after management, specifying whether thresholds of significance have been exceeded;
- Identification of beneficiaries and losers from the proposed development;
- Specification of key risks and uncertainties that may influence the impact assessment findings, including a clear statement of limitations and/or gaps in knowledge or information;
- The specialist’s assumptions and 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;
- References for all sources of information and/or data used.

11. SPECIALIST INPUT TO MONITORING PROGRAMMES

Monitoring can be defined as the measurement of one or more variables on a once-off or repeat basis. As part of the EIA process, the specialist should provide a preliminary monitoring programme where there are risks to groundwater. A key purpose of this monitoring is to verify that the impact assessment predictions are correct and that management is being applied effectively. The monitoring programme should aim to ensure that the conditions of the Record of Decision are satisfied (should the project receive environmental authorisation). Furthermore, monitoring is undertaken in order to ensure compliance with permits and to improve understanding of the hydrogeological system. This improves the level of information on the current status of the resource and improves the ability to predict future trends. Monitoring is used to detect warning signs that significance thresholds or environmental targets are being exceeded or will be exceeded, thereby enabling prompt remedial action and/or adaptive management through the life of the project to minimise negative effects.

Monitoring can be carried out ***prior to the construction phase*** (to establish a reliable baseline), or during the ***construction***, ***operational*** and/or ***decommissioning*** phases of a project, depending on the particular risks of significant impacts during these phases and/or the need to monitor compliance with requirements.

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.

Additional principles that specialists should incorporate into their proposed monitoring programme for different stages of the project cycle are as follows:

- Monitoring programmes should be agreed to by the proponent, and approved by the relevant environmental authority.
- Monitoring programmes should reflect environmental and aesthetic policies and guidelines applicable to the area, and incorporate the approval conditions of the project.
- Monitoring programmes should be drawn up and administered by a responsible, suitably qualified person, and enforced by an appropriate agency in order to be effective.
- Monitoring programmes should have clear objectives, and be practical and measurable.

The installation of groundwater monitoring systems requires specialized knowledge, and consultation with an appropriately qualified hydrogeologist is essential.

Monitoring programmes should include:

- The specific questions to be answered by monitoring;
- The frequency and/or time of monitoring;
- Responsibility for carrying out monitoring;
- Indicators to use in monitoring. The choice of indicators would depend on the particular impacts predicted, and the receiving environment. Since monitoring often has to consider natural fluxes as well as human-induced effects, complementary indicators may be appropriate in monitoring. Indicators should be specific, measurable, achievable, relevant and timely. Appropriate indicators that can be used to evaluate the effectiveness of management actions need to be identified. Where possible indicators should be aligned with key national and provincial indicators in order to track how the project contributes to, or undermines, the realization of local or regional sustainable development targets;
- Significance thresholds or thresholds of probable concern (Section 10.3), which would trigger remedial action or other intervention;
- Responsibility for analysing and evaluating the results of monitoring, and for implementing adaptive management in response;
- Reporting requirements.

Monitoring must be tied in to an effective decision-support system which triggers appropriate management changes depending on the results of monitoring, and clearly identifies who would be responsible for implementing that management.

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: REVIEW OF SPECIALIST INPUT

This part of the guideline identifies specific review criteria that can be used as a quality check.

12. SPECIFIC EVALUATION CRITERIA

Reference should be made to the *Guideline for the review of specialist input in EIA processes* for the generic review criteria that can be applied to any specialist input. This section only provides specific guidance on reviewing hydrogeological input.

When reviewing specialist hydrogeological reports it must be judged whether the approaches and methods used 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. 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.

Reviewers should be allowed to access numerical groundwater flow or mass transport models that had been developed during the specialist assessment, so that their validity and accuracy can be tested.

Other criteria to consider during the review:

- The specialist study should 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, 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 fieldwork undertaken and indicate linkages with other specialists.
- Where modeling is used assumptions and parameters must be specified.
- Key groundwater references should be cited.

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APPENDIX A: DEFINITIONS AND ACRONYMS

DEFINITIONS

Alluvial	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.
Aquifer	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.
Discharge area	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.
Dolines	Slowly subsiding land in karstic terrain that result from the compaction of unconsolidated debris due to being dewatered.
Fatal flaw	A fatal flaw is defined as an impact that could have a "no-go" implication for the project.
Groundwater	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.
Groundwater dependent Ecosystem	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).
Recharge areas	Areas of land that allow groundwater to be replenished through infiltration or seepage from precipitation or surface runoff.
Significant Water Resource	Although this term is widely used in the National Water Act (Act 36 of 1998), no definition is given. It is expected that Catchment Management Agencies will define the “significant water resources” in their Water Management Areas. This determination is likely to be based on consideration water resources’ relative and potential contribution to water supply needs, and may also include consideration of its contribution to ecosystems.
Sinkhole	The sudden development of a hole in the ground due to the collapse of rock material into a sollution cavern. This is the result of a lowered water table, which enables the erosion of debris material in the solution cavern and results in the successive downward collapse of the roof of the cavern, until the surface is reached.
Water resource	All water bodies in the hydrological cycle, including underground water.
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

BAT	Best available technology
BPEO	Best Practicable Environmental Option
DEA&DP	Department of Environmental Affairs and Development Planning
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
IDP	Integrated Development Plan
NEMA	National Environmental Management Act
NWA	National Water Act
RDM	Resource Directed Measures
RQO	Resource Quality Objectives
SDC	Source Directed Controls
SDF	Spatial Development Framework
TMG	Table Mountain Group
TOR	Terms of reference

UNITS

µg/L	Micrograms per liter
mg/L	Miligrams per liter
g/s	Grams per second
kg/s	Kilograms per second
m/s	Metres per second
L/s	Litres per second
m/day	Metres per day

APPENDIX B: MODEL TERMS OF REFERENCE FOR SPECIALIST INPUT

Terms of reference for specialist input should include the following elements:

1) Project description
2) Overview of EIA process and timeframes
3) Specific issues and information requirements to be addressed by the specialist
4) Key sources of information
5) Assumptions, limitations and uncertainties
6) Approach to be used
7) Requirements to attend meetings and workshops
8) Requirements to liaise and exchange information with other specialists
9) Protocol for stakeholder engagement
10) Report template providing structure of contents, formatting styles and standard terminology (including impact assessment criteria if applicable)
11) Clarification of review and integration process
12) Requirements for specialist sign off on the specialist report and inputs to integrated reports
13) Summary of tasks, deliverables and due dates
14) Budget and payment schedule, including penalty clause for late delivery
15) Confidentiality agreement
16) Protocols for communication with outside parties during the project

APPENDIX C: EXAMPLE HYDROCENSUS DATA SHEET

HYDROCENSUS DATA SHEET

SITE IDENTIFICATION :
POINT ID :

SITE OWNER PARTICULARS
Name :
Address :
Contact Tel. Numbers :

WELL TYPE :

WELL USE (& volume) :

WELL DIMENSIONS
Inside Diameter :
Total Depth :
Screen :

REST WATER LEVEL :

APPROXIMATE DISTANCES TO

POLLUTING ACTIVITIES
Septic Tank :
Waste Dumps :
Domestic Waste :
Animal Waste :
Vehicle sites :
Burial Sites :
Other :

DATE :

TIME :

COMMENTS

Data Collected By :