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Appendix I

4. Requirements for risk management

4.1 Generic requirements

4.1.1 General

4.1.1.1 Any organisation that

a) owns or is responsible for the maintenance of:

- buildings on dolomite land that is categorized for commercial and miscellaneous nonresidential usages C1 to C8 and low rise dwelling units RL 1 to 3 or high rise dwelling units RH 1 to RH3 in interconnected complexes in accordance with SANS 1936-1; or
- infrastructure on dolomite land; or
- mines on dolomite land or over dolomite;

b) develops parcels of dolomite land that are categorized as RN 1 to RN 3 in accordance with of SANS 1936-1 shall ensure that the requirement in 4.1.1.2 to 4.1.1.4 (inclusive) are complied with.

4.1.1.2 A systematic dolomite risk management programme (see figure 1) shall be established, documented, implemented and maintained in accordance with this part of SANS 1936 to ensure that.

a) the development risk associated with the formation of sinkholes or dolines in dolomite land remains an acceptable development risk

b) the current land usage does not compromise the future use of such land.

4.1.1.3 The performance of the risk management programme shall be regularly reported to the organization's management for review and performance improvement.

4.1.1.4 The occurrence of any sinkholes is dealt with in accordance with of 4.1.4.

4.1.1.5 The responsibility, authority and lines of reporting of all persons who undertake any of the following shall be clearly stated in the dolomite risk management strategy:

- a) identify, observe critically or record any incident or situation, which occurs in a particular place during a particular interval of time, that might impact upon the management of risk;
- b) initiate action to mitigate risk;
- c) initiate, recommend or suggest risk mitigation measures;
- d) direct, supervise or control activities associated with the treatment of risks until the level of risk define acceptable;
- e) check, record progress or verify the implementation of risk mitigation measures; and
- f) communicate and consult internally and externally regarding an identified source of potential harm or a situation with a potential to cause loss, as appropriate.

4.1.1.6 The organization shall identify resource requirements and provide suitable resources, including the assignment of suitably trained personnel to establish, document, implement and maintain the dolomite risk management strategy.

4.1.1.7 The organization shall identify the support or expertise available (or both) to assist those responsible for managing risks.

4.1.1.8 The organization's accounting officer or accounting authority shall ensure that a review of the dolomite risk management program is carried out

- a) internally at specified intervals not exceeding one year, and sufficient to ensure its continuing suitability and effectiveness in complying with the requirements of this part of SANS 1936, and the organization's stated risk management policy and objectives; and
- b) every five years by an independent competent person.

4.1.1.9 The organization shall retain records of the reviews undertaken in terms of 4.1.1.8.

NOTE 1 The appropriate design of any development is fundamental to ensuring short, medium and long-term safety and stability. Although appropriate design and development planning form the cornerstones of a sustainable development, water precautionary measures,

monitoring and maintenance should form part of ongoing risk management. South African research shows that 96 % of sinkholes and dolines that have occurred to date are man-induced, generated by ingress of water from leaking water-bearing infrastructure, poor storm-water management, etc. or due to artificial lowering of the level. Consequently, intervention through an integrated, comprehensive and pro-active dolomite risk management strategy, will serve to reduce the incidences of sinkhole formation and related losses and dangers, by reducing the likelihood of water gaining entry into the subsurface profile or uncontrolled de-watering of the dolomite aquifer occurring.

NOTE 2 The principle that is applied is that hazard plus dolomite risk management equals acceptable development risk. Failure to appropriately manage the risk can result in the occurrence of sinkholes and dolines.

NOTE 3 Sinkhole and doline events, apart from leading to loss of life or damage to property (or both), can trigger negative perceptions as the suddenness and scale is often alarming to workers and communities alike. This can have serious economic consequences. Dolomite risk management can take place at three levels, namely:

- a) local authority level;
- b) bulk service provider, utility organization and government department level; or
- c) individual development level.

The principles of dolomite risk management are essentially the same at all three levels, however specifics may differ. For example, a local authority is responsible for development planning and policies, whereas bulk service providers, such as waterboards, mainly consider the impact of their assets within their reserve on surrounding landowners and vice versa and homeowners are responsible for the maintenance and monitoring of their individual properties.

4.1.2 Risk evaluation criteria

The risk evaluation criteria shall include at least the following:

- a) the number of incidences of failure to comply with the requirements of the dolomite risk management strategy; and

b) the occurrence of sinkholes and dolines on the dolomite land covered by the dolomite risk management strategy.

NOTE The number of incidences of rejection of the dolomite risk management strategy by internal and external stakeholders in its implementation.

4.1.3 Measures for mitigating risk

4.1.3.1 Risk management strategies shall incorporate steps to mitigate risk before, during and after construction.

4.1.3.2 Ongoing water precautionary measures and the monitoring and maintenance of buildings or infrastructure (or both) shall form an integral part of any dolomite risk management program aimed at the mitigation of the negative impacts of urban development on the metastable conditions prevalent in dolomite land.

4.1.3.3 Mitigation measures shall, as appropriate, include:

- a) placing restrictions on land use and development densities;
- b) establishing requirements for the management of surface drainage;
- c) establishing requirements for the management and monitoring of groundwater levels;
- d) establishing requirements for improving the effectiveness of measures taken in accordance with SANS 1936-3 to mitigate risk;
- e) establishing requirements for the maintenance of water-bearing structures and services and measures taken in accordance with SANS 1936-3 to mitigate risk;
- f) identification of all the risks that are to be managed for the lifetime of the development;
and
- g) establishing suitable risk management controls, processes, procedures and measures to manage the identified risks.

4.1.4 Emergency reaction

Responsible persons shall be identified, notified in writing of their duties, and trained to respond to emergency situations as a result of sinkhole formation.

NOTE Responsible persons should know, for example, where to cut off the water supply if piping is ruptured as a result of the instability, and when to evacuate buildings.

4.1.5 Dealing with the occurrence of a sinkhole

4.1.5.1 A competent person shall be appointed to investigate the occurrence of the formation of any sinkhole or doline. Such investigation shall initially focus on the cause and sphere of influence of a sinkhole or doline so that the detailed investigation and subsequent rehabilitation can take place within 30 d of the event, unless the competent person recommends an extension for technical reasons.

NOTE For safety reasons there might be “a waiting period” require for the stabilization of the sinkhole base or side walls to ensure rehabilitation worker safety.

4.1.5.2 The accounting authority, developer or owner, as relevant, shall in the event of instability (severe cracking, doline or sinkhole formation) occurring within the jurisdiction of a local authority, report such occurrence as well as the remedial measures taken to such authority within 24 h of the event occurring.

4.1.5.3 The competent person shall

- a) recommend the method by which the sinkhole shall be rehabilitated;
- b) ensure that the rehabilitation intent is satisfied when the sinkhole within a development is repaired in accordance with the requirements of SANS 2001-BE4; and
- c) monitor the rehabilitated sinkhole for a period of time to ensure the quality of the repair.

4.2. Requirements for the preparation of a provisional dolomite risk management strategy (DRMS)

4.2.1 A competent person shall compile a provisional DRMS for the proposed development as part of the phase 2 detailed investigation conducted in accordance with the requirements of SANS 1936-2. Such a strategy shall address at least the following, as relevant:

- a) Risk and permissible land usages in accordance with the requirements of SANS 1936-2.

- b) Any restrictions that may be placed on developments for reasons of dolomite risk management, e.g. building line restrictions over rehabilitated sinkholes.
- c) Risk zonation in relation to a site development plan.
- d) Risk zonation in relation to the provision of infrastructure.
- e) All precautionary measures required to support development for designated and potential future land uses.
- f) Stormwater management requirements taking account of:
- topography of site (ground elevations);
 - location of stormwater pipes and canals;
 - points of discharge onto adjoining properties;
 - areas of anticipated poor drainage;
 - points of discharge into the local authority's stormwater system;
 - design specifications;
 - priority maintenance areas; and
 - linkages to and integration with regional stormwater management arrangements.
- g) The delineation of areas of restricted movement, such as high risk areas or existing or latent sinkholes.
- h) The identification and demarcation of monitoring areas in accordance with the monitoring area designations derived from tables 1 and 2, based on the inherent risk characterization and knowledge of problems or sensitive areas that might exist.
- i) Ground water monitoring requirements (see annex A).
- j) Inspection schedule of water-bearing services, stormwater drainage and structures, as relevant, indicating the nature of inspection and monitoring activities.

k) Maintenance programme which takes account of short, medium and long-term maintenance requirements in relation to the nature, age and type of services and structures, prioritizes maintenance tasks according to monitoring area designations and establishes the work and procedures associated with the following:

- routine service replacement;
- repair of service after damage;
- repair of service after instability;
- responsibilities for undertaking repairs and the like.

l) Emergency reaction programme which includes emergency procedures.

m) Recording of incidents, such as sinkhole or doline formation, damage and the actions taken.

n) Dolomite risk awareness programme.

o) Arrangements to lodge records relating to routine service replacement and the repair of service after damage or instability, ground subsidence events and structural damage in an accessible databank and to report such events to the council for Geoscience.

p) The identification of all owners of registered servitudes that wet services traverse and which are not maintained by the local authority.

Table 1 — Area designation components of the risk reduction measures

1	2
Area designation	Risk reduction measures
A	Visual inspections of ground, structures and above-ground infrastructure (e.g. roads, stormwater canals, ditches). Any evidence of cracking or ground settlement should immediately be reported and investigated.
B	Visual inspection of stormwater system for blockages.

	Any evidence of blockages should be reported and cleared immediately.
C	Testing of wet services for leaks. Any leaks to be reported and repaired immediately.
D	Monitoring of structures and ground levels. Any evidence of movement shall be reported and investigated.
E	Monitoring of the groundwater level. Evidence of lowering shall be reported to the Local Authority and the Department of Water Affairs. On de-watered compartments, such as on the Far West Rand, monitoring of levels need only commence once de-watering has ceased and level rise takes place.
<p>NOTE 1 The monitoring area designation is described in terms of the risk reduction measures and the frequency of activities as follows: Monitoring area designation = (area designation from table 1) frequency designation from table 2 e.g. (A)DAILY or (E)24</p> <p>NOTE 2 Measures associated with area designation A to C are intended to monitor, control and therefore prevent concentrated ingress of water.</p> <p>NOTE 3 Measure associated with area designation D aims to monitor the potential effects of triggering mechanisms (i.e. water ingress or level drawdown) by means of, for example, precision leveling.</p> <p>NOTE 4 Measure associated with area designation E is intended to monitor level drawdown. In the case of presently de-watered compartments, monitoring would intend to track the pace of de-watering and signify a time period during which related ground movement events could take place.</p>	

Table 2 — Frequency designations component of the monitoring area designation

1	2
Annotation	Frequency of activities
Daily	Activities to be undertaken daily.
Weekly	Activities to be undertaken weekly.

1	Activities to be undertaken once a month.
3	Activities to be undertaken quarterly.
6	Activities to be undertaken bi-annually.
12	Activities to be undertaken annually.
24	Activities to be undertaken once every two years.
0	NO ACTION REQUIRED
TBD	TO BE DETERMINED

NOTE 1 The monitoring area designation is described in terms of the risk reduction measures and the frequency of activities as follows:

Monitoring area designation = (area designation from table 1) frequency designation from table 2
e.g. (A)DAILY or (E)24

NOTE 2 Areas of no risk require no monitoring at all from a dolomite risk management perspective. For example areas on Witwatersrand Supergroup rocks may be designated as such, indicating that no action is required to lower the risk of dolomite related instability.

NOTE 3 Areas of low risk are assigned a low priority and require basic monitoring and maintenance activities at long intervals. For example areas on thick Karoo Supergroup rocks (in excess of 30 m) may be designated as (ABC)24(DE)0 indicating that all identified activities which control ingress water need only be undertaken once every two years with precision structure and ground leveling and monitoring not being required. However, where such rocks overlie dolomite residuum below the original level a designation of (ABC)24(E)1 might apply, indicating that activities which control the ingress of concentrated water remain necessary once every two years but level monitoring is critical and should be undertaken once a month.

Within an already de-watered compartment such monitoring should only commence once mining has ceased and the level is allowed to recover.

NOTE 4 Areas of high risk and therefore high priority in terms of monitoring and maintenance should receive attention more frequently. Such areas are typically characterized by:

- a) metastable subsurface conditions or latent sinkhole formation
- b) high risk conditions
- c) poor subsurface conditions e.g. cavitation, sample or air loss
- d) previous sinkhole or doline formation
- e) palaeo-sinkhole or palaeo-doline structures

- f) geological contact areas
- g) fault zones
- h) anticipated ground settlement
- i) ponding of water, etc.

For example, an area in which various sinkholes have already been reported and where the area is designated as high risk or even medium to high risk from an ingress of water perspective a (ABCD)3(E)0 or even (AB)daily(D)3(E)0 designation might apply, indicating the need to undertake activities controlling ingress of water quarterly, or even daily, with no action required to monitor the level.

NOTE 5 In areas where it was not possible to assign an inherent risk characterization at the time of reporting, a difficulty presents itself in terms of the determination of monitoring and frequency thereof. In such a case a designation (ABCDE) TBD should be assigned, indicating that these are yet to be determined as no data or insufficient data exist and the inherent risk classification is undetermined.

4.2.2 The monitoring area designations shall be clearly demarcated on the site development plan.

NOTE 1 The DRMS should be specific as by the time that a phase 2 investigation is undertaken, the development plan as well as the design of the services is complete. Only under exceptional circumstances may be DRMS be generic and present the principles only, for example commercial developments where individual properties are to be sold and developed at a later stage.

NOTE 2 Despite man's best effort to minimize the occurrence of instability, the occurrence of sinkholes, dolines and severe cracking of structures or of the ground surface cannot be totally precluded. Treatment of dolomite related instability consists of five components:

- a) emergency reaction;
- b) timeous reporting;
- c) investigation of incident;
- d) rehabilitation; and
- e) ongoing monitoring.

NOTE 3 A database, be it in electronic or hard copy form, is an important part of a DRMS as it allows for continuity of meaningful management. A database should contain the following:

- a) the dolomite stability and geotechnical report;
- b) old, yet relevant, reports and correspondence;
- c) a layout plan showing position of structures;
- d) a layout plan with location of services;
- e) the zonation map;
- f) stormwater plan;
- g) records of inspection and testing;
- h) records of maintenance (detailing when, how and what was undertaken);
- i) a register of damaged structures;
- j) a record of sinkhole and doline occurrences (with rehabilitation taken);
- k) monitoring areas;
- l) groundwater monitoring; and
- m) “no-go areas”.

NOTE 4 The database referred in to note 3 should include photographic records.

4.3 Specific requirements for local authorities

4.3.1 Regional dolomite risk management strategy

4.3.1.1 Every local authority with dolomite land in its area of jurisdiction shall establish and implement an active, regional DRMS that

- a) is contained in a policy signed off by the accounting officer and which is approved by the council of such authority;

b) addresses:

- development planning and policy;
- the risk management of all its buildings and infrastructure, located in both new and existing townships;

c) focuses on land usage, buildings and infrastructure owned by or under the control of the local authority and the day-to-day operations of the local authority that have a potential impact on dolomite risk;

d) facilitates the incorporation of any individual DRMS developed for new townships or developments (or both);

e) contains the local authority's policy and procedures on the enforcement of restrictions on developments in respect of complexes and individual erven, including restrictions relating to swimming pools and other water-retaining amenities;

f) devises measures to prevent land invasion on dolomite area designation of D4 sites;

g) establishes procedures for dealing with the situations where dolomite area designation D4 is invaded sites are;

h) permeates every decision-making level and decision-making process within the organizational structure of the local authority;

i) links the approval of new developments, where appropriate, to the submission and implementation of a DRMS and the compliance certification by competent persons responsible for applying any aspect of SANS 1936-2 or SANS 1936-3, as relevant, on all township and construction drawings; and

j) ensures that building control officers are notified of any specific construction requirements and precautionary measures relating to new and existing developments, as well as any restrictions relating to existing developments so that these requirements and measures may be effectively enforced.

4.3.1.2 The regional DRMS shall be informed and supported by:

- a) the creation of a database system that stores relevant geotechnical and infrastructural data within the local authority's area of jurisdiction, and which preferably can be manipulated in an interactive manner;
- b) the collating of all available dolomite risk hazard mapping in dolomite land falling within the local authority's area of jurisdiction;
- c) an understanding and documenting or recording of the geological, geohydrological and risk zonation of the dolomite land falling within the local authority's area of jurisdiction;
- d) the dolomite risk characterization of all developed areas in accordance with the requirements of SANS 1936-2.

NOTE A local authority's database system should comprise the following elements:

- a) the local authority area of jurisdiction;
- b) topo-cadastral information of the subregion;
- c) the simplified geology of the region;
- d) the gravity of the subregion (where available);
- e) the borehole and piezometer distribution;
- f) geohydrological basin or aquifers (where available);
- g) hydrological basins (where available);
- h) Records of sinkholes, dolines structures, slump structures, etc.;
- i) Provisional risk characterisation of available data;
- j) Town layout superimposed on the risk zonation;
- k) Infrastructure including bulk and internal reticulation imposed on the risk zonation;
- l) primary monitoring areas; and
- m) "No-go areas".

4.1.3.1 The regional DRMS shall, as necessary, be complimented by:

- a) an emergency reaction plan that is integrated with the local authority's disaster management plan;
- b) a value assessment of infrastructure in the context of risk and useful future lifespan;
- c) the implementation of projects to rehabilitate life-threatening open sinkholes;
- d) the introduction of a wet services master plan which defines the budget requirements of individually prioritized and targeted wet services upgrading projects in respect of dolomite land within a phased upgrading programme;
- e) the systematic investigation of wet services for current serviceability state and appropriateness of design in accordance with SANS 1936-1, in relation to the assigned dolomite area designations in SANS 1936-1;
- f) devising detailed upgrading programmes for services in key installations;
- g) devising and implementing of groundwater level monitoring programmes; and
- h) devising and implementing precise monitoring programmes in problematic areas determined to be priority monitoring areas including visual inspection and reporting programmes.

NOTE Managers of emergency services should be provided with information regarding dolomite land and briefed on the implications thereof. It is essential that these managers and emergency services personnel fully understand what a sinkhole is, the possible stages of development and how large an area to evacuate around a potential event.

4.3.2 Designation of a risk manager and officers

4.3.2.1 The accounting officer of the local authority shall designate, in writing, a risk manager to implement the local authority's risk management strategy and any other risk management officers that may be required to execute various tasks and report actions and outcomes, including the performance of maintenance checks on infrastructure and the detection and repair or rectification of leaking services.

NOTE These officers may represent various Departments that are impacted by and impact on development on dolomite land, e.g. Water and Sanitation, Roads and Stormwater, Town Planning, Building Inspectorate, Disaster Management, Treasury, etc.

4.3.2.2 Risk management officials shall submit written reports on their findings to the risk manager who will ensure that all reports are entered into a database.

4.3.2.3 The risk manager shall be responsible for ensuring that risk management officers are conversant with all relevant procedures including who to contact and when evacuation is necessary in the event of a sinkhole formation, understand their duties and what preventative and remedial actions need to be taken in any given circumstance.

4.3.3 Wet services in servitudes that are not maintained by the local authority

The local authority shall notify owners of registered servitudes transversed by wet services and which are not maintained by the local authority, of the risk such services pose to developments. The local authority shall issue such an owner with a specification which establishes monitoring and inspection requirements and shall take measures ensure that the specification is complied with.

4.3.4 Minimum maintenance requirements

4.3.4.1 Leaks in the sewer and water reticulation shall be repaired on a prioritized basis such that the response time for a repair team to reach the repair site and commence with the repair of any leak detected, measured from the time that a leak is reported, shall be not more than:

- a) 1 h for pipes of diameter of 75 mm and greater; and
- b) 1½ h for pipe of diameter less than 75 mm.

4.3.4.2 Sewer mains shall be checked for watertightness by means of an air test at intervals not exceeding two years and repairs shall be undertaken where necessary.

4.3.4.3 The stormwater systems shall be inspected for blockages and leaks at intervals not exceeding one year and repairs or cleaning (or both) shall be undertaken where required.

4.3.4.4 All bulk services shall be inspected for watertightness or blockages at intervals not exceeding one year and cleared or repaired (or both) where required.

4.3.4.5 Officials who receive and log reports from the public on disruptions in services and the like shall be provided with contingency plans including maps showing the monitoring areas, and shall be briefed on the implications of leaks and the like in these areas. Special reporting procedures shall be established to ensure that maintenance teams are promptly advised of leaks, and the like in dolomite areas.

4.3.5 Requirements for building control officers

Building control officers shall, once every two years, visually inspect areas to ensure that water is not damming up on properties.

4.3.6 Notification of residents living on dolomite land

4.3.6.1 The local authority shall inform residents of dwelling houses categorized as RN 1 to RN 4 in accordance with of SANS 1936-1 every two years in writing of the risks and their responsibilities in relation to

- a) the prompt reporting of leaks and any subsidence;
- b) refraining from making illegal connections and proceeding with the erection of new buildings and the installation of swimming pools without local authority permission;
- c) ensuring that water does not dam up on their properties.

4.3.6.2 The local authority shall fully brief the councillors whose wards fall within dolomite land, as well as leaders of community structures and organisations whose constituents reside on such land, of the potential risks and maintenance requirements for services in these areas and the necessity to report any leakage, blockages or ponding of water in these areas to designated council officials.

4.4 Specific requirements for new developments

4.4.1 The DRMS associated with a new development shall be prepared by a competent person who shall base such strategy on the generic risk management strategy contained in the geotechnical report prepared in accordance with the requirements of SANS 1936-2. Such a strategy shall record the names, professional registration numbers and contact particulars of all competent persons appointed to ensure that the development proceeds strictly in

accordance with the requirements of SANS 1936-1 and that suitable construction procedures, methods, techniques and controls are exercised during construction.

4.4.2 The DRMS shall be reviewed and, if necessary, modified during and after construction.

4.4.3 The developer shall remain responsible for the implementation of the management plan until such time as such responsibility can be transferred to and accepted in writing by the owner of the development or the accounting authority and, in the case of municipal services, to the local authority (or both).

4.5 Specific requirements for interconnected complexes

4.5.1 The accounting authority shall ensure that residents are aware of the risks associated with living on dolomite land with particular reference to the impact of concentrated infiltration of surface water on the stability of the area. New residents shall be briefed on such risks within one month of moving into a complex.

4.5.2 The body corporate or any other organization that acts as a body corporate shall be responsible for implementing and undertaking a DRMS in their area of responsibility. The local authority shall be annually informed of the status of risk management in the complex.