GUIDELINES FOR THE INTEGRATED PLANNING AND DESIGN OF UNDERGROUND COAL MINES

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Project No : COL 814
Date : November 2001

i) Foreword

Mine planning and design involves the compilation and integration of all relevant geological, geotechnical, mining, engineering and economic data into a single document to define and describe the exploitation strategy for a particular mineral or coal deposit within acknowledged and identified legal, financial and regulatory requirements and constraints. Mine planning and design is an iterative and continuous process which starts at the conceptual stages of a new mining project, when the need for such a mining venture has been identified, and is only completed at the end of the mine’s life when successful mine closure has been achieved.

The primary objective of any mining plan should be the effective integration of all the activities involved in the overall mining process that will meet predetermined targets with regard to health, safety, environmental, productivity and unit cost criteria.

The South African coal mining industry and its stakeholders acknowledge that effective mine planning and design forms the basis of any successful mining operation in meeting its objectives, both in terms of physical and financial performances, as well as in fulfilling its social and environmental obligations. A guideline document to assist present and future mine owners, employers and managers in preparing mining plans and operational strategies in a structured and systematic manner was seen as a way of further enhancing the safety and health standards on all South African underground coal mining operations.

This guideline document has been compiled with the assistance of many experienced mining personnel and is based on an extensive literature review and benchmarking of national and international “best practices” related to underground coal mine planning and design principles.

It is the author’s wish that this guideline document will contribute to the overall objectives of the South African mining industry with regard to safety, health, environmental, productivity and unit cost performance strategies.

ii) Introduction

- The goal of the planning and design of underground coal mining operations is a strategy for designing an integrated mineral exploitation system that will ensure that coal is extracted and prepared at a desired market specification, at a minimum unit cost, within acknowledged safety, health, social, legal and regulatory constraints.
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- A large number of specific engineering, scientific and economic disciplines contribute interactively to the overall mine planning and design process, thus making it a true multi-disciplinary activity.

Given the complexity of the mineral excavation process, ***planning*** assumes the correct selection, co-ordinated operation and integration of all subsystems, whereas ***design*** applies to the traditionally held engineering design of subsystems. In other words, planning in the context of this guideline document refers to the consideration of the interrelationships that exist in the design processes and assures that the subsystems of all underground coal mining operations are in harmony with the overall mine design strategy. Planning therefore identifies key interrelationships that must be considered in the design stage. The design stage is that point where active system structures are developed and alternative options evaluated. An optimum design for any mining system is one that has considered the effects of each subsystem on all others and optimises the objectives of the whole system.

The planning and design process throughout the life cycle of any mining project typically consists of the following five unique and identifiable phases, as described in **PART A** of this guideline document:

- Phase 1: project data collection and investigations
- Phase 2: evaluation, planning and design
- Phase 3: construction and mine establishment
- Phase 4: mining operations
- Phase 5: mine decommissioning and closure.

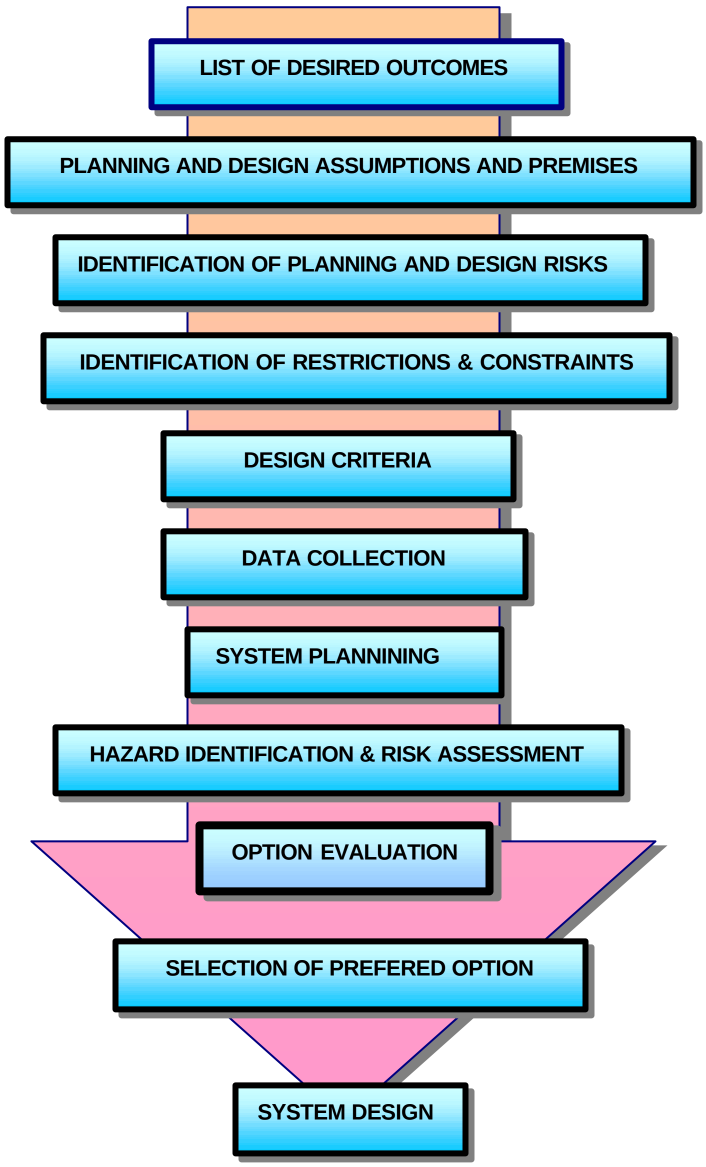
} **PART A**

The planning and design process associated with each of these phases consists of the following typical elements and is detailed in **PART 'B'** of this guideline document:

- identification of desired outcomes
- statement of all planning and design assumptions and premises
- identification of planning and design risks
- identification of planning and design restrictions and constraints
- statement of planning and design criteria to be used
- data collection
- system planning
- hazard identification and risk assessment
- evaluation of options
- identification of the best or preferred options
- system design.

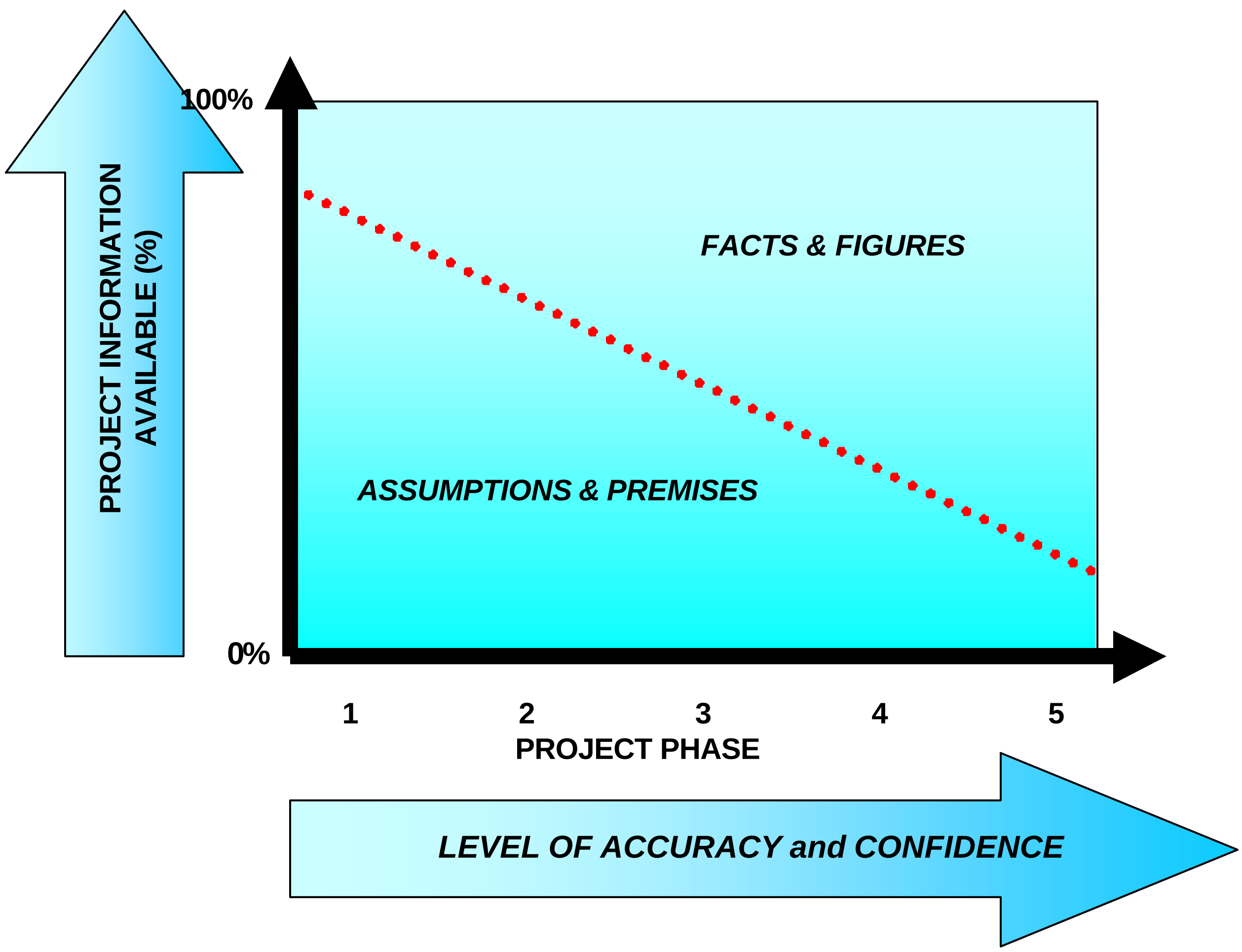
PART B

THE PLANNING AND DESIGN PROCESS



During the initial phases of any mine planning and design study, a number of assumptions and premises have to be made and accepted. As the planning and design process progresses from one phase to another, the amount of relevant data available for evaluation purposes increases, resulting in a corresponding increase in the confidence and accuracy level of the relevant mining plan.

INCREASED ACCURACY AND CONFIDENCE WITH INCREASED DATA



iii) Objectives

This guideline document aims to provide a single document that will:

a) assist the employer in meeting his/her responsibilities in terms of Sections 2.(1)(a) and 2.(1)(b) of the Mine Health and Safety Act, 1996 (Act 29 of 1996) by ensuring that *all* underground coal mining operations are, as far as reasonably practicable, designed, constructed and equipped to provide conditions for safe operation and a healthy working environment

and

- ensure, as far as reasonably practicable, that the mine is commissioned, operated, maintained and decommissioned in such a way that employees can perform their work without endangering the health and safety of themselves or any other person
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b) assist the employer in identifying the occupational health and safety hazards and risks associated with each subsystem of the mine planning and design process in accordance with Section 11 of the Mine Health and Safety Act, 1996 (Act 29 of 1996) and propose possible methods whereby the significant risks can be eliminated, controlled at source, minimised or managed through effective monitoring programmes

c) incorporate the findings of relevant Health and Safety Research Projects, as published by SIMRAC, into the mine planning and design process

d) identify the relevant statutory regulations, standards and mandatory Codes of Practice that impact on the mine planning and design process

e) identify the required minimum standards for Public Reporting on coal exploration results

f) ensure the effective integration of all mining, engineering, scientific and economic disciplines required in the mine planning and design process

g) serve as a checklist of all aspects to be addressed during the mine planning and design stages of any underground coal mining operation.

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PART A
The systematic planning and design process for underground coal mining operations – from inception to closure

1. PHASE 1: INVESTIGATIVE STUDIES

1.1 Market analysis

The mine planning and design process for any new coal mining operation commences with the identification and analysis of specific market needs and requirements. These needs and requirements may be the result of increased export capacities, additional power station demand, shortages within specific sectors of the domestic coal market, or the replacement of older mines that have reached the end of their economic lives.

- Whatever the reason, the following market-related factors form the basis of any coal mine planning and design studies:
- tonnage profile to be satisfied
- specific coal quality requirements
- product size distribution required
- unit costs at which the product can be sold.

1.2 Geological target area identification

A *geological target generation study* is the initial geological evaluation aimed at identifying a coal resource or coal reserve that could possibly satisfy the potential markets identified under Subsection 1.1 above. This part of the investigative phase consists of a desktop study, including a literature review of all available data relative to the area under consideration. Limited fieldwork, where applicable, is recommended for the evaluation of a coal occurrence that may be suitable for the establishment of a mining project.

The objective of the initial geological study is to identify a particular coal deposit or a number of coal deposits, with sufficient physical and coal quality continuation, that will satisfy the identified market requirements.

1.2.1 Literature survey

Before any exploration work is started, a review of all the available information related to the proposed exploration area is essential. This survey will be required in order to:

- establish the geological setting of the area
- identify any previous geological exploration work and mining activities performed in the area
- collate all available information on coal quality
- establish surface and mineral ownership and title
- delineate cultural and topographical features, including survey control data
- evaluate the regional infrastructure and development
- evaluate the potential environmental impacts of any new mining project.

Included in the literature survey is the preparation of base maps, which should be generated at a scale appropriate to the level of detail sought.

1.2.2 Regional mapping

The literature survey will assist in defining the level of detail required in any future field mapping to be done. In some areas, regional mapping may be useful during the reconnaissance phase and provide the framework for the successive evaluation phases. Field mapping may include the tracing of marker beds, the measuring of stratigraphic sections and the location of major faults, igneous intrusions and any other features that may affect the continuity of coal seams.

1.2.3 Remote surveys

Satellite remote sensing and aerial photography provide assistance with the interpretation of topographical, geological, structural and environmental aspects. Airborne magnetic surveys and electromagnetic surveys may be necessary for the delineation of faults, igneous intrusions and depth of weathering. Pre-survey or post-survey ground geophysical follow-up work may be required to determine the expected geophysical responses and/or to evaluate any anomalies detected.

1.2.4 Surface surveys

Topographical maps can be used effectively during the initial stages of the project to establish property boundaries, cultural features and topographic control.

However, land surveying may also be required to locate specific property boundaries, lease boundaries and borehole sites.

It is important to set up the project survey datum relative to the national reference grid early in the exploration programme in order to reduce or eliminate any surface or land survey discrepancies that may appear later in the mine planning and design programme. It is essential that all borehole sites be accurately co-ordinated with respect to the project survey datum and the national reference grid.

1.2.5 Legal status of the target area

In terms of Section 5 of the Minerals Act, 1991 (Act 50 of 1991), only the holder of the right to any mineral, or, as the case may be, any person who has acquired the consent of such holder in accordance with Section 6 (1) (b) shall have the right to enter upon such land for purposes of prospecting.

The literature search should therefore include a deed search to identify the status of surface and mineral right holdings over the geological target area. Special attention must be paid to conditions specified in the title deeds with respect to:

- surface freehold
- surface rights
- coal and/or mineral rights
- notices in terms of Section 170 of the Mineral Rights Act in respect of coking coal
- leasehold of coal and/or other coal-related minerals i.e. fireclay, oil shales, etc.
- ancillary rights forthcoming from various title deeds (e.g. deeds of cession), etc.
- registered servitudes (e.g. ESKOM power lines and substations, railway lines and stations, roads, buildings and trading sites, pipelines, oil containers, etc.).

1.2.6 Environmental Impact Assessment

Any new mine will have a significant social, environmental and economic effect on the immediate surrounding area. To avoid any possible future litigation or disapproval for the project, it is recommended that a preliminary environmental impact assessment be conducted before embarking on a major exploration campaign.

The objectives of this preliminary environmental impact assessment will be to:

i. identify the pre-mining environmental conditions in and around the proposed prospecting area with respect to:
   - topography
   - soil types
   - land capability
   - land use
   - natural vegetation and plant life
   - animal life
   - surface water
   - other water sources
   - air quality
   - noise levels
   - sites of archaeological and cultural interest
   - sensitive landscapes
   - visual aspects
   - regional socio-economic structures
   - interested and affected parties.

ii. determine the potential impact of the new mining project on the items listed above

iii. identify methods and procedures that could be introduced to eliminate, control or minimise the impacts identified

iv. determine the post-mining conditions after mine closure

v. identify the potential environmental risks associated with mining on the proposed target area.

If the identified risks are within acceptable limits, the mine planning and design process can progress to the next stage.

1.3 Conceptual economic study

Once the initial target area identification and preliminary environmental impact assessment have been completed, a conceptual economic study of the proposed project area must be done. This is typically a desktop evaluation of the coal resource associated with the project target area and can be used as a preliminary comparison of alternatives, or a decision to reject or shelve the project. The conceptual economic study is used primarily to justify and motivate the need for further studies, such as additional geological exploration and drilling, laboratory test work, market research or more detailed engineering investigations. It will give a preliminary indication of the order of magnitude of the capital costs, operating costs, expected revenue and profitability of the identified area.

SABS 0320: 2000 defines a '**coal resource'** as an occurrence of coal of economic interest in the Earth's crust in such a form, quality and quantity that there are reasonable and realistic prospects for eventual economic extraction within a time period of 50 years. The location, quantity, coal quality, continuity and geological characteristics of a coal resource are known, estimated or interpreted from specific geological evidence and knowledge, or interpreted from a well-constrained and portrayed geological model. Coal resources are subdivided, in order of increasing geological confidence and in respect of geoscientific evidence, into Reconnaissance, Inferred, Indicated and Measured categories.

It is recommended that a minimum seam thickness of 0,5 metres be used to define the maximum lateral extent of a coal resource.

A coal resource shall include the full coal seam above the minimum thickness cut-off and coal quality cut-off, as defined by the competent person. It is permissible to subdivide the full coal seam into defined subseams and quote them separately, such that the sum of the individual subseam coal resources equals the full seam coal resource. The coal resource can be subdivided into different thickness and depth categories. The basis used for the reporting of a coal resource must be clearly stated (e.g. gross in situ, etc.).

Since limited information is available on the target area at this stage of the project evaluation programme, the conceptual economic study is generally based on a large number of assumptions, premises and/or information extrapolated from neighbouring mines or mines with similar geological and operating conditions. The estimation accuracy of a conceptual economic study will seldom be better than plus or minus 30%. **THE RESULTS OF A CONCEPTUAL ECONOMIC STUDY SHOULD NOT BE USED FOR PUBLIC REPORTING PURPOSES.**

1.4 Prospecting permit

If the conceptual economic study indicates that the proposed project area warrants further geological exploration and test work, a prospecting permit in terms of Sections 6 and 8 of the Minerals Act, 1991 (Act 50 of 1991) must first be obtained from the Director, Mineral Development, Department of Minerals and Energy. Each application for permission to prospect must be supported and accompanied by the following documentation:

- a certified copy of the title deed and proof of mineral rights holding, or
- written consent from the mineral right holder, with special reference to the mineral that will be prospected for and the time period for which consent is given

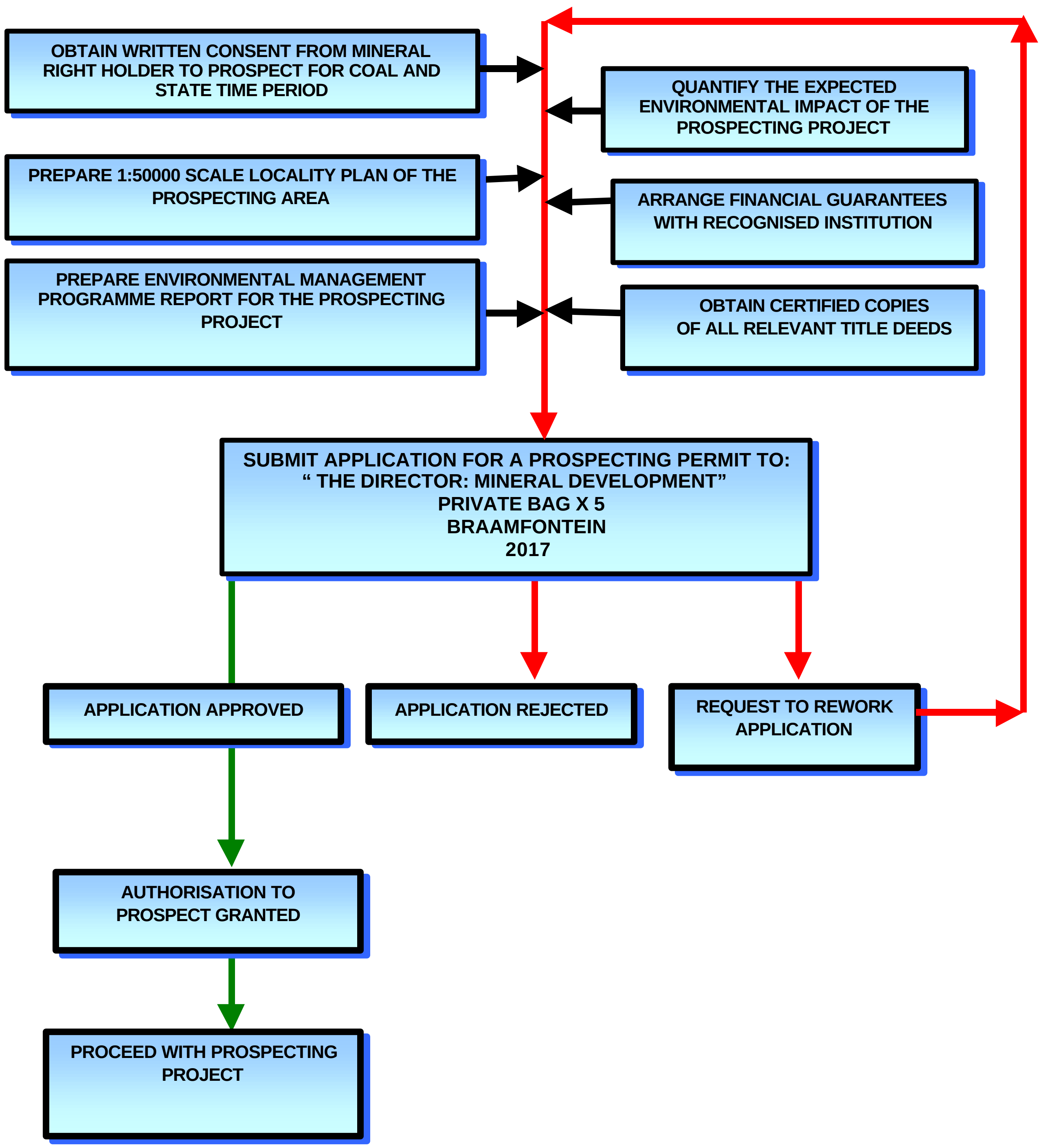
- a 1:50 000 topocadastral plan on which the locality of the prospecting area is clearly and accurately indicated
- an Environmental Management Programme Report (EMPR) prepared for the exploration programme in accordance with the guidelines given in the *Aide–Mémoire for the preparation of environmental management programme reports for prospecting and mining,* issued by the Department of Minerals and Energy. The expected environmental impacts of the exploration programme must be assessed and a clear indication must be given of how these impacts will be neutralised, mitigated or acceptably managed.

Prior to the approval of the Environmental Management Programme (EMPR) and the granting of a prospecting permit, financial guarantees in the form of:

- a cash deposit with the Director, Mineral Development and/or
- a trust fund and/or
- a guarantee from a recognised bank or other acceptable financial institution

must be in place in order to ensure that funds will be available at the end of the exploration programme to rehabilitate that portion of the prospecting area that has not been rehabilitated in accordance with the approved EMPR by the prospecting permit holder involved.

APPLICATION FOR A PROSPECTING PERMIT



1.5 Outcomes of Phase 1

The primary outcomes of Phase 1 of the mine planning and design process will be:

- the identification of a specific market sector to be satisfied and the relevant product specifications to be met
- the identification of a potential geological target area that could be developed into a successful mining project
- the granting of permission to undertake further exploration and geological investigations on the selected target area
- a decision by the owner or project developer to proceed to the next phase of the project or to abandon the project.

1.6 Public reporting

The results of a conceptual economic study should only be used by the owner or project developer for the purposes of making a decision on whether or not further work on the project is warranted. The results of a conceptual study cannot be used for public reporting purposes.

2 PHASE 2: EVALUATION, PLANNING AND DESIGN

2.1 Introduction

The objective of the evaluation, planning and design phase of the new mining project is to systematically evaluate the prospecting area with regard to the coal resources/coal reserves available, and the technical and economic viability of the proposed mining project. As the mining project progresses from the initial exploration and conceptual economic evaluation stage to the time when a management decision is made to develop and mine a specific coal deposit, a number of studies will have to be conducted on the property. Each of these will be based on increasing amounts of data, will require increasing amounts of time to prepare, and will have increasing degrees of accuracy. The following specific studies are identified and prescribed in the *SAMREC Code* and *The South African Guide to the Systematic Evaluation of Coal Resources and Reserves* (SABS 0320: 2000):

- pre-feasibility study
- feasibility study
- bankable document.

Although there is no prescribed format for reporting the results of any of these studies, they must be constructed so as to support a continuum of decisions on whether to proceed to the next phase of the project or not. To meet this requirement, the following information and data will typically be included in all of the studies listed above:

- **Project Description**: geographical area, existing access routes, topography, climate, project history, concessionary terms, schedule for the development of the mine and any processing facilities.
- **Geology**: regional geology, detailed description of the project area, preliminary reserve calculations, plans for detailed target evaluation.
- **Mining**: geometry of the coal deposit, proposed mining plan (including alternatives considered), required plant and equipment.
- **Processing**: technical description of coal washing and processing facilities.
- **Other Operating Needs**: availability of energy, water, spare parts and equipment (fuel, explosives, replacement parts, etc.).
- **Transportation**: description of the additional and necessary transportation facilities (roads, airstrips, bridges, harbours, railway lines etc.).

- **Towns and Related Facilities**: housing for employees, schools, medical facilities, company offices, other buildings and infrastructure.
- **Labour Requirements**: estimates of work force requirements broken down according to qualifications, skills and local availability.
- **Environmental Protection**: plans to reduce or minimise environmental damage, description of relevant environmental legislation.
- **Legal Considerations**: review of mining laws, taxation, foreign-investment regulations, political factors and other legal aspects affecting project viability.
- **Economic Analysis**: cost estimates for plant and equipment, infrastructure, materials, labour, other factors: e.g. market analysis, including production, consumption and price formulation for the relevant coal products; revenue forecasts based on expected production and coal prices; cash flow and net present value analysis; sensitivity analysis.

2.2 Pre-feasibility study

Definition: *A pre-feasibility study is the first evaluation, planning and design study following a successful geological exploration campaign. It provides a preliminary assessment of the economic viability of a coal deposit and forms the basis for justifying further investigations. It summarises all geological, mining, coal processing, engineering, environmental, marketing, legal and economic information accumulated on the project*. (The South African Guide to the Systematic Evaluation of Coal Resources and Reserves (SABS 0320: 2000) and the SAMREC Code.)

Objectives: The objectives of a pre-feasibility study are to:

- prepare suitable and detailed comparison of alternatives
- provide meaningful economic evaluations of the proposed mining project
- define areas in need of further detailed investigations
- assist with the decision to proceed with detailed environmental studies
- assist in defining the scope of the feasibility study or the shelving/rejection of a project.

Input requirements:

i. **Geology**: In terms of the *SAMREC Code* and *The South African Guide to the Systematic Evaluation of Coal Resources and Coal Reserves* (SABS 0320:2000), the pre-feasibility study should at least be based on indicated coal resources. "Indicated coal resources " can be defined as that part of an in situ coal resource for which tonnage, densities, shape, physical characteristics and coal quality can be estimated with a moderate level of confidence. It is based on exploration, sampling and testing information gathered by means of appropriate techniques from locations such as outcrops, trenches, pits, workings and boreholes. To be classified as an “indicated coal resource”, the borehole density must be at least:

- four boreholes per 100 ha (approximately 500 metre spacing) for multiple-seam deposit types, or
- one cored borehole with quality data per 100 ha (approximately 1 000 metre spacing) for thick interbedded-seam deposit types.

Although in most situations the minimum borehole density will allow a reasonable estimate of the coal resource with a moderate level of confidence, this will not necessarily hold true for structurally and sedimentologically complex areas and areas with significant variability in the coal quality.

The physical and coal quality points of observation data must be evaluated using a three-dimensional electronic model of the coal deposit. Indicative mining limits and coal quality trends must be delineated. The potential impact of sedimentological variations, structural disturbances and intrusive activity must be evaluated. Geophysical investigations relevant to the particular coal deposit can be undertaken. Indicative geotechnical, geohydrological and environmental assessments must be made. Depending on the top size of the product, large-diameter drilling may be necessary to evaluate product quality, coal washing, product yields, preliminary coal processing plant design and preliminary coal utilisation aspects.

ii. **Mining:** The primary objectives of the mining plan include but are not limited to:

- delineate the potential mining limits
- select the preferred mining horizon
- select the preferred mining method
- prepare preliminary mining plans and underground layouts based on the geological data available
- identify possible positions where the shaft and/or shaft systems can be located
- identify the appropriate shaft types and shaft dimensions relevant to the underground layouts, mining plans and production requirements
- determine the type and number of underground equipment needed to meet the production requirements and targets
- determine the type and extent of underground and surface services required to effectively support the mining operation

- determine the labour and training requirements to ensure an effective and safe mining operation
- identify possible hazards and the associated risks that could impact on the health and safety of employees, as well as the technical and economic integrity of the mining operation
- identify all aspects of the mining operation that could have an effect on the environment and list the methods that will be introduced to minimise and/or negate these negative effects
- prepare mining schedules for the life of the mine, or 20 years, whichever is the minimum, in increments of five years
- calculate the estimated operating and capital costs associated with the proposed mining plan
- identify areas and aspects that need further and more detailed investigations.

Outcomes:

i. The outcome of a pre-feasibility study will determine whether the coal resource can be reclassified as a probable coal reserve.

ii. The pre-feasibility study is used for ranking the coal resource in the market place. If for any reason the project is marginal, further assessment may be postponed or the project could be rejected.

iii. A pre-feasibility study should be carried out before a feasibility study to allow the preliminary economic feasibility of the project to be determined and to assist in defining the scope of the feasibility study or, alternatively, as a motivation for the shelving or rejection of a project.

iv. The pre-feasibility study will identify specific areas that need to be further investigated for geological modelling, mine planning and design, and health, safety and environmental reasons.

v. The market status evaluation is based on the product type, geographical location and approximate costs of standard mining methods and transport systems. Market prices will partly determine the minimum annual tonnage required, plus the maximum transport distance that can be allowed for the project to be viable.

vi. As a result of the relatively low level of accuracy of the input data used and the general lack of detailed design drawings associated with pre-feasibility studies, the estimation accuracy will generally be in the range 15% to 25%.

2.3 Feasibility study

Definition: *A feasibility study assesses in detail the technical soundness and economic viability of a mining project (SABS 0320: 2000). It is seldom undertaken unless there is a reasonable assurance that the proposal is viable and represents a detailed economic evaluation that serves as a basis for the investment decision and allows for the preparation of a bankable document for project financing. The study constitutes an audit of all geological, geotechnical, mining, engineering, coal processing, environmental, marketing, legal and economic information accumulated on the project. The feasibility study provides a basis for evaluating the potential viability of the project and serves as a reference for Board approval for a project to proceed*. (SAMREC Code and SABS 0320:2000.)

Objectives: The objectives of the feasibility study include, but are not limited to:

- assess in detail the technical soundness and economic viability of a mining project
- serve as the basis for the investment decision
- serve as the basis for the preparation of a bankable document to obtain project financing
- provide detailed design specifications for the mine establishment and construction phase
- serve as the basis for applying for mining authorisation and approval of the Environmental Management Programme Report (EMPR).

Input requirements:

i. Geology

For the geological investigations that form part of the feasibility study, the cored borehole spacing must be reduced to a minimum of eight cored boreholes per 100 hectares (approximately 350 metre spacing) for all coal deposit types in order to define the coal deposit as a measured or indicated coal resource. The feasibility study may NOT be undertaken on inferred coal resources. A "measured coal resource" is that part of an in situ coal resource for which tonnage, densities, shape, physical characteristics and coal quality can be estimated with a high level of confidence. It is based on detailed and reliable exploration, sampling and testing information gathered by means of appropriate techniques from locations such as outcrops, trenches, pits, workings and boreholes. The locations are spaced closely enough to confirm physical and coal quality continuity.

The physical point of observation data and the coal quality point of observation data must have been evaluated using a three-dimensional computer model of the coal deposit. Mining limits and coal quality trends must be delineated.

Although the minimum borehole density will allow a reasonable estimate of the coal resource to be made with a high level of confidence in most situations, this will not necessarily hold true for structurally and sedimentologically complex areas with significant variability in the coal quality. The competent person must make the judgement as to whether the physical and coal quality continuity is confirmed, and must state the basis of the decision in the feasibility report. Detailed geophysical investigations relevant to the particular deposit should be undertaken. Complete geotechnical, geohydrological and environmental assessments must be made.

Depending on the top size of the product, large-diameter drilling may be necessary to confirm the product quality, coal washability, product yields, detailed coal processing plant design and coal utilisation aspects.

The level of measured coal resources should cover at least the first five-year mining window or the payback period, whichever is the longer.

ii. Mining

The objectives of the mining section of the feasibility study include, but are not limited to:

- define the mining limits
- define the selected mining horizons
- define the selected mining method for each geotechnical area based on known geological hazards, structures, jointing and changes in rock type and strength, or any factor that may impact on mining
- prepare and present detailed mining plans and underground layouts for each geotechnical area based on known geological hazards, structures, jointing and changes in rock type and strength, or any other factor that may impact on mining
- describe the regional, panel, and roadway support strategies to be followed during the mining process for each identified geotechnical area
- prepare and provide detailed design parameters for the shaft and/or shaft systems with respect to location, type, layout , equipment and dimensions;
- prepare and provide detailed specifications and design criteria for all underground equipment to be used, with special reference to systems and procedures that will ensure the safety and health of all employees involved in the mining processes

- prepare and provide detailed specifications and design criteria for all underground and surface services required to ensure an effective, safe and healthy mining environment
- determine the labour and training requirements to ensure an effective, safe and healthy mining operation
- identify possible hazards and the associated risks that could have an effect on the health and safety of employees, as well as the technical and financial integrity of the mining operation. Details of the methods and/or procedures that will be introduced to eliminate, reduce or control the identified hazards and risks must be stated
- provide details of the environmental management programme, including financial provisions, that will be introduced during the life cycle of the mining operation to meet all regulatory environmental requirements
- prepare mining schedules for the life of the mine, or 20 years, whichever is the minimum. These schedules should include details of the yearly increments of the first five-year development plan, with the remaining life in increments of five years
- prepare detailed operating and capital cost estimates associated with the proposed mining plan.

Outcomes:

The outcome of a feasibility study will determine whether the coal resource can be classified as a coal reserve.

A detailed coal quality assessment of a bulk sample is recommended for product evaluation and coal utilisation test work. Trial mining operations and/or a pilot plant study may be required, especially if a new product/area is being proposed. The estimation accuracy of a feasibility study will usually be in the range 10% to 15%.

2.4 Bankable document

Definition: *A 'bankable document' is a public report prepared for the purposes of informing investors or potential investors and their advisers or financial institutions on the outcomes and results of a company's exploration results and the resultant feasibility study. This document is prepared and presented for the purpose of arranging project finance either by means of a cash loan or listing on a national or international stock exchange.*

For the purposes of ensuring that the process of reporting for mineral companies is consistent with internationally accepted standards, the main principles governing the operation and application of the SAMREC Code are: transparency, materiality and competence.

- **Transparency** requires that the reader of a bankable document is provided with sufficient, clear and unambiguous information to understand the report and is not misled.
- **Materiality** requires that a bankable document contains all the information that decision-makers, investors and their professional advisers would reasonably require, and reasonably expect to find, in the report, for the purpose of making a reasoned and balanced judgement regarding the mineralisation being reported, mineability and the risks associated therewith.
- **Competence** requires that the bankable document be based on the work of a suitably qualified, responsible and experienced person who is subject to an enforceable professional code of ethics.

Taking into account the requirements of the SAMREC Code, SABS 0320:2000 and various internationally accepted standards, Appendix A provides a guideline for the general layout and composition of a feasibility study and/or a bankable document.

2.5 Mining authorisation

Prior to the establishment of a mine or the commencement of any mining activities, authorisation in terms of Sections 9 and 10 of the Minerals Act, 1991 (Act 50 of 1991) must be obtained from the Director, Mineral Development, Department of Minerals and Energy. Such mining authorisation (either a permit or a licence) will only be granted on condition that:

(a) The applicant is in possession of an approved Environmental Management Programme (EMP)

(b) The Director, Mineral Development, is satisfied:

- with the manner in which and scale on which the applicant intends to mine

- the manner in which the applicant intends to rehabilitate disturbances
- that the applicant has the ability and can make the necessary provision to mine optimally and safely, and to rehabilitate any disturbances
- with the extent of mineralisation of the land, water or tailings.

Each application for mining authorisation must be supported and accompanied by the following documentation:

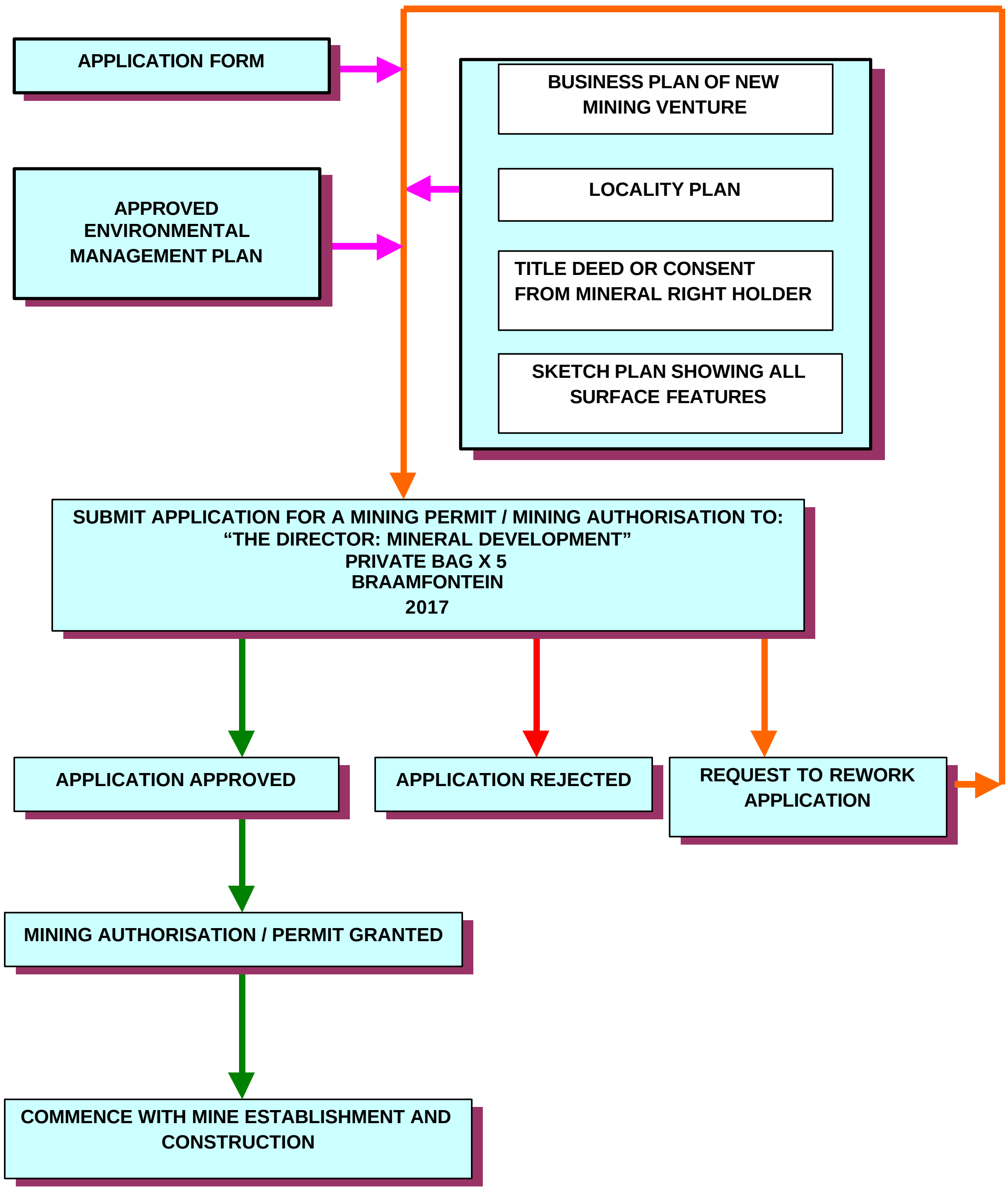
- a completed application form and the prescribed application fee
- a certified copy of the title deed and proof of mineral right holding

  or
- written consent from the mineral right holder with special reference to the mineral to be mined and the time period
- a locality plan (topocadastral plan on a scale of 1:50 000) on which the proposed mining area is clearly and accurately indicated
- a sketch plan which indicates the following features:
  - a north point
  - suitable scale (between 1:500 and 1: 10 000)
  - property boundaries
  - property descriptions
  - location of mineral (coal)
  - layout of mining operations and other activities
  - roads, railways and rivers
  - buildings, dwellings and other structures
  - power lines and pipelines
  - dams, canals, weirs, bridges and crossings
  - land use of the surface.

- a business plan which describes at least the following:
  - background of the applicant
  - mineral reserves
  - markets for minerals (and/or coal)
  - intended life of the mine
  - capital investment and current assets
  - cost outlay of mine establishment
  - running cost of production
  - cash flow
  - production rates
  - economic viability of the proposed mine

- indication as to when the mining operation is likely to commence.

APPLICATION FOR A MINING AUTHORISATION or MINING PERMIT



2.6 Outcomes of Phase 2

The primary outcomes of Phase 2 of the mine planning and design process will include but are not limited to:

- a detailed geological assessment of the project area based on borehole spacings of at least eight cored boreholes per 100 hectares
- definition of the coal deposit as a measured or indicated coal reserve
- a detailed technical and economic assessment of the mineability of the coal reserves
- a detailed mining plan supported by production schedules for a period of 20 years, or the life of the mine, whichever is the longer
- an approved Environmental Management Programme Report
- a management decision on the future of the mining project.

In the event of a decision being made to proceed with the project, the following documents must be prepared and submitted:

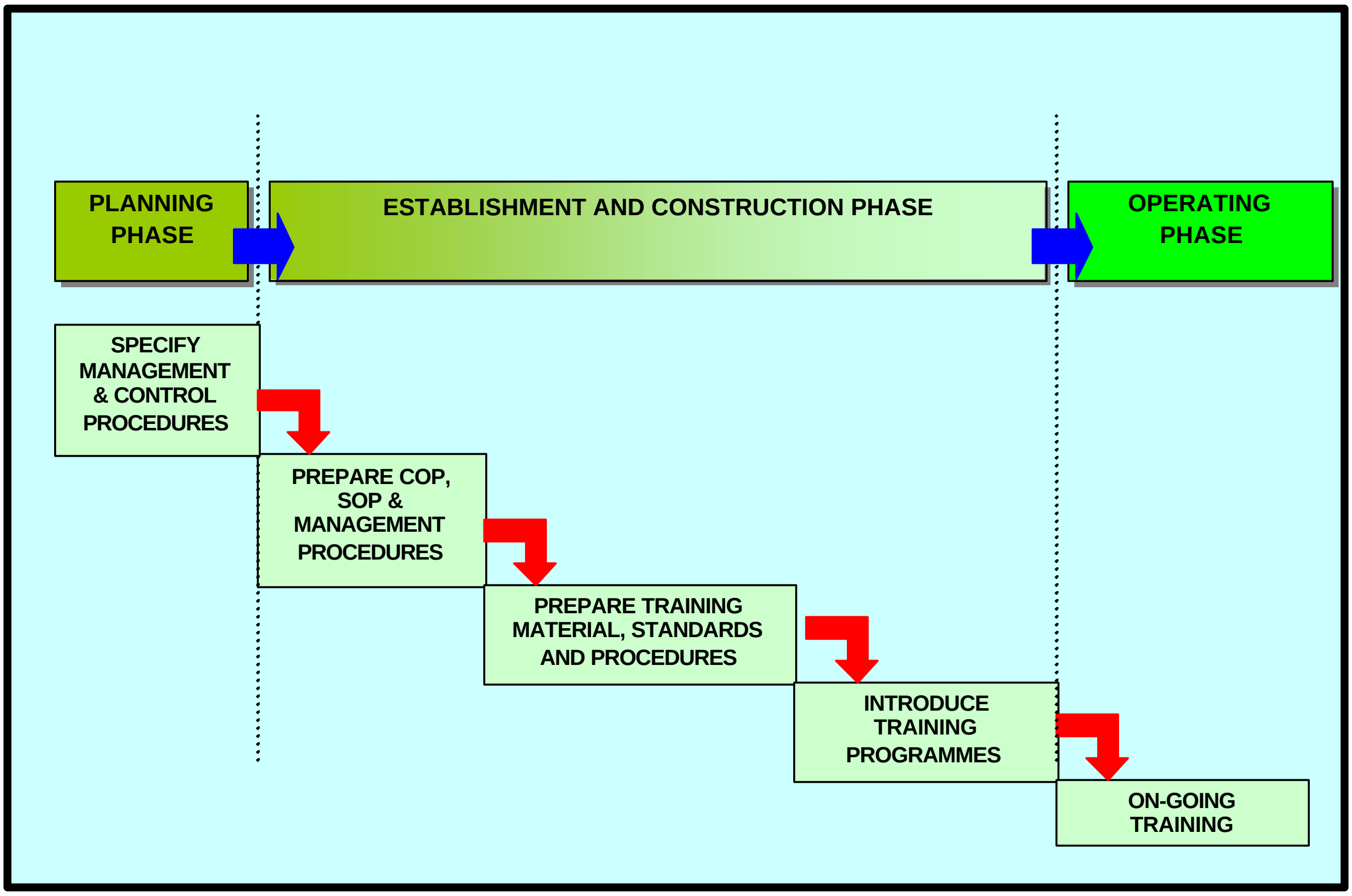
- a bankable document for purposes of public reporting or informing investors and/or potential investors of details pertaining to the proposed project
- an application for mining authorisation or a mining permit.

3. PHASE 3: MINE ESTABLISHMENT AND CONSTRUCTION PHASE.

3.1 Introduction

The establishment and construction phase of any mining operation is that period from when a mining authorisation or mining permit is obtained until the time when production commences. The primary objectives of the mine planning and design function during this period are to:

- improve the level of geological confidence
- commence with the planning and design strategy as required for the production/operational phase
- prepare and compile all relevant Codes of Practice (COPs), Standard Operating Procedures (SOPs) and Management Systems as defined in the feasibility study to meet the requirements of Section 9 of the Mine Health and Safety Act, 1996 (Act 29 of 1996)
- prepare training manuals and introduce training programmes to ensure that, as far as reasonably practicable, all employees are trained and qualified to perform their work safely and without risk to their health and that every employee becomes familiar with work-related hazards and risks and the measures required to eliminate, control and minimise those hazards and risks as specified in Section 10 of the Mine Health and Safety Act,1996 (Act 29 of 1996).



i. Geological investigations

The pre-production geological investigations must focus on improving the level of geological confidence during the early part of the project, and represents the transition from the measured definition of the resource to more detailed "grade control" borehole drilling requirements. For the pre-production geological investigations, the borehole spacing should be reduced to a level sufficient to define the coal deposit as at least a measure or indicated coal resource in order to define a proven coal reserve and/or a probable coal reserve within the mining area. For at least the first five-year production period, or up to the end of the payback period, whichever is the minimum, the geological data must be at the proven coal reserve level. Pre-production geological investigations call for the detailed delineation of the coal seam sub-outcrop and of the limit of oxidation. The drilling requirements during the one to two-year budget window and the two to five-year medium-term mining window must be defined. The additional boreholes must be drilled to bring the borehole drilling density to the required density within the specified time windows, namely "grade control" in a one to two year window, "medium term" in years two to three, and "measured" to at least year five.

ii. Mine planning

The objectives and methods of mine planning are identical to those required and specified for the Operational/Production Phase as detailed in Chapter 4.

4. PHASE 4: OPERATIONAL/PRODUCTION PHASE

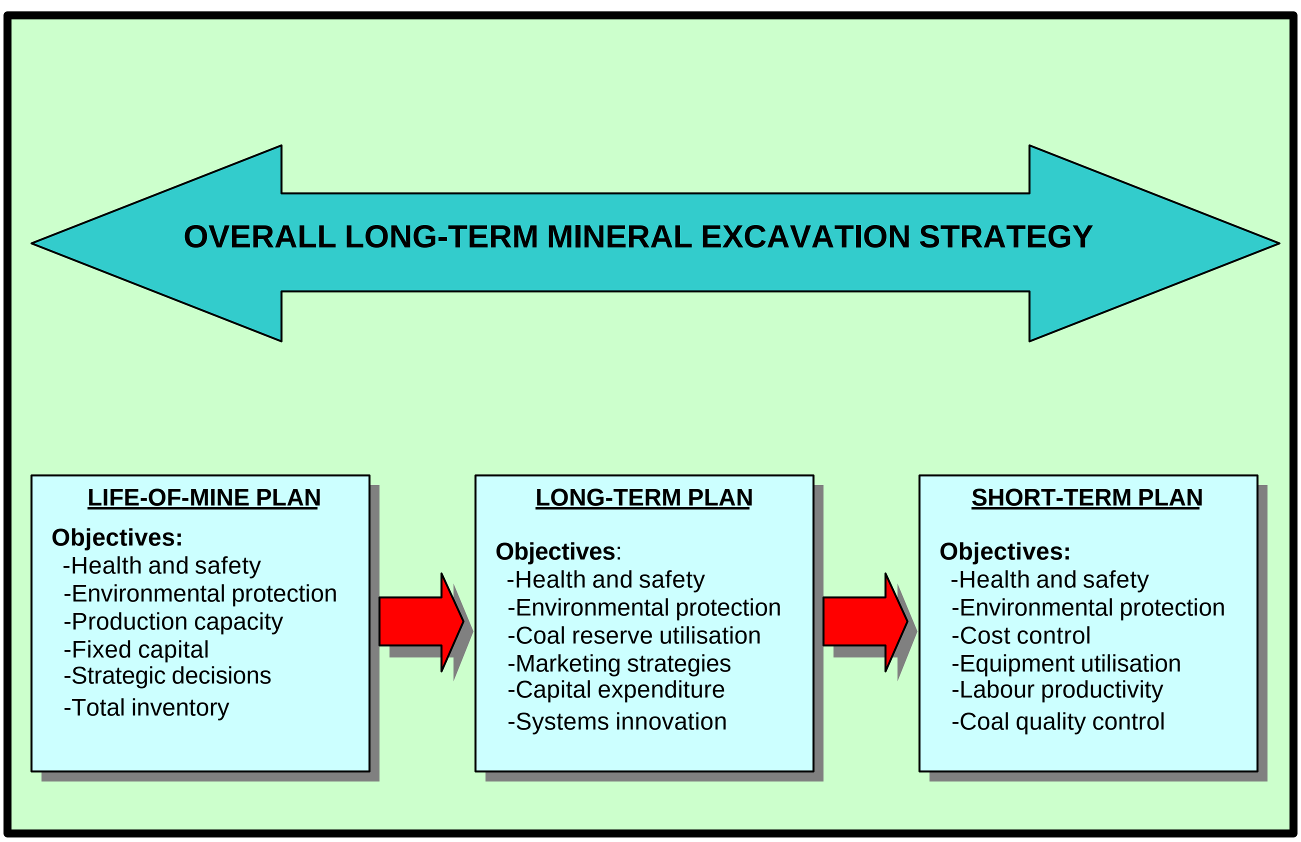
4.1 Introduction

A systematic and structured planning process throughout the life of the underground coal mine project is absolutely essential to ensure an effective, safe and economically viable operation. Three distinct levels of planning are recognised:

i. Life-of-mine planning (LOM)
ii. Long-term planning (LTP), which follows from the life-of-mine plan
iii. Short-term planning, which in turn follows from the long-term plan.

Each of these three levels of planning represents a different level of risk and has a different objective. It follows therefore that the planning criteria for each phase should be different. Structured and integrated planning means that all of these planning stages are closely interlinked. For example, every activity in the short-term plan benefits the long-term objectives as defined in the life-of–mine plan. This interaction can be illustrated diagrammatically as follows:

THE OPERATIONAL MINE PLANNING PROCESSES



Life-of-mine plan

Development of the life-of-mine plan is the first step in the mining operational planning process and has the following objectives:

- define the inventory of the coal reserve that is mineable within the assumed technical and economic parameters
- define the production capacity for the remaining life of the mine
- define the infrastructure required over the life of the mine to sustain the planned production rates
- determine the fixed capital costs
- determine the impacts of the mining processes on the environment and define methods and procedures to eliminate or control these impacts as per the approved Environmental Management Programme Report
- identify the potential technical, financial, health and safety risks associated with the mining processes and specify methods whereby these risks can be eliminated, reduced or controlled.

In terms of the requirements of the SAMREC Code, SABS 0320:2000 and generally accepted international standards, a life-of-mine plan covers a period of at least 20 years, or life-of-mine, whichever is the shorter.

Long-term planning

Once the inventory and spatial location of the coal reserves, current and future shaft positions, mine residue dumps and other permanent surface infrastructure have been defined in the life–of–mine plan, a long-term plan is necessary to devise an operating and mining strategy for the purposes of:

- maximising return for investors
- minimising risk to investors
- maximising the life of the mine and the utilisation of available resources
- minimising health, safety and environmental risks.

These objectives can only be met by means of careful and detailed scheduling of all the activities associated with the mining processes and the identification of the most effective and optimum options. To meet the requirements set by the SAMREC Code and SABS 0320:2000, the long-term plan (also referred to as the ‘development plan’) requires detailed scheduling for the current year of operation and further details on an annual basis for five years. The remaining life of the mine outside the five-year window should be evaluated at intervals of a maximum of five years over the life of the mine.

Short-term planning

On the basis of the long-term plan now defined, short-term plans must now be drawn up to cover each one-year business cycle. The major objectives of short-term planning are:

- coal quality control
- cost control
- efficient equipment utilisation
- capital productivity
- labour productivity
- maintaining and improving health, safety and environmental standards.

The short-term planning process is therefore primarily concerned with the day-to-day (up to annual) mining operations. Equipment utilisation includes planning for major equipment overhauls and/or replacements, while production scheduling is focused on maintaining the required coal production rates at the specified grade. Critical evaluation of existing health, safety and environmental standards forms an integral part of the short-term mine planning process in order to identify methods and procedures that will assist in enhancing these key performance areas. Short-term planning must ensure that the long-term planning goals are achieved on a daily, weekly and monthly basis.

4.2 Input requirements

4.2.1 Geological information

The SAMREC Code (SABS 0320:2000) requires that during the operational or mining phase, the geological investigations should continue for the purpose of delineating the coal reserve by drilling boreholes to provide proven coal reserves for a minimum of five years (or the life of the mine) ahead of the planned mining operations. More detailed geological drilling may be required in the immediate vicinity of the mining operations for grade control, geotechnical and/or safety and health reasons. This grade control and/or geotechnical drilling can typically cover a one to two–year mining window for underground operations. The computerised geological model is progressively updated, at least annually, from the additional geological data that are collected as part of the operational geological drilling programme.

Monitoring of the physical and coal quality parameters of the coal reserve is an ongoing activity and forms an integral part of the operational planning process. To measure the accuracy and integrity of the geological database and computerised modelling, the predicted coal reserves and their associated qualities must be periodically reconciled with the coal actually mined and this must be reported in the “Mining Report”. A detailed explanation of any variances between predicted and actual values must be provided.

4.2.2 Mining information

The mining section of the short-, medium- and long-term plans is primarily concerned with the detailed planning, design and scheduling of all underground activities. Typical input parameters used for these plans are:

- equipment performance levels achieved to date
- expected future equipment performance levels
- labour efficiencies
- operating standards and procedures that will ensure that the coal is extracted in the most efficient manner
- infrastructural and support services required to ensure the health and safety of all personnel involved with the mining processes
- design parameters that must be adhered to in order to fulfil the requirements as detailed in the approved Environmental Management Programme Report (EMPR).

4.3 Outcomes of the operational/mining plan

The results and outcomes of the operational/mining plan must be compiled in a "Mining Report" which can be used for public reporting purposes. The "Mining Report" is defined as: *"a report which reflects the state of development and exploitation of a coal deposit during its economic life, including current mining plans, and is used for forecasting operating budgets, reviewing and updating operating procedures, and identifying future mining exploitation strategies and associated equipment and infrastructural requirements".*

5. PHASE 5: DECOMMISSIONING PHASE AND MINE CLOSURE

5.1 Introduction

Decommissioning activities start when a mine, or part of a mine, ceases production and continue until the mine closure process has been successfully completed. The primary objective of the mine planning and design function during this period is to develop strategies that will:

a) ensure compliance with the approved Environmental Management Programme Report
b) minimise the impact of mine closure on the environment
c) minimise future health and safety risks
d) ensure sustainable economic development potential.

5.2 Input requirements

5.2.1 Geological information

The geological information required for the purposes of planning a mine closure is concerned mainly with identifying the location and extent of geological features that could:

a) impact on the long-term stability of the underground workings
b) result in surface subsidence or the formation of sinkholes
c) be a source of pollution
d) pose health and safety risks.

5.2.2 Mining information

The information required for the mining section of the mine closure study will consist of:

a) the identification of the actions that need to be implemented in order to comply with the requirements as detailed in the Environmental Management Programme Report
b) the identification of factors that could have an effect on long-term health, safety and environmental risks
c) the identification of strategies that need to be implemented in order to eliminate, reduce or control the identified hazards and risks.

5.2.3 Surface environment

The strategies that need to be implemented to ensure the long-term sustainability of the surface environment form the key input parameters to the mining plan. These strategies include:

a) the identification of surface structures to be demolished and/or removed
b) the identification of areas to be rehabilitated
c) measures to be introduced to control and manage ongoing water seepage and rainwater from mine residue deposits
d) measures to be introduced to prevent uncontrolled subsidence
e) measures for preventing and controlling dust and water pollution
f) sealing of underground workings and rehabilitation of dangerous excavations
g) other measures deemed necessary for the purposes of ensuring long-term health, safety and environmental standards.

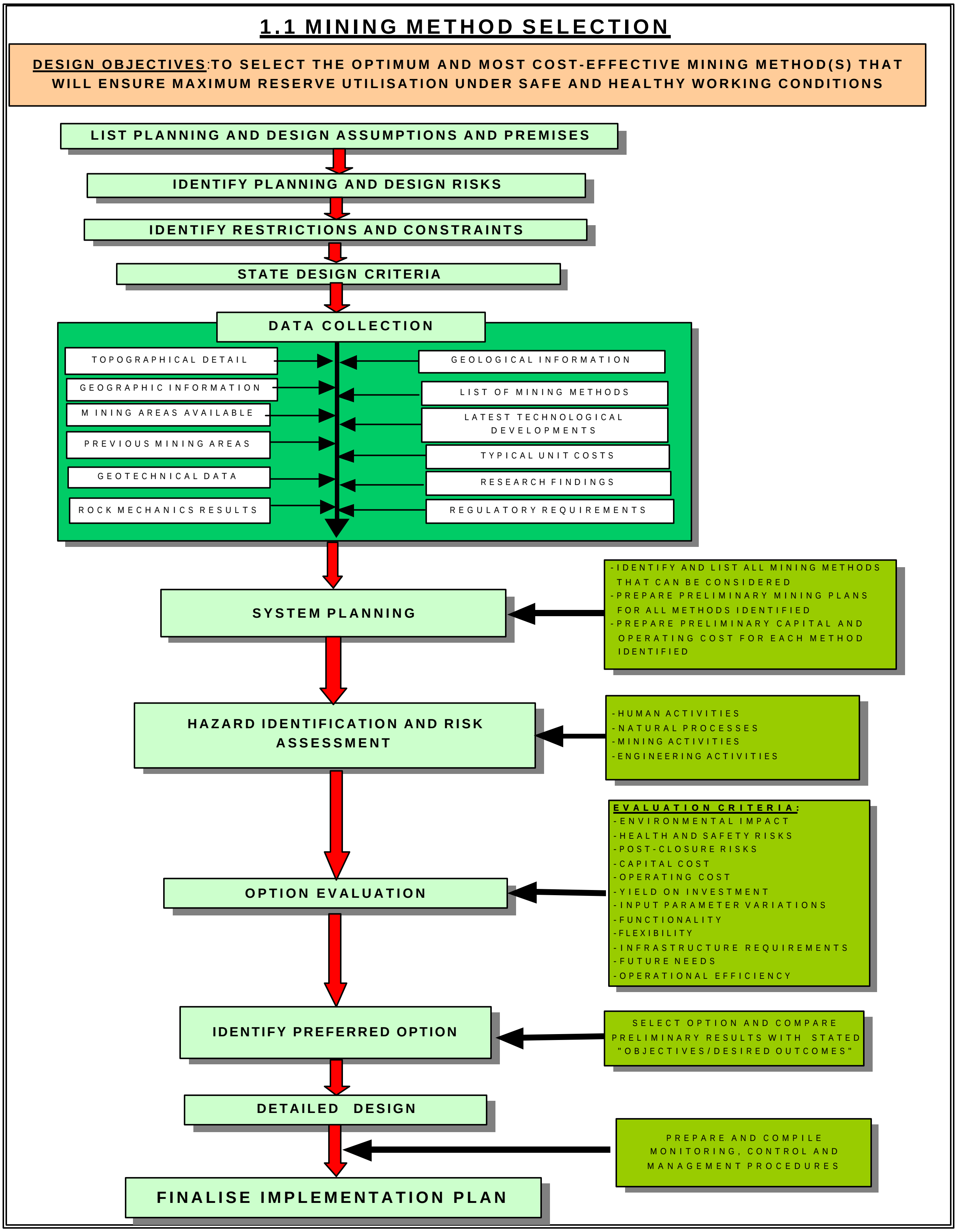
5.3 Outcomes of the mine closure planning report

The primary outcome of the mine closure planning report is the identification of the strategies and procedures that are required to meet all criteria as defined in the Environmental Management Programme Report in order to minimise the impact of mine closure on health, safety and environmental risks.

PART B:
Guidelines for the integrated underground coal mine planning and design processes

1. UNDERGROUND CORE BUSINESS PROCESSES

1.1 Mining method selection



Objectives/desired outcomes: To select the optimum and most cost-effective mining method(s) for a given coal deposit in order to ensure maximum utilisation of available coal reserves and coal resources under safe and healthy working conditions during the expected life cycle of the mine, having minimum impact on the surface environment.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the various mining methods that will be considered for a given coal deposit due to regulatory requirements, as well as physical, technical, and environmental conditions, e.g.

- surface structures to be protected
- mine boundaries
- geological features
- strata control and roof-support strategies
- servitudes
- rivers, dams and other water courses
- other factors that may be considered to be of importance.

Step 4: Design criteria

Identify and list the required design criteria for the mining method selection process.

Step 5: Data collection

The following basic information will be required for the underground mining method selection process:

1) Surface plans indicating:

- existing infrastructure, e.g. roads, railway lines, railway stations, water supply lines, power lines
- infrastructure that needs to be protected
- location of rivers, streams, dams and potential flood lines
- surface contour lines (digital terrain model)
- land utilisation, e.g. extent and intensity of agricultural, industrial and other economic activities

- townships, dwellings and other residential areas
- sensitive ecological and environmental areas.

2) Mining areas: Plans indicating:

- property boundaries
- extent of mineral/coal rights
- coal outcrops
- coal sub-outcrops
- extent of coal reserves.

3) Geological information: Detailed geological plans and information for each coal seam indicating:

- floor contours
- roof contours
- coal seam thickness contours
- coal quality contours
- inter-seam parting thickness
- in-seam parting thickness
- contours of selected mining heights
- depth below surface contours
- geological structures, e.g. sills, dykes, faults, burnt coal, hydrological areas
- other information relevant to the particular project.

4) Previous mining areas: General plans indicating the location and extent of previous mining activities, possible water accumulation and any other information that could affect the final mining method selection process.

5) Government regulations, statutory requirements and international standards applicable to mining, e.g.

- Minerals Act, 1991 (Act 50 of 1991)
- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- SABS Standards
- DME Guidelines
- ISO Standards.

6) Relevant research findings and publications related to the selection of underground mining methods, e.g. SIMRAC Research Reports.

7) Geotechnical and rock mechanics results: The results of a geotechnical and rock mechanics investigation defining the extent and location of the different geotechnical areas.

8) Alternative mining methods that can be considered: Identify and list possible mining methods that can be considered for the coal deposit under investigation.

9) Available technology: Identify and list the latest technologies and developments that could influence the mining method selection process, e.g.

- mining equipment available
- mining layouts
- mining operational procedures
- management and control strategies.

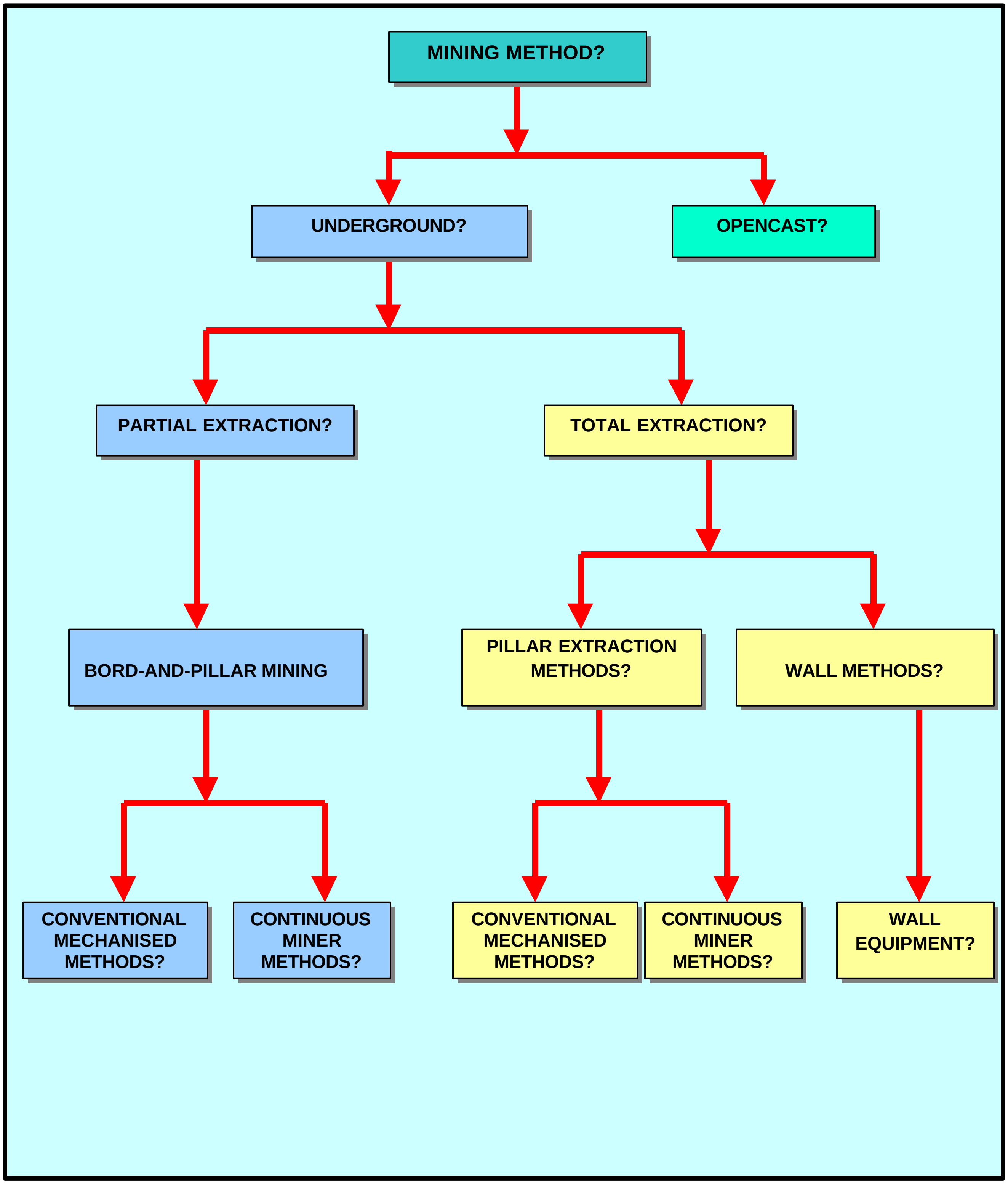
10) Unit operating costs: Typical unit operating costs for different mining methods and processes.

Step 6: Preliminary design (system planning)

Identify and list the different mining methods that will be considered for the coal deposit under investigation, e.g.

- opencast or underground mining?
- total extraction or partial extraction?
- pillar mining or wall mining?
- continuous mining methods or conventional mechanised mining methods?, etc.

MINING METHOD SELECTION



Economic factors and the overall profitability of the proposed mining operation play a major role in the final decision on whether the project will go ahead or not. The primary objective of the initial mining method selection process is therefore to identify a particular mining method, and its associated capital and operating costs, that will yield the highest return on investments within predetermined health, safety and environmental constraints. To achieve this objective, preliminary mining plans and capital and operating cost estimates must be developed for each of the identified mining methods.

Step 7: Hazard identification and risk assessment

For each of the preliminary mining method options developed under Step 6, identify and list all the significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the operating, decommissioning and closure phases of that underground mining option. Identify procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary underground mine design specifications.

Step 8: Sensitivity analysis and option evaluation

Test the sensitivity of each of the preliminary underground mine design options to:

- environmental impacts
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- yield on capital invested
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: Selection of preferred option

Identify and select the underground mining method that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: Detailed design

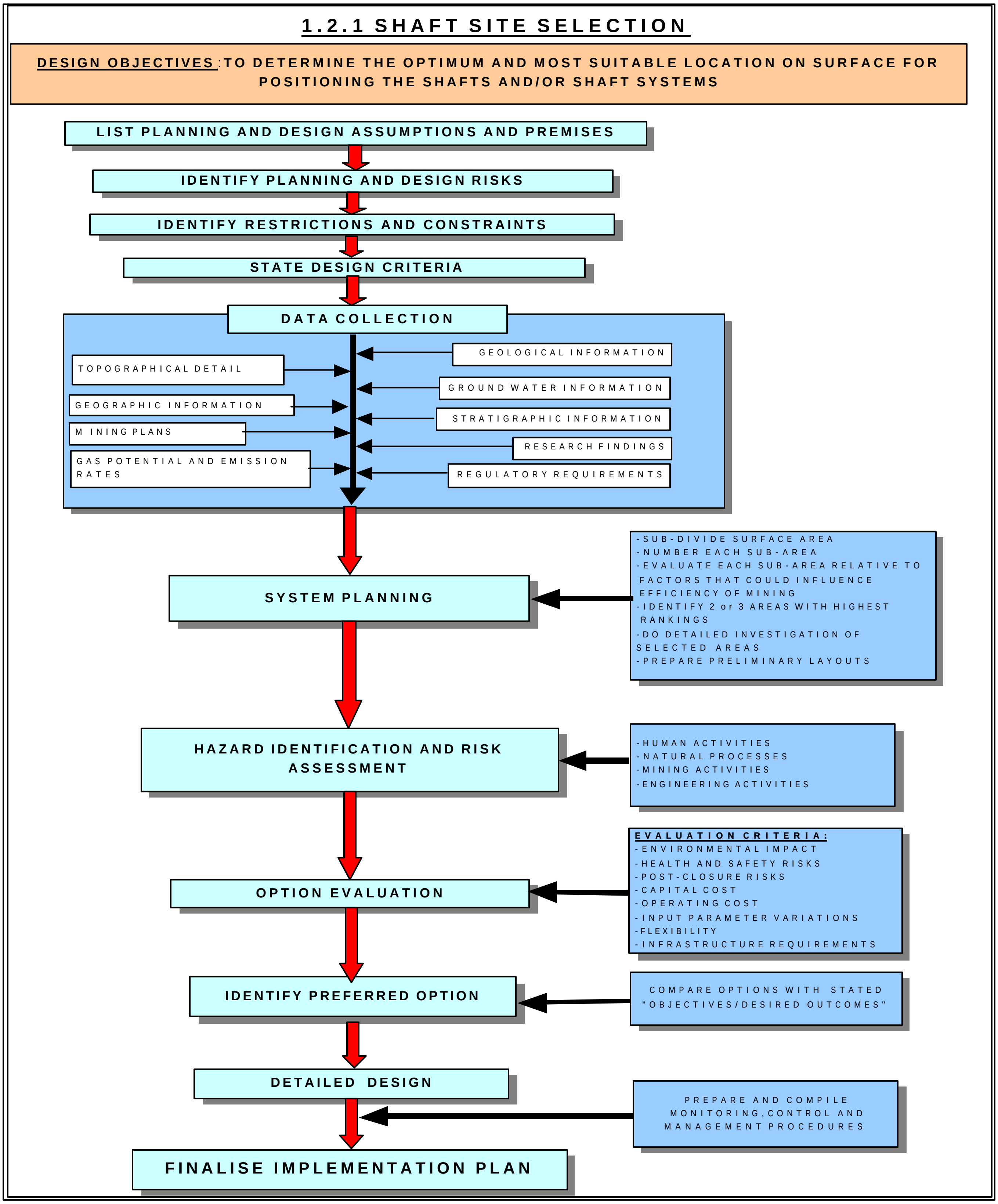
Prepare a detailed design of the underground mining layout based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Prepare the monitoring, control and management procedures to be introduced and followed during the mine's operational, decommissioning and closure phases to ensure that the required standards in terms of health, safety and environmental conditions are maintained.

1.2 MINE ACCESS/EXIT SYSTEMS PLANNING

1.2.1 Shaft site selection



Objectives/desired outcomes: To determine the optimum and most suitable location on surface for positioning the shafts and/or shaft systems for a specific underground mining layout that will ensure effective, safe and healthy underground working conditions over the life cycle of the mine, with minimum surface environmental impacts.

Step 1: Planning and design assumptions and premises
Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks
Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints
Identify and list all regulatory requirements, as well as the physical, technical and environmental factors that will have an influence on the positioning of the shaft systems.

Step 4: Design criteria
Identify and list the required design criteria for the shaft system location.

Step 5: Data collection
The following basic data will be required to determine the optimum shaft site location:

1) **Topographical information (plans)** indicating:
    - surface contour lines
    - streams, rivers, dams and potential flood lines
    - land utilisation, e.g. extent and intensity of agricultural and industrial activities
    - townships, dwellings and other residential areas
    - vegetation: density and extent of natural and adverse vegetation
    - existing infrastructure, e.g. roads, railway lines, railway stations, water supply lines, power lines
    - sensitive ecological and environmental areas.

2) **Geographical information**: relative distances to major infrastructure, e.g. towns, railway and export facilities, major customers.

3) **Mining plans** indicating:
    - primary and secondary development layouts
    - panel layouts
    - other major underground infrastructure.

4) **Underground geological information** indicating:

- seam thickness
- seam gradients
- seam depths
- coal qualities
- major geological features, e.g. slips, faults, dykes, sills, intrusions, etc.

5) **Ground water information**: e.g.

- quantities of ground water
- qualities of ground water
- depth of water table
- impervious layers
- water compartments
- permeabilities
- extent of current water usage.

6) **Stratigraphic column** in the vicinity of the proposed shaft location(s):

- depth and type of weathered overburden
- dolerite intrusions
- dolerite sills
- depth and type of hard overburden material
- quality of roof strata above coal seam
- quality of floor strata under coal seam
- sub-floor conditions.

7) Gas potential and emission rates

Determine the possibility of gas being present at the potential shaft site and the emission rates thereof.

8) Research findings

Identify and collect all relevant publications, research reports and findings related to shaft site selection and shaft design (e.g. SIMRAC Research Reports).

9) **Regulatory requirements**

Identify and list all regulations, SABS Standards and international standards that may influence the positioning of the shafts and/or shaft systems in a particular area.

Step 6: **<u>Site selection (system planning)</u>**

1) Divide the total surface area overlying the proposed underground mine into squares of equal dimensions (e.g. 1 000 m x 1 000 m). Assign a unique identification to each of these squares.
2) Identify and list all the factors that could influence the efficiency of the whole mining operation if the shaft or shaft system were to be positioned in a particular location. Evaluate each of the squares generated under Step 1 above against these parameters by assigning high values to positive factors and low values to negative effects.
3) Identify the two or three squares with the highest accumulated rankings.
4) Carry out detailed investigations on each of the selected squares by means of additional borehole drilling, soil tests, alternative underground mine layouts, detailed topographical investigations, site inspections, etc.
5) Based on the results of the detailed investigations of the selected areas, identify a specific location for the placement of the proposed shaft or shaft system.

Step 7: **<u>Hazard identification, risk assessment and environmental impact assessment</u>**

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the construction, commissioning, operating, decommissioning and closure phases of the shaft's life. Identify and list the potential impacts of the proposed shaft and/or shaft system on the environment. Identify procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary shaft design specifications.

Step 8: **<u>Evaluation of options</u>**

Test the sensitivity of the selected shaft site to:

- possible environmental impacts
- health and safety risks
- post-closure impacts
- capital cost
- operating cost
- input parameter variations
- flexibility of the system
- infrastructure requirements.

Step 9: **<u>Selection of the preferred option</u>**

Select and identify the particular shaft site(s) that will best meet the criteria stated under "Objectives/desired outcomes".

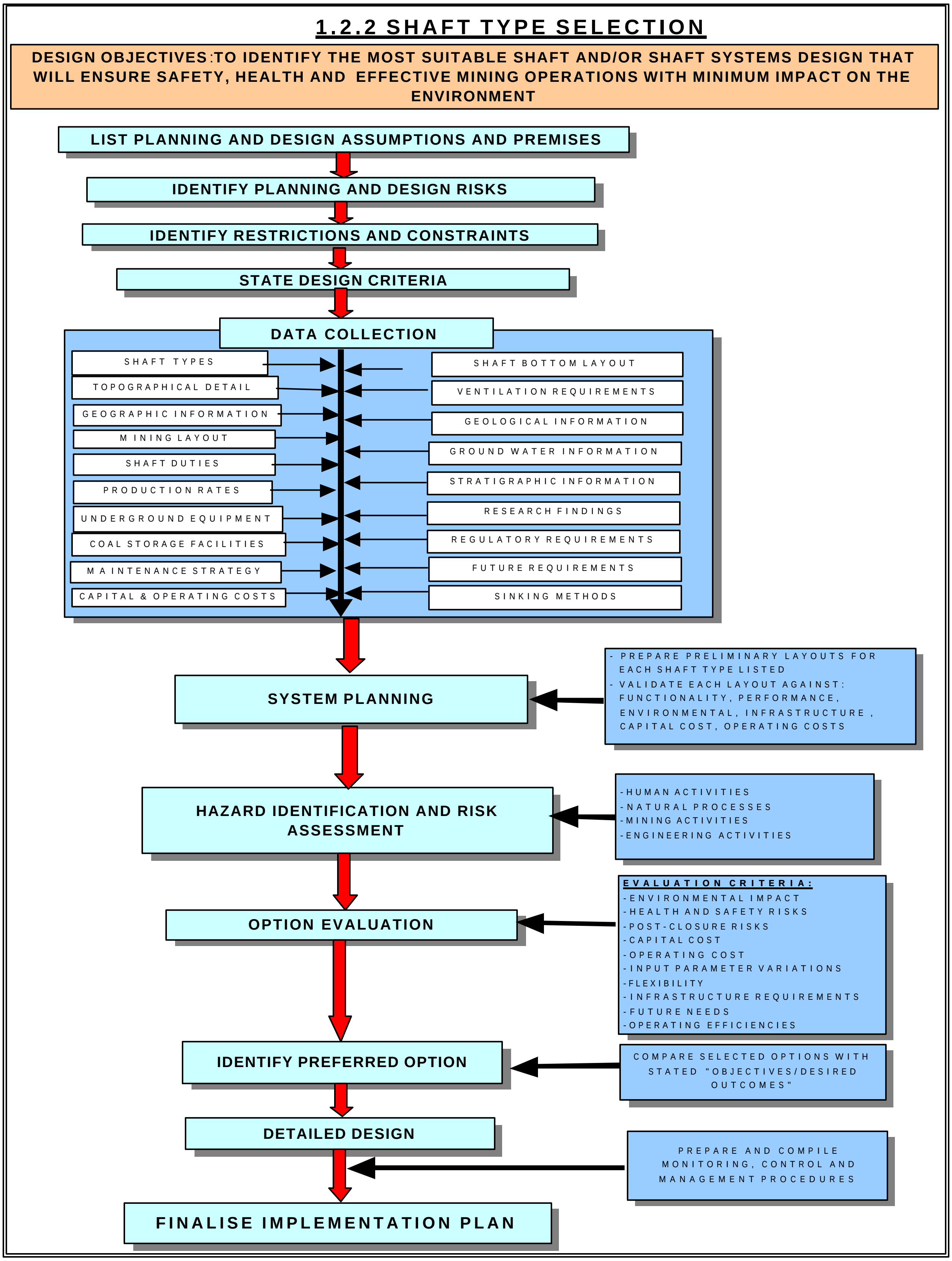
Step 10: Detailed design

Prepare a detailed design based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Prepare the necessary monitoring, control and management procedures to be introduced and followed during the shaft sinking and mine operational phases to ensure that the required standards in terms of health, safety and environmental conditions can be maintained.

1.2.2 Shaft type selection



Objectives/desired outcomes: To identify the most suitable shaft system design for a specific coal deposit that will ensure the safety and health of employees, will ensure an effective mining operation and have minimum impacts on the environment.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints that will influence the types of shaft that can be considered due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the shaft types to be considered.

Step 5: Data collection

The following basic data will be required to determine the optimum type of shaft for a specific underground coal mining layout and production requirement:

1) Identification of the different types of shafts that can be considered, e.g. vertical shafts, inclined shafts, steep wide shafts, steep double-deck shafts, shallow wide shafts, steep narrow shafts, etc.

2) Shaft duties and/or capacities in terms of:
   - total number of personnel to be transported underground on a daily basis
   - number of employees working underground at any given point in time
   - shift schedules
   - mode of surface transport for personnel, material and coal
   - mode of underground transport for personnel, material and coal
   - mode of shaft transport for personnel, material and coal.

3) Coal production rates expressed in:
   - average rates per hour, day, month or year
   - minimum rates per hour, day, month or year

- maximum rates per hour, day, month or year.

4) Equipment to be transported underground:
   - type of equipment
   - dimensions of equipment
   - weight of equipment
   - frequency of shaft transport required.

5) Ventilation and airflow:
   - air quantities required to ventilate underground workings
   - maximum and minimum air velocities permissible
   - gas-emission rates.

6) Detailed surface information relative to the shaft site selected:
   - topography
   - ground slopes
   - surface gradients
   - flooding potential.

7) Stratigraphic column of the area where the shaft/shaft systems will be established:
   - depth of soft, weathered overburden
   - type of soft, weathered overburden
   - depth and type of overburden material that will be encountered during shaft-sinking operations
   - presence of geological features such as dolerite dykes, sills, slips, faults and/or other discontinuities
   - presence of water compartments, fissures and/or other ground water occurrences
   - quality of coal roof in vicinity of shaft bottom
   - quality of coal floor in vicinity of shaft bottom
   - requirements for shaft lining and other support mechanisms.

8) Shaft bottom layout:
   - details of the proposed shaft bottom layout and design.

9) Underground mining layouts with special reference to:
   - personnel travelling ways
   - equipment travelling routes

- coal haulage/conveyor routes
- ventilation and air flow.

10) Underground coal storage (bunkers) facilities relative to their:
    - positions
    - capacities
    - design features.

11) Coal-conveying characteristics and information e.g.
    - maximum allowable belt speed
    - coal dust-generating potential
    - conveyor belt curvatures
    - drive and tail-end arrangements and area required for installation.

12) Maintenance strategy and requirements:
    - location where maintenance will be done
    - frequency and type of maintenance.

13) Shaft sinking:
    - methods
    - timing and schedules.

14) Future shaft requirements

15) Capital cost of shaft sinking and establishment of infrastructure

16) Operating cost associated with different shaft types

17) Government regulations and international standards, e.g.
    - Minerals Act, 1991 (Act 50 of 1991).
    - SABS Standards
    - ISO Standards.

18) Relevant research findings and publications related to shaft type selection.

Step 6: <u>Preliminary design (system planning)</u>

For each of the shaft systems identified under paragraph 1 of Step 5 above, prepare a preliminary design layout. Validate these preliminary design layouts against functionality, performance criteria, relevant government regulations, environmental requirements, infrastructure requirements, capital and operating costs and time needed to implement.

Step 7: Hazard identification and risk assessment

For each shaft system identified above, list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the construction, commissioning, operating, decommissioning and closure phases of the shaft's life.

Identify and list the procedures, systems and/or design principles that will be required to eliminate, reduce or control the identified risks and incorporate these into the preliminary shaft design specifications.

Step 8: Sensitivity analysis and evaluation of options

Test the sensitivity of the preliminary shaft design options to:

- environmental impacts
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: Selection of the preferred option

Select and identify the shaft type(s) that will best meet the criteria stated under "Objectives/desired outcomes".

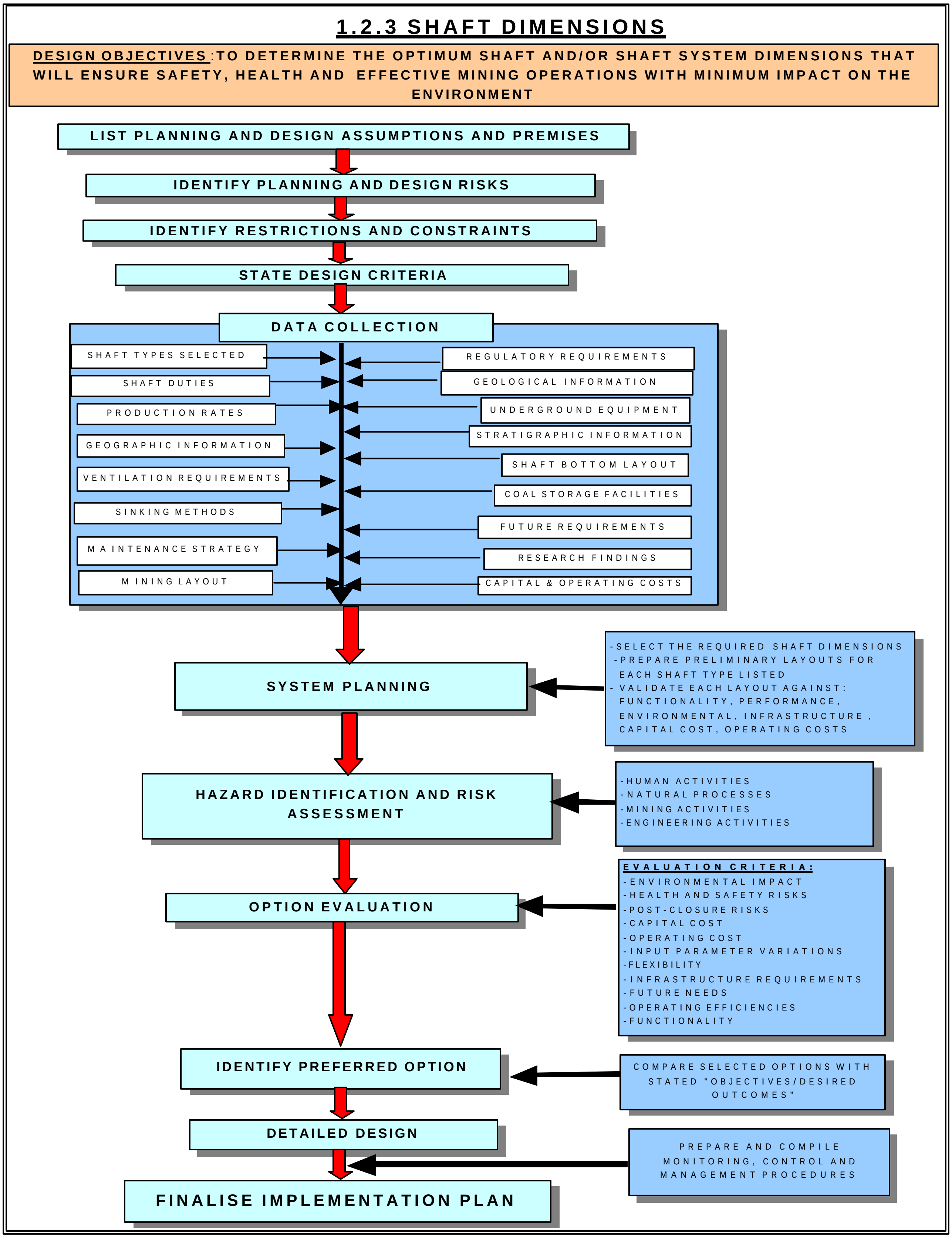
Step 10: Detailed design

Prepare a detailed design based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Prepare the monitoring, control and management procedures to be introduced and followed during the shaft sinking, mine operational, decommissioning and closure phases to ensure that the required standards in terms of health, safety and environmental conditions are maintained.

1.2.3 Shaft dimensions



Objectives/desired outcomes: To determine the optimum shaft dimensions for a specific underground coal mining operation in order to provide cost-effective operating conditions complying with acceptable health, safety and environmental standards.

Step 1: Planning and design assumptions and premises
Identify and list all planning and design assumptions and premises.

Step 2: Planning and design risks
Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints
Identify and list all restrictions and constraints that will influence the dimensions of the shafts and/or shaft systems due to regulatory requirements, as well as physical, technical and/or environmental conditions.

Step 4: Design criteria
Identify and list the required design criteria to be considered for the shaft dimensions.

Step 5: Data collection
The following basic input data will be required to determine the optimum shaft dimensions for the shaft type(s) selected:

1) Details of the shaft type(s) selected.

2) Required shaft duties and/or capacities in terms of:
   - total number of personnel to be transported underground on a daily basis
   - number of employees underground at any given point in time
   - shift schedules
   - mode of surface transport for personnel, material and coal
   - mode of underground transport for personnel, material and coal
   - mode of shaft transport for personnel, material and coal.

3) Coal production rates expressed in:
   - average rates per hour, day, month or year
   - minimum rates per hour, day, month or year
   - maximum rates per hour, day, month or year.

4) Equipment to be transported underground:

- type of equipment
- dimensions of equipment
- weight of equipment
- frequency of shaft transport required.

5) Ventilation and airflow:

- air quantities required to ventilate underground workings
- maximum and minimum air velocities permissible
- gas-emission rates.

6) Detailed surface information relative to the shaft site selected, e.g.

- topography
- ground slopes
- surface gradients
- flooding potential.

7) Stratigraphic column of the area where the shaft/shaft systems will be established:

- depth of soft, weathered overburden
- type of soft, weathered overburden
- depth and type of overburden material that will be encountered during shaft-sinking operations
- presence of geological features such as dolerite dykes, sills, slips, faults and/or other discontinuities
- presence of water compartments, fissures and/or other ground water occurrences
- quality of coal roof in vicinity of shaft bottom
- quality of coal floor in vicinity of shaft bottom
- requirements for shaft lining and other support mechanisms.

8) Shaft bottom layout.

9) Underground mining layouts with special reference to:

- personnel travelling ways
- equipment travelling routes
- coal haulage/conveyor routes
- ventilation and airflow.

10) Underground coal storage (bunkers) facilities relative to their:

- positions
- capacities
- design features.

11) Coal-conveying characteristics and information e.g.

- maximum allowable belt speed
- coal dust-generating potential
- conveyor belt curvatures
- drive and tail-end arrangements and area required for installation.

12) Maintenance strategy and requirements:

- location where maintenance will be done
- frequency and type of maintenance.

13) Shaft sinking:

- methods
- timing and schedules.

14) Future shaft requirements.

15) Capital cost of shaft sinking and establishment of infrastructure.

16) Operating cost associated with different shaft sizes.

17) Government regulations and international standards, e.g.

- Minerals Act, 1991 (Act 50 of 1991)
- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- SABS Standards
- ISO Standards.

18) Relevant research findings and publications related to shaft dimension selection.

Step 6: <u>Preliminary design (system planning)</u>

Based on the input parameters identified in Steps 1 to 5 above, select the required dimensions and prepare a preliminary design layout of the shaft system that will best suit the topographical, geological, environmental and mining requirements, and the conditions of the proposed mining project.

Validate these preliminary designs against functionality, performance criteria, relevant government regulations, environmental requirements, infrastructure requirements, capital and operating costs and time needed to implement.

Step 7: **<u>Hazard identification and risk assessment</u>**

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the construction, commissioning, operating, decommissioning and closure phases of the shaft's life.

Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary shaft design specifications.

Step 8: **<u>Sensitivity analysis and evaluation of options</u>**

Test the sensitivity of the preliminary shaft designs to:

- health and safety risks
- environmental impacts
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: **<u>Selection of preferred option</u>**

Select and identify the shaft type(s) that will best meet the criteria stated under "Objectives/desired outcomes".

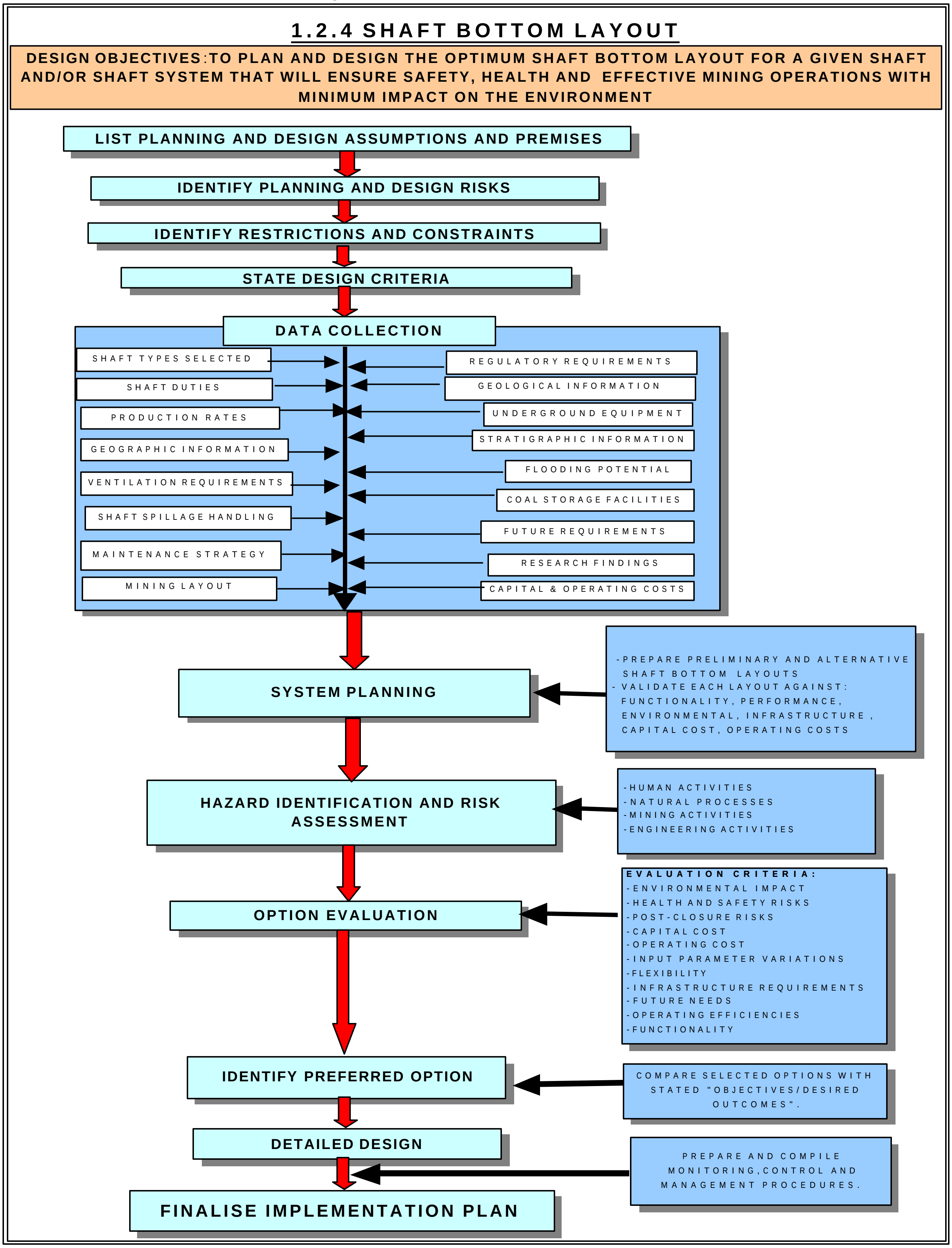
Step 10: **<u>Detailed design</u>**

Prepare a detailed design based on the outcomes of Steps 1 to 9 above.

Step 11: **Monitoring, control and management procedures**

Prepare the monitoring, control and management procedures to be introduced and followed during the shaft sinking, mine operational, decommissioning and closure phases to ensure that the required standards in terms of health, safety and environmental conditions are maintained.

1.2.4 Shaft bottom layouts



Objectives/desired outcomes: To plan and design the shaft bottom layout for a given shaft and/or shaft system that will ensure minimum health, safety and environmental risks and maximum operating efficiencies.

Step 1: Planning and design assumptions and premises
Identify and list all planning and design assumptions and premises.

Step 2: Planning and design risks
Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints
Identify and list all restrictions and constraints related to regulatory requirements, as well as physical, technical, and/or environmental conditions that will influence the layout of the shaft bottom.

Step 4: Design criteria
Identify and list the required design criteria for the shaft bottom layout being considered.

Step 5: Data collection
The following basic input data will be required to determine the optimum shaft bottom layout for the shaft type(s) selected:

1) Details of the shaft type(s) selected.

2) Required shaft duties and/or capacities in terms of:
   - total number of personnel to be transported underground on a daily basis
   - number of employees underground at any given time
   - shift schedules
   - mode of surface transport for personnel, material and coal
   - mode of underground transport for personnel, material and coal
   - mode of shaft transport for personnel, material and coal.

3) Coal production rates expressed in:
   - average rates per hour, day, month or year
   - minimum rates per hour, day, month or year
   - maximum rates per hour, day, month or year.

4) Equipment to be transported underground:

- type of equipment
- dimensions of equipment
- weight of equipment
- frequency of shaft transport required.

5) Ventilation and airflow:

- air quantities required to ventilate underground workings
- maximum and minimum air velocities permissible
- gas-emission rates.

6) Detailed surface information relative to the shaft site selected, e.g.

- flooding potential.

7) Stratigraphic column of the area where the shaft/shaft system and shaft bottom will be established:

- depth and type of overburden material that will be encountered during shaft-sinking operations
- presence of geological features such as dolerite dykes, sills, slips, faults and/or other discontinuities
- presence of water compartments, fissures and/or other ground water occurrences
- quality of coal roof in vicinity of shaft bottom
- quality of coal floor in vicinity of shaft bottom
- requirements for shaft lining and other support mechanisms.

8) Underground mining layouts with special reference to:

- personnel travelling ways
- equipment travelling routes
- coal haulage/conveyor routes
- ventilation and airflow.

9) Underground coal storage (bunkers) facilities relative to their:

- positions
- capacities
- design features.

10) Coal-conveying characteristics and information, e.g.

- maximum allowable belt speed
- coal dust-generating potential
- conveyor belt curvatures
- drive and tail-end arrangements and area required for installation.

11) Maintenance strategy and requirements:

- location where maintenance will be done
- frequency and type of maintenance.

12) Shaft sinking:

- methods
- timing and schedules.

13) Shaft spillage handling options.

14) Future shaft requirements.

15) Capital cost of shaft sinking and establishment of infrastructure.

16) Operating cost associated with different shaft bottom layouts and designs.

17) Government regulations and international standards, e.g.

- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- ISO Standards.

18) Relevant publications and research findings related to the selection of shaft bottom layouts

Step 6: **<u>Preliminary design (system planning)</u>**

Based on the input parameters listed under Steps 1 to 5 above, identify and prepare alternative shaft bottom layouts that will best suit the geological, environmental and mining requirements and conditions of the proposed mining project.

Validate these preliminary designs against functionality, performance criteria, relevant government regulations, environmental requirements, infrastructure requirements, capital and operating costs and time needed to implement.

Step 7: **<u>Hazard identification and risk assessment</u>**

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the construction, commissioning, operating, decommissioning and closure phases of the shaft's life.

Identify procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary specifications for the shaft bottom design

Step 8: **<u>Sensitivity analysis and evaluation of options</u>**

Test the sensitivity of the preliminary shaft bottom layout and design to:

- environmental impacts
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: **<u>Selection of preferred option</u>**

Select and identify the shaft bottom layout that will best meet the criteria stated under "Objectives/desired outcomes".

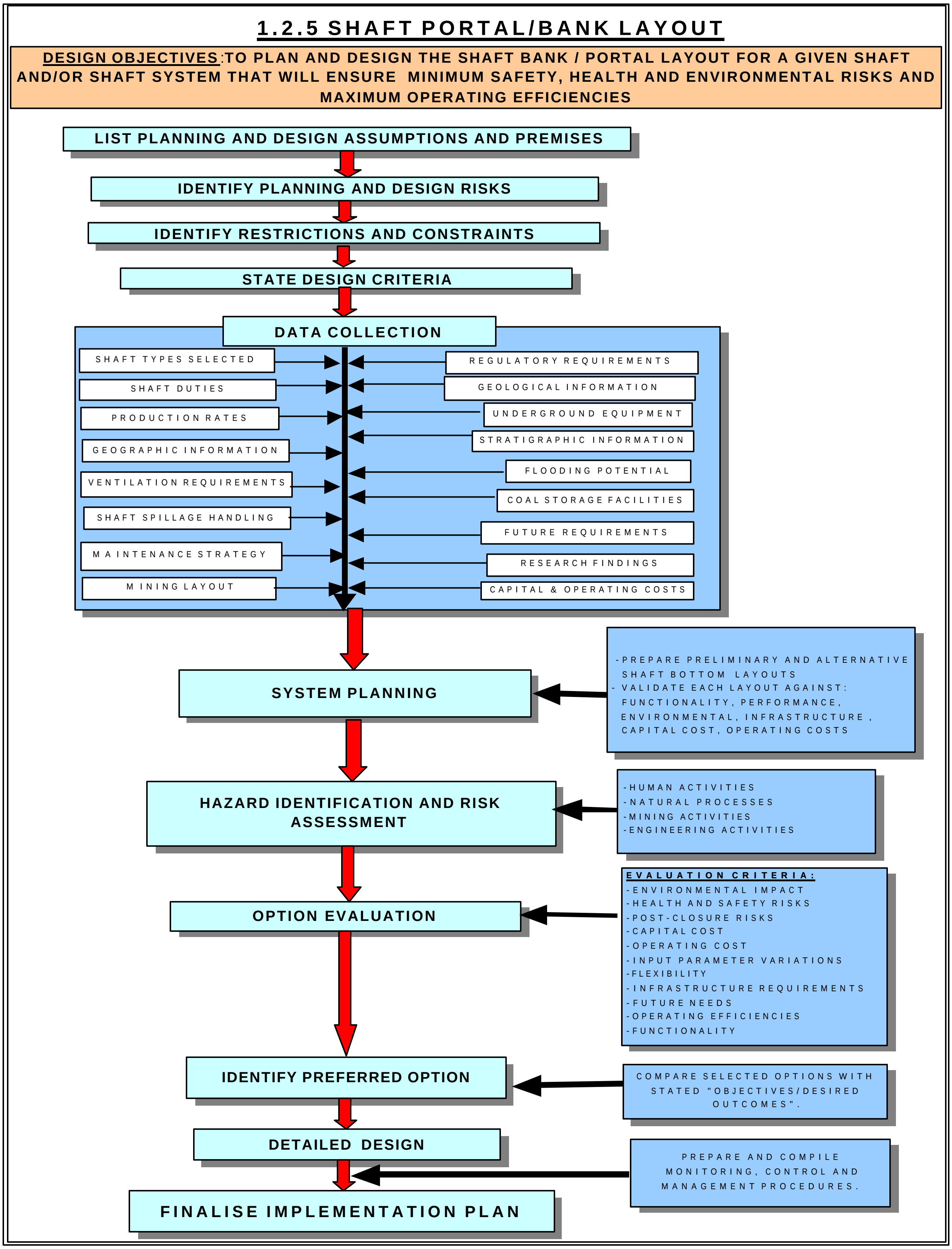
Step 10: **<u>Detailed design</u>**

Prepare a detailed design of the shaft bottom layout based on the outcomes of Steps 1 to 9 above.

Step 11: **<u>Monitoring, control and management procedures</u>**

Prepare the monitoring, control and management procedures to be introduced and followed during the shaft sinking, mine operational, decommissioning and closure phases to ensure that the required standards in terms of health, safety and environmental conditions at the shaft bottom are implemented and maintained.

1.2.5 Shaft portal/bank layout



Objectives/desired outcomes: To plan and design the shaft portal/bank layout for a given shaft and/or shaft system that will ensure minimum health, safety and environmental risks and maximum operating efficiencies.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints imposed on shaft systems, portal layouts and bank designs due to regulatory requirements, as well as physical technical, and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the required shaft portal/bank layout.

Step 5: Data collection

The following basic data will be required to determine the optimum shaft portal/bank layout and design strategy:

1) Topographical information (plans) indicating:
    - surface contour lines
    - streams, rivers, dams and potential flood lines
    - land utilisation, e.g. extent and intensity of agricultural and industrial activities
    - townships, dwellings and other residential areas
    - vegetation; density and extent of natural and adverse vegetation
    - existing infrastructure, e.g. roads, railway lines, railway stations, water supply lines, power lines
    - sensitive ecological and environmental areas
    - topography
    - ground slopes
    - surface gradients
    - flooding potential.

2) Geographical information:

- relative distances to major infrastructure, e.g. towns, railway and export facilities
- relative distances to major customers.

3) Required shaft duties and/or capacities in terms of:

- total number of personnel to be transported underground on a daily basis
- shift schedules
- mode of surface transport for personnel, material and coal
- mode of underground transport for personnel, material and coal
- mode of shaft transport for personnel, material and coal.

4) Coal production rates expressed in:

- average rates per hour, day, month or year
- minimum rates per hour, day, month or year
- maximum rates per hour, day, month or year.

5) Equipment to be transported underground:

- type of equipment
- dimensions of equipment
- weight of equipment
- frequency of shaft transport required.

6) Ventilation and airflow:

- air quantities required to ventilate underground workings
- maximum and minimum air velocities permissible
- details of ventilation layout and design.

7) Stratigraphic column of the area where the shaft/shaft systems will be established:

- depth of soft, weathered overburden
- type of soft, weathered overburden
- depth and type of overburden material that will be encountered during shaft-sinking operations.

8) Surface layout plans indicating:

- proposed positions of coal processing plant, offices, workshops, changehouse facilities, lamp room, self-contained self-rescuer store room and general stores
- planned positions and routes of mine access roads, railway lines load-out facilities
- planned positions and routes of main power lines and electricity distribution network
- planned positions and routes of main water supply reservoirs and pipe lines
- planned position of hostels and/or mine residential area.

9) Ground water information, e.g.

- quantities of ground water
- qualities of ground water
- depth of water table
- impervious layers
- water compartments
- permeabilities
- extent of current usage.

10) Meteorological information, e.g.

- prevailing wind direction
- annual rainfall figures (maximum, minimum, average).

11) Research findings:

Identify and collect all relevant publications, research reports (e.g. SIMRAC Research Reports) and other information on the subject of portal/bank construction and design.

12) Regulatory requirements:

Identify and list all regulations, SABS Standards and other requirements that could have an influence on the portal/bank construction and design.

Step 6: <u>Portal/bank layout (system planning)</u>

Prepare alternative portal/bank layouts for the shaft systems selected, taking into account the data collected as part of Step 5 above.

Step 7: **Hazard identification, risk assessment and environmental impact assessment**

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the construction, commissioning, operating, decommissioning and closure phases of the shaft's life, specifically in the shaft portal/bank area. Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary shaft portal/bank design specifications.

Step 8: **Evaluation of options**

Test the sensitivity of the preliminary portal/bank layouts to:

- environmental impacts
- health and safety risk;
- post-closure impacts
- capital cost
- operating cost
- relative ease with which personnel, material, equipment and coal can be handled
- variations in input parameters
- flexibility
- infrastructure requirements.

Step 9: **Selection of preferred option**

Select and identify the portal/bank layout option that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: **Detailed design**

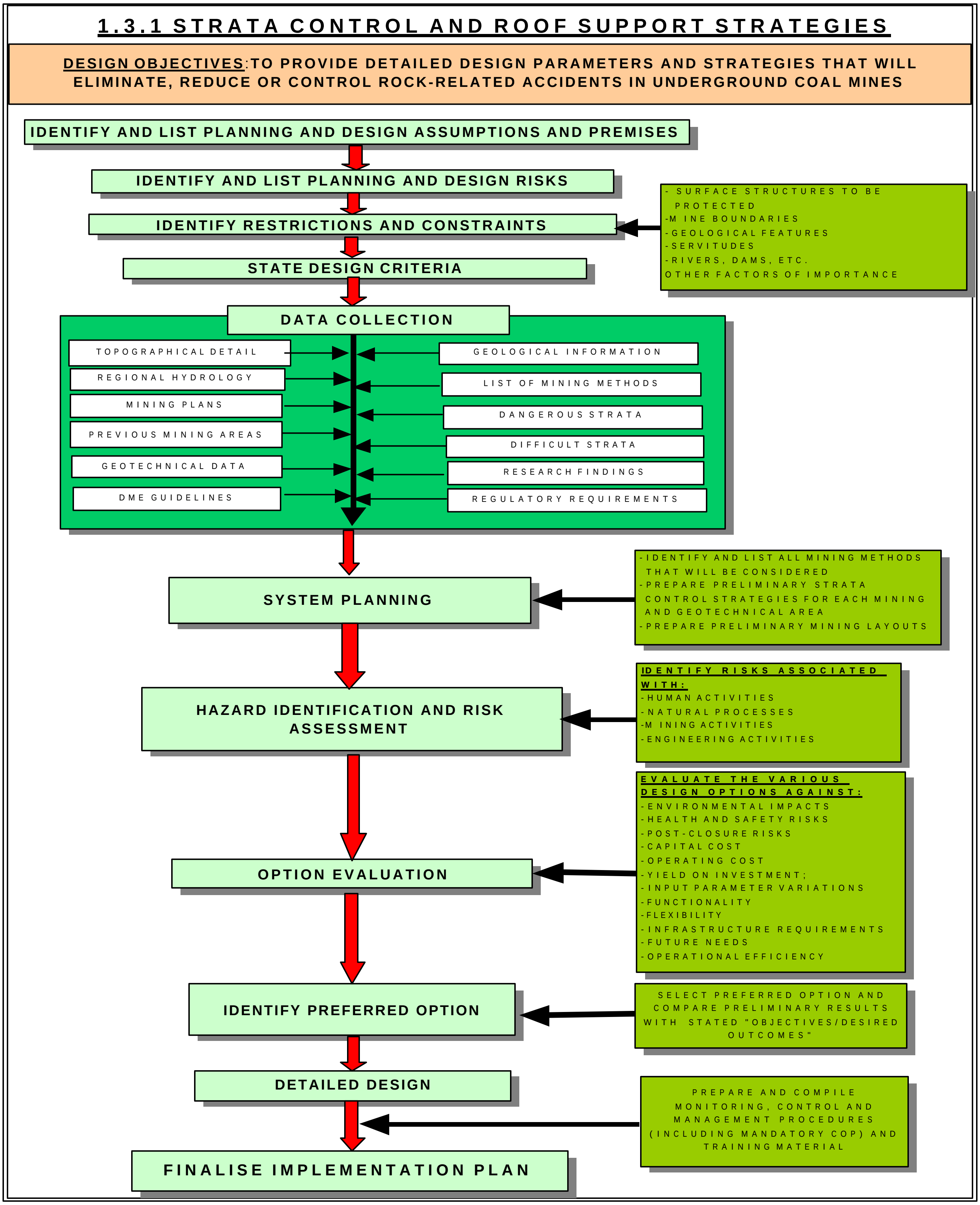
Prepare a detailed design based on the outcomes of Steps 1 to 9 above.

Step 11: **Monitoring, control and management procedures**

Prepare monitoring, control and management procedures to be introduced and followed at the shaft portal/bank area during the shaft-sinking and mine operational phases in order to ensure that the required standards in terms of health, safety and environmental conditions can be maintained.

1.3 UNDERGROUND LAYOUTS AND SCHEDULING

1.3.1 Strata control and roof support strategies



Objectives/desired outcomes: To provide detailed design parameters and strategies that will eliminate, reduce or control rock related incidents in underground coal mining operations.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints that will impact on the strata control and roof support strategies to be introduced in the underground mining layouts due to regulatory requirements, as well as physical, technical and/or environmental conditions, e.g.

- surface structures to be protected
- mine boundaries
- geological features
- servitudes
- rivers, dams and other water courses
- other factors that may be of importance.

Step 4: Design criteria

Identify and list the required design criteria to be considered for the strata control and roof support strategies for the underground workings.

Step 5: Data collection

To determine the required design principles for strata control and roof support strategies for a new underground coal mining operation, the following data will be required:

1) Geological setting: Geological structures, such as faults, dykes and stratigraphy around individual seams; dangerous or difficult strata must be identified and highlighted.

2) A mining plan showing seams to be mined, average and range of mining depths, seam thickness, dip and strike.

3) Regional hydrology, e.g. occurrence of ground water and/or any relevant hydrological information.

4) Geotechnical areas based on known geological hazards, structures, jointing and changes in rock type and strength, or any other factor that may impact on mining, the regional support strategy, or panel and roadway support strategies.

5) Geotechnical information that will affect the stability of the underground coal mine workings and associated infrastructure, e.g.

- geological discontinuity features
- geotechnical units, i.e. structural units, lithological units, strength units
- rock mass ratings
- uniaxial compressive strength
- Young's Modulus and Poisson's Ratio
- tensile strength
- cohesion
- friction angle
- propensity of the rock/coal to slake and/or swell
- indications of principal stress directions and relative magnitudes
- geotechnical information for infrastructure placing and construction.

6) Relevant publications and research findings, e.g. SIMRAC Research Reports.

7) Department of Minerals and Energy *Guideline for the Compilation of a Mandatory Code of Practice to Combat Rockfall Accidents in Collieries.*

8) Government regulations and international standards, e.g.

- Minerals Act, 1991 (Act 50 of 1991)
- Mine Health and Safety Act, 1996 (Act 29 of 1996.
- ISO Standards.

Step 6: Preliminary design (system planning)

Based on the input parameters and information collected under Steps 1 to 5 above, prepare separate strata control and roof support strategies and specifications for:

- bord-and-pillar mining areas
- roadways
- high-extraction panels
- areas where subsidence control is required
- areas where changes in ground conditions occur.

1) Bord-and-pillar mining pillar design

Pillars must be designed to suitable safety factors using the Salamon and Munro (1976) formula or any other formula with proven applicability. Safety factors must be specified for the following:

a) main development
b) secondary development
c) production panels.

In all cases cognisance must be taken of any structures that already exist or that can be erected during the life of the mine. Such structures must be protected by designing pillars to the appropriate safety factors. Where the coal strength is known to be different from the average value of 7,2 MPa that was derived by Salamon and Munro (1967), the locally applicable value must be used.

NB! Deviations from the Salamon and Munro (1967) formula must be approved by the Chief Inspector, Department of Minerals and Energy.

2) Roadway roof support design methodology

Coal mining roofs can be broadly classified into three main types:

a) Those for which no systematic roof support is required (i.e. massive sandstone roofs); in this case a specific roof support strategy must be specified and designed.

b) Suspension-type roofs (i.e. roofs consisting of a relatively thin layer of weak material overlain by stronger layers).

   Suspension-type roofs must be supported by means of a suitable support system designed by a suitably qualified rock engineering practitioner. The design must be based on the weight of the weak material, multiplied by a suitable safety factor, balanced by the load-bearing capacity of the support system. The load-bearing capacity of the system must be determined by suitable and internationally recognised test procedures.

   Special attention must be given to potential failures between support components, i.e. to the support of discontinuities and the pre-support protection measures (maximum drivage distance before support is installed, temporary supports, canopy protection and the time delay before installing support).

c) Roofs where beam creation is required (i.e. where a thick layer of weak material such as shale, mudstone or another laminated material overlies the coal seam).

Where a thick, weak roof occurs, an artificial beam must be created by placing roof support in such a way that the shear stresses in the roof are countered. Alternatively, prop support or long anchors must be installed to provide sufficient suspension resistance. The support must be designed by a qualified rock engineering practitioner/consultant.

Attention must also be given to inter-support element failures, the support of discontinuities and pre-support measures (i.e. maximum drivage distance before support is installed, temporary supports, canopy protection and the time delay before installing support).

3) **Generic roof support requirements**

(i) Discontinuities: Joints, slips and other geological discontinuities must receive priority attention during the design and operating phases. An effective, scientifically motivated discontinuity support system or systems must be specified, beginning with the identification of the hazard and covering all steps up to the final safe situation.

(ii) Road width: The specification of the maximum tolerable road width is an integral part of the roof support design process, be it a massive, strong roof or a thick weak material.

In the absence of historical data (as is typical with new mines), the maximum road width must be calculated on the basis of the standard beam theory, taking into account the thickness of the roof layers, the loading of the beam and the tensile strength of the roof material.

(iii) Burnt coal: Special support requirements, making provision for extended area coverage (i.e. wire mesh, shotcrete, etc.) are required in areas of burnt coal. The maximum pre-support drivage distance in burnt coal must be specified in the design.

(iv) Ribside support: Where ribside spalling could pose a hazard due to depth, mining height, weak or burnt coal, etc., a suitable ribside support strategy must form part of the roof support design specifications.

(v) Water and gas pressure: In cases where gas or water pressure could pose a hazard, suitable measures such as pressure-relieving holes or additional support must be included in the roof support design strategy.

(vi) Quality control measures and testing procedures for all material to be used for roof support purposes must be specified.

(vii) In the design stage of any new underground coal mine, a procedure to determine changes in roof conditions must be specified.

4) High-extraction panel and pillar design strategy

The strata control and roof support strategies to be adopted for high-extraction coal mining are largely dependent on the behaviour of the overburden strata and pillars. Panel widths should be designed to ensure one of two options: i.e. that the overburden either fails or remains intact, and then the pillars should be designed to cater for the predicted stress levels.

For instance, if it is decided to mine in such a manner that an overlying dolerite sill in the overburden remains intact, then higher stress levels will develop on stooping pillars and this increased stress must be taken into account when sizing the pillars. The same is true for inter-panel pillars and chain pillars in longwalling.

The decision on whether to allow the overburden to fail or not should be based on the following underground stress conditions:

- surface control
- ground water control, i.e. water influx into the mine and environmental considerations.

In the case of stooping, the strategy must take into account the direction in which pillar extraction is to be done (i.e. from the high to the lower stress side of the panel, or on the basis of trends in geological discontinuities) and the pillar extraction method to be used, as well as the stooping support (i.e. roof bolt or timber breaker lines).

The design of the panels and pillars for high-extraction mining should be done by a suitably qualified rock engineering practitioner. Where existing panels are considered for stooping, a suitably qualified rock engineering practitioner must carry out an investigation.

5) **Subsidence control**

In the case of high-extraction mining or any other mining method that could lead to subsidence of the surface, the strategy should include plans for handling subsidence effects. This will require a survey of the surface use, be it agriculture or man-made (artificial) structures.

Consideration must also be given to the consequences of rapid drainage of flooded areas. The nature and magnitude of such subsidence must be predicted, followed by a prediction of the effects of the subsidence. These could include ponding, drying up of boreholes or cosmetic, architectural or structural damage to artificial structures.

The design strategy should include a method of handling these effects, for instance mitigation of ponds, compensation for crop losses, or repair, replacement or abandonment of structures. The subsidence-prediction model must include the prediction of surface strains and tilts and must use proven and established methods, either the methods developed in a specific mining region or one of the more general methods such as those proposed by Schümann or Van der Merwe.

6) **Stability of bord intersections and service excavations**

Special strategies must be developed for bord intersections and larger service excavations.

7) **Protection of mine access**

Detailed strategies, based on sound rock engineering principles, must be developed for the protection of shafts and/or other main entrances.

Step 7: Hazard identification and risk assessment

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the operating, decommissioning and closure phases for each of the underground mining layouts and associated strata control and roof support strategy options considered.

Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary underground mining layout and design specifications.

Step 8: **Sensitivity analysis and evaluation of options**

Test the sensitivity of the preliminary roof support and strata control options to :

- environmental impacts
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: **Selection of the preferred option**

Identify and select the underground roof support and strata control option that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: **Detailed design**

Prepare a detailed design of the roof support and strata control options based on the outcomes of Steps 1 to 9 above.

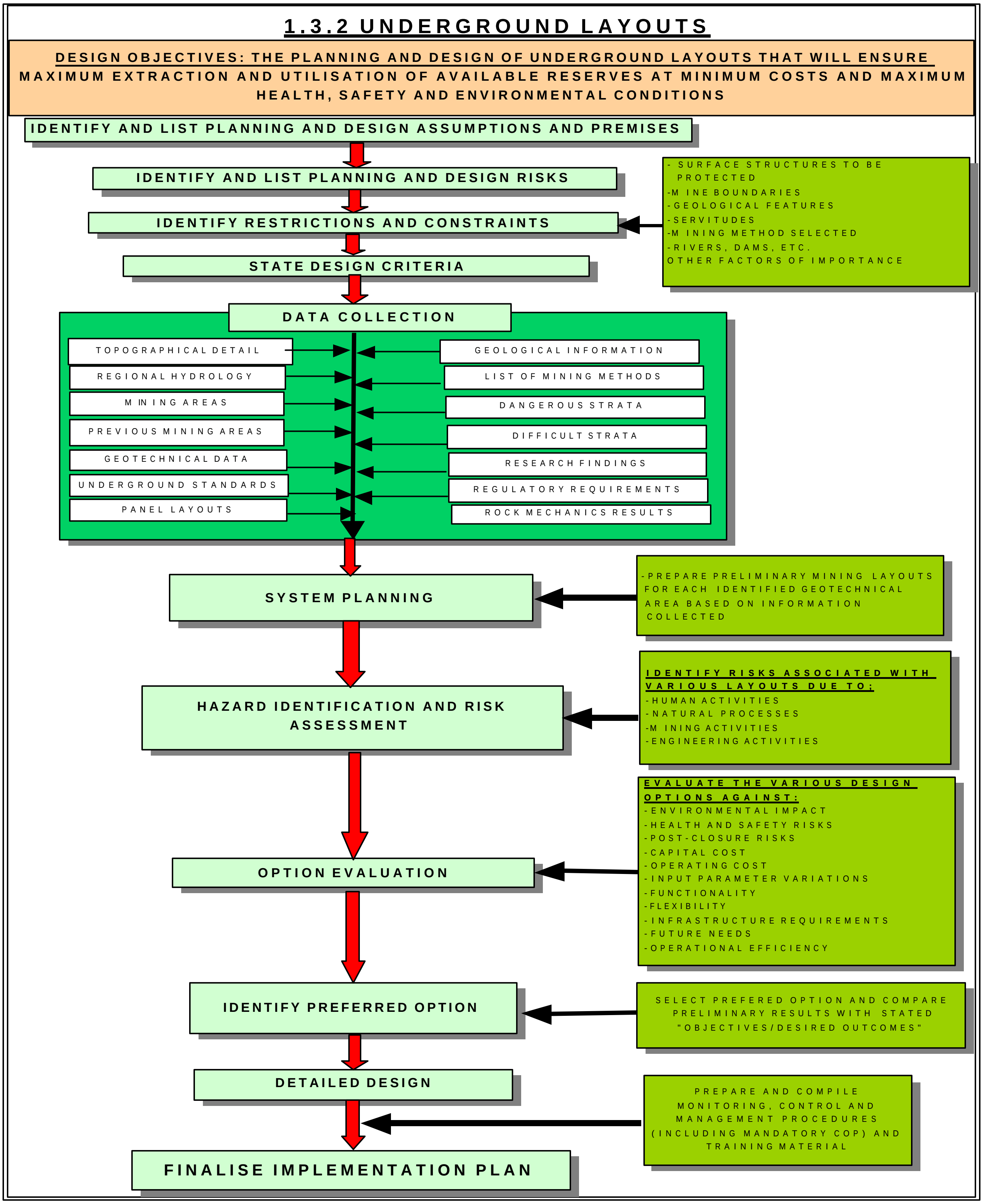
Step 11: **Monitoring, control and management procedures**

i. Identify and prepare the monitoring, control and management procedures that will ensure a safe, healthy and effective mining operation within the constraints of the proposed underground mining area.

ii. Prepare Codes of Practice and/or standard operating procedures applicable to strata control and rock mechanics. (The code of practice must be drawn up as prescribed in document GME 7/4/118-AB2: *Guideline for the Compilation of a Mandatory Code of Practice to Combat Rockfall Accidents in Collieries).*

iii. Prepare sufficient and relevant training material.

1.3.2 Underground layouts



Objectives/desired outcomes: The planning and design of underground layouts that will ensure maximum extraction and utilisation of available coal resources at minimum capital and operating costs under safe, healthy and environmentally responsible conditions.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints that will have an influence on the underground mining layouts due to regulatory requirements, as well as physical, technical and/or environmental conditions, e.g.

- surface structures to be protected
- mine boundaries
- geological features
- mining method selected
- strata control and roof support strategies
- servitudes
- rivers, dams and other water courses.

Step 4: Design criteria

Identify and list the required design criteria to be considered for the underground workings.

Step 5: Data collection

The following basic information will be required to develop underground mining layouts:

1) **Surface plans indicating:**
   - existing infrastructure
   - infrastructure that need to be protected
   - location of rivers, streams and dams.

2) **Mining areas:** Plans indicating:
   - property boundaries
   - extent of mineral/coal rights
   - coal outcrops
   - coal sub-outcrops

- extent of coal reserves.

3) **Geological information:** Geological plans for each coal seam indicating:
   - floor contours
   - roof contours
   - coal seam thickness contours
   - coal quality contours
   - contours of selected mining heights
   - depth below surface contours
   - geological structures, e.g. dykes, faults, burnt coal, hydrological areas
   - contours of interburden thickness between mineable seams
   - other information relevant to the particular project.

4) **Previous mining areas:** General plans indicating the extent of previous mining activities, possible water accumulation and other information that may be considered to be of importance.

5) **Primary development standards:** Define primary development standards in terms of:
   - number of roads per development section
   - roof support and strata control strategies
   - pillar dimensions
   - road widths
   - safety factors.

6) **Secondary development standards:** Define secondary development standards in terms of:
   - number of roads per secondary development section
   - roof support and strata control strategies
   - pillar dimensions
   - road widths
   - safety factors.

7) **Panel layout:** Define typical panel layouts in terms of:
   - number of roads
   - roof support and strata control strategies
   - in-panel pillar dimensions
   - road widths
   - safety factors

- maximum panel lengths
- inter-panel barrier pillar widths.

8) **Government regulations, statutory requirements and international standards,** e.g.
   - Minerals Act, 1991 (Act 50 of 1991)
   - Mine Health and Safety Act, 1996 (Act 29 of 1996)
   - SABS Standards
   - DME guidelines
   - ISO Standards.

9) **Relevant publications and research findings** related to underground panel layouts, e.g. SIMRAC Research Reports.

10) **Geotechnical and rock mechanics results:** The results of a detailed geotechnical and rock mechanics investigation defining the support strategies to be followed in each identified geotechnical area.

11) **Mine ventilation results** indicating the mine ventilation strategies to be followed to prevent the possible accumulation of dangerous and/or flammable gases, to assess explosion potential and to control dust-generating areas.

Step 6: Preliminary design (system planning)

Based on the input parameters and information collected under Steps 1 to 5 above, prepare preliminary underground layouts that will best suit the prevailing geological and geotechnical conditions in the defined mining area.

Step 7: Hazard identification and risk assessment

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the operating, decommissioning and closure phases for each of the underground mining layout options considered.

Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary underground mining layout and design specifications.

Step 8: **<u>Sensitivity analysis and evaluation of options</u>**

Test the sensitivity of the preliminary mining layouts and design options to:

- environmental impacts
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: **<u>Selection of the preferred option</u>**

Identify and select the underground mining layout that will best meet the criteria stated under "Objectives/desired outcomes".

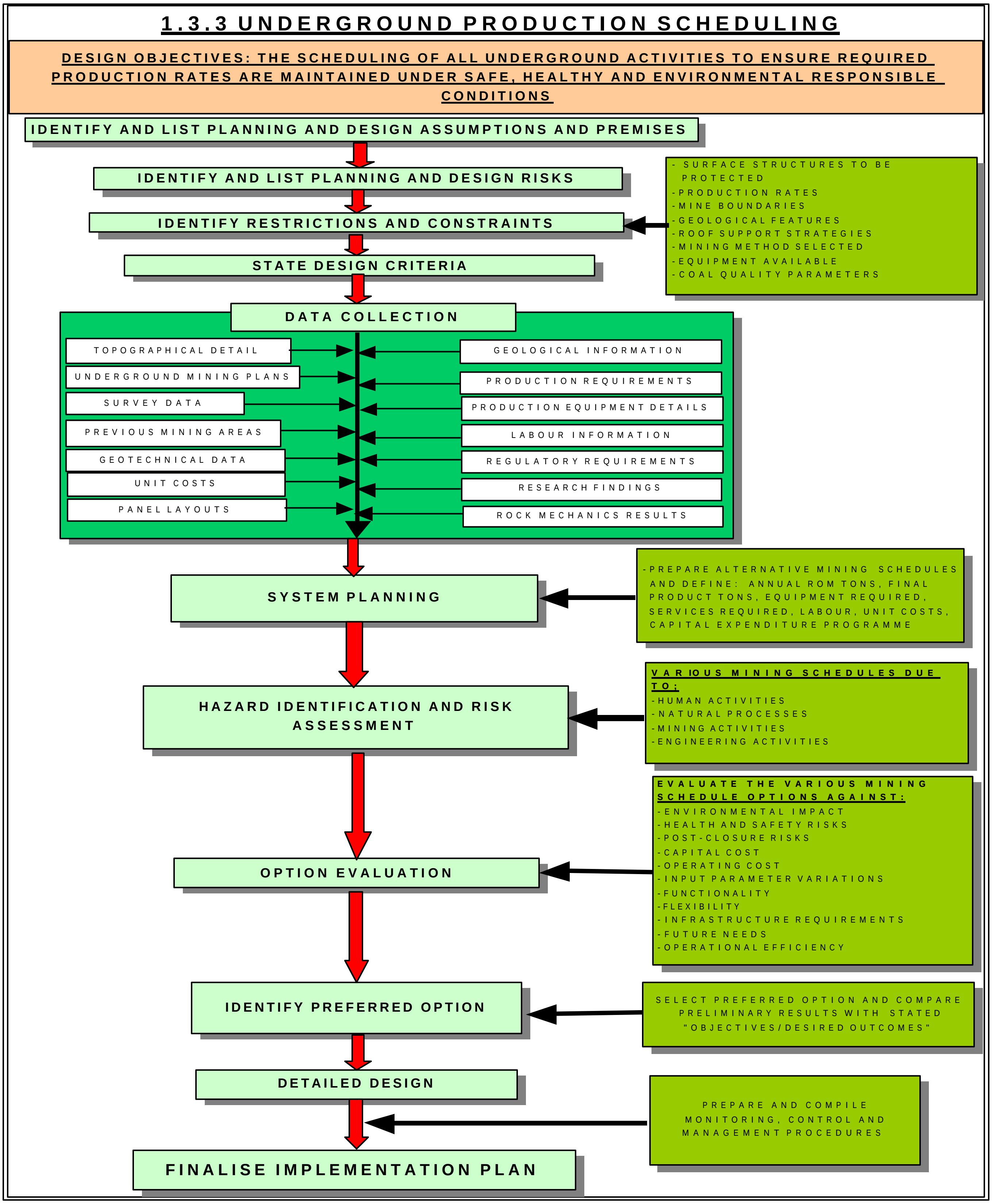
Step 10: **<u>Detailed design</u>**

Prepare a detailed design of the underground layout based on the outcomes of Steps 1 to 9 above.

Step 11: **<u>Monitoring, control and management procedures</u>**

Prepare the monitoring, control and management procedures to be introduced and followed during the mine's operational, decommissioning and closure phases to ensure that the required standards in terms of health, safety and environmental conditions are maintained.

1.3.3 Underground production scheduling



Objectives/desired outcomes: The primary objectives of the underground production scheduling for a given mining layout are as follows:

a) to ensure that the required production output rates are achieved on a continuous basis throughout the life of the mine in the most cost-effective manner, under safe, healthy and environmentally responsible conditions
b) to ensure the effective blending of run-of-mine coal from different areas within the mining plan in order to meet the required final product specifications and to maximise available coal reserves/resources
c) to ensure that at any time during the life of the mine sufficient pit room has been developed to facilitate timeous and cost-effective relocation from one production area to another
d) to ensure the timeous installation of all required underground and surface structures, services, and equipment to facilitate an efficient, safe and healthy mining operation.

Step 1: Planning, design and scheduling assumptions and premises

Identify and list all planning design and scheduling assumptions and premises.

Step 2: Identification of planning, design and scheduling risks

Identify and list all planning, design and scheduling risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints that will influence mine scheduling, e.g.

- underground development rates
- availability of underground equipment, services and infrastructure
- mining method selected
- surface structures to be protected
- strata control and roof support strategies
- control and management of underground water
- presence of geological features, e.g. dykes, faults, sills, etc.
- coal quality parameters to be achieved
- equipment production rates.

Step 4: Mine scheduling criteria

Identify and list the required mine and production scheduling criteria to be considered.

Step 5: Data collection

The following basic information will be required for the preparation of underground production schedules:

1. Surface plans indicating:
    - existing infrastructure
    - infrastructure that needs to be protected
    - location of rivers, streams and dams.

2. Underground mining plans for each seam to be mined indicating:
    - property boundaries
    - extent of mineral/coal rights
    - coal outcrops
    - coal sub-outcrops
    - extent of coal reserves
    - position(s) of shafts and/or shaft systems
    - position and layout of primary developments
    - position and layout of secondary and tertiary developments
    - position and layouts of production panels
    - extent and location of previous mining areas.

3. Geological information: Geological plans for each coal seam to be mined indicating:
    - floor contours
    - roof contours
    - coal seam thickness contours
    - coal quality parameter contours
    - contours of selected mining heights
    - location and extent of geological features, e.g. dykes, faults, burnt coal, hydrological areas
    - contours of interburden thickness between mineable seams
    - other geological information that is considered relevant to mine and production scheduling.

4. Survey data: The latest information related to:
    - positions of all underground mining faces
    - positions of underground services, structures and facilities.

5. Production requirements: Detailed specifications of the annual, monthly and weekly production targets to be achieved in terms of:
    - final product output rates
    - final product quality parameters.

6. <u>Details of mine production equipment</u>, e.g.

- average production rates achieved to date
- expected future production rates
- maintenance policies and procedures.

7. <u>Labour-related information</u>, e.g.

- basic conditions of employment
- shift schedules
- leave provision and entitlement
- training requirements.

8. <u>Government regulations, statutory requirements and international standards</u>, e.g.

- Minerals Act, 1991 (Act 50 of 1991)
- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- SABS Standards
- DME Guidelines
- ISO Standards.

9. <u>Relevant research findings and publications</u> related to underground coal mine production scheduling.

10. <u>Geotechnical and rock mechanics results</u>: The results of a detailed geotechnical and rock mechanics investigation defining the support strategies to be followed in each identified geotechnical area.

11. <u>Costs</u>: e.g. unit operating costs and capital costs for each identified mining machine, installation, etc. to be purchased or installed.

Step 6. <u>Preliminary schedules (system planning)</u>

Based on the input parameters and information identified and collected under Steps 1 to 5 above, prepare alternative mining production schedules for the life of the mine. Each production schedule must provide detailed information related to:

- annual run-of-mine tons produced and the associated coal qualities
- annual tonnages of final product produced and the associated coal qualities
- annual mining equipment requirements
- underground services, facilities and infrastructure requirements

- labour requirements
- average annual unit operating cost
- capital expenditure programme required to meet the targeted final output rate.

Step 7. Hazard identification and risk assessment

For each of the mining schedules generated, identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the life cycle of the mine. Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks. Incorporate these strategies into the relevant underground mining schedules.

Step 8. Sensitivity analysis and evaluation of options

Test the sensitivity of each of the mine scheduling alternatives to:

- environmental impacts
- health and safety risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the schedule
- infrastructure requirements
- future production needs
- operational, labour and managerial efficiencies
- reserve utilisation.

Step 9. Selection of the preferred option

Identify and select the mining schedule that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10. Detailed scheduling

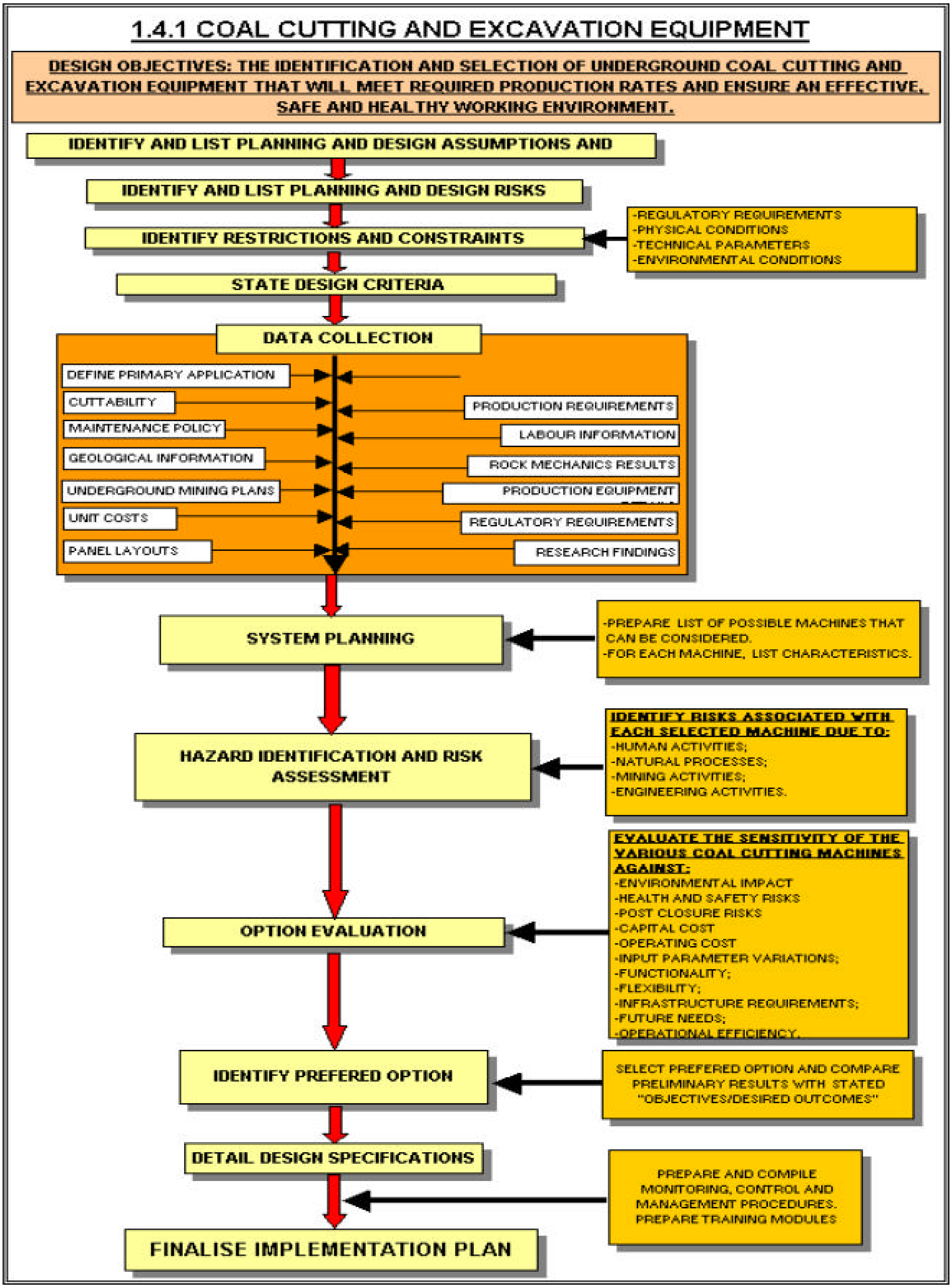
Prepare a detailed mine and production schedule based on the outcomes of Step 9 above.

Step 11. Monitoring, control and management procedures

Prepare the necessary monitoring, control and management procedures to be introduced and followed during the mine's operational, decommissioning and closure phases to ensure that the required health, safety and environmental standards are maintained.

1.4 UNDERGROUND EQUIPMENT

1.4.1 Coal cutting and excavation equipment



Objectives/desired outcomes: The identification and selection of the type and number of underground coal cutting and excavation machines that will meet the required production outputs and will ensure a safe, healthy and effective mining operation within the constraints of prevailing geological conditions and the prescribed mining plan.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises relating to the selection of coal cutting and excavation equipment.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints imposed on underground coal cutting and excavation equipment due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the coal cutting and excavation equipment.

Step 5: Data collection

To prepare a detailed design specification for, and on the basis of this to select, the underground coal cutting and excavation equipment, the following information will be required:

1) Define the primary application of the coal cutting and excavation equipment.
2) Determine typical underground conditions under which these machines will be required to operate, e.g.
   - total seam thickness
   - required mining height (maximum, minimum, average)
   - gas-emission rates and concentrations
   - floor conditions
   - floor gradients (maximum, minimum, average)
   - expected roof conditions
   - maximum dust concentration levels allowed
   - required pillar dimensions
   - typical panel layout.

3) Determine the coal cuttability index:

- type of material to be cut
- dimensions and frequency of stone bands that will be encountered
- cuttability index of material to be cut (minimum, maximum, average).

4) Production requirements:

- production output rates per hour, day, month or year (maximum, minimum, average)
- typical size distribution of coal required.

5) Other operating parameters that may influence the selection criteria:

- shift schedules
- maintenance policies and schedules
- power source.
- capability and competency of the workforce

6) Relevant publications, guidelines, research findings, Government regulations and standards that could influence the ultimate selection of coal cutting and excavation equipment e.g.

- Mine Health and Safety Act,1996 (Act 29 of 1996)
- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- DME Guidelines
- SIMRAC Research Reports
- ISO Standards.

Step 6: System planning (preliminary design)

Prepare a list of possible machines that can be considered for the underground coal cutting and excavation processes.

For each individual machine identified, determine and list the

- power requirements
- critical dimensions (height, width, length)
- ergonomic layout
- emission levels
- braking systems
- turning radius

- operational performances
- tramming speeds
- tramming times
- waiting time
- change-out time
- cutting and/or excavation time

  cycle time
- coal cutting mechanisms
- acquisition, operational and disposal costs
- performance reliability
- service intervals
- service life
- life-cycle costing
- availability of spares and supplier support
- standard safety equipment fitted.
- operating skills required
- training requirements

Step 7: <u>Hazard identification and risk assessment</u>

Identify and list all significant hazards and risks that could result from human activities, natural processes, mining activities and/or engineering activities. Using the list of possible equipment already compiled, identify and list all modifications and/or alterations that will be required on each machine to eliminate, reduce or control the identified risks.

Step 8: <u>Sensitivity analysis and evaluation of options</u>

Test the sensitivity of the coal cutting and excavation equipment selected to:

- environmental impacts
- release of harmful gases
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs

- operational efficiencies
- meeting production needs.
- operating skills required
- training needs

Step 9: Selection of the preferred option

Identify and select the type and number of coal cutting and excavation machines that will best meet the criteria stated under “Objectives/desired outcomes”.

Step 10: Detailed design

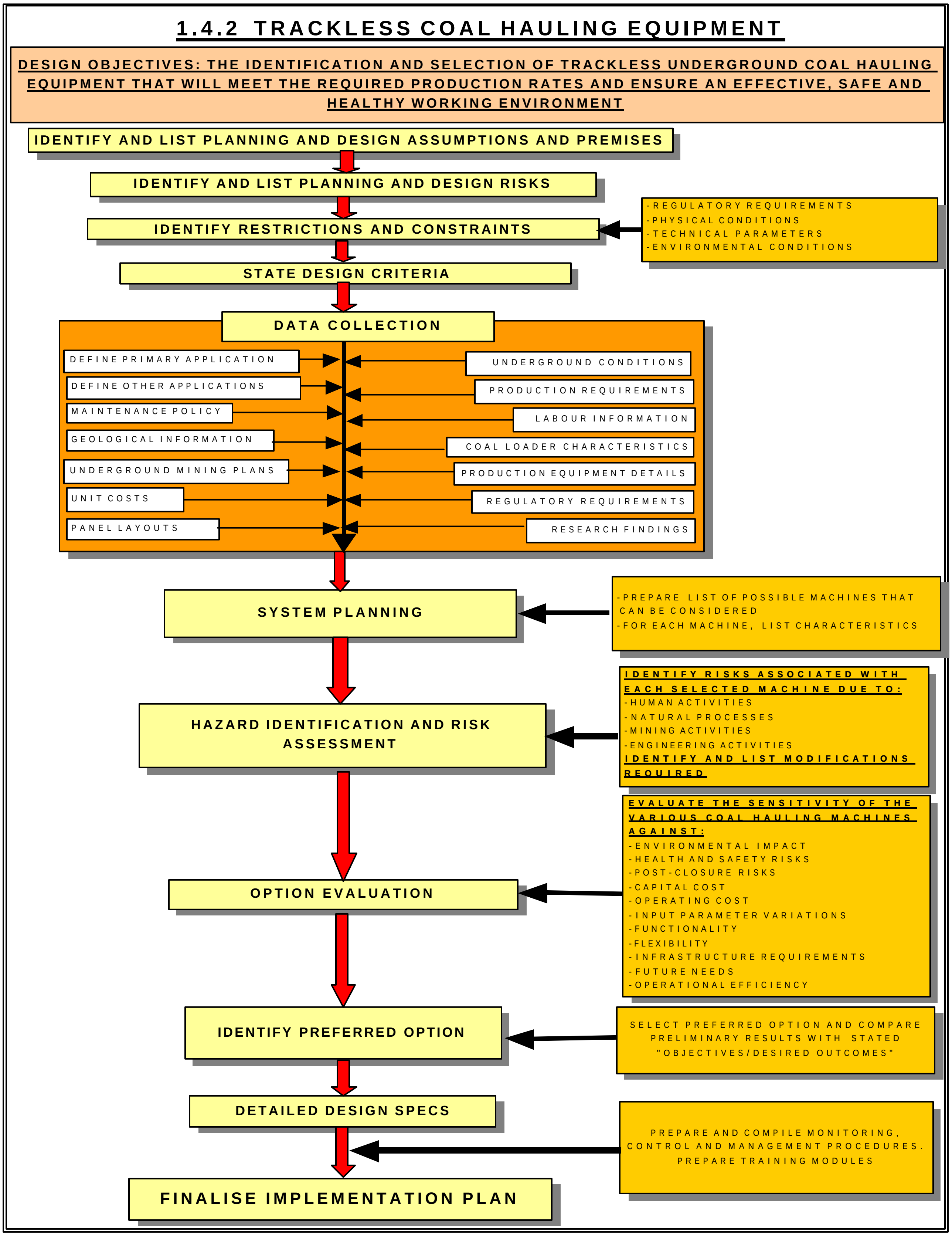
Prepare detailed equipment specifications for the coal cutting and excavation equipment, based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Identify and list all the monitoring, control and management procedures that will be required to ensure the safe, healthy and effective operation of the coal cutting and excavation equipment throughout the life cycle of the underground mine.

Prepare the necessary Codes of Practice and training material.

1.4.2 Trackless underground coal hauling equipment



Objectives/desired outcomes: The identification and selection of the type and number of underground coal hauling equipment (machines) that will meet the required production outputs and will ensure a safe, healthy and effective mining operation within the constraints of the prevailing geological conditions and prescribed mining plan.

Definition: *'Trackless underground coal hauling equipment' means any machine, self-propelled or otherwise, that is*

a) *used for the purpose of performing mining, transport or associated operations in an underground coal mine specific to coal hauling*
b) *is mobile by virtue of its movements on wheels, skids, caterpillar tracks, mechanical shoes or any other device fitted to the machine, but excludes:*
    - *any such machine that is railbound*
    - *scraper winches and scoops*
    - *static winches and winding machinery installations and any equipment attached thereto*
    - *underground coal crushing and/or feeder-breaker installations*
    - *conveyor belt installations and any equipment attached thereto*
    - *light commercial vehicles*
    - *trackless underground utility vehicles.*

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises relating to the selection of the trackless underground hauling equipment.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the trackless underground coal hauling equipment due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the trackless underground coal hauling equipment.

Step 5: Data collection

To determine the number and type of trackless underground coal hauling machines required for the planned underground coal mining operation, the following information will be required:

1) Define the primary applications of the trackless underground coal hauling machines (e.g. hauling coal from the loader to the feeder-breaker or any other identified discharge point).

2) Define any other application for which the trackless underground coal hauling machines could be used, e.g. clean-up of spillage, transportation of material, etc.

3) Determine typical underground conditions under which these machines will be required to operate, e.g.
   - total coal seam thickness
   - planned mining height (maximum, minimum, average)
   - possible gas concentrations and emission rates
   - general floor conditions
   - floor gradients (maximum, minimum, average)
   - expected roof conditions
   - expected dust concentrations
   - planned roadway widths (maximum, minimum, average)
   - planned turning circle clearances (maximum, minimum, average)
   - dangerous areas, obstructions or restricted clearances
   - underground layouts indicating:
     - ⇒ typical position of the feeder-breaker or other coal discharge installation relative to the coal loader
     - ⇒ typical routes used by pedestrians, cyclists and trackless coal hauling machines
     - ⇒ provision of illumination for the general area in which the transport of people, material, coal or explosives takes place by means of trackless machines, e.g. position and spacing of such lights, intensity and dispersion of light, and reflectivity of the surrounding area.

4) Determine the characteristics of the material to be hauled, e.g.
   - density (in situ, loose)
   - swell factor
   - size distribution.

5) Determine the production requirements in terms of:

- planned production output rates (maximum, minimum, average) per hour, day, month and/or year
- size distribution of coal and/or other material to be hauled.

6) Other operating parameters required:

- type and size of coal loaders
- production rates of coal loaders
- shift schedules
- maintenance policy and schedules
- power source.
- operating skills
- operator training

7) Relevant publications, guidelines, research findings, Government regulations and standards that could influence the ultimate selection of the trackless underground coal hauling equipment, e.g.

- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- DME Guidelines
- SIMRAC Research Reports
- ISO Standards.

Step 6: <u>System planning (preliminary design)</u>

Prepare a list of possible machines that can be considered for the underground coal hauling and transportation processes.

For each individual machine identified, determine and list the:

- power requirements
- critical dimensions (height, width, length)
- ergonomic layout
- emission levels
- braking systems
- turning radius
- operational performances

- tramming speeds
- loading times
- tramming times
- waiting time
- change-out time
- coal discharge mechanisms
- acquisition, operational and disposal costs
- performance reliability
- service intervals
- service life
- life-cycle costing
- availability of spares and supplier support
- standard safety equipment fitted.
- operating skills required
- training requirements

(loading times, tramming times, waiting time, change-out time: cycle time)

Step 7: <u>Hazard identification and risk assessment</u>

Identify and list all significant hazards and risks that could result from human activities, natural processes, mining activities and/or engineering activities. Using the list of possible trackless coal hauling equipment, identify and list all modifications and/or alterations that will be required for each machine in order to eliminate, reduce or control the identified risks.

Step 8: <u>Sensitivity analysis and evaluation of options</u>

Test the sensitivity of the identified trackless coal hauling equipment to:

- environmental impacts
- release of harmful gases
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements

- future production needs
- operational efficiencies
- meeting the required production needs.

Step 9: Selection of the preferred option

Based on the outcomes of the evaluation processes described in Steps 1 to 8 above, identify and select the type and number of trackless coal hauling equipment (machines) that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: Detailed design

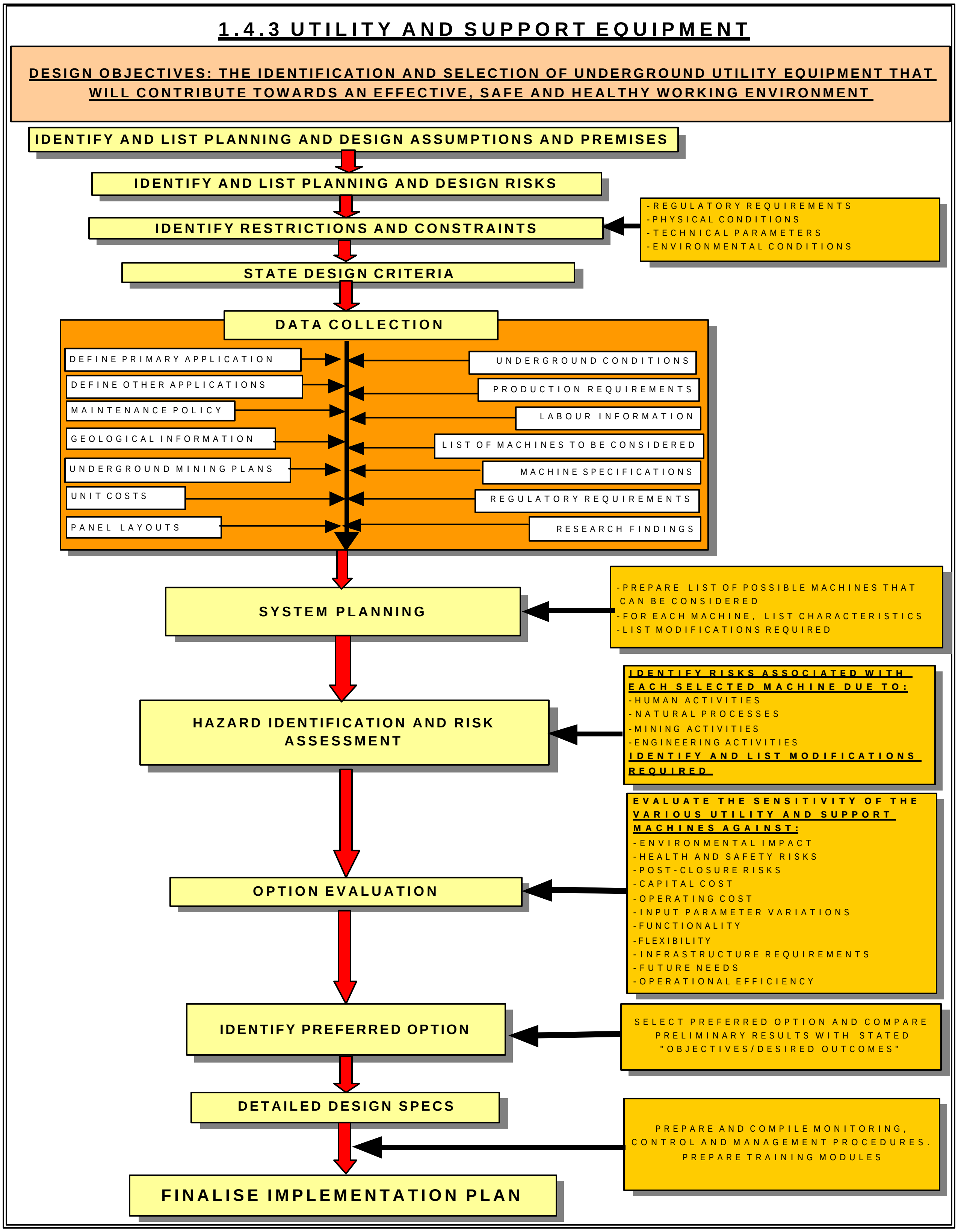
Prepare detailed equipment specifications for the trackless coal hauling equipment selected.

Step 11: Monitoring, control and management procedures

Identify and list all the monitoring, control and management procedures that will be required to ensure the safe, healthy and effective operation of the trackless coal hauling equipment throughout the life cycle of the underground mine.

Prepare the necessary Codes of Practice and training material.

1.4.3 Utility and support equipment (e.g. roof bolters, LHDs, multi-purpose vehicles, etc.)



Objectives/desired outcomes: The selection and specification of the type and number of trackless underground utility and support machines which, if properly complied with and implemented, will contribute towards achieving improved health, safety and production standards and conditions in the planned underground mine.

Definition: "*Trackless underground utility and support machines" means any machine, self-propelled or otherwise, that is*

a) used for the purpose of performing mining, transport or associated operations in an underground coal mine

b) not a primary coal cutting, loading and/or hauling machine

c) mobile by virtue of its movement on wheels, skids, caterpillar tracks, mechanical shoes or any other device fitted to the machine, but excludes :

- *any such machine that is railbound*
- *scraper winches and scoops*
- *static winches and winding machinery installations and any equipment attached thereto*
- *underground coal crushing and/or feeder-breaker installations*
- *conveyor belt installations and any equipment attached thereto*
- *light commercial vehicles.*

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises relating to the selection of the trackless underground utility and support equipment.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the underground utility and support equipment due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the underground utility and support equipment.

Step 5: <u>Data collection</u>

To determine the number and type of trackless utility and support machines required for the planned underground coal mining operation, the following information will be required:

1) Define the primary applications of the trackless underground utility and support machines, e.g. roof bolting, transport of personnel and material, stone dusting, road building and maintenance, etc.
2) Define any other application for which the trackless underground utility and support machines could be used (e.g. clean-up of spillage)
3) Determine typical underground conditions under which these machines will be required to operate, e.g.
    - total coal seam thickness
    - planned mining height (maximum, minimum, average)
    - possible gas concentrations and emission rates
    - general floor conditions
    - floor gradients (maximum, minimum, average)
    - expected roof conditions
    - expected dust concentrations
    - planned roadway widths (maximum, minimum, average)
    - planned turning circle clearances (maximum, minimum, average)
    - dangerous areas, obstructions, or restricted clearance
    - underground layouts indicating:
        - typical position of the feeder-breaker or other coal discharge installation relative to the coal loader
        - typical routes used by pedestrians, cyclists and other underground mining machines
        - provision of illumination for the general area in which the transport of people, material, coal or explosives takes place by means of trackless machines, e.g. position and spacing of such lights, intensity and dispersion of light, and reflectivity of the surrounding area.

4) Determine the total production requirements for each type of trackless utility and support machine (maximum, minimum, average)

5) Determine other operating parameters, e.g.
    - shift schedules
    - maintenance policy and schedules
    - power source (electric, battery or diesel-operated).

6) Prepare a list of possible trackless utility machines that can be considered for the tasks identified under paragraph 1) above.

7) For each machine listed under paragraph 6), determine and list the manufacturer's specifications relating to:

- critical dimensions (height, width, length)
- ergonomic layout
- emission levels
- braking systems
- turning radius
- operational performance
- total production capabilities
- acquisition, operational and disposal costs
- life-cycle costing
- maintenance procedures and standards
- service intervals
- availability of spares and supplier support
- reliability
- standard safety equipment fitted.
- operating skills required
- training requirements

Step 6: <u>System planning (equipment selection)</u>

1) Select one (or more) of the machine types listed under paragraph 6) above.

2) Based on the operational performances of the machine types selected and the total production requirements, calculate the total number of trackless utility units required.

3) For each machine selected, identify possible modifications that will be required to enhance the health and safety of personnel and/or production performances, e.g.

- provision of an effective service braking system
- provision of parking brakes
- provision of emergency brakes
- Roll Over Protection and Falling Objects Protection systems
- equipment to assist with the safe boarding of, alighting from, riding on or working on top of machines
- effective design and operation of tow bars and coupling devices

- fitting of lights to identify the front, rear and sides of the machines
- fitting of adjustable lights to illuminate places critical to safe operations
- systems to negate unexpected incapacitation of the driver/operator
- vibration-control devices
- noise-control systems
- systems to warn people working or travelling in close proximity to the utility and service machines, e.g. audible alarm, hooter or clearly visible flashing light.
- systems to enhance operator efficiencies

Step 7: Hazard identification and risk assessment

Taking into consideration the planned underground layout, general operating conditions and equipment specifications, compile a list of potential hazards and the associated risks for the selected machines caused by

- human activities
- natural processes
- mining activities
- engineering activities that will impact on the safety and health of personnel working with, or in the vicinity of, the trackless utility and service equipment.

Step 8: Sensitivity analysis and evaluation of options

Evaluate the sensitivity of the trackless utility and service machines selected in terms of:

- environmental impacts
- health and safety risks
- post-closure impact
- capital cost
- operating cost
- variations in input parameters
- system flexibility
- infrastructural and maintenance requirements
- production output requirements.
- operating skills required
- training needs

Step 9: **<u>Selection of the preferred option</u>**

Identify and select the underground trackless utility and service machines that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: **<u>Detailed design</u>**

Prepare detailed design specifications for the selected trackless utility and service machines to be used underground.

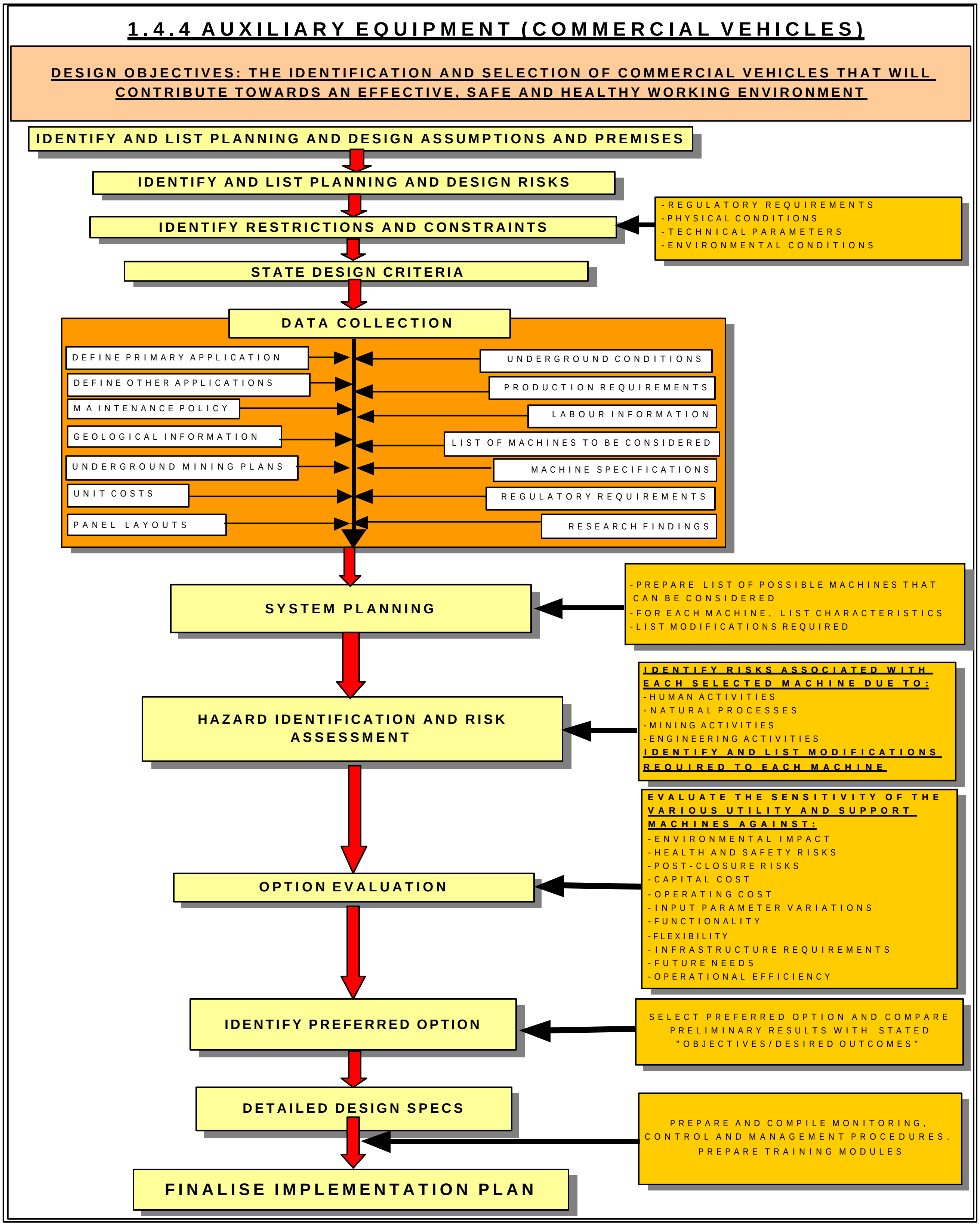
Step 11: **<u>Monitoring, control and management procedures</u>**

i. Identify the monitoring, control, management, maintenance and operating standards and procedures that will ensure the safe and effective use of all underground trackless utility machines.

ii. Prepare the mandatory Code of Practice as prescribed by the Department of Minerals and Energy document, DME 16/3/2/2-A2 entitled *Guideline for the Compilation of a Mandatory Code of Practice on Trackless Mobile Machinery.*

iii. Prepare all the required training material that will ensure the safe and effective use of underground trackless utility machines.

1.4.4 Auxiliary equipment (e.g. commercial vehicles)



Objectives/desired outcomes: The identification, selection and specification of the type and number of commercial vehicles which, if properly complied with and implemented, will contribute towards achieving improved health, safety and production standards in the planned underground mine.

Definition: For the purposes of this guideline document, a ‘commercial vehicle’ is defined as: “*any vehicle that is commercially available and specifically designed, built and approved for use on public roads”.*

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises that relate to the selection of the commercial vehicles to be used underground.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the use of commercial vehicles in an underground coal mining environment due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the commercial vehicles to be used underground.

Step 5: Data collection

To determine the number and type of commercial vehicles required for the planned underground coal mining operation, the following information will be required:

1) Define the planned application(s) of the commercial vehicles, e.g. supervisory vehicles, transporters of material, equipment, explosives and personnel.

2) Determine the typical environmental conditions under which these vehicles will be required to operate, e.g. gas concentrations, floor conditions, bord widths, floor gradients, minimum and maximum roadway heights, ventilation conditions.

3) Prepare a list of possible vehicles that can be considered for use underground.

4) For each vehicle identified above, list its:

- ergonomic layout
- emission levels
- critical dimensions (height, width, length)
- type of drive (4-wheel or 2-wheel)
- braking system
- gear ratio
- carrying capacity
- turning radius
- operational performance
- acquisition, operational and disposal cost
- probable life-cycle costs
- maintenance procedures and standards
- reliability and services provided by supplier
- service intervals
- expected economical service life
- availability of spare parts
- standard safety equipment fitted.
- operating skills requirements

Step 6: <u>Equipment selection (preliminary design)</u>

1) Select one (or more) of the vehicles identified under Step 5 (item 3) for the applications listed under Step 5 (item 1).

2) For each vehicle selected, identify the possible modifications that will be required, e.g.

- modifications to the load box to allow personnel to be carried
- modifications to the load box to allow explosives to be transported
- installation of Roll Over Protection and Falling Objects protection systems
- installation of fail-safe brakes
- rubberising of the load box and chassis
- installation of spark arrestors
- extensions to the differential breather pipe
- lowering of the differential gear ratio
- installation of a governor to limit engine speeds
- derating of the diesel injection pump
- application of special sign-writing on doors, etc.
- fitting of fire extinguishers

- installation of additional lighting
- installation of a reverse siren
- provision of stop blocks
- installation of bull bars
- modifications to the gear box in order to lock out higher gears
- installation of a gear lock and/or alarm immobiliser
- installation of a brake-testing device
- fitting of special tyres for use on rough terrain
- addition of a separate compartment for storing tools/equipment
- flame-proofing.

Step 7: Hazard identification and risk assessment

Identify and list all significant hazards and risks associated with the use of commercial vehicles underground as a result of human activities, natural processes, mining activities and/or engineering activities. Using the list of possible commercial vehicles that can be considered for underground use, identify and list all modifications and/or alterations that will be required for each machine in order to eliminate, reduce or control the identified risks.

Step 8: Sensitivity analysis and evaluation of options

Test the sensitivity of the commercial vehicles selected to:

- environmental impacts
- release of harmful gases
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- meeting production needs.
- operator skills requirements
- training needs

Step 9: **Selection of the preferred option**

Identify and select the type and number of commercial vehicles that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: **Detailed design**

Prepare detailed equipment specifications for the selected commercial vehicles based on the outcomes of Steps 1 to 9 above.

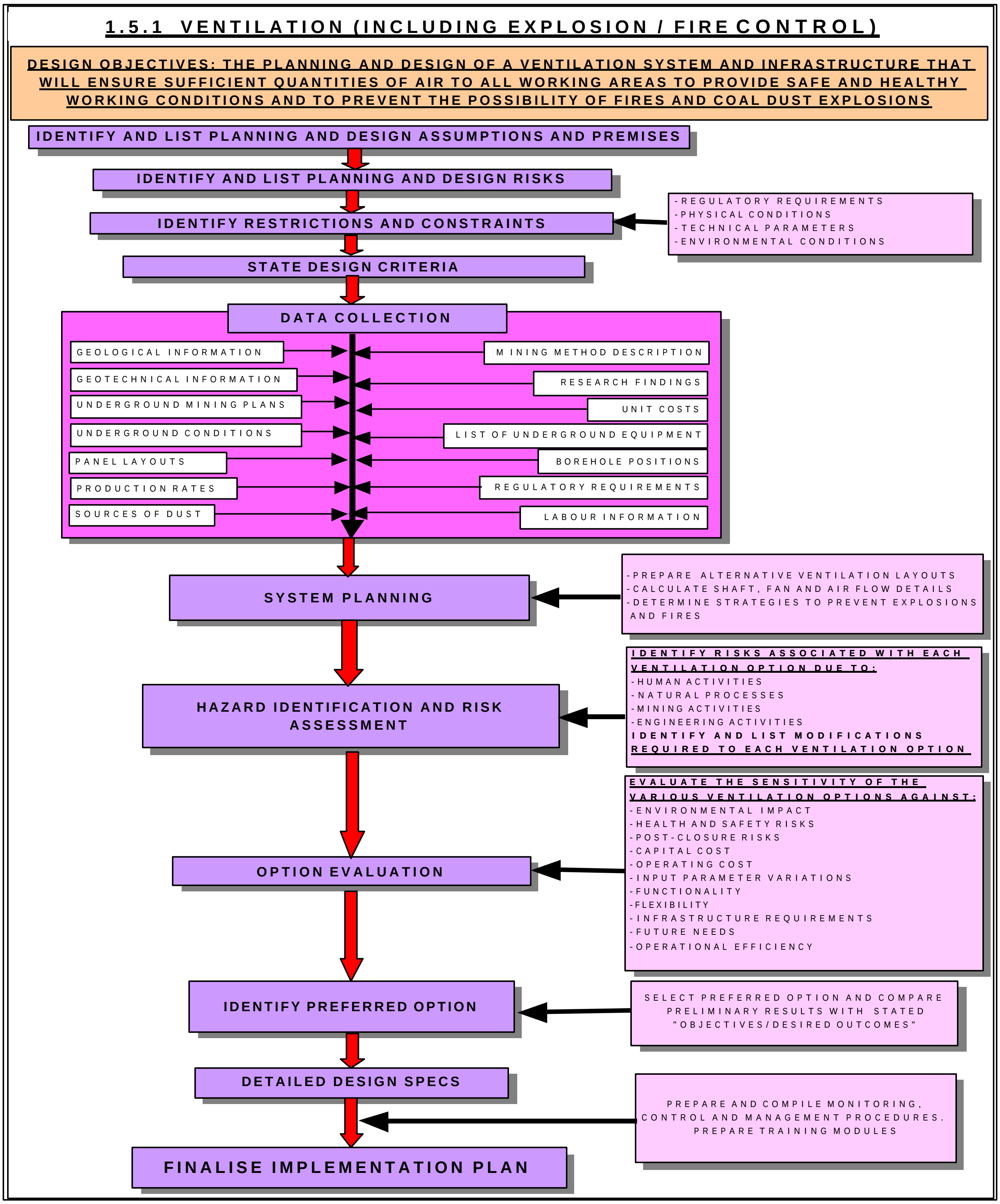
Step 11: **Monitoring, control and management procedures**

Identify and list all the monitoring, control and management procedures that will be required to ensure the safe, healthy and effective operation of the commercial vehicles underground throughout the life cycle of the mine.

Prepare the necessary Codes of Practice and training material.

1.5 UNDERGROUND SUPPORT SERVICES

1.5.1 Mine ventilation and the prevention of underground fires and coal dust explosions



Objective/desired outcomes: The planning and design of a mine ventilation system, associated infrastructure and control mechanisms that will ensure the effective supply of sufficient quantities of air to the designated underground working areas for the purposes of providing safe and healthy working conditions and for the prevention of underground fires and coal dust explosions.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises relating to the mine ventilation requirements and the prevention of underground fires and coal dust explosions.

Step 2: Identification of planning and design risks

Identify and list all ventilation planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the underground ventilation layout and design due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the underground ventilation layout and design and for the strategies to prevent possible underground fires and coal dust explosions.

Step 5: Data collection

For the effective planning and design of the underground mine ventilation layout, as well as strategies to prevent underground fires and coal dust explosions, the following information will be required:

1) Geological and coal seam data:
   - coal seams to be mined
   - coal seam thicknesses
   - in-seam methane content and emission rates
   - K_{ex} values (explosibility indices)
   - proximate analysis
   - location and extent of dolerite dykes, sills, burnt coal
   - location and extent of slips, faults and coal displacements.
   - geological discontinuities.

2) Geotechnical information relating to the stability of the underground coal mine workings and associated infrastructure, e.g.

- geotechnical units, i.e. structural units, lithological units, strength units
- propensity of the rock/coal to slake and/or swell
- indications of principal stress directions and relative magnitudes
- geotechnical information for infrastructure placing and construction.

3) Mining layout and design indicating:

- type, layout and dimensions of proposed shaft systems
- main development ends: number of and cross-sectional dimensions of intake and return airways
- secondary development ends: number of and cross-sectional dimensions of intake and return airways
- panel layouts: in-panel pillar dimensions, bord widths, barrier pillar positions and dimensions, number of and cross-sectional dimensions of intake and return airways
- main conveyor belt routes and conveyor transfer points
- positions of underground crushers and feeder-breakers
- main travelling/transport routes for personnel, material and equipment.

4) Equipment database:

- List of all primary, secondary and auxiliary equipment to be used underground, with special reference to: requirements for flame-proofing, dust-generating potential, cutting drum speed, pick design and methods for preventing frictional ignitions.
- Details of electrical apparatus to be used underground, with special reference to the requirements for flame-proofing and intrinsic safety.

5) Description of the mining methods indicating:

- the mining method proposed for each geotechnical area
- the degree of mechanisation
- planned production rates
- potential sources of coal dust
- proposed measures for dust control
- methods to be used for removing accumulations of coal dust in the face area before the application of stone dust, and in conveyor belt roads, tramming and travelling routes and return airways.

6) Relevant publications, guideline documents, research findings, Government regulations and standards that could influence the layout and design of the underground ventilation system, e.g.

- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- DME Guidelines
- SIMRAC Research Reports
- ISO Standards.

7) Other information, i.e.

- positions of exploration and other boreholes.

Step 6: <u>System planning (preliminary design)</u>

Based on the proposed mining plan, prepare alternative ventilation layouts indicating shaft size requirements, main fan characteristics, auxiliary fan requirements, airflow rates in each working area and strategies to be followed to prevent underground fires and coal dust explosions.

Step 7: <u>Hazard identification and risk assessment</u>

Identify and list the significant hazards and risks associated with each of the mine ventilation options as a result of human activities, natural processes, mining activities and/or engineering activities. Identify and list all the modifications and/or alterations to these ventilation layouts and designs that will be required in order to eliminate, reduce or control the identified risks.

Step 8: <u>Sensitivity analysis and evaluation of options</u>

Test the sensitivity of the mine ventilation layout and design options selected to:

- environmental impacts
- release of harmful gases
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system

- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- meeting production needs.

Step 9: <u>Selection of the preferred option</u>

Identify and select the ventilation layout and design option and its associated strategies to prevent underground fires and coal dust explosions that best meet the criteria stated under "Objectives/desired outcomes".

Step 10: <u>Detailed design</u>

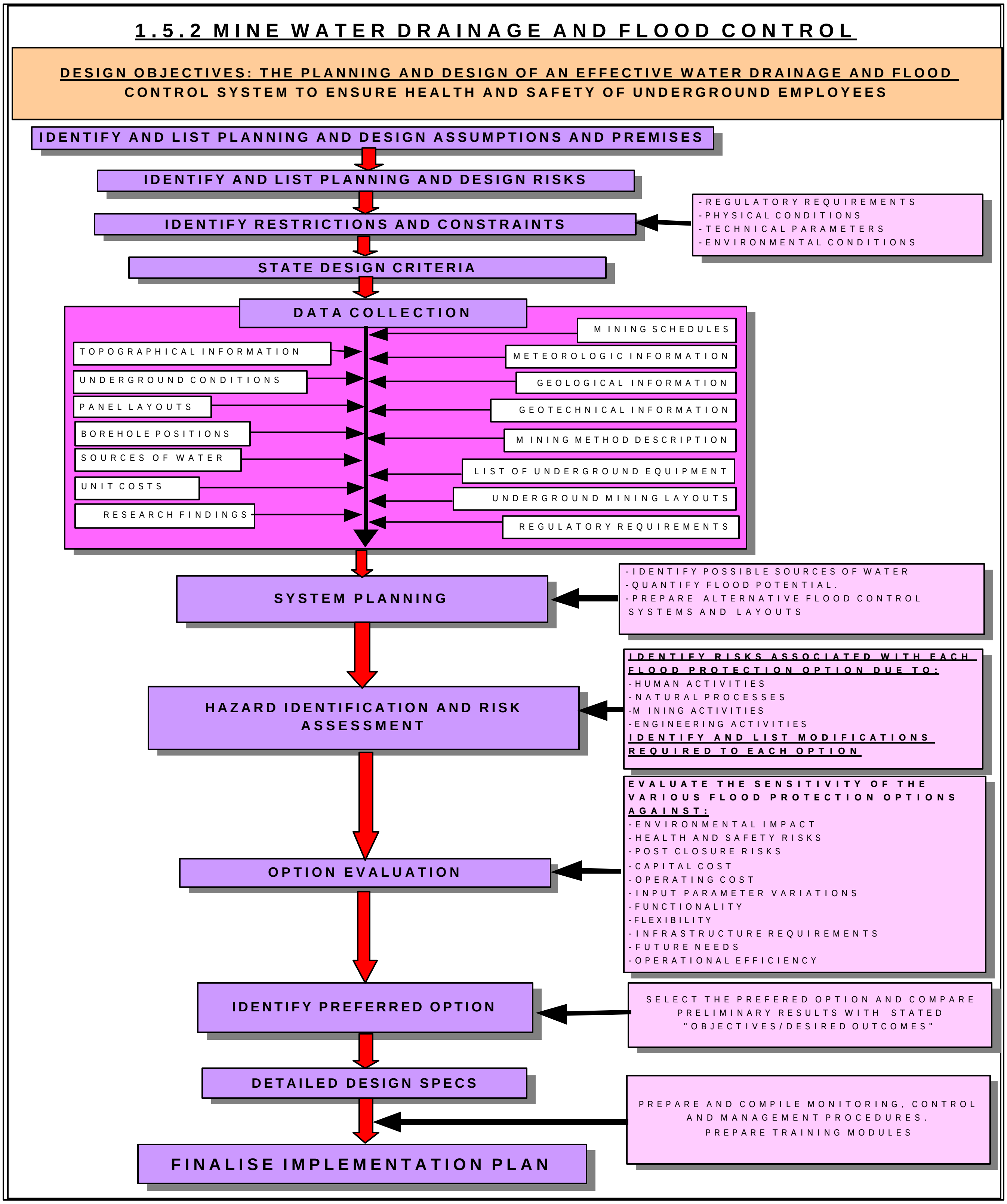
Prepare detailed equipment and layout specifications for the proposed ventilation system design based on the outcomes of Steps 1 to 9 above.

Step 11: <u>Monitoring, control and management procedures</u>

Identify and list all the monitoring, control and management procedures that will be required for the ventilation option selected in order to ensure a safe, healthy and effective underground operation throughout the life cycle of the mine.

Prepare the mandatory Codes of Practice as prescribed by the Department of Minerals and Energy and the necessary training material.

1.5.2 Mine water drainage and flood control



Objective/desired outcomes: The planning and design of an effective mine water drainage and flood-control system that will ensure the health and safety of all underground employees and the protection of mine workings and equipment.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises relating to the requirements of a mine water drainage system and the prevention of flooding of the underground workings.

Step 2: Identification of planning and design risks

Identify and list all mine water drainage and flood-control planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the layout and design of the underground water drainage and flood-control system due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the underground water drainage system and strategies to prevent possible flooding of the underground workings as a result of a sudden inrush of water.

Step 5: Data collection

For effective planning and design of the underground water drainage and flood-control system, the following information will be required:

1) Topographical information:
   - surface contour lines
   - streams, rivers, dams and potential flood lines;
   - other surface water accumulations that could impact on the underground mining areas.

2) Meteorological data, e.g. annual rainfall statistics (minimum, maximum and average rainfall figures per time period).

3) Ground water information, e.g.
   - quantities of ground water present
   - qualities of ground water
   - depth of water table
   - impervious layers

- water compartments
- permeabilities
- extent of current water usage.

4) Geological data:
   - coal seams to be mined
   - coal seam thicknesses
   - location and extent of dolerite dykes, sills, burnt coal
   - location and extent of slips, faults and coal displacements
   - depth and type of weathered overburden
   - depth and type of hard overburden
   - quality of roof strata above coal seam
   - quality of floor strata under coal seam
   - coal floor contour lines.

5) Geotechnical information relating to the stability of the underground coal mine workings and associated infrastructure, e.g.
   - geological discontinuity features
   - geotechnical units, i.e. structural units, lithological units, strength units
   - propensity of the rock/coal to slake and/or swell
   - indications of principal stress directions and relative magnitudes
   - geotechnical information for infrastructure placing and construction.

6) Mining layout and designs indicating:
   - type, layout and dimensions of proposed shaft systems
   - main development ends: number of and cross-sectional dimensions
   - secondary development ends: number of and cross-sectional dimensions
   - panel layouts: in-panel pillar dimensions, bord widths, barrier pillar positions and dimensions
   - main conveyor belt routes and conveyor transfer points
   - positions of underground crushers and feeder-breakers
   - main travelling/transport routes for personnel, material and equipment.

7) Equipment database:
   - List of all primary, secondary and auxiliary equipment used underground, with special reference to the protection requirements in the event of flooding or a sudden inrush of water

- Details of electrical apparatus used underground, with special reference to the protection requirements in the event of flooding or a sudden inrush of water.

8) Description of the mining methods indicating:
   - the mining method proposed for each geotechnical area
   - the degree of mechanisation
   - planned production rates
   - potential sources and quantities of ground water
   - proposed measures for the control of water influx
   - methods to be used to remove accumulations of water.

9) Relevant publications, guideline documents, research findings, Government regulations and standards that could influence the layout and design of the surface and underground flood protection and water-control system, e.g.
   - Mine Health and Safety Act, 1996 (Act 29 of 1996)
   - Minerals Act, 1991 (Act 50 of 1991)
   - SABS Standards
   - DME Guidelines;
   - SIMRAC Research Reports, e.g. COL 702
   - ISO Standards.

10) Other information, i.e.
   - Positions of exploration and other boreholes that could cause water to enter the underground workings.

Step 6: <u>System planning (preliminary design)</u>

Based on the proposed mining plan, and on the known sources and possible quantities of water that could enter the underground workings at any given time, identify possible areas for the positioning of underground water storage and catchment dams, taking into account the natural flow of water and the nature of the mining floor. Prepare preliminary plans of the proposed underground dams and/or installations and the required equipment, methods and procedures for preventing, controlling and managing possible accumulations of water.

Step 7: <u>Hazard identification and risk assessment</u>

Identify and list the significant hazards and risks associated with excess water accumulations and/or flooding of the mine workings as a result of human activities, natural processes, mining activities and/or engineering activities. Identify and list all the modifications and/or alterations to the preliminary layouts and designs of the proposed underground dams and water control systems that will be required in order to eliminate, reduce or control the identified risks.

Step 8: Sensitivity analysis and evaluation of options

Test the sensitivity of the flood protection and underground water-control system layout and design options selected to:

- environmental impacts
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- meeting production needs.

Step 9: Selection of the preferred option

Identify and select the flood protection and underground water-control layout and design option and the associated strategies and infrastructure that will meet the criteria stated under "Objectives/desired outcomes".

Step 10: Detailed design

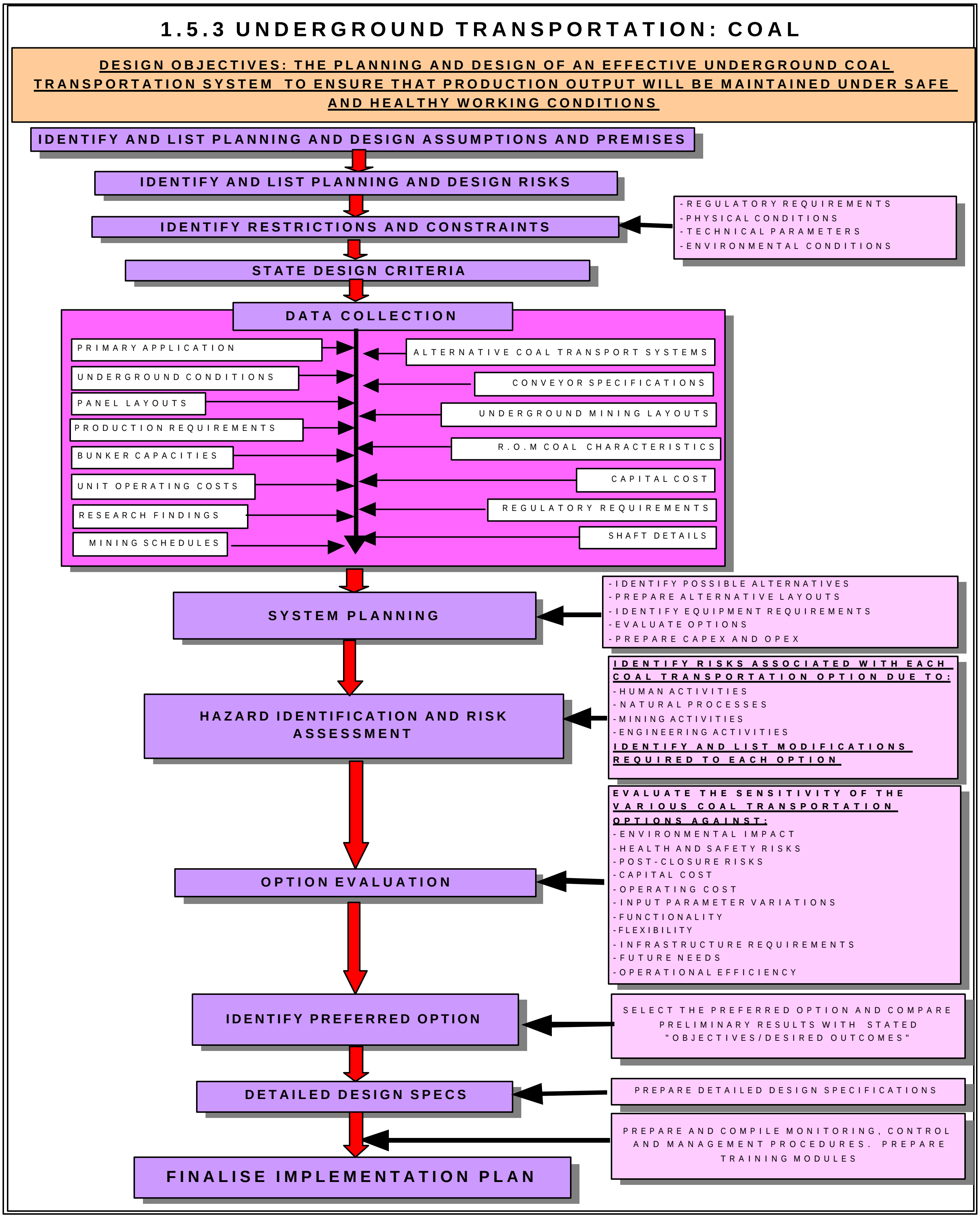
Prepare detailed design drawings and equipment specifications for the proposed flood protection and water-control system based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Identify and list all the monitoring, control and management procedures that will be required for the flood protection and water-control option selected in order to ensure a safe, healthy and effective underground operation throughout the life cycle of the mine.

Prepare the necessary Codes of Practice, operating procedures and training material.

1.5.3 Underground transportation: coal



Objectives/desired outcomes: To plan and design an effective underground coal transportation system to ensure that the required output rates from the various production sections can be maintained over the life cycle of the mine under safe and healthy operating conditions, within the constraints of prevailing geological conditions, the prescribed mining plan and production schedules.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises related to the selection of the underground coal transportation system.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the underground coal transportation system due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the underground coal transportation system.

Step 5: Data collection

For effective planning and design of the underground coal transportation system required for the coal mining operation, the following information will be required:

1) Define the primary application(s) of the underground coal transportation system, e.g. coal transportation from the production sections to the surface run-of-mine stockpile or another identified discharge point.

2) List all the coal transportation systems that will be considered and evaluated (e.g. conveyor belt installations, trucks, LHDs, etc.)

3) Determine typical underground conditions under which the underground transportation system will be required to operate, e.g.
   - total coal seam thickness
   - planned mining heights (maximum, minimum, average)
   - possible gas concentrations and emission rates
   - general floor conditions

- floor gradients (maximum, minimum, average)
- expected roof conditions
- expected dust concentrations
- planned roadway widths (maximum, minimum, average)
- dangerous areas, obstructions or restricted clearances
- underground mining layouts and production schedules indicating:
  - ⇒ primary, secondary and tertiary development roadways
  - ⇒ typical panel layouts indicating the position of the feeder-breaker or any other coal discharge installation
  - ⇒ typical routes used by pedestrians, cyclists and trackless coal hauling machines
  - ⇒ ventilation and airflow characteristics
  - ⇒ provision of illumination for the general area in which the transport of people, material, coal or explosives takes place by means of trackless machines, e.g. position and spacing of such lights, intensity and dispersion of light, and reflectivity of the surrounding area.

4) Determine and list typical characteristics of the material to be transported, e.g.
   - density (in situ, loose)
   - swell factor
   - size distribution.

5) Determine the production requirements in terms of:
   - planned production output rates (maximum, minimum, average) per hour, day, month and/or year
   - size distribution of coal and/or other material to be transported.

6) Other operating parameters required:
   - type and size of coal loaders
   - production rates of coal loaders
   - shift schedules
   - maintenance policy and schedules
   - power source.

7) Underground coal storage and surge capacities to be introduced.

8) Shaft layout and design details:

- shaft types selected
- shaft bottom layout
- shaft dimensions
- shaft capacities.

9) Conveyor belt details, e.g.

- maximum allowable belt speeds
- coal dust-generating potential
- belt curvatures
- drive-end and tail-end arrangements and area required for installation.

10) Relevant publications, guidelines, research findings, Government regulations and standards that could influence the ultimate selection and design of the underground coal transportation system, e.g.

- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- DME Guidelines
- SIMRAC Research Reports
- ISO Standards.

Step 6: <u>System planning (preliminary design)</u>

1) Prepare a list of possible alternative coal transportation systems that can be considered for the underground operation.

2) For each alternative system identified, prepare preliminary layouts based on the proposed mining plan and determine:

- location and extent of the system
- equipment requirements and specifications
- underground coal storage and bunker facilities required
- surge capacity of the system
- power requirements
- critical dimensions and specifications (height, width, length)
- ergonomic layout
- operational performances
- coal discharge mechanisms

- acquisition, operational and disposal costs
- expected production output rates
- performance reliability
- service intervals
- service life
- life cycle costing
- availability of spares and supplier support
- standard safety equipment fitted.
- personnel involved.

Step 7: <u>Hazard identification and risk assessment</u>

Identify and list all significant hazards and risks associated with each of the underground coal transportation systems being considered that could result from human activities, natural processes, mining activities and/or engineering activities. Identify and list all the modifications and/or alterations to each system that will be required in order to eliminate, reduce or control the identified risks.

Step 8: <u>Sensitivity analysis and evaluation of options</u>

Test the sensitivity of the various coal transportation systems being considered to:

- environmental impacts
- release of harmful gases
- coal dust-generating potential
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- meeting the required production needs
- human elements

Step 9: Selection of the preferred option

Based on the outcomes of the evaluation processes described in Steps 1 to 8 above, identify and select the underground coal transportation system that will best meet the criteria stated under "Objectives/desired outcomes".

Step 10: Detailed design

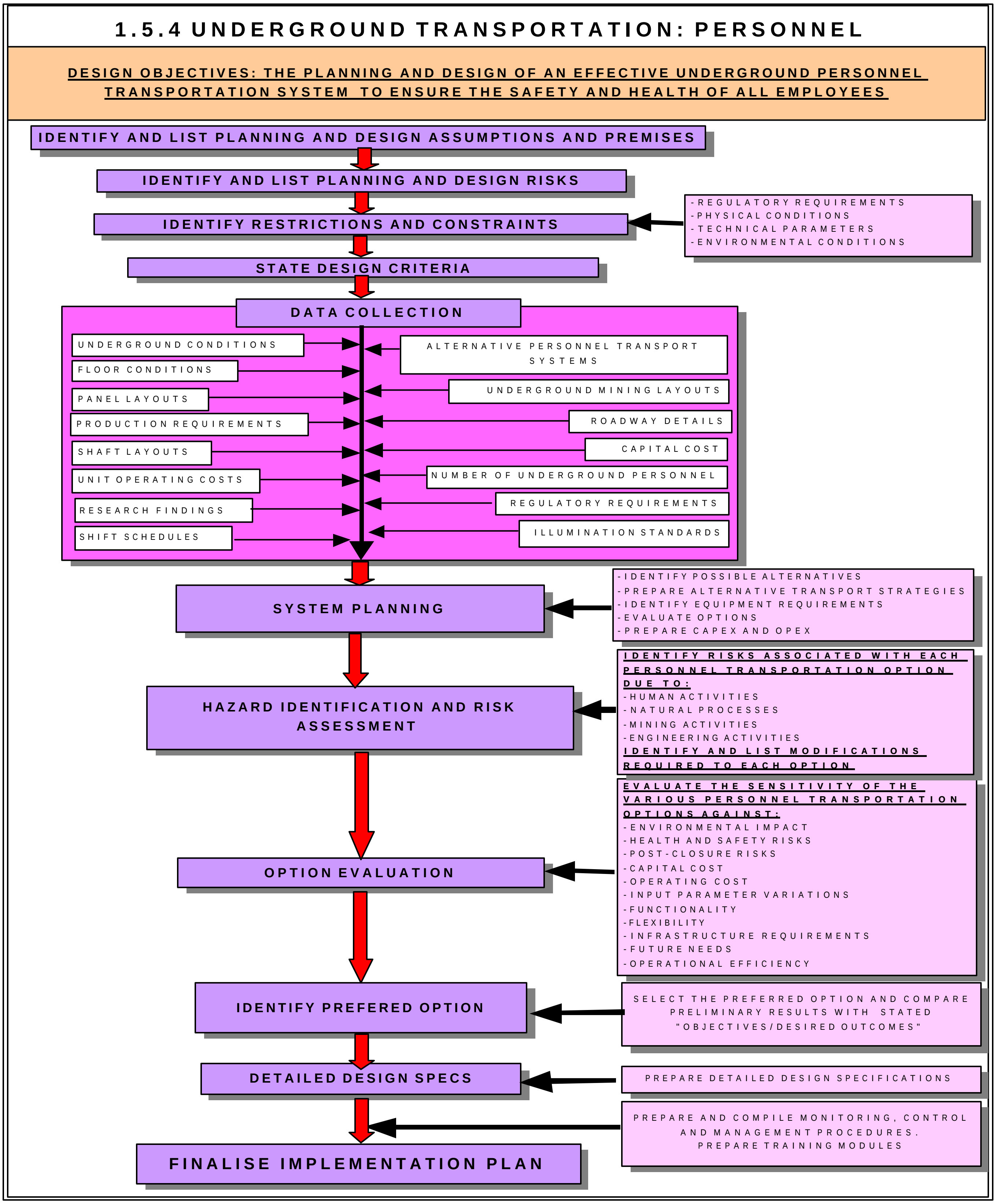
Prepare detailed layout drawings and equipment specifications for the underground coal transportation system selected.

Step 11: Monitoring, control and management procedures

Identify and list all the monitoring, control and management procedures that will be required to ensure the safe, healthy and effective operation of the underground coal transportation system throughout the life cycle of the underground mine.

Prepare the necessary Codes of Practice and training material.

1.5.4 Underground transportation: personnel



Objectives/desired outcomes: To plan and design an effective underground personnel transportation system that will ensure the safety and health of all employees involved in the underground mining operation.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises related to the selection of the personnel transportation system.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the underground transportation of personnel due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the underground personnel transportation system.

Step 5: Data collection

For effective planning and design of the underground personnel transportation system that will be required for the coal mining operation, the following information will be required:

1) List all possible personnel transportation systems that will be considered and evaluated (e.g. commercial vehicles, flame-proof vehicles, conveyor belts, etc.)

2) Determine typical underground conditions under which the underground personnel transportation system will be required to operate, e.g.
    - total coal seam thickness
    - planned mining heights (maximum, minimum, average)
    - possible gas concentrations and emission rates
    - general floor conditions
    - floor gradients (maximum, minimum, average)
    - expected roof conditions
    - expected dust concentrations
    - planned roadway widths (maximum, minimum, average)
    - dangerous areas, obstructions, or restricted clearances
    - underground mining layouts indicating:

- ⇒ primary, secondary and tertiary development roadways
- ⇒ typical panel layouts
- ⇒ typical routes used by pedestrians, cyclists and trackless coal hauling machines
- ⇒ ventilation and airflow characteristics
- ⇒ provision of illumination for the general areas in which transport of people, material, coal or explosives takes place by means of trackless machines, e.g. position and spacing of such lights, intensity and dispersion of light, and reflectivity of the surrounding area.

3) Other operating parameters required:

- total number of people to be transported
- surface transport methods
- shaft transport methods
- shift schedules
- frequency of personnel transport required
- maintenance policies and schedules
- operator competency and skills.

4) Shaft layout and design details:

- ♦ shaft types selected
- ♦ shaft bottom layout
- ♦ shaft dimensions
- ♦ shaft capacities.

5) Relevant publications, guidelines, research findings, Government regulations and standards that could influence the ultimate selection and design of the underground personnel transportation system, e.g.

- ▪ Mine Health and Safety Act, 1996 (Act 29 of 1996)
- ▪ Minerals Act, 1991 (Act 50 of 1991)
- ▪ SABS Standards
- ▪ DME Guidelines
- ▪ SIMRAC Research Reports
- ▪ ISO Standards.

Step 6: System planning (preliminary design)

1) Prepare a list of possible alternative personnel transportation systems that can be considered for the proposed underground mining operation.

2) For each alternative system identified, prepare preliminary strategies based on the proposed mining plan, shift schedules and total number of personnel to be transported underground.

3) For each strategy, determine:
   - equipment requirements and specifications
   - critical dimensions (height, width, length)
   - ergonomic layout
   - operational performances
   - acquisition, operational and disposal costs
   - performance reliability
   - service intervals
   - service life
   - life cycle costing
   - availability of spares and supplier support
   - standard safety equipment fitted
   - availability of trained and competent operators
   - training requirements.

Step 7: Hazard identification and risk assessment

Identify and list all significant hazards and risks associated with each of the underground personnel transportation systems that could result from human activities, natural processes, mining activities and/or engineering activities. Identify and list all the modifications and/or alterations to each system that will be required in order to eliminate, reduce or control the identified risks.

Step 8: Sensitivity analysis and evaluation of options

Test the sensitivity of the various personnel transportation options to:

- environmental impacts
- exposure of personnel to harmful gases
- exposure of personnel to coal dust
- physical safety in the underground mine environment

- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- meeting the required production needs
- operator efficiencies

Step 9: Selection of the preferred option

Based on the outcomes of the evaluation processes described in Steps 1 to 8 above, identify and select the underground personnel transportation system that will meet the criteria stated under "Objectives/desired outcomes".

Step 10: Detailed design

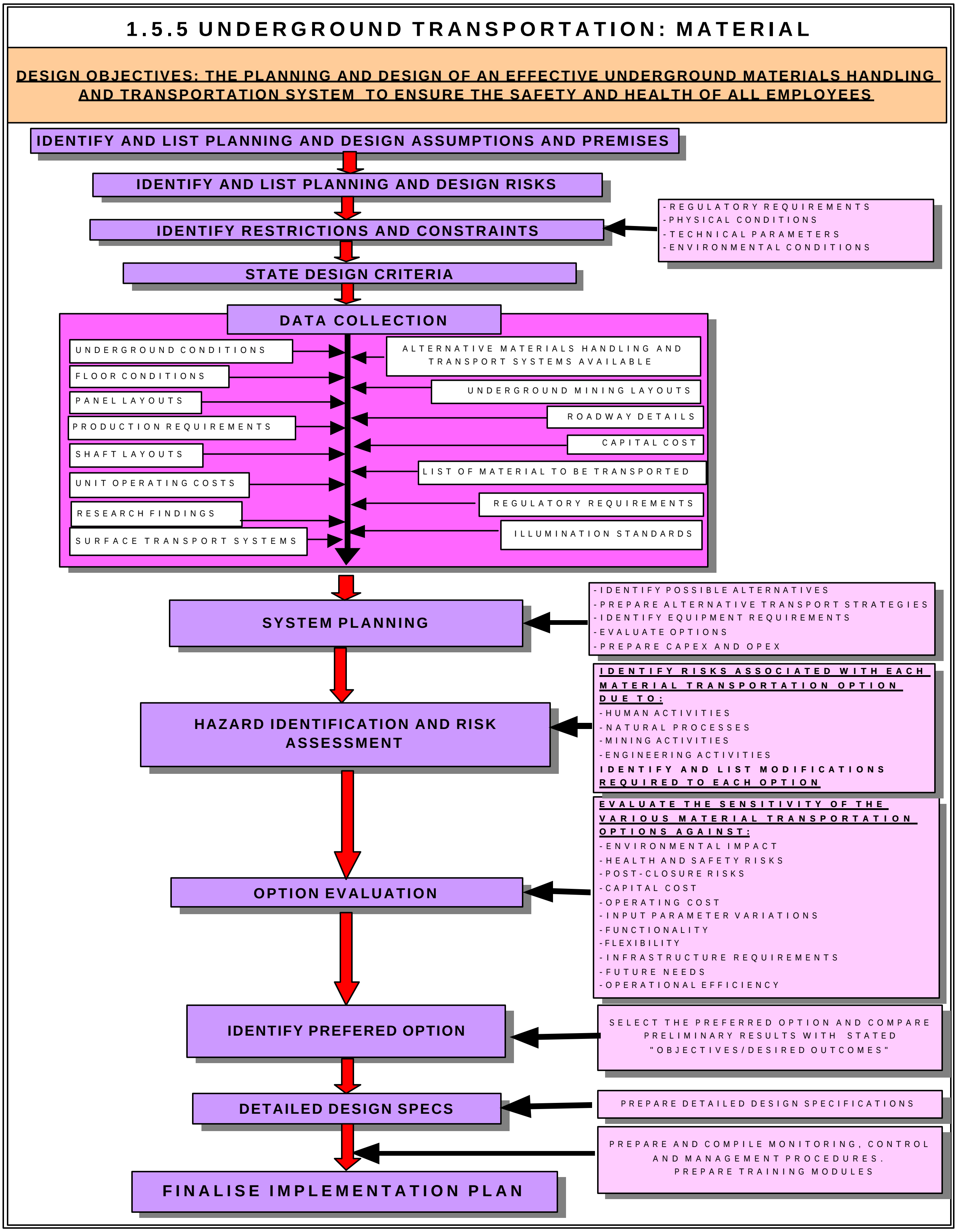
Prepare detailed design and equipment specifications for the underground personnel transportation system selected.

Step 11: Monitoring, control and management procedures

Identify and list all the monitoring, control and management procedures for the personnel transportation system that will be required in order to ensure the safety and health of all employees throughout the life cycle of the underground mine.

Prepare the necessary Codes of Practice, management procedures and training material.

1.5.5 Underground transportation: material



Objectives/desired outcomes: To plan and design an effective underground materials handling and transportation system for the underground coal mining operation to ensure maximum operating efficiencies with the minimum effect on the safety and health of employees involved in the underground mining operation.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises related to the selection of the materials handling and transportation system.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints applicable to the transportation of materials underground due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the underground material transportation system.

Step 5: Data collection

For the effective planning and design of an underground material handling and transportation system for the coal mining operation, the following information will be required:

1) Identify and list all material that needs to be handled and transported underground.

2) Identify and list the quantities of each type of material to be transported and the frequency of such operations.

3) Identify and list all possible materials handling and transportation systems that will be considered and evaluated (e.g. commercial vehicles, flame-proof vehicles, utility vehicles, etc.).

4) Determine typical underground conditions under which the underground materials handling and transportation system will be required to operate, e.g.
   - total coal seam thickness
   - planned mining heights (maximum, minimum, average)

- possible gas concentrations and emission rates
- general floor conditions
- floor gradients (maximum, minimum, average)
- expected roof conditions
- expected dust concentrations
- planned roadway widths (maximum, minimum, average)
- dangerous areas, obstructions, or restricted clearances
- underground mining layouts indicating:
  - ⇒ primary, secondary and tertiary development roadways
  - ⇒ typical panel layouts
  - ⇒ coal haulage and conveyor routes
  - ⇒ typical routes used by pedestrians, cyclists and trackless machines
  - ⇒ ventilation and airflow quantities and characteristics
  - ⇒ provision of illumination for the general areas in which the transport of people, material, coal or explosives takes place by means of trackless machines, e.g. position and spacing of such lights, intensity and dispersion of light, and reflectivity of the surrounding area.

5) Other operating parameters related to materials handling and transportation:

- surface transport methods
- shaft transport methods
- shift schedules
- maintenance policies and schedules
- availability of skilled and competent operators.

6) Shaft layout and design details:

- shaft types selected
- shaft bottom layout
- shaft dimensions
- shaft capacities.

7) Maintenance strategies and requirements, e.g. frequency and type of maintenance tasks to be performed underground.

8) Emergency and rescue strategies.

9) Capital cost of the various materials handling and transportation systems identified.

10) Operating cost of the various materials handling and transportation systems identified.

11) Relevant publications, guidelines, research findings, Government regulations and standards that could influence the ultimate selection and design of the underground materials handling and transportation system, e.g.
    - Mine Health and Safety Act, 1996 (Act 29 of 1996)
    - Minerals Act, 1991 (Act 50 of 1991)
    - SABS Standards
    - DME Guidelines
    - SIMRAC Research Reports
    - ISO Standards.

Step 6: <u>System planning (preliminary design)</u>

1) Prepare a list of possible alternative materials handling and transportation systems that can be considered for the proposed underground mining operation.

2) For each alternative system identified, prepare preliminary strategies based on the proposed mining plan, shift schedules and total quantities, volumes and mass of material to be transported underground.

3) For each strategy identified, determine:
    - equipment requirements and specifications
    - critical dimensions of the materials handling equipment (height, width, length)
    - ergonomic layout
    - operational performances
    - acquisition, operational and disposal costs
    - performance reliability
    - service intervals
    - service life
    - life cycle costing
    - availability of spares and supplier support
    - standard safety equipment fitted
    - personnel requirements.

Step 7: <u>Hazard identification and risk assessment</u>

Identify and list all significant hazards and risks associated with each of the underground material transportation systems that could be result from human activities, natural processes, mining activities and/or engineering activities. Identify and list all the modifications and/or alterations to each system that will be required in order to eliminate, reduce or control the identified risks.

Step 8: Sensitivity analysis and evaluation of options

Test the sensitivity of the various materials handling and transportation options to:

- environmental impacts
- exposure of personnel to harmful gases
- exposure of personnel to coal dust
- physical safety in the underground mine environment
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- meeting the required production needs
- operator involvement.

Step 9: Selection of the preferred option

Based on the outcomes of the evaluation processes described in Steps 1 to 8 above, identify and select the underground materials handling and transportation system that will meet the criteria stated under "Objectives/desired outcomes".

Step 10: Detailed design

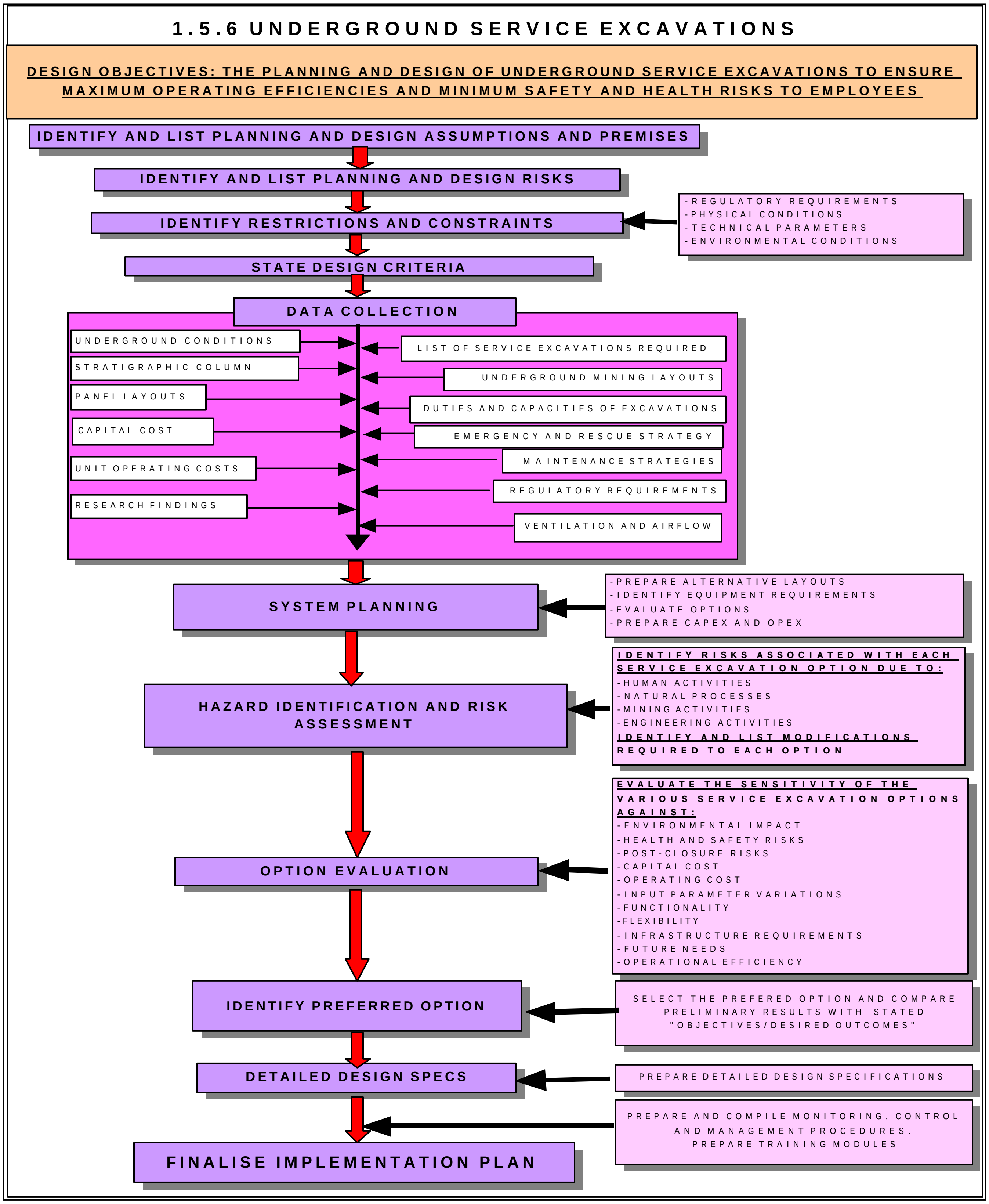
Prepare detailed design and equipment specifications for the underground materials handling and transportation system selected.

Step 11: Monitoring, control and management procedures

Identify and list the monitoring, control and management procedures for the materials handling and transportation system that will be required in order to ensure the safety and health of all employees throughout the life cycle of the underground mine.

Prepare the necessary Codes of Practice, management procedures and training material.

1.5.6 Underground service excavations



Objectives/desired outcomes: To plan and design the necessary service excavations (e.g. workshops, pump chambers, rescue bays, coal bunkers, underground stores, etc.) that will be required for a specific underground coal mining operation to ensure maximum operating efficiencies with minimum health, safety and environmental risks.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints that will influence the layout and design of the various service excavations due to regulatory requirements, as well as physical, technical and/or environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the various service excavation layouts to be considered.

Step 5: Data collection

The following basic input data will be needed to determine the optimum layout and dimensions of the various underground service excavations required for a specific underground coal mining operation:

1) Identification of the various service excavations that will be required for a specific underground coal mining operation.

2) The required duties and/or capacities of each service excavation identified.

3) Underground mining layouts and production schedules.

4) Ventilation and airflow:
   - the air quantities and velocities required to ventilate underground service excavations
   - maximum and minimum air velocities permissible
   - possible gas-emission rates.

5) Stratigraphic column of the areas in which the various service excavations will be located:

- depth and type of overburden/roof material that will be encountered during excavation operations
- presence of geological features such as dolerite dykes, sills, slips, faults and/or other discontinuities
- presence of water compartments, fissures and/or other ground water occurrences
- quality of the coal roof in the vicinity of the planned service excavations
- quality of the coal floor in the vicinity of the planned service excavations;
- requirements for sidewalls and other support mechanisms.

6) Underground mining layouts, with special reference to:

- personnel travelling ways
- equipment travelling routes
- coal haulage/conveyor routes
- ventilation and airflow
- strata control and roof support strategies.

7) Maintenance strategies and requirements:

- frequency and type of maintenance tasks to be performed underground.

8) Emergency and rescue strategies.

9) Capital cost of the various types of service excavation.

10) Operating cost associated with the various types of service excavation.

11) Government regulations and international standards, e.g.

- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- ISO Standards.

12) Relevant publications and research findings related to service excavation layouts and design.

Step 6: **Preliminary design (system planning)**

Based on the input parameters listed under Steps 1 to 5 above, identify and prepare alternative layouts for each of the identified service excavations that will best suit the geological, environmental and mining requirements and conditions of the proposed mining project.

Validate these preliminary layouts and designs against rock mechanics principles, functionality, performance criteria, relevant government regulations, environmental requirements, infrastructure requirements, capital and operating costs and time needed to implement.

Step 7: **Hazard identification and risk assessment**

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the construction, commissioning, operating, decommissioning and closure phases for each service excavation. Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary specifications for the service excavations.

Step 8: **Sensitivity analysis and evaluation of options**

Test the sensitivity of the preliminary service excavation layouts and designs to:

- environmental impacts
- stability
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies
- health and safety risks.

Step 9: **Selection of the preferred option**

Select and identify the service excavation layout that will best meet the criteria stated under “Objectives/desired outcomes”.

Step 10: Detailed design

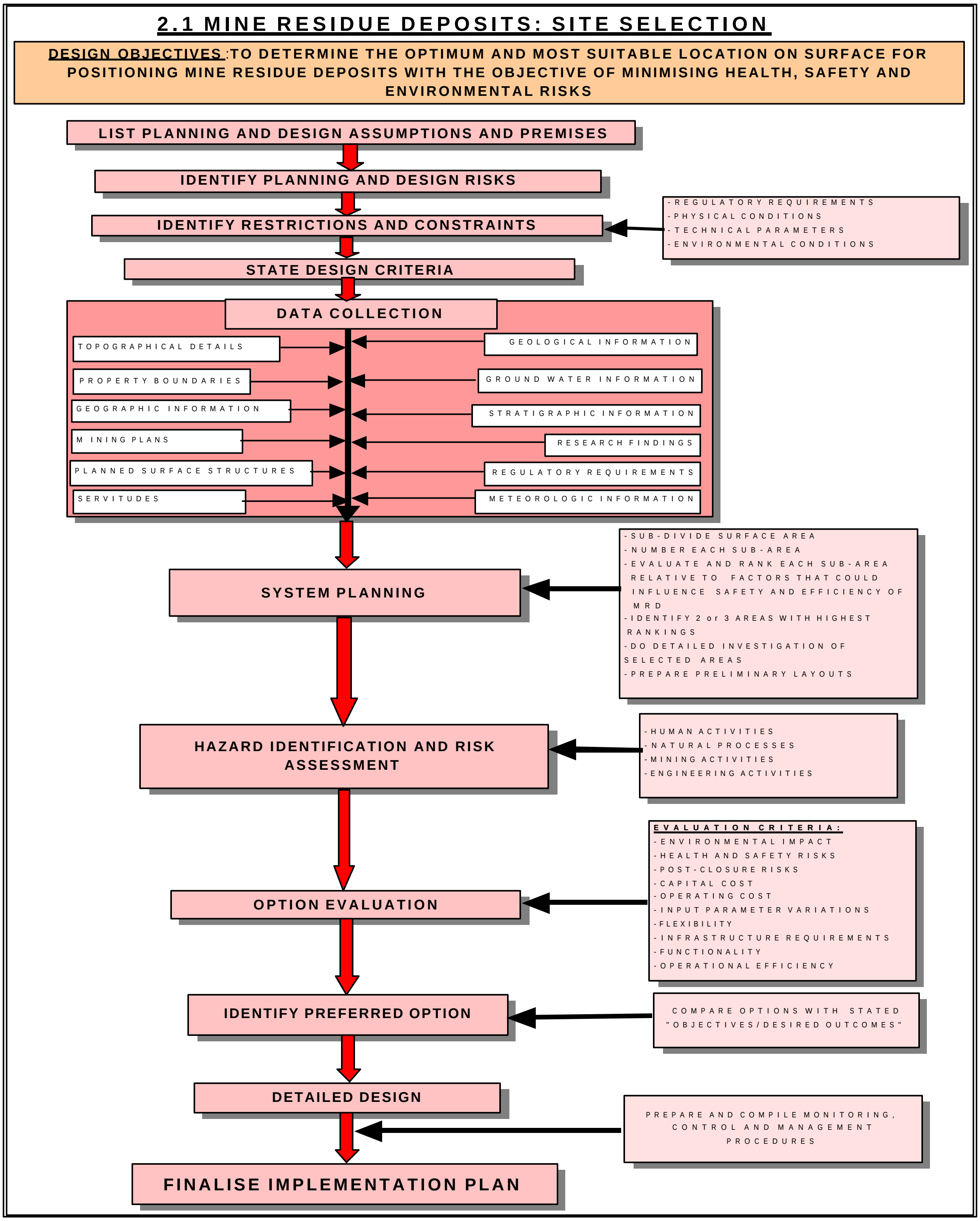
Prepare a detailed design for each of the required service excavations based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Prepare the monitoring, control and management procedures to be introduced and followed during the excavation, equipping, operational, decommissioning and closure phases for each of the service excavations to ensure that the required standards in terms of health, safety and environmental conditions are implemented and maintained.

2. SURFACE SERVICES AND INFRASTRUCTURE

2.1 Mine residue deposits: site selection



Objectives/desired outcomes: To determine the optimum and most suitable location on surface for positioning mine residue deposits (e.g. coal discard dumps, waste dumps and/or slimes dams) that will ensure effective, safe and healthy conditions over the life of the mine, with minimum surface environmental impacts.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints influencing the placing of residue deposits on surface due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the location of the residue deposits.

Step 5: Data collection

The following information will be required to select the optimum position for the mine residue deposits:

1) Topographical information (plans) indicating:
   - surface contour lines
   - streams, rivers, dams, potential flood lines
   - land utilisation, e.g. extent and intensity of agricultural, industrial and human activities
   - townships, dwellings and other residential areas
   - vegetation: density and extent of natural and adverse vegetation
   - existing infrastructure, e.g. roads, railway lines, railway stations, water supply lines
   - sensitive ecological and environmental areas;
   - drainage patterns.

2) Mining plans indicating:
   - shaft positions
   - planned underground mining layouts

- major underground infrastructure
- areas where total extraction of the coal seams will take place
- extent of planned surface subsidence
- major mine surface structures, e.g. offices, workshops, roads, etc.
- planned production rates.

3) Other planned surface structures, e.g.
   - coal washing plant
   - surface crushing plants
   - surface stockpiles (run-of-mine and clean coal)
   - load-out facilities
   - surface conveyor belt routes.

4) Property boundaries, legal constraints and servitudes.

5) Meteorological information, e.g. climate, rainfall patterns and prevailing wind direction.

6) Geology, geomorphology and hydrology information.

7) Geological structures, e.g. faults, dykes, joints and fractures.

Step 6: <u>Site selection (system planning)</u>

1) Divide the total surface area within the property boundaries of the mine into squares of equal dimensions (e.g. 1 000 m x 1 000 m) and assign a unique identification number to each.

2) Rank each square against the parameters listed under Step 5 above by assigning high values to those factors that will influence the position of the mine residue deposit positively and low values to those that will have a negative impact.

3) Identify the two or three areas that yield the highest accumulated rankings.

4) Prepare a detailed investigation study for each of the two or three areas selected by means of additional drilling, soil tests, hydrological tests and topographical analysis. Special attention must be given to:
   - health, safety and environmental considerations
   - the extent of the post-closure aftercare measures and controls that will be required
   - restrictions on the future use of properties or affected water supplies

- social (including public acceptance) and economic considerations
- special factors that need to be considered in the detailed design phase (e.g. stability, geology, geomorphology and hydrology).

Step 7: Hazard identification and risk assessment

Identify and list all significant hazards and risks associated with human activities, natural processes, mining activities and engineering activities during the operating, decommissioning and closure phases for each of the mine residue deposit sites selected. Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary residue deposit layout and design specifications.

Step 8: Sensitivity analysis and evaluation of options

Test the sensitivity of the preliminary sites selected to:

- environmental impacts
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: Selection of the preferred option

Identify and select the site that will best meet the criteria stated under "Objectives/desired outcomes".

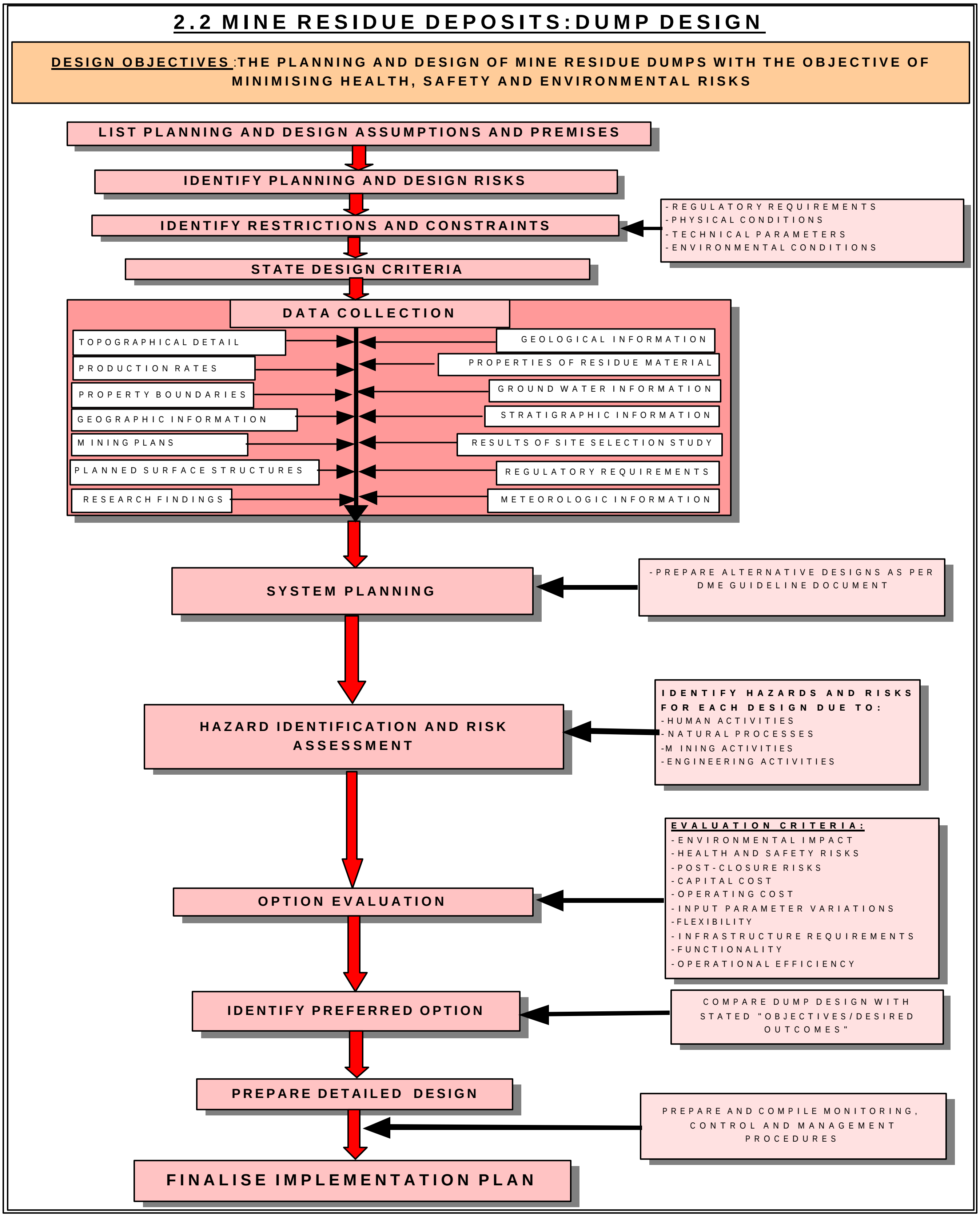
Step 10: Detailed design

Prepare a detailed design of the mine residue deposit site layout based on the outcomes of Steps 1 to 9 above.

Step 11: Monitoring, control and management procedures

Identify and list the monitoring, control and management procedures for the construction and operating phases of the mine residue deposit that will ensure safe, healthy and effective operation within the constraints of the mine residue deposit area selected.

2.2 Mine residue deposits: dump design



Objectives/desired outcomes: The planning and design of facilities and/or structures for the placement and storage of residual material derived from underground coal mining operations, with the objective of eliminating and/or minimising health, safety and environmental risks.

Step 1: Planning and design assumptions and premises

Identify and list all planning and design assumptions and premises.

Step 2: Identification of planning and design risks

Identify and list all planning and design risks.

Step 3: Identification of restrictions and constraints

Identify and list all restrictions and constraints influencing the placing of residue dumps due to regulatory requirements, as well as physical, technical and environmental conditions.

Step 4: Design criteria

Identify and list the required design criteria for the mine residue dump.

Step 5: Data collection

To prepare a detailed design of the mine residue dump(s), the following information will be required:

1) Results of the residue site selection study.

2) Specific information relating to the selected site in terms of:
    - land use
    - topography and surface drainage
    - infrastructure and man-made features
    - climate
    - flora and fauna
    - geology, including faults, joints and fractures
    - soil types
    - ground water morphology, flow, quality and usage
    - surface water.

3) Specific information relating to the residue material to be deposited, e.g.

    Physical characteristics:
    - size distribution of the principle constituents
    - permeability of the compacted material
    - void ratios of the compacted material

- consolidation or settling characteristics of the residue material under its own weight and that of any overburden
- shear strength of the compacted material
- relative density of the solid constituents
- water content of the residue material at the time of deposition, after compaction, and during other phases in the life of the mine residue deposit.

Chemical characteristics, e.g.

- toxicity
- propensity to oxidise and/or decompose
- propensity to undergo spontaneous combustion
- pH and chemical composition of the water separated from the solids
- stability, reactivity and the rate of the latter
- factors affecting synergy and the sequence of reactions
- neutralising potential.

Transportation characteristics, e.g.

- the propensity of the constituent materials to be transported by airborne, surface water or ground water mechanisms.

Radiological characteristics (where appropriate), such as:

- the constituent radionuclides and their activity concentrations
- the activity media aerodynamic diameter of particles that become airborne
- the predicted radon-exhalation rates at the time of deposition, after compaction.

4) Current and projected rates of residue production throughout the life of the mine.

5) Relevant publications, guidelines, research findings, Government regulations and international standards, e.g.

- Mine Health and Safety Act, 1996 (Act 29 of 1996)
- Minerals Act, 1991 (Act 50 of 1991)
- SABS Standards
- DME Guidelines.
- ISO Standards
- Chamber of Mines Guidelines.

Step 6: **System planning (preliminary design)**

Prepare a preliminary design of the proposed mine residue dump as prescribed in DME Guideline Document 16/3/2/5 – A1 entitled: *Guideline for the Compilation of a Mandatory Code of Practice on Mine Residue Deposits*.

Step 7: **Hazard identification and risk assessment**

Identify and list all significant hazards and risks associated with human activities, natural processes, mining, coal processing and engineering activities during the operating, decommissioning and closure phases of the mine residue dump. Identify the procedures, systems and/or design principles that will eliminate, reduce or control the identified risks and incorporate these into the preliminary layout and design specifications for the mine residue dump.

Step 8: **Sensitivity analysis and evaluation of options**

Test the sensitivity of the preliminary mine residue dump design to:

- environmental impacts
- releases of harmful contaminants
- physical safety of the mine residue dump
- regulatory requirements
- health and safety risks
- post-closure risks
- capital cost
- operating cost
- variations in input parameters
- functionality of the system
- flexibility of the system
- infrastructure requirements
- future production needs
- operational efficiencies.

Step 9: **Selection of the preferred option**

Identify and select the preliminary mine residue dump design that will best meet the criteria stated under “Objectives/desired outcomes”.

Step 10: <u>Detailed design</u>

Prepare a detailed design of the mine residue dump layout based on the outcomes of Steps 1 to 9 above.

Step 11: <u>Monitoring, control and management procedures</u>

Identify and list all the monitoring, control and management procedures that will be required to ensure the safe, healthy and effective operation of the mine residue dump during the construction, operational and mine closure phases.

Prepare the mandatory Code of Practice as per DME Guideline Document, DME 16/3/2/5 – A1. Prepare training manuals.

APPENDIX 1
SALIENT FACTORS REQUIRING CONSIDERATION IN A MINING PROJECT FEASIBILITY STUDY

1. EXECUTIVE SUMMARY

- 1.1 Project description
- 1.2 Project summary

2. INTRODUCTION

- 2.1 Project description
- 2.2 Geography
  - 2.2.1 Location: proximity to population centres, supply depots and services
  - 2.2.2 Topography
  - 2.2.3 Access systems
  - 2.2.4 Climatic conditions
  - 2.2.5 Surface conditions: vegetation, streams and water accumulations
- 2.3 Project history
- 2.4 Mining lease and legal status
  - 2.4.1 Ownership: surface, coal
  - 2.4.2 Mineral rights, mining rights
- 2.5 Markets and market potential
  - 2.5.1 Market identification and product specification
  - 2.5.2 Expected price levels and trends: supply-demand, competitive cost levels
  - 2.5.3 Product sales characteristics: sales terms, letters of intent, contract duration, provisions for amendments and escalations, procedures/ requirements for sampling, quality control and umpiring

3. GEOLOGY AND RESOURCE ESTIMATES

- 3.1 Regional geology
- 3.2 Local geology
- 3.3 Exploration programme and results
- 3.4 Data collection procedures
- 3.5 Geological resource interpretation
  - 3.5.1 Geological data validation
  - 3.5.2 Geological cut-off parameters
  - 3.5.3 Geological model
  - 3.5.4 Geological discount factors
  - 3.5.5 Geological confidence levels and categories
- 3.6 Resource statement

4. MINING

- 4.1 Geotechnical factors
- 4.2 Mining method selection and extraction rates
- 4.3 Dilution and contamination
- 4.4 Mining recovery factors
- 4.5 Mineable reserve statement
- 4.6 Mine design and infrastructure
  - 4.6.1 Shaft system requirements, positioning and design criteria
  - 4.6.2 Underground mine layout and design parameters
  - 4.6.3 Strata control and roof support strategies
  - 4.6.4 Ventilation requirements and strategies to prevent underground fires and coal dust explosions
- 4.7 Production rates and scheduling

- 4.8 Mining equipment requirements
  - 4.8.1 Primary mining equipment

4.8.2 Utility and support equipment
4.8.3 Auxiliary equipment
4.9 Underground support services
4.9.1 Mine water drainage and flood control
4.9.2 Underground transportation and materials handling
4.9.3 Underground service excavations
4.10 Maintenance policies and procedures
4.11 Manpower requirements: recruitment strategies and schedules, training

5. COAL PROCESSING
5.1 Mineralogy
5.2 Metallurgical test work: procedures and results
5.3 Processing plant design criteria
5.3.1 Processing method
5.3.2 Processing recovery factors
5.3.3 Product specifications and quality control
5.3.4 Discard handling and specifications
5.4 Maintenance policies and procedures
5.5 Manpower requirements, recruitment scheduling and training

6. WATER MANAGEMENT SYSTEM
6.1 Hydrology
6.2 Potable and process water: sources, quantity, quality, availability and costs
6.3 Mine water: quantity, quality, drainage method, treatment requirements and specifications
6.4 Water supply and distribution network
6.5 Water management and quality control systems

7. SUPPORT FACILITIES AND SERVICES
7.1 Site development and infrastructure requirements
7.2 Buildings; description and layout
7.3 Power requirements and distribution
7.4 Product transportation: methods, distances and costs
7.5 Communication systems
7.6 Security
7.7 Fire prevention and medical services
7.8 Warehousing, stores and materials handling

8. ENVIRONMENTAL MANAGEMENT
8.1 Company objectives
8.2 Statutory requirements
8.3 Current land use
8.4 Relocation and rehabilitation
8.5 Environmental management programme
8.6 Mine closure objectives and strategies

9. HEALTH AND SAFETY
9.1 Company objectives
9.2 Statutory requirements
9.3 Hazard identification and risk assessment
9.4 Health and safety strategies and management programme

10. PROJECT IMPLEMENTATION
10.1 Objectives and priorities
10.2 Project plan
10.3 Construction management strategies
10.4 Project schedule
10.5 Project organisation

10.6 Engineering and design facilities
10.7 Procurement and expediting
10.8 Statutory requirements

11. COMMISSIONING
11.1 Schedule of activities
11.2 Mine pre-development
11.3 Process commissioning

12. PRE-PRODUCTION
12.1 Programmes and procedures
12.2 Operating and maintenance systems
12.3 Manpower build-up and recruitment strategies
12.4 Inventories

13. PERSONNEL: REQUIREMENTS, RECRUITMENT AND TRAINING
13.1 Company objectives and policies
13.2 Availability and type of skilled/unskilled labour
13.3 Organisational structure and manning levels
13.4 Recruitment policies, procedures and schedules
13.5 Training policies, procedures and schedules

14. CAPITAL COST ESTIMATES
14.1 Summary of capital requirements
14.2 Estimate base and level of accuracy
14.3 Contingency
14.4 Detailed capital cost breakdown, e.g.
- exploration
- mine, plant and infrastructure establishment
- coal reserve development
- spares and supply inventories
- working capital

15. OPERATING COST ESTIMATES
15.1 Summary
15.2 Estimate methodology
15.3 Production schedule and productivity
15.4 Operating cost details

16. FINANCIAL ANALYSIS
16.1 Summary
16.2 Project costs
16.3 Financial plan
16.4 Financial projection
16.5 Sensitivity analysis

APPENDIX 2

Research methodology

1. Objectives

The primary objective of this research programme is to prepare and present a guideline document that sets out the mine planning and design procedures during the life cycle of any underground coal mining operation. This guideline document must incorporate the requirements and expectations of all relevant statutory-, monetory-, and regulatory authorities. To enhance the effectiveness and use it must serve as a reference document and be presented in a format that can easily be used by a multi-disciplinary mine planning and design project team.

2. Research strategy and findings

The general strategy followed during this research programme is to collect information and data as it applies to underground coal mine planning and design from the following sources:

- International coal mining companies and related industries
- South African coal mining companies
- Governmental and other authorities
- published literature and research findings

The results of this investigation clearly indicate that although various components and sub-elements of the mine planning and design process are available in the form of company standards or Governmental requirements, no single document or guideline is available that covers the entire scope of mine planning and design over the life-cycle of a mining project.

Information received from the following organisations are used as basis for compiling the guideline document and their participation in this project is acknowledged:

- Anglo Coal
- Ingwe Coal Corporation
- Sasol Coal
- Duiker Mining (Pty) Ltd.
- Kumba Resources
- Department of Minerals and Energy
- Director: Mineral Development
- South African Institute of Mining and Metallurgy
- South African Bureau of Standards
- Office of the Survey General
- Deeds Office of South Africa
- University of Pretoria

- Australasian Institute of Mining and Metallurgy
- Runge Mining (Australia) (Pty) Ltd.
- Society for Mining, Metallurgy and Exploration (USA)

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