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List of acronyms and abbreviations

°*C*	Degree Celsius
μ	Micro (x10^{-6})
μg/m^3	micrograms per cubic metre
AMD	Acid mine drainage
AQA	Air Quality Act No. 39 of 2004
ASLA	American Society of Landscape Architects
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
Au	gold
BAM	Betta attenuation monitor
CARA	Conservation of Agricultural Resources Act No. 43 of 1983
CBD	Central business district
CDSM	Chief Directorate: Surveys and Mapping
CIL	Carbon-in-leach
CM	Chamber of Mines of South Africa
COD	Chemical oxygen demand
CPI	Consumer price index
CSIR	Council for Scientific and Industrial Research
DEAT	Department of Environment and Tourism, Republic of South Africa
DME	Department of Minerals and Energy, Republic of South Africa
DME (QLD)	Department of Minerals and Energy, Queensland, Australia
DSS	Decision-support system
DST	Decision-support tool

DWAF	Department of Water Affairs and Forestry, Republic of South Africa
EC	Electrical conductivity
ECA	Environmental Conservation Act No. 73 of 1989
Ed.	Editor
Eds.	Editors
EIA	Environmental impact assessment
EMF	Environmental management framework
EMP	Environmental management plan
EMPR	Environmental management programme report
EMProgramme	Environmental management programme
EPA	Environmental Protection Agency
ERGO	East Rand Gold and Uranium Company Limited
ERWAT	East Rand Water
ESRI	Environmental Systems Research Institute
et al.	'et alia'; and others
FP	Fine particulates
GDACE	Gauteng Department of Agriculture, Conservation and Environment
GDP	Gross domestic product
GIS	Geographical information system
GN	Government notice
GPS	Geographical positioning system
HDS	High-density separation
i.e.	'id est'; in other words; that is
IAP	Interested and affected party
IDP	Integrated development plan
IEM	Integrated environmental management

IEPD	Integrated environmental planning and design
IIED	International Institute for Environment and Development
IP	Inhalable particulates
Ir	Iridium
IUCN	International Union for the Conservation of Nature and Natural Resources
k	Permeability
kg	Kilogram
kt	Kiloton
LDO	Land development objectives
LI	Landscape Institute
m	Metre
M	Mega (10^6)
m.a.s.l.	Metres above sea level
m/s	Metre per second
m^3	Cubic metre
MA	Minerals Act No. 50 of 1991
MAA	Multiple accounts analysis
MAC	Mining Association of Canada
mm	Millimetre
MMSD	Mining, Minerals and Sustainable Development
MPRDA	Minerals and Petroleum Resources Development Act No. 28 of 2002
MRD	Mine residue deposit
Mt	Mega tonne
Mtpm	Mega tonne per month
NA	Not available
NCHM	National Cultural History Museum

NEDLAC	National Economic Development and Labour Council
NEMA	National Environmental Management Act No. 107 of 1998
NGT	Nominal group technique
NHMRC	National Health and Medical Research Council
NPV	Net present value
NR	Not relevant
NRF	National Research Foundation
NSW EPA	New South Wales Environmental Protection Agency
NWA	National Water Act No. 36 of 1998
Os	Osmium
OVA	Objective valuation approaches
ozt	Troy ounce (32,151 ozt = 1000 g)
p.	Page
Pd	Palladium
PGE	Platinum group element
PGM	Platinum group metal
PM_{10}	Fine particles with aerodynamic diameters less than 10 µm
$PM_{2,5}$	Fine particles with aerodynamic diameters less than 2,5 µm
pp.	Pages
Pt	Platinum
q	Darcy flux
RA	Risk assessment
Rh	Rhodium
RO	Reverse osmosis
RP	Respirable particulates
RPM	Rustenburg Platinum Mines (Pty) Ltd

RQO	Resource quality objective
RSA	Republic of South Africa
Ru	Ruthenium
RUSLE	Revised Universal Soil Loss Equation
s	Second
SABS	South African Bureau of Standards
SAHRA	South African Heritage Resources Agency
SEA	Strategic environmental assessment
SEF	Strategic Environmental Focus (Pty) Ltd
SP	Suspended particulates
SRK	Steffen Robertson and Kirsten (Pty) Ltd
SVA	Subjective valuation approach
TDF	Tailings disposal facility
TDS	Total dissolved solids
TEOM	Tapered element oscillating microbalance
THRIP	Technology and Human Resources for Industry Programme
tpa	Dry tonnes per annum
tpm	Dry tonnes per month
TSF	Tailings storage facility
TSP	Total suspended particulates
TSS	Total suspended solids
TWQR	Target water quality ranges
UP	University of Pretoria
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation

VAC	Visual absorption capacity
VIA	Visual impact assessment
Vol.	Volume
WDCS	Waste discharge charge system
WHO	World Health Organisation
WRC	Water Research Commission
WSSD	World Summit on Sustainable Development
WWCW	Waste water care works
ZVI	Zone of visual influence

List of technical terms

acid mine drainage	Also referred to as acid mine drainage (AMD) or acid rock drainage (ARD). Acid drainage is the seepage of sulphuric acid solutions from mines and tailings, produced by the interaction of oxygen in ground and surface water with sulphide minerals exposed by mining (DME, 2006:4).
aquifer	Bear (1979) and NWA (1998) describes an aquifer as a geologic formation, or group of formations such as porous, water-saturated layers of sand, gravel, or bed rock which contains water and permits significant amounts of water to move through it under ordinary field conditions. Parsons (2004) describes it as strata or a group of interconnected strata comprising of saturated earth material capable of conducting groundwater and of yielding useable quantities of groundwater to borehole(s) and/ or springs(a supply rate of 0,1 L/s is considered a useable quantity). The emphasis of UNEP's definition is on a geologic formation's ability to yield an economically significant amount of water (UNEP, 2005:80).
bulk density	The mass of dry soil per unit bulk volume. The bulk volume is determined before drying to constant mass at 1050 °*C*. Values range roughly from 1000 - 1800 kg/m^3, although higher values may be found in compacted soils (van der Walt and van Rooyen, 1990: 20).
chemical oxygen demand	Chemical oxygen demand (COD) is an indicator of the potential environmental impact of effluent to water. The COD is a laboratory measure of the quantity of oxygen required to oxidise the constituents of a liquid effluent. The lower the COD, the lower the potential for reduction in the concentration of dissolved oxygen in the receiving water (UNEP, 2005:80).
closure	A process which begins during the pre-feasibility phase of a mining project, and continues through operations to lease relinquishment. It sets clear objectives and guidelines, makes financial provision and establishes effective stakeholder engagement leading to successful relinquishment of lease (DME, 2006:4).
concentrate	Concentrate is the product of ore treatment and contains metal at a higher concentration than the source ore. In metallurgical processes for the production of nickel and copper, concentrate is smelted to produce a metallic compound suitable for further refining (UNEP, 2005:80).

concentration	The purpose of concentration is to separate those particles with high values (concentrate) from those with lower values (tailings). Methods for concentration vary according to ore type, but three general classes are in use: gravity separation, magnetic separation, and froth flotation (Vick, 1983:6).
configuration	Configuration is the term use to refer to a particular combined arrangement of embankment side slope and cover for an impoundment which can result in several configurations.
confined aquifer	A confined aquifer is a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.
conservation	The management of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. The wise use of natural resources to prevent loss of ecosystem function and integrity.
contamination	The introduction of any poisonous or polluting substance into the environment (Parsons, 2004 and Oxford, 2002).
cumulative effects	The summation of effects that result from changes caused by a development on conjunction with other past, present or reasonably foreseeable actions (LI, 2002:119).
dam	The term includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (DWAF, 1999).
decision	A decision is defined as an action that must be taken when there is no more time for gathering facts (Moody, 1983:4).
decision-making	The sequence of steps, actions or procedures that result in decisions, at any stage of a scheme (DEAT, 2002:21).
decision-support system	A decision-support system (DSS) is a system that supports decision making by assisting in the organisation of factors and relations between the latter within a rational framework (Sage, 1991:1).
decommissioning	The activity or process that begins after cessation of mineral production (including metallurgical plant production) and ends with closure. It involves, inter alia, the removal of unwanted infrastructure, the making safe of dangerous excavations and surface rehabilitation with a view to minimising the adverse environmental impacts of mining activities remaining after cessation of mineral production. It includes the aftercare or maintenance that may be needed until closure (CM, 1996:1).

deposit — A dump, heap, pile or filling which usually projects above the natural ground surface. Deposits can be formed by mechanical or hydraulic deposition of material. Deposit includes terms such as slimes dams, tailings impoundments, and mineral, tailings, course waste and waste-rock dumps (CM, 1996:1).

dirty water system — The term includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste (DWAF, 1999).

dispersion (groundwater) — Dispersion is the measure of spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

disposal *versus* deposition — From a larger point of view, it is only tailings deposition i.e. placement that ceases at the end of the operation stage and not the disposal thereof. Tailings management will and must continue until such time as the deposited tailings is assured to be permanently stable and environmentally innocuous (Vick, 1983:324).

dolerite — A fine-grained gabbro. In RSA usage, the preferred term for what is called diabase in the U.S.A. Etymol. Greek doleros, deceitful, in reference to the fine-grained character of the rock which makes it difficult to identify megascopically (van der Walt et al., 1990: 43).

ecosystem — Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space.

effective soil depth — The depth of soil material that plant roots can penetrate readily to obtain water and plant nutrients. The depth to a layer that differs sufficiently from the over-lying material in physical or chemical proper-ties to prevent or seriously retard the growth of roots (van der Walt et al., 1990: 47).

effluent — Liquid fraction of the tailings slurry or pulp with soluble chemicals.

environment — Environment has a number of definitions depending on the context:

- environment means the aggregate of surrounding objects, conditions and influences that influence the life and habits of man or any other organism or collection of organisms (ECA, 1989);
- environment means the surroundings within which humans exist and that are made up of:-
  - the land, water and atmosphere of the earth;
  - micro organisms, plant and animal life;
  - any part or combination of the afore-mentioned and the interrelationships among and between them; and
  - the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being (NEMA, 1998);
- environment means the associated cultural, social, soil, biotic,

atmospheric, surface an ground water aspects associated with landfill that are, or could potentially be, impacted on by the landfill (DWAF, 1998:G-4);

- or the environment is defined as those parts of the socio-cultural, biophysical and economic environment affected by the scheme (DEAT, 2002:20).

environmental impact	An environmental impact is any change in a state of any component of the environment, whether adverse or beneficial, such as water, air, land, natural resources, flora, fauna, and that wholly or partially results from activities, projects or developments (DEAT, 2002:20 and SABS, 1998:5).
erosion	Erosion includes a group of processes by which soil are entrained and transported across a given surface through the action of water, wind, ice or other agents, including the subsidence of soil (CARA, 1983; Galetovic, 1998:1-1).
facility	The term "facility", in relation to an activity, includes any installation and appurtenant works for the storage, stockpiling, disposal, handling or processing of any substance (DWAF, 1999:2).
fatal flaw	Any problem, issue or conflict (real or perceived) that could result in a scheme being rejected or stopped (DEAT, 2002:21).
fault	A fault is a fracture or a zone of fractures along which there has been displacement.
fauna	The animal life of a region.
flora	The plant life of a region.
flux	Flow of energy, fluid, or particles per unit of area per unit of time (Park, 2007).
forb	A herbaceous plant other that grasses.
freeboard	The vertical height difference between the lowest point on the perimeter wall and the supernatant water level on the dam at any time (SABS, 1998:5).
geographical information system	Computerised database of geographical information that can be easily updated and manipulated (LI, 2002:119).
gradation	Gradation refers to the grain size distribution.
grassland	A natural vegetation formation type in which grasses and forb species are dominant.
groundwater	Also known as subsurface water is water occurring below the ground in the saturated zone. (Bear, 1979). Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems (Parsons, 2004).

groundwater resource	Subterranean water that occurs naturally or that can be obtained from below the ground surface, of such quality and in such quantities as would be required to sustain a recognised water use (SABS, 1998:5).
groundwater table	Groundwater table is the surface between the zone of saturation and the zone of aeration – i.e. the surface of an unconfined aquifer.
gully erosion	The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 300 mm to 600 mm to more than 20 m (van der Walt et al., 1990:50).
habitat	Type of environment in which fauna and flora lives.
hazard	Hazard refers to the capacity of a substance, a structure, an activity or an event to produce an adverse effect on life or property, including health, safety or environment (DME (QLD), 1995).
hydraulic conductivity	Hydraulic conductivity (*k*) is a measure of the amount of water transmitted through a porous medium in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the area (Vick, 1983:257). Also known as permeability.
hydraulic gradient	The term hydraulic gradient can imply a hydraulic potential gradient, hydraulic pressure gradient or hydraulic head gradient. In each case the gradient is the change in magnitude (of potential, pressure or head) per unit of distance in the direction of maximum rate of increase thereof. The hydraulic gradient generally determines the rate and direction of water flow in soil (van der Walt et al., 1990: 148).
hydraulic head	The elevation with respect to a specified reference level at which water stands in a piezometer connected to the point in question in the soil. Its definition can be extended to soil above the water table if the piezometer is replaced by a tension meter. The hydraulic head in systems under atmospheric pressure may be identified with a potential expressed in terms of the height of a water column. More specifically it is the sum of the gravitational and hydrostatic pressure (or metric) potentials, expressed as a head (H = hg + hp) (van der Walt et al., 1990: 148).
hypothesis	A supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation (Oxford, 2002:570).
indigenous	Any species of plant, shrub or tree that occurs naturally in South Africa.

land capability	This is the extent to which land can meet the needs of one or more uses under defined conditions of management, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. Land capability involves consideration of (i) the risks of land damage from erosion and other causes and (ii) the difficulties in land use owing to physical land characteristics, including climate (van der Walt et al., 1990: 79).
land use	The primary use of the land, including both rural and urban activities (LI, 2002:120). Land use is not a feature of the environment as such but represents the current status of the land surface as a whole and therefore also reflects the condition of the environment (van Riet et al., 1997:13)
landform	An element of and within the landscape with specific shape characteristics. This may also refer to an artificial element which can be compared to a natural landform and is subject to the same geomorphologic processes (Rademeyer and van den Berg, 2005; Park, 2007). It is the combinations of slope and elevation that produce the shape and form of the land (LI, 2002:120).
landscape	Depending on the context, landscape can have any of the following meanings: • Scenery, either natural or modified by human activities which is often used to refer to scenery that can be seen from a single viewpoint (Park, 2007). • All the natural features, such as fields, hills, forests, and water that . distinguish one part of the earth's surface from another pad; usually. that portion of land or territory which the eye can comprehend in a 6 single .view (van der Walt et al., 1990: 81). • Landscape is made up of a landform component (topography), landcover (vegetation, built form, soil colour, water and other man-made infrastructure), and atmospheric conditions. • A tract of land with its distinguishing characteristics and features, especially considered as a product of shaping processes and agents (DME, 2006:4). • Human perception of the land conditioned by knowledge and identity with a place (LI, 2002:120).
leaching	Leaching involves removal of minerals from the ground particles by direct contact with solvent, usually a strong acid or alkaline solution depending on the type of ore (Vick, 1883:8).
mine residue	Mine residue includes any debris, discard, tailings, slimes, screenings, slurry, rock, foundry sand, beneficiation plant waste, ash and any other waste product derived from or incidental to the operation of a mine or activity and which is stockpiled, stored or accumulated for potential re-use or recycling or which is disposed of (DWAF, 1999:2).

mine residue deposit	Mine residue deposit includes any dump, tailings impoundment, slimes dam, ash dump, rock dump, in-pit deposit and any other heap, pile or accumulation of residue remaining at termination, cancellation or expiry of a prospecting right, mining right, mining permit, exploration right or production right (MPRDA, 2002).
mine residue deposit	The term Mine Residue Deposit (MPRDA, 2002:16) is the generic term used for describing mining waste to the panel of visual experts participating in the research, whereas the terms Tailings Disposal Facility (TDF), tailings dam and tailings impoundment are interchangeably used throughout this thesis.
mine residue stockpile	Mine residue stockpile means any debris, discard, tailings, slimes, screening, slurry, rock, foundry sand, beneficiation plant waste, ash or any other product derived from or incidental to a mining operation and which is stockpiled, stored or accumulated for potential re-use, or which is disposed of, by the holder of a mining right, mining permit or production right (MPRDA, 2002).
mineral	A mineral includes inter alia sand, soil, clay, gravel, rock, ore, coal and tailings. A mineral occurs in, on or under the earth, water or tailings, as a liquid, solid or gas (DME, 2000).
mineral waste	Mineral wastes comprise of; mined rock, which has no economic ore, tailings, which are the fine sand like residue after the mineral has been extracted from the rock and slag, which is the solid residue from the smelting process. The generation of mineral wastes is directly related to ore type, economic grade and the type of mine (DME, 2006:4).
mineral waste deposits	Mined rock particles, varying in size, that contain no economically viable ore (DME, 2006:4).
mineral waste residues	Refers to tailings impoundments, slimes dams, rock dumps and sand dumps (DME, 2006:4).
mining	Mining is the making of any excavation for the purpose of winning a mineral, and it includes any other associated activities and processes (DME, 2000).
mitigation	Measures including any process, activity or design to avoid, reduce, remedy or compensate for adverse landscape and visual effects of a development project (LI, 2002:121).
non-renewable resources	Resources that exist in a fixed quantity in the earth's crust and thus theoretically can be completely depleted are called non-renewable resources. It must be noted that these resources can be depleted much faster than they are formed.
ore	Metalliferous rock from which metallic compounds are extracted as valuables.

overburden	Material recently deposited by a transportation mode that occurs immediately adjacent to the surface horizon of a contemporaneous soil. A term used to designate disturbed or undisturbed material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials, ores, lignites, or coals, especially those deposits mined from the surface by open cuts (van der Walt et al., 1990: 100).
partial closure	The closure of a part, section or portion of a mine. The environmental management issues that need to be addressed for partial closure are the same, as those required for closure of the whole mine.
particulates	Fine solid particles which remain individually dispersed in air (UNEP, 2005:81).
permeability	A measure of the rate at which water can percolate through soil or rock, usually expressed in cubic metres per second (m^3/s). Also known as hydraulic conductivity (Park, 2007).
phreatic aquifer	An aquifer in which a water table (= phreatic surface) serves as its upper boundary. A phreatic aquifer is directly recharged from the ground surface above it, except where impervious layers exist between the phreatic surface and the ground surface (Bear, 1979).
phreatic surface	The phreatic surface is the level of saturation in the impoundment and the embankment – i.e. the surface along which pressure in the fluid equals atmospheric pressure. In natural systems without flow it is often equal to the water table.
pioneer species	Hardened, annual plants, which can grow in very unfavourable conditions. Benefits of having these species include less runoff and more available moisture, cooler soil surfaces and less evaporation, protection against wind and build up of organic matter thereby increased enrichment of the soil.
piping	Piping refers to subsurface erosion along a seepage pathway within or beneath an embankment which results in the formation of a low-pressure conduit allowing concentrated flow.
pollution	Pollution is the contamination of resources such as water, air, soil and land with harmful or poisonous substances.
porosity	Porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.
post-closure after use	The use of which a mining site, or part of a site, is determined when mineral extraction is completed.
potentially renewable resource	A potentially renewable resource can be renewed fairly rapidly (hours to several decades) through natural processes. Examples of such resources include forest trees, grassland grasses, wild animals, fresh lake and stream water, fresh air, and fertile soil.

qualitative	Relating to or involving comparisons based on qualities.
quantitative	Expressible as a quantity or relating to or concerned with the measurement by quantity (Oxford, 2002:955).
rare species	Species, which have naturally small populations, and species, which have been reduced to small (often unstable) populations by man's activities.
reclamation	The return of a disturbed site to an agreed-upon land use.
red data	A list of species, fauna and flora that require environmental protection. Based on the IUCN definitions.
rehabilitation	The return of disturbed land to a stable, productive and self-sustaining condition, after taking into account beneficial uses of the site and surrounding land.
remediation	The clean-up or mitigation of pollution or of contamination of soils or water by pre-determined methods.
renewable resources	Solar, wind and wave energy is considered to be a renewable resource because on a human time scale it is essentially inexhaustible. It is expected to last at least 6,5 billion years while the sun completes its life cycle.
residue	Residue includes any debris, discard, tailings, slimes, screenings, slurry, rock, foundry sand, beneficiation plant waste, ash and any other waste product derived from or incidental to the operation of a mine or activity and which is stockpiled, stored or accumulated for potential re-use or recycling or which is disposed of (DWAF, 1999:2).
residue deposit	The term residue deposit, includes any dump, tailings impoundment, slimes dam, ash dump, rock dump, in-pit deposit and any other heap, pile or accumulation of residue (DWAF, 1999).
residue deposit	Means any residue stockpile remaining at termination, cancellation or expiry of a prospecting right, mining right, mining permit, exploration right or production right (MPRDA, 2002).
residue stockpile	means any debris, discard, tailings, slimes, screening, slurry, rock, foundry sand, beneficiation plant waste, ash or any other product derived from or incidental to a mining operation and which is stockpiled, stored or accumulated for potential re-use, or which is disposed of , by the holder of a mining right, mining permit or production right (MPRDA, 2002).
resource	Resources whose location, grade and quality are known, or estimated from specific geological evidence, and includes economic, marginally economic and sub-economic components. It also encompasses demonstrated and inferred subdivisions (DME, 2000a).

restoration	Recreating the original topography and re-establishing the previous land use in a self-sustaining condition.
rill erosion	An erosion process in which numerous small channels a few centimetres deep are formed; occurs mainly on recently cultivated soils (van der Walt et al., 1990: 50).
ring dike impoundment layout	The ring dike impoundment layout method is best suited for flat terrains and requires a relatively high quantity of embankment fill in relation to the storage volume produced. Also, ring-type impoundments are usually laid out with a regular geometry (Vick, 1983: 119).
risk	Risk refers to a combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence. Hazard refers to an attribute or situation that in particular circumstances could lead to harm (DEFRA, 2000). Risk, in relation to tailings impoundments, includes the potential for failure leading to the flow of slurry or the discharge of tailings or seepage into the environment through mechanisms such as wind and water resulting in environmental impacts.
runoff	That portion of the precipitation on an area which is discharged from the area through stream channels, That which is lost without entering the soil is called surface runoff and that which enters the soil before reaching the stream is called ground water runoff or seepage flow from ground water. (In soil science "runoff" usually refers to the water lost by surface flow; in geology and hydrology "runoff" usually includes both surface and subsurface flow) (van der Walt et al., 1990: 116).
saltation	A mode of sediment transport in which the particles are moved progressively forward in a series of short intermittent leaps, jumps, hops or bounces from a surface; e.g. sand particles skipping downwind by impact and rebound along a desert surface, or bounding downstream under the influence of eddy currents that are not turbulent enough to retain the particles in suspension and thereby return them to the stream bed at some distance downstream (van der Walt et al., 1990: 116).
saturated zone	The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere (Parsons, 2004).
scenario	A picture of a possible feature (LI, 2002:121).

sediment	(1) Any material carried in suspension by water, which would settle to the bottom if the water lost velocity. (2) Fine water-borne matter deposited or accumulated in beds. Sediment is ordinarily transported as suspended sediment, by saltation or as bed load (van der Walt et al., 1990: 11p).
sediment yield	The sediment yield from a surface is the sum of the soil losses minus deposition in macro-topographic depressions, at the toe of the hill slope, along field boundaries, or in terraces and channels sculpted into the hill slope (Galetovic, 1998:1-1).
sheet erosion	The removal of a fairly uniform layer of soil from the land surface by runoff water (van der Walt et al., 1990: 50).
significance	Impact magnitude is the measurable change, i.e. intensity, duration and likelihood. Impact significance is the value placed on the change by different affected parties, i.e. level of significance and acceptability. It is an anthropocentric concept, which makes use of value judgements and science-based criteria, i.e. socio-cultural, biophysical and economic. Such judgements reflect the political reality of impact assessment in which significance is translated into public acceptability of impacts (DEAT, 2002:21).
simulation	Simulation is to create a representative and accurate two-dimensional image of a future or proposed scheme through the use of computer modified photographs and computer graphics.
slope	The vertical difference in height between the highest and the lowest points of a portion of land. The ratio method defines slope as a ratio of the horizontal distance to the vertical elevation difference. The percentage method defines slope as a percentage, dividing the difference in the vertical elevation by the horizontal distance and converting this decimal to a percentage.
slope aspect or slope orientation	The slope and direction of the land surface. Combines with the sun's vertical angle and planar direction to determine the relative amount of solar radiation incident on the ground surface at any given time (Motloch, 2001).
soil	A mixture of organic and inorganic substances, the composition and structure of the latter is derived from the parent rock material. Soil also contains bacteria, fungi, viruses and micro-arthropods, nematodes and worms.
soil loss	Soil loss is that material actually removed from the particular hill slope or hill slope segment. The soil loss may be less than erosion due to on-site deposition in micro-topographic depressions on the hill slope (Galetovic, 1998:1-1).

species diversity	A measure of the number and relative abundance of species (see biodiversity).
species richness	The number of species in an area or habitat.
sphere of influence	Sphere of influence is the term used in this report to describe the three-dimensional mine residue storage or disposal facility zone of influence within which an effect on the environment is anticipated. This zone is the spatial overlay or sum of the different environmental aspect zones of influence and is also representative of a particular configuration at a specific moment in time.
spigotting discharge method	Spigotting accomplishes the deposition of an above-water tailings beach around the perimeter of a tailings impoundment and requires the tailings discharge pipe be relocated periodically to from a series of adjacent and overlapping deltas (Vick, 1983:10).
spoil	Bulk waste material produced along with the marketable mineral: production waste, substandard and unmarketable material, overburden, etc. that has to be disposed of.
stakeholders	A subgroup of the public whose interest may be positively or negatively affected by a proposal or activity and/or who are concerned with a scheme or activity and its consequences. The term therefore includes the proponent, authorities and all interested and affected parties (IAPs) (DEAT, 2002:23).
stockpile	The term "stockpile", includes any heap, pile, slurry pond and accumulation of any substance where such substance is stored as a product or stored for use at any mine or activity (DWAF, 1999).
subsoil	Subsoil means those layers of soil and weathered rock immediately beneath the topsoil that overlay the hard rock formation.
subsurface water	All water found below the surface of the earth, including soil water, capillary water and groundwater (Parsons, 2004:2-3).
sustainable development	Sustainable development means the integration of social, economic and environmental factors into planning, implementation and decision making so as to ensure that mineral and petroleum resources development serves present and future generations (MPRDA, 2002 and NEMA, 1998).
tailings	Tailings is any fine-grained waste materials from metallurgical processing including slimes and residue. It mainly comprises finely ground rock and may contain process chemical residues (DME, 2000; UNEP, 2005:80; Vermeulen, 2002).
tailings storage facility	TSF - The overall area used to confine tailings, and may include one or more tailings impoundment compartment. The facility's functions are to provide a site for waste residue disposal, achieve solids settling and improve water quality.

threatened species	Species, which have naturally small populations, and species, which have been reduced to small (often unstable) populations by man's activities.
threshold	A specified level in grading effects, for example, of magnitude, sensitivity or significance (LI, 2002:121).
topsoil	The upper layer of soil which supports plant growth. Generally this layer contains nutrients, organic matter and seed (UNEP, 2005:82).
total dissolved solids	Total dissolved solids (TDS) is a term that expresses the quantity of dissolved material in a sample of water.
transmissivity	Transmissivity (T) is the rate at which groundwater can flow through an aquifer and is defined as the product of hydraulic conductivity and saturated aquifer thickness (Park, 2007; Vick, 1983:257).
upstream raising method	This raising method requires that a starter dike is constructed, and the tailings is discharged peripherally from the crest to form a beach. The beach then becomes the foundation for a second perimeter dike. This process continues as the embankment increases in height (Vick, 1983:71).
VAC	Visual Absorption Capacity is the capacity the surrounding environment has to camouflage or reduce the visual impact of the impoundment.
vadose zone	Vadose zone is the zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is that between the land surface and the surface of the zone of saturation, that is, the water table.
variable	The term variable refers to whatever characteristic being investigates or analysed (Wisniewski, 1997:15).
visual absorption capacity	Visual Absorption Capacity is the capacity the surrounding environment has to camouflage or reduce the visual impact of the impoundment.
visual envelope	Extent of potential visibility to or from a specific area or feature (LI, 2002:121).
visual impact	Any positive or negative change in appearance of the landscape as a result of development (Park, 2007).
visualisation	Computer simulation, photomontage or other technique to illustrate the appearance of a development (LI, 2002:121).
water table	Water table is the surface between the vadose zone and the groundwater, that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere (Parsons, 2004).

wetlands	Areas of land that are periodically or permanently waterlogged for a sufficient period of time to sustain aquatic processes and biological activity adapted to the wet environment. Wetlands include vleis, bogs, mires, swamps, marshes, dolomitic eyes and pans.
worst-case situation	Principle applied where the environmental effects may vary, for example, seasonally to ensure the most severe potential impact is assessed (LI, 2002:121).
zone of visual influence	Area within which a proposed development may have an influence or effect on visual amenity (LI, 2002:121).

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APPENDICES

The Influence of Environmental Impacts on Tailings Impoundment Design

APPENDIX A: VISUAL

Appendix A1: Details of the NGT participants

Appendix A2: Presentation of Visualisations to experts

Appendix A3: Presentation of Visualisations to experts

Appendix A4: Zone of visual perception results

Appendix A1: Details of the NGT study participants

The following people, listed alphabetically, were on the panel of experts for the visual perception study using the nominal group technique study method.

Bakker, K.A.
Breedlove, G.
Fisher, R.
Gärtner, R.
Hindes, C.
Marais, V.
O'Rourke, E.
Rademeyer, B.
Rust, E.
Saidi, F.
Trichard, L.G.
van den Berg, M.J.
van Rensen, C.
van Wyk, F.H.
Vosloo, P.
Young, G.A.

CREDENTIALS

Bakker Karel A

Personal information

Nationality:	South African
Parent Firm:	University of Pretoria
Home language:	English / Afrikaans

Educational qualifications

- PhD (Arch) - University of Pretoria (January 2001)
- M.Arch (cum laude) - University of Pretoria (1993)
- B.Arch - University of Pretoria (1981)

Registration

- Member of the SA Council of Architects
- Member South African Institute of Architects National Heritage Committee
- Member of the International Committee on Monuments and Sites (ICOMOS). (The International Committee on Monuments and Sites is an international conservation body)

Key areas of expertise

- Prof Bakker is a professor at the Department of Architecture at the University of Pretoria and also practices as an architect with Cultmatrix CC (Heritage Management Consultants). His main fields of research are: Archaic Greek architecture, African architecture and settlement, urban regeneration and heritage management.

CREDENTIALS

Breedlove Gwen

Personal information

Nationality:	South African
Parent Firm:	African EPA / University of Pretoria
Position:	Associate Professor
Home language:	English / Afrikaans

Educational qualifications

- PhD (Cultural landscape evaluations) – University of Pretoria (2003)
- ML.Arch - Texas A&M University (1986)
- BL.Arch - University of Pretoria

Registration

- Pr. LArch (SA)

Key areas of expertise

- Co-ordination, compilation, editing and review of Environmental Impact Assessments and Scoping Reports for linear and other type of projects regulated under the Environmental Conservation Act.
- Writing of Environmental Management Programme Reports (EMPRs), and Environmental Assessments and Environmental Management Programmes (EMPs) required by the Mineral and Petroleum Resources Development Act for platinum, coal, clay and aggregate mines.
- Master plan development.
- The compilation and editing of Scoping Reports.
- Visual impact assessments.
- Design and drawing of landscape plans, details, concepts and presentation perspectives for various projects.
- Art and Aesthetics in the Landscape.
- Cultural Landscape identification and classification.
- Social Ecology.
- Landscape classifications.
- Environmental Potential Atlas for South Africa with the Dept. of Env. Affairs and Tourism.
- Environmental Management Framework for South Africa with Dept. of Env. Affairs and Tourism.
- Tourism Potential Atlas for South Africa with Dept. of Env. Affairs and Tourism.

CREDENTIALS

Fisher Roger

Personal information

Nationality:	South African
Parent Firm:	University of Pretoria
Position:	Professor in Architecture
Home language:	English / Afrikaans

Educational qualifications

- PhD (Arch) - University of Pretoria (1993)
- M.Arch (cum laude) - University of Pretoria (1989)
- B.Arch - University of Pretoria (1982)

Registration

- Member of the SA Council of Architects

Key areas of expertise

- Prof Fisher is a professor at the Department of Architecture at the University of Pretoria and has been lecturing at the University for more than 20 years. He acted as Head of the Department of Architecture for the period April 2003 to August 2004. Prof Fisher has also published extensively in the fields of architecture, architectural conservation and heritage, and sustainability and the built environment.

CREDENTIALS

Gärtner Renate

Personal information

Nationality:	South African
Parent Firm:	Strategic Environmental Focus (Pty) Ltd
Position:	Project Advisor: Environmental Management Unit
Home language:	German/English/Afrikaans

Educational qualifications

- Fasset Leadership and Management Course (2004)
- Course in Environmental Law, Policy, Assessment and Reporting (2000)
- Registered as Tour Guide for Gauteng (1997)
- BL.Arch - University of Pretoria (1991)

Registration

- Certified Environmental Assessment Practitioner of South Africa
- Registered as a Professional Landscape Architect with the South African Council for the Landscape Architectural Profession

Key areas of expertise

- Environmental Impact Assessment

Project managed and undertook numerous Scoping Reports, Exemption applications and Environmental Management Plans, as required by the Environment Conservation Act No. 73 of 1989. Project experience includes the establishment of various housing typologies, infrastructure development (including roads and pipelines), resorts and filling stations as well as community development and social upliftment projects. Involved in various Blue IQ Projects funded by the Gauteng Provincial Government, which include the City Deep Industrial Development Zone, The Innovation Hub and the Automotive Supplier Park.

- Landscape Architecture

Professional experience includes the development of master plans and landscape development plans for rezoning applications. Involved in landscape designs, concepts, construction details, site inspections and maintenance supervision. Production of sketch designs, design proposals, cost estimations and motivational reports. Worked in a team on the preparation of concepts, maps, sketches and a master plan for Gaborone. Gained international experience by working at various Landscape Architect companies in Germany.

CREDENTIALS

Hindes Clinton

Personal information

Nationality:	South African
Parent Firm:	University of Pretoria
Position:	Lecturer
Home language:	English / Afrikaans

Educational qualifications

- ML.Arch (cum laude) – University of Pretoria
- BL.Arch (cum laude) – University of Pretoria

Key areas of expertise

- Landscape architectural education and curriculum development
- Design theory of landscape architecture
- History of 20th C landscape architectural design
- Site planning and design
- PhD study commencing on the role and nature of design theory in landscape architecture practice and education

CREDENTIALS

Marais Vanessa

Personal information

Nationality:	South African
Parent Firm:	Galago Ventures
Position:	Environmental Specialist
Home language:	English/Afrikaans

Educational qualifications

- BL.Arch – University of Pretoria

Registration

- Registered as a Professional Landscape Architect with the South African Council for the Landscape Architectural Profession

Key areas of expertise

Vanessa Marais is a professional Landscape Architect and has specialized in the development of management processes and guidelines for the review of environmental impact assessments. She has been extensively involved in policy decisions relating to environmental impact management within the ambit of the national context. Her field of expertise is environmental impact management, evaluation and review with analysis of processes used for environmental impact management.

While working at a big engineering firm, her experience in the field of Environmental Impact Assessments (EIAs) has enabled her to develop mechanisms for determining impacts associated with developments as well as mitigating measures for environmental management lans (EMP). Her background as Landscape Architect is an advantage in the planning and management of environmental management frameworks (EMFs). She gained valuable experience in project management while contributing to various projects in the environmental field. This experience together with her extensive knowledge of Environmental Legislation acquired at the Department of Environmental Affairs and Tourism, makes her the ideal candidate for environmental manager. She was the project leader for the Mbombela State of the Environment Report that was undertaken in 2003 and 2004. She also used the vast experience in EIAs and EMPs and externally audited environmental conditions at three construction projects, including the Kruger Mpumalanga International Airport.

A significant project she was recently involved in is the Centurion Over-Arching Environmental Framework for which the team received a Merit Award from the Institute for Landscape Architects in South Africa (ILASA) for outstanding work in the environmental field of Landscape Architecture. She was also involved in the specialist studies for the Lesedi Environmental Framework 2005.

CREDENTIALS

O'Rourke Eamon

Personal information

Nationality:	South African
Parent Firm:	Strategic Environmental Focus (Pty) Ltd
Position:	Unit Manager: Landscape Architecture
Home language:	English / Afrikaans

Educational qualifications

- BL.Arch – University of Pretoria (1992)

Registration

- Registered as a Professional Landscape Architect with the South African Council for the Landscape Architectural Profession (SACLAP)
- Member on the SACLAP Council
- Professional member of the Institute of Landscape Architects of South Africa
- Council member on the Council for the Built Environment (CBE)
- Member on the Certification Board for the certification of Environmental Assessment Practitioners

Key areas of expertise

- Environmental Impact Assessment
- Landscape design including design frameworks, master plans, concept development and detail design
- Open space planning and management
- Environmental Management Plans
- Visual impact assessment for a variety of projects (power and transmission lines, national roads, buildings

CREDENTIALS

Rademeyer Brian

Personal information

Nationality:	South African
Parent Firm:	University of Pretoria
Position:	PhD research student
Home language:	English / Afrikaans

Educational qualifications

- M.Sc. (Geography and Environmental Management) - Rand Afrikaans University (2001)
- BL.Arch - University of Pretoria (1997)

Registration

- Certified environmental practitioner of South Africa registered with the Certification Board of Environmental Assessment Practitioners of South Africa (EAPSA).

Key areas of expertise

- Writing of Environmental Management Programme Reports (EMPRs) and Environmental Assessments and Environmental Management Programmes (EMPs) required by the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) for platinum, coal, clay and aggregate mines.
- Compiling of Basic Assessments, Environmental Impact Assessments and Environmental Management Plans as required by the National Environmental Management Act 107 of 1998 (NEMA).
- Master Plan development.
- Landscape design.

CREDENTIALS

Rust Eben

Personal information

Nationality:	South African
Parent Firm:	University of Pretoria
Position:	Associate Professor of Geotechnical Engineering
Home language:	English / Afrikaans

Educational qualifications

- PhD, Geotechnical Engineering - University of Surrey, UK (1997)
- M.Eng, (Cum Laude), Geotechnical Engineering - University of Pretoria (1991)
- B.Eng. (Hons), Civil Engineering - University of Pretoria (1985)
- B.Sc, Civil Engineering - University of Pretoria (1979)

Registration

- Engineer 89012 (1989)

Key areas of expertise

- Specialist knowledge of theoretical soil mechanics and advanced geotechnical design
- Geotechnical in situ testing and instrumentation,
- Numerical analysis and design
- Behaviour of tropical soils and soft clays
- Earth fill dam design
- Tailings dam analysis and design
- Risk analysis
- Environmental geo-technology
- Advanced soils laboratory testing

CREDENTIALS

Saidi Finzi

Personal information

Nationality:	Zambian
Parent Firm:	University of Pretoria
Position:	Lecturer
Home language:	English / Nyanja

Educational qualifications

- ML.Arch - University of Newcastle upon Tyne (1994)
- B.Arch - Copperbelt University (1991)

Key areas of expertise

- Lecturing in various Landscape and architectural course-modules
- Design of various buildings types
- Design Competition adjudication
- Design and drawing of landscape plans, details, concepts and presentation perspectives for various projects

CREDENTIALS

Trichard Louis G

Personal information

Nationality:	South African
Parent Firm:	LTLA Development Management
Position:	Founding member
Home language:	English / Afrikaans

Educational qualifications

- BL.Arch – University of Pretoria (1977)

Registration

- Pr. LArch (SA) 88033

Key areas of expertise

- Resource Development Strategies and Management
- Landscape Management and Maintenance
- Resort Site Utilization and Conservation
- Sports, Recreation and Public Open Space Planning
- Urban Landscaping, Design and Pedestrianization
- Cemeteries, Memorial Gardens and Memorial Parks

CREDENTIALS

van den Berg Mader J

Personal information

Nationality:	South African
Parent Firm:	Strategic Environmental Focus / University of Pretoria
Position:	Qualified landscape architect
Home language:	English / Afrikaans

Educational qualifications

- ML.Arch (Prof) - University of Pretoria (2004)
- B.Sc Hons (Landscape Architecture) - University of Pretoria (2003)
- B.Sc (Landscape Architecture) - University of Pretoria (2002)

Key areas of expertise

- Environmental landscape planning and design
- Computer aided design
- Visual impact assessment
- Graphic design
- Rehabilitation planning
- Garden design and implementation
- Irrigation design and implementation

CREDENTIALS

van Rensen Chris

Personal information

Nationality:	South African
Parent Firm:	African EPA
Position:	Director
Home language:	English / Afrikaans

Educational qualifications

- B.Eng (Civil) – University of Pretoria

Key areas of expertise

- Environmental projects
- Mining related projects
- Other Engineering related projects
- Structural Engineering
- GIS systems
- Infrastructure development engineering
- Water related projects
- Roads

CREDENTIALS

van Wyk Frans H

Personal information

Nationality:	South African
Parent Firm:	University of Pretoria
Position:	Lecturer – Department of Architecture
Home language:	English/Afrikaans

Educational qualifications

- BL.Arch – University of Pretoria

Registration

- Pr . LArch (SA)

Key areas of expertise

- Landscape Architecture
- Open Space Conservation Planning
- Urban Design
- Landscape Heritage

CREDENTIALS

Vosloo Piet

Personal information

Nationality:	South African
Parent Firm:	KWP / University of Pretoria
Position:	Director in charge of KWP Landscape Architecture Division Senior Lecturer – Department of Architecture
Home language:	English/Afrikaans

Educational qualifications

- ML. Arch (cum laude) - University of Pretoria (1990)
- B.Arch - University of Pretoria (1978)
- B.Sc (Building Science) - University of Pretoria (1974)

Registration

- Registered with the SA Council for the Architectural Profession as a Pr Arch since 1978
- Registered with the SA Council for the Landscape Architectural Profession as a Pr LArch since 1993

Key areas of expertise

- Commercial, industrial, and educational facilities
- Museums and related heritage facilities
- Landscape design in various fields
- Environmental impact assessments and scoping reports
- Environmental and urban ecological planning
- Site Master planning

CREDENTIALS

Young Graham A

Personal information

Nationality:	South African
Parent Firm:	Newtown Landscape Architects / University of Pretoria
Position:	Member Newtown Landscape Architects
	Lecturer – Department of Architecture
Home language:	English/Afrikaans

Educational qualifications

- BL.Arch - University of Toronto, Canada (1978)

Registration

- Pr. LArch (SA)

Key areas of expertise

- Landscape and urban design
- Ecological planning and design
- Environmental planning including environmental impact assessments and environmental management programmes
- Visual impact assessments
- Open space planning including frameworks, resort planning and detail urban park design
- Site and landscape design for domestic, commercial and industrial sites
- Landscape master planning for quarry end-use and landfill (solid waste) end-use plans
- Landscape rehabilitation and management

Appendix A2: Presentation of visual perception study

Delphi Research Method

Delphi exercise – general information *(1 of 3)*

A Delphi exercise is a discussion by knowledgeable participants with the aim of reaching an acceptable level of agreement and consensus on the results

Delphi Research Method

Delphi exercise – general information *(2 of 3)*

The Delphi exercise concept is based on the premises that:

(1) opinions of experts are justified as inputs to decision-making where absolute answers are unknown;

(2) a consensus of experts will provide a more accurate response to a question than a single expert.

Delphi Research Method

Delphi exercise – general information *(3 of 3)*

The general procedures for this exercise are as follows:

(1) experts are polled on a series of visualisations;

(2) responses are tabulated, analysed, and the results fed back to the experts; and

(3) experts reconsider and evaluate their answers in light of the information generated by the aggregate responses. This process is repeated until consensus is reached.

Delphi Research Method

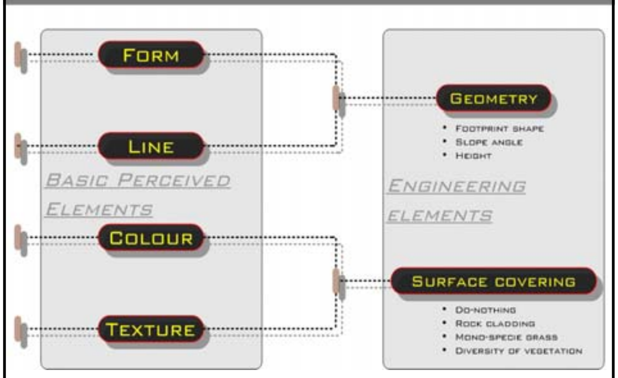
Delphi exercise – Nominal Group Technique

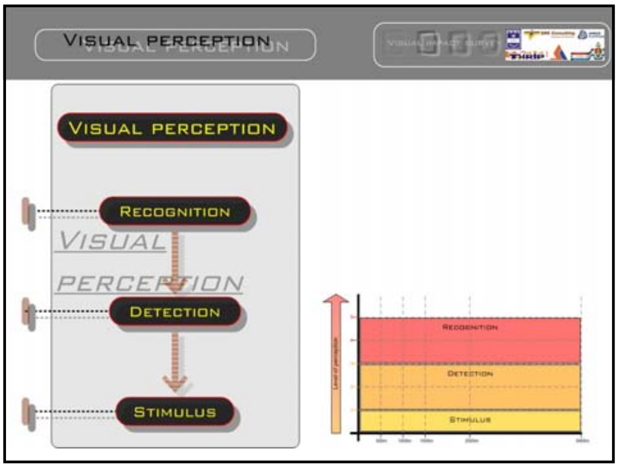
The Nominal Group Technique (NGT):

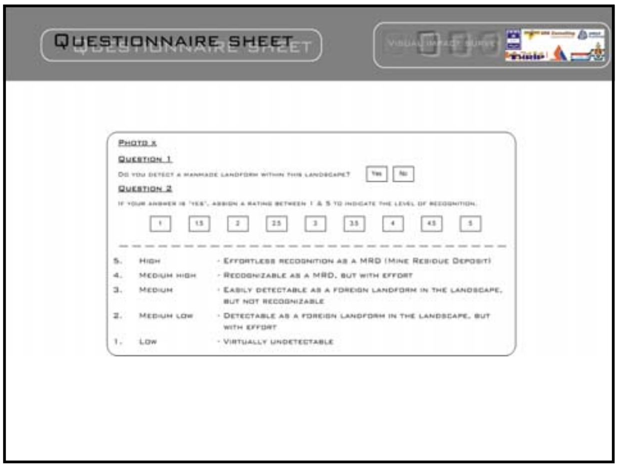
(1) employs face-to-face meetings and discussions by knowledgeable participants to obtain and combine expert opinion in the hope of reaching an agreeable conclusion; and

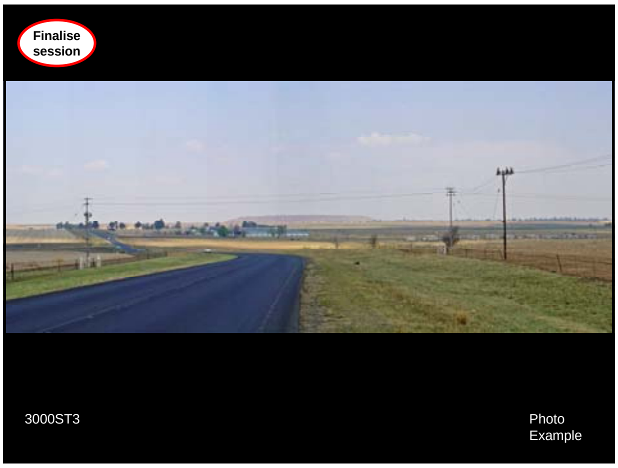
(2) allows for information to be collected in less time whereas the Delphi technique is applied where experts are not readily available or within reasonable travelling distance.

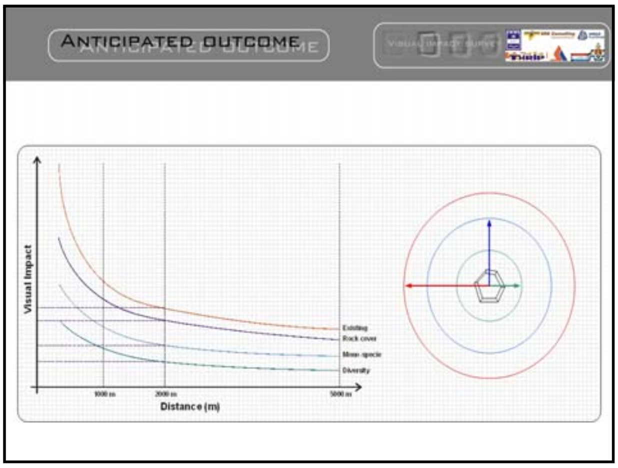
Basic perceived elements




VISUAL PERCEPTION
VISUAL PERCEPTION
RECOGNITION
VISUAL PERCEPTION
DETECTION
STIMULUS
RECOGNITION
DETECTION
STIMULUS


QUESTIONNAIRE SHEET
PHOTO X
QUESTION 1
DO YOU DETECT A MANMADE LANDFORM WITHIN THIS LANDSCAPE?
Yes
No
QUESTION 2
IF YOUR ANSWER IS "YES", ASSIGN A RATING BETWEEN 1 & 5 TO INDICATE THE LEVEL OF RECOGNITION.
1
1.5
2
2.5
3
3.5
4
4.5
5
5. HIGH - EFFORTLESS RECOGNITION AS A MRD (MINE RESIDUE DEPOSIT)
4. MEDIUM HIGH - RECOGNIZABLE AS A MRD, BUT WITH EFFORT
3. MEDIUM - EASILY DETECTABLE AS A FOREIGN LANDFORM IN THE LANDSCAPE, BUT NOT RECOGNIZABLE
2. MEDIUM LOW - DETECTABLE AS A FOREIGN LANDFORM IN THE LANDSCAPE, BUT WITH EFFORT
1. LOW - VIRTUALLY UNDETECTABLE


Finalise session
3000ST3
Photo Example


ANTICIPATED OUTCOME
Visual Impact
Existing
Rock cover
Mono specie
Diversity
1000 m
2000 m
5000 m
Distance (m)

Visual impact survey

25 August 2004

Click enter button to proceed with survey

7200WG6 Photo 1

3000ST3 Photo 2

8200WG3 Photo 3

800WT3 Photo 4

3000SG6 Photo 5

3600WT6 Photo 6

2000SS6 Photo 7

2500NT Photo 8

8200WD6 Photo 9

8200WR6 Photo 10

3000ST6 Photo 11

1000ST3 Photo 12

8200WG6 Photo 13

8300WT3 Photo 14

3600WG3 Photo 15

7200WT6 Photo 16

1000WG3 Photo 17

8200WT6 Photo 18

1000WD3 Photo 19

8200WR3 Photo 20

1000WR6 Photo 21

3600WS6 Photo 22

3600WT3 Photo 23

3000SR6 Photo 24

2000WT3 Photo 25

8200WT3 Photo 26

1000NT Photo 27

3000SD6 Photo 28

1000WS3 Photo29

8200WS6 Photo 30

2000SS3 Photo 31

1000WT3 Photo 32

2000SG3 Photo 33

7200WS6 Photo 34

3600WG6 Photo 35

2000SR3 Photo 36

3600WD3 Photo 37

7200WR6 Photo 38

2000SR6 Photo 39

3600WR3 Photo 40

2000ST3 Photo 41

7200WD6 Photo 42

8200WD3 Photo 43

1000WS6 Photo 44

3600WD6 Photo 45

3000SG3 Photo 46

2000SD3 Photo 47

7200WD3 Photo 48

2000ST6 Photo 49

3000SD3 Photo 50

3000SR3 Photo 51

3600WR6 Photo 52

3000SS6 Photo 53

1000WT6 Photo 54

3000SS3 Photo 55

3600WS3 Photo 56

6000WT3 Photo 57

7200WG3 Photo 58

2000SG6 Photo 59

1000WG6 Photo 60

7200WR3 Photo 61

1000WR3 Photo 62

7200WS3 Photo 63

8200WS3 Photo 64

1000WD6 Photo 65

2000SD6 Photo 66

7200WT3 Photo 67

The end. Thank you for your participation.

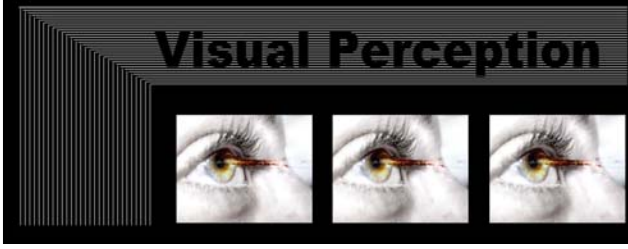
Appendix A3: Presentation of visual perception results

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Visual Perception Experiment

Managing the visual impact of tailings impoundments

5 October 2005



DELPHI RESEARCH METHOD

- Background
- Visual impact assessment
- Experiment impoundment site
- Applying the predicted results

DELPHI RESEARCH METHOD

- **Background**
- Visual impact assessment
- Experiment impoundment site
- Applying the predicted results

DELPHI RESEARCH METHOD

Background

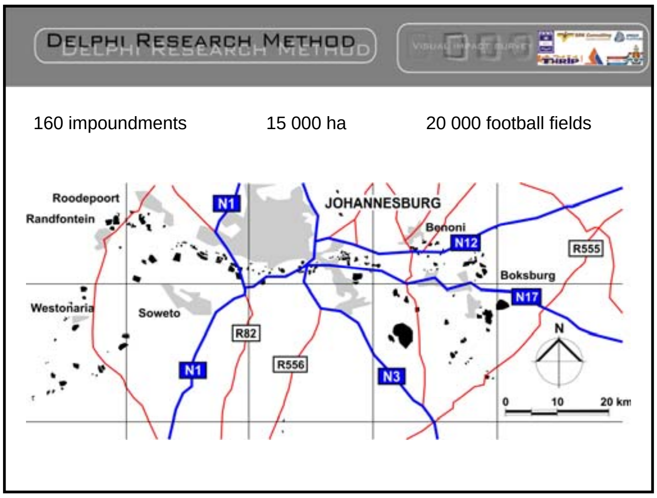
- *Problem statement*
- *General model*

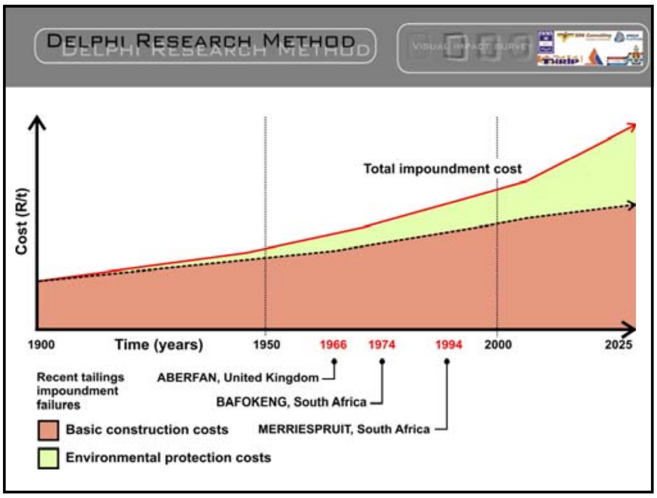
DELPHI RESEARCH METHOD

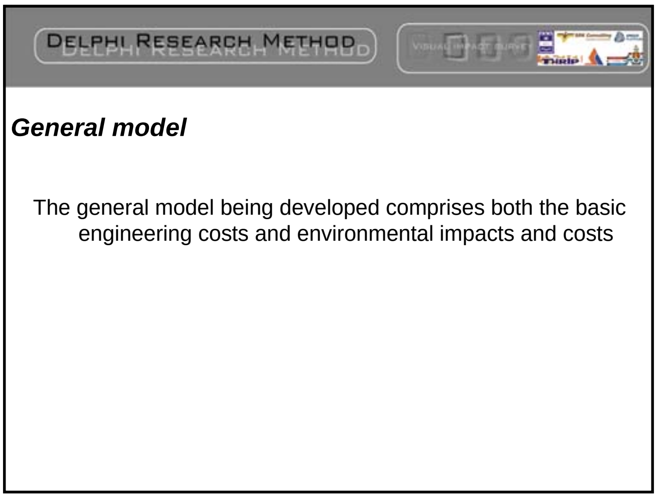
Problem statement

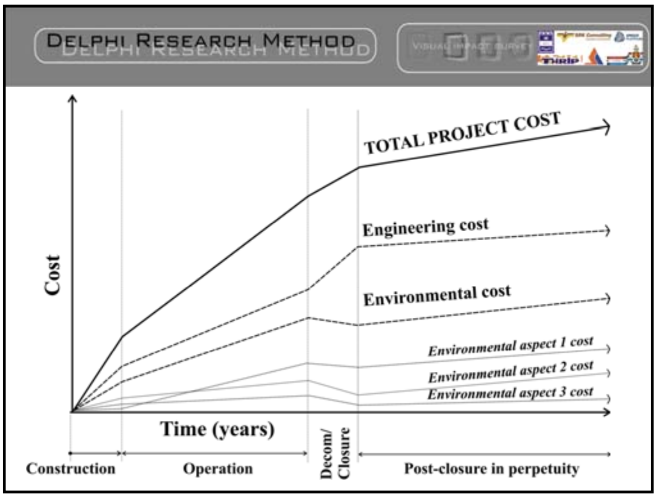
Need for rational decision-making with regard to tailings impoundment engineering costs and environmental impacts and costs

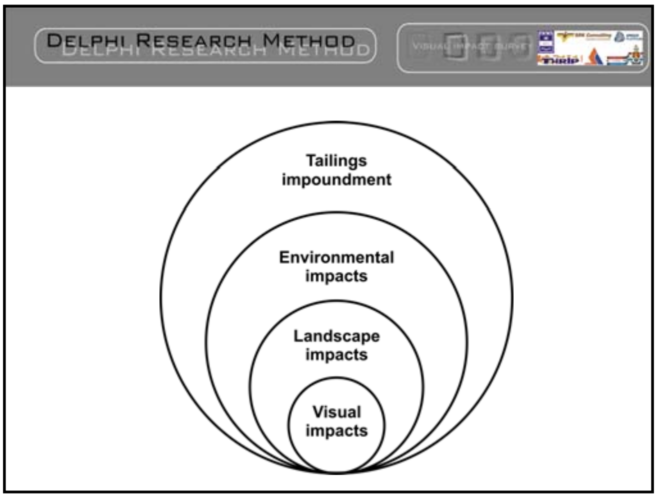
---


DELPHI RESEARCH METHOD
160 impoundments
15 000 ha
20 000 football fields
Roodepoort
Randfontein
JOHANNESBURG
Benoni
Boksburg
Westonaria
Soweto
N1
N12
N17
N3
R555
R82
R556
N
0
10
20 km

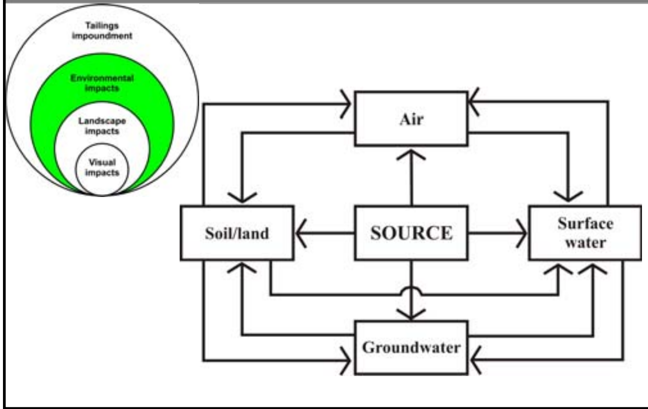

DELPHI RESEARCH METHOD
Cost (R/t)
Total impoundment cost
1900
Time (years)
1950
1966
1974
1994
2000
2025
Recent tailings impoundment failures
ABERFAN, United Kingdom
BAFOKENG, South Africa
MERRIESPRUIT, South Africa
Basic construction costs
Environmental protection costs


DELPHI RESEARCH METHOD
General model
The general model being developed comprises both the basic engineering costs and environmental impacts and costs


DELPHI RESEARCH METHOD
Cost
TOTAL PROJECT COST
Engineering cost
Environmental cost
Environmental aspect 1 cost
Environmental aspect 2 cost
Environmental aspect 3 cost
Time (years)
Construction
Operation
Decom/ Closure
Post-closure in perpetuity


DELPHI RESEARCH METHOD
Tailings impoundment
Environmental impacts
Landscape impacts
Visual impacts

Delphi Research Method



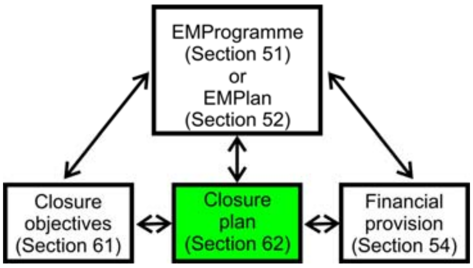
Delphi Research Method

Mining legislation requirements (1 of 4)

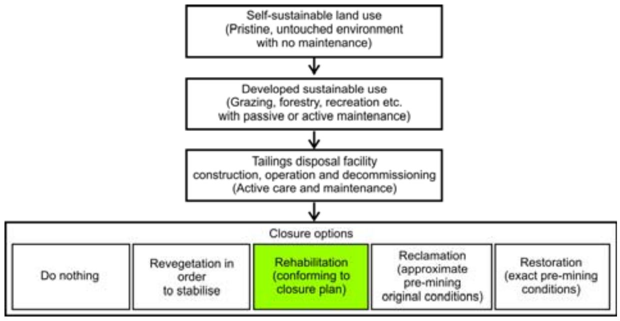
Section 38(1)d of the MPRDA requires rehabilitation to either:

- a natural state;
- a predetermined state;
- a land use which conforms to the generally accepted principle of sustainable development

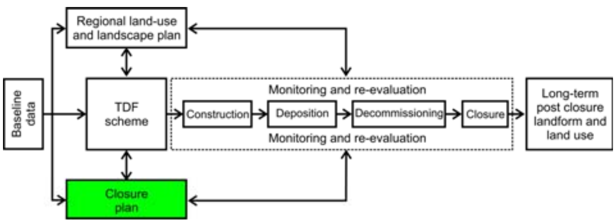
Delphi Research Method



Delphi Research Method

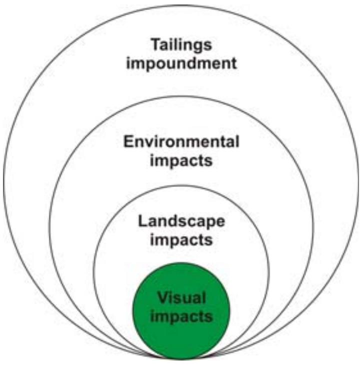


Delphi Research Method



Delphi Research Method

- Background
- **Visual impact assessment**
- Experiment impoundment site
- Applying the predicted results



DELPHI RESEARCH METHOD

Visual impact assessment

- *Visual impact assessment*
- *Physical characteristics*
- *Zone of visual influence*
- *Visual distance zones*
- *Visual perception*

DELPHI RESEARCH METHOD

Visual impact assessment (1 of 3)

Visual impact assessment studies require two judgements:

- estimation of the size of the impact; and
- a determination of the necessity and extent of impact mitigation

DELPHI RESEARCH METHOD

Visual impact assessment (2 of 3)

Visual impact of a scheme influenced by the following factors:

- physical and visual characteristics of a scheme;
- visibility of scheme;
- distance of observer(s) from scheme;
- the environmental setting; and
- disposition and visual preference of viewers

DELPHI RESEARCH METHOD

Visual impact assessment (3 of 3)

Visual impact of a scheme may be estimated through:

- describing the visual characteristics of scheme;
- delineate zone of visual influence;
- identify and assess viewer characteristics; and
- assess impact of the scheme on the environment

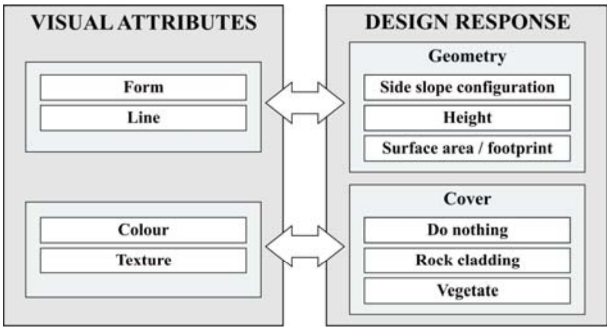
DELPHI RESEARCH METHOD

Physical characteristics of scheme (1 of 2)

Different geometries and covers can be used to camouflage or disguise a scheme.

The premise is that the visual effect may be reduced by changing the perceived appearance of the scheme.

DELPHI RESEARCH METHOD

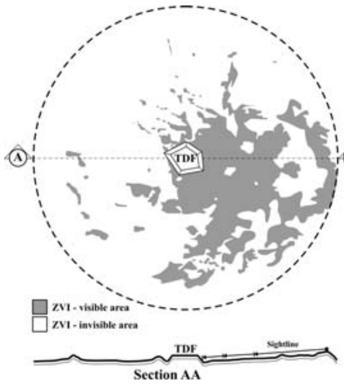


DELPHI RESEARCH METHOD

Zone of visual influence *(1 of 2)*

The zone of visual influence are the locations from which actual or proposed scheme or structure is visible and is generally shown on a ZVI map

DELPHI RESEARCH METHOD

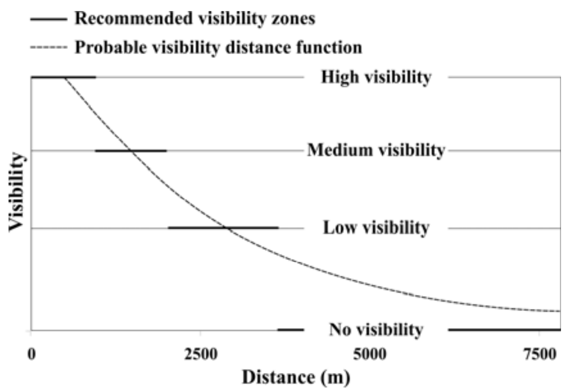


DELPHI RESEARCH METHOD

Visual distance zones *(1 of 2)*

It is convenient to subdivide the zone of visual influence into subzones and these are defined as visual distance zones

DELPHI RESEARCH METHOD



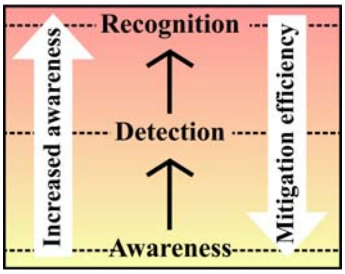
DELPHI RESEARCH METHOD

Visual perception *(1 of 2)*

Visual perception is not just a seeing activity but an act of interpretation - albeit largely subconscious

Although the process is the interpretation of a continuum in practice a series of thresholds occur which may be described as progressing from awareness through detection to recognition

DELPHI RESEARCH METHOD



DELPHI RESEARCH METHOD

Background

Visual impact assessment

Experiment impoundment site

Applying the predicted results

DELPHI RESEARCH METHOD

Experiment impoundment site

Impoundment characteristics

Photographing procedure

Manipulation of photographs

Assessment of visualisations

Results

DELPHI RESEARCH METHOD

Experiment impoundment site *(1 of 6)*

The test impoundment site:

- abandoned scheme or in process of being closed
- within environment with low visual absorption capacity
- as many different covers possible

DELPHI RESEARCH METHOD

Locality

DELPHI RESEARCH METHOD

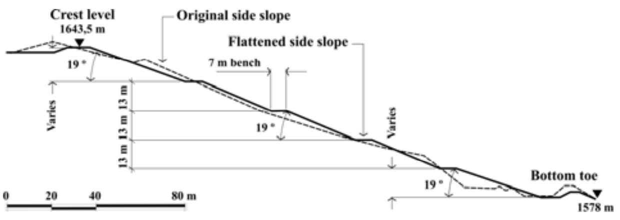
ERGO Daggafontein

+- 500 ha 68 m at highest point cycloned up-stream ring dyke

DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY

Profile of side slope



DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY

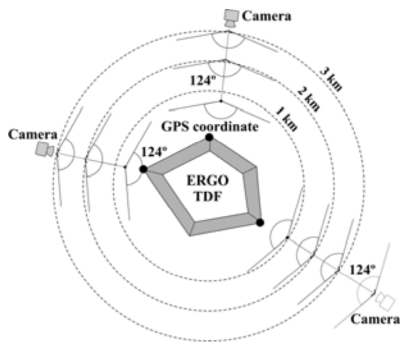
Photographing procedure *(1 of 3)*

The test impoundment site:

- was photographed from distances ranging from 800 m and 8300 m
- GPS points were taken around the base of the impoundment
- photographs were taken to the nearest GPS point
- tried to limit interference from other structures and man-made elements

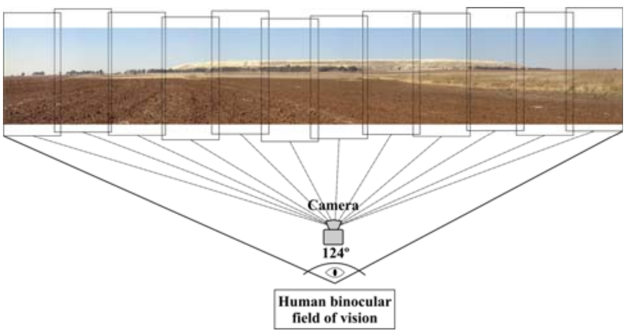
DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY



DELPHI RESEARCH METHOD

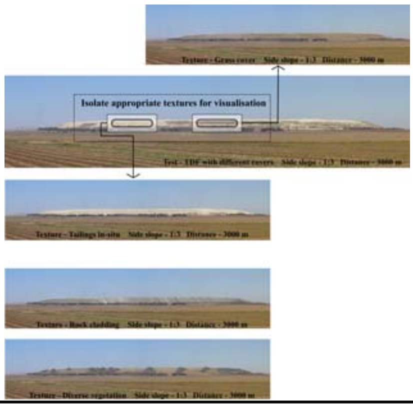
VISUAL IMPACT SURVEY

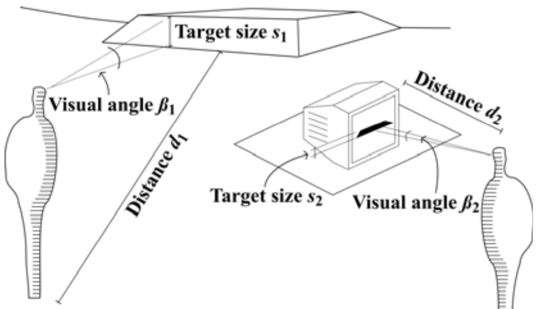


Manipulation of photographs *(1 of 3)*

The manipulation of site photographs included the following steps:

- photographs were taken to include all sorts of textures
- texture were isolated at different distances
- the range of textures were superimposed on to the whole panoramic photograph
- the manipulated simulations could then be viewed on a computer screen – sized to what viewer would see





$$s_2 = s_1 d_2/d_1$$

Assessment of visualisations *(1 of 7)*

The Nominal Group Technique (NGT) study method,
an application from the Delphi technique,
was used to assess the visualisations and develop
the perception versus distance curves

Delphi technique – general information *(2 of 7)*

A Delphi exercise is a discussion by knowledgeable participants with the aim of reaching an acceptable level of agreement and consensus on the results

Delphi technique – general information *(3 of 7)*

The concept is based on the premises that:

- opinions of experts are justified as inputs to decision-making where absolute answers are unknown;
- a consensus of experts will provide a more accurate response to a question than a single expert; and
- process is repeatable and is used by researchers to produce defendable data.

DELPHI RESEARCH METHOD

Delphi technique – general information *(4 of 7)*

The general procedures are as follows:

- experts are polled on a series of visualisations;
- responses are tabulated, analysed, and the results fed back to the experts; and
- experts reconsider and evaluate their answers in light of the information generated by the aggregate responses. This process is repeated until consensus is reached.

DELPHI RESEARCH METHOD

Nominal Group Technique *(5 of 7)*

Application of the Delphi technique

The Nominal Group Technique (NGT):

- employs face-to-face meetings and discussions by knowledgeable participants to obtain and combine expert opinion in the hope of reaching an agreeable conclusion; and
- allows for information to be collected in less time whereas the Delphi technique is applied where experts are not readily available or within reasonable travelling distance.

DELPHI RESEARCH METHOD

Visualisation X

Question 1

Do you detect a manmade landform within this landscape? [Yes] [No]

Question 2

If the answer is 'Yes', assign a rating between 1 and 5 to indicate the level of perception.

[1] [1,5] [2] [2,5] [3] [3,5] [4] [4,5] [5]

Level of Perception		
	5. High	- Effortless recognition as a MRD
	4. Medium High	- Recognizable as MRD, but with effort
	3. Medium	- Easily detectable as a foreign landform in the landscape, but not recognizable as a MRD
	2. Medium Low	- Detectable as a foreign landform in the landscape, but with effort
	1. Low	- Virtually undetectable as a foreign landform in the landscape

Note: MRD - Mine Residue Deposit, a generic term for Tailings Disposal Facility (TDF)

DELPHI RESEARCH METHOD

Visualisations presented to panel *(7 of 7)*

- Each scenario, i.e. impoundment configuration, has different viewing distances
- Viewing distances ranged from 1000 m to 8200 m
- 12 panellists rated the manipulated panoramic photographs

3000ST3 Photo 1

3000SG6 Photo 5

3000ST6 Photo 11

8300WT3 Photo 14

3600WG3 Photo 15

3000SD6 Photo 28

2000ST6 Photo 49

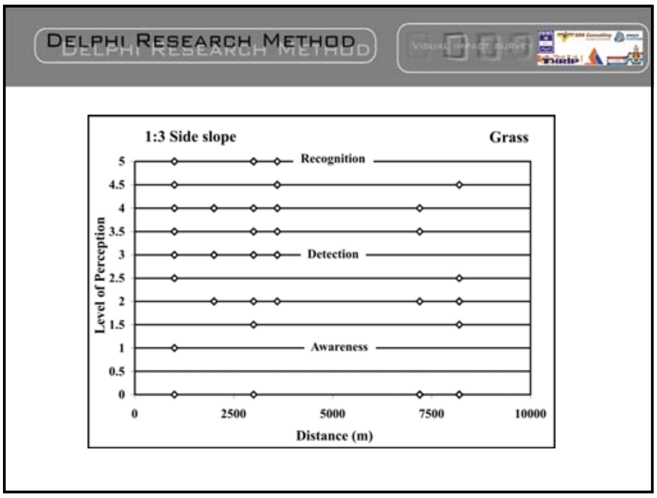
Delphi Research Method

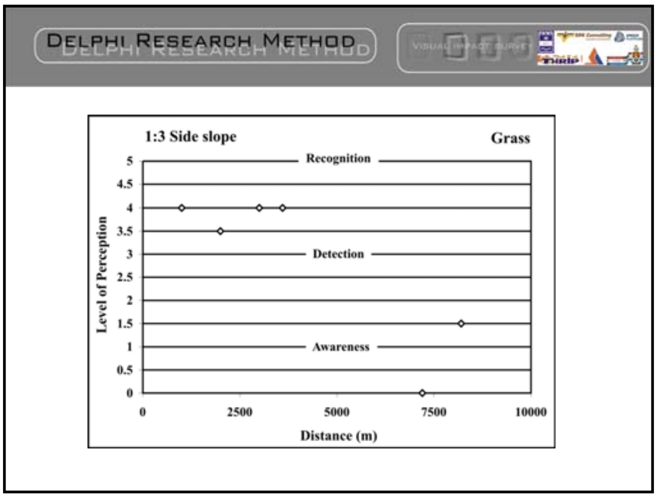
Results

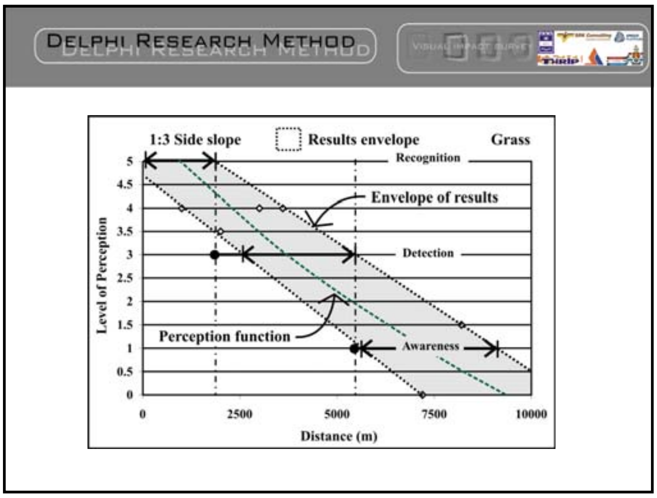
The following slides indicate:

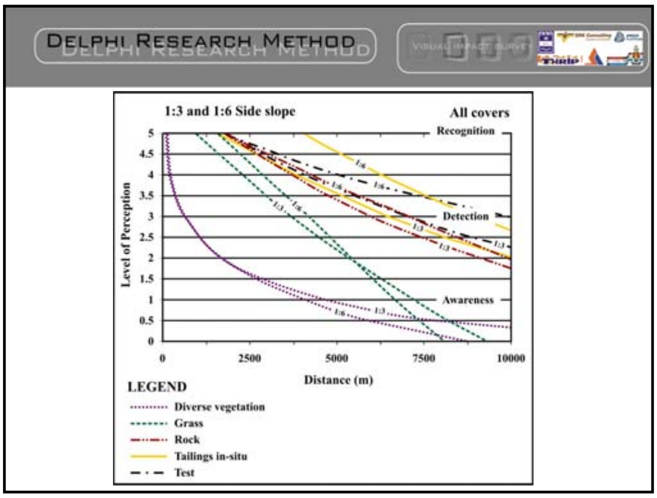
- the initial results from the experts' ratings for the manipulated simulations before discussion and reaching consensus.
- the consensus results for the same visualisations after discussion.
- the envelope indicating the limits of the consensus results indicates the range of the maximum distances or each perception level.

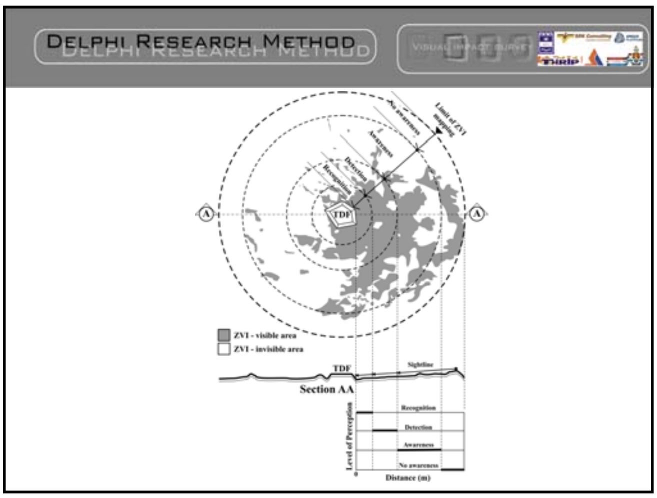
Impoundment covered with grass and an overall side slope of 1:3

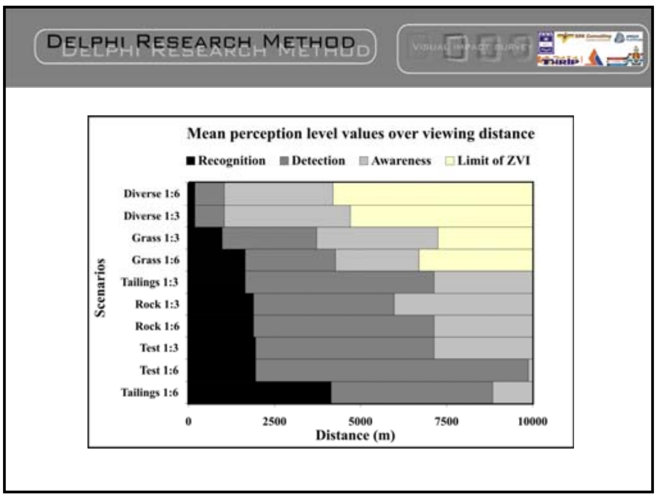

Delphi Research Method
1:3 Side slope
Grass
Recognition
Detection
Awareness
Level of Perception
Distance (m)


Delphi Research Method
1:3 Side slope
Grass
Recognition
Detection
Awareness
Level of Perception
Distance (m)

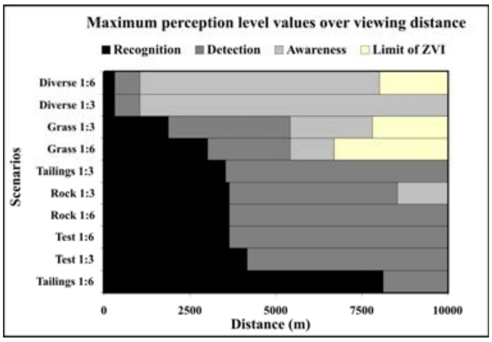

Delphi Research Method
1:3 Side slope
Results envelope
Grass
Recognition
Envelope of results
Detection
Perception function
Awareness
Level of Perception
Distance (m)


Delphi Research Method
1:3 and 1:6 Side slope
All covers
Recognition
Detection
Awareness
Level of Perception
Distance (m)
LEGEND
Diverse vegetation
Grass
Rock
Tailings in-situ
Test


Delphi Research Method
TDF
ZVI - visible area
ZVI - invisible area
Sightline
Section AA
Recognition
Detection
Awareness
No awareness
Level of Perception
Distance (m)

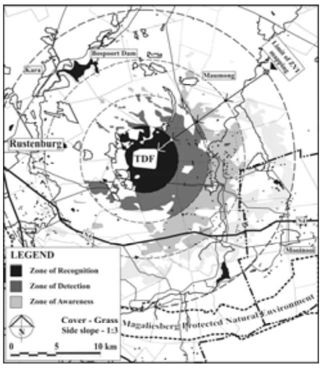

Delphi Research Method
Mean perception level values over viewing distance
Recognition
Detection
Awareness
Limit of ZVI
Diverse 1:6
Diverse 1:3
Grass 1:3
Grass 1:6
Tailings 1:3
Rock 1:3
Rock 1:6
Test 1:3
Test 1:6
Tailings 1:6
Scenarios
Distance (m)

DELPHI RESEARCH METHOD

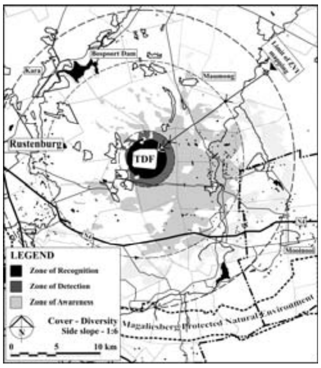


DELPHI RESEARCH METHOD

DELPHI RESEARCH METHOD



DELPHI RESEARCH METHOD



DELPHI RESEARCH METHOD

Background

Visual impact assessment

Experiment impoundment site

Applying the predicted results

DELPHI RESEARCH METHOD

Applying the predicted results in the field

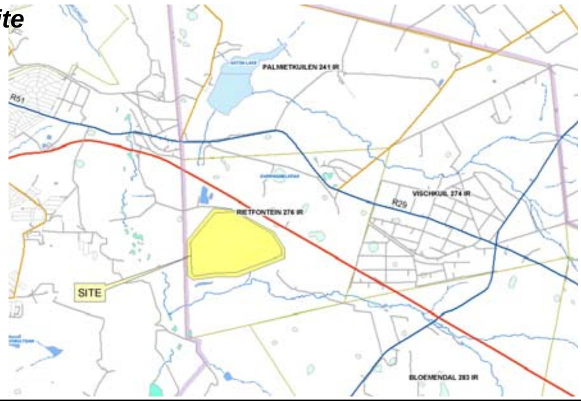
The following process was followed:

- locate suitable impoundment
- determine typical side slope and cover characteristics
- compile ZVI map using GIS
- use predicted maximum perception level versus viewing distance results to determine zones of influence
- 24 visual receptor view points were identified
- take panoramic photographs from pre-determined view points

DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY

Site



DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY

Land use

DELPHI RESEARCH METHOD

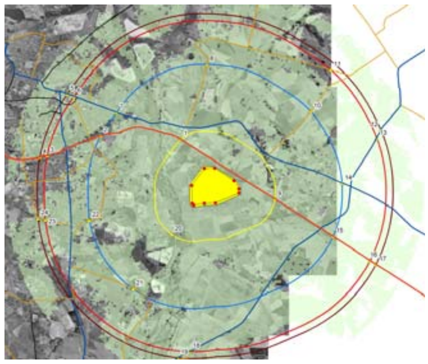
VISUAL IMPACT SURVEY

ZVI

DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY

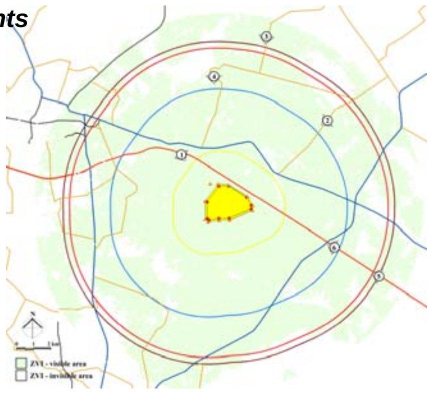
Points



DELPHI RESEARCH METHOD

VISUAL IMPACT SURVEY

View points



Visual Perception Experiment

Managing the visual impact of tailings impoundments

RESULTS FROM PREDICTED VIEWING POINTS

5 October 2005

Panel discussion

DELPHI RESEARCH METHOD

Panel discussion

Points to be discussed:

- overall experimental procedure followed
- predicted results perception versus distance curves
- general observations
- applying the results in practice
- panoramic photographs taken in the field
- research gaps

5150WT3 Photo 6

The end

Appendix A4: Zone of visual perception results

List of figures

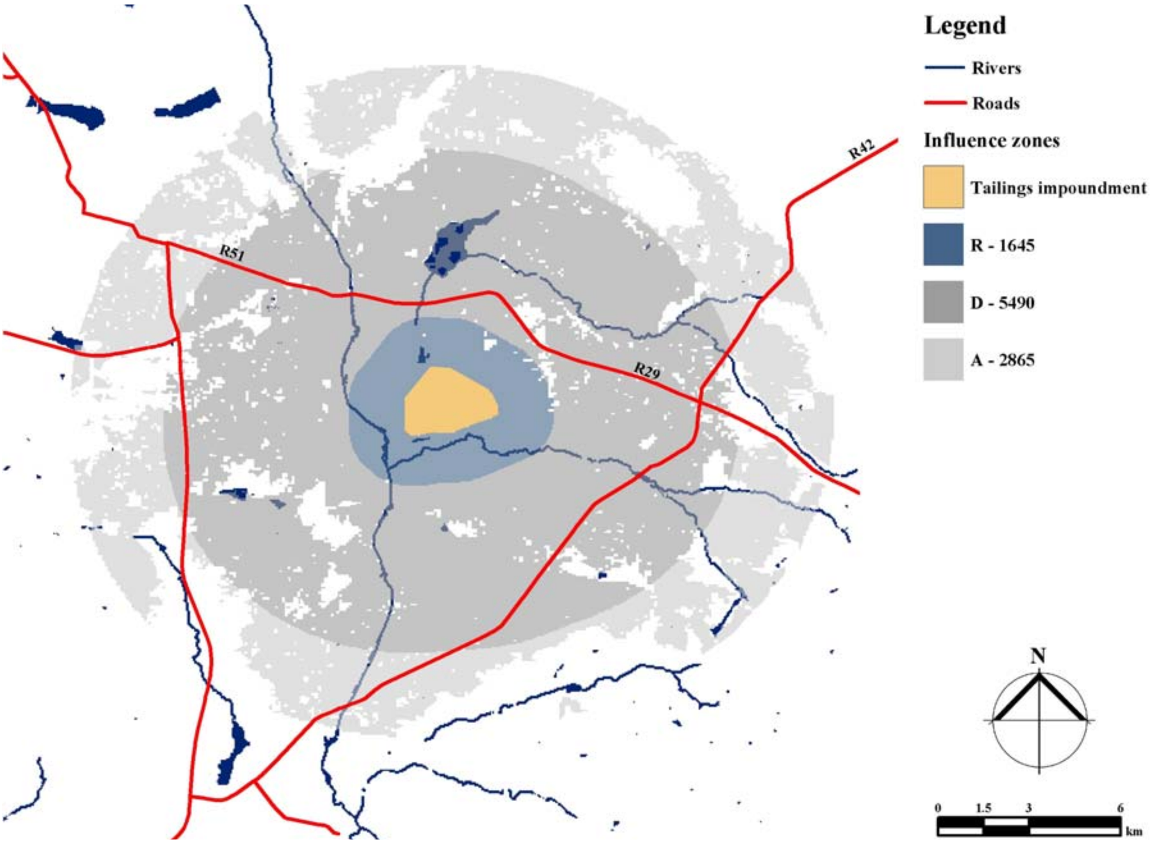


Figure A. 1: Scenario 1 visual perception zones of influence (VS1)

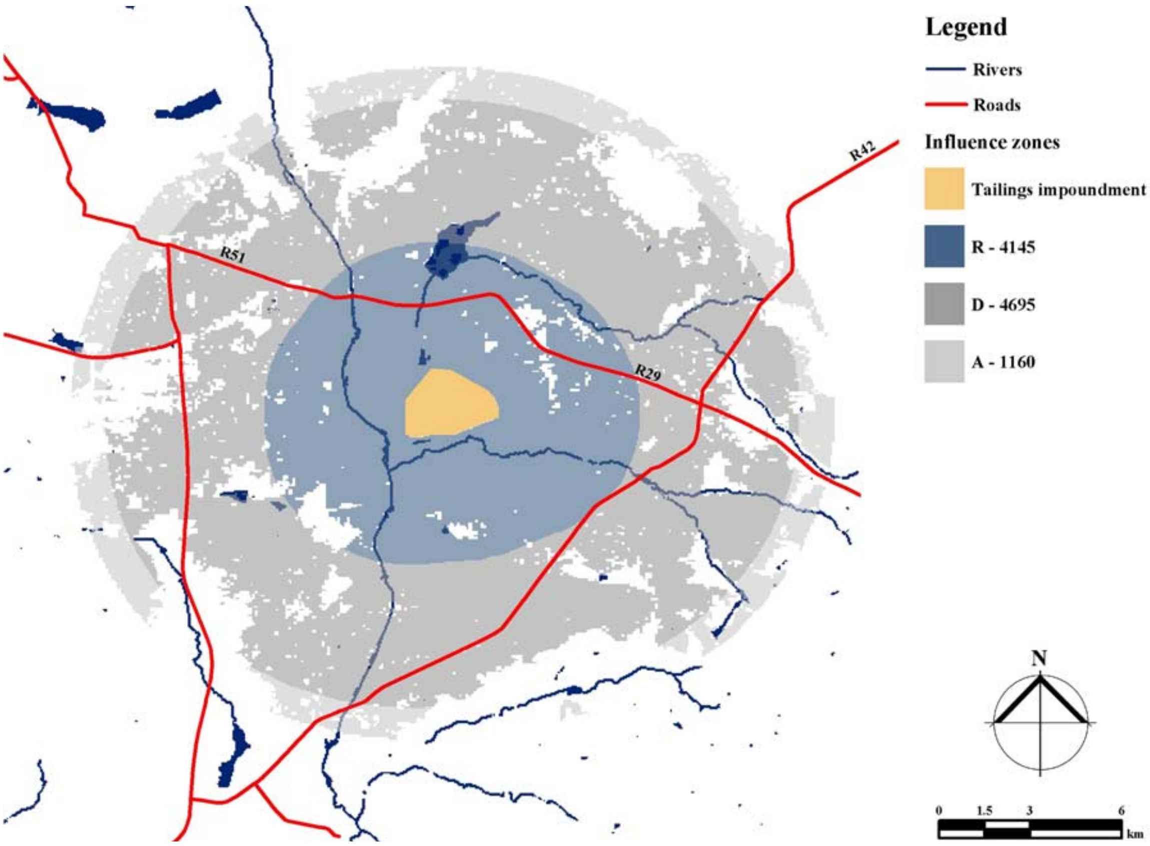


Figure A. 2: Scenario 2 visual perception zones of influence (VS2)

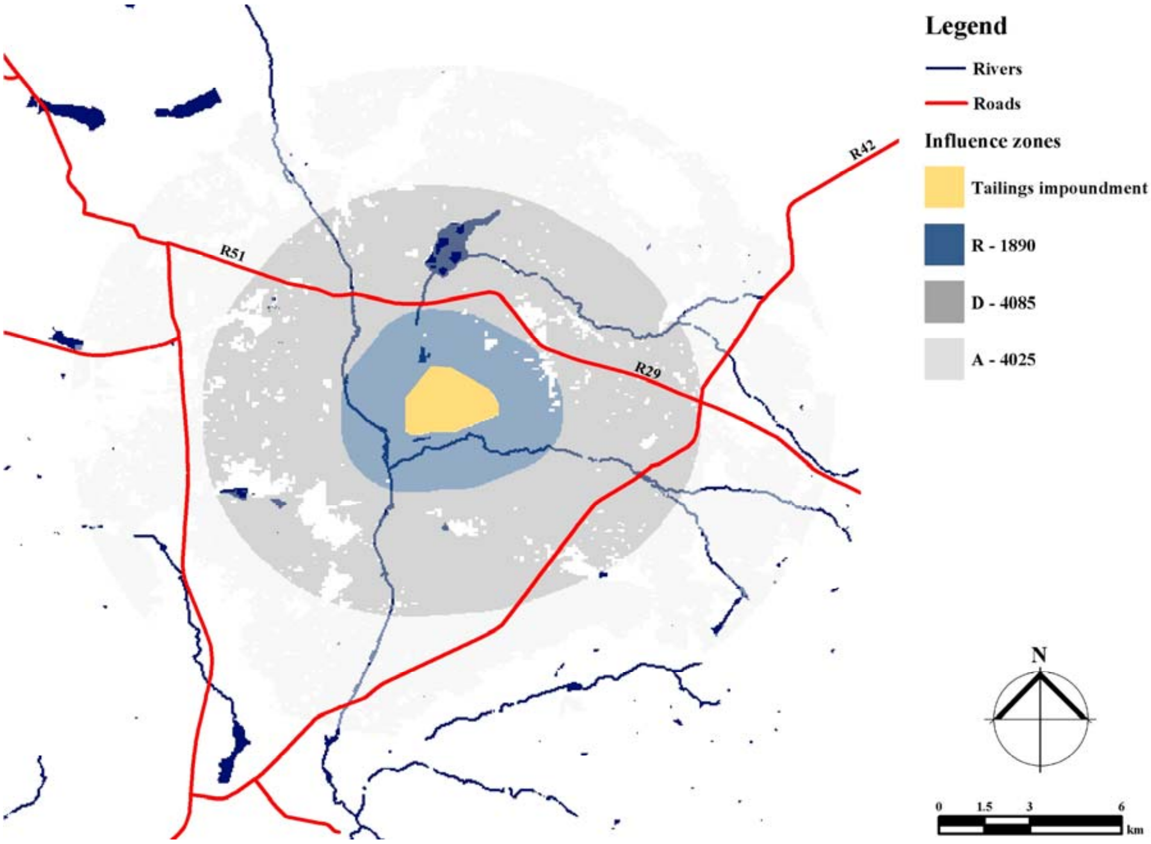


Figure A. 3: Scenario 3 visual perception zones of influence (VS3)

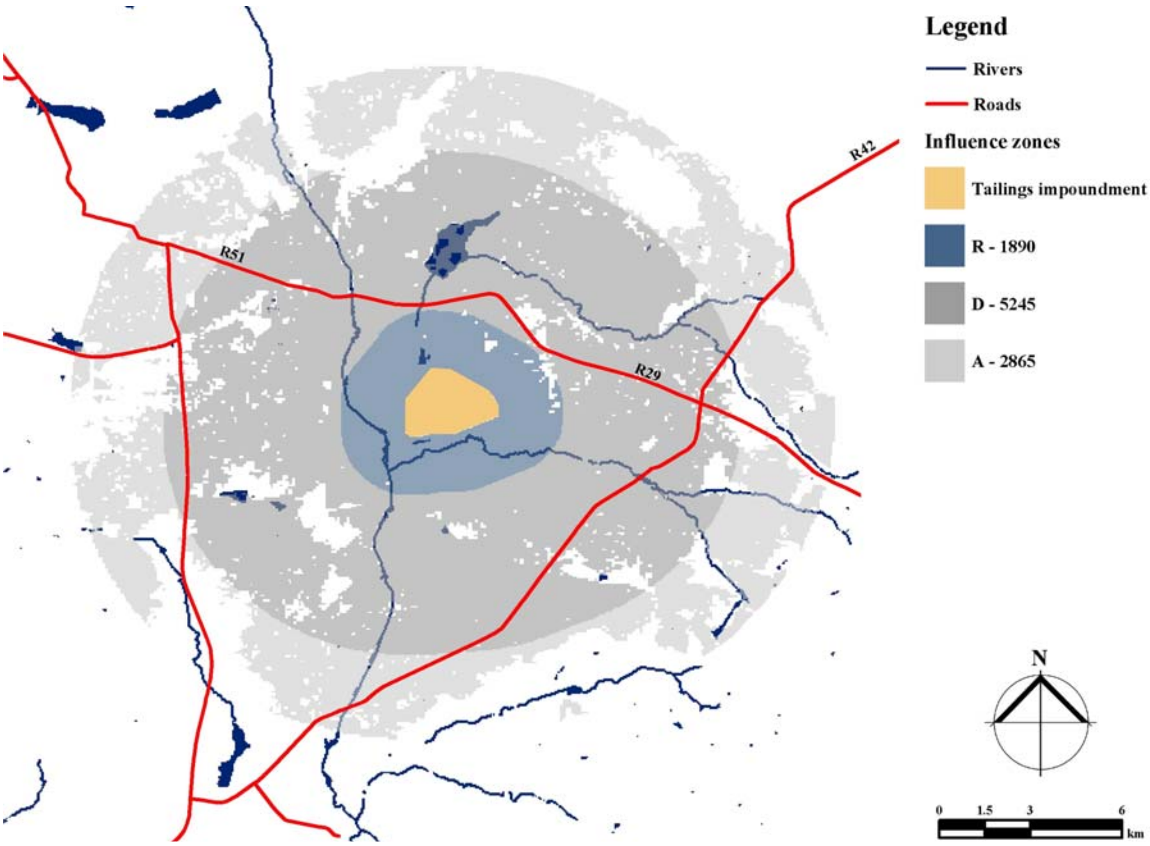


Figure A. 4: Scenario 4 visual perception zones of influence (VS4)

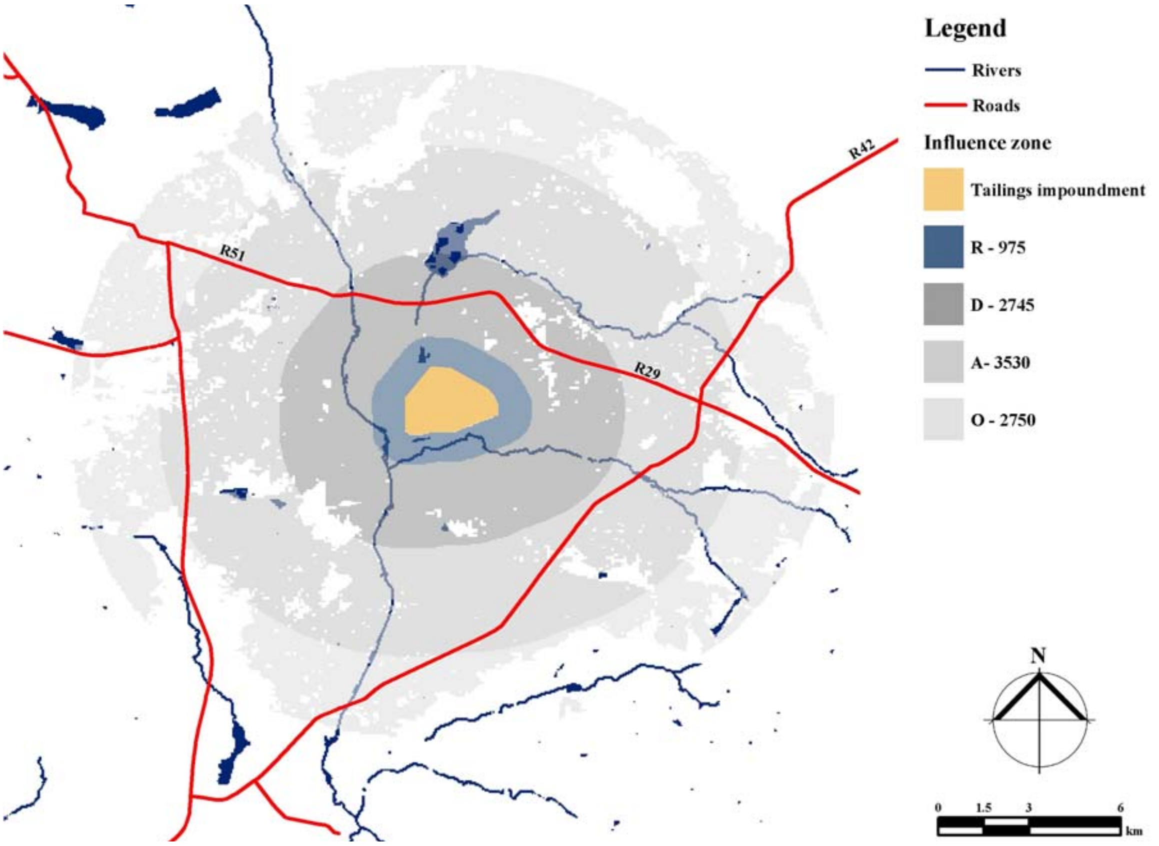


Figure A. 5: Scenario 5 visual perception zones of influence (VS5)

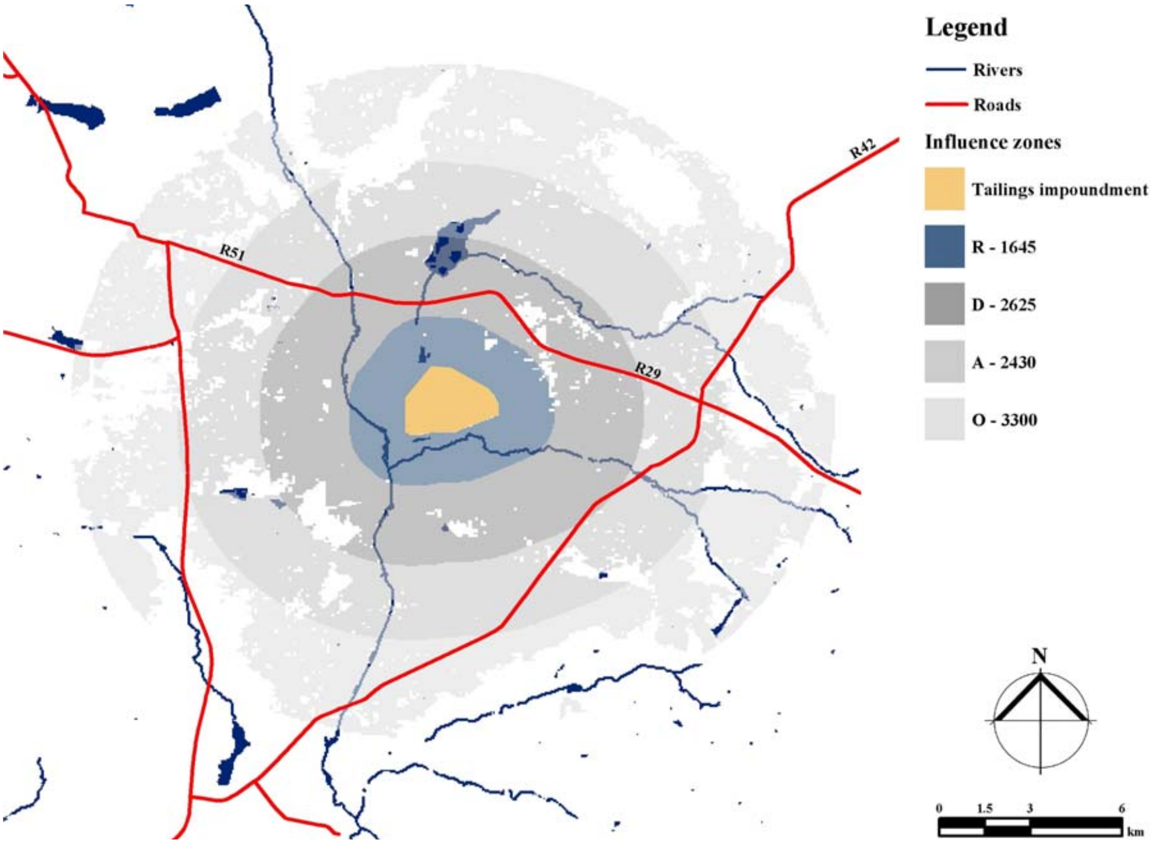


Figure A. 6: Scenario 6 visual perception zones of influence (VS6)

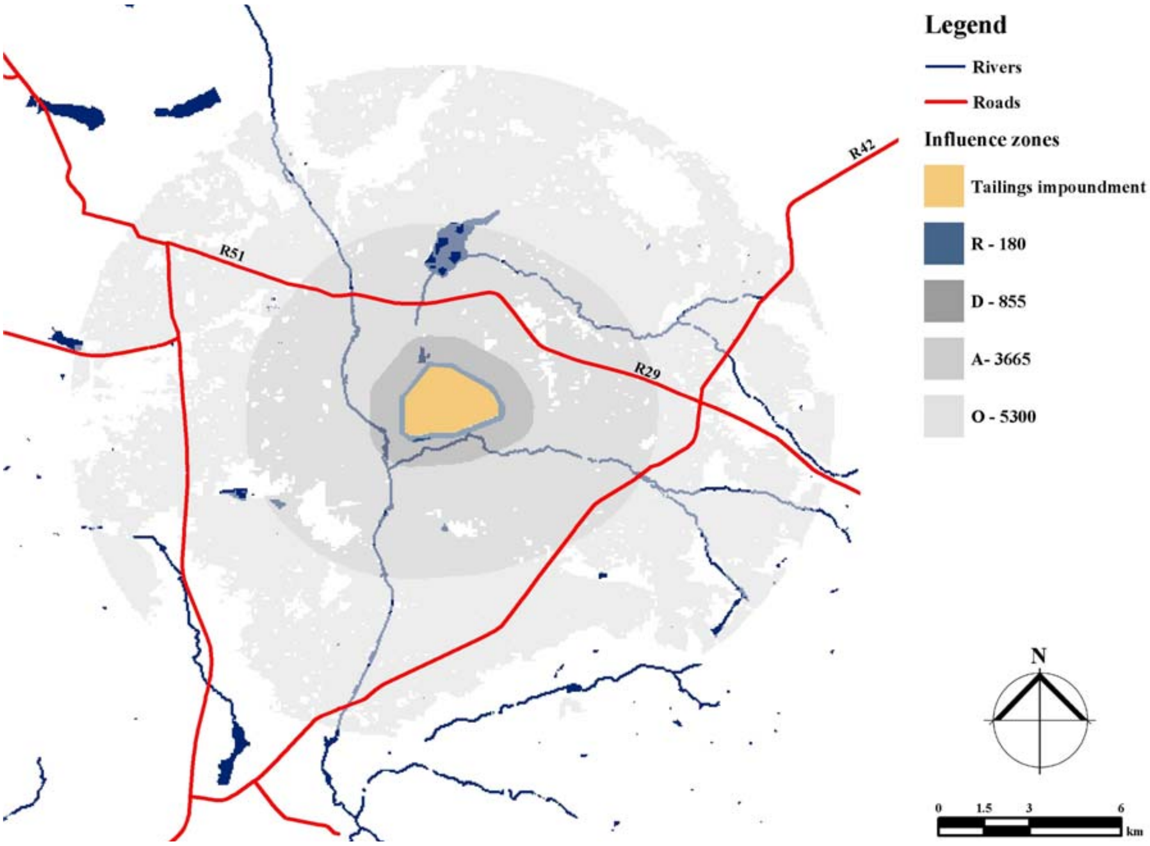


Figure A. 7: Scenario 7 visual perception zones of influence (VS7)

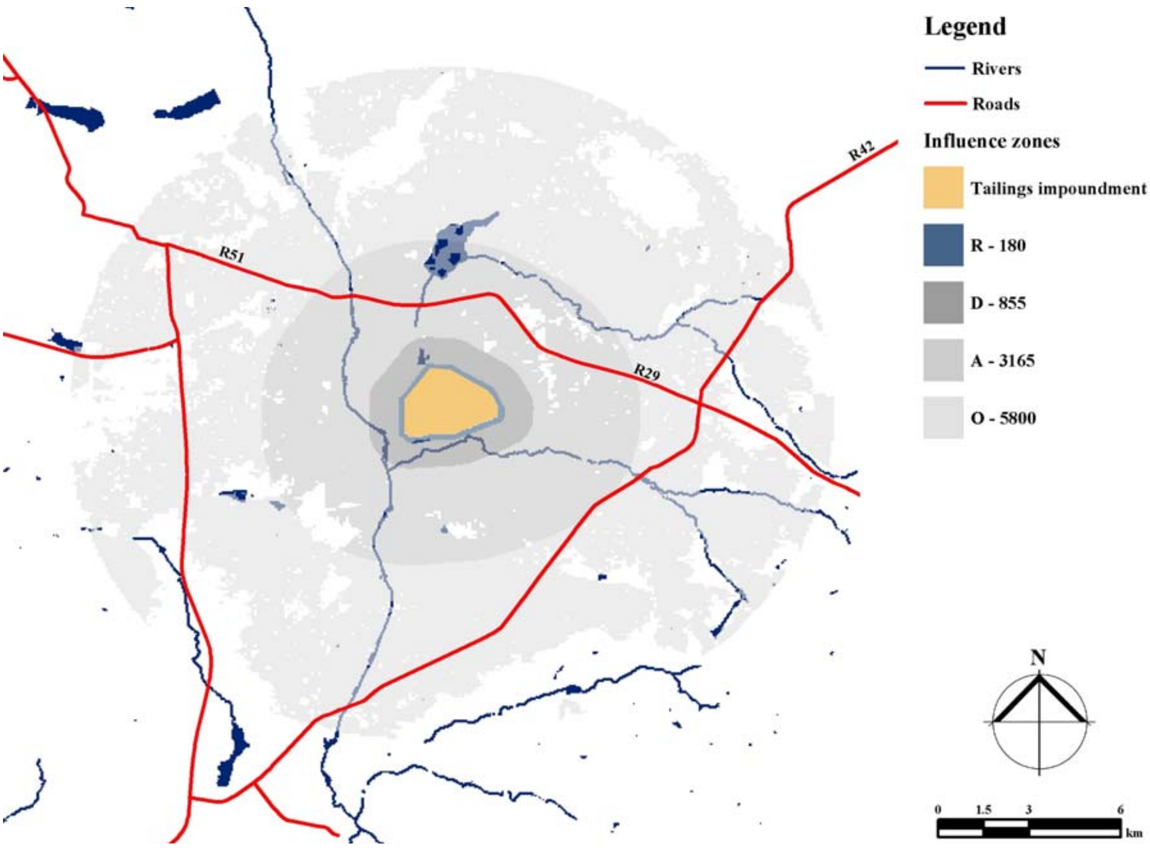


Figure A. 8: Scenario 8 visual perception zones of influence (VS8)

The Influence of Environmental Impacts on Tailings Impoundment Design

APPENDIX B: AIR

List of figures

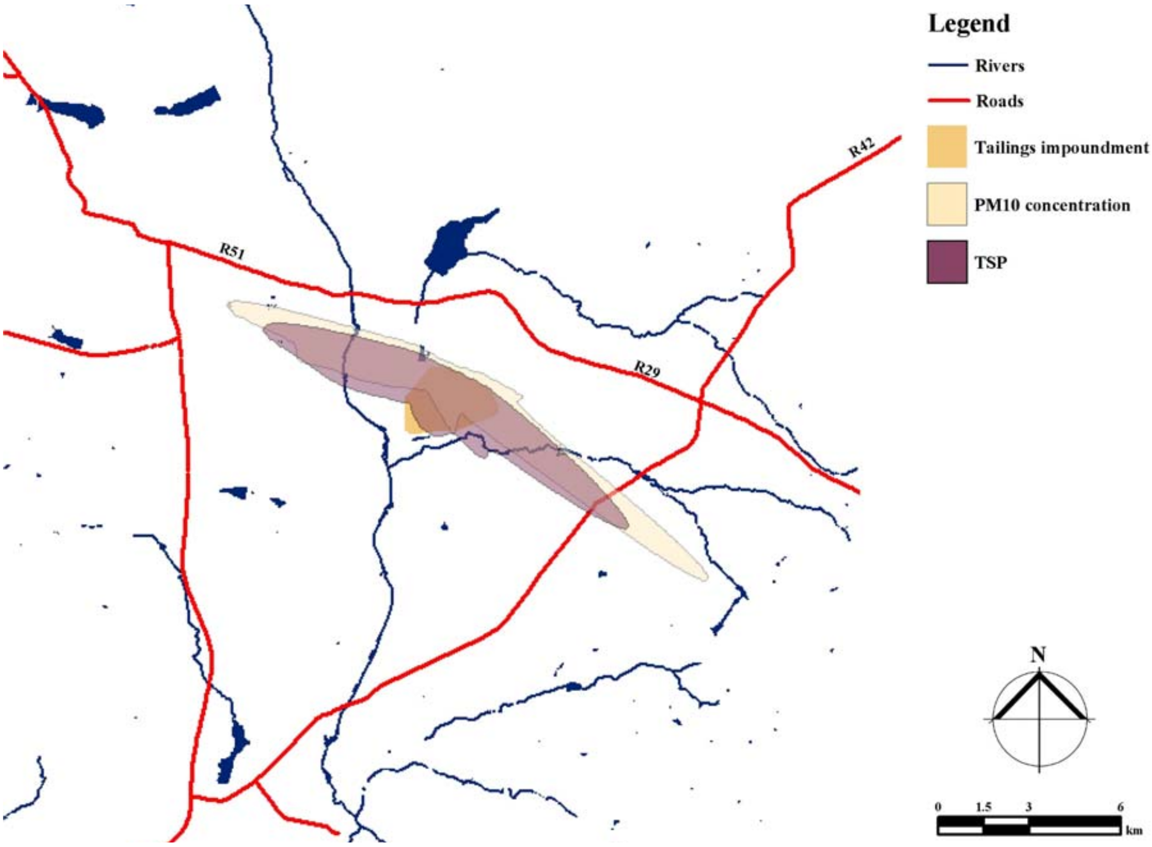


Figure B. 1: *1:1,5 embankment side slope with no cover (AS1)*

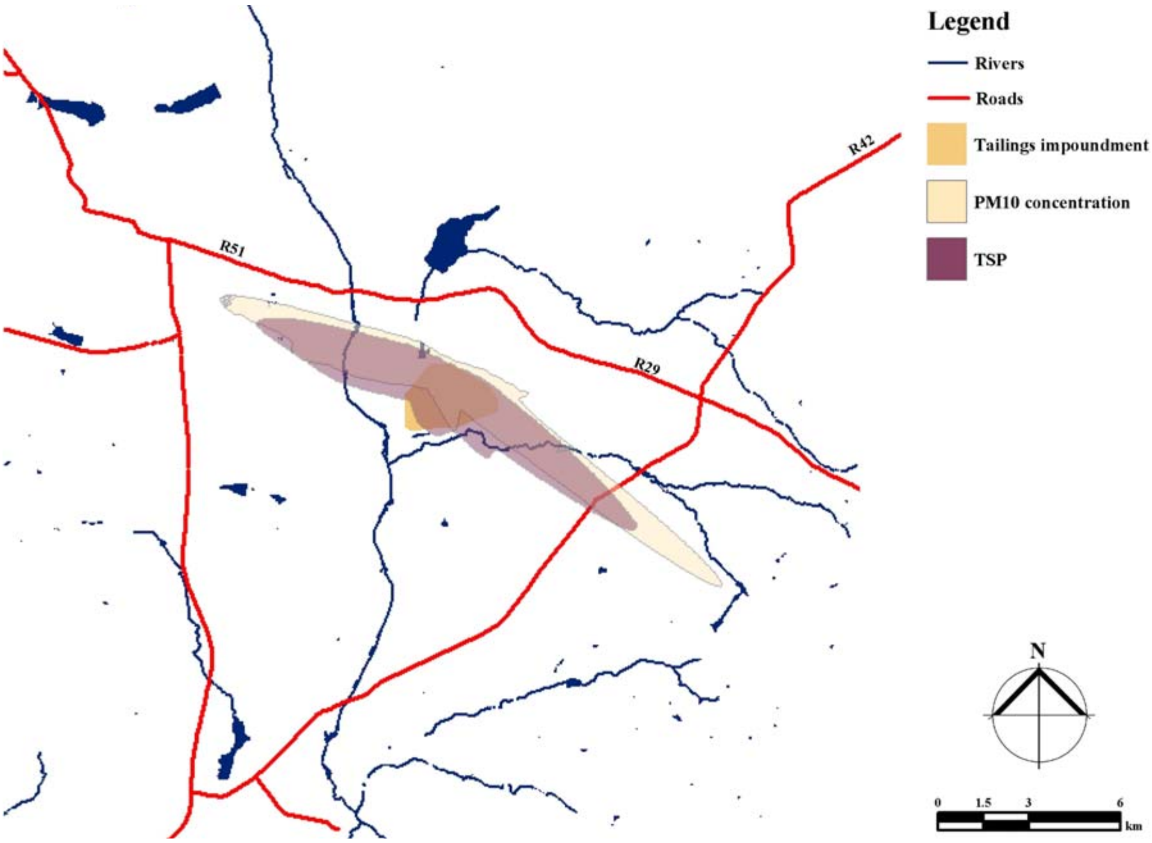


Figure B. 2: *1:3 embankment side slope with no cover (AS2)*

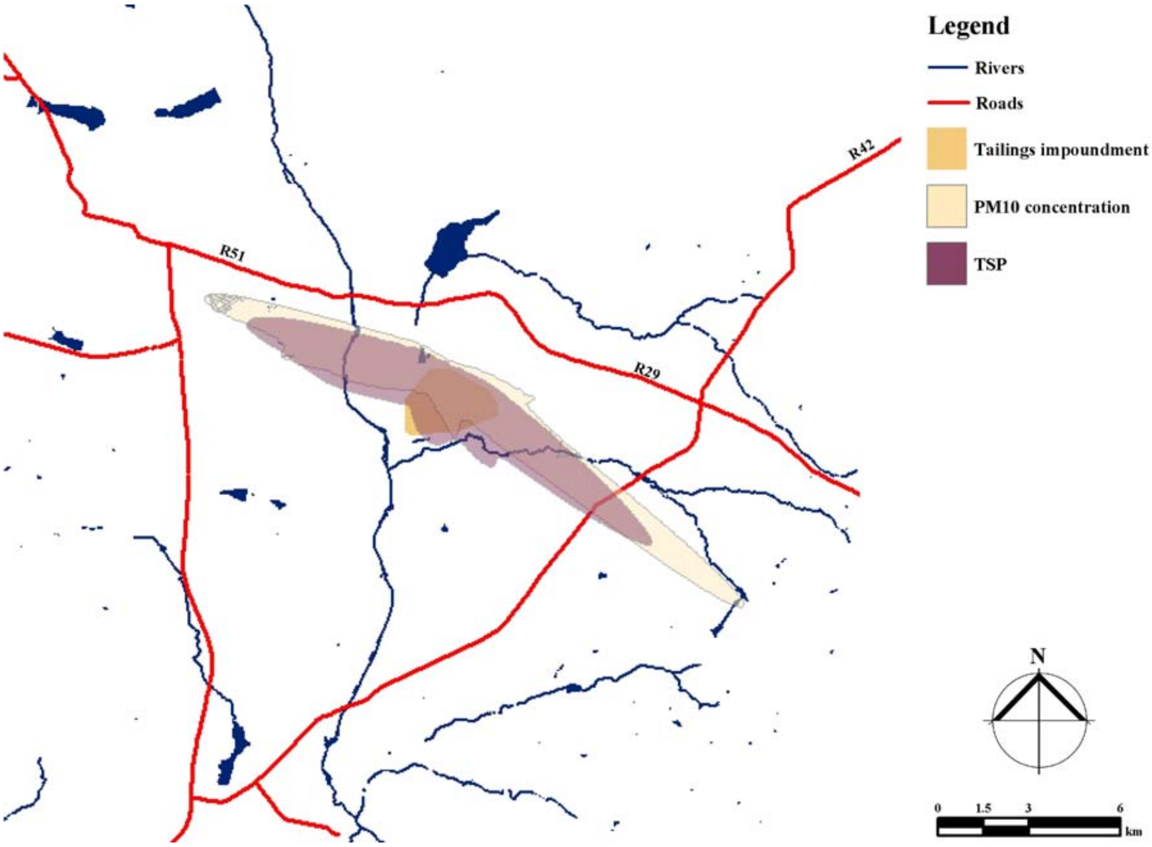


Figure B. 3: 1:6 embankment side slope with no cover (AS3)

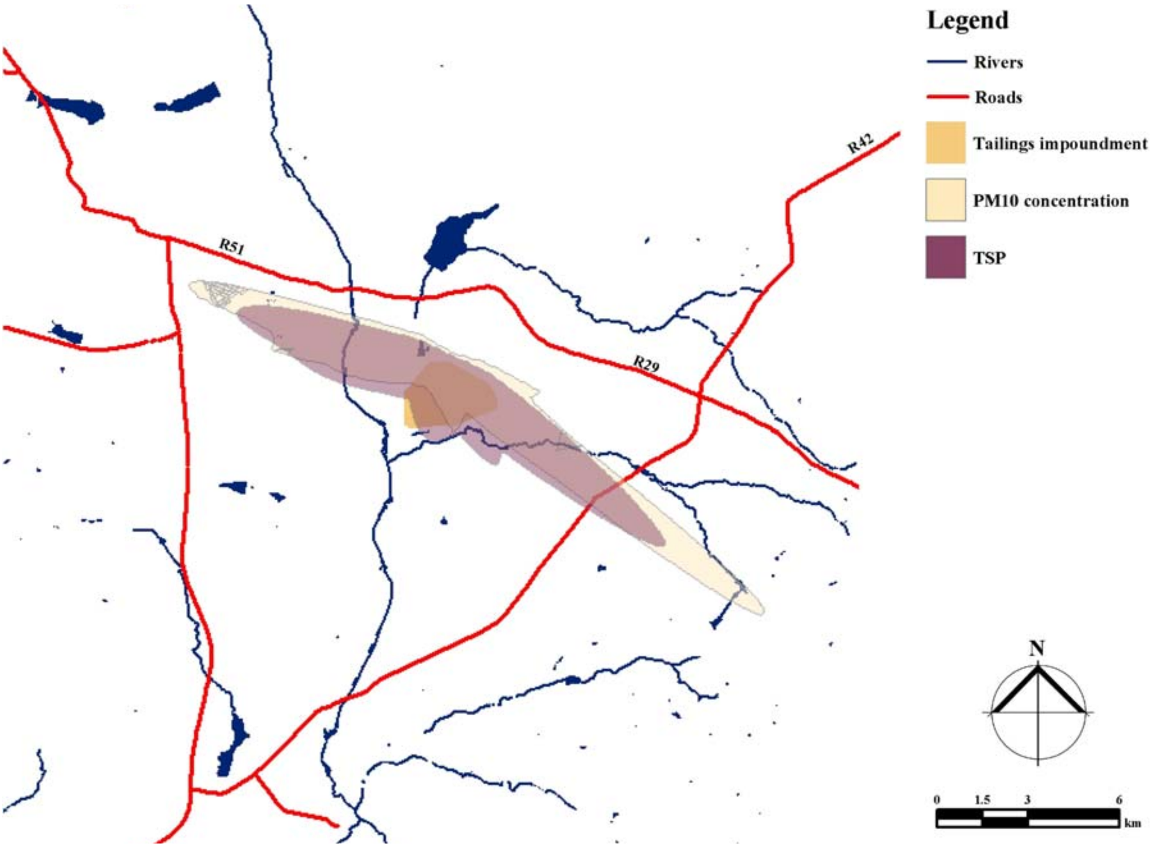


Figure B. 4: 1:9 embankment side slope with no cover (AS4)

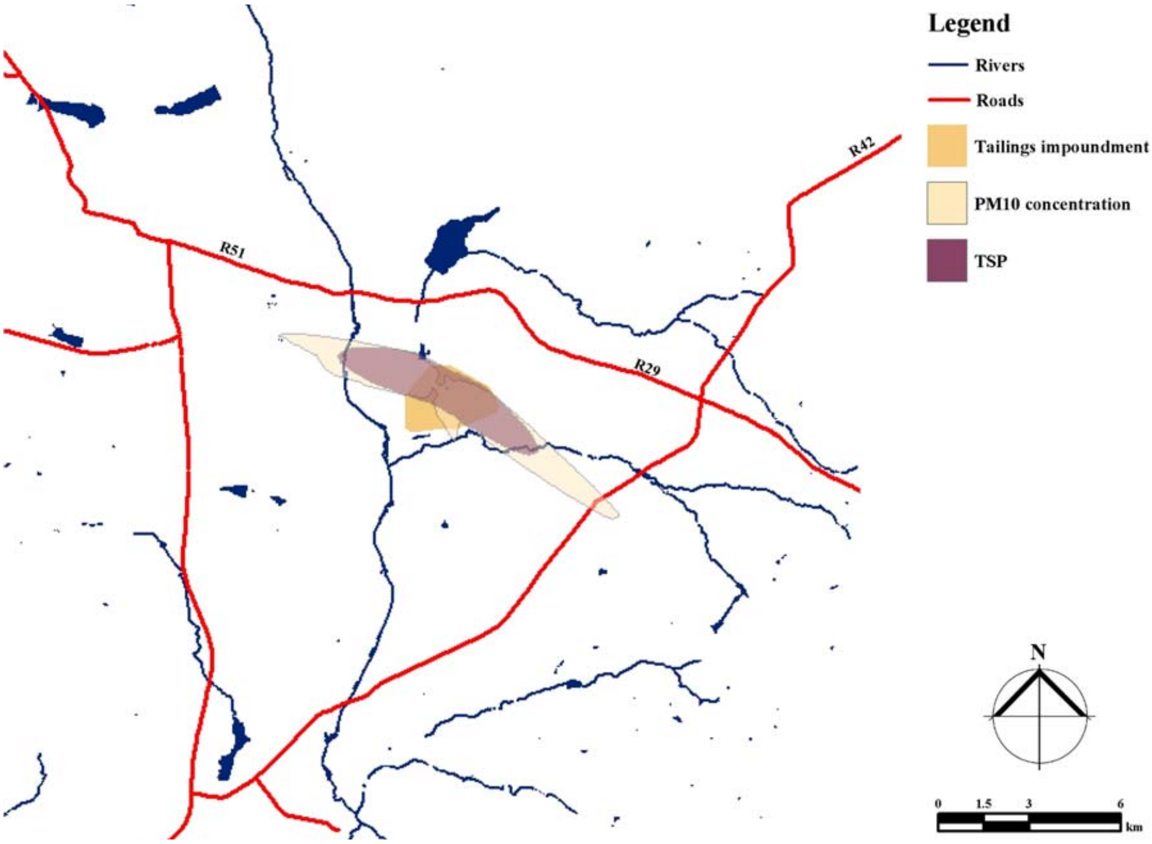


Figure B. 5: 1:1,5 embankment side slope with 50% control efficiency (AS9)

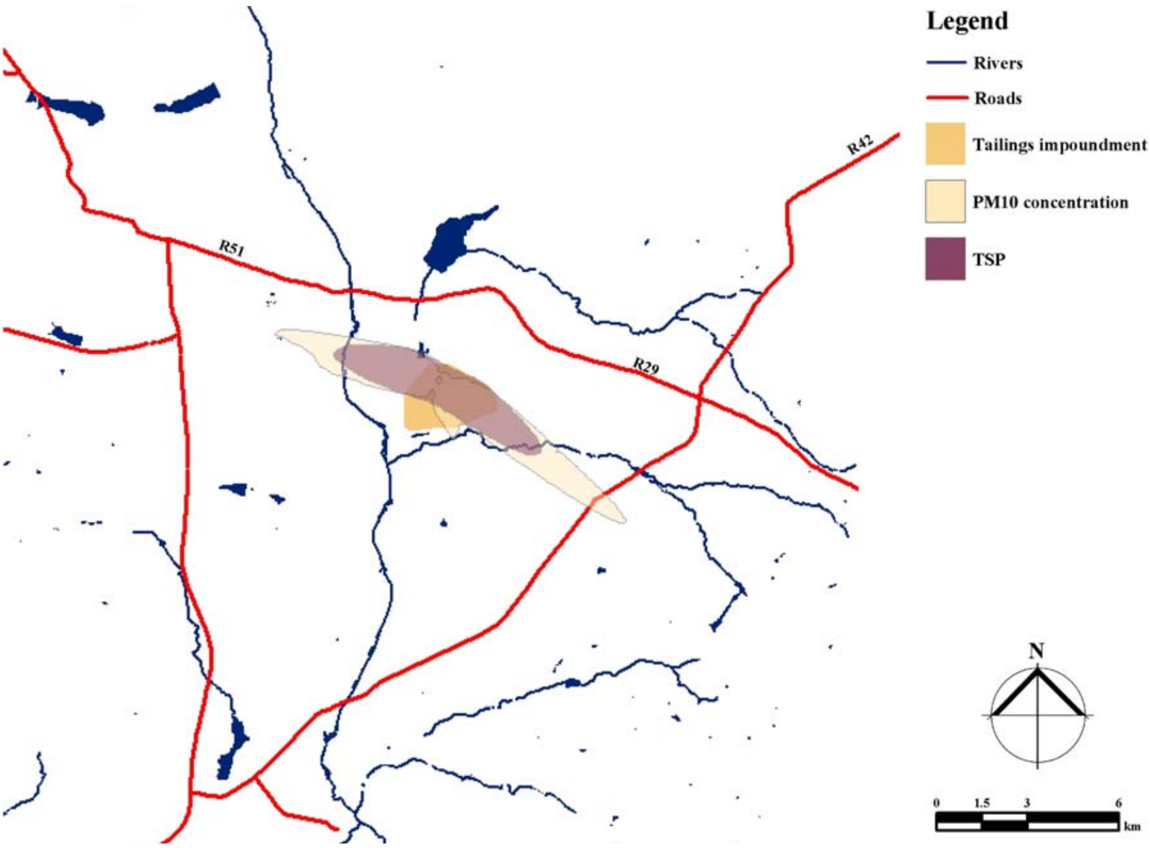


Figure B. 6: 1:3 embankment side slope with 50% control efficiency (AS10)

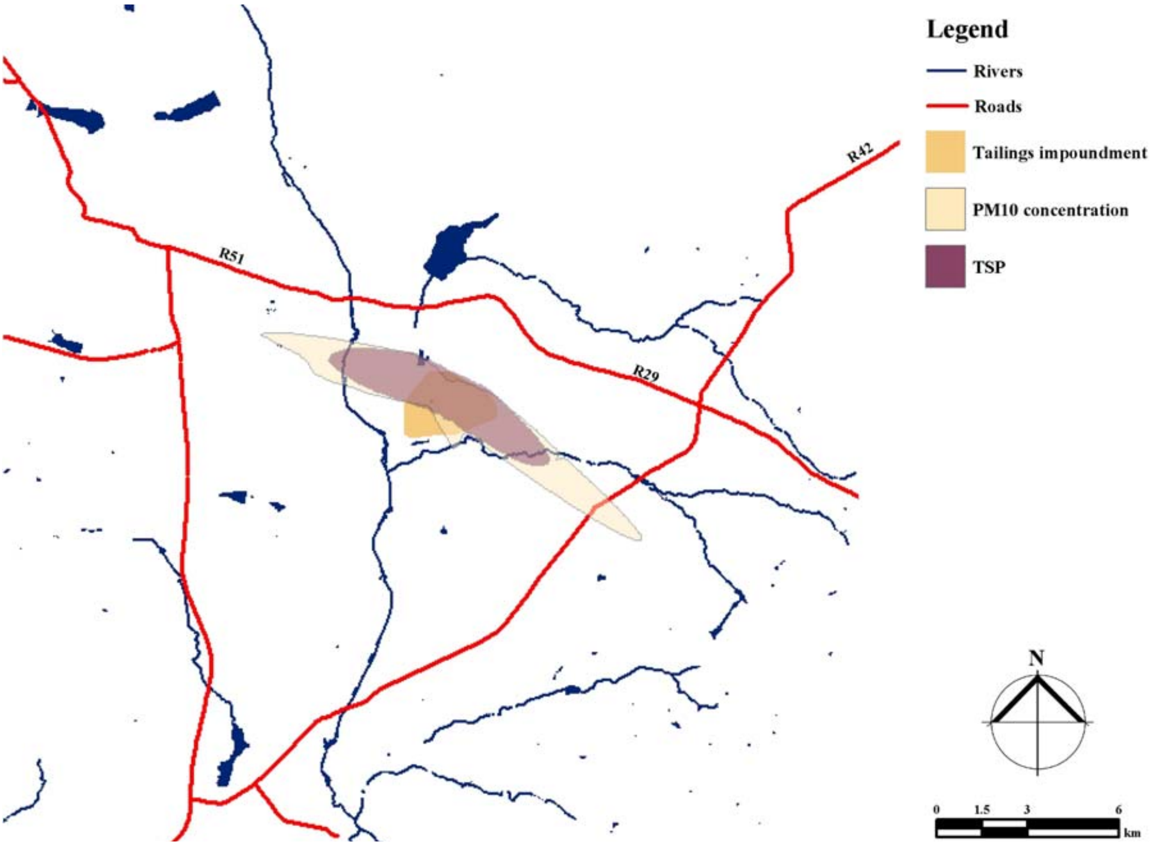


Figure B. 7: 1:6 embankment side slope with 50% control efficiency (AS11)

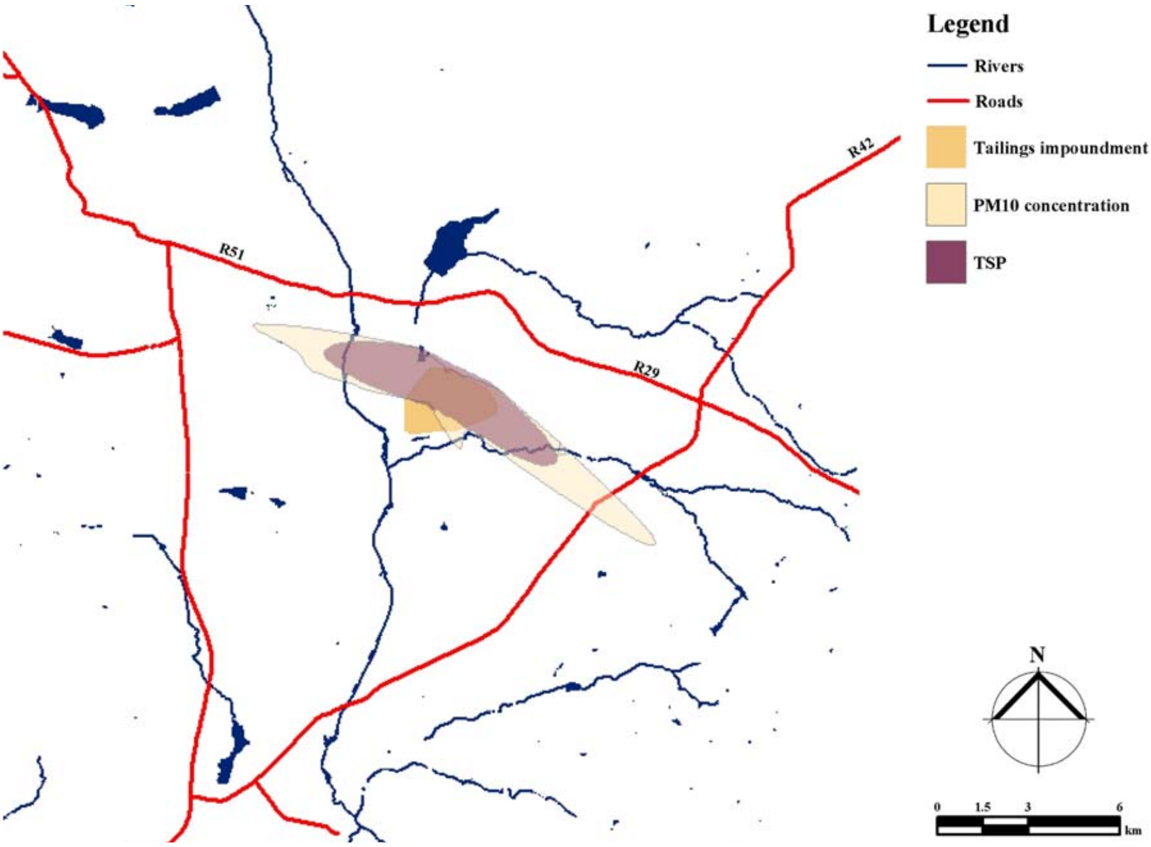


Figure B. 8: 1:9 embankment side slope with 50% control efficiency (AS12)

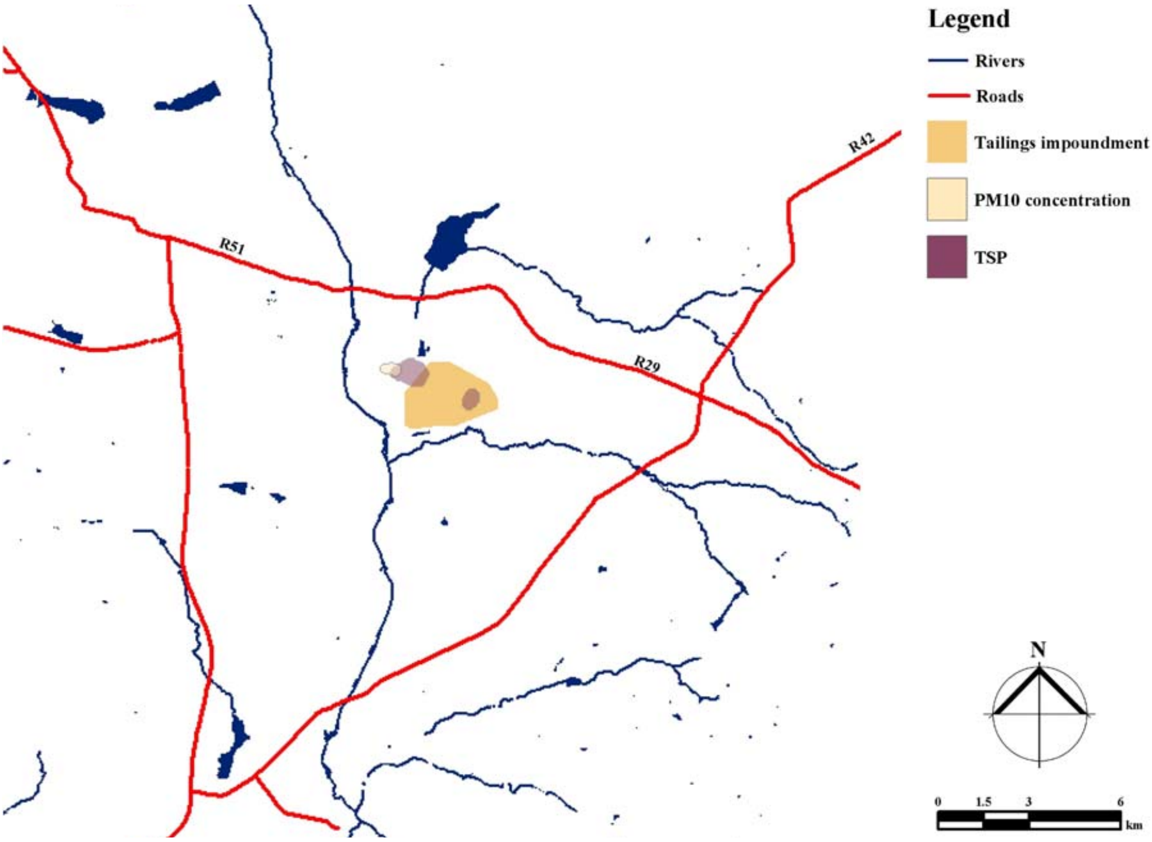


Figure B. 9: 1:1,5 embankment side slope with 80% control efficiency (AS13)

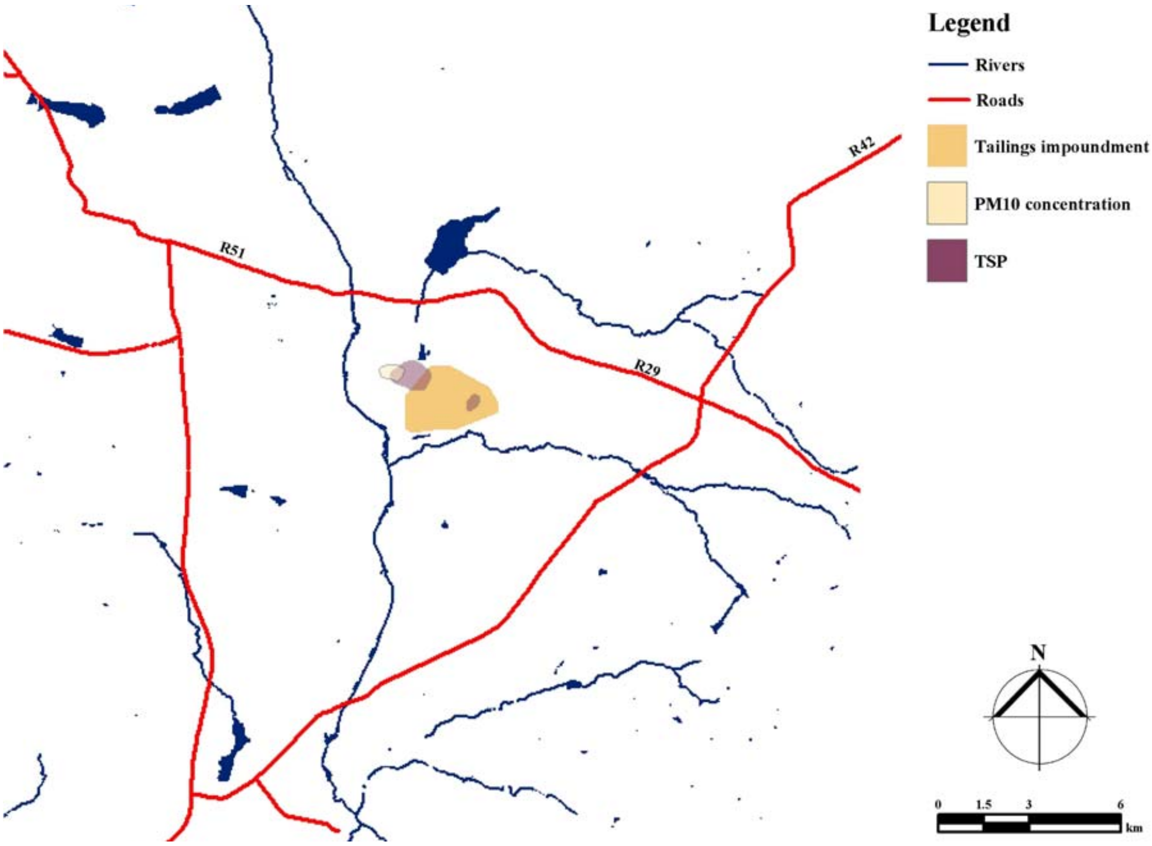


Figure B. 10: 1:3 embankment side slope with 80% control efficiency (AS14)

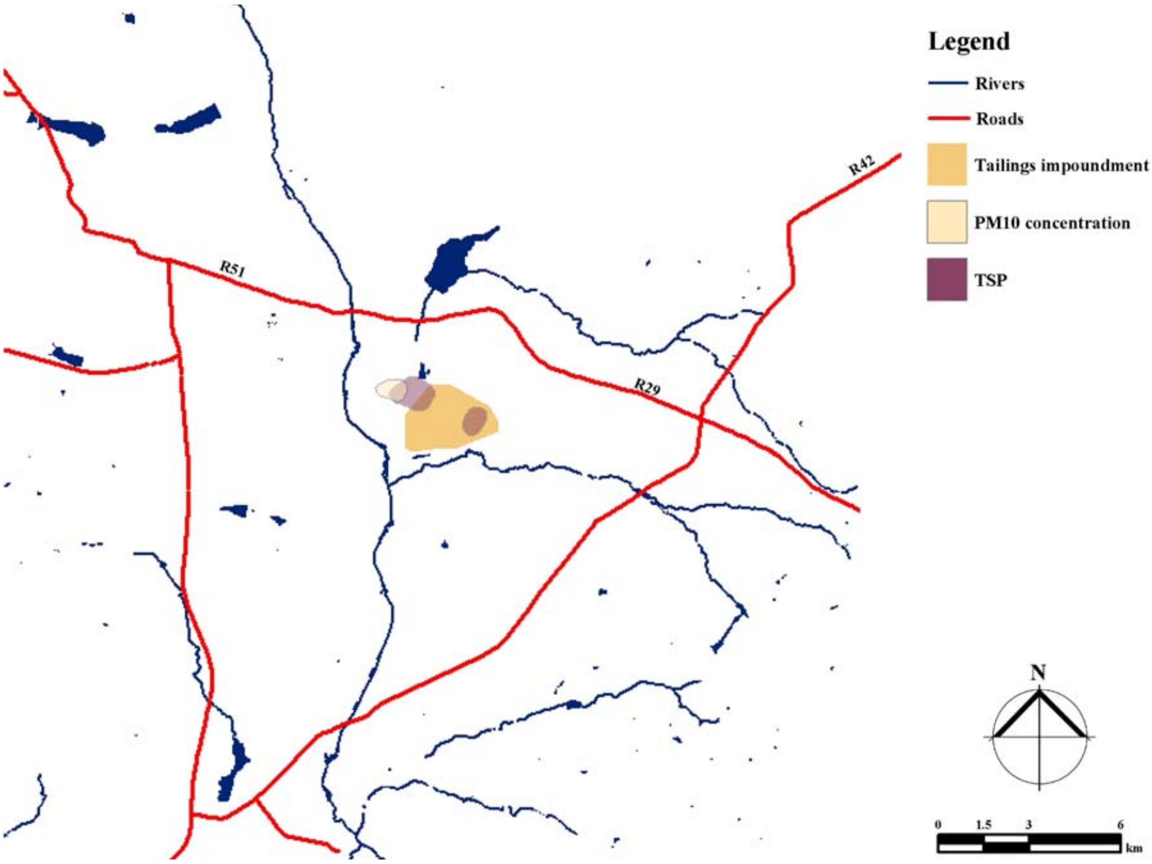


Figure B. 11: 1:6 embankment side slope with 80% control efficiency (AS15)

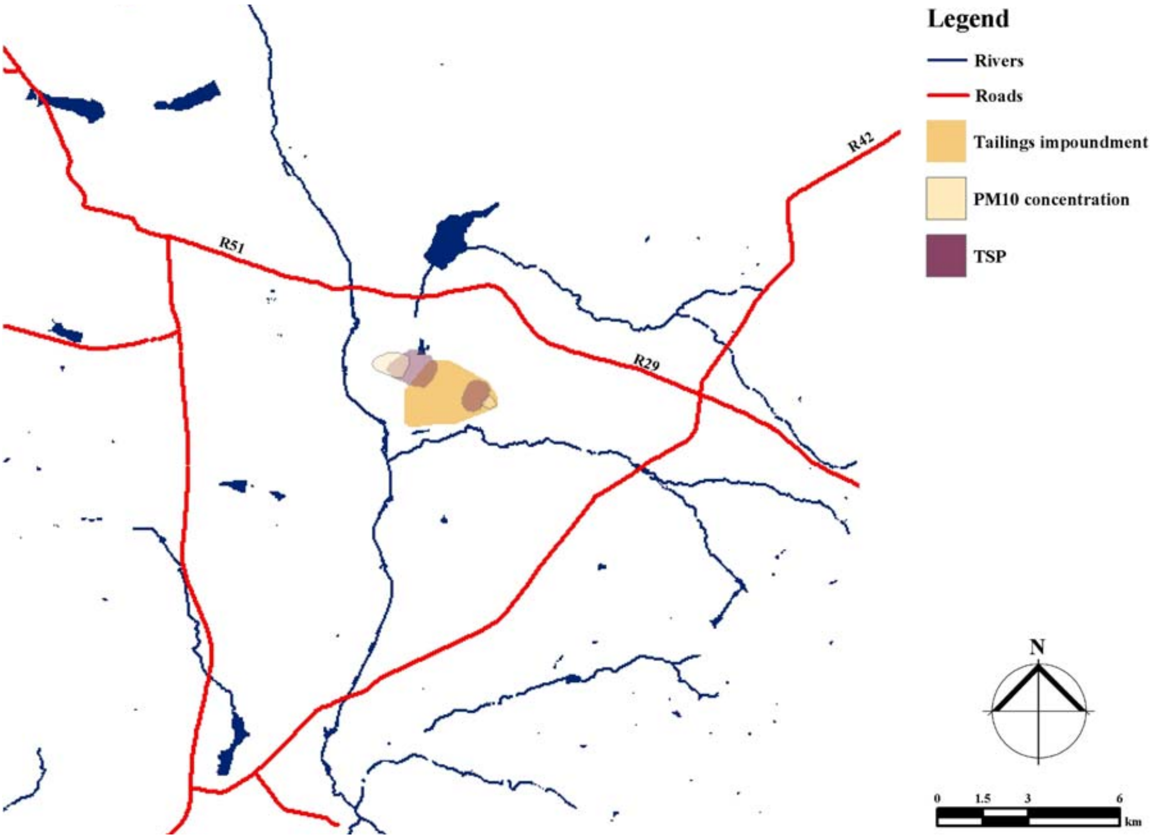


Figure B. 12: 1:9 embankment side slope with 80% control efficiency (AS16)

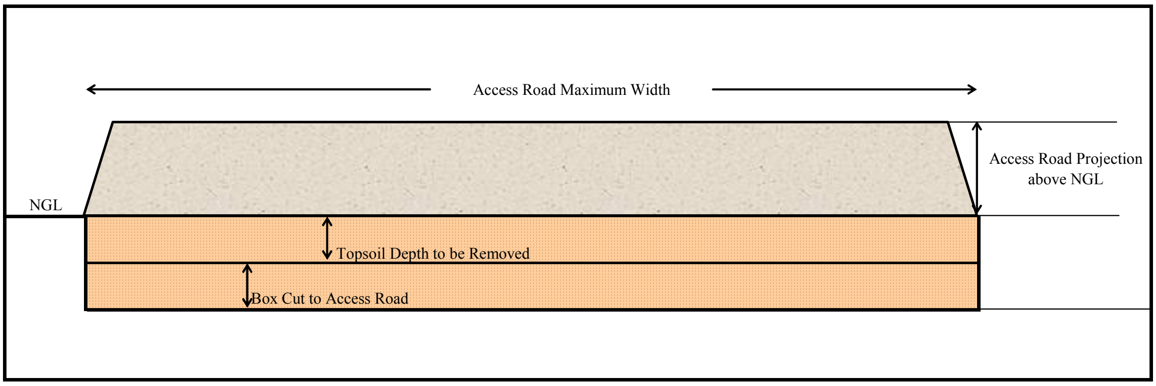
APPENDIX C: ENGINEERING COST MODEL

Appendix C1: Engineering specification sheets

C.1 Access and perimeter roads

SPECIFICATION SHEET FOR ACCESS ROAD CONSTRUCTION

Typical Cross Section through Access Road



Notes and Specifications

1. Access road width is a variable defined by user input, default value of 5.0m
2. Access road length is a variable either defined by user input or calculated by model
3. Topsoil depth to be removed is a variable defined by user input, default value 0.15m
4. Depth of box cut to access road is a variable defined by user input, default value 0.15m
5. Access road projection above NGL is a variable defined by user input, default value of 0.3m
6. Total fill thickness required is a variable dependant on user input, default value of 0.6m defined as depth of topsoil removal (0.15m) + depth of box cut (0.15m) + fill above NGL (0.3m)
7. Clear and grub material to be disposed of within freehaul distance
8. Topsoil to be stockpiled within freehaul distance for re-use
9. Material from box cut excavation to be stockpiled for re-use elsewhere
10. Suitable construction material to be sourced from borrow area **or** ex-excavation **or** ex-stockpile
11. All construction material available within 2km freehaul distance
12. Compaction effort required defined as minimum of four passes with one tonne vibratory roller

Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Access road width	m	5.00
2	Access road length	m	2000.00
3	Access road depth of topsoil to be removed	m	0.15
4	Access road depth of box cut	m	0.15
5	Access road fill above NGL thickness	m	0.30

C.2 Tailings delivery, ring main and distribution pipelines

SPECIFICATION SHEET FOR DELIVERY AND DISTRIBUTION PIPING

Notes and Specifications

1	Delivery pipeline diameter is a variable defined by user input, default value of 250NB
2	Delivery piping specification; Grade B 6mm thick steel piping, rubber lined (6mm), in standard 9.144m lengths flanged at both ends
3	Delivery pipelines number of is a variable defined by user input, default value of 2No
4	Delivery pipeline route length is a variable defined by user input
5	All delivery pipeline specials and non standard lengths are to be rubber lined
6	Delivery pipeline plinths have dimensions 1.25m width x 0.75m height x 0.3m thickness. Rate to include for excavation, formwork, concrete (Class 15Mpa), float finish, backfill and cast in items (16mm diameter mild steel guide rods 600mm long and skid plates, 80 x 4 flat bar 1.0m long)
7	Spacing between delivery pipeline plinths is a variable defined by user input, default value of 3.05m
8	Delivery piping number of specials (bends, T-pieces) is a variable defined by user input, default value of 10No. Rate to be indicative only
9	Delivery piping number of non-standard lengths is a variable defined by user input, default value of 20No. Rate to be indicative only
10	Valves are specified as ATVAL Type KE pinch valve (closed body) with diameter equal to delivery pipeline diameter, rate to include for the supply and installation of hydraulic pack
11	Valves number of is a variable defined by user input default value of 10No
12	Distribution pipeline diameter is a variable defined by user input, default value of 250NB
13	Distribution piping specification; Grade B 6mm thick steel piping, unlined, in standard 9.144m lengths flanged at both ends with 75mm stub ends at 2.5m centers (defined)
14	Distribution pipeline route length is a variable defined by user input, default value equal to tailings dam perimeter
15	Distribution piping number of specials (bends, T-pieces) is a variable defined by user input, default value of 20No. Rate to be indicative only
16	Distribution piping number of non-standard lengths is a variable defined by user input, default value of 40No. Rate to be indicative only
17	Starter wall length, average height and inner slope gradient are variables either defined by user input or calculated by model
18	Layflat hosing is specified as 75mm diameter, length of hosing required is calculated by model

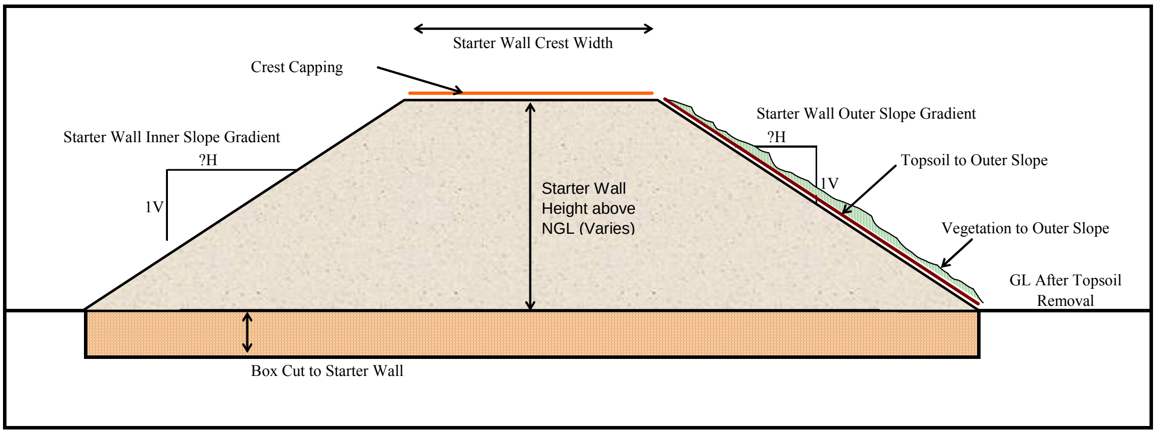
Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Delivery pipeline number of	No	2.00
2	Delivery pipeline route length	m	2000.00
3	Delivery pipeline specials (bends, T-pieces etc) number of per pipeline	No	10.00
4	Delivery pipeline non standard lengths number of per pipeline	No	20.00
5	Delivery pipeline spacing between plinths	m	3.05
6	Distribution piping route length	m	2000.00
7	Distribution piping spacing between spigots	m	2.50
8	Starter wall length	m	1000.00
9	Starter wall average height	m	7.00
10	Starter wall inner slope gradient (1V :?H)	Ratio	2.00
11	Layflat hosing average length per spigot	m	15.65
12	Distribution piping specials (bends t-pieces) number of	No	20.00
13	Distribution piping non standard lengths number of	no	40.00
14	Valves number of	No	10.00

C.3 Starter wall

SPECIFICATION SHEET FOR STARTER CONSTRUCTION

Typical Cross Section through Starter Wall



Notes and Specifications

1 Starter wall crest width is a variable defined by user input, default value of 5m
2 Starter wall length is a variable either defined by user input or calculated by model
3 Starter wall depth of box cut is a variable defined by user input, default value 0.15m
4 Starter wall inner slope gradient is a variable defined elsewhere by user input
5 Starter wall outer slope gradient is a variable defined elsewhere by user input

6 Starter wall height above NGL varies according to user input defined elsewhere; total fill volume, base area and outer side slope area are calculated by model
7 Starter wall crest capping thickness is a variable defined by user input, default value of 0.2m
8 Starter wall topsoil to outer slope thickness is a variable defined by user input, default value 0.15m
9 Starter wall cladding to outer slope thickness is a variable defined by user input, default value of 0.2m
10 Material from box cut excavation to be stockpiled for re-use as fill material
11 Suitable construction material to be sourced from borrow area **or** ex-excavation **or** ex-stockpile
12 All construction material available within 2km freehaul distance
13 Compaction effort required, defined as minimum of six passes with suitable vibratory roller

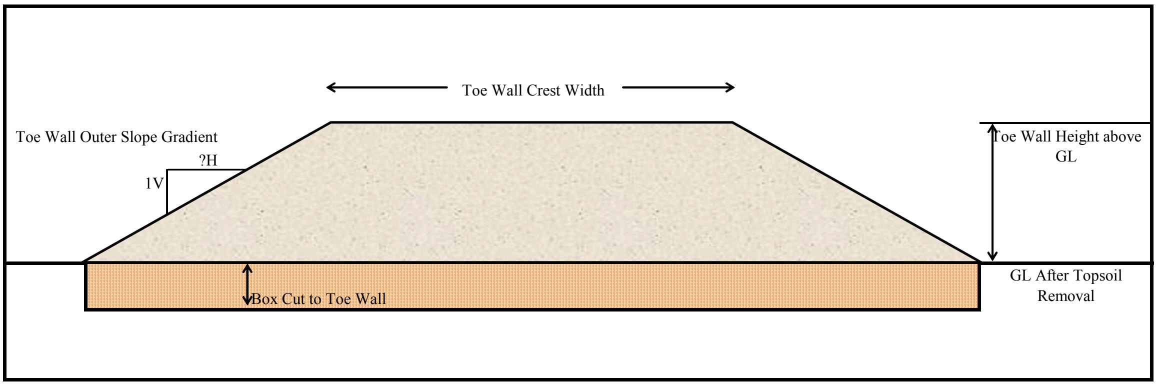
Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Starter wall crest width	m	5.00
2	Starter wall length	m	1000.00
3	Starter wall depth of box cut	m	0.15
4	Starter wall fill volume (above GL)	m^3	150000.00
5	Starter wall base area	m^2	12000.00
6	Starter wall crest capping thickness	m	0.20
7	Starter wall outer slope area	m^2	15000.00
8	Starter wall topsoil to outer slope thickness	m	0.15
	OR		
	Starter wall cladding to outer slope thickness	m	0.20

C.4 Toe wall

SPECIFICATION SHEET FOR TOE WALL CONSTRUCTION

Typical Cross Section through Toe Wall



Notes and Specifications

1 Toe wall crest width is a variable defined by user input, default value of 2m
2 Toe wall length is a variable either defined by user input or calculated by model
3 Topsoil depth to be removed is a variable defined by user input, calculated elsewhere, default value 0.15m
4 Toe wall depth of box cut is a variable defined by user input, default value 0.15m
5 Toe wall height above GL is a variable defined by user input, default value of 1.0m
6 Toe wall outer slope gradient is a variable defined by user input, default value of 1V : 2H
7 Material from box cut excavation to be stockpiled for re-use as fill material
8 Suitable construction material to be sourced from borrow area **or** ex-excavation **or** ex-stockpile
9 All construction material available within 2km freehaul distance
10 Nominal compaction effort required, defined as minimum of two passes with light vibratory roller

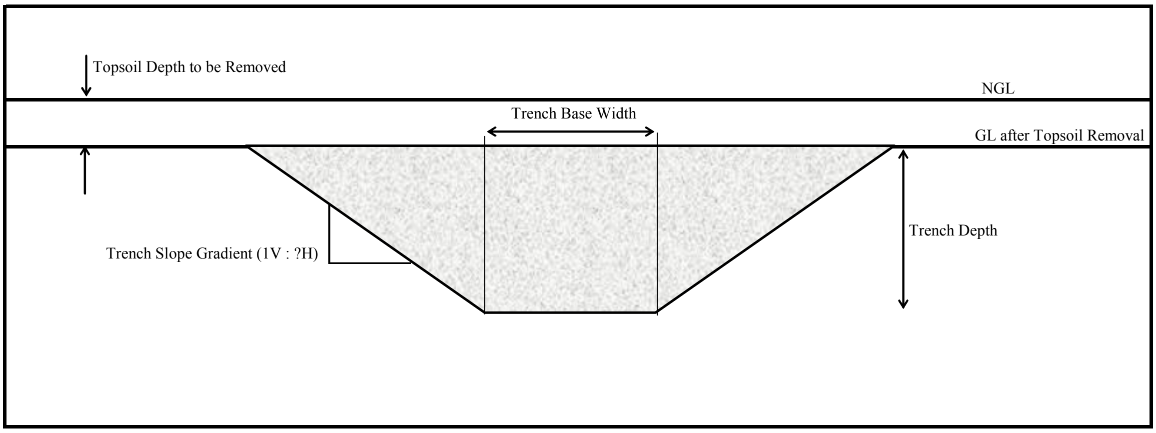
Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Toe wall crest width	m	2.00
2	Toe wall length	m	1000.00
3	Toe wall depth of box cut	m	0.15
4	Toe wall height above GL	m	1.00
5	Toe wall outer slope gradient (1V :?H)	Ratio	2.00

C.5 Solution trench

SPECIFICATION SHEET FOR CONSTRUCTION OF SOLUTION TRENCH

Typical Cross Section through Solution Trench



Notes and Specifications

1. Length of solution trench is calculated by model
2. Solution trench depth is a variable defined by user input, default value 1m
3. Solution trench base width is a variable defined by user input, default value 1m
4. Solution trench side slope gradient is a variable defined by user input, default value 1V : 2H
5. Clear and grub material to be disposed of within freehaul distance (quantified elsewhere)
6. Topsoil to be stockpiled within freehaul distance for re-use (quantified elsewhere)
7. Material from excavation to be stockpiled for re-use as fill material

Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Solution trench length	m	1000.00
2	Solution trench depth	m	1.00
3	Solution trench base width	m	1.00
4	Solution trench side slope gradient (1V : ?H)	Ratio	2

Quantification

		Unit	Quantity
1	Solution trench excavation *Calculation [solution trench sectional area x length of solution trench]*	m^3	5000.00

Base Rates

		Unit	Rate
1	Solution trench excavation	R/m^3	5

Applicable CPI Factors to Base Rates

		Unit	CPI Factor
1	Rate for solution trench excavation	Factor	1.1

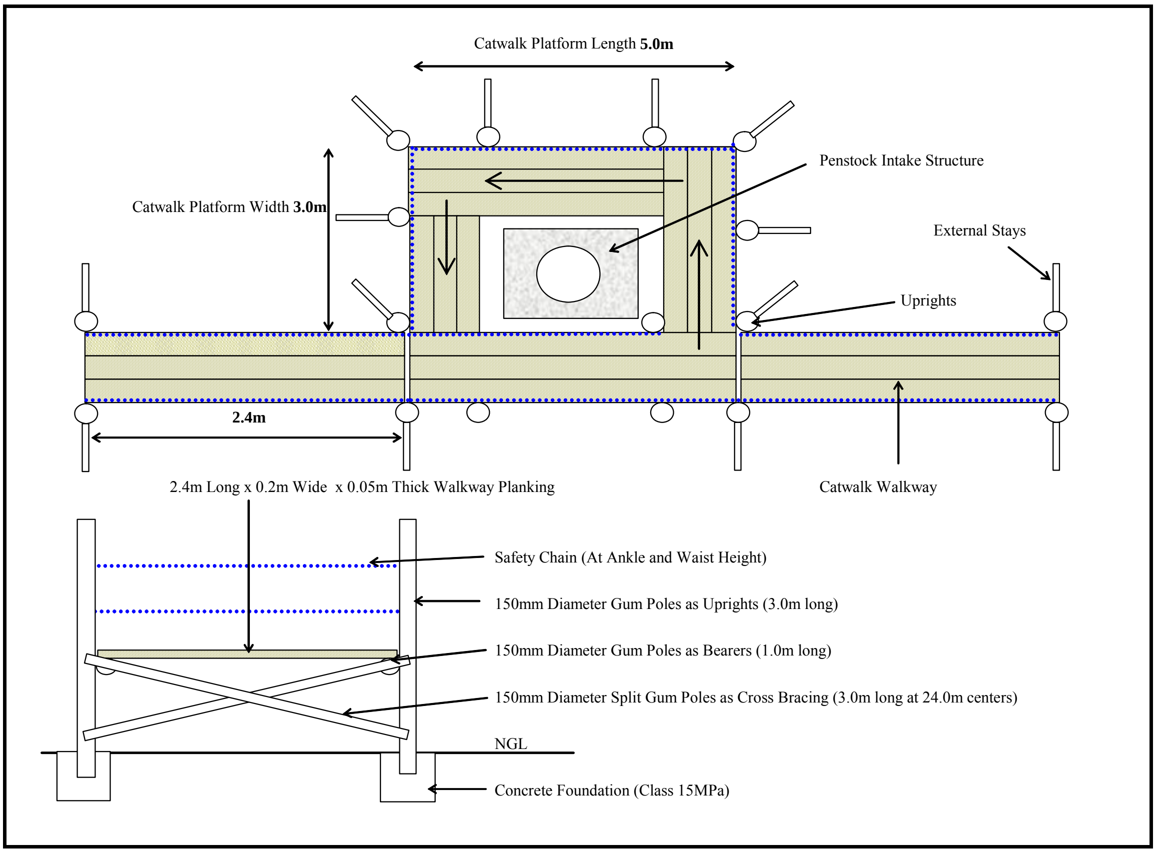
Final Rates for Construction of Solution Trench

		Unit	Final Rate
1	Solution trench excavation	R/m^3	7.7

C.6 Catwalk

SPECIFICATION SHEET FOR INSTALLATION OF CATWALK WALKWAY AND PLATFORMS

Typical Sections through Catwalk Installation



Notes and Specifications

1. Catwalk length is a variable defined by user input, default value equal to penstock pipeline length
2. Catwalk platforms number of is a variable defined by user input, default value of 4No
3. All timber is to be Tanolith treated prior to delivery to site
4. Installation rate is to be all inclusive for materials (timber, concrete, safety chain, nuts, bolts etc), excavation, fixing and backfill

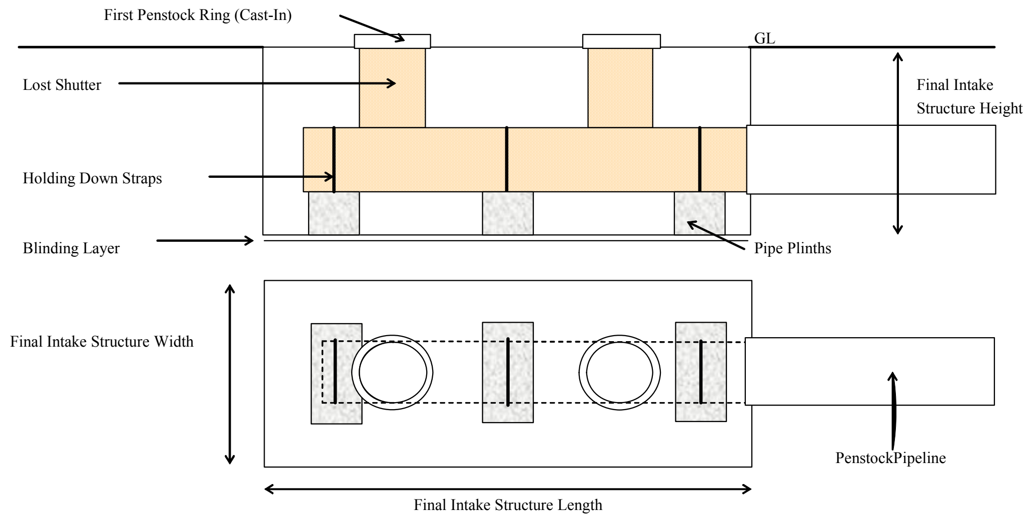
Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Catwalk length	m	300.00
2	Catwalk number of platforms	m	4.00

C.7 Penstock

SPECIFICATION SHEET FOR CONSTRUCTION OF FINAL INTAKE STRUCTURES

Typical Cross Section through Final Intake Structures



Notes and Specifications

1 Number of final penstock intake structures is a variable defined by user input, default value of 1No
2 Final penstock structure excavation width is a variable defined by user input, default value of 2.0m
3 Final penstock structure excavation length is a variable defined by user input, default value of 3.0m
4 Final penstock structure height is a variable defined by user input, default value of 1.2m
5 Final penstock structure width is a variable defined by user input, default value of 1.5m
6 Final penstock structure length is a variable defined by user input, default value of 2.5m
7 Number of pipe plinths is a variable defined by user input, default value of 3No. Dimensions 800 x 200 x 200, rate to be all inclusive

8 Number of penstock rings per structure is a variable defined by user input, default value of 2No. Rings to be SABS approved with 510mm diameter
9 Blinding thickness is a variable defined by user input, default value of 75mm
10 Anchor straps to be 80 x 5 mild steel, rate to include for HD bolts and is indicative only

11 Lost shutter to be manufactured with 3mm mild steel with dimensions to suit inner diameter of penstock pipeline and penstock rings, rate to be indicative only
12 All excavated material to be retained for backfill or disposed of within construction area
13 Blinding layer to be constructed with 15Mpa / 19mm concrete
14 All concrete is specified as Class 30Mpa / 19mm
15 Compaction effort required defined as minimum of four passes with one tonne vibratory roller

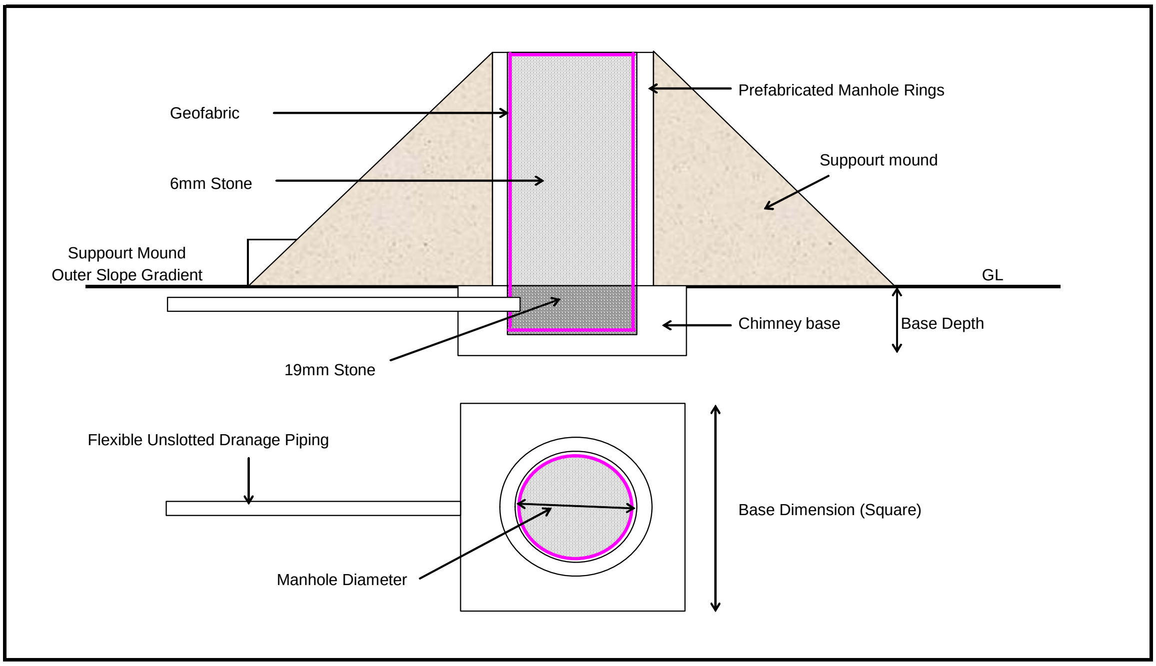
Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Penstock final intake number of	No	1.00
2	Penstock final intake structure excavation width	m	2.00
3	Penstock final intake structure excavation length	m	3.00
4	Penstock final intake structure height	m	1.20
5	Penstock final intake structure width	No	1.50
6	Penstock final intake structure length	m	2.50
7	Penstock final intake structure blinding thickness	m	0.075
8	Penstock final intake structure plinths number of	m	3.00
9	Penstock final intake structure number of penstock rings per structure	m	2.00

C.8 Drains

SPECIFICATION SHEET FOR CONSTRUCTION OF ELEVATED DRAIN CHIMNEYS

Typical Cross Section through Elevated Drain Chimney



Notes and Specifications

1 Elevated drain length that requires chimney outlets is a variable defined by user input or calculated by model, default value of length of starter wall
2 Spacing between elevated drain chimneys is a variable defined by user input, default value of 50m
3 Number of elevated drain chimneys is calculated by model

4 Elevated drain chimneys average height is a variable defined by user input or calculated by model, default value of maximum height of starter wall
5 Elevated drain chimney base has dimensions 1.5 x 1.5 x 0.35, rate to include for formwork, concrete (Class 25MPa), float finish and cast-in unslotted Drainex coupling (160mm diameter)
6 Elevated drain chimney to be constructed with pre-fabricated manhole rings 1.0m diameter, first ring to be cast into base
7 Height of 6mm stone drainage layer is equal to chimney height
8 Thickness of 19m stone drainage layer is equal to base internal height defined as 0.25m
9 Drainage piping is specified as 160mm diameter 'Drainex' flexible HDPE unslotted piping, but is quantified elsewhere
10 Geofabric is specified as Bidum A4
11 6mm stone is to be washed and must meet the following grading criteria

Sieve size (mm)	Percentage passing
9.50	100
6.70	85 - 100
4.75	0 - 30
3.35	0 - 5
Dust	Nil

12 19mm stone is to be washed and must meet the following grading criteria

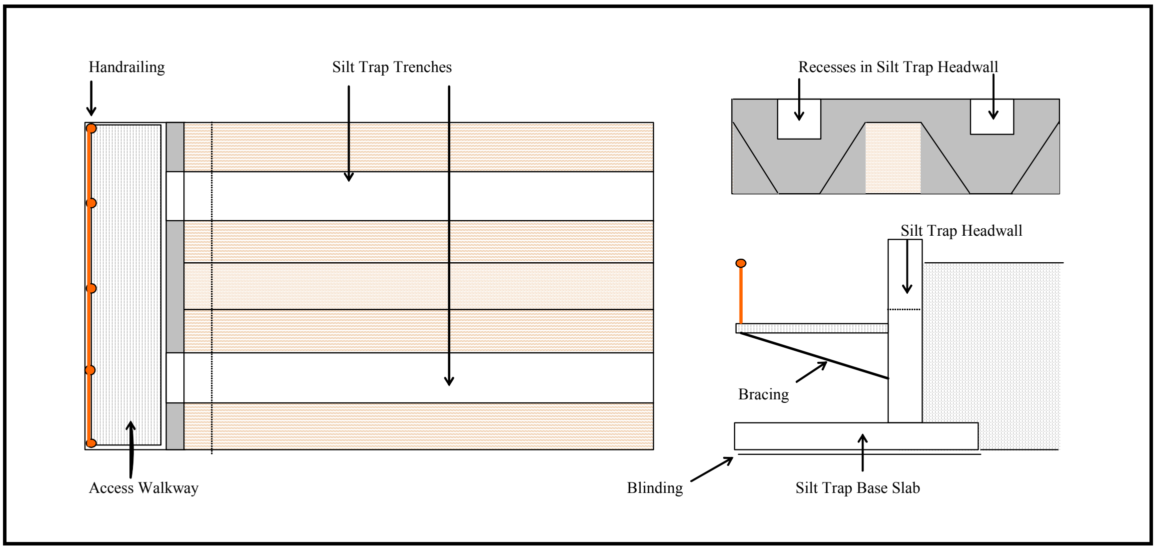
Sieve size (mm)	Percentage passing
26.50	100
19.00	85 - 100
13.20	0 - 30
9.50	0 - 5
Dust	Nil

13 All excavated material to be stockpiled for re-use

C.9 Silt trap

SPECIFICATION SHEET FOR CONSTRUCTION OF SILT TRAP HEADWALL AND TRENCHES

Typical Cross Sections through Silt Trap



Notes and Specifications

1 Silt trap topsoil depth to be removed is a variable defined by user input, default value of 0.15m
2 Silt trap headwall length is a variable defined by user input, default value of 20m
3 Silt trap headwall height is a variable defined by user input, default value of 1.7m
4 Silt trap headwall thickness is a variable defined by user input, default value of 0.3m
5 Silt trap base width is a variable defined by user input, default value of 1.2m
6 Silt trap base thickness is a variable defined by user input, default value of 0.3m
7 Silt trap recess to headwall have dimensions 1.0 x 1.0m
8 Silt trap trench length is a variable defined by user input, default value of 20m
9 Silt trap trench base width is a variable defined by user input, default value of 2.0m
10 Silt trap trench side slope gradient is a variable defined by user input, default value of 1V : 2H
11 Silt trap trench depth is a variable defined by user input, default value of 1.5m
12 Silt trap length of handrailing is calculated by model, specified as mild steel galvanised tubular 2 rail type. Hand rail size 34 x 2.5, ball type stanchion type 43 x 3.0, all connections to be welded. Rate to be indicative only
13 Silt trap walkway flooring width is defined as 1.0m, specified as light duty galvanised 40 x 4.5 gratings to be connected to walkway frame constructed out of 80 x 80 x 8 L section beams with bracing at both ends and at 1.2m intervals. Rate to be indicative only
14 Clear and grub material to be disposed of within construction area
15 Topsoil removed is to be stockpiled for re-use within freehaul distance
16 All excavated material to be retailed for use as backfill or disposed of within the construction area
17 Blinding layer to be constructed with 15Mpa / 19mm concrete, thickness specified as 0.150m
18 All concrete is specified as Class 30Mpa / 19mm
19 Mass of rebar per volume of concrete is a variable defined by user input, default value of 120kg/m3
20 Compaction effort required defined as minimum of four passes with one tonne vibratory roller

Known Dimensions / Parameters and Variables

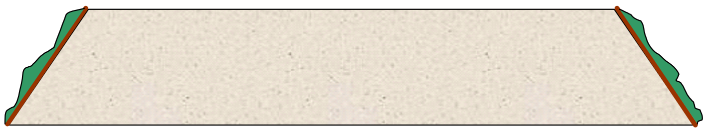
		Unit	Quantity
1	Silt trap topsoil depth to be removed	m	0.15
2	Silt trap headwall length	m	20.00
3	Silt trap headwall height	m	1.70
4	Silt trap headwall thickness	m	0.30
5	Silt trap base width	m	1.20
6	Silt trap base thickness	m	0.30
7	Silt trap recess to headwall dimensions (square)	m	1.00
8	Silt trap trench length	m	20.00

C.10 Cover

SPECIFICATION SHEET FOR CLADDING OF TAILINGS DAM OUTER SLOPES

Typical Cross Section through Tailings Dam

Option One: Topsoil and Vegetate



Option Two: Clad with Rockfill

Notes and Specifications

1 Tailings dam outer slope are is calculated by model elsewhere

2 Topsoil depth is a variable defined by user input, default value of 0.15m. Rate to be based on collection of topsoil from stockpile within 2 km's

3 Vegetation of outer slopes is to be achieved by hand planting, species mix is as follows

Species	Common Name	Variety	Rate (kg/Ha)
Cenchrus ciliaris	Blue buffalo grass	Molopo	5
Chloris gayana	Rhodes grass	Katambora	3
Cynodon dactylon	Kweek	Bermuda	10
Digitaria eriantha	Smuts finger grass	Irene	5

4 Rockfill cladding thickness is a variable defined by user input, default value of 0.3m. Rate to be based on the free supply of material to be collection from within a 2 km radius

Known Dimensions / Parameters and Variables

		Unit	Quantity
1	Tailings dam outer slope area	m^2	80000.00
2	Tailings dam topsoil cladding thickness	m	0.15
3	Tailings dam rockfill cladding thickness	m	0.30