11 CONCLUSION

It can be concluded that negative visual impacts would result from the construction, operational, decommissioning and closure phases of the proposed Moonlight Iron Ore Project. Although the proposed project site will be rehabilitated during closure of the Project, the WRD and the TSF will still be visible and will contribute to the negative visual impact even after closure.

The proposed study area has a slightly rolling topography with extended woodlands, koppies and the Lephalale River to the south and east of the study area. The visual resource value of the area is rated as being ***high*** and the sense of place is that of a serene natural environment.

Sensitive viewers within the study area include viewers traveling on the local roads, especially the road between Marnitz and Melinda, visitors staying at the Game Lodges and farmsteads. Although residents from the surrounding villages are also considered to be sensitive viewers these villages are located **outside the 'zone of potential influence' and the** Project is not visible from the villages.

The visual intrusion of the proposed Project is ***high*** as there are no other similar activities located with the area. The visibility of the proposed Project is ***high*** for motorist travelling between Marnitz and Melinda and only ***moderate*** for viewers from the lodges / game farms and farmsteads. The main reason for this is the existing vegetation and the slightly rolling topography that screen most of the views from sensitive viewers. It is therefore recommended that as much of the vegetation as possible should be kept in order to screen the proposed Project from sensitive viewers.

The severity of the proposed Project is considered to be ***high*** for motorist travelling on local roads in the vicinity of the Project and ***moderate*** for the lodges / game farms and the farmsteads.

The significance of the visual impact is rated as being ***high***. If the mitigation measures, as discussed in Section 9, are implemented successfully the significance of the visual impact will remain ***high***. The main reason for this is the fact that the TSF will remain on site and will still be visible above the tree line. It will still be intrusive to the study area and will contribute to the negative visual impact after closure.

The proposed Project will have a significant impact after sunset. The study area is currently exposed to the impact of lights from the farmsteads, game lodges and the small villages. The lights from the mining activities will light up the area after sunset and will be more visible over a longer distance; it will therefore **have a visual impact beyond the 'zone of potential influence'.**

NLA

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APPENDIX A: LIST OF FIGURES

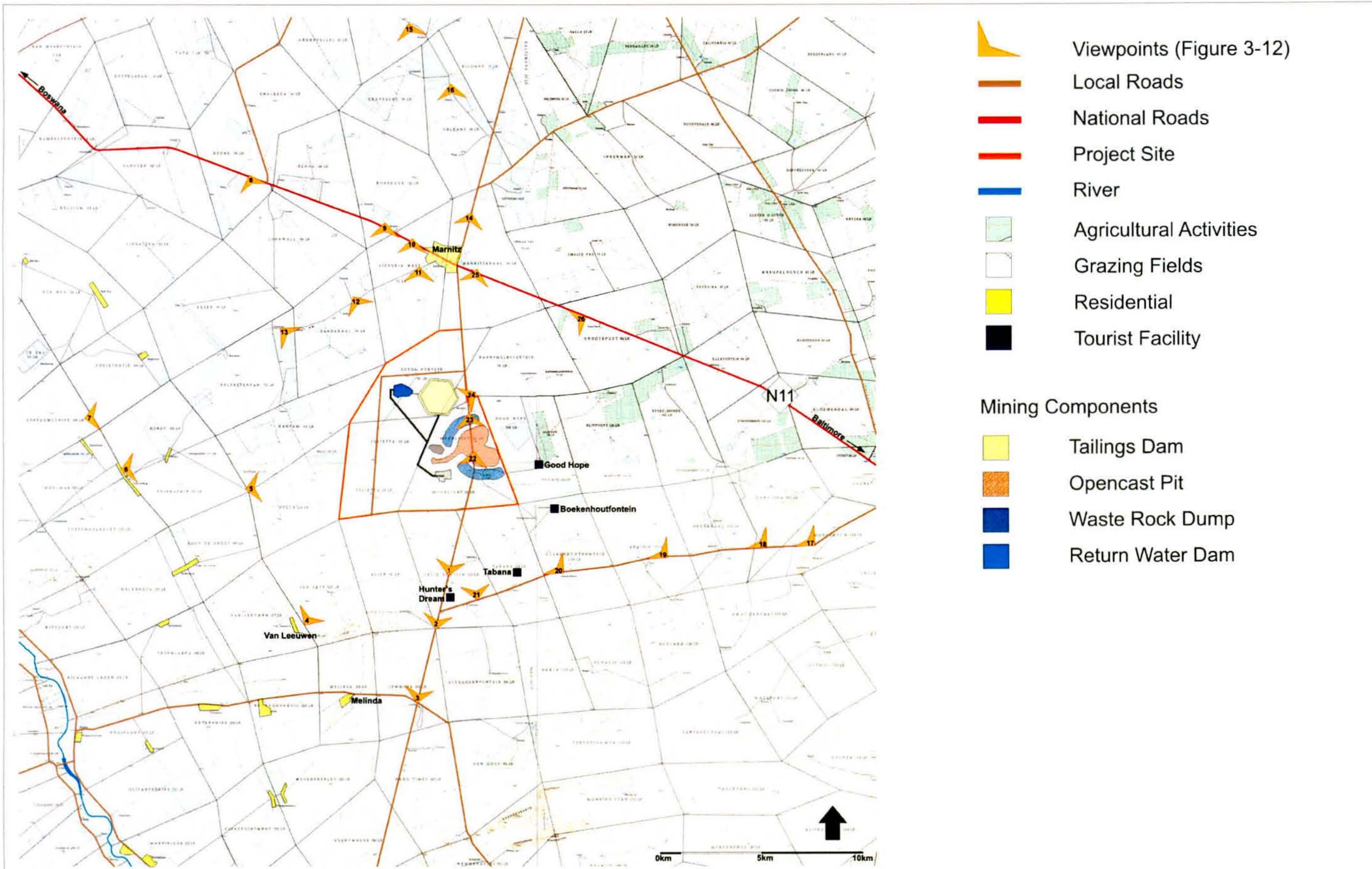


Figure 1: LOCALITY & VIEWS - Moonlight Iron Ore Mine

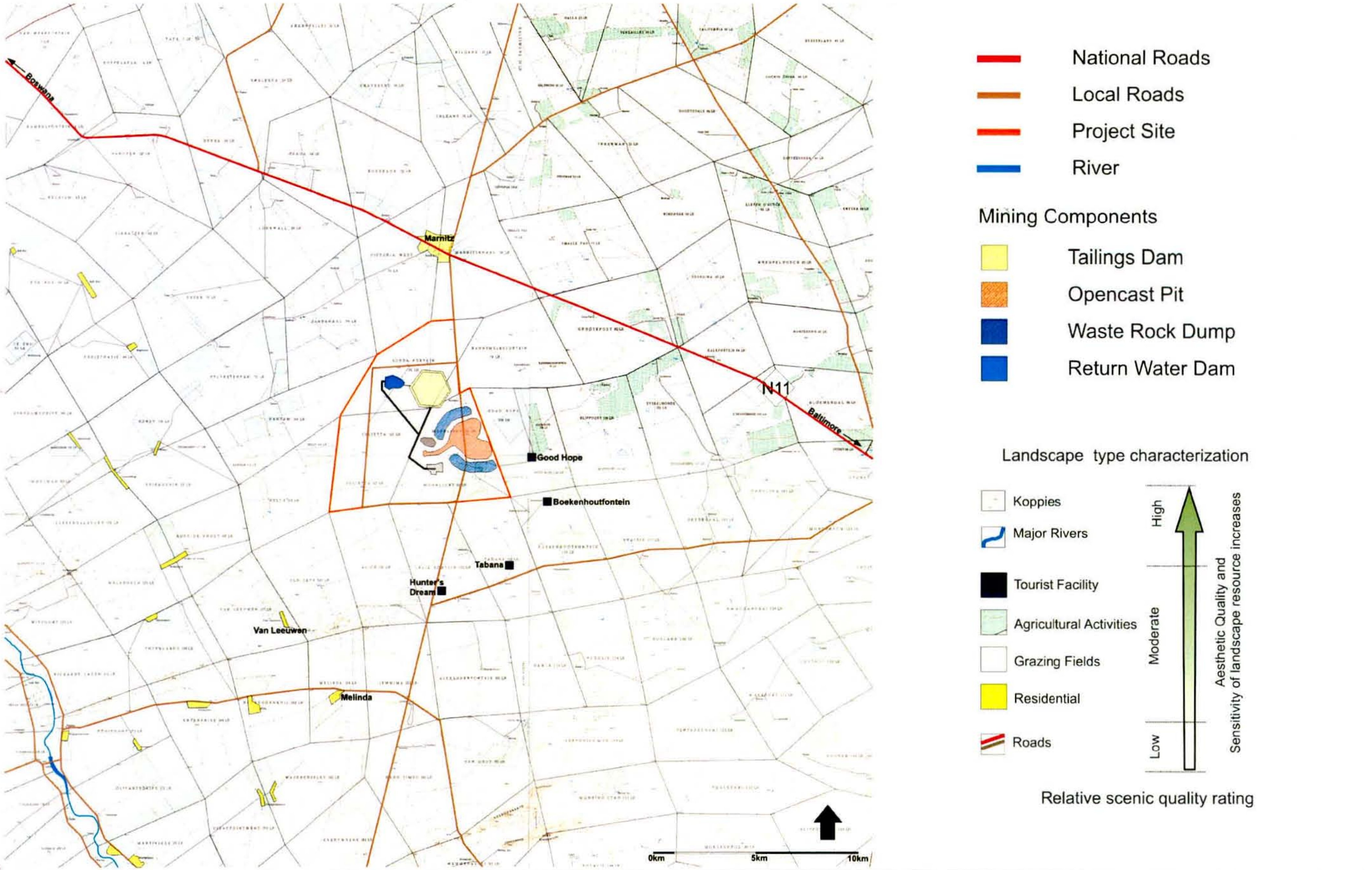


Figure 2: VISUAL RESOURCE - Moonlight Iron Ore Mine

View 1: From local road, view towards the proposed plant (left) and waste rock dump (right)

View 2: From local road (intersection), view towards the proposed plant (left) and waste rock dump (right)

View 3: From local road (intersection), view towards the proposed plant (left) and waste rock dump (right)

Refer to Figure 1 for the location of the viewpoints

Figure 3: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

NLA

View 4a: From Van Leeuwen Village, view towards the proposed project site

View 4b: From Van Leeuwen Village, view towards the proposed project site

View 5: From local road, view towards the proposed tailings facility (left), plant (middle) and waste rock dump (right)

Refer to Figure 1 for the location of the viewpoints

Figure 4: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

NLA

View 6: From local road, view towards the proposed project site

View 7: From local road, view towards the proposed project site

View 8: From local road, view towards the proposed tailings storage facility

Refer to Figure 1 for the location of the viewpoints

Figure 5: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

NLA

View 9: From local road, view towards the proposed tailings storage facility

View 10: From local road, view towards the proposed tailings storage facility

View 11: From local road, view towards the proposed tailings storage facility

Refer to Figure 1 for the location of the viewpoints

Figure 6: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

View 12a: From local road, view towards the proposed tailings storage facility

View 12b: From local road, view towards the proposed tailings storage facility

View 13: From local road, view towards the proposed tailings storage facility

Refer to Figure 1 for the location of the viewpoints

Figure 7: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

View 14: From local road, view towards the proposed project site

View 15: From local road, view towards the proposed project site

View 16: From local road, view towards the proposed project site

Refer to Figure 1 for the location of the viewpoints

Figure 8: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

View 17: From local road, view towards the proposed project site

View 18: From local road, view towards the proposed project site

View 19: From local road, view towards the proposed project site

Refer to Figure 1 for the location of the viewpoints

Figure 9: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

NLA

View 20: From local road, view towards the proposed project site

View 21: From local road, view towards the proposed project site

View 22: From local road, view towards the proposed project site

Refer to Figure 1 for the location of the viewpoints

Figure 10: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

NLA

View 23: From local road, view towards the proposed project site

View 24: From local road, view towards the proposed project site, tailings storage facility

View 25: From local road, view towards the proposed project site

Refer to Figure 1 for the location of the viewpoints

Figure 11: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

View 26: From local road, view towards the proposed project site

Refer to Figure 1 for the location of the viewpoints

Figure 12: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

Before

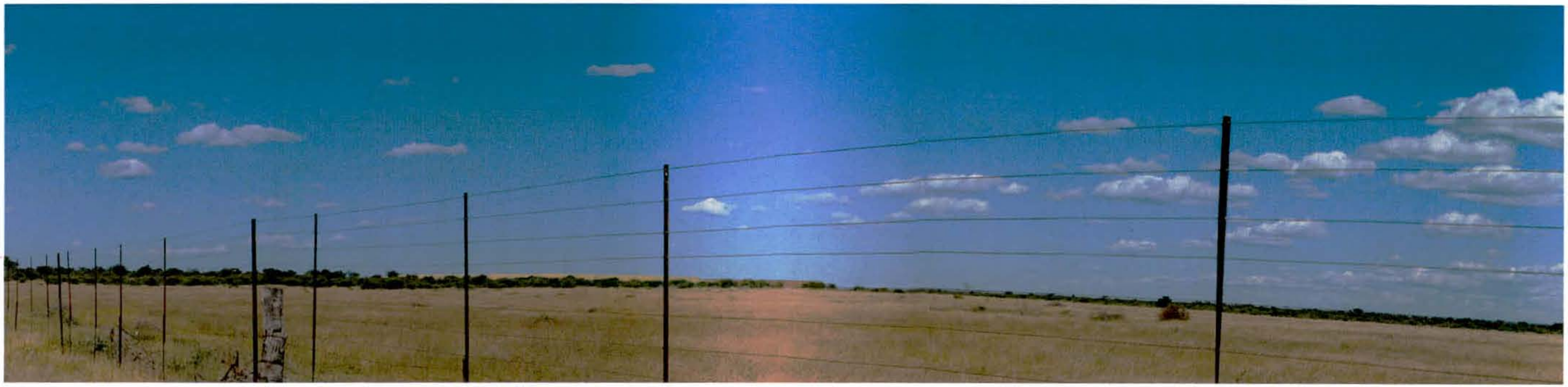
After

View 1: From local road, view towards the proposed plant (left) and waste rock dump (right)

Refer to Figure 1 for the location of the viewpoints

Figure 13: SIMULATION - Moonlight Iron Ore Mine

Before



After

View 13: From local road, view towards the proposed tailings storage facility

Refer to Figure 1 for the location of the viewpoints

Figure 14: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

Before

After

View 24: From local road, view towards the proposed project site, tailings storage facility

Refer to Figure 1 for the location of the viewpoints

Figure 15: LANDSCAPE CHARACTER - Moonlight Iron Ore Mine

NLA

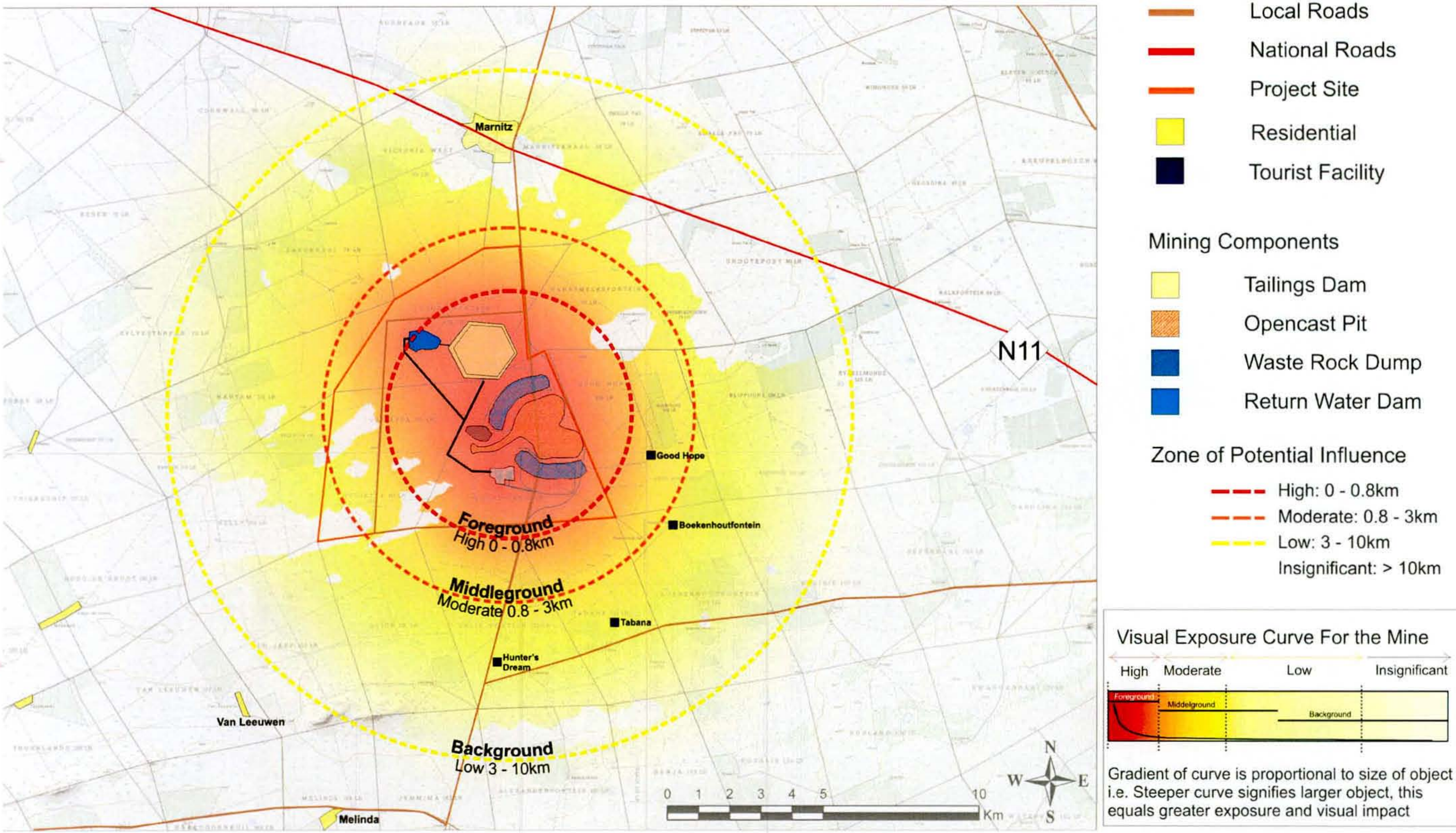


Figure 16: VIEWSHED ANALYSIS - Moonlight Iron Ore Mine

APPENDIX B: DETERMINING A LANDSCAPE AND THE VALUE OF THE VISUAL RESOURCE

In order to reach an understanding of the effect of development on a landscape resource, it is necessary to consider the different aspects of the landscape as follows:

Landscape Elements and Character

The individual elements that make up the landscape, including prominent or eye-catching features such as hills, valleys, savannah, trees, water bodies, buildings and roads are generally quantifiable and can be easily described.

Landscape character is therefore the description of pattern, resulting from particular combinations of natural (physical and biological) and cultural (land use) factors and how people perceive these. The visual dimension of the landscape is a reflection of the way in which these factors create repetitive groupings and interact to create areas that have a specific visual identity. The process of landscape character assessment can increase appreciation of what makes the landscape distinctive and what is important about an area. The description of landscape character thus focuses on the *nature of the land*, rather than the response of a viewer.

Landscape Value – all encompassing (Aesthetic Value)

Aesthetic value is the emotional response derived from the experience of the environment with its particular natural and cultural attributes. The response can be either to visual or non-visual elements and can embrace sound, smell and any other factor having a strong impact on human thoughts, feelings and attitudes (Ramsay 1993). Thus aesthetic value encompasses more than the seen view, visual quality or scenery, and includes atmosphere, landscape character and sense of place (Schapper 1993).

Aesthetic appeal (value) is considered high when the following are present (Ramsay 1993):

- *Abstract qualities*: such as the presence of vivid, distinguished, uncommon or rare features or abstract attributes;
- *Evocative responses*: the ability of the landscape to evoke particularly strong responses in community members or visitors;
- *Meanings*: the existence of a long-standing special meaning to a particular group of people or the ability of the landscape to convey special meanings to viewers in general;
- *Landmark quality*: a particular feature that stands out and is recognised by the broader community.

Sense of Place

Central to the concept of a sense of place is that the place requires uniqueness and distinctiveness. The primary informant of these qualities is the spatial form and character of the natural landscape together with the cultural transformations and traditions associated with historic use and habitation. According to Lynch (1992) sense of place "is the extent to which a person can recognize or recall a place as being distinct from other places - as having a vivid, or unique, or at least particular, character of its own". Sense of place is the unique value that is allocated to a specific place or area through the cognitive experience of the user or viewer. In some cases these values allocated to the place are similar for a wide spectrum of users or viewers, giving the place a universally recognized and therefore, strong sense of place.

Scenic Quality

Assigning values to visual resources is a subjective process. The phrase, "**beauty is in the eye of the beholder," is often quoted to emphasize the subjectivity in determining scenic values. Yet, researchers** have found consistent levels of agreement among individuals asked to evaluate visual quality.

Studies for perceptual psychology have shown human preference for landscapes with a higher visual complexity particularly in scenes with water, over homogeneous areas. On the basis of contemporary research landscape quality increases when:

- Topographic ruggedness and relative relief increase;
- Where water forms are present;
- Where diverse patterns of grasslands and trees occur;
- Where natural landscape increases and man-made landscape decreases;
- And where land use compatibility increases and land use edge diversity decreases (Crawford 1994).

Scenic Quality - Explanation of Rating Criteria:

(After The Visual Resource Management System, Department of the Interior of the USA Government, Bureau of Land Management)

Landform: Topography becomes more interesting as it gets steeper or more massive, or more severely or universally sculptured. Outstanding landforms may be monumental, as the Fish River or Blyde River Canyon, the Drakensberg or other mountain ranges, or they may be exceedingly artistic and subtle as certain badlands, pinnacles, arches, and other extraordinary formations.

Vegetation: (Plant communities) Give primary consideration to the variety of patterns, forms, and textures created by plant life. Consider short-lived displays when they are known to be recurring or spectacular (wildflower displays in the Karoo regions). Consider also smaller scale vegetational features, which add striking and intriguing detail elements to the landscape (e.g., gnarled or wind beaten trees, and baobab trees).

Water: That ingredient which adds movement or serenity to a scene. The degree to which water dominates the scene is the primary consideration in selecting the rating score.

Colour: Consider the overall colour(s) of the basic components of the landscape (e.g., soil, rock, vegetation, etc.) as they appear during seasons or periods of high use. Key factors to use when rating "colour" are variety, contrast, and harmony.

Adjacent Scenery: Degree to which scenery outside the scenery unit being rated enhances the overall impression of the scenery within the rating unit. The distance which adjacent scenery will influence scenery within the rating unit will normally range from 0-8 kilometres, depending upon the characteristics of the topography, the vegetative cover, and other such factors. This factor is generally applied to units which would normally rate very low in score, but the influence of the adjacent unit would enhance the visual quality and raise the score.

Scarcity: This factor provides an opportunity to give added importance to one or all of the scenic features that appear to be relatively unique or rare within one physiographic region. There may also be cases where a separate evaluation of each of the key factors does not give a true picture of the overall scenic quality of an area. Often it is a number of not so spectacular elements in the proper combination that produces the most pleasing and memorable scenery - the scarcity factor can be used to recognize this type of area and give it the added emphasis it needs.

Cultural Modifications: Cultural modifications in the landform / water, vegetation, and addition of structures should be considered and may detract from the scenery in the form of a negative intrusion or complement or improve the scenic quality of a unit.

Scenic Quality Inventory and Evaluation Chart

(After The Visual Resource Management System, Department of the Interior of the USA Government, Bureau of Land Management)

Key factors	**Rating Criteria and Score**	.	.
Landform	High vertical relief as expressed	Steep canyons, mesas,	Low rolling hills,

	in prominent cliffs, spires, or massive rock outcrops, or severe surface variation or highly eroded formations including major badlands or dune systems; or detail features dominant and exceptionally striking and intriguing such as glaciers. **5**	buttes, cinder cones, and drumlins; or interesting erosional patterns or variety in size and shape of landforms; or detail features which are interesting though not dominant or exceptional. **3**	foothills, or flat valley bottoms; or few or no interesting landscape features. **1**
Vegetation and landcover	A variety of vegetative types as expressed in interesting forms, textures, and patterns. **5**	Some variety of vegetation, but only one or two major types. **3**	Little or no variety or contrast in vegetation. **1**
Water	Clear and clean appearing, still, or cascading white water, any of which are a dominant factor in the landscape. **5**	Flowing, or still, but not dominant in the landscape. **3**	Absent, or present, but not noticeable. **0**
Colour	Rich colour combinations, variety or vivid colour; or pleasing contrasts in the soil, rock, vegetation, water or snow fields. **5**	Some intensity or variety in colours and contrast of the soil, rock and vegetation, but not a dominant scenic element. **3**	Subtle colour variations, contrast, or interest; generally mute tones. **1**
Influence of adjacent scenery	Adjacent scenery greatly enhances visual quality. **5**	Adjacent scenery moderately enhances overall visual quality. **3**	Adjacent scenery has little or no influence on overall visual quality. **0**
Scarcity	One of a kind; or unusually memorable, or very rare within region. Consistent chance for exceptional wildlife or wildflower viewing, etc. National and provincial parks and conservation areas *** 5+**	Distinctive, though somewhat similar to others within the region. **3**	Interesting within its setting, but fairly common within the region. **1**
Cultural modifications	Modifications add favourably to visual variety while promoting visual harmony.	Modifications add little or no visual variety to the area, and introduce no discordant elements.	Modifications add variety but are very discordant and promote strong

	2	**0**	disharmony. **-4**

Scenic Quality (i.e. value of the visual resource)

In determining the quality of the visual resource both the objective and the subjective or aesthetic factors associated with the landscape are considered. Many landscapes can be said to have a strong sense of place, regardless of whether they are considered to be scenically beautiful but where landscape quality, aesthetic value and a strong sense of place coincide - the visual resource or perceived value of the landscape is considered to be very high.

When considering both objective and subjective factors associated with the landscape there is a balance between landscape character and individual landscape features and elements, which would result in the values as follows:

Value of Visual Resource – expressed as Scenic Quality
(After The Landscape Institute with the Institute of Environmental Management and Assessment (2002))

High	Moderate	Low
Areas that exhibit a very positive character with valued features that combine to give the experience of unity, richness and harmony. These are landscapes that may be considered to be of particular importance to conserve and which may be sensitive change in general and which may be detrimental if change is inappropriately dealt with.	Areas that exhibit positive character but which may have evidence of alteration to /degradation/erosion of features resulting in areas of more mixed character. Potentially sensitive to change in general; again change may be detrimental if inappropriately dealt with but it may not require special or particular attention to detail.	Areas generally negative in character with few, if any, valued features. Scope for positive enhancement frequently occurs.

APPENDIX C: METHOD FOR DETERMINING THE MAGNITUDE (SEVERITY / INTENSITY) OF LANDSCAPE AND VISUAL IMPACT

A visual impact study analysis addresses the importance of the inherent aesthetics of the landscape, the public value of viewing the natural landscape, and the contrast or change in the landscape from the project.

For some topics, such as water or air quality, it is possible to use measurable, technical international or national guidelines or legislative standards, against which potential effects can be assessed. The assessment of likely effects on a landscape resource and on visual amenity is more complex, since it is determined through a combination of quantitative and qualitative evaluations. (The Landscape Institute with the Institute of Environmental Management and Assessment, 2002).

Landscape impact assessment includes a combination of objective and subjective judgments, and it is therefore important that a structured and consistent approach is used. It is necessary to differentiate between judgments that involve a degree of subjective opinion (as in the assessment of landscape value) from those that are normally more objective and quantifiable (as in the determination of magnitude of change). Judgment should always be based on training and experience and be supported by clear evidence and reasoned argument. Accordingly, suitably qualified and experienced landscape professionals carry out landscape and visual impact assessments (The Landscape Institute with the Institute of Environmental Management and Assessment (2002).

Landscape and visual assessments are separate, although linked, procedures. The landscape baseline, its analysis and the assessment of landscape effects all contribute to the baseline for visual assessment studies. The assessment of the potential effect on the landscape is carried out as an effect on an environmental resource, i.e. the landscape. Visual effects are assessed as one of the interrelated effects on populations.

Landscape Impact

Landscape impacts derive from changes in the physical landscape, which may give rise to changes in its character and from effects to the scenic values of the landscape. This may in turn affect the perceived value ascribed to the landscape. The description and analysis of effects on a landscape resource relies on the adoption of certain basic principles about the positive (or beneficial) and negative (or adverse) effects of change in the landscape. Due to the inherently dynamic nature of the landscape, change arising from a development may not necessarily be significant (Institute of Environmental Assessment & The Landscape Institute, 2002).

Visual Impact

Visual impacts relate to the changes that arise in the composition of available views as a result of changes to the landscape, to people's responses to the changes, and to the overall effects with respect to visual amenity. Visual impact is therefore measured as the change to the existing visual environment (caused by the physical presence of a new development) and the extent to which that change compromises (negative impact) or enhances (positive impact) or maintains the visual quality of the area.

To assess the magnitude of visual impact four main factors are considered.

Visual Intrusion:

The nature of intrusion or contrast (physical characteristics) of a project component on the visual quality of the surrounding environment and its compatibility / discord with the landscape and surrounding land use.

Visibility:

The area / points from which project components will be visible.

Visual exposure:

Visibility and visual intrusion qualified with a distance rating to indicate the degree of intrusion.

Sensitivity:

Sensitivity of visual receptors to the proposed development.

Visual Intrusion / contrast

Visual intrusion deals with the notion of contextualism i.e. how well does a project component fit into the ecological and cultural aesthetic of the landscape as a whole. Or conversely what is its contrast with the receiving environment. Combining landform / vegetation contrast with structure contrast derives overall visual intrusion / contrast levels of high, moderate, and low.

Landform / vegetation contrast is the change in vegetation cover and patterns that would result from construction activities. Landform contrast is the change in landforms, exposure of soils, potential for erosion scars, slumping, and other physical disturbances that would be noticed as uncharacteristic in the natural landscape. Structure contrast examines the compatibility of the proposed development with other structures in the landscape and the existing natural landscape. Structure contrast is typically strongest where there are no other structures (e.g., buildings, existing utilities) in the landscape setting.

Photographic panoramas from key viewpoints before and after development are presented to illustrate the nature and change (contrast) to the landscape created by the proposed development. A computer simulation technique is employed to superimpose a graphic of the development onto the panorama. The extent to which the component fits or contrasts with the landscape setting can then be assessed using the following criteria.

- Does the physical development concept have a negative, positive or neutral effect on the quality of the landscape?
- Does the development enhance or contrast with the patterns or elements that define the structure of the landscape?
- Does the design of the project enhance and promote cultural continuity or does it disrupt it?

The consequence of the intrusion / contrast can then be measured in terms of the sensitivity of the affected landscape and visual resource given the criteria listed below. For instance, within an industrial area, a new sewage treatment works may have an insignificant landscape and visual impact; whereas in a *valued* landscape it might be considered to be an intrusive element. (Institute of Environmental Assessment & The landscape Institute, 1996).

Visual Intrusion

High	**Moderate**	**Low**	**Positive**
If the project: - Has a substantial negative effect on the visual quality of the landscape; - Contrasts dramatically with the patterns or elements that define the structure of the landscape; - Contrasts dramatically with land use, settlement or enclosure patterns; - Is unable to be **'absorbed' into the** landscape.	If the project: - Has a moderate negative effect on the visual quality of the landscape; - Contrasts moderately with the patterns or elements that define the structure of the landscape; - Is partially compatible with land use, settlement or enclosure patterns. - **Is partially 'absorbed'** into the landscape.	If the project: - Has a minimal effect on the visual quality of the landscape; - Contrasts minimally with the patterns or elements that define the structure of the landscape; - Is mostly compatible with land use, settlement or enclosure patterns. - **Is 'absorbed' into the** landscape.	If the project: - Has a beneficial effect on the visual quality of the landscape; - Enhances the patterns or elements that define the structure of the landscape; - Is compatible with land use, settlement or enclosure patterns.
Result Notable change in landscape characteristics over an extensive area and / or intensive change over a localized area resulting in	*Result* Moderate change in landscape characteristics over localized area resulting in a moderate change to key views.	*Result* Imperceptible change resulting in a minor change to key views.	*Result* Positive change in key views.

major changes in key views.			

Visual intrusion also diminishes with scenes of higher complexity, as distance increases, the object becomes less of a focal point (more visual distraction), and the observer's attention is diverted by the complexity of the scene (Hull and Bishop, 1988).

Visibility

A viewshed analysis was carried out to define areas, which contain all possible observation sites from which the development would be visible. The basic assumption for preparing a viewshed analysis is that the observer eye height is 1.8m above ground level. Topographic data was captured for the site and its environs at 10m contour intervals to create the Digital Terrain Model (DTM). The DTM includes features such as vegetation, rivers, roads and nearby urban areas. These features were 'draped' over the topographic data to complete the model used to generate the viewshed analysis. It should be noted that viewshed analyses are not absolute indicators of the level of significance (magnitude) of the impact in the view, but merely a statement of the fact of potential visibility. The visibility of a development and its contribution to visual impact is predicted using the criteria listed below:

Visibility

High	**Moderate**	**Low**
Visual Receptors If the development is visible from over half the zone of potential influence, and / or views are mostly unobstructed and/or the majority of viewers are affected.	*Visual Receptors* If the development is visible from less than half the zone of potential influence, and / or views are partially obstructed and or many viewers are affected	*Visual Receptors* If the development is visible from less than a quarter of the zone of potential influence, and / or views are mostly obstructed and / or few viewers are affected.

Visual Exposure

Visual exposure relates directly to the distance of the view. It is a criterion used to account for the limiting effect of increased distance on visual impact. The impact of an object in the foreground (0 – 800m) is greater than the impact of that same object in the middle ground (800m – 5.0km) which, in turn is greater than the impact of the object in the background (greater than 5.0km) of a particular scene.

Distance from a viewer to a viewed object or area of the landscape influences how visual changes are perceived in the landscape. Generally, changes in form, line, colour, and texture in the landscape become less perceptible with increasing distance.

Areas seen from 0 to 800m are considered foreground; foliage and fine textural details of vegetation are normally perceptible within this zone.

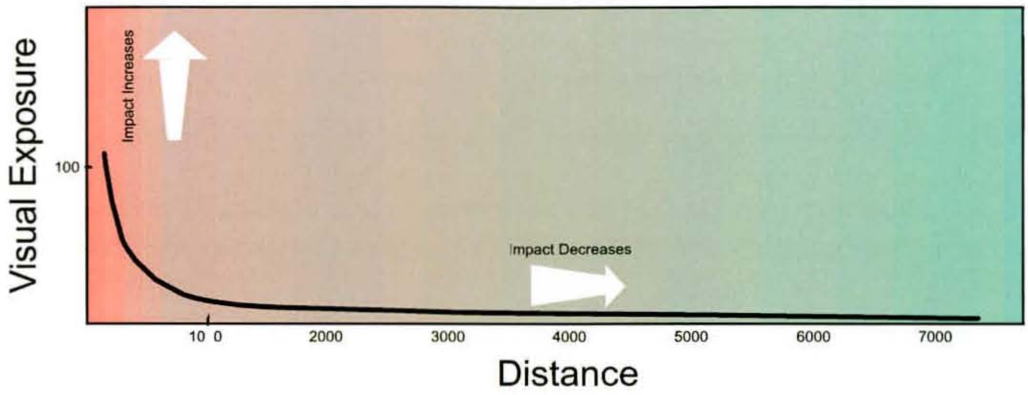
Areas seen from 800m to 5.0km are considered middle ground; vegetation appears as outlines or patterns. Depending on topography and vegetation, middle ground is sometimes considered to be up to 8.0km.

Areas seen from 5.0km to 8.0km and sometimes up to 16km and beyond are considered background. Landforms become the most dominant element at these distances.

Seldom seen areas are those portions of the landscape that, due to topographic relief or vegetation, are screened from the viewpoint or are beyond 16km from the viewpoint. Landforms become the most dominant element at these distances.

The impact of an object diminishes at an exponential rate as the distance between the observer and the object increases. Thus, the visual impact at 1000m would be 25% of the impact as viewed from 500m. At 2000 m it would be 10% of the impact at 500m. The inverse relationship of distance and visual impact is well recognised in visual analysis literature (e.g. Hull and Bishop (1988)) and is used as important criteria for the study. This principle is illustrated in the figure below.

Effect of Distance on Visual Exposure



Sensitivity of Visual Receptors

When visual intrusion, visibility and visual exposure are incorporated, and qualified by sensitivity criteria (visual receptors) the magnitude of the impact of the development can be determined.

The sensitivity of visual receptors and views will be depended on:

- The location and context of the viewpoint;
- The expectations and occupation or activity of the receptor;
- The importance of the view (which may be determined with respect to its popularity or numbers of people affected, its appearance in guidebooks, on tourist maps, and in the facilities provided for its enjoyment and references to it in literature or art).

The most sensitive receptors may include:

- Users of all outdoor recreational facilities including public rights of way, whose intention or interest may be focused on the landscape;
- Communities where the development results in changes in the landscape setting or valued views enjoyed by the community;
- Occupiers of residential properties with views affected by the development.
- These would all be high (5)

Other receptors include:

- People engaged in outdoor sport or recreation (other than appreciation of the landscape, as in landscapes of acknowledged importance or value); (3)
- People travelling through or past the affected landscape in cars, on trains or using other transport modes; (0)

- People at their place of work. (0)

The least sensitive receptors are likely to be people at their place of work, or engaged in similar activities, whose attention may be focused on their work or activity and who therefore may be potentially less susceptible to changes in the view.

In this process more weight is usually given to changes in the view or visual amenity which are greater in scale and visible over a wide area. In assessing the effect on views, consideration should be given to the effectiveness of mitigation measures, particularly where planting is proposed for screening purposes (Institute of Environmental Assessment & The Landscape Institute (1996).

Sensitivity of Visual Receptors

High (5)	Moderate (3)	Low (0)
Users of all outdoor recreational facilities including public rights of way, whose intention or interest may be focused on the landscape; Communities where the development results in changes in the landscape setting or valued views enjoyed by the community; Occupiers of residential properties with views affected by the development.	People engaged in outdoor sport or recreation (other than appreciation of the landscape, as in landscapes of acknowledged importance or value); People travelling through or past the affected landscape in cars, on trains or other transport routes;	The least sensitive receptors are likely to be people at their place of work, or engaged in similar activities, whose attention may be focused on their work or activity and who therefore may be potentially less susceptible to changes in the view (i.e. office and industrial areas). Roads going through urban and industrial areas

Magnitude (Severity / Intensity) of the Visual Impact

Potential visual impacts are determined by analysing how the physical change in the landscape, resulting from the introduction of a project, are viewed and perceived from sensitive viewpoints. Impacts to views are the highest when viewers are identified as being sensitive to change in the landscape, and their views are focused on and dominated by the change. Visual impacts occur when changes in the landscape are noticeable to viewers looking at the landscape from their homes or from parks, and conservation areas, highways and travel routes, and important cultural features and historic sites, especially in foreground views.

The magnitude of impact is assessed through a synthesis of visual intrusion, visibility, visual exposure and viewer sensitivity criteria. Once the magnitude of impact has been established this value is further qualified with spatial, duration and probability criteria to determine the *significance* of the visual impact.

For instance, the fact that visual intrusion and exposure diminishes significantly with distance does not necessarily imply that the relatively small impact that exists at greater distances is unimportant. The level of impact that people consider acceptable may be dependent upon the purpose they have in viewing the landscape. A particular development may be unacceptable to a hiker seeking a natural experience, or a household whose view is impaired, but may be barely noticed by a golfer concentrating on his game or a commuter trying to get to work on time (Ittleson *et al.*, 1974).

In synthesising these criteria a numerical or weighting system is avoided. Attempting to attach a precise numerical value to qualitative resources is rarely successful, and should not be used as a substitute for reasoned professional judgment. (Institute of Environmental Assessment and The Landscape Institute, 1996).

Magnitude (Severity / Intensity) of Visual Impact

High	Moderate	Low	Negligible
Total loss of or major alteration to key elements / features / characteristics of the baseline. I.e. Pre-development landscape or view and / or introduction of elements considered to be totally uncharacteristic when set within the attributes of the receiving landscape. High scenic quality impacts would result.	Partial loss of or alteration to key elements / features / characteristics of the baseline. I.e. Pre-development landscape or view and / or introduction of elements that may be prominent but may not necessarily be considered to be substantially uncharacteristic when set within the attributes of the receiving landscape. Moderate scenic quality impacts would result	Minor loss of or alteration to key elements / features / characteristics of the baseline. I.e. Pre-development landscape or view and / or introduction of elements that may not be uncharacteristic when set within the attributes of the receiving landscape. Low scenic quality impacts would result.	Very minor loss or alteration to key elements / features / characteristics of the baseline. I.e. Pre-development landscape or view and / or introduction of elements that are not uncharacteristic with the surrounding landscape – approximating the 'no change' situation. Negligible scenic quality impacts would result.

Cumulative effects

Cumulative landscape and visual effects (impacts) result from additional changes to the landscape or visual amenity caused by the proposed development in conjunction with other developments (associated with or separate to it), or actions that occurred in the past, present or are likely to occur in the foreseeable future. They may also affect the way in which the landscape is experienced. Cumulative effects may be positive or negative. Where they comprise a range of benefits, they may be considered to form part of the mitigation measures.

Cumulative effects can also arise from the intervisibility (visibility) of a range of developments and / or the combined effects of individual components of the proposed development occurring in different locations or over a period of time. The separate effects of such individual components or developments may not be significant, but together they may create an unacceptable degree of adverse effect on visual receptors within their combined visual envelopes. Intervisibility depends upon general topography, aspect, tree cover or other visual obstruction, elevation and distance, as this affects visual acuity, which is also influenced by weather and light conditions. (Institute of Environmental Assessment and The Landscape Institute, 1996).

APPENDIX D: CRITERIA FOR SIGNIFICANCE OF IMPACT ASSESSMENT

The impact assessment methodology is based on the Hacking method of determination of the significance of impacts (Hacking, 1998). Part A provides the definition for determining impact consequence (combining severity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D.

PART A: DEFINITION AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of severity, spatial extent and duration**
Criteria for ranking of the SEVERITY of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate / measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable / will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable / will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional / national

PART B: DETERMINING CONSEQUENCE

SEVERITY = L

DURATION	Long term	**H**	Medium	Medium	Medium

	Medium term	M	Low	Low	Medium
	Short term	L	Low	Low	Medium

SEVERITY = M

DURATION	Long term	H	Medium	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Low	Medium	Medium

SEVERITY = H

DURATION	Long term	H	High	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Medium	Medium	High
			L	M	H
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional / national
			SPATIAL SCALE		

PART C: DETERMINING SIGNIFICANCE					
PROBABILITY	Definite / Continuous	H	Medium	Medium	High
(of exposure to impacts)	Possible / frequent	M	Medium	Medium	High
	Unlikely / seldom	L	Low	Low	Medium
			L	M	H
			CONSEQUENCE		

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

***H = high, M= medium and L= low and + denotes a positive impact.**

APPENDIX E: CRITERIA FOR PHOTO / COMPUTER SIMULATION

To characterize the nature and magnitude of visual intrusion of the proposed project, a photographic simulation technique was used. This method was used according to Sheppard (in Lange 1994), where a visual simulation is good quality when the following five criteria are met.

Representativeness:	A simulation should represent important and typical views of a project.
Accuracy:	The similarity between a simulation and the reality after the project has been realized.
Visual clarity:	Detail, parts and overall contents have to be clearly recognizable.
Interest:	A simulation should hold the attention of the viewer.
Legitimacy:	A simulation is defensible if it can be shown how it was produced and to what degree it is accurate.

To comply with this standard it was decided to produce a stationary or static simulation (Van Dortmont in Lange, 1994), which shows the proposed development from a typical static observation points (Critical View Points).

Photographs are taken on site during a site visit with a manual focus, 50mm focal depth digital camera. All camera settings are recorded and the position of each panoramic view is recorded by means of a GPS. These positions, coordinates are then placed on the virtual landscape (see below).

A scale model of the proposal is built in virtual space, scale 1:1, based on CAD (vector) information as supplied by the architect / designers. This model is then placed on a virtual landscape, scale 1:1, as produced by means of GIS software. The accuracy of this depends on the contour intervals.

The camera views are placed on the points as recorded on the virtual landscape. The respective photographs are overlaid onto the camera views, and the orientation of the cameras adjusted accordingly. The light source is adjusted to suit the view. Each view is then rendered as per the process above.

APPENDIX F: DECLERATION OF INDEPENDENCE

Declaration of Independence

I, Graham A Young hereby declare that Newtown Landscape Architects cc, an independent consulting firm, has no interest or personal gains in this project whatsoever, except receiving fair payment for rendering an independent professional service.

Consultant name: Graham Young

Signature:

Date: 18 January 2011

APPENDIX G: CURRICULUM VITAE

Since 1994

Graham Young PrLArch

PO Box 36, Fourways, 2055

Tel: 27 11 462 6967

Fax: 27 11 462-9284

www.newla.co.za graham@newla.co.za

Graham is a landscape architect with thirty years' experience. He has worked in Southern Africa and Canada and has valuable expertise in the practice of landscape architecture, urban design and environmental planning. He is also a senior lecturer, teaching urban design and landscape architecture at post and under graduate levels at the University of Pretoria. He also specializes in Visual Impact Assessments.

EXPERIENCE: **NEWTOWN LANDSCAPE ARCHITECTS cc.** ***Member***

Current — Responsible for project management, landscape design, urban design, and visual impact assessment.

Senior Lecturer: Department of Architecture, University of Pretoria.

1991 - 1994 — **GRAHAM A YOUNG LANDSCAPE ARCHITECT** - ***Sole proprietor***

1988 - 1989 — Designed major transit and CBD based urban design schemes; designed commercial and recreational landscapes and a regional urban park; participated in inter-disciplinary consulting teams that produced master plans for various beachfront areas in KwaZulu Natal and a mountain resort in the Drakensberg.

1989 - 1991 **CANADA** - *Free Lance*

Designed golf courses and carried out golf course feasibility studies (Robert Heaslip and Associates); developed landscape site plans and an end-use plan for an abandoned mine (du Toit, Allsopp and Hillier); conducted a visual analysis of a proposed landfill site. .

1980 - 1988 **KDM (FORMERLY DAMES AND MOORE)** - *Started as a Senior Landscape Architect and was appointed Partner in charge of Landscape Architecture and Environmental Planning in 1984.* Designed commercial, corporate and urban landscapes; completed landscape site plans; developed end-use master plans for urban parks, college and technikon sites; carried out ecological planning studies for factories, motorways and a railway line.

1978 - 1980 **DAYSON & DE VILLIERS** - *Staff Landscape Architect*

Designed various caravan parks; designed a recreation complex for a public resort; conducted a visual analysis for the recreation planning of Pilgrims Rest; and designed and supervised the installation of various private gardens.

EDUCATION:

Bachelor of Landscape Architecture, 1978, (BLArch), University of Toronto, Canada;

Completing a master's degree in Landscape Architecture, University of Pretoria; Thesis: Visual Impact Assessment;

Senior Lecturer - Department of Architecture, University of Pretoria.

PROFESSIONAL:

Registered Landscape Architect – South African Council for Landscape Architectural Profession (2001);

Board of Control for Landscape Architects of South Africa (1987) – Vice Chairman 1988 to 1989;

Professional Member - Institute of Landscape Architects Southern Africa (1982) – President 1986 - 1988;

Member Planning Professions Board 1987 to 1989;

Member International Association of Impact Assessment;

AWARDS:

Torsanlorenzo International Prize, Landscape design and protection 2nd Prize Section B: Urban Green Spaces, for Intermediate Phase Freedom Park (2009)

Phase 1 and Intermediate Phase Freedom Park: Special Mention World Architecture Festival, Nature Category (2008)

Moroka Park Precinct, Soweto: ILASA Merit Award for Design (2005) and Gold Medal United Nations Liveable Communities (LivCom) Award (2007)

Isivivane, Freedom Park: ILASA Presidential Award of Excellence Design (2005)

Information Kiosk, Freedom Park: ILASA Merit Award for Design (2005)

Moroka – Mofola Open Space Framework, Soweto: ILASA Merit Award for Planning (2005)

Mpumalanga Provincial Government Complex: ILASA Presidential Award of Excellence (with KWP Landscape Architects for Design (2003)

Specialist Impact Report: Visual Environment, Sibaya Resort and Entertainment World: ILASA Merit Award for Environmental Planning (1999);

Gillooly's Farm, Bedfordview (with Dayson and DeVilliers): ILASA Merit Award for Design;

COMPETITIONS:

Pan African Parliament International Design competition – with MMA architects (2007) Finalist

Leeuwpan Regional Wetland Park for the Ekurhuleni Metro Municipality (2004) Landscape Architectural Consultant on Department of Trade and Industries Building (2002) – Finalist

Landscape Architecture Consultant on Project Phoenix Architectural Competition, Pretoria (1999): Winner;

Mpumalanga Legislature Buildings (1998): Commissioned;

Toyota Fountain (1985): First Prize - commissioned;

Bedfordview Bike/Walkway System - Van Buuren Road (1982): First Prize - commissioned;

Portland Cement Institute Display Park (1982): Second Prize

CONTRIBUTOR:

Joubert, O, 10 Years + *100 Buildings – Architecture in a Democratic South Africa Bell-Roberts Gallery and Publishing*, South Africa (2009)

- Freedom Park Phase 1 and Intermediate Phase (NBGM), Pretoria, Gauteng

Galindo, M, *Collection Landscape Architecture*, Braun, Switzerland (2009)

- Freedom Park Phase Intermediate Phase (NBGM), Pretoria, Gauteng

In *1000 X Landscapes*, Verlagshaus Braun, Germany (2008)

- Freedom Park Phase 1 and Intermediate Phase (NBGM), Pretoria, Gauteng
- Riverside Government Complex (NLAKWP), Nelspruit, Mpumalanga;
- Moroka Dam Parks Precinct, Soweto, Gauteng.

In *Johannesburg: Emerging/Diverging Metropolis*, Mendrision Academy Press, Italy (2007)

- Moroka Dam Parks Precinct, Soweto, Gauteng.

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B.Sc Degree in Environmental Science from the University of North West, Potchefstroom Campus (2003). M.Sc Degree in Ecological Remediation and Sustainable Utilization from the University of North West, Potchefstroom Campus (2007). She is currently employed by Newtown Landscape Architects working on the following projects.

EXPERIENCE: **Environmentalist: Newtown Landscape Architects**

Responsible for the environmental work, which includes Basic Assessments, Environmental Impact Assessments (Scoping & EIA), Environmental Management Plans (EMP), Environmental Auditing as well as Visual Impact Assessments.

Current Projects:

- **Orchards Extension 49-53,** Pretoria - Environmental Impact Assessment and Environmental Management Plan
- **Tanganani Ext 8,** Johannesburg - Environmental Impact Assessment and Environmental Management Plan
- **Diepsloot East Development,** Diepsloot - Environmental Impact Assessment and Environmental Management Plan
- **Klerksoord Ext 25 & 26,** Pretoria – Environmental Impact Assessment
- **Ennerdale Ext 16,** Johannesburg - Environmental Impact Assessment and Environmental Management Plan
- **Glen Marais Ext 102 & 103,** Kempton Park - Basic Assessment and Environmental Management Plan
- **Princess Plot 229,** Princess - Environmental Assessment (S24G Application)

- **Uthlanong Drive Upgrade** – Mogale City Local Municipalty project in Kagiso, Basic Assessment for the upgrade of the stormwater and the roads
- **Luipaardsvlei Landfill Site** – Mogale City Local Municipalty project in Krugersdorp, the expansion of the existing landfill site.
- **MCLM Waste Water Treatment Works** – Mogale City Local Municipalty project in Magaliesburg, the expansion of the existing facility.
- **Rand Uranium** (Golder Associates Africa (Pty) Ltd), Randfontein – VIA
- **Dorsfontein West Expansion** (GCS (Pty) Ltd), Kriel – VIA
- **Mine Waste Solutions** (GCS (Pty) Ltd), Stilfontein – VIA
- **Ferreira Coal Mining** (GCS (Pty) Ltd), Ermelo – VIA
- **De Wittekrans Mining** (GCS (Pty) Ltd), Hendrina – VIA

EDUCATION:

May 2009	Public Participation Course, International Association for Public Participation, Golder Midrand
May 2008	Wetland Training Course on Delineation, Legislation and Rehabilitation, University of Pretoria.
April 2008	Environmental Impact Assessment: NEMA Regulations – A practical approach, Centre for Environmental Management: University of North West.
Feb 2008	Effective Business Writing Skills, ISIMBI
Oct 2007	Short course in Geographic Information Systems (GIS), Planet GIS
Jan 2004 – April 2007	M.Sc Degree in Ecological Remediation and Sustainable Utilization, University of North West, Potchefstroom Campus.
	Thesis: Tree vitality along the urbanization gradient in Potchefstroom, South Africa.
Jan 2001 – Dec 2003	B.Sc Degree in Environmental Science, University of Potchefstroom

PROFESSIONAL REGISTRATION:

Sep 2009	Professional National Scientist – 400204/09

APPENDIX O: BLASTING STUDY

Specialist report prepared by Blast Management & Consulting, June 2011

Blast Management & Consulting

Report:
Environmental Impact Assessment:
Ground Vibration and Air Blast Study
Turquoise Moon Trading 157 (Pty) Ltd.
Turquoise Moon Project
Dated 07 June 2011

Ref No: Turquoise Moon~EIAReport110607V01

Quality Service on Time

Date: 2011/06/13

Signed:
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List of Acronyms used in this Report

Air Pressure Pulse	APP
Blasted Tonnage	T
East	E
Explosives (Trinitrotoluene)	TNT
Frequency	Freq
Gas Release Pulse	GRP
North	N
North East	NE
North West	NW
Noxious Fumes	NOx's
Rock Pressure Pulse	RPP
Peak Particle Velocity	PPV
South	S
South East	SE
South West	SW
United States Bureau of Mine	USBM
West	W

List of Units used in this Report

Air Blast	dB
Charge Height	m
Cup Density	Gr/cm^3
Ground Vibration	mm/s
Kilometre	km
Frequency	Hz
Mass	kg
Meter	m
Milliseconds	msec
Peak Acceleration	mm/s^2
Peak Displacement	mm
Peak Particle Velocity	mm/s
Powder Factor	kg/m^3
Vector Sum Peak Particle Velocity	mm/s
Coordinates (South African)	WGS 84

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1 Executive Summary

Turquoise Moon Trading 157 (Pty) Ltd (Turquoise Moon) is proposing to develop an iron ore mine in North Western Limpopo area. The proposed Moonlight mining operation will comprise an open pit mine, mineral processing facilities, mine residue disposal facilities and various support infrastructure and services. The iron ore prospect covers an area referred to as the Moonlight project area. The Moonlight project area comprises the farms Moonlight 111LR, Gouda Fontein 886 and Julietta 112LR. It is located along the N11 between Mokopane (Potgietersrus) and the Botswana border, near to the town of Marnitz, and approximately 60 km north and 145 km north-west of Lephalale (Ellisras) and Polokwane,

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed new opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. Due to time constraints this study will review possible influences that blasting may have on the surrounding area in respect of these aspects initially as a desktop study with options to obtain greater detail in follow-up visit to the site and surroundings. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations is evaluated over an area as wide as 3500m from the mining area considered. The range of structures expected is typical framing community with structures that could range from well build to informal building style. These could include rural type buildings to brick and mortar structures, cement brick structures, and industrial structures. The project area consists mainly of one opencast pit area.

Results from the evaluation presented show that predicted influence at the surrounding structures with regards to maximum charge used the ground vibration will be significant up to distances of approximately 644m from pit boundary. A maximum ground vibration level of 6.8 mm/s is expected at the nearest private house. This level is still below the lower safe level recommended. Structures further that this pint is significantly further and levels are relatively low. There are no specific structures that are of damage concern. The mine's owns structures are more exposed than private structures.

The project area does have a possibility of presence of people and farms animals. However consideration was given to possible influence. All animals and people should not be present within 500m from the blasting operations. Possible injury is not expected at distances further than the 500m boundary.

Air blast from blasting operations is expected to be less of concern than ground vibration. Air blast is however controllable through applying proper control measures on stemming lengths and stemming material. The use of predictions gives indication that if it goes wrong the extent of damage will at least be known beforehand. Air blast levels calculated for blasting operations did not show levels of concern for the nearest private structures. The nearest farm stead is expected only to experience 120dB. This well within accepted levels but could be a nuisance. The reduction of charge mass per delay will have significant reduction of air blast with safe blasting limit reduced in distance from the mine boundary. Additional controls may also be used in the stemming that will add to reduce the effects of air blast.

This concludes this investigation and outcome for the Turquoise Moon Project it will be possible to operate this mine in a safe and effective manner. The author wishes to indicate as well that this document is not purely an evaluation but had the intention to be a working document that can be used in practice to maintain good neighbour ship with its neighbours.

2 Introduction

Turquoise Moon Trading 157 (Pty) Ltd (Turquoise Moon) is proposing to develop an iron ore mine in North Western Limpopo area. The proposed Moonlight mining operation will comprise an open pit mine, mineral processing facilities, mine residue disposal facilities and various support infrastructure and services. The iron ore prospect covers an area referred to as the Moonlight project area. The Moonlight project area comprises the farms Moonlight 111LR, Gouda Fontein 886 and Julietta 112LR. It is located along the N11 between Mokopane (Potgietersrus) and the Botswana border, near to the town of Marnitz, and approximately 60 km north and 145 km north-west of Lephalale (Ellisras) and Polokwane.

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed new opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. This study will review possible influences that blasting may have on the surrounding area in respect of these aspects. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

3 Protocols and Objectives

The protocols applied in this document are based on the author's experience, guidelines from literature research, client requirements and general indicators from the various acts of South Africa. There is no direct reference in the following acts with regards to requirements and limits on the effect of ground vibration and air blast specifically and some of the aspects addressed in this report. The acts consulted are: National Environmental Management Act No. 107 of 1998, Mine Health and Safety Act No. 29 of 1996, Mineral and Petroleum Resources Development Act No. 28 of 2002.

The guidelines and safe blasting criteria are according international accepted standards and specific applied in this document is the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and recommendations on air blast. There are no specific South African standard and the USBM is well accepted as standard for South Africa. However it is sure that the protocols and objectives will fall within the broader spectrum as required by the various acts.

The objective of this document is to outline the expected environmental effects that blasting operations could have on the surrounding environment. This study investigates the related influences of expected ground vibration, air blast, fly rock, and noxious fumes. These effects are investigated in relation to the surroundings of the blast site and possible influence on the neighbouring houses and owners or occupants.

Objectives can be summarized according to the following steps taken as part of the EIA study with regards specifically to ground vibration and air blast due to blasting operations.

- 3.1 Background information of the proposed site
- 3.2 Mining operations and Blasting Operation Requirements
- 3.3 Effects of blasting operations:
- 3.3.1 Ground vibration
- 3.3.2 Air blast
- 3.3.3 Fly rock

3.3.4	Noxious fumes
3.4	Site specific Aspects applicable
3.5	Risk Assessment
3.6	Mitigations
3.7	Recommendations
3.8	Conclusion

4 Visualisation of the Proposed Site

The Turquoise Moon Project development will be located along the N11 between Mokopane (Potgietersrus) and the Botswana border, near to the town of Marnitz, and approximately 60 km north of Lephalale (Ellisras) and 145 km north-west from Polokwane, . The Moonlight project area comprises the farms Moonlight 111LR, Gouda Fontein 886 and Julietta 112LR in the Limpopo Province at geographic coordinates S23 13 15.8 E28 12 59.2. Figure 1 shows geographical locality plan of the proposed project area. Figure 2 shows an aerial view of the proposed mining area. Figure 3 shows aerial view of the mining area and surroundings with points of interest.

The site was reviewed and presented hereafter. Site was reviewed / scanned using Google Earth imagery. Information sought from review was typically what surface structures are present in a 3500m radius from the proposed mine boundary that will require consideration during modelling of blasting operations. This could consists of houses, general structures, power lines, pipe lines, reservoirs, mining activities, roads, shops, schools, gathering places, possible historical sites etc. A list was prepared as best possible for each structure in the vicinity of the pit areas. The list prepared covers structures and points of interest (POI) in the 3500m boundary. A list of structure locations was required for determining the allowable ground vibration limits and air blast limits possible. Reason for using 3500m influence area is that in general we observe that even at relative far distances the levels of vibration could still be such that it falls within the "people's perception" criteria of "perceptible". These levels may not be damaging but is still perceptible and gives reason for complaints. The 3500m is based on experience and used as standard by Blast Management & Consulting (BM&C). The points of interest list compiled are provided in Table 1 below.

Figure 1: Locality of the project area

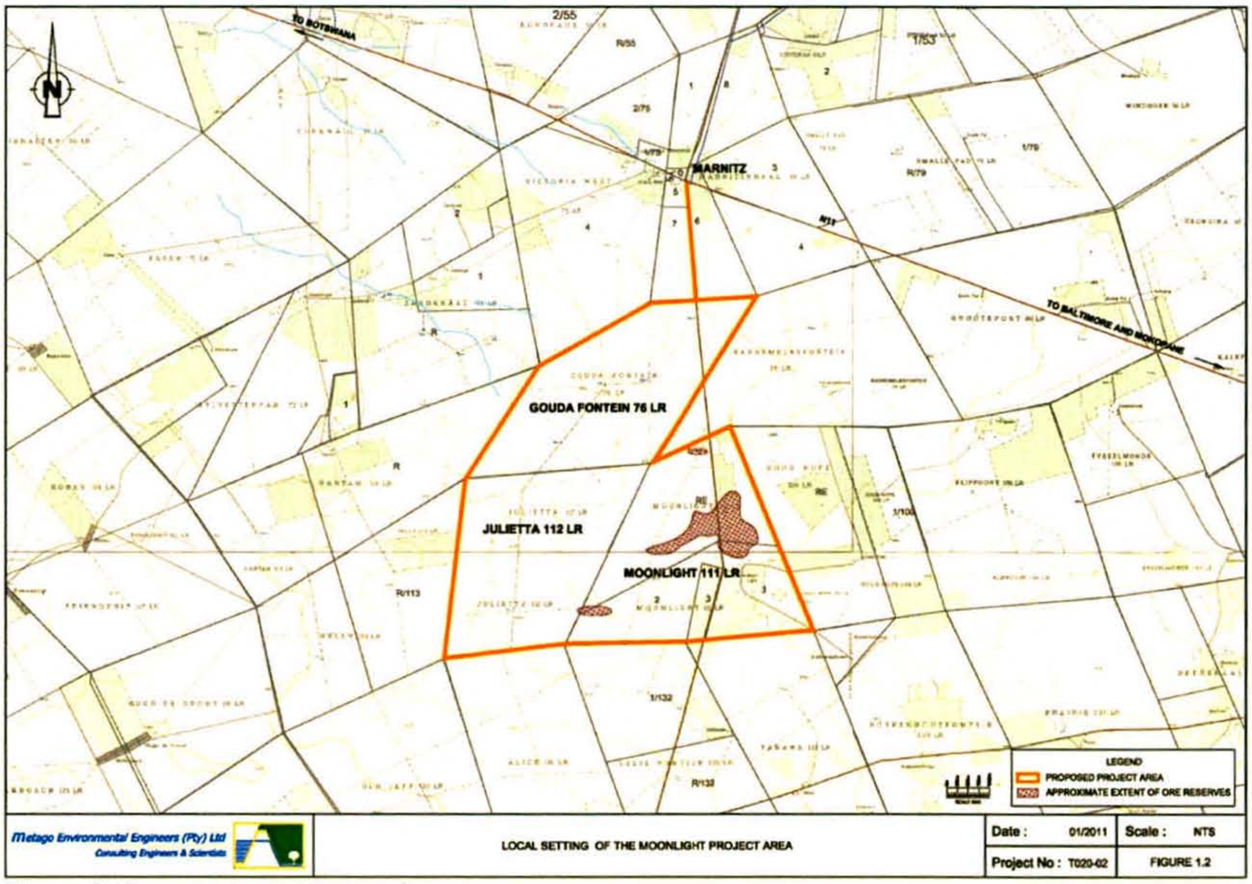

Figure 2: Proposed mining area layout.

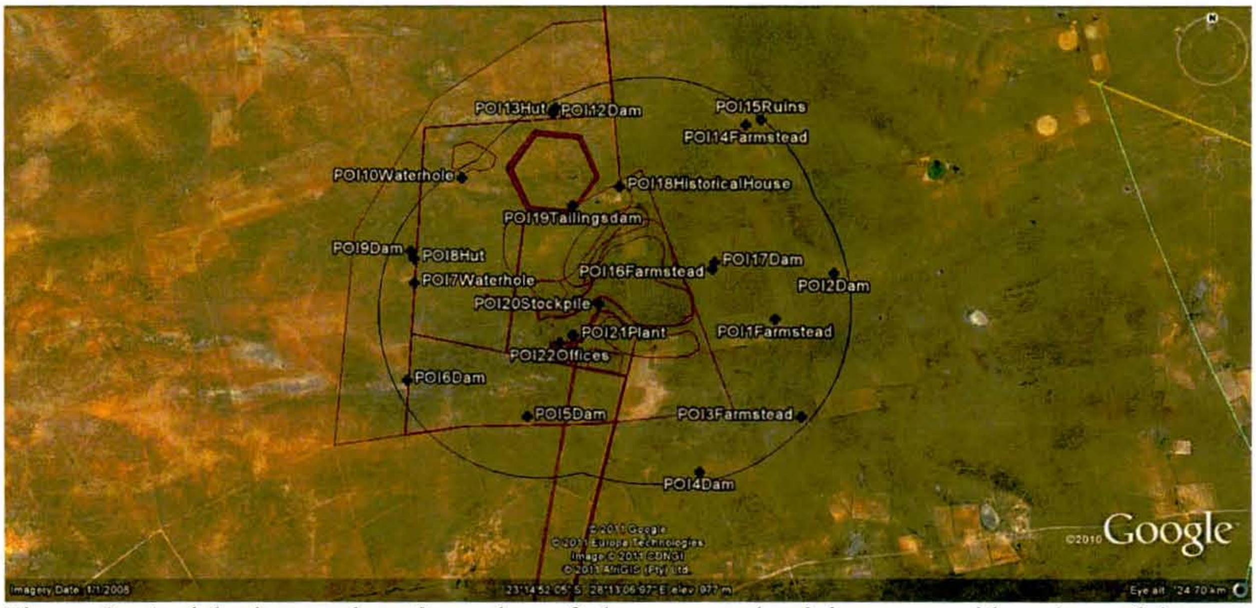

Figure 3: Aerial view and surface plan of the proposed mining area with points of interest identified.

Note: Green Crosses POI indicators

Table 1: List of points of interest used

Owner	Tag	Description	Y	X
Private	1	Farmstead	76715	2572695
Private	2	Dam	75430	2571674
Private	3	Farmstead	76133	2574852
Private	4	Dam	78373	2576078
Private	5	Dam	82149	2574876
Private	6	Dam	84815	2574084
Private	7	Waterhole	84658	2571931
Private	8	Hut	84653	2571388
Private	9	Dam	84737	2571228
Private	10	Waterhole	83618	2569609
Private	11	Dam	81559	2568042
Private	12	Dam	81609	2568168
Private	13	Hut	81604	2568120
Private	14	Farmstead	77383	2568410
Private	15	Ruins	77046	2568294
Private	16	Farmstead	78109	2571602
Private	17	Dam	78050	2571441
Private	18	Historical House	80144	2569780
Mine	19	Tailings dam	81167	2570206
Mine	20	Stockpile	80592	2572372
Mine	21	Plant	81139	2573069
Mine	22	Offices	81438	2573243

5 Mining and Blasting Operations

The mining method will be conventional drilling and blasting operations. The mining operation detail provided indicates opencast pit area with no formal pit design and layout with designs yet. Proposed drilling and blasting information used in this report is based on information provided on expected drilling and blasting operations. Blast designs are required in order to define expected ground vibration, air blast and fly rock influences and levels. Possible outcomes of the blast designs are used for simulation of data required. The following technical design details used for this operation are provided in Table 2 below. Two basic configurations were designed: Ore and waste material blasts.

Table 2: Information on blast designs used

Technical Aspect	Ore	Waste
B/H Diameter (mm)	140	140
Explosive Density (g/cm^3)	1.18	1.18
Burden (m)	3	4.3
Spacing (m)	3.5	5
Bench Height (m)	6.1	11.1
Min Depth (m)	6.1	11.1
Average Depth (m)	6.1	11.1
Linear Charge Mass (kg)	18.16	18.16
P/F Blasthole (kg/m^3)	0.74	0.58

Stemming Length (m)	3.5	3.5
Column Length (m)	2.6	7.6
Explosives Per B/H (kg)	47	138
Sub-drill (m)	0.00	0.00

6 Effects of Blasting Operations:

Blasting operations have effect to its surroundings. These effects can manifest in the form of ground vibration, air blast, fumes, fly rock etc. The application of explosives breaking rock will always have a positive and negative manifestation of different energies. It is the effects that have negative outcome that we concentrate on and that will need to be managed. The following sections address the reason, prediction, modelling and control on aspects like ground vibration, air blast, fly rock and fumes.

6.1 Ground Vibration

Explosives are used to break rock through the shock waves and gasses yielded from the explosion. Ground vibration is a natural result from blasting activities. The far field vibrations are inevitable, but un-desirable by products of blasting operations. The shock wave energy that travels beyond the zone of rock breakage is wasted and could cause damage and annoyance. The level or intensity of these far field vibration is however dependant on various factors. Some of these factors can be controlled to yield desired levels of ground vibration and still produce enough rock breakage energy.

Factors influencing ground vibration are the charge mass per delay, distance from the blast, the delay period and the geometry of the blast. These factors are controlled by planned design and proper blast preparation.

The larger the charge mass per delay - not the total mass of the blast, the greater the vibration energy yielded. Blasts are timed to produce effective relief and rock movement for successful breakage of the rock. A certain quantity of holes will detonate within the same time frame or delay and it is the maximum total explosive mass per such delay that will have the greatest influence. All calculations are based on the maximum charge detonating on a specific delay.

Secondly is the distance between the blast and the point of interest / concern. Ground vibrations attenuate over distance at a rate determined by the mass per delay, timing and geology. Each geological interface a shock wave encounters will reduce the vibration energy due to reflections of the shock wave. Closer to the blast will yield high levels and further from the blast will yield lower levels.

Thirdly the geology of the blast medium and surroundings has influences as well. High density materials have high shock wave transferability where low density materials have low transferability of the shock waves. Solid rock i.e. norite will yield higher levels of ground vibration than sand for the same distance and charge mass. The precise geology in the path of a shock wave cannot be observed easily, but can be tested for if necessary in typical signature trace studies - which are discussed shortly below.

6.1.1 Prediction

When predicting ground vibration and possible decay, a standard accepted mathematical process of scaled distance is used. The equation applied (Equation 1) uses the charge mass and distance with two site constants. The site constants are specific to a site where blasting is to be done. In new opencast operations a process of testing for the constants is normally done using a signature trace study in order to predict ground vibrations accurately and safely. The utilization of the scaled distance prediction formula is standard practice. The analysis of the data will also give an indication of frequency decay over distance.

Equation 1:

$$PPV = a(\frac{D}{\sqrt{E}})^{-b}$$

Where:

y = Predicted ground vibration
a = Site constant
b = Site constant
D = Distance
E = Explosive Mass

Applicable and accepted factors a&b for new operations is as follows:
Factors:

a = 1143
b = -1.65

Utilizing the abovementioned equation and the given factors, allowable levels for specific limits and expected ground vibration levels can then be calculated for various distances.

Review of the type of structures observed around the mine operation and the limitations that may be typically applicable indicated that various different levels of ground vibration are necessary to consider. These are the 6 mm/s, 12.5 mm/s, 25.0 mm/s levels, 50mm/s and for some structures and installations up to maximum of 150mm/s. The blast design indicates that 47kg will be loaded in an ore blastholes and 138kg in a waste blasthole. Considering general timing systems to be used it is expected that as much as 4 blastholes could detonated simultaneously. In extreme cases this can be up to 6 blastholes. In order to evaluate the possible influence the author selects three charge masses that will span the range of possible charge mass per delay. Therefore a single blasthole from waste blast will yield 138kg charge, 4 blastholes detonating simultaneously from a waste blast will yield 552kg and 6 blastholes detonating simultaneously from a waste blast will yield 828kg. These charge masses are used for modelling aspects in this report. Considering the parameters, ground vibration and charge mass, the following calculations were done for consideration in this report. Attention will be given to levels of 12.5 mm/s, 25 mm/s and 50 mm/s.

Firstly the distance required from specific charge masses to maintain different vibration limits (12.5 mm/s, 25 mm/s and 50 mm/s) was calculated and presented table 3 below. The charge masses used are representative of minimum and maximum charges that can be expected from a typical blast. Figure 4 shows the graphic representation of data provided in table 3.

Table 3: Distances Required for Maintaining Specific Vibration Levels at Specific Charge Masses

No.	Charge Mass (kg)	Distance (m) 12.5mm/s PPV Limit	Distance (m) 25mm/s PPV Limit	Distance (m) 50mm/s PPV Limit
1	100.0	154	101	67
2	200.0	218	143	94
3	300.0	267	176	115
4	400.0	309	203	133
5	500.0	345	227	149
6	600.0	378	248	163
7	700.0	408	268	176
8	800.0	437	287	188
9	900.0	463	304	200
10	1000.0	488	321	211
11	1100.0	512	336	221
12	1200.0	535	351	231
13	1300.0	557	366	240
14	1400.0	578	379	249
15	1500.0	598	393	258
16	1600.0	617	406	267
17	1700.0	636	418	275
18	1800.0	655	430	283
19	1900.0	673	442	290
20	2000.0	690	454	298

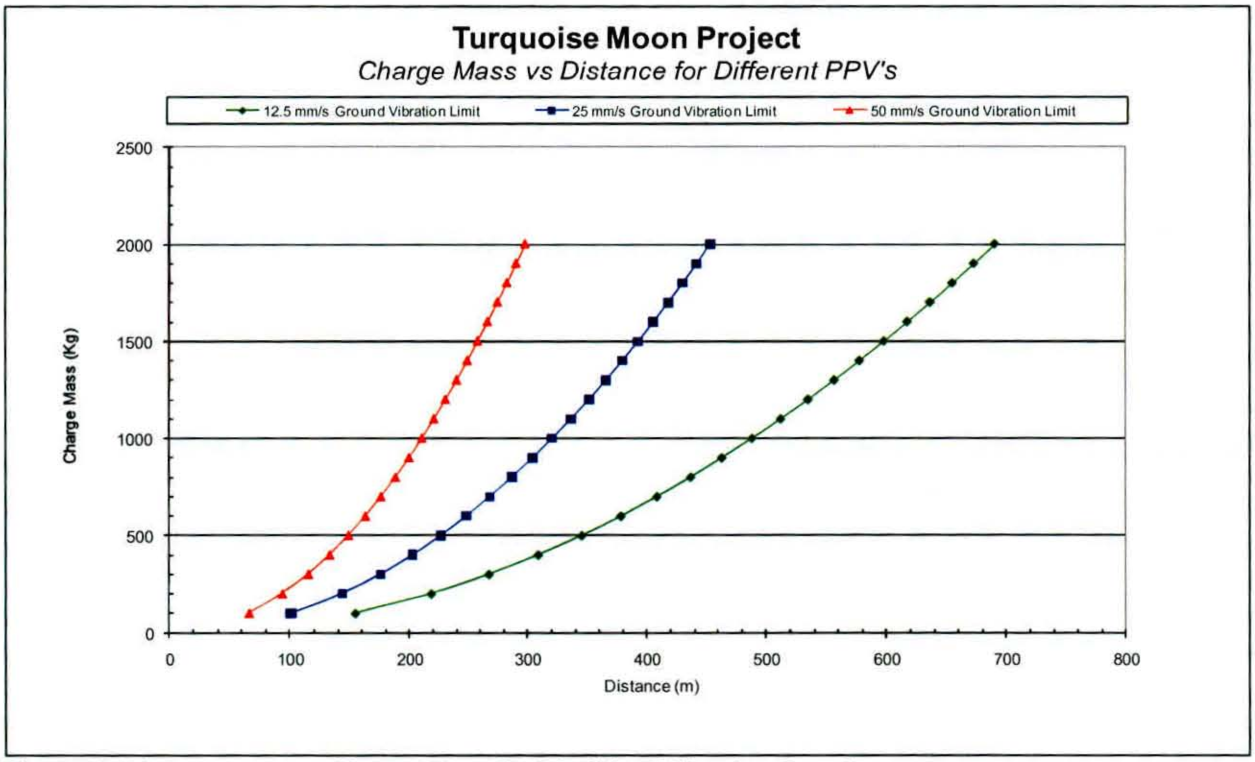

Figure 4: Distance versus Charge Mass for Limiting Vibration Levels

Secondly the required charge masses to yield different vibration levels (12.5 mm/s, 25 mm/s and 50 mm/s) at various distances was calculated and presented in Table 4 below. This is used to consider what maximum charge mass can be allowed for specific distance of interest.

Table 4: Limiting Charge Masses at Specific Distances for Maintaining Specific Ground Vibration Levels

No.	Distance (m)	Max Charge Mass (kg) 12.5mm/s PPV Limit	Max Charge Mass (kg) 25mm/s PPV Limit	Max Charge Mass (kg) 50mm/s PPV Limit
1	50.0	10	24	56
2	100.0	42	97	225
3	150.0	94	219	507
4	200.0	168	389	901
5	250.0	262	608	1408
6	300.0	378	875	2027
7	400.0	671	1556	3604
8	500.0	1049	2430	5631
9	600.0	1511	3500	8108
10	700.0	2056	4764	11036
11	800.0	2686	6222	14415
12	900.0	3399	7875	18244
13	1000.0	4196	9722	22523
14	1250.0	6557	15190	35193
15	1500.0	9442	21874	50678
16	1750.0	12851	29773	68978
17	2000.0	16785	38888	90094
18	2500.0	26227	60762	140772
19	3000.0	37767	87497	202711
20	3500.0	51405	119093	275912

Based on the design presented on expected drilling and charging design, the following Table 5 shows expected ground vibration levels (PPV) for various distances calculated at three different charge masses. A low charge mass, the expected medium charge mass per delay and a maximum charge mass as worst case scenario. The charge masses are 138kg, 552kg and 828kg.

Table 5: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 138kg Charge	Expected PPV (mm/s) for 552kg Charge	Expected PPV (mm/s) for 828kg Charge
1	50.0	104.7	328.7	459.3
2	100.0	33.4	104.7	146.4
3	150.0	17.1	53.7	75.0
4	200.0	10.6	33.4	46.6
5	250.0	7.4	23.1	32.3
6	300.0	5.4	17.1	23.9
7	400.0	3.4	10.6	14.9
8	500.0	2.3	7.4	10.3
9	600.0	1.7	5.4	7.6
10	700.0	1.3	4.2	5.9
11	800.0	1.1	3.4	4.7
12	900.0	0.9	2.8	3.9
13	1000.0	0.7	2.3	3.3
14	1250.0	0.5	1.6	2.3
15	1500.0	0.4	1.2	1.7
16	1750.0	0.3	0.9	1.3
17	2000.0	0.2	0.7	1.0
18	2500.0	0.2	0.5	0.7
19	3000.0	0.1	0.4	0.5
20	3500.0	0.1	0.3	0.4

Figure 5 below shows the relationship of ground vibration over distance for the three charges considered as given in Table 5 above. The attenuation of ground vibration over distance is clearly observed. Ground vibration attenuation follows a logarithmic trend and the graph indicates this trend. Indicated on the graph as well are the limits that should be applicable due to the various structures and types of installations in this area as given above. The graph can be used to scale expected ground vibration at specific distances for the same maximum charges as used in this report. The expected vibration level at specific distance can be read from the graph, provided the same maximum charges are applicable, or by rough estimate if the charge per delay should be between the charge masses applied for this case.

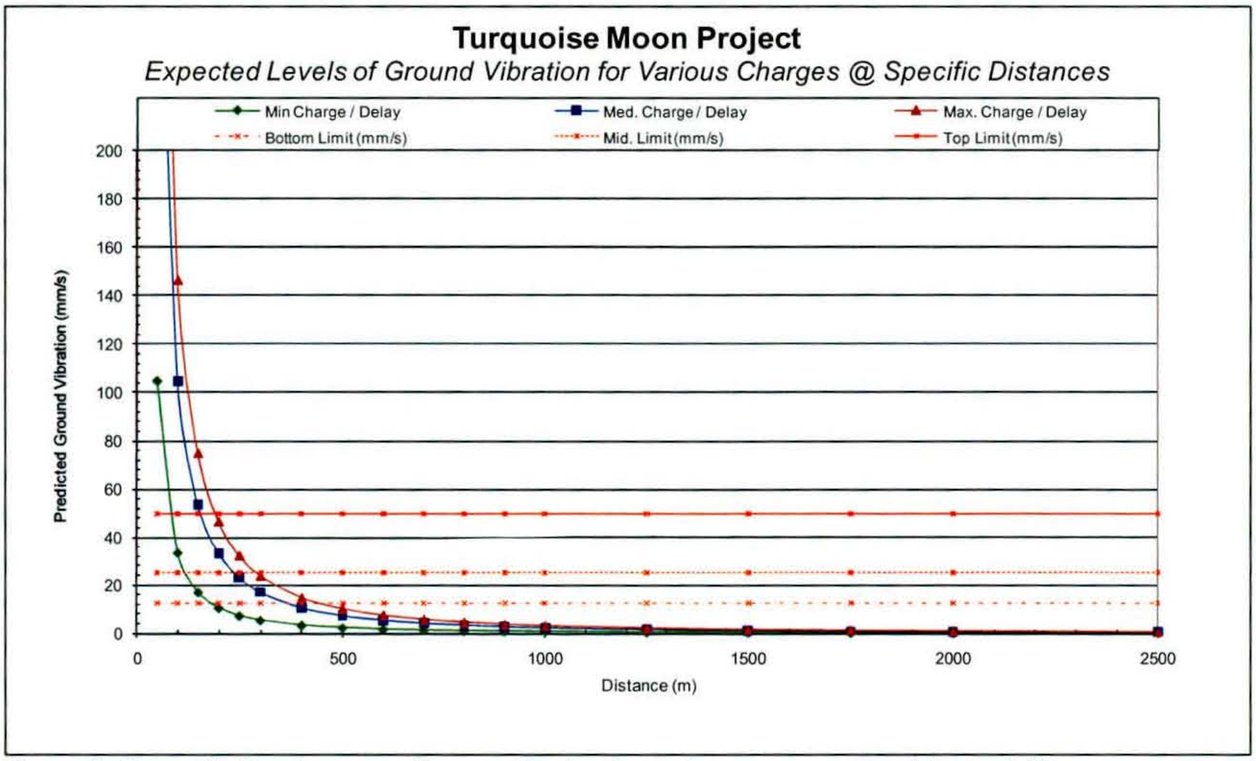

Figure 5: Ground vibration over distance for the three charge masses used in modelling

6.1.2 Limitations on Structures

Limitations on ground vibration are in the form of maximum allowable levels for different installations and structures. These levels are normally quoted in peak particle velocity or as ground vibration in millimetres per second (mm/s). There are unfortunately no exact South African standard. Thus currently the United States Bureau of Mines (USBM) criterion for safe blasting is applied where private structures are of concern. This is a process of evaluating the vibration amplitudes and frequency of the vibrations according to set rules for preventing damage. The vibration amplitudes and frequency is then plotted on a graph. The graph indicates two main areas:

- The Safe Blasting Criteria Area
- The Unsafe Blasting Criteria Area

When ground vibration is recorded and the amplitude in velocity (mm/s) is analysed for frequency it plots this relationship on the USBM graph. If data falls in the lower part of the graph then the blast was done safely. If the data falls in the upper part of the graph then the probability of inducing damage to mortar and brick structures increases significantly. There is a relationship between amplitude and frequency due to the natural frequencies of structures. This is normally low - below 10 Hz - and thus the lower the frequency, the lower the allowable amplitude. Higher frequencies allows for higher amplitudes. The extra lines on the graph are more detailed for specific type walls and structure configurations. Locally we are only concerned with the lowest line on the USBM graph. Due to possible poor state structures in an area additionally a 12.5mm/s limit may be added. A further guide of 25mm/s is also added.

This is a pre blast analysis but predictions help us determine expected amplitudes and experience has taught us what frequencies could be expected. The USBM graph for safe blasting was developed by the United States Bureau of Mines through research and data accumulated from sources other than their own research. Figure 6 shows an example of a USBM analysis graph with 6mm/s and 25mm/s guidelines added.

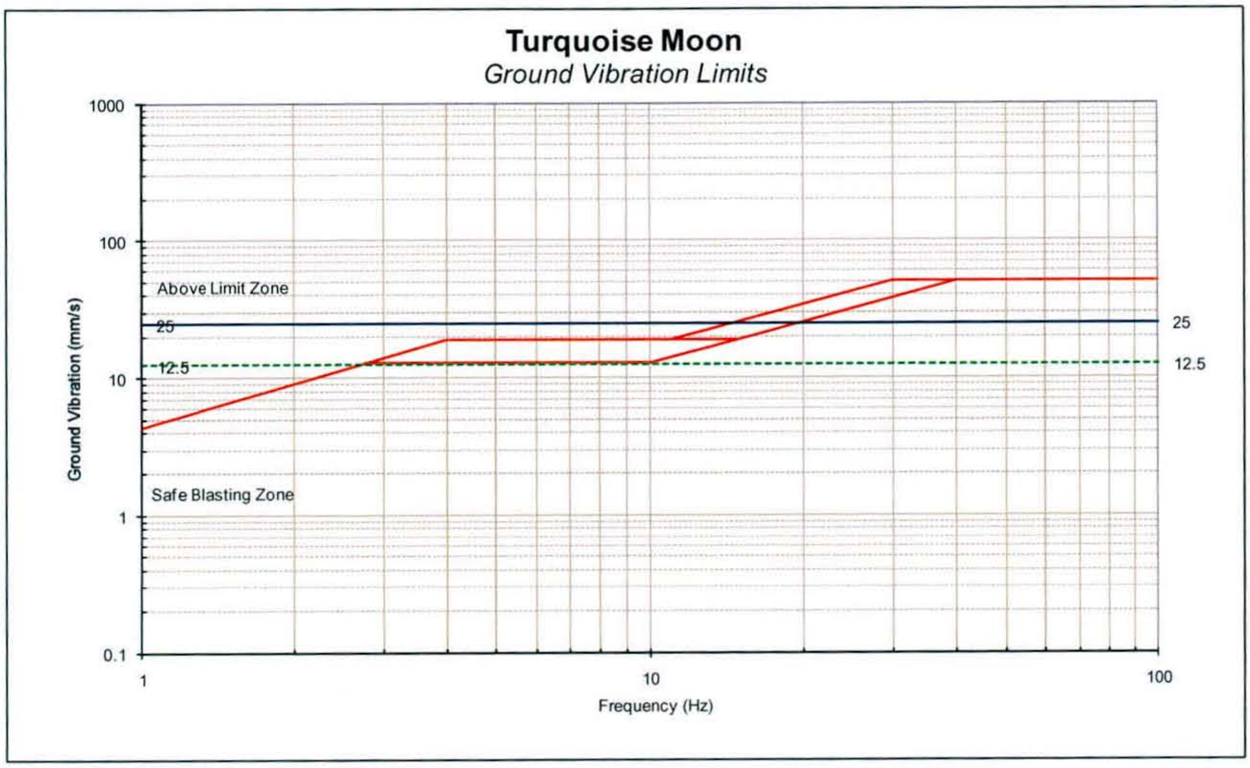

Figure 6: USBM Analysis Graph

Additional limitations that should be considered are as follows, these were determined through research and various institutions:

- National Roads/Tar Roads: 150 mm/s
- Steel pipelines: 50 mm/s
- Electrical Lines: 75 mm/s
- Railway: 150 mm/s
- Concrete aged less than 3 days: 5mm/s
- Concrete after 10 days: 200 mm/s
- Sensitive Plant equipment: 12 or 25 mm/s depending on type – some switches could trip at levels less than 25 mm/s.

Considering the above limitations, BM&C work is based on the following:

- USBM criteria for safe blasting
- The additional limitations provided

- Consideration of private structures
- Should these structures be in poor condition is the basic limit of 25 mm/s reduced to 12.5 mm/s or even when structures are in very poor condition limits will be restricted to 6 mm/s
- We also consider the input from other consultants in the field locally and internationally.

6.1.3 Limitations with Regards to Human Perceptions

A further aspect of ground vibration and frequency of vibration is the human perception. It should be realized that the legal limit for structures is significantly greater than the comfort zones for people. Humans and animals are sensitive to ground vibration and vibration of the structures. Research has shown that humans will respond to different levels of ground vibration and at different frequencies.

Ground vibration is experienced as "Perceptible", "Unpleasant" and "Intolerable" (only to name three of the five levels tested) at different vibration levels for different frequencies. This is indicative of the human's perceptions on ground vibration and clearly indicates that humans are sensitive to ground vibration. This "tool" is only a guideline and helps with managing ground vibration and the respective complaints that people could have due to blast induced ground vibrations. Humans already perceive ground vibration levels of 4.5 mm/s as unpleasant.
Generally people also assume that any vibrations of the structure - windows or roofs rattling - will cause damage to the structure. Air blast also induces vibration of the structure and is the cause of nine out of ten complaints. (See Figure 7)

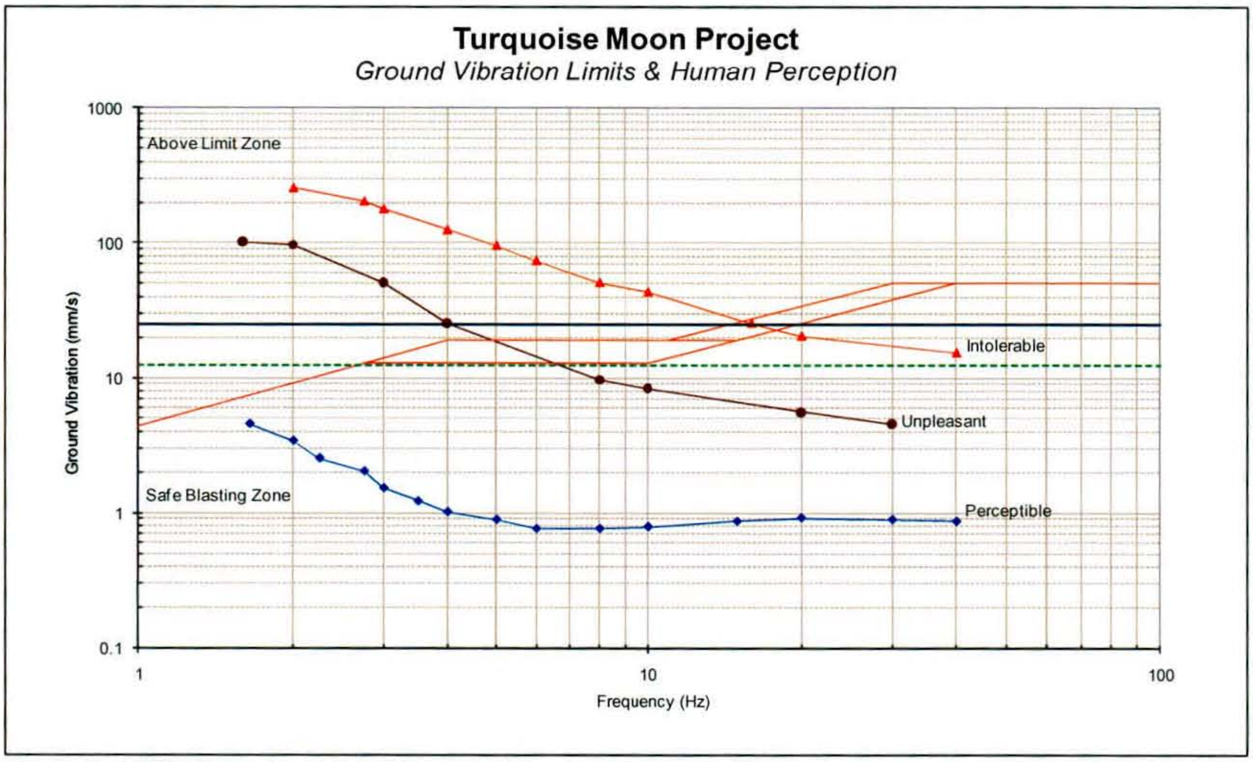

Figure 7: USBM Analysis with Human Perception

6.2 Air blast

Air blast or air-overpressure is pressure acting and should not be confused with sound that is within audible range (detected by the human ear). Sound is also a build up from pressure but is at a completely different frequency to air blast. Air blast is normally associated with frequency levels less than 20 Hz, which is the threshold for hearing. Air blast is the direct result from the blast process although influenced by meteorological conditions the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result.

The three main causes of air blasts can be observed as:

a) Direct rock displacement at the blast; the air pressure pulse (APP)
b) Vibrating ground some distance away from the blast; rock pressure pulse (RPP)
c) Venting of blast holes or blowouts; the gas release pulse (GRP)

6.2.1 Limitations on structures

The recommended limit for air blast currently applied in South Africa is 134 dB. This is specifically pertaining to air blast or otherwise known as air-overpressure. This takes into consideration where public is of concern. Air-overpressure is pressure acting and should not be confused with sound that is within audible range (detected by the human ear). However, all attempts should be made to keep air blast levels generated from blasting operations below 120 dB or greater magnitude toward critical areas where public is of concern. This will ensure that the minimum amount of disturbance is generated towards the critical areas surrounding the mining area.

Based on work carried out by Siskind *et.al.* (1980)[1], monitored air blast amplitudes up to 135 dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies (down to 1 Hz). Persson *et.al.* (1994)[2] Have published the following estimates of damage thresholds based on empirical data (Table 8). Levels given in Table 6 are at the point of measurement.

Table 6: Damage Limits for Air Blast

Level	Description
120 dB	Threshold of pain for continuous sound
>130 dB	Resonant response of large surfaces (roofs, ceilings). Complaints start.
150 dB	Some windows break
170 dB	Most windows break
180 dB	Structural Damage

Further it must be noted that the weakest point on a structure is the windows and ceilings.

All attempts should be made to keep air blast levels generated from blasting operations well below 120 dB where public is of concern. This will ensure that the minimum amount of disturbance is generated towards the critical areas surrounding the mining area and limit the possibility of complaints due to the secondary effects from air blast.

6.2.2 Limitations with regards to human perceptions

Considering the human perception and misunderstanding that could occur between ground vibration and air blast BM&C generally recommends that blasting be done in such a way that air blast levels is kept below 120dB. In this way it is certain that fewer complaints will be received for blasting operations. The effects on structures that startled people are significantly less – thus no reason for complaining. It is the actual influence on structures like rattling of windows or doors or large roof surface's that startle people. These effects are sometimes misjudged as ground vibration and considered as damaging to the structure.

Initial limits for evaluation conditions have been set at 120dB, 134dB and less than 134dB. USBM limits are 134 dB for nuisance, at this level 5% of residents would be expected to complain, because they are startled and frightened; even 120dB could sometimes lead to rattling windows, feelings of annoyance and fright.

6.2.3 Prediction

An aspect that is not normally considered as pre-operation definable is the effect of air blast. This is mainly due to the fact that air blast is an aspect that can be controlled to a great degree by applying basic rules. Air blast is the direct result from the blast process, although influenced by meteorological conditions, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result.

Standards do exist and predictions can be made, but it must be taken in to account that predictions of air blast is most effective only when used in conjunction with charges on surface and normally referred to detonation of TNT as a reference. Blasts that are normally covered show the least effect on air blast. However even covered blasts with the use of detonating cord can yield high air blast levels when pieces of the detonation cord that is used for indicators are not covered. Covered blasting is normally used in blasting of trenches etc. in close proximity of structures.

The following equation is associated with predictions of air blast, but is considered by the author as subjective. The only real fact is that actual air blast does decrease over distance and nominally at a rate of -6dB for each doubling of the distance from the source. In this report a standard equation to calculate possible air blast values was used. This equation does not take temperature or any weather conditions into account. Values were calculated using a cube root scaled distance relationship from expected charge masses and distance. Equation 2 is normally used where no actual data exists.

Equation 2:

$$dB = 165 - 24 \log 10 \frac{\mathrm{D}}{\mathrm{E}^{1/3}}$$

Where:

L = Air blast level (dB)
D = Distance from source (m)
E = Maximum charge mass per delay (kg)

Although the above equation was applied for prediction of air blast levels, additional measures are also recommended in order to ensure that air blast and associated fly-rock possibilities are minimized completely. As discussed earlier the prediction of air blast is very subjective. Following in Table 7 below is a summary of values predicted according to Equation 2. Figure 8 shows the graphical relationship for air blast as set out in Table 7.

Table 7: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 138kg Charge	Air blast (dB) for 552kg Charge	Air blast (dB) for 828kg Charge
1	50.0	141	146	148
2	100.0	134	139	140
3	150.0	130	135	136
4	200.0	127	132	133
5	250.0	125	129	131
6	300.0	123	127	129
7	400.0	120	124	126
8	500.0	117	122	124
9	600.0	115	120	122
10	700.0	114	119	120
11	800.0	112	117	119
12	900.0	111	116	117
13	1000.0	110	115	116
14	1250.0	108	113	114
15	1500.0	106	111	112
16	1750.0	104	109	111
17	2000.0	103	108	109
18	2500.0	101	105	107
19	3000.0	99	103	105
20	3500.0	97	102	103

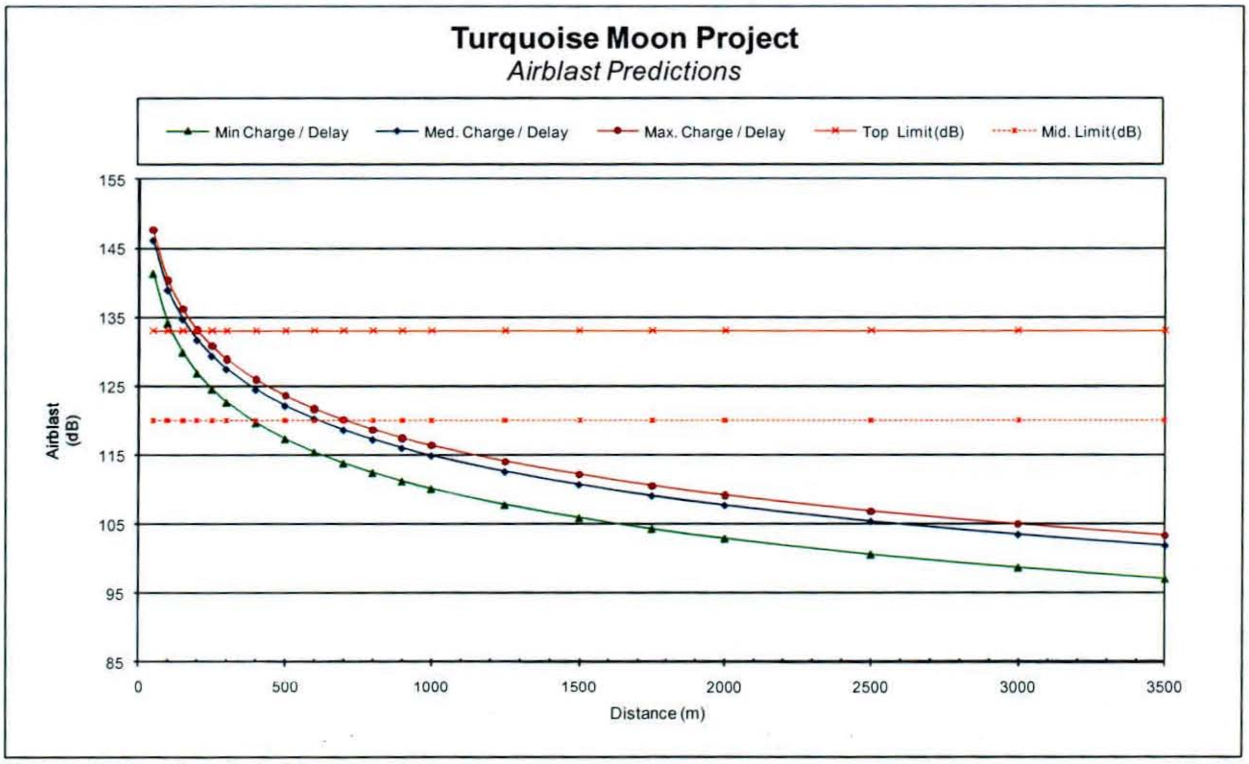

Figure 8: Predicted air blast levels

6.3 Fly Rock

6.3.1 Causes

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities within large coal mines are designed to cast the blasted material much greater distances than practices in a quarrying or hard rock operations. This movement should be in the direction of the free face, and therefore the orientation of the blasting is important. Material or elements travelling outside of this expected range may be considered to be fly rock.

Fly rock from blasting can result from three mechanisms due to the lack of confinement of the energy in the explosive column. The main mechanisms are:

a) Face burst - burden conditions usually control fly rock distances in front of the face
b) Cratering - If the stemming height to hole diameter ratio is too small or the collar rock is weak
c) Rifling - If the stemming material is ejected with insufficient stemming height or inappropriate stemming material is used

In short the following list is typical causes of fly rock:

a) Burden to small,
b) Burden to large,
c) Stemming length to short,
d) Out of sequence initiation of blastholes,
e) Drilling inaccuracies,
f) Incorrect blasthole angles,
g) Over charged blastholes.

It is possible to blast without any fly rock with proper confinement of the explosive charges within blast holes using proper stemming procedures and materials. Stemming is further required to ensure that explosive energy is efficiently used to its maximum. Free blasting with no control on stemming cannot be allowed as this will result in poor blast results and possible damage to any nearby structures.

6.3.2 Predictions

The use of prediction calculations for fly rock is in my opinion secondary to the basics of blast preparation. Question is why should there be fly rock? Blasts can be shot without fly rock occurring by using basic guidelines on blast preparation and specifically stemming control. Quality of preparation will certainly have influence on the final blast result. Predictions on the possibility of fly rock are useful for operations that are hampered by the past incidents of fly rock and situations where back tracking needs to be done where fly rock did occur and fault analysis needs to be done. Predictions may also be used to consider what minimum confinement that may be allowed in certain circumstances. Work done in this field did show various considerations of the process of fly rock generation. Considering fly rock predictions will also require that specific "calibration" must be done at the specific site. The blast layout, geology, explosives, stemming material etc. will all play a specific role in the prediction of fly rock and needs to be tested for.
Prediction considered is based on the areas where fly rock may originate from in the blasting process: Face Burst, Cratering and Stemming ejection.

Research as done by Richards, Moore has shown the following equations. The following equations will be applied:

Equation 3: Face Burst

$$L = \frac{k^2}{g} \times \left(\frac{\sqrt{m}}{B}\right)^{2.6}$$

Equation 4: Cratering

$$L = \frac{k^2}{g} \times \left(\frac{\sqrt{m}}{SH}\right)^{2.6}$$

Equation 5: Stemming Ejection

$$L = \frac{k^2}{g} \times \left(\frac{\sqrt{m}}{SH}\right)^{2.6} \times \sin 2\theta$$

Where:

θ	= Drill hole angle
L	= Maximum Throw (m)
m	= Charge mass / m (kg/m)
B	= Burden (m)
SH	= Stemming height (m)
g	= Gravitational constant
k	= Factor value

The Richards & Moore research has shown that a factor applicable for the above equation ranges between 13.5 for a coal environment and 27 for a hard rock environment. Figure 9 below shows the relationship burden or stemming length towards expected throw distance. Throw distance considered here on the same level as the free face. Landing level of elements lower than free face could see longer distances. Optimal throw distance is also observed at 45 degree angles of departure.

(Intentionally Left Open)

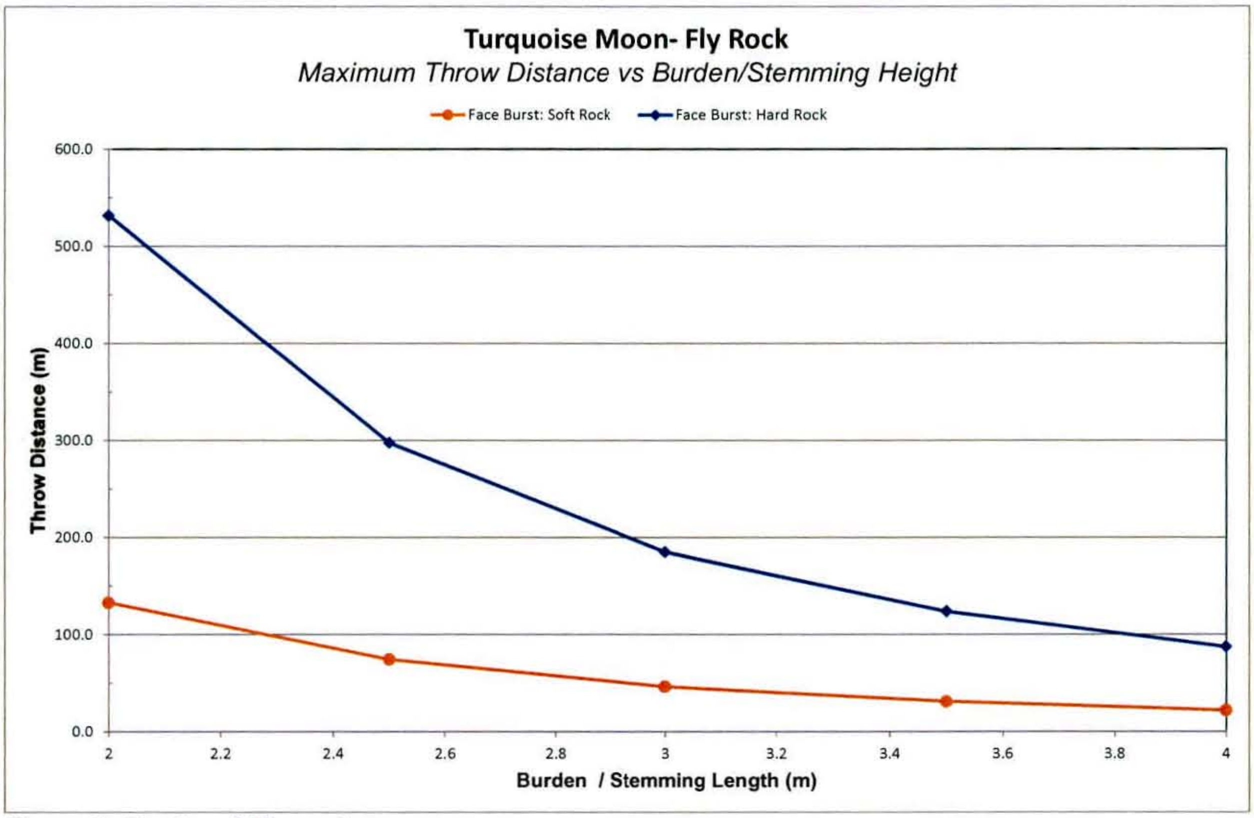

Figure 9: Predicted Fly rock

Face burdens are as important to prevent fly rock as proper stemming controls. There is direct relationship between blast free face burden and probability of fly rock from the face. A further equation can be used for ensuring the face burden is not insufficient. Applying equation 6 and the scaled burden is not less than $0.7m^{3/2}kg^{-1/2}$ it is not expected to have fly rock from the face.

Equation 6: Scaled burden

$$Bs = \left(\frac{B}{\sqrt{Mc}}\right)$$

Where:

- Bs = Scaled Burden ($m^{3/2}kg^{-1/2}$)
- Mc = Charge mass / m (kg/m)
- B = Burden (m)

Table 8 below shows the relationship of face burdens on the scaled burden and gives indication of which scaled burdens are problematic for the typical designs used in this report.

Table 8: Relationship between face burden and scaled burden.

Scaled Burden ($m^{3/2}kg^{-1/2}$)	0.59	0.70	0.82	0.84	0.94	1.06
Min. Face Burden (m)	2.5	3	3.5	3.6	4	4.5

Red: Problematic areas

6.3.3 Impact of fly rock

The occurrence of fly rock in any form will have impact if found to travel outside the safe boundary. This safe boundary may be anything between 10 m or 500m. If a road or structure or people or animals are closer than 500m from a blast irrespective of the possibility of fly rock or not precautions should be taken to stop the traffic, remove people or animals for the period of the blast. Fact is fly rock will cause damage to the road, vehicles or even death to people or animals.

6.4 Noxious Fumes

Explosives currently used are required to be oxygen balanced. Oxygen balance refers to the stoichiometry of the chemical reaction and the nature of gases produced from the detonation of the explosives. The creation of poisonous fumes such as nitrous oxides and carbon monoxide are particular undesirable. These fumes present themselves as red brown cloud after the blast detonated. It has been reported that 10 to 20 ppm has been mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary edema. It has been predicted that 50% lethality would occur following exposure to 174 ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

6.4.1 Causes

Factors contributing to undesirable fumes are typically: poor quality control on explosive manufacture, damage to explosive, lack of confinement, insufficient charge diameter, excessive sleep time, and specific types of ground can also contribute to fumes.

Poor quality control on explosives will yield improper balance of the explosive product. This is typically in the form of too little or too much fuel oil or incorrect quantities of additives to the mixture. Improper quality will cause break down on the explosives product that may result in poor performance. A "burning" may occur that increases the probability of fumes in the form of NO and NO_2.

Damage to explosives occur when deep blasthole are charged from the top of the hole and literally fall into the hole and get damage at the bottom. The bottom is normally the point of initiation and damaged explosives will not initiate properly. A slow reaction to detonation is forced and again contributes negatively to the explosives performance and fume creating capability.

Studies showed that inadvertent emulsion mixture with drill cuttings can also be a significant contributing factor to NOx production. The NO production from the detonation of emulsion equally mixed (by mass) with drill cuttings increased by a factor of 2.7 over that of emulsion alone. The corresponding NO_2 production increased by factor of 9 while detonation propagated at a steady Velocity of Detonation.

Water also has visible effect on the generation of fumes from emulsion explosives. Tests have shown that the detonation velocity may not be influenced as much but the volumes of fumes generated were significantly higher.

Further is also known that for certain ground types, especially the oxidized type materials could have an advert effect on explosives as well. These ground materials types tends to react with the explosives and causes more than expected fumes.

Drill diameter is also contributing factor to explosive performance and the subsequent generation of fumes. Explosives are diameter dependant for optimal performance. If diameter is too small for a specific product improper detonation will occur and may result in a burning of the product rather than detonation. This will have an adverse effect of more fumes created. Each explosive product has a critical diameter. It is the smallest diameter where failure to detonate properly occurs. ANFO blends are normally not good for small diameter blastholes and emulsion explosives can be sued in the smaller diameter blastholes.

6.4.2 Control

Control actions on fumes will include the use the proper quality explosives and proper loading conditions. Quality assurance will need to be achieved from the supplier with quality checks on explosives from time to time. Further action is to prevail from loading blastholes at long periods prior to blasting. Excessive sleeping of charged blastholes will add to fumes generation and should be prevented. Additional measures could include placing stemming plugs at the bottom of the hole and loading emulsion from the bottom up will excluded mixing of drill chippings with the explosives in initiation area. The checking of blastholes for water will ensure that charging crew charges blasthole from the bottom (which should be a standard practise) and displaces the water. This will also ensure proper initiation of the blasthole.

6.5 Vibration impact on provincial and national roads

The influence of ground vibration on tarred roads are expected when levels is in the order of 150 mm/s and greater. Or when there is actual movement of ground when blasting is done to close to the road or subsidence is caused due to blasting operations. Normally 100 blasthole diameters are a minimum distance between structure and blasthole to prevent any cracks being formed into the surrounds of a blasthole. Crack forming is not restricted to this distance. Improper timing arrangements may also cause excessive back break and cracks further than expected. Fact remain that blasting must be controlled in the vicinity of roads. Air blast does not have influence on air blast by virtue of the type of structure. There is no record of influence on gravel roads due to ground vibration. The only time damage can be induced is when blasting is done next to the road and there is movement of ground. Fly rock will have greater influence on the road as damage from falling debris may impact on the road surface if no control on fly rock is considered.

6.6 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.
Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is "Promote good neighbour ship". This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it, could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

In general it is also in an operator's financial interests not to blast where there is a viable alternative. Where there is a possibility of avoiding blasting, perhaps through new technology, this should be carefully considered in the light of environmental pressures. Historical precedent may not be a helpful guide to an appropriate decision.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure. The measures include the need for the following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,
- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,
- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,
- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

6.7 Cracking of houses and consequent devaluation

Houses in general have cracks. It is reported that a house could develop up to 15 cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur and a result is shown in Figure 10 below.
Figure 10: Example of blast induced damage. A typical X crack formations is observed.

Observing cracks of this form on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied or else stated was not always applied in the country side when houses were built. Thus damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

6.8 Water well Influence from Blasting Activities

The exact quantity and location of water wells on and around the site is not known yet to the author. The author has not had much experience on the effect of blasting on water wells but specific research was done and results from this research work are presented.

Case 1 looked at 36 case histories. Vibration levels up 50mm/s were measured. The well yield and aquifer storage improved as the mining neared the wells, because of the opening of the fractures from loss of lateral confinement, not blasting. This is similar to how stress-relief fractures form. At one site the process was reversed after the mine was backfilled. It was more likely the fractures were recompressed. It was stated that blasting may cause some temporary (transient) turbidity similar to those events that cause turbidity without blasting.
Such as:

1. Natural sloughing off inside of the well bore due to inherent rock instability. This can be accelerated by frequent over pumping. This is common to wells completed through considerable thickness of poorly consolidated and/or highly fractured clay stones and shale's.
2. Significant rainfall events. The apertures of the shallow fractures that are intersected by a domestic well are commonly highly trans missive, thus will transmit substantial amounts of shallow flowing and rapidly recharging water. This water will commonly be turbid and can enter the well in high volumes. The lack of grouting of the near surface casing commonly allows this to happen. Also, if the top of the well is not grouted properly surface water can enter along the side of the casing and flow down the annulus.

The Berger Study observed ground-water impacts from manmade stress-release caused the rock mass removal during mining, but nothing from the blasting. The water quality and water levels were unaffected by the blasting. The "opening up" of the fractures lowered the ground-water levels by increasing the storage or porosity.

A study tested wells 50m from a blast. Wells exhibited no quality or quantity impacts. Blast pressure surges ranged from 3 to 10cm. Blasting caused no noticeable water table fluctuations and the hydraulic conductivity was unchanged. The pumping of the pit and encroachment of the high wall toward the wells dewatered the water table aquifer.

It may then be concluded from the studies researched as follows: Depending on the well construction, litho logic units encountered, and proximity to the blasting, it is believed that large shots could act as a catalyst for some well sloughing or collapse. However, the well would have to be inherently weak to begin with. The small to moderate shots will not show to impact wells. The minor water fluctuations attributed to blasting may cause a short term turbidity problem, but do not pose any long term problems. This fluctuation would not cause well collapse, as fluctuations from recharge and pumping occurs frequently. Long term changes to the well yield are more likely due to the opening of fractures from loss of lateral confinement. Short term dewatering of wells is caused by the opening of the fractures creating additional storage. A longer term dewatering is caused by encroachment of the high wall and pumping of the pit water. The pit acts like a large pumping well. It is not believed that long term water quality problems will be caused by blasting alone. The possible exception is the introduction of residual nitrates, from the blasting materials, into the ground water system. This is only possible through wells that are hydro logically connected to a blasting site. Most of the long term impacts on water quality are due to the mining (the breakup of the rocks). The influence will also be dependant if wells are beneath the excavation. Stress relief effects occur at shorter distances in this instance.

The results observed and levels recorded during research done showed that levels up to 50mm/s or even higher in certain cases did not have any noticeable effect. It seems that safe conditions will be in the order of the 50mm/s. In addition to this there are certain aspects that will need to be addressed prior to blasting operations.

7 Site specific review and modelling of the various aspects from blasting operations:

The area surrounding the proposed mining areas was reviewed for structures, traffic, roads, human interface, animals interface etc. Various installations and structures were observed. These are listed in Table 1. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. Possible effects of blasting operations are presented here. In evaluation three charge mass scenarios are considered with regards to ground vibration and air blast. The blast designs considered showed that the possible charges per delay expected range between 138 and 828kg. A single blasthole from waste blast will yield 138kg charge, 4 blastholes detonating simultaneously from the waste blast will yield 552kg hard and six blastholes will yield 828kg. Single blasthole detonation and multiple blasthole detonation is achieved through the use of different initiation technologies i.e. shock tube or electronic delay detonators.

Ground vibration and air blast was calculated from the edge of the pit outline and modelled accordingly. Blasting further away from the pit edge will certainly have lesser influence on the surroundings. A worst case is then applicable with calculation from pit edge. As explained previously reference is only made to some structures and these references covers the extent of all structures surrounding the mine.

The following aspects with comments are addressed for each of the evaluations done:
Ground Vibration Modelling Results
Ground Vibration and human perception
Vibration impact on national and provincial road
Vibration will upset adjacent communities
Cracking of houses and consequent devaluation
Air blast Modelling Results
Impact of fly rock
Noxious fumes Influence Results

Please note that this analysis does not take geology, topography or actual final drill and blast pattern into account. The data is based on good practise applied internationally and considered very good estimates based on the information provided and supplied in this document.

7.1 Review of expected ground vibration

Presented herewith are the expected ground vibration level contours. Discussion of level of ground vibration and relevant influences is also given. Expected ground vibration levels were calculated for each of the structure locations or POI's considered surrounding the mining area. Evaluation is given for each POI with regards to human perception and structure concern. Evaluation is done in form of the criteria what humans experience and where by structures could be damaged. This is according to accepted criteria for prevention of damage to structures and when levels are low enough to have no significant influence. Tables are provided for each of the different charge modelling done with regards to No., Structure, Shortest Distance (m), Max Charge, Predicted PPV (mm/s), and Possible Concern. The No." is only number order. "Structure" is description of the structure. The "Shortest Distance" is the distance between the structure and edge of the pit area. The "Max Charge" is the charge size in kg used for the specific modelling or calculations. The "Predicted PPV (mm/s)" is the calculated ground vibration for the structure and the "possible concern" indicates if there is any concern for structure damage or not or human perception. Indicators used are such as "perceptible", "unpleasant", "intolerable" which stems from the humans perception information given and indicators such as "high" or "low" is given whereby there is possibility of damage to a structure or no significant influence is expected and concern is low. Levels below 0.76 mm/s could be considered as to be low or negligible possibility of influence.

Ground vibration is calculated and modelled for minimum, medium and maximum charge mass at specific distances from the opencast mining area. These levels are then plotted and overlaid with current mining plans to observe possible influences at structures identified. Structures or POI's for consideration are also plotted in this model. Ground vibration predictions were done considering distances ranging from 50 to 3500m around the opencast mining area.

Provided as well with each simulation are indicators of the ground vibration limits used: 6, 12.5 and 25mm/s. 6 mm/s is indicated as a "Solid Blue" line, 12.5mm/s "Intermittent Blue" line and 25mm/s as a "Intermittent Red" line. This enables immediate review of possible concerns that may be applicable to any of the privately owned structures, social gathering areas or installations. Consideration can also then be given to influence on sensitive installations within the mine boundary.

Data is provided as follows: Vibration contours followed by table with predicted ground vibration values and evaluation.

7.2 Calculated Ground Vibration Levels

Presented are simulations for expected ground vibration levels from three different charge masses. The outcome of the simulation from minimum charge is presented in Figure 11; Figure 12 shows zoomed area of figure 11, medium charge in Figure 13 and maximum charge in Figure 14 below. The expected level for each of the identified structures, possible influence and concern is also considered and presented directly after each vibration contour is the following tables Table 9, Table 10 and Table 12 below.

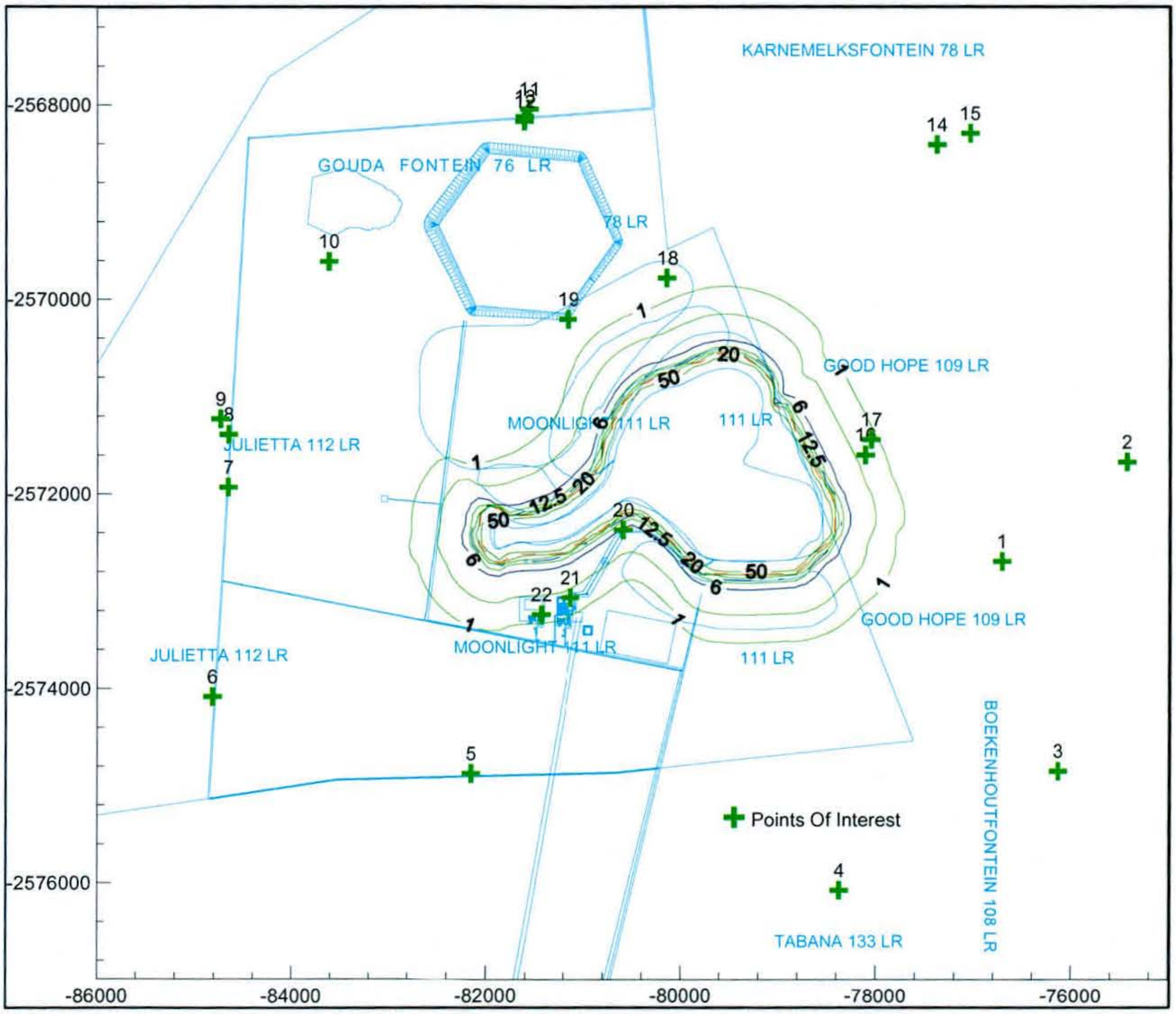

Figure 11: Ground vibration influence from minimum charge

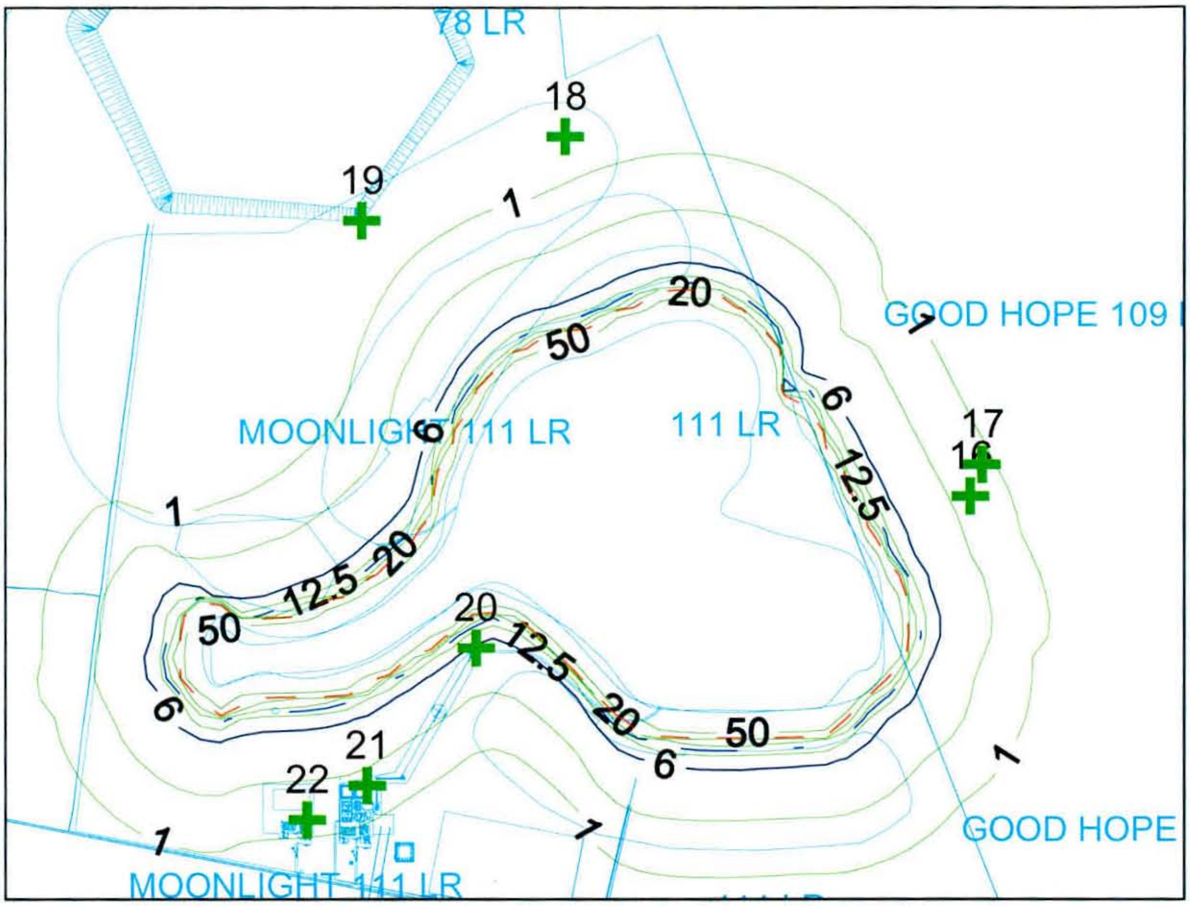

Figure 12: Zoomed area for ground vibration influence from minimum charge

Table 9: Ground vibration evaluation for minimum charge

Owner	Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
Private	1	Farmstead	25	1873	0.3	Too Low	Acceptable	Acceptable
Private	2	Dam	25	3175	0.1	Too Low	Acceptable	Acceptable
Private	3	Farmstead	25	3433	0.1	Too Low	Acceptable	Acceptable
Private	4	Dam	25	3436	0.1	Too Low	Acceptable	Acceptable
Private	5	Dam	25	2324	0.2	Too Low	Acceptable	Acceptable
Private	6	Dam	25	3279	0.1	Too Low	Acceptable	Acceptable
Private	7	Waterhole	25	2736	0.1	Too Low	Acceptable	Acceptable
Private	8	Hut	25	2863	0.1	Too Low	Acceptable	Acceptable
Private	9	Dam	25	2996	0.1	Too Low	Acceptable	Acceptable
Private	10	Waterhole	25	3159	0.1	Too Low	Acceptable	Acceptable
Private	11	Dam	25	3189	0.1	Too Low	Acceptable	Acceptable
Private	12	Dam	25	3097	0.1	Too Low	Acceptable	Acceptable
Private	13	Hut	25	3138	0.1	Too Low	Acceptable	Acceptable
Private	14	Farmstead	25	3054	0.1	Too Low	Acceptable	Acceptable
Private	15	Ruins	25	3361	0.1	Too Low	Acceptable	Acceptable
Private	16	Farmstead	25	644	1.5	Perceptible	Acceptable	Acceptable
Private	17	Dam	25	787	1.1	Perceptible	Acceptable	Acceptable
Private	18	Historical House	25	1055	0.7	Too Low	Acceptable	Acceptable
Mine	19	Tailings dam	25	1145	0.6	Too Low	Acceptable	Acceptable
Mine	20	Stockpile	25	250	7.4	Unpleasant	Acceptable	Acceptable

Mine	21	Plant	25	613	1.7	Perceptible	Acceptable	Acceptable
Mine	22	Offices	25	749	1.2	Perceptible	Acceptable	Acceptable

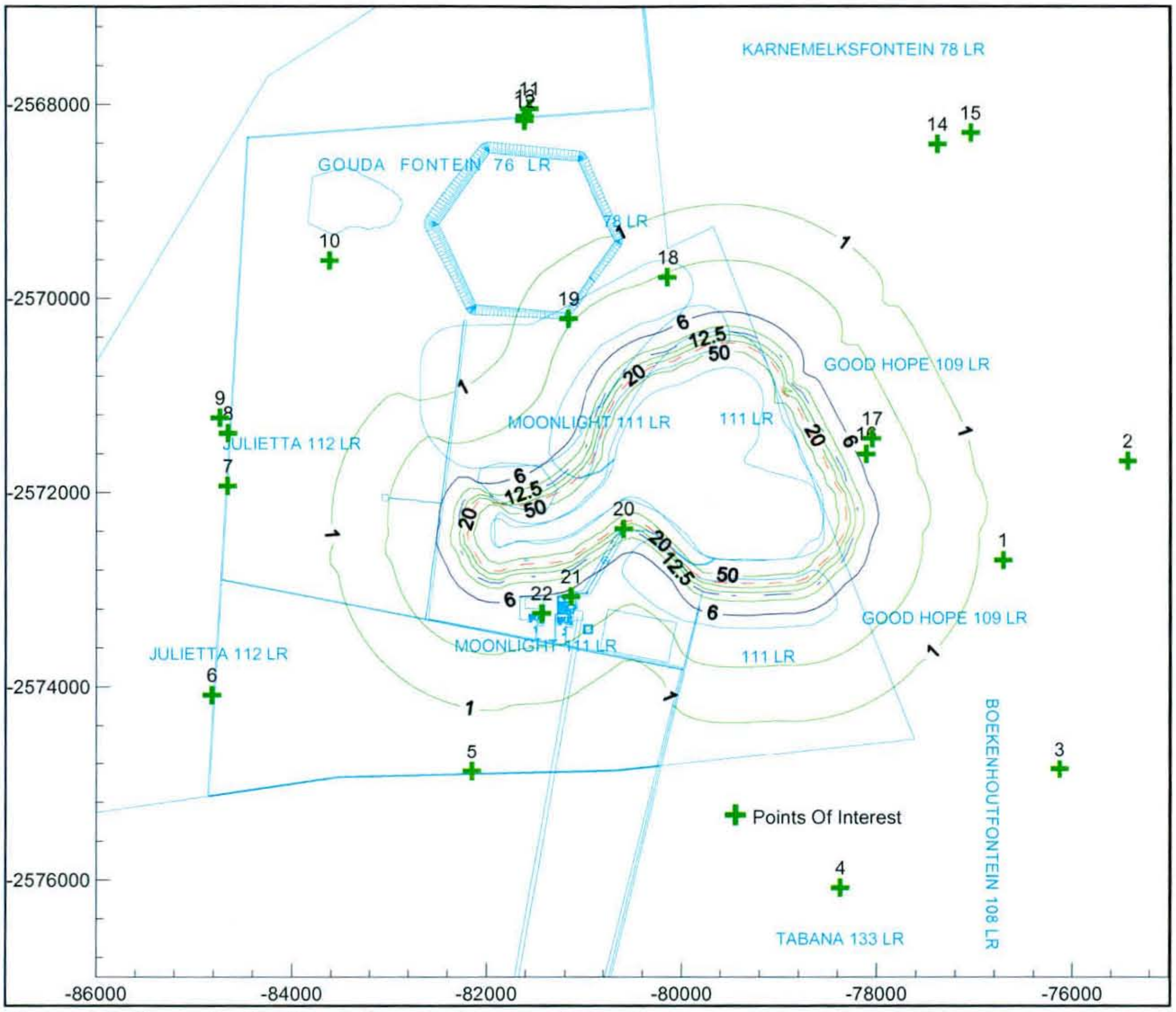

Figure 13: Ground vibration influence from medium charge

Table 10: Ground vibration evaluation for medium charge

Owner	Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
Private	1	Farmstead	25	1873	0.8	Perceptible	Acceptable	Acceptable
Private	2	Dam	25	3175	0.3	Too Low	Acceptable	Acceptable
Private	3	Farmstead	25	3433	0.3	Too Low	Acceptable	Acceptable
Private	4	Dam	25	3436	0.3	Too Low	Acceptable	Acceptable
Private	5	Dam	25	2324	0.6	Too Low	Acceptable	Acceptable
Private	6	Dam	25	3279	0.3	Too Low	Acceptable	Acceptable
Private	7	Waterhole	25	2736	0.4	Too Low	Acceptable	Acceptable
Private	8	Hut	25	2863	0.4	Too Low	Acceptable	Acceptable
Private	9	Dam	25	2996	0.4	Too Low	Acceptable	Acceptable
Private	10	Waterhole	25	3159	0.4	Too Low	Acceptable	Acceptable
Private	11	Dam	25	3189	0.3	Too Low	Acceptable	Acceptable
Private	12	Dam	25	3097	0.4	Too Low	Acceptable	Acceptable

Private	13	Hut	25	3138	0.4	Too Low	Acceptable	Acceptable
Private	14	Farmstead	25	3054	0.4	Too Low	Acceptable	Acceptable
Private	15	Ruins	25	3361	0.3	Too Low	Acceptable	Acceptable
Private	16	Farmstead	25	644	4.8	Perceptible	Acceptable	Acceptable
Private	17	Dam	25	787	3.5	Perceptible	Acceptable	Acceptable
Private	18	Historical House	25	1055	2.1	Perceptible	Acceptable	Acceptable
Mine	19	Tailings dam	25	1145	1.9	Perceptible	Acceptable	Acceptable
Mine	20	Stockpile	25	250	23.1	Intolerable	Acceptable	Acceptable
Mine	21	Plant	25	613	5.3	Perceptible	Acceptable	Acceptable
Mine	22	Offices	25	749	3.8	Perceptible	Acceptable	Acceptable

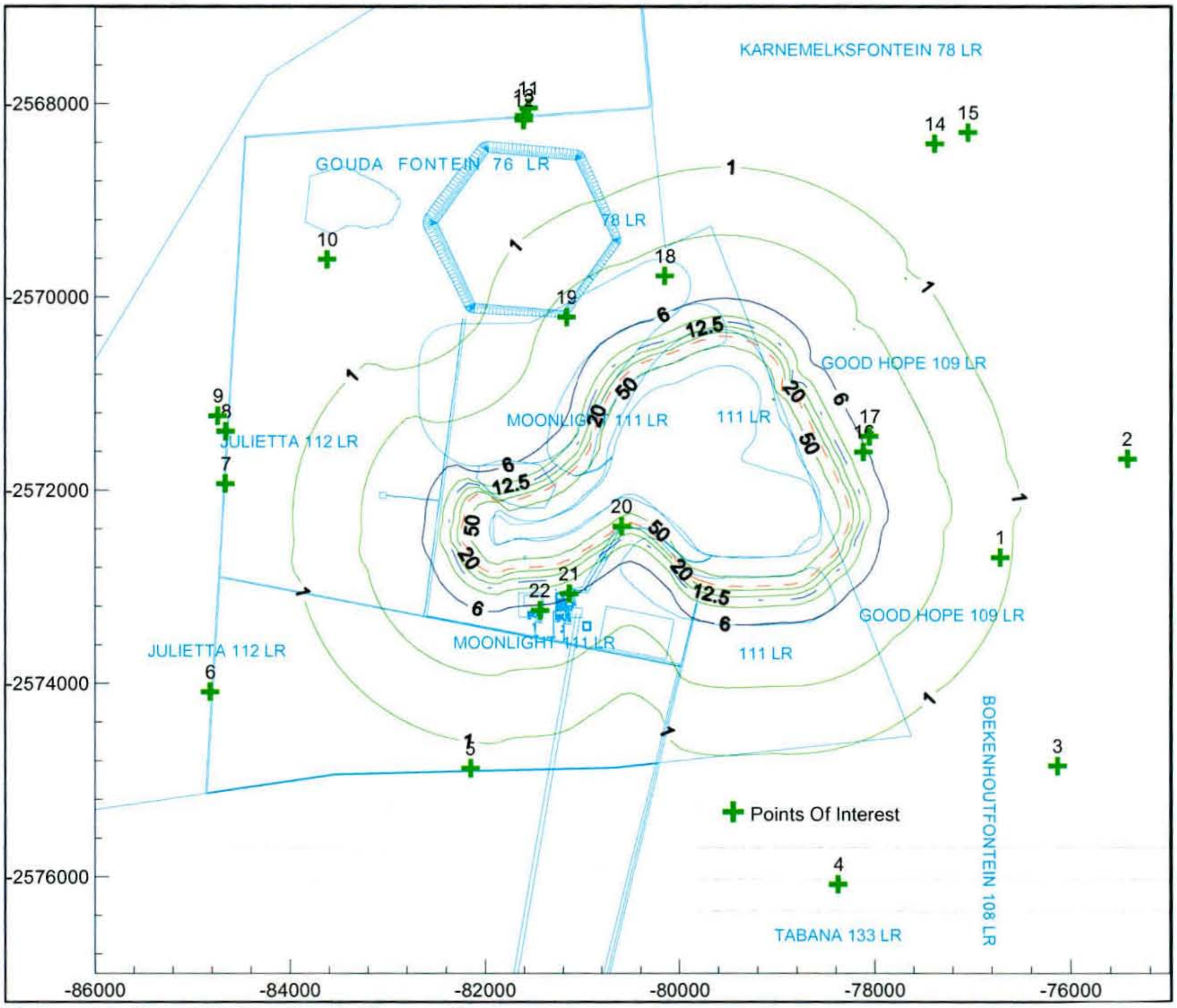

Figure 14: Ground vibration influence from maximum charge

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Table 11: Ground vibration evaluation for maximum charge

Owner	Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
Private	1	Farmstead	25	1873	1.2	Perceptible	Acceptable	Acceptable
Private	2	Dam	25	3175	0.5	Too Low	Acceptable	Acceptable
Private	3	Farmstead	25	3433	0.4	Too Low	Acceptable	Acceptable
Private	4	Dam	25	3436	0.4	Too Low	Acceptable	Acceptable
Private	5	Dam	25	2324	0.8	Perceptible	Acceptable	Acceptable
Private	6	Dam	25	3279	0.5	Too Low	Acceptable	Acceptable
Private	7	Waterhole	25	2736	0.6	Too Low	Acceptable	Acceptable
Private	8	Hut	25	2863	0.6	Too Low	Acceptable	Acceptable
Private	9	Dam	25	2996	0.5	Too Low	Acceptable	Acceptable
Private	10	Waterhole	25	3159	0.5	Too Low	Acceptable	Acceptable
Private	11	Dam	25	3189	0.5	Too Low	Acceptable	Acceptable
Private	12	Dam	25	3097	0.5	Too Low	Acceptable	Acceptable
Private	13	Hut	25	3138	0.5	Too Low	Acceptable	Acceptable
Private	14	Farmstead	25	3054	0.5	Too Low	Acceptable	Acceptable
Private	15	Ruins	25	3361	0.4	Too Low	Acceptable	Acceptable
Private	16	Farmstead	25	644	6.8	Unpleasant	Acceptable	Acceptable
Private	17	Dam	25	787	4.9	Perceptible	Acceptable	Acceptable
Private	18	Historical House	25	1055	3.0	Perceptible	Acceptable	Acceptable
Mine	19	Tailings dam	25	1145	2.6	Perceptible	Acceptable	Acceptable
Mine	20	Stockpile	25	250	32.3	Intolerable	Problematic	Problematic
Mine	21	Plant	25	613	7.3	Unpleasant	Acceptable	Acceptable
Mine	22	Offices	25	749	5.3	Perceptible	Acceptable	Acceptable

7.3 Summary of ground vibration levels

Highlighted areas in the tables above indicate areas of concern for both human perception and structure integrity. If levels indicate human perception as intolerable and / or problematic for structures then it is considered a serious concern and needs mitigation. The maximum charge only is expected to yield levels that could be experienced as unpleasant at one private farmstead and as perceptible at two other privately owned farmstead and dam. The POI's of concern here is 1, 5 and 16. Levels expected are well below the minimum safe level used in this report. The mine structures will be influence more than that of privately owned structures. The historical house indicated at point 18 is expected not to be severely influence. The maximum level of ground vibration expected from maximum charge is 3.0mm/s. This is well within limits for historical sites.

7.4 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to various frequencies and plotted with expected human perceptions on the safe blasting criteria graph (See Figure 15 below). On the graph are indicators of the effect of vibration amplitude at various distances for three specific frequencies 15, 30 and 60 Hz. The frequency range selected is the expected range for frequencies that will be measured for ground vibration.

Review of the maximum charge in relation to human perception it is seen that 2500m from the blast people will experience the ground vibration as *"Perceptible"*. At 2500m the expected ground vibration levels are still less than the lower safe blasting limit – less than 12.5mm/s but will be experienced by people as *"unpleasant"*. At distance of 400m and closer there is strong indication that people will experience the ground vibration as *"Intolerable"*. Distances closer than 300m will exceed the minimum indicated or proposed safe limits and people will experience these levels more severe. Figure 15 below shows this effect of ground vibration with regards to human perception for maximum charge.

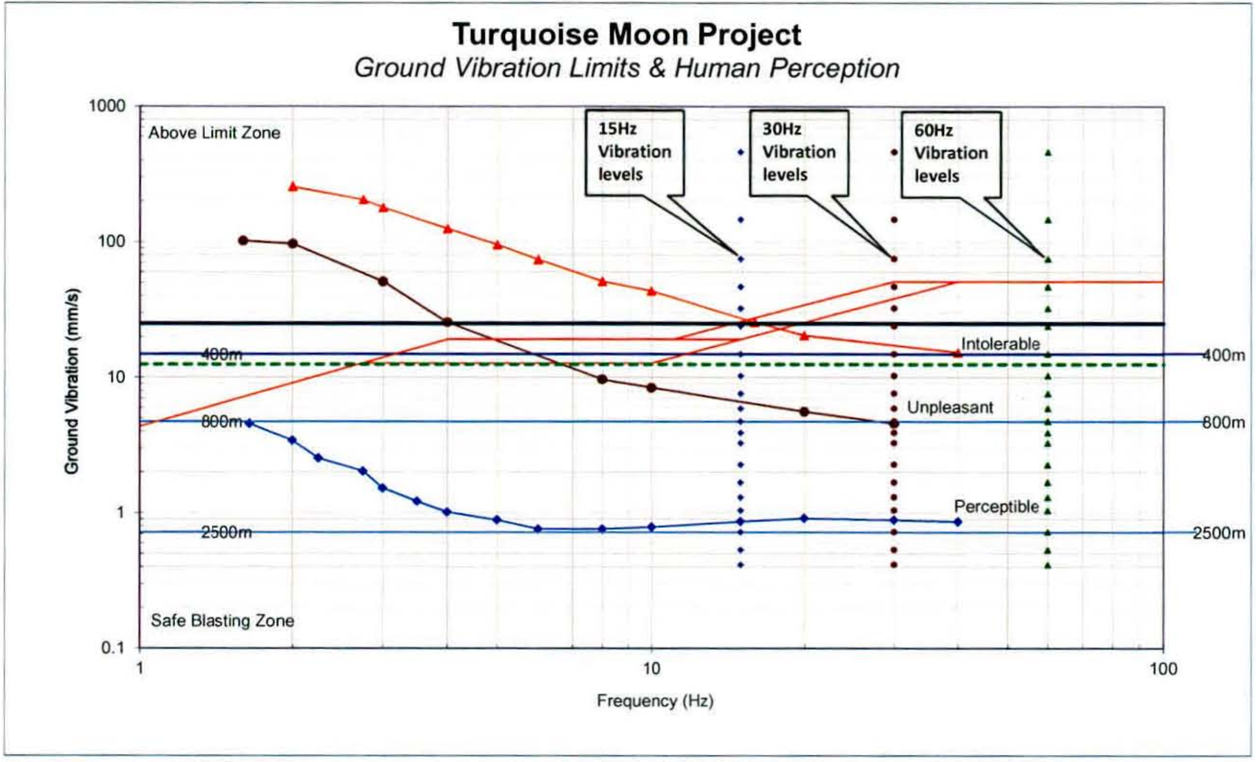

Figure 15: The Effect of Ground Vibration with Regards to Human Perception plotted with the criteria for safe blasting at the highest charge mass applied.

7.5 Vibration impact on roads

The project area is approximately 6km south of the nearest national road – N11. The closest road is the D1347 secondary road. This road will be re-rout around the mining are taking well away from possible impact. There is currently no real possible danger or impact on these roads.

7.6 Vibration will upset adjacent communities

Ground vibration and air blast generally upset communities or people living in the vicinity of mining operations. There are houses that will be less than 1000m from the pit edge that will need to be considered. Levels at these structures are expected to be low but could still be unpleasant and such that it could upset the occupants of neighbouring farms. Further to this is that people's perception stretches significantly further into the area and will need to be considered.

Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is "Promote good neighbour ship". This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it, could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure.

7.7 Borehole collapse / Muddying and pollution of borehole water

Specific private boreholes were not observed on plans or information provided. There are however expected to be water wells in the area. It is uncertain if these are fed from streams or fountains. A detail list should however be constructed of boreholes and the distances checked for possible influence. Boreholes should not be closer than 200m from blasting operations when maximum charge is considered. At 200m levels expected is 46.6mm/s. If there water monitoring holes inside the mine boundary it does have risk of being damaged to due to close proximity to the actual pit area.

7.8 Air blast

The effect of air blast, if not controlled properly, is in my opinion a factor that could be problematic. Maybe not in the sense of damage being induced but rather having an impact – even at low levels of roofs and windows that could result in complaints from people. In more than one case this effect is misunderstood and people consider this effect as being ground vibration and damaging to their house structures. Section 5 gives detail on the selection of the charges sizes applied.

As with ground vibration evaluation is given for each structure with regards to the calculated levels of air blast and concerns if applicable. Evaluation is done in form of the criteria what humans experience and where by structures could be damaged. This is according to accepted criteria for prevention of damage to structures and when levels are low enough to have no significant influence. Tables provided with each of different charge modelling shows information with regards to **No., Structure, Shortest Distance (m), Max Charge, Air blast (dB), and Possible Concern.** The No." is only number order. "Structure" is description of the structure. The "Shortest Distance" is the distance between the structure and edge of the pit area. The "Max Charge" is the charge size in kg used for the specific modelling or calculations. The "Air Blast (dB)" is the calculated air blast level at the structure and the "possible concern" indicates if there is any concern for structure damage or not or human perception. Indicators used are "Problematic" where there is real concern for possible damage, "Complaint" where people will be complaining due to the experienced effect on structures – not necessarily damaging, "Acceptable" is if levels are less than 120 dB and low where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115dB could be considered as to be low or negligible possibility of influence.

Table 12 shows that the applied limits and recommended levels for each of the charges considered. The maximum charge may exceed limits at distances 200m. The recommended limit of 120dB is observed at distances greater 700m. These distances are reduced to 150m for the medium charge allowed limit and 600m for recommended limit. Further reduction to 100m for the smallest charge allowed limit and 400m for the recommended limit.

Table 12: Expected air blast levels

Distance (m)	Air blast (dB) for 138kg Charge	Air blast (dB) for 552kg Charge	Air blast (dB) for 828kg Charge
50.0	141	146	148
100.0	134	139	140
150.0	130	135	136
200.0	127	132	133
250.0	125	129	131
300.0	123	127	129
400.0	120	124	126
500.0	117	122	124
600.0	115	120	122
700.0	114	119	120
800.0	112	117	119
900.0	111	116	117
1000.0	110	115	116
1250.0	108	113	114
1500.0	106	111	112
1750.0	104	109	111
2000.0	103	108	109
2500.0	101	105	107
3000.0	99	103	105
3500.0	97	102	103

Presented herewith are the expected air blast level contours. Discussion of level of air blast and relevant influences are also given for the pit area. Air blast was calculated and modelled from the boundary for minimum, medium and maximum charge mass at specific distances from each of the pit areas. This means that air blast is taken from the edge – the most outer point of the pit area on plan as if it would be the closest place where drilling and blasting will be done to the area of influence. The calculated levels are then plotted and overlaid with current mining plans to observe possible influences at POI's identified. Air blast predictions were done considering distances ranging from 50 to 3500m around the opencast mining area.

7.9 Review of expected air blast

Presented are simulations for expected air blast levels from three different charge masses. Minimum, medium and maximum charge evaluations are shown in the figures below and summary table of outcome given after each charge configuration air blast contour.

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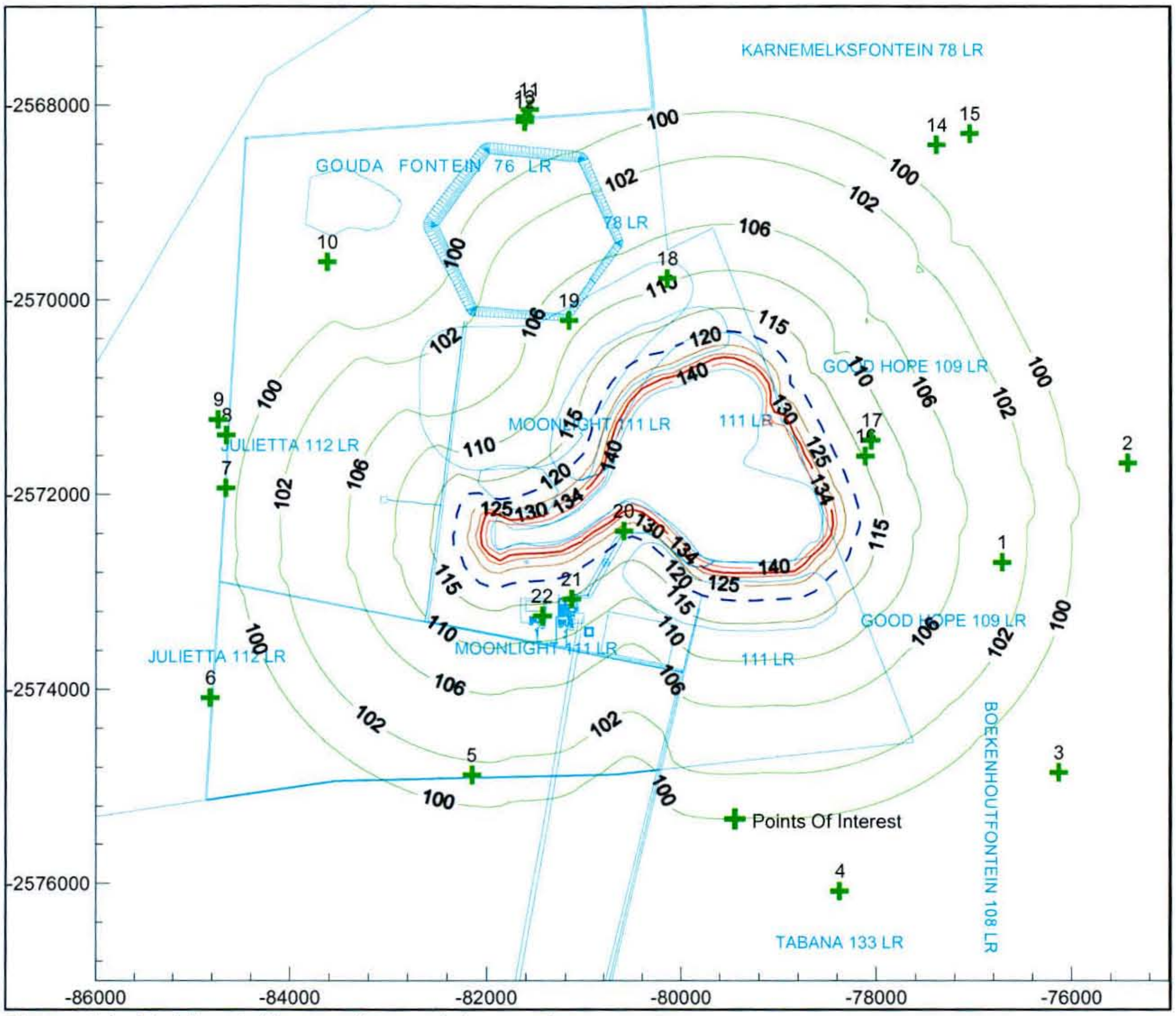

Figure 16: Air blast influence from minimum charge

Table 13: Air blast evaluation for minimum charge

Owner	Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
Private	1	Farmstead	1873	103.6	Acceptable
Private	2	Dam	3175	98.1	Acceptable
Private	3	Farmstead	3433	97.3	Acceptable
Private	4	Dam	3436	97.3	Acceptable
Private	5	Dam	2324	101.3	Acceptable
Private	6	Dam	3279	97.7	Acceptable
Private	7	Waterhole	2736	99.6	Acceptable
Private	8	Hut	2863	99.2	Acceptable
Private	9	Dam	2996	98.7	Acceptable
Private	10	Waterhole	3159	98.1	Acceptable
Private	11	Dam	3189	98.0	Acceptable
Private	12	Dam	3097	98.3	Acceptable
Private	13	Hut	3138	98.2	Acceptable
Private	14	Farmstead	3054	98.5	Acceptable
Private	15	Ruins	3361	97.5	Acceptable

Private	16	Farmstead	644	114.7	Acceptable
Private	17	Dam	787	112.6	Acceptable
Private	18	Historical House	1055	109.6	Acceptable
Mine	19	Tailings dam	1145	108.7	Acceptable
Mine	20	Stockpile	250	124.6	Complaint
Mine	21	Plant	613	115.2	Acceptable
Mine	22	Offices	749	113.1	Acceptable

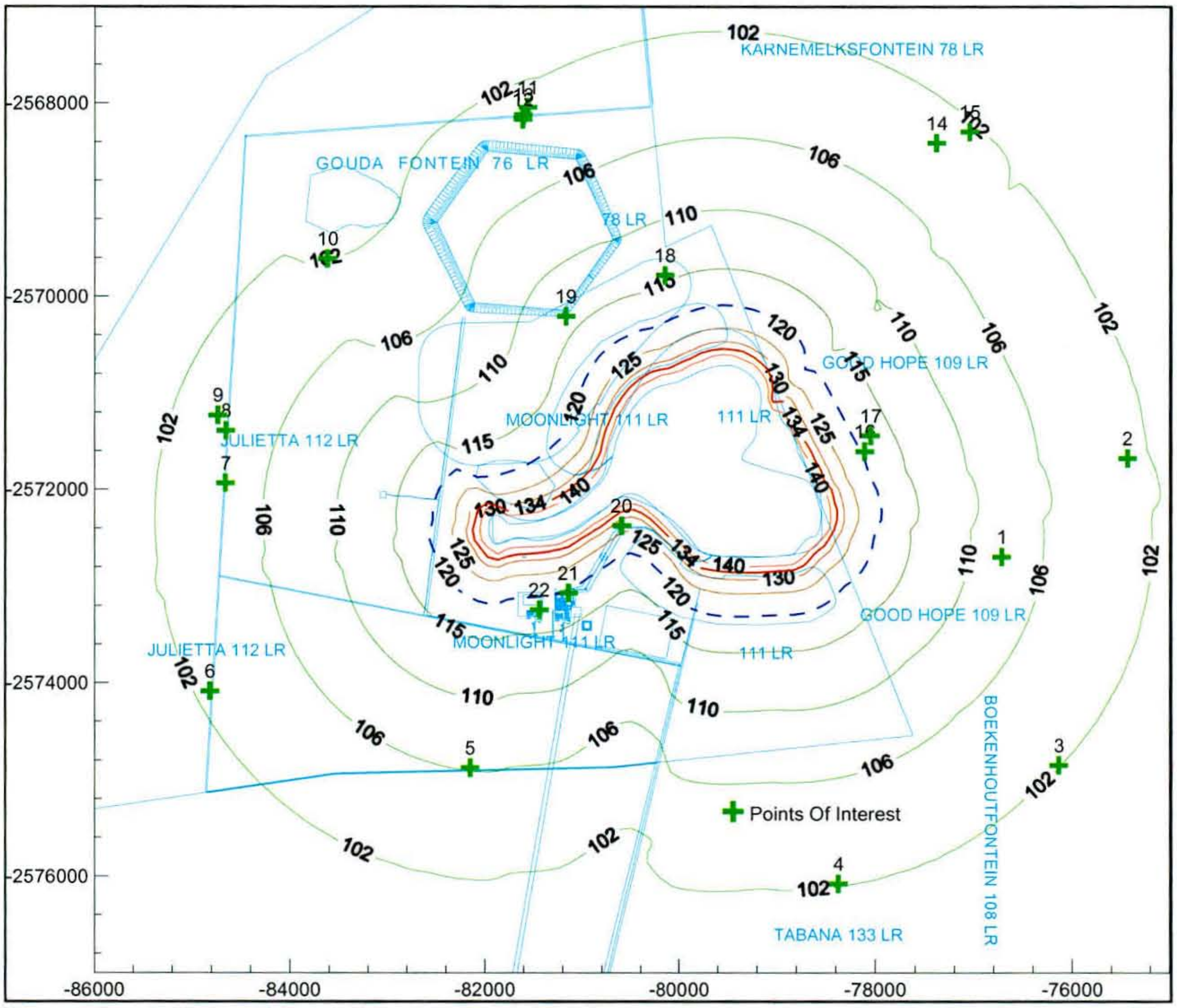

Figure 17: Air blast influence from medium charge

Table 14: Air blast evaluation for medium charge

Owner	Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
Private	1	Farmstead	1873	108.4	Acceptable
Private	2	Dam	3175	102.9	Acceptable
Private	3	Farmstead	3433	102.1	Acceptable
Private	4	Dam	3436	102.1	Acceptable
Private	5	Dam	2324	106.1	Acceptable
Private	6	Dam	3279	102.6	Acceptable

Private	7	Waterhole	2736	104.4	Acceptable
Private	8	Hut	2863	104.0	Acceptable
Private	9	Dam	2996	103.5	Acceptable
Private	10	Waterhole	3159	102.9	Acceptable
Private	11	Dam	3189	102.8	Acceptable
Private	12	Dam	3097	103.2	Acceptable
Private	13	Hut	3138	103.0	Acceptable
Private	14	Farmstead	3054	103.3	Acceptable
Private	15	Ruins	3361	102.3	Acceptable
Private	16	Farmstead	644	119.5	Acceptable
Private	17	Dam	787	117.4	Acceptable
Private	18	Historical House	1055	114.4	Acceptable
Mine	19	Tailings dam	1145	113.5	Acceptable
Mine	20	Stockpile	250	129.4	Complaint
Mine	21	Plant	613	120.0	Complaint
Mine	22	Offices	749	117.9	Acceptable

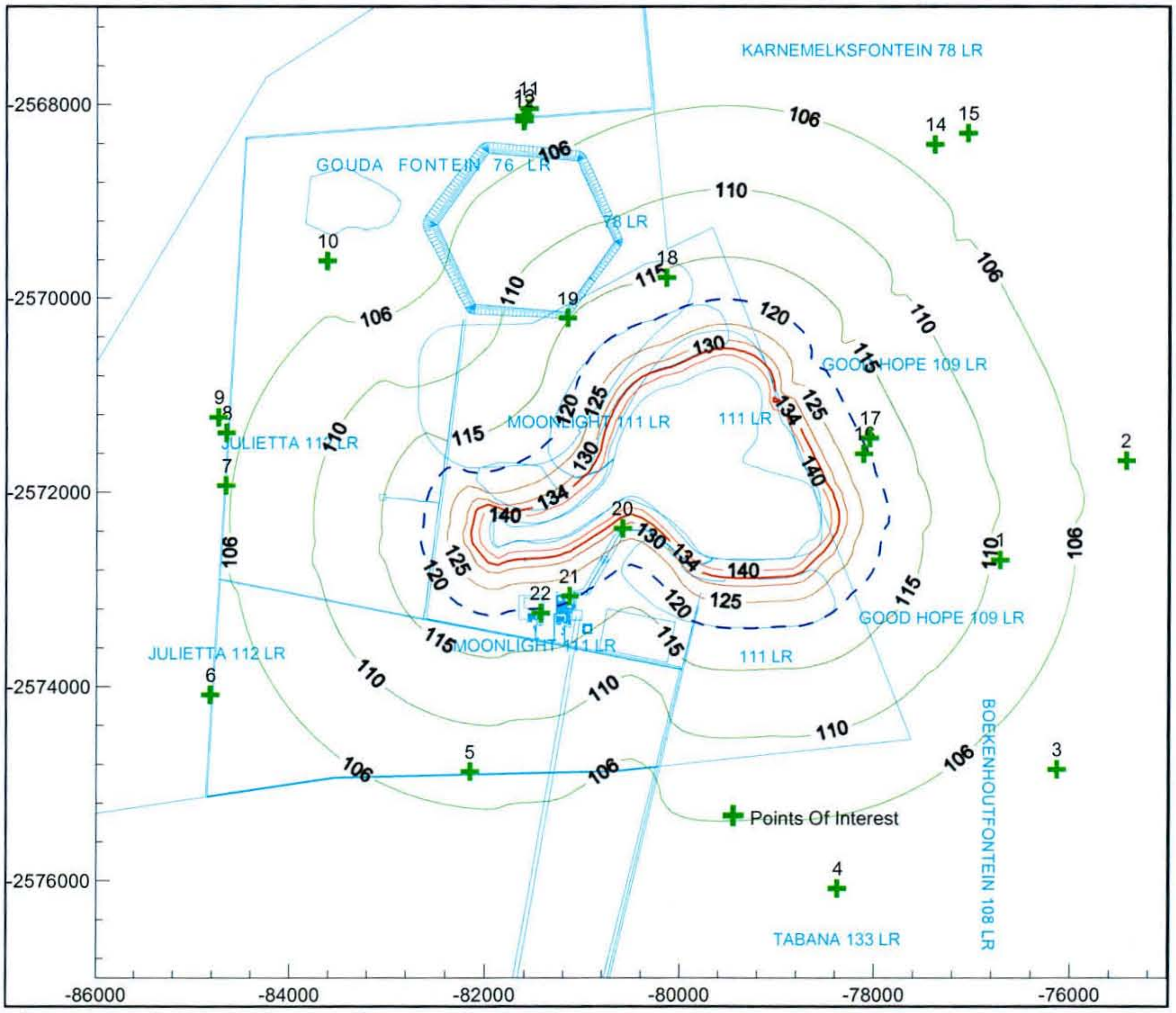

Figure 18: Air blast influence from maximum charge

Table 15: Air blast evaluation for maximum charge

Owner	Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
Private	1	Farmstead	1873	109.8	Acceptable
Private	2	Dam	3175	104.3	Acceptable
Private	3	Farmstead	3433	103.5	Acceptable
Private	4	Dam	3436	103.5	Acceptable
Private	5	Dam	2324	107.6	Acceptable
Private	6	Dam	3279	104.0	Acceptable
Private	7	Waterhole	2736	105.9	Acceptable
Private	8	Hut	2863	105.4	Acceptable
Private	9	Dam	2996	104.9	Acceptable
Private	10	Waterhole	3159	104.4	Acceptable
Private	11	Dam	3189	104.3	Acceptable
Private	12	Dam	3097	104.6	Acceptable
Private	13	Hut	3138	104.4	Acceptable
Private	14	Farmstead	3054	104.7	Acceptable
Private	15	Ruins	3361	103.7	Acceptable
Private	16	Farmstead	644	120.9	Complaint
Private	17	Dam	787	118.8	Acceptable
Private	18	Historical House	1055	115.8	Acceptable
Mine	19	Tailings dam	1145	114.9	Acceptable
Mine	20	Stockpile	250	130.8	Complaint
Mine	21	Plant	613	121.4	Complaint
Mine	22	Offices	749	119.4	Acceptable

7.10 Summary of findings for air blast

Review of the air blast levels it is expected that levels will only of concern at the nearest privately owned structure for the maximum charge only. This structure at POI 16 is 644 m from edge. Levels are such that it could possibly have a nuisance effect levels expected are less than damaging criteria. The rest of the area is expected to experience significantly less effect from air blast. There is however still a significant responsibility on the drilling and blasting team to ensure that levels are maintained below damaging criteria and also below recommended levels.

7.11 Fly-rock Modelling Results and Impact of fly rock

Review of the factors that contribute to fly rock it is certain that if no stemming control is exerted there will be fly rock. Possible reduction of stemming length to 2m for the blast configuration applied could see fly rock up to 530m possible travel for hard rock material. This distance is slightly short of the nearest farm structures but not private land. Figure 19 below shows the relationship burden or stemming length towards expected throw distance. Throw distance considered here on the same level as the free face. Landing level of elements lower than free face could see longer distances. Optimal throw distance is also observed at 45 degree angles of departure. The maximum distance travel of 530m is just greater than the normal safe blasting clearance area. It is expected that no person or animal should be present in this area and thus the possibility of injury also reduced. Concern is also for mine structures inside the mining area. Mine structures could be damaged and have a costs effect. Careful attention must be given to stemming control to ensure that fly rock minimised as much as possible. Specific attention will be required for blasting at distances closer than 500 m from surrounding structures.

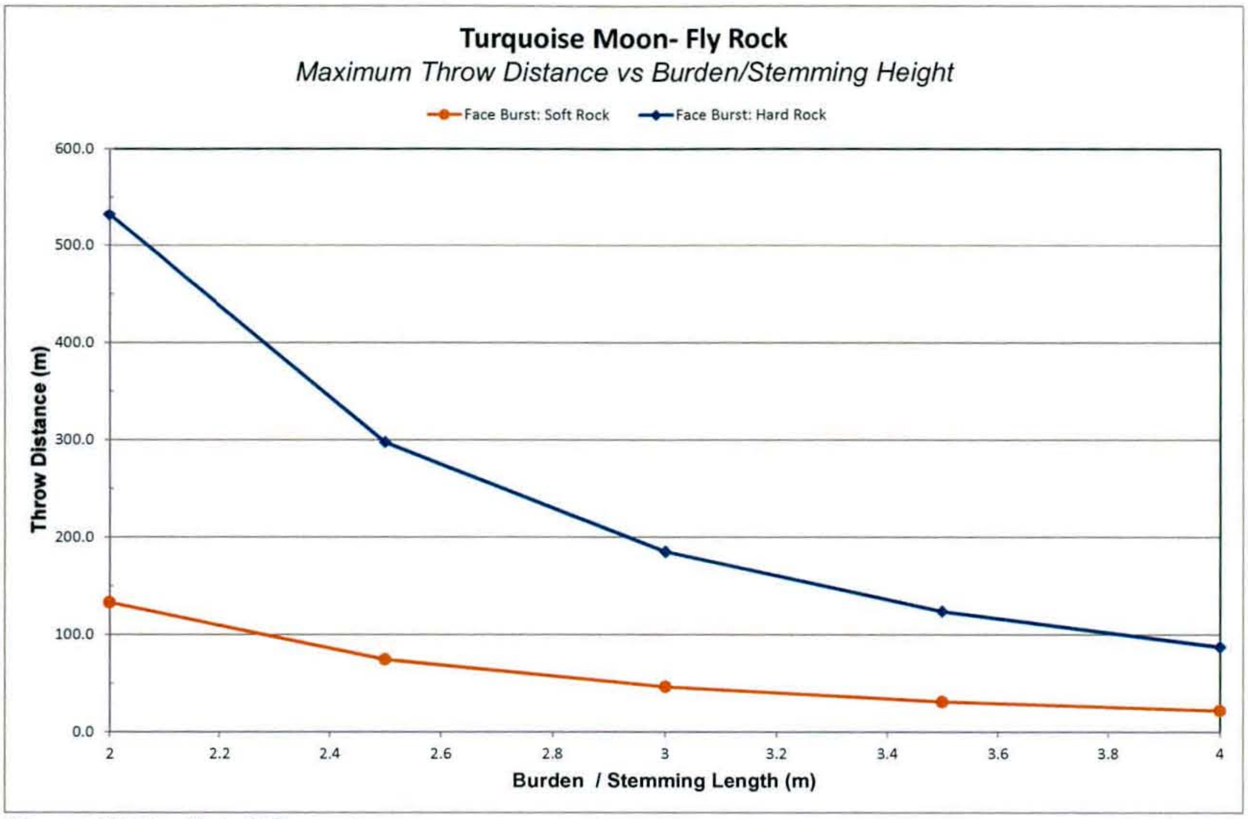

Figure 19: Predicted Fly rock

7.12 Noxious fumes Influence Results

The occurrence of fumes in the form the NOx gaseous format is not a given and very dependent on various factors. However the occurrences of fumes should be closely monitored. It is not assumed that fume will travel to any part nearby farm stead but again if anybody is present in the path of cloud travel it could be problematic.

8 Potential Environmental Impact Assessment

Following is impact assessment of the various concerns covered by this report. The matrix below in Table 16 was used for analysis and evaluation of aspects discussed in this report. Outcome of analysis is provided in Table 17 for pre- and post-mitigation. This risk assessment is a one side analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

Table 16: Evaluation matrix criteria

Magnitude:=M	*Scale:=S*
10 - Very high/don't know	5 – International
8 – High	4 – National
6 – Moderate	3 – Regional
4 – Low	2 – Local

2 – Minor	1 – Site only
	0 – None
Duration:=D	*Probability:=P*
5 – Permanent	5 – Definite/don't know
4 - Long-term (ceases with the operational life)	4 – Highly probable
3 - Medium-term (5-15 years)	3 – Medium probability
2 - Short-term (0-5 years)	2 – Low probability
1 – Immediate	1 – Improbable
	0 – None

Table 17: Risk Assessment Outcome

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION					
		M	D	S	P	TOTAL	SP
Operational Phase: Mining of Coal (Opencast)							
Issues related to Blasting							
Ground Vibration	Blasting	6	4	2	3	30	L
Air Blast	Blasting	4	4	2	3	26	L
Fly rock	Blasting	6	4	2	3	30	L
Fumes	Blasting	4	4	2	3	26	L

Possible Mitigation could yield the following: (only indicative)

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	RECOMMENDED MITIGATION MEASURES/ REMARKS	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION					
			M	D	S	P	TOTAL	SP
Ground Vibration	Blasting	Reduced Charge Mass per delay, Different initiation systems, different drilling and charging	6	4	2	3	30	L
Air Blast	Blasting	Stemming control, Reduced charging, initiation system	4	4	2	3	26	L
Fly rock	Blasting	Stemming control, Reduced charging, initiation system	6	4	2	3	30	L
Fumes	Blasting	Restricted sleep time, correct product for correct conditions	4	4	2	3	26	L

9 Mitigations

Based on the work done in this report there are current no specific mitigations that will be required. The levels of ground vibration and air blast expected are well within the safe blasting criteria. There is however still responsibility on blasting teams to conduct blasting in such a manner that the possible effects remain low and not induce complaints.

10 Recommendations

Recommendations are provide in two parts, firstly what will definitely be required and secondly is proposed for additional controls.

10.1 Required Recommendations

10.1.1 Safe blasting distance from communities

A minimum recommendation is that 500m must be maintained from blast done. This may be greater but not less. It is also a function of the blaster to determine what he considers the safe distance.

10.1.2 Evacuation

All person animals within 500m from a blast must be cleared and where necessary evacuation must be conducted with all the required pre-blast negotiations.

10.1.3 Road Closure

It is not expected that there will be roads within 500m from blasting. Care must be taken when blasting is done should planned road deviations not have been done as currently planned.

10.1.4 Monitoring

Monitoring is always a good preventative measure. It is highly recommended that a monitoring program be put in place. The historical house at point 18 should be considered as a point of measurement in a monitoring programme. Further will a monitoring programme also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to proper relationships with the neighbours.

10.1.5 Photographic Inspections

A base line of structure inspection should be considered for all privately owned structures within 1500m from the mine. The historical house should be inspected and detail photographic survey done prior to any blasting operations being conducted.

10.1.6 Recommended ground vibration and air blast levels

The following ground vibration and air blast levels are recommended for blasting operations in this area. Table 18 below gives limits for ground vibration and air blast.

Table 18: Recommended ground vibration air blast limits

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
National Roads/Tar Roads:	150	N/A
Steel pipelines:	50	N/A
Electrical Lines:	75	N/A
Railway:	150	N/A
Transformers	25	N/A
Water Wells	50	N/A
Houses/Structures	USBM Criteria or 12 mm/s	Shall not exceed 134dB at point of concern but 120 dB preferred
Rural Mud houses/structures	6	

stemming material. The use of predictions gives indication that if it goes wrong the extent of damage will at least be known beforehand. Air blast levels calculated for blasting operations did not show levels of concern for the nearest private structures. The nearest farm stead is expected only to experience 120dB. This well within accepted levels but could be a nuisance. The reduction of charge mass per delay will have significant reduction of air blast with safe blasting limit reduced in distance from the mine boundary. Additional controls may also be used in the stemming that will add to reduce the effects of air blast.

This concludes this investigation and outcome for the Turquoise Moon Project it will be possible to operate this mine in a safe and effective manner. The author wishes to indicate as well that this document is not purely an evaluation but had the intention to be a working document that can be used in practice to maintain good neighbour ship with its neighbours.

13 Curriculum Vitae of Author

Author joined Permanent Force at the SA Ammunition Core for period Jan 1983 - Jan 1990. During this period I was involved in testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition. For the period Jul 1992 - Des 1995 Worked at AECI Explosives Ltd. Initially I was involved in testing science on small scale laboratory work and large scale field work. Later on work entailed managing various testing facilities and testing projects. Due to the restructuring of Technical Department I was retrenched but fortunately could take up appointment with AECI Explosives Ltd.'s Pumpable Emulsion explosives group for underground applications. December 1995 to June 1997 I gave technical support to the Underground Bulk Systems Technology business unit and performed project management on new products. I started Blast Management & Consulting in June 1997. Main areas of concern were Pre-blast monitoring, Insitu monitoring, Post blast monitoring and specialized projects.

I have obtained the following Qualifications:

1985 - 1987 Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992 BA Degree, University Of Pretoria
1994 National Higher Diploma: Explosives Technology, Technikon Pretoria
1997 Project Management Certificate: Damelin College
2000 Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997 and work has been on various levels for all the major mining companies in South Africa. Some of the projects where BM&C has been involved are:

Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby PTY Ltd, Iso-Seismic surveys for Impala Platinum Limited, Iso-Seismic surveys for Kromdraai Opencast Mine, Photographic Surveys for Kriel Colliery, Photographic Surveys for Goedehoop Colliery, Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village, Photographic Surveys for Aquarius – Everest South Project, Photographic Surveys for Kromdraai Opencast Mine, Photographic Inspections for various other companies including Landau Colliery, Platinum Joint Venture – three mini pit areas, Continuous ground vibration and air blast monitoring for various Coal mines, Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road, Monitoring of ground vibration induced on surface in Underground Mining environment, Monitoring and management of blasting in close relation to water pipelines in opencast mining environment, Specialized testing of explosives characteristics, Supply and service of seismographs and VOD measurement equipment and accessories, Assistance in protection of ancient mining works for Rhino Minerals (PTY) LTD, Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads, Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village, Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section : 1000 houses / structures.

BM&C have installed a World class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects describe and discussed here are only part of the capability and professional work that is done by BM&C.

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APPENDIX P: LAND USE STUDY

Specialist report prepared by Scientific Aquatic Services and TerraAfrica Consult, June 2011