SAEON Offices
Private Bag x1021
Phalaborwa
South Africa
Tel: 013 735 3534
Fax: 013 735 3544
Int. Code: +27
www.saeon.ac.z

Biodiversity Monitoring Plan for Palabora Mining Company
October 2011 onwards

Dr Tony Swemmer,
SAEON Ndlovu Node
6 October 2011

with contributions from Dave Wright (Fauna and Flora International)

Introduction

The following proposal is for biodiversity monitoring on the properties of Palabora Mining Company (PMC), in accordance with the PMC Biodiversity Action Plan (BAP) and the ecological accounting requirements of Rio Tinto. The work would commence in 2011, and would continue for the remainder of the mining and rehabilitation lifespan of PMC, subject to future monitoring needs of PMC and financial resources available.
All work proposed here would be conducted by the South African Environmental Observation Network (SAEON), by SAEON staff, contractors or post-graduate students. SAEON is a non-profit research facility managed by the National Research Foundation and funded primarily by the Department of Science & Technology. All costs charged for the proposed research would be for the purposes of cost recovery by SAEON, and not for financial profit.

The biodiversity on the various PMC properties is threatened by both regional and global-scale threats, such as global climate change and the degradation of the Olifants River, and local-scale impacts that are a direct result of the mining activities conducted by PMC. The latter are described in the PMC BAP. This plan incorporates the following biodiversity monitoring requirements expressed by PMC:

- The requirement of Rio Tinto to produce a Quality Hectares metric for its various properties.
- The need to monitor the status of the various Biodiversity Features described in PMC's Biodiversity Action Plan.
- Continued monitoring of species or taxa of particular conservation concern, which have been the focus of monitoring efforts in previous years, and for which some baseline data exist.

- Concern about the specific environmental problems that are unique to PMC, and are therefore not adequately captured by the general monitoring requirements of Rio Tinto, such as
- negative ecological impacts created by the growing number of elephants in the region.

Geographic coverage

This plan incorporates all the land currently owned and managed by PMC. This land is classified into the following **land units**, on the basis of variation in the biodiversity, management activities and monitoring needs:

1) **PMC Disturbed:** parts of the mining area of PMC where the topsoil has not been removed or covered with waste material or physical infrastructure, including artificial wetlands and the fringes of dams. A few relatively undisturbed syenite koppies fall within this unit.
2) **PMC Rehabilitation:** rock dumps and the slopes of slimes dams built on the mining area of PMC, where vegetation is in a process of active or passive rehabilitation. This includes a few syenite koppies that were partially buried by rock or tailings.
3) **Cleveland:** Cleveland Game Reserve, which is further subdivided into
   a) **Koppies**: isolated syenite intrusions on Cleveland.
   b) **Riparian**: vegetation alongside perennial rivers on Cleveland (Olifants and Selati rivers).
   c) **Cleveland Terrestrial:** main area of Cleveland excluding Koppies and Riparian vegetation, and including natural wetlands.
4) **Vereeniging:** a portion of undisturbed and unused land to the south of the Olifants River, which is open to the Kruger National Park (to the east) and the Klaserie Private Nature Reserve (to the west and south)
5) **Pompey**: Pompey farm, located north of Lulekani, and further subdivided into
   a) **Pompey Protected**: the area within the fenced portion of Pompey which has not been disturbed by strip-mining.
   b) **Pompey Unprotected**: the area outside the fenced portion, which has not been disturbed by strip-mining but is impacted by wood-cutting, and grazing of domestic livestock.
   c) **Pompey Rehabilitation**: areas with the fenced portion of Pompey which have previously been strip-mined.

Aims

The following deliverables would be provided:

1. Quality coefficients (as described in the draft PMC BAP) for the year 2012, for:
   a. PMC Disturbed, Cleveland, Vereeniging and Pompey Protected, based on comparisons of ecosystem structure with benchmark sites in the Kruger National Park (KNP).
   b. PMC Rehabilitation area, based on indicators of biodiversity and ecological processes benchmarked against sites in KNP.
   c. Pompey Rehabilitation area, based on comparisons with Pompey Protected area.
2. Studies of the ecological processes that drive restoration of the PMC Rehabilitation area and the Pompey Rehabilitation area, and of the effectiveness of any rehabilitation interventions.
3. Annual monitoring and evaluation of the various biodiversity features contained in the PMC BAP

The proposal is structured according to these 3 deliverables, referred to as the **Quality Hectares** project, **Biodiversity Features** project and **Restoration Studies** project.

Methodology

The ecological variables that need to be monitored to achieve the above aims are described below. To reduce costs and data collection times, the same variables and data are used for more than one project wherever possible.

1. Quality hectares

PMC needs to report its impacts in terms of Quality Hectares, calculated as hectares (per land unit) multiplied by quality coefficient for that land unit. In order to derive quality coefficients for each land unit other than PMC Rehabilitation, comparisons will be made with benchmark sites considered to be representative of the natural condition of the ecosystems of the area. Note that these are not intended to represent conditions of the actual areas covered by PMC prior to mining began in the 1950's. Instead, they represent the current status of protected / conserved areas. In this way, the effect of environmental factors external to PMC can be accounted for, e.g. if increasing elephant impacts lead to the loss of biodiversity at the benchmark site and as well as in Cleveland, then the quality coefficient for Cleveland would not be reduced. However, if elephant impacts resulted in substantially greater loss of biodiversity on Cleveland, relative to the benchmark, then the quality coefficient would be lower. In addition, to elephant impacts, global climate change and degradation of the Olifants and Selati Rivers are external factors that threaten the biodiversity of both PMC lands and neighbouring protected areas.

Benchmark sites

Benchmark quality coefficients will be based on an average of the neighbouring conservation areas to account for the uncertainty in land-use if the area had not been managed by PMC. This will include an estimated average of neighbouring conservation areas, based heavily on Kruger National Park (KNP) directly adjacent to Cleveland. The benchmark sites will include different areas that contain the appropriate analogs for the major ecosystem types within Cleveland (i.e. koppies, riparian, and terrestrial). For koppies, there are 5 large koppies in KNP within 20km of the Cleveland boundary that are of similar size to the major Cleveland koppies, and numerous koppies in the Phalaborwa municipal area. For riparian, the stretch of the Olifants River directly downstream of Cleveland provides a good benchmark (at least for impacts not related to freshwater pollution). For the main terrestrial area and drainage lines, the area of KNP directly adjacent to Cleveland is suitable.

For Pompey, a quality coefficients will be calculated separately for the Pompey Protected area, the Pompey Unprotected Area and the Pompey Rehabilitation area. For the Protected and Unprotected areas, a research site in KNP at Malopeni will be suitable as a benchmark. This site is only 8km away, has an altitudinal difference of only 30m and some baseline ecological data for the site already exists. This approach will allow for a comparison of Pompey relative to a well protected conservation land-use as well as to a rural land-use that is typical of current conditions in the surrounding area.
For the Pompey Rehabilitation area, a nearby portion of the unmined Pompey Protected area will suffice as a benchmark. This particular Quality Hectare value will indicate the success of rehabilitation relative to the condition of the ecosystem before strip-mining began.

Components for Quality Coefficients

The Rio Tinto quality coefficient is based on the vegetation condition scores described by Parks et al (2003) [1], and originally derived for assessing the state of vegetation in Australian forest and heath ecosystems. This methodology has been modified here to create a set of conditions more appropriate to the semi-arid savanna ecosystems in the PMC region. The general approach, of using broad-scale measurements the structure of an ecosystem as a surrogate for biodiversity, has been maintained. This proposed components and formulae are offered here as an informed estimate, for discussion and amendment with regional experts. All members of the informal PMC specialist biodiversity stakeholder group, and any other relevant experts, will be invited to comment and improve these components and formulae

For the terrestrial ecosystems in **PMC Disturbed, Cleveland and Pompey**, the following components will be scored, and weighted according to the associated optimal value (some have a negative scale e.g. a greater cover of alien plants results is a smaller value):

Scale	Component	Max value (/100)
Site	Projected tree cover	10
	Density of tall trees	10
	Cover of perennial grasses	10
	Cover of herbaceous plants (dry season)	10
	Cover of alien plants	10
	Gully erosion along drainage lines	5
	Density of tall trees on Koppies[1]	10
	Width of Riparian patches (per km river)[1]	10
Landscape[2]	Patch size	10
	Neighbourhood	10
	Distance to core area[3]	5

[1]Cleveland only
[2] Parkes et al (2003)
[3] Cleveland will be used as the core area

A subset of the above will be used for the **Pompey Rehabilitation** area:

Scale	Component	Max value (/100)
Site	Projected tree cover	15
	Density of tall trees	20
	Cover of perennial grasses	20
	Cover of herbaceous plants (dry season)	15
	Cover of alien plants	15
	Gully erosion along drainage lines	15

For the **PMC Rehabilitation area**, a comparison of ecosystem structure (or composition) with benchmark sites is not appropriate, as the dumps and tailings dams that compromise these areas provide a unique topography and substrate that has no analogy in undisturbed areas. Successional processes will result in one or more novel ecosystems in this area that are unique to the region, rather than a convergence to an undisturbed state. Therefore, one cannot rely on the similarity of

[1] Parkes, D., Newell, G. & Cheal, D. (2003) Assessing the quality of native vegetation: the 'habitat hectares' approach. *Ecological Management & Restoration* **4**, S29-S38.

structure as an indicator of the state of biodiversity within these systems. Biodiversity will need to be measured directly, at least for selected taxa, or indicator species need to be derived. These data can then be evaluated against the same benchmark sites in KNP as above.

In addition to biodiversity, the ecological functioning of the rehabilitating ecosystems should be included in the calculation of the quality coefficient. While these ecosystems may never have the same composition or structure of the pre-mining state, ecological process could be restored to levels comparable to those in undisturbed areas. Thus with appropriate management, these novel ecosystems may come to resemble undisturbed systems in terms of the rate of critical ecological processes, such as primary production (the conversion of energy into biomass), secondary production (the conversion of plant biomass into animal biomass), regulation of water flows (infiltration, evapotranspiration and run-off), and nutrient retention and cycling (decomposition and soil mineralization). For the calculation of the quality coefficient, ecological variables that provide some indication of the rate of these key processes will be compared with the KNP benchmark sites. In addition, the landscape-scale components used above will again be used, as these are relevant to overall ecosystem integrity, regardless of the structure or composition of the systems.

The following components will be used as surrogate measures of biodiversity and key ecological processes, for each dump and dam within PMC Rehabilitation:

Scale	**Component**	**Associated ecological process**	**Max value (/100)**
BIODIVERSITY			
Site	Plant diversity (species richness & functional diversity)		8
	Bird diversity (species richness & functional diversity)		8
	Small mammal species richness		8
	Reptile species richness		8
	Dung beetle species richness		8
Landscape	Diversity of vegetation types		10
ECOLOGICAL PROCESSES			
Site	Herbaceous production	Net primary productivity	5
	Tree growth rates (stand level)	Net primary productivity	5
	Frequency of visits by large herbivores	Secondary productivity	5
	Dung beetle diversity (species richness, functional diversity)	Secondary productivity, Nutrient retention and cycling	5
	Patch & inter-patch sizes (herbaceous layer)	Regulation of water flow	5
	Occurrence of gulley erosion	Regulation of water flow	5
	Soil organic matter content	Nutrient retention and cycling	5
Landscape	Patch size[1]		5
	Neighbourhood		5
	Distance to core area[2]		5

[1] In this case, the extent of the slopes of a particular dump or dam

[2] Cleveland will be used as the core area

2. Restoration studies

In order to record progress in the restoration of the Rehabilitation areas, and to evaluate the success of any management interventions, it is proposed that a number of key variables be monitored repeatedly. Most of these will be derived from the Quality Hectares work described above, so that the sampling done in 2012 for the Rehabilitation areas will form the baseline of future restoration studies. While additional work may be required in future years, in response to different management actions, the following work would be repeated regularly following the initial Quality Hectares work:

- resampling of biodiversity, on a subset of sites – plants, birds, small mammals, reptiles and dung beetles (every 3 years)
- mapping of vegetation types (every 3 years)
- monitoring of large herbivore visits (annually)
- sampling of herbaceous production (annually – note that annual sampling is required for trend detection, due to high inter-annual variability)
- sampling of tree cover (every 3 years)
- landscape function analysis (LFA) – as done in 2011 (every 3 years)
- soil organic matter analysis (every 3 years)

3. Monitoring Biodiversity Features

The following Biodiversity Features included in the PMC BAP will be monitored at appropriate intervals to determine whether their integrity or abundance is changing over:

1. Koppies
2. Riparian zones of the Olifants and Selati Rivers
3. Rare and Threatened Species (10 bird species, Wild Dog, Hippopotamus, Matumi trees)
4. Bats

Koppies

The syenite koppies located on PMC mining area and Cleveland add significantly to the biodiversity of the PMC lands due to their unique plant and animal communities. The tree, forb and reptile communities are considered to be particularly important in this regard, as many species of these taxa that are found on these koppies do not occur in neighbouring protected areas. Monitoring will therefore focus on these groups. As elephant browsing poses an imminent threat to the tree communities of the koppies, monitoring of the tree layer will be done intensively. This will also serve to improve our understanding of the current and future effects of elephants on biodiversity in general. Sampling will include:

- Elephant damage, mortality and growth of dominant tree species (annually)
- Plant diversity (every 3 years)
- Reptile diversity (every 3 years)

Riparian zones

The riparian areas along the Olifants and Selati Rivers are small but contribute a disproportionately large amount to the overall biodiversity and ecosystem services of Cleveland. Monitoring is intended to detect changes in the overall integrity of these unique ecosystems. As for the Koppies, elephant pose a threat to his integrity, and intensive monitoring of the tree layer is included to gain a predictive understanding of impacts. Sampling will include:

- Elephant damage, mortality and growth of dominant tree species (annually)
- Extent and horizontal structure of riparian patches (every 3 years)
- Riparian vegetation structure - tree canopy cover and height distributions; herbaceous cover (every 3 years, and following major floods)

- Plant diversity (every 3 years)

Rare and threatened species

The species listed in the BAP as Biodiversity Features consist of 11 bird species, 2 mammal species (Wild Dog and Hippopotamus) and 1 plant species (Matumi). The bird and mammal species are highly mobile and have home ranges that extend beyond the boundaries of the PMC lands. The abundance of these species on PMC is therefore dependent on not only the persistence of suitable habitat on PMC lands, but also conditions in neighbouring areas. Similarly, the persistence of Matumi trees on PMC is dependent upon conditions in the Olifants and Selati Rivers upstream of PMC. Monitoring of these species on PMC alone is therefore of little value, or even contrary to PMC's biodiversity action plans, unless the status of these species in neighbouring areas can be established. For example, if the abundance of one of these species on PMC were to decline drastically, the management of PMC would be assumed to be responsible for the decline, unless it could be shown that cause originated beyond the boundaries of PMC. Likewise, it would be futile for PMC to initiate management actions to halt a decline of the species on PMC lands if the cause of the decline is external. Therefore it is important to monitor abundances of these species both within and outside of PMC lands. As for the Quality Hectares, this would include comparisons with benchmark sites (or rather populations) in KNP.

The following methods will be used for each species (or group of species):

- River birds (Pel's fishing owl, White-crowned lapwing, Saddle-billed stork, Yellow-billed stork, White-backed night-heron): surveys of occurrences and nesting sites (for Pel's fishing owl) along the Olifants and Selati Rivers on Cleveland, four times a year. Equivalent surveys on the Olifant's River in KNP for external data. Data will also be compared to the Pel's fishing owl surveys conducted both upstream and downstream of PMC by the Endangered Wildlife Trust.
- Southern ground-hornbill: annual survey of active nests on Cleveland and Pompey, making use of PMC ranger observations to locate new nests. Data will be compared to estimates of population trends of this species in KNP, obtained from the Endangered Wildlife Trust.
- Raptors (White-backed vulture, Hooded vulture, Martial eagle): annual count of active nests on PMC lands, again with assistance from rangers. For external comparison, average nest density will be sampled in an equivalent area of KNP (annually). Again ranger observations will be needed to guide sampling.
- Red-billed oxpecker and Yellow-billed Oxpecker:
- Wild dog: annual collation of sightings data from guides and rangers on Cleveland and Pompey. These data will be compared with sightings in a neighbouring area of KNP.
- Hippopotamus: annual counts on foot.
- Matumi: annual survey of population structure, including recording of any elephant damage, along the Olifants and Selati Rivers on Cleveland. Equivalent surveys on the Olifant's River in KNP for external data.

Bats

The current BAP does not indicate any particular bat species of concern, and research is needed to determine whether bats require dedicated monitoring. It is therefore proposed that a detailed bat survey be conducted in 2012 and the results used to review the importance of bats before continuing with long-term monitoring. The 2012 survey results will be used to establish the absence of any species which occur in the region and would be expected occur on PMC lands. This would provide an initial indication of the health of the bat community on PMC, and inform future monitoring work.

Workplan

2011 - 2012

The following table lists the various activities starting from October 2011 that would be required to complete the Quality Hectares project by the end of 2012. This also includes work that would form the first year of the long-term monitoring required for the Biodiversity Features and Restoration Studies projects. Costs of report writing are factored in, as is a non-profit administration fee. Interim reports would be provided on bi-annually, with a final report containing Quality Hectare values delivered in **December 2012**.

- Total costs amount to **R195 000** for the last quarter of 2011, and **R485 000** for 2012.

SAEON workplan for 2011 and 2012

Year	Quarter[1]	Activity	Required for: Project (variable)	Cost (R)
2011	4	Purchase camera traps (x 20)	Quality Hectares & Restoration Studies (large herbivore visits)	60 000
	4	Analysis of ARC veld condition survey of 2011	Quality Hectares (perennial grass cover)	3 200
	4	Dung beetle survey	Quality Hectares & Restoration Studies (dung beetle diversity)	81 600
	4	Bird survey	Quality Hectares & Restoration Studies & Biodiversity Features (bird diversity, red-billed oxpecker monitoring)	29 200
	4	Analysis of previous plant species surveys	Quality Hectares (plant diversity)	6 400
	4	Reptile survey	Quality Hectares & Restoration Studies & Biodiversity Features (reptile diversity)	0[2]
		Administration fee (8%)		14 432
		TOTAL		**195 000**
2012	all	Camera trap maintenance, analysis	Quality Hectares & Restoration Studies (large herbivore visits)	16 280
	all	Riparian bird surveys (x 4)	Biodiversity Features (river bird monitoring)	5 600
	1	Aerial photo analysis	Quality Hectares & Biodiversity Features (tree cover, landscape-scale metrics, riparian patch sizes, vegetation types)	40 000
	1	Vegetation transects	Quality Hectares (perennial grass cover, tall tree density, tree diversity, herbaceous cover, alien plant cover)	34 600
	1	Drainage line survey	Quality Hectares (alien plant cover, gully erosion)	3 360
	1	Analysis of LFA data from 2011	Quality Hectares (herbaceous patch structure)	3 200
	1	Herbaceous plant survey	Quality Hectares & Restoration Studies & Biodiversity Features (plant diversity)	46 300
	2	Herbaceous biomass measurements	Quality Hectares & Restoration Studies (herbaceous production)	19 640
	2	LFA survey	Quality Hectares & Restoration Studies (herbaceous patch structure)	71 600
	2	Tree plot monitoring	Quality Hectares & Biodiversity Features (tall tree density, elephant impacts)	30 800
	2	Tree size measurements	Quality Hectares (tree growth rates)	6 120
	2	Riparian tree transects	Biodiversity Features (riparian vegetation structure, Matumi monitoring, elephant impacts, plant diversity)	7 240
	3	Small mammal survey	Quality Hectares & Restoration Studies (small mammal diversity)	50 000
	3	Soil survey	Quality Hectares & Restoration Studies (soil organic matter)	34 360
	3	Bat survey	Biodiversity Features (bats)	60 000
	4	Collate ground-hornbill data	Biodiversity Features (ground-hornbill monitoring)	4 800
	4	Nest survey	Biodiversity Features (raptor monitoring)	5720
	4	Collate wild dog sightings data	Biodiversity Features (wild dog monitoring)	4 800
		Administration fee (8%)		35 682
		TOTAL		**485 000**

[1] Quarters: 1 = Jan-Mar, 2 = Apr–Jun, 3 = Jul–Sep, 4 = Oct-Dec

[2] Payment already received for 2011 failed survey – survey to be repeated with no additional cost

2013 onwards

Activities for 2013 and beyond would involve the annual to tri-annual measurements of monitoring variables required for the Biodiversity Features and Restoration Studies projects. About one third of the variables sampled in 2012 would repeated, and the remainder would only be repeated in 2014 or 2015, creating a staggered 3 year cycle. Deliverables would in the form of on-going annual or bi-annual reports, or according to specific requirements of PMC.

- Annual costs would amount to approximately **R230 000** for 2013 with similar costs for each subsequent year (subject to inflationary increases).

The following activities would be undertaken annually:

Activity	**Required for: Project (variable)**
Camera trap maintenance, analysis	Restoration Studies (large herbivore visits)
Herbaceous biomass measurements	Restoration Studies (herbaceous production)
Bird survey	Biodiversity Features (bird diversity, red-billed oxpecker monitoring)
Collate ground-hornbill data	Biodiversity Features (ground-hornbill monitoring)
Collate wild dog sightings data	Biodiversity Features (wild dog monitoring)
Nest survey	Biodiversity Features (raptor monitoring)
Riparian bird surveys (4 per year)	Biodiversity Features (river bird monitoring)
Riparian tree transects	Biodiversity Features (elephant impacts, Matumi monitoring)
Tree plot monitoring	Biodiversity Features (elephant impacts)

The following would be conducted every third year:

1st year of 3 year cycle	**Activity**	**Required for: Project (variable)**
2013	Reptile survey	Biodiversity Features & Restoration Studies (reptile diversity)
2013	Small mammal survey	Biodiversity Features & Restoration Studies (small mammal diversity)
2014	Plant survey	Biodiversity Features & Restoration Studies (plant diversity)
2014	Mapping vegetation types	Restoration Studies (diversity of vegetation types)
2014	LFA sampling	Restoration Studies (herbaceous patch structure)
2014	Soil sampling	Restoration Studies (soil organic matter)
2014	Tree cover survey	Restoration Studies (tree cover)
2015	Dung beetle survey	Biodiversity Features & Restoration Studies (dung beetle diversity)
2015	Riparian patch mapping (using aerial photography)	Biodiversity Features (riparian patch structure)
2015	Riparian transects	Biodiversity Features (riparian vegetation structure)