

## **1.0 EXECUTIVE SUMMARY**

### **1.1 INTRODUCTION**

This report comprises the findings of a study into the impact on vegetation in the Lower Ok Tedi and Middle Fly floodplain due to the operations of the Ok Tedi Mine. The study area is restricted to the catchment floodplain of the Ok Tedi below Iogi, and the Fly River between Kiunga and Everill Junction. The report deals with the actual vegetation dieback measurements, the classification of vegetation type within the floodplain and defines the potential extent of future dieback.

### **1.2 VEGETATION DIEBACK**

#### **1.2.1 Causes of Vegetation Dieback**

The most important factors affecting vegetation growth that lead to dieback conditions are:

- Root zone waterlogging from severe and prolonged inundation, resulting in anoxic conditions in the root zone with associated root death and canopy defoliation.
- Physical damage to plants from fast flowing water, including uprooting and destruction of seedlings and saplings and exposure and damage of roots.
- Sediment deposition which exacerbates anoxia and buries seedlings and smaller plants.

When a soil is flooded, gas exchange between the soil and air is drastically reduced. Shortly after a soil is inundated, micro-organisms consume practically all of the oxygen in the water and soil. The poor soil aeration associated with flooding induces a number of changes in the soil and in plants which adversely influence growth. Toxic compounds accumulate in waterlogged soils and shortly after flooding, plants exhibit sequential changes in metabolism and physiological processes. When flooding is prolonged most plants will die, although flood tolerance variability will result in differing response times. Depriving higher plant tissues of oxygen will in all cases lead to death. The length of time higher plants can survive without oxygen varies with species and conditions under which anoxia is imposed. The severity and duration of flooding influence plant disease incidence, and each disease manifests itself at a particular threshold of flooding severity. Flooding, particularly an increase in flooding frequency and duration, will greatly alter species composition in an environment. Specific findings include:

- Older trees generally tolerate flooding much better than seedlings or saplings.
- Flowing water both softens and washes away soil. As flooding continues, saplings may be pushed over, buried in mud, uprooted or floated away.
- The seeds of the majority of land plants will not germinate under water and will lose their vitality under such conditions. The flood tolerance characteristics of seedlings will determine species composition and occurrences in flooded sites.
- Flood tolerant species can absorb nutrients from waterlogged soils with no ill effects until soil reduction overpowers the capacities of the roots to oxidise reduced compounds and transform toxins to less harmful products. A lack of oxygen in the root environment causes an immediate decrease in nutrient uptake and redistribution of nitrogen from older to younger leaves. Intact roots will take up nutrients, under anoxic conditions, better than excised roots.
- Habitats that are prone to flooding usually support a distinctive flora. Rushes, sedges and reeds will predominate in permanently inundated areas. The predominance of monocotyledons in wetland plant communities, however, does not mean that this group has any special ability to survive without oxygen. A conversion to an aquatic community from a wetland plant community will occur when the depth of flooding increases to cover the grass canopy for an extended period or when the flood duration precludes the establishment of new root systems and oxidation of the soil.

The failure of trees to survive prolonged flooding during the growing season will vary greatly with duration of flooding, species and age of trees. Trees will not exhibit an immediate adverse response to “above threshold” flooding. The period of latency in manifestation of impact due to flooding will vary significantly between species, and can be from days to several years.

### 1.2.2 Dieback Flooding Thresholds

Flooding thresholds have been defined, in excess of which vegetation dieback conditions will manifest. Flooding thresholds, in terms of frequency, duration and depth, have been established for six vegetation communities. Floodplain flooding duration has been identified as the primary factor that will induce vegetation dieback.

**Table 1.1 Estimated Floodplain Inundation Thresholds for Vegetation Dieback**

	FREQUENCY	DURATION	DEPTH
Lowland Tropical Rainforest	20%	< 1 month	not applicable
Floodplain Forest (non-flood tolerant)	30%	1 - 6 months	not applicable
Floodplain Forest (flood tolerant)	40%	6 months	not applicable
Mixed Forest/Grass, Swamp Savannah	50%	6 months - 1 year	3 - 4 metres
Grass/Swamp (non-flood tolerant)	40%	1 - 6 months	3 - 4 metres
Grass/Swamp (flood tolerant)	97%	3 years	1.5 - 2 metres

One of the following processes will take place in the dieback affected zones as a function of the severity and duration of flooding.

- **Recovery** - where the original community was stressed and exhibited the first signs of anoxia, but where plants have not died. Once the flooding conditions fall below the threshold the community will recover to its original composition.
- **Conversion** - where the original community has died out and a more appropriate (more flood tolerant in the case of flooding impacts) community invaded.
- **Re-establishment** - where the original vegetation community recovers, by succession, after the period of adverse flooding impact.

### 1.2.3 Current Flooding Frequencies

Current and pre-mine flooding frequencies have been derived for the Ok Tedi/Fly River catchment. Based on the variability of flooding frequency at each site, as a function of topography, frequency ranges rather than a single estimate need to be assessed in determining the potential impact on vegetation.

**Table 1.2 Current Overbank Flooding Frequency Ranges**

	Pre-mine Frequency Range	Current Frequency Range
Konkonda (Lower Ok Tedi)	5% – 30%	20% - 85%
Kiunga (Upper Middle Fly)	15% - 45%	Similar to pre-mine
Kuambit (Middle Fly)	15% - 50%	40% - 70%
Obo (Lower Middle Fly)	20% - 95%	Similar to pre-mine

Flooding frequencies have increased significantly at both Konkonda and Kuambit during the period of Ok Tedi Mine operations. Flooding frequencies at both Kiunga and Obo remain relatively unchanged.

### 1.2.4 Current Dieback Extent

Vegetation dieback extent has been determined for the period to 10 January 1998. Dieback extent has been estimated from remotely sensed images (Landsat TM) and verified by extensive ground truthing. Dieback estimates for 1997 are as follows:

**Table 1.3 Dieback Estimates 1997**

ZONE	REGENERATION (km <sup>2</sup> )	DEFOLIATION (EARLY STRESS) (km <sup>2</sup> )	STRESS (km <sup>2</sup> )	DIEBACK (km <sup>2</sup> )	DIEBACK (EL NINO) (km <sup>2</sup> )	TOTAL (km <sup>2</sup> )
KONKONDA	15.5	7.3	12.1	31.0	-	<b>65.9</b>
D'ALBERTIS JUNCTION	-	17.3	30.9	70.7	-	<b>118.9</b>
UPPER FLY	-	8.0	31.2	11.3	-	<b>50.5</b>
WYGERIN	-	-	58.5	35.8	0.3	<b>94.6</b>
MABADUAM	-	-	29.5	8.3	67.6	<b>105.4</b>
MIDDLE FLY	-	16.8	24.4	1.5	-	<b>42.7</b>
<b>TOTAL</b>	<b>15.5</b>	<b>49.4</b>	<b>186.6</b>	<b>158.6</b>	<b>67.9</b>	<b>478.0</b>

A total of 478 square kilometres has been affected by vegetation dieback in the Ok Tedi/Middle Fly floodplain. For the purposes of dieback modelling the *Early Stress* and *Dieback (El Nino)* have been omitted, resulting in a total of 361 square kilometres.

Significant observations on the 1997 estimates include:

- Vegetation dieback has increased from 176 to 478 square kilometres in 1997.
- Dieback increase in the Lower Ok Tedi has slowed significantly. This is because the majority of the floodplain has already been impacted and further expansion will be restricted to the tributaries to the Ok Tedi.
- Dieback has been observed and monitored above D'Albertis Junction, on the Fly River, and extends to Kiunga. Although not reported in previous epochs, this area has not been monitored previously, and dieback in early stages may have existed prior to 1997.
- Dieback extent in the Middle Fly has increased in area six times since the 1996 evaluation. Although the magnitude was not expected, an increase was expected as the increased floodplain inundation conditions moved into the Middle Fly catchment. Although the ground truthing reported isolated dieback above Manda, the overall analysis has been restricted to Mabaduam due to difficulties in discriminating an "El Nino" impact from a "mine" impact.
- The area of land immediately north of Binge River is severely dieback affected. This area has been classified as *Dieback (El Nino)* as it was not possible to discriminate whether the dieback was mine induced or a function of the extensive fires during the El Nino drought. This area contributes 25% of the total Middle Fly dieback area.
- With the aid of ground truthing it has been possible to include zones of *early stress*. These are zones in which trees are exhibiting the first signs of anoxia intolerance. 10% of the total impacted area has been classified in this manner.

## 1.3 VEGETATION CLASSIFICATION

### 1.3.1 Species Composition

Papua New Guinea has some of the most species-rich terrestrial environments in the world. These environments are influenced by large variations in rainfall, altitude, soil and history of disturbance. The Lower Ok Tedi and Middle Fly catchment is subject to seasonal inundation, which has a dramatic effect on the distribution pattern of vegetation species. A complex pattern of fire, flood and drought maintains a naturally occurring changing vegetation regime.

The vegetation in the Lower Ok Tedi, the upper Middle Fly and the margins of the lower Middle Fly, comprises of lowland tropical rainforest and alluvial floodplain forest. In the middle of the catchment the swamp woodland savannahs predominate. The grass swamp zones dominate below Manda, although there are also isolated pockets in the middle reaches of the catchment. Below Manda, in the grassed floodplain, the vegetation regime ranges from permanent open swamps to dense mesophyll rainforest on the extensive levee systems.

### 1.3.2 Vegetation Classes

For the purposes of dieback prediction a detailed, species specific, classification is neither warranted nor practical. A broad class classification is required, which defines the fundamental vegetation communities. The vegetation classes defined comprise *Rainforest*, *Floodplain Forest*, *Mixed* (Floodplain Forest, Savannah and Grass/Swamp), *Grass/Swamp*, *Lakes* and *River*. The catchment floodplain comprises approximately 920 km<sup>2</sup> of rainforest, 2193 km<sup>2</sup> of floodplain forest, 1324 km<sup>2</sup> of mixed vegetation, 1084 km<sup>2</sup> of grass/swamp, 261 km<sup>2</sup> of lakes and 113 km<sup>2</sup> of river.

The area of the catchment floodplain is approximately 5,900 square kilometres. The sediment floodplain (that portion of the floodplain that the sediment laden water of the Ok Tedi and Fly River would flood) is approximately 2,400 square kilometres.

## 1.4 POTENTIAL FOR FUTURE DIEBACK

The prediction of future dieback extent is a complex process of analysis involving evaluation of:

- Future overbank flooding frequencies.
- Vegetation threshold levels, on the basis of flooding frequency, duration and depth.
- Spatial distribution of vegetation species within the catchment.
- Maximum impact areas for each zone or reach.

This report has aimed to define the latter three components, with estimated flooding frequencies deriving from the independent sediment transport study. All components are combined in the dieback modelling phase to give estimates of future dieback.

Maximum impact areas are the sub-areas of the catchment that could **potentially** be impacted by dieback given that the dieback threshold limits will be exceeded. The areas do not reflect a **predicted** dieback impact, although given that the critical threshold value is exceeded, the area will be impacted. It is feasible that certain sections of the maximum area will not be impacted if threshold values are not achieved.

The *Pessimistic* maximum impact area for dieback in the Ok Tedi/Middle Fly floodplain is 3789 km<sup>2</sup>, the *Expected* 2569 km<sup>2</sup> and the *Optimistic* 1883 km<sup>2</sup>. These estimates exclude the *Grass/Swamp* classification.