INTERNATIONAL ALUMINIUM INSTITUTE

Sustainable Development Series

Third Bauxite Mine Rehabilitation Survey

JUNE 2004
Website: http://www.world-aluminium.org
The information contained in this report is based upon data submitted by the operating companies which have participated in the survey and has not been verified by the IAI.
In 1991 and 1998, the International Aluminium Institute (IAI) commissioned surveys regarding bauxite mine rehabilitation programmes that had been undertaken by operations around the world. The aim in both cases was to provide data on the environmental impacts of bauxite mines and their rehabilitation programmes. In 2003, a third survey was carried out to follow up and extend the first two. The results of the 2003 survey are the subject of this document. Twenty-three operations, which mine 70% of the world's total production of bauxite, responded to the 2003 survey comprised of 2002 data. This compares to 65% in 1991 and 72% in 1998. While percentage coverage of world production was down, operations in only 8 countries were covered by the 1998 survey compared to 12 countries (including Russia) in 2002. In all but two countries (where specific company issues affected data reporting), the number of operations reporting remained equal or increased between the two surveys. Three mine sites (operated by a single company) in one country, which reported separately in the 1998 survey, reported combined data for 2002.

The survey shows that bauxite miners are making substantial efforts towards the sustainable development of the industry. In 2002, 83% of the total area mined was rehabilitated, compared to 79% in 1998. Operations, representing 97.2% of the total reported bauxite, have formal, written rehabilitation procedures compared with operations mining 88% of the reported bauxite in 1998 and 82% in 1991. Bauxite mining operations are continually striving to improve their environmental performance through formal frameworks (12 mines, representing 69% of reported production, have ISO 14001 certification), by employing specialist staff and by supporting environmental research and development projects. Operations are conserving and in many areas improving the natural capital of the areas in which they mine, through the identification of possible environmental impacts and by taking appropriate actions to monitor and minimise these impacts. For instance, 19 operations, representing 95% of reported bauxite production, monitor the quality of surface water leaving the mines, compared to 85% in 1998. Typically the minimisation of environmental impacts is achieved by setting environmental standards, often reinforced by legislation, and by developing environmental planning, training, management, monitoring and rehabilitation processes that enable the standards to be met. The success of various operations in developing innovative environmental management and rehabilitation techniques is shown by the number of awards these environmental programmes have amassed.

Bauxite miners are engaging with local communities and endeavouring to ensure that the benefits of mining are shared with present and future generations. Good environmental management and rehabilitation, which ensures that all potential land-use options are conserved, is one way in which the industry is meeting its responsibility to the wider, global community. Other ways in which the industry supports the maintenance and development of local communities are by:

- Providing well-paid employment under conditions that comply with accepted labour standards;
- Providing training opportunities;
- Supporting local businesses;
Supporting community initiatives;
Supporting various social programmes;
Building infrastructure that will benefit the communities into the future;
Providing compensation for those people who are disadvantaged or displaced by mining.

The amounts that the respondents spend on community projects annually are substantially more than those reported in the 1998 survey – US$904,000 for operations with a company town and US$130,000 for those without, compared to a mean figure of US$75,000 in 1998. Formal links between the community and the miners are a feature of most operations. These links empower communities by providing a forum through which they can have input to, and be kept informed of, significant decisions that may affect them. Most operations (19 mines, representing 86% of reported production) also have formal procedures through which community complaints can be addressed.

Industry groups will continue to promote the principle that all operators should adopt the existing best environmental practices of the industry. In addition, all operators will be encouraged to make further improvements in their environmental management and rehabilitation procedures and to continue to ensure that the benefits of mining are shared with existing and future populations in the communities in which they operate. Future surveys will show how successful industry groups have been at promoting the concepts of sustainable development and continuous improvement throughout the industry.

In order to give further encouragement to the process of continuous improvement, the IAI has established a Bauxite Mining and Alumina Refining Task Force to spread good practice throughout the global industry; to monitor critical performance data and to develop a possible voluntary objective. The IAI will also be monitoring performance in accordance with certain key indicators on a regular annual basis in addition to this periodic survey every four years.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>1</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>5</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>6</td>
</tr>
<tr>
<td>SURVEY RESULTS</td>
<td>9</td>
</tr>
<tr>
<td>MINE INFRASTRUCTURE</td>
<td>12</td>
</tr>
<tr>
<td>BIOGEOGRAPHY</td>
<td>14</td>
</tr>
<tr>
<td>GENERAL REHABILITATION</td>
<td>16</td>
</tr>
<tr>
<td>WILDLIFE AND FLORA PROTECTION</td>
<td>21</td>
</tr>
<tr>
<td>SOIL PROTECTION AND MANAGEMENT</td>
<td>24</td>
</tr>
<tr>
<td>REVEGETATION</td>
<td>26</td>
</tr>
<tr>
<td>ENVIRONMENTAL IMPACTS</td>
<td>29</td>
</tr>
<tr>
<td>LEGISLATION AND REGULATIONS</td>
<td>32</td>
</tr>
<tr>
<td>THE ECONOMIC AND SOCIAL DIMENSIONS</td>
<td>33</td>
</tr>
<tr>
<td>HUMAN RESOURCES</td>
<td>37</td>
</tr>
<tr>
<td>MINE REHABILITATION PROMOTIONAL ACTIVITIES</td>
<td>38</td>
</tr>
<tr>
<td>RESEARCH AND DEVELOPMENT PROJECTS</td>
<td>39</td>
</tr>
<tr>
<td>APPENDIX 1</td>
<td>41</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>41</td>
</tr>
</tbody>
</table>
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The aluminium industry makes a significant contribution to the global economy and to many individual national economies in over 30 countries. The International Aluminium Institute (IAI), the global forum of aluminium producers, currently has 26 member companies responsible for more than 75% of world primary aluminium production and a significant proportion of the world’s secondary production. The Institute’s Life Cycle Committee is working to develop an understanding of the positive and negative contributions that aluminium makes to the environmental and economic well being of the world’s population during the entire ‘life cycle’ of the material.

Aluminium Production and Life Cycle

In 1991 and 1998, the IAI commissioned surveys regarding the bauxite mine rehabilitation work carried out by operations around the world. Twenty-three bauxite-mining operations responded to the latest survey compared with 27 in 1998 and 18 in 1991 (three of the operations which reported in the 1998 survey reported combined data for 2002). Operations in four countries participated for the first time. The respondents account for 69% of the world’s production of bauxite as compared to 72% in 1998 and 65% in 1991.

Bauxite and Aluminium

After iron, aluminium is the world’s second most used metal. Aluminium production is growing as more and more applications are developed for this adaptable, durable and recyclable metal. All around the world, aluminium is in increasing demand. Aluminium has become a common and essential element in everyday life. The business traveller, the tourist and the freight company now depend on aluminium. The commercial aviation and space industries would never have achieved “lift off” without aluminium. Aluminium comprises around 65% of an Airbus A380’s structural weight.” In motor vehicles, the lower weight of aluminium reduces fuel consumption and emissions and improves safety through better vehicle handling and through better energy absorption in the event of a collision. Aluminium facilitates the construction of corrosion-resistant and low maintenance buildings. Aluminium in packaging preserves the quality of food and medicines, reduces waste and provides added convenience for users.
Aluminium's capacity to be recycled indefinitely, its resistance to corrosion and its wide range of uses more than compensate for the high-energy requirement of primary production. As well as this, recycling aluminium requires only 5% of the energy of primary production. Approximately one third of the world demand for aluminium is currently supplied from recycled aluminium alloys.

Bauxite, the raw material for the production of aluminium, is mined in many countries worldwide. Known reserves of high quality bauxite are sufficient to provide over 300 years supply. Aluminium compounds make up 7.3% of the earth's crust so there is little possibility that supplies will be exhausted. Most of the bauxite mined is refined into alumina using the Bayer process. Some of the alumina is used in the chemical and other industries but the majority is transformed into aluminium by the Hall/Heroult process. Four to six tonnes of bauxite are required to produce one tonne of aluminium metal. This is a modest use of mineral resources compared to many other materials. Bauxite mines usually operate for many decades and are mostly owned or associated with alumina and aluminium producers.

Sustainable Development

Since the 1992 United Nations Conference on Environment and Development, the bauxite industry, and the minerals industry in general, have increasingly seen the sustainable development model as the best framework for addressing the concerns of the industry and external stakeholders. The Bauxite Mine Rehabilitation Survey is encompassed within the IAI Global Aluminium Sustainable Development Initiative, which sets out a number of voluntary objectives or targets for member companies and uses 22 performance indicators to monitor the industry's environmental, economic and social performance. The most generally accepted definition of sustainable development is that of the Brundtland Commission (World Commission on Environment and Development 1987) that defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' A sustainable mining operation, therefore, is one that brings long-term social and economic benefits without causing lasting environmental damage or social dislocation.

Bauxite miners have been leaders in developing environmental management programmes and rehabilitation procedures for the minerals industry. In 1984 the United Nations Environment Programme issued a set of guidelines for the assessment of the environmental impacts of bauxite mines and alumina refineries, which has been used by many operations as an aid to developing their own procedures and standards.

Minimising the environmental impacts of mining, protecting and restoring biodiversity, and rehabilitating disturbed areas to maintain the full range of possible land-uses protects natural capital. Net benefits to local communities, regions and countries from bauxite mining can come from:
- Investment;
- Export earnings;
- Compensation payments;
- Federal, state and municipal tax payments;
- Employment;
- Education and training;
- The development of local industries and businesses;
- The development of infrastructure;
- The provision of health and other community programmes.

This survey documents the measures taken by bauxite miners to maintain natural capital and to provide a net social and economic benefit from bauxite mining to local, regional and global communities.
Global Aluminium Sustainable Development Initiative

Voluntary Objectives
1. An 80% reduction in Perfluorocarbon (PFC) greenhouse gas emissions per tonne of aluminium produced for the Industry as a whole by 2010 vs. 1990;
2. A minimum of a 33% reduction in fluoride emissions for the Industry as a whole per tonne of aluminium produced by 2010 vs. 1990. This target figure to be reviewed after 3 years;
3. A 10% reduction in smelting energy usage for the Industry as a whole per tonne of aluminium produced by 2010 vs. 1990;
4. A 50% reduction in the Lost Time Accident Rate and Recordable Accident Rate by 2010 vs. 2000 for the Industry as a whole, with a review of the 50% target in 2006;
5. Implementation of Management Systems for Environment (including ISO 14000 or equivalent certification) and for Health and Safety in 95% of Member plants by 2010;
6. Implementation of an Employee Exposure Assessment and Medical Surveillance Programme in 95% of Member plants by 2010;
7. The Industry to monitor its recycling performance globally and to use the data to establish a voluntary target. The Industry will develop a global action programme in support of the voluntary targets, thereby encouraging a significant increase in the volume of aluminium metal from old (post consumer) scrap;
8. The Industry will monitor annually aluminium shipments for use in transport in order to track aluminium’s contribution through light-weighting to reducing greenhouse gas (GHG) emissions from road, rail and sea transport.

Performance Indicators – Environmental
1. Global PFC emissions and average PFC emissions per tonne of aluminium produced;
2. Aluminium shipment to the transportation sectors;
3. Global annual total of old and new scrap recycled and the total of the resulting metal;
4. Fresh water consumption (m3 per tonne of aluminium produced);
5. The global percentage of plants with EMAS and/or ISO.14001 qualifications for environment as well as the global percentage of plants that have Health and Safety management systems in place;
6. Average land used for mining and percentage of mined areas rehabilitated annually;
7. Global SO2/BaP/Particulate emissions and average emissions per tonne of aluminium produced; Global SO2/BaP/Particulate emissions and average emissions per tonne of aluminium produced;
8. Global fluoride emissions and average fluoride emissions per tonne of aluminium produced;
9. The Global Energy Mix showing energy use, including renewable resources, for aluminium production;
10. Tonnes of bauxite residue deposited per tonne of alumina produced; tonnes of spent pot lining deposited per tonne of aluminium produced; percentage of bauxite residue and spent pot lining processed or re-used; tonnes of salt slag deposited from dross sent for processing by Member Companies, per tonne of aluminium produced;
11. Global GHG emissions (CO2 equivalents) and average emissions per tonne of alumina and aluminium produced;

Economic
12. Global primary aluminium and alumina production statistics;
13. Use of aluminium (as consumption per head of the population);
14. Contribution to GDP (measured as net-added value);
15. Total direct employment (to include an indication of the indirect employment multiplier effect);
16. Level of investment (to include new assets, maintenance, environmental protection and research and development);
17. The wages ratio (average aluminium wages as compared to the national average wages);

Social
18. The global percentage of plants with formal mechanisms for consulting the local community;
19. Percentage of plants with workforce training/education schemes and youth employment programmes. (Training performance/hour/person/year);
20. Community Initiatives to improve health, education, environment and the local community;
21. The global percentage of plants that have employee exposure assessment and medical surveillance programmes;
22. Global Recordable Accident Rate (number of recordable accidents per million working hours) and Global Lost Time Accident Rate (lost time accidents per million working hours).

Survey Methods
Twenty-three operations (respondents) in twelve countries, including, for the first time, Russia, completed the survey questionnaire between April and July 2003 regarding data from 2002. The total annual production of bauxite attributed to the respondents is 99.1 million dry tonnes. This compares with 27 respondents to the 1998 survey (producing 89.8 million dry tonnes of bauxite annually) and 18 respondents to the 1991 survey (producing 70.1 million dry tonnes of bauxite annually). The questionnaire consisted of 131 questions.

The results from the three surveys are not strictly comparable, because of some variation in the company participation in the three surveys. They do however show evidence of trends over time. The questionnaire can be found on the IAI website.
BAUXITE PRODUCTION

The greatest number of operations, including the six largest, began mining between 1960 and 1985. The oldest operation was established in 1916 and the most recent in 1998. The total annual production of bauxite by the 23 respondents is 99.1 million tonnes, 70% of the total world production of 141 million tonnes (United States Geological Survey 2002). The figure of 99.1 million tonnes is referred to as total reported bauxite in this document. More than 98% of the total reported bauxite is mined by open-cast/open cut methods. At one operation (0.5% of reported bauxite), all the mining is underground and at another two operations ore is mined by both underground and open cut methods. Most bauxite is produced by a few large operations. The largest operation mines 25 million tonnes of bauxite a year while the smallest operation mines only 112,666 tonnes. Five operations mine more than 6.5 million tonnes per annum compared with six in 1998 and five in 1991. The aggregate output from the five largest mines was nearly 70 million tonnes in 2002 (70.4% of the total reported bauxite), nearly 68 million tonnes in 1997 (73% of the total reported bauxite) and just over 54 million tonnes in 1990 (77% of the total reported bauxite).

There is no relationship between production rates of bauxite and extractable alumina content. The largest producer has one of the lowest available alumina contents, indicating that other factors are also important in determining the viability of an operation.

Bauxite mines operate for long periods of time. The mean expected life of the operations surveyed is a further 27.4 years (range 1-100 years), slightly less than the 32-33 years in the previous surveys. The mean expected lifespan of the operations from commissioning to closure is 64.2 years. The total reserves of bauxite at the reporting operations total around 4,231 million tonnes.

Large areas of land are under lease or concession for bauxite mining (Table 1). In total only around 9% of the lease areas are expected to be disturbed by mining. Most of the lands under concession or lease are owned by governments (Table 2). Four operations expect to disturb 1 km² (100 ha) or less, while five operations expect to disturb more than 50 km² (5,000 ha) - median 6.4 km² (639 ha). The largest operation, which produces 25 million tonnes of bauxite per annum, will disturb around 500 km² (50,000 ha) of land during its 110 year projected lifespan. The total area likely to be disturbed over the average lifespan of all the operations combined is 1,472 km² (147,225 ha). This area is substantial, but small when compared to areas disturbed for other purposes. For example, an estimated 4,700 km² (470,000 ha) of land was cleared in Australia in 1999 alone, mostly for agriculture and urban development (Australian Bureau of Statistics 2002) more than three times the total area likely to be disturbed during the life of all the reporting operations combined.
The area mined each year at the different operations depends on production rates and the depth of the ore bodies. Individual ore-bodies at different mines differ markedly in area. Most operations have ore-bodies of 0.02-0.54 km² (2-54 ha) and the median area for the 19 operations that provided mean values is 0.15 km² (15 ha). The largest ore-bodies are at an operation with a contiguous deposit of 350 km² (35,000 ha), two operations with average ore-body areas of 5-6 km² (500-574 ha), and two other operations that reported ore-bodies with areas ranging from 0.03-7 and 0.2-5.5 km² (3-700 and 20-550 ha). The total reported area mined is 20 km² (2,015 ha) per annum, compared with 14 km² (1,381 ha) in 1991 and 16 km² (1,591 ha) in 1998. Only five operations mine more than 1 km² (100 ha) per annum and a further five mine between 0.2 and 1 km² (20 and 100 ha). The median area mined is 0.2 km² (16.5 ha) per annum. The two largest operations mine 5.7 and 6.7 km² (572 and 673 ha) per annum and the smallest 0.01 km² (0.8 ha).

An average 4.92 dry tonnes of bauxite and 2.04 tonnes of available alumina are mined from each square metre on a production-weighted basis (49,199 dry tonnes of bauxite and 20,381 tonnes of available alumina per ha). In the 1991 and 1998 surveys the production-weighted means were 5.24 and 5.65 tonnes of bauxite per square metre (52,393 and 56,457 tonnes per ha). Some of the largest producers mine the lowest grade and/or thinnest ore deposits. In 2000 the average price of bauxite imported into the USA was US$23.09 per tonne (US Geological Survey 2002). Using this price, the average value of bauxite mined per square kilometre is US$114 million on a production-weighted basis (US$1.14 million per ha).

The average thickness of bauxite deposits varies from 2-30m. The median of 22 operations is 4.8m with the remaining operator reporting a range of 5-30m for their underground mine. Median overburden thickness at the 20 open-cut mines is 2.1 metres. Eight operations have an overburden thickness of 1m or less, six have 1-5m, four have 6-10m and two greater than 10m. The three underground mines reported overburden depths of 20-100m, 70-105m and 250-300m.

Many of the operations have been operating for decades and the median area cleared for mining and infrastructure to date is 4 km² (400 ha). The greatest area cleared is 200 km² (19,964 ha) by an operation that has been mining since 1962. The total area cleared, at the 22 operations that answered this question, is 522 km² (52,224 ha), corresponding to about 35% of the area expected to be cleared during the life of the current operations. 17.4% of the clearing has been for infrastructure and 82.6% for mine pits.
Beneficiating ore (improving its properties) reduces the amount of material that needs to be transported and refined. However, the benefits of beneficiating need to be weighed against the amount of energy and water used in the process and the need to dispose of the fine waste produced. Three sites enrich their ore by washing (22.3% of total reported production). Four sites dry 15-90% of their ore and two sites calcine 2.5% and 26.3% of their ore respectively (Figure 1). There has been a trend to less ore being beneficiated; nearly half the bauxite was beneficiated in previous surveys.
Mine Infrastructure

A total of 61 km$^2$ (6,130 ha) have been cleared for infrastructure, including transportation systems, at the 21 operations that answered this question - 17.4% of the total area cleared. Nearly 72% of this will eventually be rehabilitated. The area cleared for infrastructure has increased significantly since the earlier surveys - 19 km$^2$ (1,872 ha) was the reported figure in 1991 and 32 km$^2$ (3,244 ha) in 1998. One operation has cleared 20 km$^2$ (2,000 ha), substantially more than any other site – nine operations have cleared 0.6 km$^2$ (60 ha) or less and only six operations have cleared more than 4 km$^2$ (400 ha) for infrastructure. The operations with the largest clearing for infrastructure are also those where rehabilitation will be most delayed, 60 years for the operation with 20 km$^2$ (2,000 ha) cleared.

Transport distances to alumina refinery stockpiles or to shipping points range from less than 10 to more than 320 km. Twelve operations are 50 km or less from a shipping point or refinery, three are 51-100 km, one operation reported a transport distance of 2-120 km, three are 100-200 km and four further than 200 km. In 1998, the maximum was 135 km and most were in the range 10-30 km. In 1991, the maximum was 51 km and most were less than 10 km. The changes since the earlier surveys show both the effect of new operations coming online (and the inclusion of older operations that did not respond to earlier surveys survey) and the maturing of established operations that are mining bauxite reserves further from their associated refineries or shipping points.

Estimates of the average energy required to mine and transport bauxite from the 16 operating mines that reported a figure, give a mean value of 102 MJ per dry tonne of bauxite mined (range 13-231 MJ per tonne and median 78 MJ per tonne). Diesel fuel and fuel oil provide the bulk of the energy used to mine and transport bauxite (Figure 2).

Operators have adopted a number of strategies to use energy more efficiently and to reduce emissions, both of which are key factors in the improvement of environmental performance. These strategies include:

- Purchasing larger, more energy efficient mining equipment and trucks;
Indian Aluminium Company Ltd

The industry is committed to the continuous improvement of energy conservation in all areas and to a sustainable future. To this end, Indal has adopted a Corporate Energy Policy, through which the Company will strive to:

◆ Adopt cleaner and more efficient energy sources for all its operations;
◆ Reduce wastage and improve productivity to minimise energy consumption;
◆ Benchmark with the best-in-business and install systems and practices to match them;
◆ Recognise efforts of its employees and their family members in energy conservation initiatives;
◆ Create awareness and motivate all concerned in improving energy efficiency throughout the life cycle of aluminium products;
◆ Enhance use of renewable energy/waste heat, wherever feasible;
◆ Minimise transmission/transit losses;
◆ Incorporate energy efficient designs and technology in all future projects/acquisitions;
◆ Set up an effective Energy Performance Assurance process.
Nearly 98% of bauxite is mined in tropical regions and those with a Mediterranean-type climate (Figure 3). Bauxite is formed through the leaching of soluble minerals and so it is not surprising that mines are generally situated in areas of high rainfall (mean 1,487mm per annum). Fifteen operations, which mine 69.3% of the bauxite, monitor environmental conditions so that seasonal and climatic changes can be determined.

Most of the bauxite is mined on plateaux as found in previous surveys (Figure 4).

Nineteen operations reported details of the vegetation cover before mining; an additional three operations stated that the land was barren prior to mining. Various types of forest covered 65.9% of the land, averaged over the 19 operations. This is slightly less than was found in 1998 (75.5%). Native hardwood was the most common original vegetation type (40.9%) followed by tropical rainforest (15.0%) and native pasture (7.9%) (Table 3). In the 1998 survey the most common vegetation types were native hardwood (58.4%), tropical rainforest (14.5%) and native pasture (14.5%). The 19 sites for which pre-mining vegetation data were available represent more than 95% of the mean amount of land cleared for mining in the last five years. Assuming that the proportions of various pre-
mining vegetation types reported are applicable to these recently cleared areas, then 89.0% of the recently cleared land was forested before mining commenced and 8.1% was used for various forms of agriculture (Table 3).

Bauxite mines are generally located in areas where vegetation was not degraded before mining began (Figures 5 and 6).

<table>
<thead>
<tr>
<th>Original vegetation</th>
<th>Averaged over operations</th>
<th>Of the total area cleared</th>
</tr>
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<tbody>
<tr>
<td>Native hardwood forest:</td>
<td>40.9%</td>
<td>75.8%</td>
</tr>
<tr>
<td>Native softwood forest:</td>
<td>6.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Commercial hardwood forest:</td>
<td>2.1%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Commercial softwood forest:</td>
<td>1.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Tropical rain forest:</td>
<td>15.0%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Subsistence farming:</td>
<td>0.5%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Slash and burn farming:</td>
<td>5.0%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Native pasture:</td>
<td>7.9%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Commercial pasture:</td>
<td>0.8%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Agricultural crops:</td>
<td>5.0%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Livestock Pasture:</td>
<td>3.5%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Urban development:</td>
<td>2.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Tilled agriculture:</td>
<td>1.6%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Wetland vegetation:</td>
<td>5.3%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Shrub land:</td>
<td>2.4%</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

Table 3: The proportion of various vegetation types that covered areas cleared for bauxite mining.
General Rehabilitation

A sustainable mining operation maintains the natural capital of the area in which it operates and rehabilitation of disturbed areas is an essential element of this process. Successful rehabilitation ensures that bauxite mining is a temporary land-use that does not compromise other land-uses in the long-term.

Integrating rehabilitation with mining reduces its environmental impact in a cost-effective manner. Eighteen operations, producing 83.9% of the reported bauxite, run rehabilitation programmes that are integrated with their mining activities. Integration is effected in a number of ways at different operations by:

- Integrating rehabilitation into mine plans;
- Making rehabilitation the responsibility of production staff and including rehabilitation targets in their performance appraisals;
- Linking rehabilitation contracts to mining contracts;
- Government regulation.

All operations have clearly defined rehabilitation objectives. These objectives include:

- Restoring pre-mining ecosystems with their ecological and other values intact;
- Establishing self-sustaining ecosystems of native plant and animal species;
- Restoring original land-uses;
- Rehabilitating to new land-uses to benefit local communities.

Considerable financial resources are committed to rehabilitation at most mines. The mean cost of rehabilitation for the 19 operations that responded to this question is US$1,196,600 per km$^2$ rehabilitated (US$11,966 per ha) and the median US$590,000 per km$^2$ rehabilitated (US$5,900 per ha). The mean amount spent per tonne of bauxite is US$0.11.

Twenty-one operations, which mine 97.2% of the total reported bauxite, have formal, written rehabilitation procedures compared with operations mining 88% of the reported bauxite in 1998 and 82% in 1991. These formal procedures cover the mine pits and the infrastructure for fifteen operations while at six they only cover the mine pits. Fifteen operations, accounting for 71.6% of production, have a long-term plan or ‘Walk Away Plan’ for their mine areas, that aims to leave a self-sustaining system with realistic land-use options in place when all mining operations have been completed. In 1998, all but one operation (85.6% of production) reported having a ‘Walk Away Plan’ compared with slightly more than half (68% of production) in 1991. Nineteen respondents, who are responsible for mining 94.6% of the total reported bauxite, have made financial provision for rehabilitating all the disturbed land and for the final decommissioning and closure of mines and associated infrastructure.

Government standards are strong drivers of mine rehabilitation efforts. Local company standards, national or international company standards, local community expectations, national community expectations, and local and international non-governmental organisations are other important influences in developing rehabilitation programmes.

The first rehabilitation undertaken by any of the
respondents in this survey was in 1965. The most recent operation to initiate rehabilitation (in 1999) was a mine established in 1997. A total of 282 km\(^2\) (28,245 ha) have been rehabilitated to date at 22 operations. Most operations rehabilitate disturbed areas progressively as they become available. Some operations have a backlog of areas to rehabilitate (Figure 7) but these may include large areas cleared for infrastructure that cannot be rehabilitated until mining is completed.

The average area rehabilitated at the reporting operations is 0.7 km\(^2\) (73 ha) but this figure is dominated by the three operations that rehabilitated more than 2 km\(^2\) (200 ha) per year. The median area rehabilitated is only 0.1 km\(^2\) (12 ha) per year. There is an agreed end land-use for rehabilitated areas at 16 operations (81.9\% of bauxite production). These agreements have been made with:

- Traditional owners;
- Landowners;
- Federal, state and municipal government agencies and regulators;
- Local communities;
- Non-government organisations with an interest in conservation.

Areas disturbed by mining are mostly rehabilitated to the original land-use. Almost all the areas rehabilitated to date have been returned to forest (79.9\% to native hardwood forest and 10.3\% to tropical rainforest). Commercial forestry and agricultural crops are important land-uses for rehabilitated land at some operations, but are minor land-uses in terms of the total area rehabilitated by the worldwide industry (Table 4). The proportion of the land rehabilitated to agriculture, averaged over all operations, is 12.6\% compared with 17.1\% in 1998.

The largest operation reported rehabilitating more than 6 km\(^2\) (600 ha) of land a year for the five years 1998-2002.
Seventeen operations, accounting for 93.4% of reported bauxite production, have monitoring and reporting programmes to assess the strengths and weakness of their rehabilitation efforts formally. Twelve of these operators (88.0% of reported production) have established plots that will be repeatedly monitored over time to study the ecology and development of rehabilitated areas.

One of the aims of sustainable development is the minimisation of resource consumption. Vegetation from areas cleared for mining is salvaged for use by 15 operations (72.5% of total reported bauxite production). Products harvested from areas to be mined include saw logs, firewood for domestic and industrial use, and fence posts. Vegetation is mulched and applied to areas undergoing rehabilitation, as well as being spread over rehabilitated areas as seed sources and as animal habitats. Efforts are being made by a number of operators to find further uses for the pre-mining vegetation (such as distribution of timber among the local population) and to reduce the amount that is burnt or buried during clearing.

Seven of the 16 operations that responded to the question (58.0% of total reported bauxite production) reported that they have burned an average 72.9% of the pre-mining vegetation.

Education of the mining workforce is an important way of instilling environmental awareness in employees and contractors. Seventeen operators, who between them mine 81.1% of the total reported bauxite, have an environmental awareness and training programme for their rehabilitation workforce. Programmes at most operations are not restricted to rehabilitation concerns and rehabilitation workers but include all the environmental aspects of the mining operation and are undertaken by all mine employees and contractors. Programmes range from an introductory one-hour session on important local issues, to comprehensive and ongoing training sessions in topics such as forest hygiene, spill management, waste management and basic environmental awareness programmes.

<table>
<thead>
<tr>
<th>Rehabilitation land-use</th>
<th>Averaged over operations</th>
<th>Of the total area rehabilitated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native forest:</td>
<td>47.0%</td>
<td>79.9%</td>
</tr>
<tr>
<td>Commercial forest:</td>
<td>11.4%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Tropical rain forest:</td>
<td>25.0%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Subsistence farming:</td>
<td>1.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Native pasture:</td>
<td>3.4%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Commercial pasture:</td>
<td>1.7%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Agricultural crops:</td>
<td>6.0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Industrial or urban development:</td>
<td>3.2%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Wetland vegetation:</td>
<td>0.1%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Recreational areas:</td>
<td>0.4%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Shrub land:</td>
<td>0.3%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Other</td>
<td>0.3%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

Table 4: Proportion of the area cleared for mining rehabilitated to various land-uses.
Planning is the key to successful rehabilitation. Most rehabilitation planning and monitoring is carried out by company employees; however, earthworks construction and vegetation establishment processes are shared between employees and contractors (Figure 8). Rehabilitation procedures comprise up to 40% of the total man-hours worked at the 14 bauxite-mining operations that responded to this question. The mean proportion of total man-hours taken up by rehabilitation is 11.5% and the median is 5.5%.

![Figure 8: Mean proportion of rehabilitation work done by company employees and contractors (two operations did not provide data)]
CASE STUDY: Companhia Geral de Minas Poços de Caldas Mine Rehabilitation Methodology

In 1978 Companhia Geral de Minas, a subsidiary of Alcoa (CGM/Alcoa), began rehabilitation work in mined-out bauxite areas in Poços de Caldas, Minas Gerais, Brazil. Final land use is based on water resources, topography, soil, silviculture and principally environmental characteristics that were present before mining began. The methodology adopted by the company for mine rehabilitation takes into consideration those aspects related to function: physical recovery (water and soil) and visual attributes; and form: recovery of biodiversity (natural succession of plants and wildlife).

The principal mitigation measures that compose Alcoa’s environmental management plan are:
- A surface drainage system and retention of runoff sediments;
- Suppression of dust caused by trucks and machines on roads and in operational areas with the use of water trucks;
- Control of emissions from truck diesel engines through rigorous engine maintenance and control programme;
- Post-mining surface regarding and recomposition of the landscape;
- Establishment of plants;
- Environmental monitoring.

At the completion of mining the terrain is regraded to maintain the same aesthetics of the natural landscape prior to mining promote water infiltration and the natural succession of plants. After regrading, topsoil is distributed uniformly over the surface in order to revitalize biologic activity and to promote a new cycle of nutrients.

The region’s soils have low natural fertility and so fertilizers are used. The holes dug for tree seedling planting are filled with a mixture of cattle manure, inorganic fertilizer, and soil. In areas where it is applicable, sub-soiling is executed to aerate the surface layers and to incorporate lime and other materials, such as organic-rich soil.

To promote plant cover the grass and legume species presently used by the company are selected for their capability to cover the surface rapidly, without acting as competition to tree seedlings that are to be planted. The tree species to be used are selected in accordance with tree surveys performed in mining concessions that are representative of the whole region.

Thirty days after planting the area is checked and dead seedlings substituted by a seedling of the same species, or by another of at least the same ecological group. Periodic inspections are made to correct those species that do not propagate. Native tree seedlings are produced in the company’s nursery in order to meet the demands of the rehabilitation programme and for donation to the local community.

Ants are the principal pest for young trees and are responsible for major damage to growth after planting. The entire planted area and adjacent areas are checked for ants during the initial periods of tree seedling growth.

Hoeing or weeding by hand around the planted seedlings is done twice a year in March and November.

Shelters, consisting of piles of forest vegetation cut before mining, are built to attract and provide a refuge for wildlife.

Fire lanes are opened around the borders of rehabilitated areas, undisturbed native forests, areas under legal permanent preservation restrictions and Private Natural Heritage Reserves.

A monitoring programme acts to identify problems and to measure the success of the areas rehabilitated by the company. Ecological factors evaluated include: the return of wildlife, nutrient recycling, seed banks, natural plant regeneration, and plant development. The monitoring of waterways has been undertaken since 1983, collecting and analyzing monthly data on colour, pH, turbidity, settled solids and suspended solids.

The company’s experience constituted one of the foundations for the elaboration of the first Revegetation Manual of Areas Disturbed by Mining in Brazil (IBAMA, 1990) issued by the federal environmental control agency. Initiatives implemented by CGM/Alcoa were the object of a number of studies, including six doctoral theses and sixteen masters theses. CGM/Alcoa was one of the first mining companies in Brazil and the first world-wide Alcoa mining location to receive ISO 14001 certification.
Wildlife and Flora Protection

Sixteen operations (60.4% of reported bauxite production) reported that they do not impact on any areas within the International Union for the Conservation of Nature (IUCN) Protected Areas Management Categories I-VI. Only two operations impact on any of the four highest IUCN Protected Areas Management Categories. These areas are managed mainly for wilderness protection and operate under a high degree of environmental control. Both sites have ISO 14001 certification. Six other operations, which mine a substantial proportion of the total reported bauxite, impact on lower categories of protected areas and this has been a significant driver for the development of environmental management best practices within the bauxite mining industry.

It is recognised that, in order to protect rare species and ecosystems, some areas should not be mined. Four of the seven operations, mining in areas that come within the IUCN Protected Areas Management Categories I-VI and six other operations (53.0% of reported production in total), have forgone part of the bauxite resource to protect biodiversity. One respondent estimates that 33% of the bauxite reserves have been forgone; two other operations estimate that they have forgone 10% and 26% respectively.

Other measures that have been taken to protect areas of native flora at 12 operations (72.4% of production) include:
- Establishing flora reserves on other company-owned land;
- Providing alternative cooking fuels to indigenous people to reduce the felling of trees for firewood;
- Relocating plants growing in cleared areas;
- Leaving strips or islands of native vegetation within mining areas;
- Providing financial and other aid to groups with an interest in conservation;
- Minimising unnecessary clearance.

Apart from quarantining areas from mining, seven operations (61.9% of production) have taken steps to retain existing wildlife habitat and 11 operations (84.9% of production) have taken specific actions to re-establish habitat as part of their rehabilitation efforts. These actions include:
- Reconstructing fauna habitats using rocks and logs taken from areas being cleared for mining;
- Providing fauna nesting boxes in rehabilitated areas;
- Using native plant species for rehabilitation.

Native fauna populations are monitored at four of the largest operations (52.9% of production) both within the rehabilitated areas and within the unmined portion of the mining concession or lease.
Mineração Rio do Norte Trombetas
Rescue of Epiphytes

Mineração Rio do Norte (MRN) is located in the west of the State of Pará, on the Trombetas River, County of Oriximiná, Brazil.

Since mining operations commenced in 1979, MRN has sought a reforestation model as close as possible to the original Amazon forest. This is a difficult task since very few species have ever been studied.

For this reason, MRN uses native tree species typical of the region in its reforestation activities, following a forest inventory carried out prior to deforestation. Up to April 2003, 5,000,000 trees of 600 species had been planted on approximately 20km².

The choice of tree species is made on the assumption that the most suitable varieties are those that attract the greatest number of fauna species, which in turn scatter the seeds of other flora species, further enriching biodiversity.

The following reforestation quality indicators are monitored:
- Soil chemical, physical and biological characteristics;
- Avifauna (birds);
- Entomofauna (insects);
- Herpetofauna (reptiles and amphibians);
- Mammalian fauna;
- Growth and mortality of the trees planted;
- Vegetal succession.

From the evaluation of older reforestations it was observed that, even with favourable shading conditions for Epiphytes growth, such species were lacking and this concern drove MRN to develop a rescue project for them. Epiphytes are plants that grow above the ground surface, using other plants as hosts, in order to gain better access to sunlight.

The purpose of the work at MRN was to expand the knowledge on Epiphytes scattering, degree of occurrence, light requirement, forest stratum and blossoming period; to identify and record the species found on the deforestation areas, on which to ground rescue and inclusion of such species in MRN’s reforestation areas; and to increase further the knowledge of the flora in the region.

**METHODOLOGY**

1) **Species’ collection, transportation, accommodation and propagation**
Collection is carried out soon after the trees are felled. The Epiphytes are packed in nylon bags and sent to the botanical garden where they are set inside host coconuts and grouped according to their collecting site. The coconut fibre is efficient in promoting rooting and settling of the transplants. Propagation happens after the blossoming of each species as the seeds ripen.

2) **Identification of species:**
Species identification is based on bibliographic sources, as well as on species available at the MRN botanical garden, already identified with the support of INPA – Instituto Nacional de Pesquisas da Amazônia (National Institute for Amazon Region Research) and Emilio Goeldi Museum.

3) **Inclusion of the collected species in MRN’s reforested areas:**
This stage takes place after proper rooting of the transplants to the coconut and during the rainy season to ensure their survival. The areas that receive the transplants are selected on the criteria of luminosity and presence of the transplant species’ preferred host plants. Such criteria were defined in surveys carried out in 2001 on the Almeidas Plateau and on the basis of publications related mainly to the Orchidaceae family. Pre-selected portions of the plants are tied to the host trees.

4) **Monitoring Activities:**
The survival rate, growth and spread of the species are monitored on a semestral basis. Spread figures are obtained by counting the plants in a progressive radius around the hostess-trees at 50 metre intervals.
Bushwhackers carrying bags containing Epiphytes rescued from areas that will be deforested.

Orchid being rescued prior to deforestation

Rescuing activities on deforested areas.
Soil Protection and Management

Sustainable mining operations protect and restore the biodiversity of the areas they affect. Restoring pre-mining biodiversity requires areas to be protected from erosion and for the original topsoil to be managed to retain its value as a seed source and growing medium. Eighteen operations (92.2% of reported bauxite production) reported that they separate the topsoil from the remaining overburden and retain it for use in rehabilitation. Topsoil is most valuable, as a source of seed, nutrients, organic matter and beneficial micro-organisms, when it is fresh. The median topsoil storage time of only nine months shows that miners recognise this fact. Several operations remove topsoil from areas being cleared and replace it immediately on rehabilitation areas. One operation stores the topsoil for an average of 10 years. This operation cleared 20 km² (2,000 ha) for transportation and infrastructure and it is likely that the long soil storage times at this operation are related to specific issues associated with ore transport and infrastructure.

Nineteen operations, accounting for 91.4% of total reported bauxite production, reshape their mined land. Reshaping blends mined areas into the surrounding landscape, reduces the likelihood of erosion, by reducing slope angles and lengths, and allows natural drainage patterns to be re-established.

Despite being located in areas with heavy seasonal rainfall, most operations rate the erosion risk at their mines as low. This is due to effective mitigation measures, which prevent soil loss during clearing, mining and stockpile storage. These include:

- Building structures to retain runoff water;
- Preventing water running on to disturbed areas or soil stockpiles;
- Vegetating soil stockpiles;
- Constructing banks, channels or ditches to control water flow.

Various measures are taken to retain topsoil on rehabilitated areas before the vegetation has grown sufficiently to protect the soil (Table 5).

Table 5: Measures taken to prevent the loss of topsoil from rehabilitated areas

<table>
<thead>
<tr>
<th>Measures taken</th>
<th>Number of operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contour ripping</td>
<td>12</td>
</tr>
<tr>
<td>Terracing</td>
<td>9</td>
</tr>
<tr>
<td>Contour banks</td>
<td>8</td>
</tr>
<tr>
<td>Dams</td>
<td>3</td>
</tr>
<tr>
<td>Hydroseeding</td>
<td>1</td>
</tr>
<tr>
<td>Drainage design</td>
<td>14</td>
</tr>
<tr>
<td>Shape Design</td>
<td>14</td>
</tr>
<tr>
<td>Silt Traps</td>
<td>7</td>
</tr>
<tr>
<td>Sumps</td>
<td>12</td>
</tr>
<tr>
<td>Mulching</td>
<td>6</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
</tr>
</tbody>
</table>

While the soils on areas mined for bauxite are often infertile, no operations reported having soils with sodicity, salinity or chemical toxicity problems (Table 6). Soil compaction during mining and rehabilitation is identified as the main adverse soil factor affecting the growth of plants.
At Alcoa World Alumina Australia’s Huntly and Willowdale Mines in Western Australia, rehabilitation commences with re-shaping of the 2 to 5m high pit walls to a maximum slope angle of 18 degrees. Recontouring of the mined-out pits aims to mimic the original, natural landscape. The overburden, which is stripped separately from the topsoil and usually stockpiled nearby, is then respread. Topsoil is then returned from newly cleared areas (a practice called direct return) or from stockpiles of topsoil when there is no opportunity for direct return. Direct return of fresh topsoil enhances the return of viable seeds, nutrients, organic matter and beneficial soil micro-organisms. To maintain these important soil properties at the surface, the topsoil is stripped and returned in as thin a layer as possible, generally 10 to 15cm.

Following topsoil return, a few tree stumps, logs and rocks are returned to the mined areas to provide habitat for fauna. The ground is then ripped to a depth of 1.5m. Ripping is carried out in summer and autumn to maximize shatter of the compacted subsoil. Contour lines at 3 to 5m vertical intervals are surveyed and marked in the field and ripping accurately follows the contours. The ripping creates furrows approximately 0.4m in height and 1.5m wide. The contour furrows are critical for preventing rainfall runoff and soil erosion.

### Table 6: Soil factors after mining that might restrict plant growth

<table>
<thead>
<tr>
<th>Soil factor</th>
<th>Number of operations</th>
<th>% of production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity</td>
<td>4</td>
<td>5.3%</td>
</tr>
<tr>
<td>Sodicity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Salinity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Chemical toxicity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Waterlogging</td>
<td>6</td>
<td>35.3%</td>
</tr>
<tr>
<td>Low water holding ability</td>
<td>7</td>
<td>32.3%</td>
</tr>
<tr>
<td>Soil compaction</td>
<td>12</td>
<td>72.5%</td>
</tr>
<tr>
<td>None identified</td>
<td>8</td>
<td>20.3%</td>
</tr>
</tbody>
</table>

At Alcoa World Alumina Australia’s Huntly and Willowdale Mines in Western Australia, rehabilitation commences with re-shaping of the 2 to 5m high pit walls to a maximum slope angle of 18 degrees. Recontouring of the mined-out pits aims to mimic the original, natural landscape. The overburden, which is stripped separately from the topsoil and usually stockpiled nearby, is then respread. Topsoil is then returned from newly cleared areas (a practice called direct return) or from stockpiles of topsoil when there is no opportunity for direct return. Direct return of fresh topsoil enhances the return of viable seeds, nutrients, organic matter and beneficial soil micro-organisms. To maintain these important soil properties at the surface, the topsoil is stripped and returned in as thin a layer as possible, generally 10 to 15cm.

Following topsoil return, a few tree stumps, logs and rocks are returned to the mined areas to provide habitat for fauna. The ground is then ripped to a depth of 1.5m. Ripping is carried out in summer and autumn to maximize shatter of the compacted subsoil. Contour lines at 3 to 5m vertical intervals are surveyed and marked in the field and ripping accurately follows the contours. The ripping creates furrows approximately 0.4m in height and 1.5m wide. The contour furrows are critical for preventing rainfall runoff and soil erosion.
All 21 operations that responded to the question reported using at least some native plant species for rehabilitation. Native tree and shrub species are widely used by operations that produce 74.1% of the reported bauxite and used to some extent by operations that produce a further 18.7% of the reported bauxite (Table 7). The majority of operations also use native herbaceous species for rehabilitation. Only two small operations use non-native tree or herbaceous species extensively in their rehabilitation.

Table 7: Vegetation establishment practices on rehabilitated bauxite mines

<table>
<thead>
<tr>
<th>Practice</th>
<th>Parameter</th>
<th>Some</th>
<th>Widely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of indigenous (native) trees or shrub species</td>
<td>Number of operations</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>18.7%</td>
<td>74.1%</td>
</tr>
<tr>
<td>Use of exotic (non native) trees or shrub species</td>
<td>Number of operations</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>33.5%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Collection and use of native seeds that self-propagate</td>
<td>Number of operations</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>15.7%</td>
<td>71.1%</td>
</tr>
<tr>
<td>Replacement of seed-bearing topsoil</td>
<td>Number of operations</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>14.9%</td>
<td>61.8%</td>
</tr>
<tr>
<td>Use of cover or nurse crops</td>
<td>Number of operations</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>13.9%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Use of indigenous herbaceous species</td>
<td>Number of operations</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>3.4%</td>
<td>61.8%</td>
</tr>
<tr>
<td>Use of exotic herbaceous species</td>
<td>Number of operations</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>% of production</td>
<td>13.6%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Ten operations (53.8% of reported bauxite production) run nurseries to propagate and grow native plant species. The median number of plants grown is 32,500 per year, the mean 125,000 per year and the maximum 700,000 per year. Native species are also established on rehabilitated areas via the sowing of seed and the replacement of topsoil. The contribution of these methods to the total diversity of plant species on rehabilitated areas varies widely. The mean proportion of the total species numbers established on rehabilitated areas is 66.3% from the planting of seedlings, 16.5% from the broadcasting of seed and 17.2% from topsoil seeding.

Nineteen operations (producing 94.0% of the total reported bauxite) reported applying inorganic or organic fertilisers or both to rehabilitated areas. Phosphorus is the most widely applied nutrient but nitrogen, potassium and micro-nutrients are also used extensively (Table 8). Mulch, lime and gypsum are applied to rehabilitated areas at a minority of operations.

Table 8: Nutrients and other ameliorants applied during rehabilitation

<table>
<thead>
<tr>
<th>Ameliorant</th>
<th>Application</th>
<th>No. of operations</th>
<th>% of reported bauxite production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Major</td>
<td>4</td>
<td>31.3%</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
<td>9</td>
<td>28.4%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Major</td>
<td>6</td>
<td>49.9%</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
<td>9</td>
<td>37.9%</td>
</tr>
<tr>
<td>Potassium</td>
<td>Major</td>
<td>5</td>
<td>32.8%</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
<td>6</td>
<td>24.5%</td>
</tr>
<tr>
<td>Micronutrients</td>
<td>Major</td>
<td>1</td>
<td>25.2%</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
<td>7</td>
<td>36.0%</td>
</tr>
<tr>
<td>Organic manures</td>
<td>Major</td>
<td>8</td>
<td>6.1%</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
<td>3</td>
<td>13.6%</td>
</tr>
<tr>
<td>Mulch</td>
<td>Slight</td>
<td>5</td>
<td>14.0%</td>
</tr>
<tr>
<td>Lime</td>
<td>Major</td>
<td>3</td>
<td>6.1%</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
<td>1</td>
<td>12.4%</td>
</tr>
<tr>
<td>Gypsum</td>
<td>Slight</td>
<td>2</td>
<td>10.5%</td>
</tr>
</tbody>
</table>

Rehabilitation can only be considered successful and sustainable if it is resilient to natural disturbances like fire and floods. Seven operations (53.2% of bauxite production) have had revegetated areas subjected to...
wildfires or prescribed burning. Most reported that only minor damage was done to the vegetation and that it recovered well afterwards. One operation reported that its rehabilitation areas are resilient to fire after around eight years. Only one operation (11.4% of production) has had revegetated areas subjected to flooding, the vegetation incurred only minor damage.

Most operations monitor the development of rehabilitation areas (Table 9). Vegetation density and cover are the most widely monitored parameters. A considerable proportion of the industry carries out more time-consuming and complex studies, such as biomass and seed production. Other studies conducted by, and for, some operations have investigated forest litter build-up, soil nutrient levels, soil development, nutrient cycling, soil fauna recolonisation and fungal recolonisation.

Table 9: The number of sites that monitor various rehabilitation parameters and the proportion of the total reported bauxite they represent. One operation reported that none of these parameters was monitored. One other operation has not yet carried out any rehabilitation and one operation did not respond to the question.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No. of operations</th>
<th>% of bauxite production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation density</td>
<td>17</td>
<td>89.9%</td>
</tr>
<tr>
<td>Vegetation cover</td>
<td>14</td>
<td>86.3%</td>
</tr>
<tr>
<td>Biomass production</td>
<td>6</td>
<td>42.6%</td>
</tr>
<tr>
<td>Native seed production</td>
<td>7</td>
<td>42.1%</td>
</tr>
<tr>
<td>Wildlife habitat</td>
<td>6</td>
<td>48.4%</td>
</tr>
<tr>
<td>Similarity to pre-existing vegeta</td>
<td>15</td>
<td>76.7%</td>
</tr>
</tbody>
</table>
Mineração Rio do Norte (MRN) is the largest producer of bauxite in Brazil. Since the beginning of its operations in 1979, MRN has been concentrating its efforts on the minimisation of its environmental impact by tackling the following five issues:

- Prohibition of hunting in the areas of influence of the industrial complex;
- Rehabilitation of mined-out areas;
- Elimination of solid particle emissions from bauxite drier chimneys;
- Disposal of bauxite beneficiation tailing;
- Rehabilitation of Batata Lake.

The reforestation of the mined-out areas is carried out exclusively using species native to the region, with seeds purchased from local riverside communities. The land is tilled in the dry season, which lasts from July to December, while the seeds are planted in the rainy season, which covers the other six months of the year. Around 700,000 cuttings from 100 different species are produced every year in the MRN nursery – 25 per km² revegetated.

In the nursery, the seeds undergo a period of dormancy, then germination. This is done in a vermiculite sower. The cuttings grow in plastic bags, protected by wire fencing in periods that range from 2 to 24 months, before they are planted.

Prior to reforestation, the sterile piles removed from the bauxite mine are spread with the use of tractors. Next, the stocked organic soil is used to cover the new surface. The land is then scarified and the cuttings planted by hand. In hillsides and sloping banks there is hydrosowing with grasses.

By June 2002, around 17 km² of mined areas had already been reforested, and more than 3.6 million cuttings had been used by the end of 2001, with a survival rate over 90%. The cost of reforestation, including the tilling of the soil, production and planting of the cuttings, monitoring and research, is US$300 per km².

The indicators of growth of the cuttings, fertility and structuring of the new soil, return of fauna and the evolution of the natural succession process of vegetation are all monitored by scientists from the Federal University of Paraíba (UFPB), the Federal University of Minas Gerais (UFMG), the National Institute of Amazonian Research (INPA) and the Emílio Goeldi Museum of the State of Pará (MPEG). The results, from field surveys and satellite photographs, clearly show that the established reforestation model is progressing rapidly.
Environmental Impacts

Identifying the possible environmental impacts of mining and establishing procedures to mitigate these impacts is a key element of sustainable development. This section deals with the issues of surface water and groundwater management, erosion control, dust control, noise control and emergency response. Measures taken to increase the efficiency of energy use have been discussed in Section B.

Many operations have extensive procedures in place to prevent hydrocarbon and chemical contamination of the surface water leaving their mines. These include:

- Storing chemicals and hydrocarbons in areas with secondary containment;
- Having documented emergency procedures in place to contain and clean up any spillages quickly;
- Having oil treatment plants for water draining from workshops, refuelling areas and vehicle parking bays;
- Disposing of waste or contaminated material in secure landfills.

The prevention of biological contamination of ground and surface water is also a priority for many operations. Most have sewage treatment plants or septic tanks to treat effluent.

<table>
<thead>
<tr>
<th>Erosion risk</th>
<th>Number of operations</th>
<th>Proportion of total reported bauxite production</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>2</td>
<td>14.5%</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
<td>30.3%</td>
</tr>
<tr>
<td>Low</td>
<td>19</td>
<td>55.2%</td>
</tr>
</tbody>
</table>

Table 11: Number of operations, and the proportion of the total reported bauxite mined that they represent, in various erosion risk categories

<table>
<thead>
<tr>
<th>Number of operations with downstream users</th>
<th>Drinking</th>
<th>Domestic</th>
<th>Irrigation</th>
<th>Industrial</th>
<th>Recreational</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>11</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 10: Number of operations where downstream users employ runoff water for various purposes

Thirteen operations, producing 77.6% of the bauxite, have downstream users of runoff water. The runoff water is used for a variety of purposes, particularly for domestic use and irrigation (Table 10).

In nineteen operations, accounting for 94.7% of the reported bauxite produced, monitor the quality of the surface water leaving their mines. Erosion control is important for maintaining water quality for downstream users and for retaining soil on-site. Two operations, that produce 14.5% of the total reported bauxite, rate the erosion potential at their mines as high. The majority of operations reported using erosion control measures, including:

- Retaining runoff in mining pits, sumps or settling ponds;
- Contour ripping;
- Landscaping to reduce slope lengths and angles;
- Earthworks such as contour banks and banks or drains to prevent water running on to disturbed areas;
- Revegetating disturbed areas promptly;
- Dosing runoff water with flocculating agents such as...
Five operations have undertaken or commissioned a baseline assessment of aquatic biology; these sites produce 43.5% of the total reported bauxite. Three of these operations and one other operation have monitoring programmes that assesses the impact of mining on aquatic fauna (these sites account for 36.8% of total reported bauxite production).

Mining only reaches or goes below the water table at three operations, which account for 14.5% of total reported bauxite production. The same number reported mining at or below the water table in the 1998 survey. Thirteen sites, accounting for 66.0% of bauxite production, monitor groundwater quality for parameters such as dissolved and suspended solids, pH and metal content. Mining is considered to have an impact on groundwater quality at four operations (17.7% of reported bauxite).

Dust can be generated during blasting, mining, transporting and crushing of bauxite. Fine dust is the most problematic, as it can cause respiratory problems, but all dusts cause some nuisance. Employees at nine operations, mining 41.8% of the total reported bauxite production, consider fugitive dust to be a problem and six operations, representing 18.6% of total reported production, reported that their neighbours consider it a problem. Dust levels within the mines are monitored by 17 operations, producing 67.7% of the bauxite. Eleven of these operations also monitor the dust levels outside the mine boundaries.

The watering of haul roads is the principal method for the alleviation of dust. This process is carried out at 22 operations, producing 99.3% of the total reported bauxite. Four of these operations (37.6% of reported production) also use chemical additives to control dust. Other dust mitigation strategies used on haul roads include paving roads and covering truckloads during transport. Most mines also use dust control strategies in other areas of their operations, for example when drilling before blasting and when crushing mined ore.

Noise from mining and transport is considered a problem by neighbours at five operations that produce 41.1% of the total reported bauxite. Noise from blasting is considered a problem by neighbours at five operations (42.8% of reported production). Noise mitigation strategies of various types (Table 12) are used at 16 sites producing 74.3% of the total reported bauxite.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Number of Operations</th>
<th>% Total reported bauxite Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintaining buffer areas</td>
<td>11</td>
<td>58.3%</td>
</tr>
<tr>
<td>Modifying the timing of operations</td>
<td>14</td>
<td>68.4%</td>
</tr>
<tr>
<td>Modifying mining equipment</td>
<td>9</td>
<td>41.2%</td>
</tr>
<tr>
<td>Changes to mining methods (e.g. using bulldozers rather than explosives to break up ore)</td>
<td>7</td>
<td>39.6%</td>
</tr>
<tr>
<td>One or more of the above</td>
<td>16</td>
<td>74.3%</td>
</tr>
</tbody>
</table>

Table 12: Number of operations (and the proportion of total reported bauxite they mine) using various noise mitigation strategies
The introduction or proliferation of noxious weeds, soil-borne diseases and pests can have a major impact on the environment. To avoid such issues, eleven operations (76.4% of production) take specific precautions including:

◆ Procedures to prevent movement of potentially infested soil and plant material;
◆ Weed and pest management and control programmes;
◆ The establishment of protocols for the introduction of new species;
◆ The use of exclusively local native plant species from seed collected from within a short distance from the mines;
◆ The use of certified weed-free seed from approved suppliers.

Twenty operations (98.1% of production) have plans in place to address emergencies (e.g. spills/releases of reagents/hazardous substances, fire, flood, earthquakes, civil unrest etc.). Most of these plans (13 operations, 76.6% of production) are integrated with community emergency plans.

CASE STUDY

On the Panchpatmali hills of Koraput district in Orissa state, India, a fully mechanized opencast mine of 4.8 million tonnes per annum capacity has been in operation since November 1985, serving feedstock to the Nalco owned Damanjodi Alumina Refinery.

Pollution control efforts at Panchpatmali include a 15m wide green belt on the periphery of all mines, garland drains and drainage control within the mines and dust suppression at source and through water sprinkling. During mining the total overburden is excavated, with the topsoil used for the reclamation and rehabilitation of mined out areas.
Legislation and Regulations

Operations have a wide range of legislation, regulations and guidelines for many aspects of their activities. State and Federal agencies are the principal environmental control bodies to which operators must report. Governments have increased their regulation of the industry in recent years. In the 1991 and 1998 surveys two operations (18.5% and 4.2% of reported production respectively) reported that there were no government regulations, licences or bonds required for them to operate. In the 2003 survey only one mine, producing 1.8% of the total reported bauxite, reported that there are no government regulations, licences or bonds required for it to operate. However, this site does have ISO 14001 certification and extensive company standards with which it must comply.

Self-regulation is an important part of the sustainable management of the industry. Operations producing more than 90% of the total reported bauxite mined are covered by internal guidelines. Twelve sites (69.0% of reported production) have ISO 14001 certification. The ISO 14001 environmental standard provides a framework for continuous improvement in environmental performance through planning, operating, monitoring and auditing environmental issues. The number of operations that have gained certification is an indication of the commitment the industry has to environmental management.

An environmental licence was required for the construction and commencement of fourteen of the operations (producing 76.6% of reported bauxite production). Nineteen of the operations (89.7% of reported production) require an environmental licence to operate and ten operations (29.3% of reported production) have had to lodge bonds or securities for rehabilitation with a regulatory authority. Eleven operations (51.9% of production) have rehabilitation completion certificates issued to them by an environmental or land management agency.

CASE STUDY

In 2002 Jamalco and the Jamaican Ministry of Agriculture Forestry Department signed a memorandum of Understanding (MOU), to establish a framework for collaboration for the successful rehabilitation of reclaimed mined-out lands through reforestation of these areas. Guided by the ‘no-net-loss’ policy, the two organizations will work to compensate for the loss of forest cover due to mining operations.

This move will see the establishment of new forests on selected reclaimed bauxite mined out areas as well as the protection and preservation of existing forests. Under the MOU, the Forestry Department will utilize its skills for the establishment and management of forests, along with a forest research programme aimed at enhancing the development and reforestation of the lands.

Specific areas of cooperation agreed on in the MOU include the development of a public education programme for farmers and students to improve understanding of the contribution of forests to local and national well-being and economic development. Provisions have also been made for other areas of collaboration to be explored. The agreement also specifically mandates the planting of suitable ornamental and lumber tree species such as cedar, ficus, acacia, wild tamarind, blue mahoe, mahogany, bitter wood, bitter damson, and Spanish elm along with fruit trees such as mango, orange, avocado, breadfruit and ackee.
The Economic and Social Dimensions

It is important that mining operations engage with local and indigenous communities, compensate them for any disruption and provide opportunities for everyone to benefit from mining. The aim is to ensure that the wealth generated by mining is shared throughout the community and will also benefit future generations.

The potential impact of mining on local communities is examined in detail for 16 operations, representing 76.4% of the total reported production, as part of their environmental assessment. At four sites (8.7% total reported production), potential impacts on indigenous communities living traditional lifestyles or scheduled castes are identified.

The largest proportion of the total reported production of bauxite (46.9%) comes from the seven operations located in areas that were sparsely populated (fewer than 1 person per square kilometre) prior to the commencement of mining (Table 13). Only 7.6% comes from areas with a pre-mining population density greater than 100 people km per square kilometre.

Bauxite is mined in countries with both developed and developing economies. 44% of the total reported bauxite is mined at four operations in countries that have high per capita GDP (greater than US$20,000) (Table 14). One quarter is mined by nine operations in countries with a per capita GDP less than US$1,000. Bauxite mining makes a significant contribution to the national economies of a number of these countries.

Local people have been displaced by eight operations, representing 49.7% of the total reported bauxite mined. In two cases the displacement was temporary and in six cases permanent (19.5% of reported production). Relatively few people have been affected, with groups ranging in size from 10 to 1,358 individuals, and all have been compensated. Compensation was purely monetary in three cases. In three other instances the compensation included employment, in five cases it included resettlement and in four cases it included the provision of alternative land. Five of the six operations where people have been displaced permanently are in countries with an average per capita GDP of less than US$3,000.

Miners benefit local communities by paying taxes and by providing employment. On average nearly two thirds of...
the employees at the mining operations are established local inhabitants (Figure 9). Twenty-one respondents, representing more than 99% of total reported bauxite production, reported paying wages above the national average. One of the two sites not paying above average wages is in a country with a high per capita GDP and one is in a country with a per capita GDP less than US$1,000.

Women generally constitute only a small proportion of the workforce in an industry that is traditionally biased towards a male workforce. On average women comprise 8.8% of the workforce; the median value is 5.0%. One relatively small operation, in a country with a per capita GDP of US$1,000-3,000, reported that women make up half of its workforce.

Three quarters of the mines are within 7 km of a residential area. The most remote operation is 157 km from the nearest non-workforce residences. Twelve operations (56.2% of production) own or manage a company town ranging in population from 250 to nearly 40,000 (mean 8,247, median 3,250).

Bauxite mining is a cornerstone of development in many regions. In addition to providing employment opportunities and support for local businesses and contractors, many operations have extensive social programmes that benefit and help the community become more sustainable in the long-term. Operations with a company town are particularly active supporters of social programmes, building vital infrastructure for current and future generations, providing training opportunities and developing socio-cultural networks that link communities together. All respondents report having programmes that help local communities. In addition to those described in Table 15, other initiatives taken by individual operations include:

- Forming a self-help group among the local population;
- Forming a self-help women’s banking system;
- Supporting land care and forest conservation programmes;
- Establishing vaccination and mosquito management plans to protect employees and local people from malaria and other diseases.

![Figure 9: Percentage of the workforce represented by local people, other nationals and expatriates](image)

Women constitute 66.4% of the workforce, while expatriates make up 3.9% and the remaining 29.7% are migrants.

<table>
<thead>
<tr>
<th>Social programme or benefit</th>
<th>Operations managing or owning company town</th>
<th>Operations without company town</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Major</td>
<td>Some</td>
</tr>
<tr>
<td>Medical care</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Provision of safe water supply</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Provision of managed wastewater system</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Provision of managed solid waste facility</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Infrastructure development</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Airport development</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Cultural development and the arts</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Preservation of local culture</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Crisis counselling (drugs, alcohol, etc.)</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Benefits to local businesses and contractors</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Schools</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Scholarship programmes</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Apprenticeship programmes</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Youth support programmes</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Parks and recreational programmes</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 15: The number of operations that support various social programmes and provide other benefits to local communities in either a major or minor manner.
The range of community programme expenditures is very wide. For operations with a company town the mean expenditure is US$904,341 and for operations without a company town US$129,534. The maximum amount spent annually on community programmes is US$3,900,000 by an operation that manages a company town with a population of 6,500. The amounts spent on community projects are substantially greater than the mean of US$75,543 and maximum of US$1,200,000 reported in the 1998 survey. The average expenditure on community programmes is US$0.16 per tonne of bauxite mined for operations with a company town and US$0.13 for operations that do not manage a company town.

Local communities need to be empowered when decisions about natural resource management that affect them are made. Consultation on bauxite mining issues is important in reducing the negative social impacts of mining at many operations. The majority of operators hold community consultation meetings and maintain formal links with community leaders to ensure that communities are informed about and have input to significant decisions (Table 16). Nineteen operations, representing 85.8% of total reported bauxite production, have formal procedures in place to deal with complaints about the operations from neighbouring communities. Most sites reported that ten or fewer formal complaints are addressed per year (median 5, average 14). The maximum number is 95, at the world’s largest bauxite mining operation, which produces about 25 million dry tonnes of bauxite per year.

Possible negative impacts on local communities, identified by operations include:
- Noise and dust;
- Increased demand on services and housing;
- Water turbidity;
- Degradation of land;
- Reduced access to public land;
- Displacement of populations practising slash and burn agriculture;
- Landscape alteration;
- Transculturisation.

Strategies to mitigate these environmental impacts include:
- Reducing the noise nuisance by monitoring noise levels and planning and scheduling operations to minimise noise impacts;
- Controlling dust by watering and maintaining roads;
- Limiting blasting times;
- Constructing settling ponds and other drainage control structures;
- Rehabilitating disturbed areas as quickly as possible;
- Putting in place procedures to minimise hydrocarbon and other spillages.

A number of the operators acknowledge the special relationship between indigenous people and the land by using traditional ecological knowledge extensively in their environmental programmes (Table 17).

<table>
<thead>
<tr>
<th>Programme</th>
<th>No. of sites</th>
<th>% Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiversity assessments</td>
<td>7</td>
<td>28.2</td>
</tr>
<tr>
<td>Rehabilitation planning</td>
<td>6</td>
<td>24.5</td>
</tr>
<tr>
<td>Rehabilitation operations</td>
<td>9</td>
<td>40.9</td>
</tr>
<tr>
<td>Seed collection</td>
<td>11</td>
<td>52.6</td>
</tr>
</tbody>
</table>

Table 17: The number of sites using traditional ecological knowledge of indigenous populations in various aspects of their environmental programmes. Many sites use indigenous knowledge for two or more of these operations.
CASE STUDY

Alcan’s Ghana Bauxite Company Limited operations are served by a Company hospital, which also provides healthcare to the inhabitants of surrounding villages. From 1995 to 2001, sampling of the surrounding communities showed an increase in those testing positive for HIV/AIDS from 7% to almost 25% of the general population.

Figure 1: Community hospital.

Measures were immediately undertaken to help protect the community and the workforce from the spread of the disease. Current strategies include supplying special medications to the hospital; providing the workforce with information on safe sex practices; implementing safe medical practices, such as using disposable syringes and scalpel blades; ensuring safe client contact measures; using only screened blood products for transfusions and introducing thorough disinfecting and cleaning methods.

Alcan Gove

In a remote part of northern Australia, the Gove bauxite mining and alumina facility has spearheaded a unique partnership to help ensure future employment opportunities for indigenous people of the region.

For thirty years Alcan’s bauxite mining and alumina processing operation (operating as Nabalco) in the Northern Territory has bridged the gap between industry, community and the environment by pioneering relationships with aboriginal people to ensure equity and continued access to regional resources.

In partnership with Yirrkala Business Enterprises (YBE), a local aboriginal company, and with 50% funding from both the federal and state governments, the YBE Nabalco Operator Training School was born. The training school provides indigenous students with nationally accredited, practical training in equipment operation, road construction, earthworks and mining. In addition, the school offers educational modules in life skills, work routines, health and safety, and financial management.

Alcan provides administration offices, equipment, training school facilities and instructors, as well as the remaining funding of the program. Annual program costs are approximately AUS$917,000. The 50% government financial support has been secured for two years.

Of the 30 original program participants, 19 graduated in February 2002 with a Certificate in Mining and Civil Plant Operations. The graduates also gained employment in a range of businesses including YBE, the Department of Infrastructure Planning and Environment, and various community organizations. A second 30-week session began in April 2002 with another 24 trainees.

The successful debut of the training school aptly proves that a balance can exist between conservation and development, and that mutually beneficial partnerships between aboriginal people and industry are possible and worthwhile.
Human Resources

To carry out world-class rehabilitation requires a workforce with environmental expertise. Seventeen operations employ or contract specialist rehabilitation staff (79.5% reported bauxite production), mostly agricultural scientists, foresters, botanist and horticulturalists. Four other operations reported that they employ, on at least a part-time basis, consultants or staff with relevant secondary or tertiary qualifications. The mean number of specialist rehabilitation staff reported employed is two, with the largest bauxite producer employing 20 specialist rehabilitation staff.

Continuous improvement in environmental management requires personnel to keep abreast of developments in the field. Industry seminars and industry publications are ranked as the preferred medium by which specialist environmental staff increase their knowledge of environmental best practice. Scientific papers and conferences are also ranked highly. Several respondents comment that visits to other mining operations and internal company sources such as a company intranet are valuable resources for environmental staff.
Mine Rehabilitation Promotional Activities

Openness and transparency in dealing with stakeholders is important in getting recognition for miners environmental management efforts. Videotapes or handouts showing specific information about mine rehabilitation are distributed to the public by 10 operations (57.0% of production). Seventeen operations (76.6% of production) provide tours of their facilities to the public. In addition, many operations hold open days for local landowners and give educational tours and presentations to school and community groups.

Many operations have developed environmental management techniques and practices that have been adopted throughout the mining industry. Ten operations (47.4% of production) reported that various best practice environmental management activities at their mines have been formally recognised with awards as outstanding or innovative either by management or by outside agencies.

CASE STUDY

Alcan Gove Pty Limited operates a successful bauxite mine and alumina refinery in the Arnhem Land region of Australia’s Northern Territory. As the Northern Territory’s largest exporter, the company makes a major economic contribution, directly employing about 1100 people and stimulating regional development. With its operations based on Aboriginal land, Alcan Gove regards local Aboriginal people as key stakeholders and places great importance on maintaining good relationships with the local community and in promoting understanding of cross-cultural values. This is achieved through:

- Public tours of the mine and refinery every Friday and special tours for schools and other interested groups on request;
- Financial and in kind sponsorship for local sporting, community and cultural groups;
- Financial, infrastructure and educational support to local schools and service providers;
- Preparation of a public HSE report and the provision of an opportunity to provide feedback;
- Exhibitions at local and Northern Territory events;
- Major sponsorship of the Northern Territory Land care awards and active support of local Land care projects.

CROCS, the Community Rewards on Continuing Safety programme, was established by Alcan to promote best practice in health and safety beyond the workplace and into the wider community. CROCS funded approximately $190,000 worth of health and safety projects for a broad cross-section of community groups from 1993 to 2000.

There is also regular communication between local communities facilitated by Alcan’s Aboriginal Liaison staff. Members of the Senior Management team also take opportunities at ceremonies and other important events to meet with the elders of various homelands.
Research and Development Projects

Nineteen operations representing 94.2% of total reported bauxite production reported undertaking or supporting environmental research compared with 16 in 1998. The research is often undertaken by the operators’ own staff, but many external research institutions and expert consultants are also utilised (Table 18). The mean number of full-time equivalent research staff involved in this research is 6 and the median 4 (only 12 operations answered this question). The two operations most involved in research have 16 and 22 full-time equivalent research staff respectively. The mean annual research and development budget for the total environmental and rehabilitation programme is US$207,430 and the maximum is US$1,100,000 (11 operations answered this question). The mean annual research and development budget for the rehabilitation programme only is US$104,792 and the maximum is $600,000 (9 operations answered this question).

Key focus areas for research include:

- Increasing plant species diversity on rehabilitated areas;
- Making rehabilitation more attractive for wildlife;
- Improving soil handling and ripping strategies;
- Vegetation succession and resilience to disturbance on rehabilitated areas;
- Soil development on rehabilitated areas;
- Nutrient cycling; recolonisation of soil fauna and mycorrhiza;
- Finding appropriate indicators of rehabilitation success and sustainability.

A number of operations have published the results of their research in peer-reviewed journals. In addition various environmental publications have been produced for a more general readership.

<table>
<thead>
<tr>
<th>Researchers utilised</th>
<th>No. of operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-house research staff</td>
<td>12</td>
</tr>
<tr>
<td>Industry research institutions</td>
<td>7</td>
</tr>
<tr>
<td>Tertiary education establishments</td>
<td>10</td>
</tr>
<tr>
<td>Regulatory agencies</td>
<td>10</td>
</tr>
<tr>
<td>Private research institutes</td>
<td>3</td>
</tr>
<tr>
<td>Government research institutes</td>
<td>9</td>
</tr>
<tr>
<td>Consultants</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 18: Institutions and individuals who undertake environmental research. Three operations reported that they do not undertake or support environmental research and one operation did not respond to the question.
CASE STUDY

The Weipa bauxite mine, located in Queensland's Western Cape, Australia, supplies bauxite to the Queensland Alumina Limited refinery in Gladstone that produces alumina as feedstock for Comalco's smelting operations. Weipa bauxite will also supply the Comalco Alumina Refinery once operations begin in late 2004.

Comalco is working with researchers from the University of Queensland's Department of Agriculture on weed management, land re-treatment and development of a post-mining land-use with cattle grazing.

In Weipa, Leucaena grass pastures and paddocks are being established on rehabilitated mined land. The project aims to determine the level of utilization and control of Leucaena and Gamba grasses, achievable by cattle grazing, as well as benefits for beef production. This is particularly useful for the Cape York Peninsula live export trade to South East Asia through the port of Weipa. Sudley Station and other cattle stations in the area intend utilizing mine pastures for settling and improving cattle for export. The notable successes of two preliminary trials have been that Leucaena was utilized and brought under control and impressive live weight gains were achieved in cattle.

Full implementation of a productive cattle-grazing system is planned for 2006. Conclusive evidence is expected to then be available for successful utilization and control of Leucaena and Gamba grasses and a potential for beef production presenting a future land use option. Establishment of sustainable cattle grazing paddocks on regenerated mined land in Weipa would provide a post mining land use and promote expansion of live cattle exports out of Weipa.

Comalco has also been working with Traditional Owners to develop end point or land relinquishment criteria which outlines the state in which the environment should be left at the end of Comalco's operations. This includes land regenerated with native flora as well as land rehabilitated for a post mining land use. Ecological measures have been formulated and determine the species richness, ground cover and absence of problem weeds. Comalco is conducting a process of community consultation to ensure acceptance of the land relinquishment criteria before it receives final approval. This consultation will be achieved through the Western Cape Communities Co-Existence Agreement Coordinating Committee.
Appendix 1

Washing Plant

Three operations beneficiate their ore by washing (representing 22.3% of total reported production) before it is transported to a refinery. All three operations recycle the washing water and two operations have revegetated storage areas for the waste solids after they have consolidated. Two operations reported that they use one and three cubic metres of water per tonne of product respectively. The three washing operations produce 133,000, 2,190,000 and 6,300,000 dry weight of waste solids per year respectively.

References


