Northern Territory Government

DEPARTMENT OF
NATURAL RESOURCES, ENVIRONMENT, THE ARTS AND SPORT

# Guidelines for Preparation of an Environmental Impact Statement

# for the

# Wonarah Phosphate Project

# by

# - Minemakers Australia Pty Ltd-

# July 2009

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# 1 INTRODUCTION

The Wonarah project proposes to mine phosphate from four open pits by a strip mining process with a treatment plant for crushing and screening and associated mine infrastructure. Stage 1 of the project would have a mine life of five to ten years and would produce approximately 12.8 million tonnes of direct shipping ore. The phosphate ore would be transported to Tennant Creek via the Barkly Highway by road trains and then transported by rail to the Port of Darwin.

The project disturbance area is approximately 2700 hectares including 200 hectares of waste rock storage, four open pits (40-60m deep), 68km of haul and access roads, an aerodrome, accommodation village, borefields and sewage treatment and landfill facilities. The mined ore would be taken to a crusher and screening plant prior to transporting offsite.

The project is located 260km east of Tennant Creek and 960km southeast of Darwin in the Barkly Tableland. The closest populated area to the project is the Wunara Community located approximately 10km from the proposed Mineral Lease boundary and comprises of 2-30 people dependent on the season.

The Northern Territory Minister for Natural Resources, Environment and Heritage has determined that this proposal requires formal assessment, under the NT *Environmental Assessment Act 1982* (EA Act), at the level of an Environmental Impact Statement (EIS). Issues of concern contributing to this decision include:

- The impacts of clearing 2700 hectares of land to flora and fauna as well as land and water quality degradation, and visual impacts;
- Mining operations may result in topsoil and subsoil erosion with subsequent impacts on the future uses of impacted land;
- Impacts of groundwater extraction on regional water levels and adjacent users;
- The leachate generating potential of waste rock and ore is unknown and waste rock and ore characterisation is required;
- Downstream impacts to surface waters including ephemeral lakes;
- Impacts to road infrastructure and stakeholders with increased vehicle use on the Barkly Highway;
- Air emissions including dust and greenhouse gases;
- The challenges of successful rehabilitation; and
- Potential impacts to archeological sites.

The proposal was referred by Minemakers under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) on 22 April 2009. A delegate for the Commonwealth Minister for the Environment, Heritage and the Arts determined on

21 May 2009 that the project is not a controlled action under the Commonwealth EPBC Act 1999.

These Guidelines have been developed to assist Minemakers in preparing an EIS for the proposed action, in accordance with Clause 8 of the Northern Territory (NT) *Environmental Assessment Administrative Procedures* of the EA Act of the Northern Territory.

# 2 GENERAL ADVICE ON GUIDELINES

## 2.1 General content

The EIS should be a stand-alone document. It should contain sufficient information to avoid the need to search out previous or supplementary reports and able to be reproduced on request by interested parties who may not wish to read the draft EIS as a whole.

The EIS should demonstrate that the proponent has identified all risks associated with the issues raised, undertaken comprehensive assessment of those risks (including quantification where practicable) and identified effective controls for significant risks. Residual risks should also be identified. All aspects of the risk assessment should be accompanied by statements about levels of uncertainty. Steps to reduce uncertainty or precautions taken to compensate for uncertainty should also be identified and their effect demonstrated.

The EIS should enable interested members of the public and the NT Minister to understand the environmental consequences of the proposed action. Information provided in the EIS should be objective, clear and succinct and, where appropriate, be supported by maps, plans, diagrams or other descriptive detail. The body of the EIS is to be written in a clear and concise style that is easily understood by the general reader. Technical jargon should be avoided wherever possible. Cross-referencing should be used to avoid unnecessary duplication of text.

Detailed technical information, studies or investigations necessary to support the main text should be included as appendices to the EIS.

Minemakers will be expected to demonstrate the implementation of industry best practice measures in design of the facility, project planning, environmental risk assessment, and in all future aspects of the life of the project.

The assessment process aims to provide a mechanism for Minemakers and the Government to gain a clear understanding of the potential extent of such impacts, and to examine the likely effectiveness of preventative measures proposed. This understanding creates an opportunity to reduce impacts by adoption of more effective up-front engineering and/or management mechanisms.

Minemakers is expected to work with close regard for community expectations and concerns and to respect that the community may perceive the level of risk for this proposal differently to the proponent. In the interest of achieving a balanced risk assessment, it is expected that Minemakers will place a high priority on communicating with the local community.

## 2.2 Format and style

The EIS should comprise three elements, namely:

- the Executive Summary;
- the main text of the document; and
- Appendices - containing detailed technical information and other information that can be made publicly available.

The structure of these Guidelines may be adopted as the format for the EIS. This format need not be followed if the required information can be presented alternatively for better effect. However, each of the elements in these Guidelines must be addressed to meet the requirements of NT Government regulatory requirements.

The Executive Summary should include a brief outline of the project and each chapter of the draft EIS, allowing the reader to obtain a clear understanding of the proposed project, its environmental implications and management objectives. The Executive Summary should be written as a stand alone document, able to be reproduced by interested parties who may not wish to read or purchase the EIS as a whole. The main text of the EIS should include a list of abbreviations, a glossary of terms to define technical terms, acronyms and abbreviations, and colloquialisms.

The appendices should include:

- a copy of these Guidelines;
- a list of persons and agencies consulted during the EIS;
- contact details for the proponent;
- names of, and work done by, the persons involved in preparing the EIS; and
- qualifications and expertise of the people involved in work contributing to the EIS.

The EIS should be written so that any conclusions reached can be independently assessed. To this end, all sources must be appropriately referenced using the Harvard Standard. The reference list should include the address of any Internet "web" pages used as data sources.

The EIS should be produced on A4 size paper capable of being photocopied, with any maps and diagrams on A4 or A3 size and in colour where possible.

The proponent should consider the format and style of the document appropriate for publication on the Internet. The capacity of the website to store data and display the material may have some bearing on how the document is constructed.

**Administration**

Fifteen bound copies of the draft EIS should be lodged with the Minister, care of the Environment, Heritage and the Arts (EHA) Division of NRETAS for distribution to NT Government advisory bodies.

The EIS should be provided on CD/DVD in ADOBE *.pdf format for placement on the NRETAS internet site (Chapters and Appendices separate). This should be done at least four days before newspaper publication. Additionally, two Microsoft Word copies should be provided to facilitate production of the Assessment Report and Recommendations.

At a minimum, the proponent is to advertise the draft EIS for review and comment in the *NT News*, the *Tennant & District Times* and *The Centralian Advocate.*

The EIS should be made available for public review at:

- Environment, Heritage and the Arts Division (Department of Natural Resources, Environment, The Arts and Sport), 2nd Floor, Darwin Plaza, 41 Smith Street Mall, Darwin;
- Minerals and Energy Information Centre, Department of Regional Development, Primary Industry, Fisheries and Resources, 3rd Floor, Paspalis Centrepoint,
  48 Smith Street Mall, Darwin;
- Northern Territory Library (NTL), Parliament House, Darwin;
- Alice Springs Public Library, (telephone 8950 0555 Email: library@astc.nt.gov.au;
- Darwin City Council Library (telephone 8930 0200 Email: dcc@darwin.nt.gov.au;

- Tennant Creek Public Library (telephone: 8962 2657 Email: library@tennantcreek.nt.gov.au
- Arid Lands Environment Centre, Alice Springs (telephone: 8952 2497) 16 John Cumming Plaza, Todd Mall, Alice Springs Email: info@alec.org.au

The Project Officer is Ms. Sally-anne Strohmayr from the EHA Division of NRETAS.
The contact phone number is (08) 8924 4002 and facsimile (08) 8924 4053 or e-mail: sally.strohmayr@nt.gov.au.

# 3 DECRIPTION OF THE PROPOSED DEVELOPMENT

This information must also include details on how the works are to be undertaken (including stages of development), design parameters for those structural aspects of the action that have impact potential.

The EIS should provide detail of the proposed location (including associated ancillary activity sites) and its surrounding environment to place the proposal in its local and regional context. The project infrastructure design and engineering for all phases of construction, operation and management of the project should be detailed and relevant plans, photos and maps should be included.

A description of how the project relates to any other projects, such as the development of the multi-user hub to be constructed in Tennant Creek should be provided. The EIS should also provide detail of direct and indirect employment and business opportunities associated with the project, including sources of workforce, skill levels required and opportunities for Indigenous people and businesses.

The following headings should be included in this section:

## 3.1 Project objectives and benefits

The EIS should contain an explanation of the objectives, benefits and justification for the project.

## 3.2 Description of the Project

The EIS should describe the project in sufficient detail to allow an appreciation of the construction, operation and closure timeframes and processes, and assist in determining the potential environmental impacts of the project. Key decision-making processes (such as risk assessments) should be detailed.

Relevant Northern Territory and Australian Government legislation, strategies and policies, as well as international and national standards, should be considered. Relevant Northern Territory Government environmental, work health and construction legislation and Guidelines, standards and codes should be considered during the design phase of the project.

The project description should outline the land requirements, land tenure, acquisition requirements (permits, rezoning and Native Title), and the tenures under which the project would be held including details of relevant legislative processes required to grant proposed tenure. The infrastructure requirements

and specifications (permanent and temporary) and ancillary activities (e.g., storage areas, putrescible waste area and power supply) should be outlined.

The project description should also consider the following, as a minimum, for all aspects and components:

### 3.2.1 Project Description and Design

The EIS should provide an overall layout of the proposed mine site, including pits, waste rock storage areas, crushing and screening plant, power generation, water supply, access and vehicle routes, any other infrastructure associated with the project, waterways, and other existing features of interest. The construction and operation of the project should be described and as a minimum include the following details:

- A description of the project's location, indicating distance from Tennant Creek, Darwin and Mt Isa;
- Comprehensive maps showing topography and the location of all project components and also indicate the project location in relation to smaller communities, pastoral leases, watercourses, ephemeral lakes and main roads;
- Current ore reserves and mine life;
- Design of open pits and their final dimensions (including maps, plans and geological cross-sections);
- Design of the permanent waste rock storages and their dimensions;
- Calculation of the total area of mineral lease and proposed area of disturbance;
- Description of mining methods, scale of operations and timetable for ore extraction and open-pit operations;
- Details of possible future extensions to the mine operation;
- For each component, discuss limitations in its location imposed by geological or geomorphological characteristics;
- Current and proposed infrastructure requirements (permanent and temporary), e.g., roads, airstrips, accommodation, communications and power, fences and pipelines;
- Identification of water requirements, including the quantity, source, usage, storage, treatment and disposal of this water during both construction and operation;

- The extraction methods, uses and rehabilitation methods for any on-site and off-site borrow material and borrow pits;
- Employment and business opportunities (direct and indirect), including sources of workforce, skill levels required and opportunities for local people and businesses; and
- Methods for storage, handling, containment and emergency management of chemicals and other hazardous substances (including fuel and explosives).

### 3.2.2 Construction Phase

Details of the construction phase of the project in the EIS should include:

- The construction timing, methods, equipment and materials;
- The construction personnel requirements;
- Details of operational traffic and freight requirements, including:
  - Vehicle types and numbers.
  - Hours of operation.
- Site security, particularly with regard to the storage of chemicals and fuels.

Construction should be consistent with NT Health and Community Services Requirements for Mining, Construction and Bush Camps (Environmental Health Information Bulletin No. 6) (Attachment A).

### 3.2.3 Operational Phase

General details of the operational phase of the project in the EIS should include:

- Details of any drilling and blasting required (including frequency);
- Description of the methods for storage, handling, containment, occupational health and safety, and emergency response details for chemicals and other hazardous substances (including fuel and explosives);
- Details of the approximate quantities of hazardous and non-hazardous substances to be stored on site.

Information to be supplied in relation to specific areas of mine operation is detailed below.

### 3.2.4 Waste Rock Management

The Notice of Intent states that Acid Mine Drainage test work underway will demonstrate that acid drainage generation will not occur. This statement must be supported by sufficient geochemical assessment and analysis and include sample selection methodology.

General details of waste rock management in the EIS should include:

- Identification of the total amount of waste rock to be produced;
- Characterisation of waste rock, including non direct shipping ore in terms of acid generation potential and neutralising capacity from static acid-base accounting;
- If waste rock is identified as having acid generation potential, results from kinetic testing, a description of the management of potential acid mine drainage and methods for waste rock and non direct shipping ore handling and disposal should be provided. The identification of classes and amounts of waste rock should be included;
- Describe proposed waste rock storage locations, dimensions, water catchments, surface treatment and final landform. Any alternative locations , surface configurations, wall/pad designs and construction, estimated flood heights and provisions for extreme rainfall and flood events, erosion protection, sub drainage and collection sumps should be discussed.
- Detection and remediation plans for potential waste rock dump seepage;
- Provide details on the linings proposed for all facilities on site including non direct shipping ore stockpile and waste rock dump facilities.
- Demonstrate that seepage from waste rock dumps will be contained;
- Demonstrate how construction quality control will be achieved;
- Describe final rehabilitation and revegetation plans for the completed waste storage facilities;
- Describe ongoing monitoring, and (contingency) management plans for the waste storage facilities after mining ceases;

### 3.2.5 Crushing and Screening

General details of the crushing and screening process in the EIS should include:

- Description of the crushing and screening process and the capacity of the crushing and screening plant;
- Identification of all input and output products (solids, gases and liquids) and pathways for each item in the process; and
- Details of any proposed stockpiling of ore on site and associated management.

### 3.2.6 Waste Management

General details of the waste management for the project in the EIS should include:

- Identification and description of all sources of waste (amount and characteristics);
- Details of effluent disposal from the mine and associated infrastructure;
- Outline of the proposed putrescible waste area location and dimensions. If any appropriate alternative locations are identified, they should be discussed;
- Details of any chemicals used which may impact on future land uses;
- Discussion of waste management strategies, including reduction, reuse, recycling, storage, transport and disposal of waste, including site drainage and erosion control;
- Details of hazardous materials (as per the *Dangerous Goods Act* and the Workplace Health and Safety Regulations) to be stored and/or used onsite, including their Material Safety Data Sheets and environmental toxicity data and biodegradability for raw materials and final products; and
- Description of waste management strategies that avoid or minimise waste generation where possible.

### 3.2.7 Exploration and Future Development

Aspects related to, but not included as part of this proposal.

- Outline briefly the potential for additional mining developments in this area, beyond the scope of this proposal; and

- Outline the impacts of any exploration activities directly related to the proposed action within the mining tenements – in particular, the potential risks to groundwater and surface water.

# 4 ALTERNATIVES

Alternative proposals, which may still allow the objectives of the project to be met, should be discussed, detailing reasons for the selection and rejection of particular options. The selection criteria should be discussed, and the advantages and disadvantages of preferred options and alternatives detailed. The short, medium and long-term potential beneficial and adverse impacts of each of the options should be considered and associated risks detailed and analysed.

Alternatives to be discussed in the EIS should include:

- Not proceeding with the project.
- Alternative locations for the project and associated infrastructure.
- Alternative sources of raw materials for the project, including water supply and hybrid renewable/alternative energy sources.
- Alternative transport options.
- Alternative extraction and processing technologies considered.
- Alternative environmental management technologies considered for moderate or higher risk impacts.
- Alternative configurations to decrease the project's carbon footprint.
- Alternative mine closure and rehabilitation options – analysis should include reference to industry 'best practice guidelines' and explore the option of:
  - backfilling the final voids with waste rock; and
  - the final post disturbance landform of the waste rock storages to be as close as possible to pre-disturbance landform.

# 5 RISK ASSESSMENT

Processes for risk management assessment are formalised in Standards Australia / Standards New Zealand (eg. AS/NZS 4360:2004; HB 436:2004; HB 158:2006). In addition, organisations such as the US Environmental Protection Agency have published guidelines for ecological risk assessment (e.g. US EPA 1998).

Information provided should permit the reader to understand the likelihood of the risk, its potential severity, and any uncertainty about the effectiveness of controls. If levels of uncertainty do not permit robust quantification of risk, then this should be clearly acknowledged.

This EIS should be undertaken with specific emphasis on identification, analysis and management of risks through a whole-of-project risk assessment process. Through this process, the EIS should:

- acknowledge and discuss the full range of risks (including quantification where practicable) and identifying management, mitigation and/or alternative actions;
- Identify and discuss the full range of the hazards presented by the proposed action, including those of special concern to the public;
- Determine the risk of the event occurring (likelihood versus consequence);
- Rank the hazards/elements quantify (where possible) and rank risks based on their level of risk;
- Identify alternatives or mitigation measures to either eliminate or manage the risk and describe the levels of uncertainty regarding risk;
- Provide a quantitative method of measuring performance of mitigation and management measures;
- Acknowledge and describe the levels of uncertainty regarding estimates of risk and the effectiveness of risk control measures in place;
- Explicitly identify those members of the community expected to accept residual risks and their consequences, providing better understanding of equity issues.

Statements about levels of uncertainty should accompany all aspects of the risk assessment. Steps taken to reduce uncertainty or precautions taken to compensate for uncertainty should also be identified and their effect(s) demonstrated.

## 5.1 Risks and Hazards to Humans and Facilities

The EIS should include an assessment of the risks to people, nearby facilities and the environment associated with the construction, operation and maintenance of the proposal including storage and transport of materials to and from the complex. Include also, potable water sourcing and quality assessment for both the

operations and the camp. Existing risks should be identified. The aim of this process is to demonstrate that:

- The proponent is fully aware of the risks to human health and safety, associated facilities and environment associated with all aspects of the development;
- The prevention and mitigation of risks to human health and safety are properly addressed in the design specifications for the facility; and
- The risks can and will be managed effectively during the construction, commissioning, operation, and decommissioning of the development.

Sufficient quantitative analysis should be provided to indicate whether risks are likely to be acceptable compared with similar ventures in Australia and internationally. Assumptions used in the analyses should be explained. Relevant standards, codes and best practice methodologies that minimise risks should be discussed.

Detailed emergency plans and response procedures will need to be developed as a contingency in the event of an emergency or accident and provided in the final Environmental Management Plan. Responsibilities and liabilities in such an event should be included.

The risk and hazard analysis will identify the critical areas that need to be addressed in management plans, monitoring programs, contingency and emergency plans.

# 6 EXISTING ENVIRONMENT, POTENTIAL IMPACTS AND MANAGEMENT

The EIS should include at a minimum:

- a comprehensive list of the relevant legislative obligations of the site and pertinent Standards, Codes of Practice and guidelines applicable to the implementation of the project;
- a detailed description of the existing environment condition of the site including an agreed end land use outlining any beneficial uses associated with the site and its area of influence;
- quantifiable measures to ensure stakeholders and regulators that the site is being managed appropriately throughout the whole of project and acknowledgement of the appropriate standards and codes of practice applicable in the management of the site;
- include an in-depth description of the areas with the potential to, or expected to, be affected by the project. Studies used to describe the

existing environment of the project area and its surrounds should be of a scope and standard sufficient to serve as a benchmark against which the impacts of the project may be assessed over an extended period. The level of detail should reflect the scale and nature of the project;

- Clearly identify, qualify and quantify, where appropriate, potential environmental and social impacts associated with the project. The section should also include an assessment of the level of significance of the impact, be it global, regional or local;
- Where relevant, discuss cumulative impacts, including the extent to which the environment is already affected by existing activities or developments;
- Detail avoidance, management and mitigation measures for the identified impacts (including rehabilitation and remediation);
- Provide performance indicators (e.g., environmental objectives);
- Indicate the reliability and validity of forecasts and predictions, confidence limits and margins of error; and
- Describe the environmental and social monitoring proposed to determine the success (or otherwise) of the management and mitigation measures for the project through operational phase and into decommissioning and closure. This will encompass at a minimum commitments for surface and groundwater quality monitoring, biological monitoring (including rehabilitation), air quality, sediment sampling, flora and fauna, weeds and soil erosion surveys.

## 6.1 Major Risks Identified

The major risks below have been identified through analysis by the Northern Territory Government of the Notice of Intent for Wonarah Phosphate Project. It is possible that further major risks will be identified in the Environmental Impact Assessment process. The major identified risks are:

1. Impacts of land clearing on flora and fauna, soil erosion, water quality and visual impacts;
2. Air quality and control including dust and greenhouse gas emissions;
3. Impacts on groundwater;
4. Impacts on surface water;
5. Rehabilitation and Decommissioning; and
6. Traffic and Transport of Ore

**The Environmental Impact Statement must demonstrate the following environmental outcomes:**

## 6.2 Impacts of land clearing

Clearing of native vegetation for the mining operations can lead to:

- Loss of biodiversity through damage/destruction of significant vegetation communities and native wildlife habitats;
- Loss of genetic diversity by isolating populations and restricting dispersal;
- Loss of landscape connectivity and refuge areas;
- Increased erosion through exposure of soil to wind and water;
- Reduced water quality;
- Changed hydrologic conditions leading to salinisation of water and soils;
- Increased potential for weed invasion and spread;
- Disruption of nutrient cycling;
- Increased emissions of greenhouse gases to the atmosphere; and
- Visual impacts to regional community and highway users.

### 6.2.1 Flora and Fauna

**Outcome**

The proponent will ensure that impacts upon native flora and fauna species and communities associated with the construction and operation of the mine are minimised and mitigated as far as possible.

*6.2.1.1 Information Requirements*

- The extent of clearing required during construction and operation;
- Describe flora and fauna species (including weed or exotic species) and biological communities (including wetlands). Flora and fauna should be surveyed and described with rare, threatened or endangered species identified against relevant Northern Territory and Commonwealth legislation. Species with Indigenous conservation values should also be described.
- Provide details of significant vegetation[1]. Significant vegetation includes:
  - Rare, threatened, endangered and regionally restricted species, vegetation types or habitats
  - Include a targeted survey of *Sporobolus latzii* mapping the distribution of the species within the whole lease, if present;

[1] Sensitive or significant vegetation communities such as mangroves, rainforest, vine thicket, monsoon vine forest, sand sheet heath, riparian or closed forest and vegetation containing large trees with hollows suitable for fauna.

- Communities that are particularly good examples of their type;
- Vegetation types which are outside their normal distribution or have other biogeographical significance;
- Ecologically outstanding areas which have importance beyond the immediate site;
- Vegetation which is the habitat or rare and threatened fauna or has outstanding diversity.

Survey methodology should:

- be developed in consultation with appropriate recognised experts in consultation with the Biodiversity Conservation Unit of NRETAS;
- target listed EPBC Act protected species that have been identified to potentially occur in the area, specifically concentrating on track surveys for the Bilby (*Macrotis lagotis)* and Mulgara (*Dasycercus cristicauda)*;
- be conducted by suitably qualified individuals.
- the survey area is to include the mining lease area and area downstream from the mining lease area due to the potential for water quality impacts to travel downstream;
- consider seasonality, species rarity, potential for occurrence of significant species and sensitivity of species to disturbance.

#### *6.2.1.2 Potential Impacts*

- Describe the impacts of land clearing on the project area and cumulative impacts on the surrounding area;
- Discuss impacts on species, communities and habitats of local, regional or national significance including sensitivity of species to disturbance;
- Describe impacts such as loss of vegetation, reduction in species abundance, introduction and increase in abundance of pest plants and animals, edge effects, reduced conditions for favourable plant growth, impacts on habitat corridors, habitat loss and fragmentation and visual impacts associated with the vegetation clearing required during the life of the project;
- Discuss potential impacts on water quality of creeks, streams and ephemeral lakes (habitat for aquatic fauna and drinking water for terrestrial species);
- The ability of identified stands of vegetation and fauna to withstand any increased pressure resulting from the project (e.g., increase in dust, light, noise, vibration, traffic and fire) and measures proposed to mitigate impacts.
- Identify pest species/noxious weeds that are likely to occur as a result of construction and operation.

*6.2.1.3 Safeguards, Management and Monitoring*

- Discuss how land clearing would occur in a manner that minimises adverse environmental impacts referring to NRETAS's Draft Land Clearing Guidelines 2009: http://www.nt.gov.au/nreta/natres/natveg/feedback.html
- Discuss ways in which impacts on species, communities and habitats can be minimised (eg timing of works, minimising disturbance catchment);
- Discuss how visual impacts of land clearing will be minimised;
- Include a weeds and feral animal management plan as part of the Environmental Management Plan; and
- Identify the monitoring program for each potential flora and fauna impact and provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.

### 6.2.2 Landform, Geology and Soils

**Outcome**

The proponent will manage and mitigate the risk of soil erosion on site and ensure sediment is prevented from entering into any surrounding waterways offsite. This should be reflected in an Erosion and Sediment Control Plan which is to be approved prior to commencing any on ground works, and subsequently implemented and completed to the satisfaction of Land Management, NRETAS.

*6.2.2.1 Information Requirements*

- Identify current land uses within the project area;
- Include detailed maps showing topographic features, geological information and soil types within the boundaries of the project area;
- Describe topographical, geological or landform features/sites that may be of conservation or economic significance.
- Describe the soil types (including properties) and land units of the project area and surrounds. Any soils requiring special management requirements (e.g., highly erosive soils or soils with suitable properties for use in rehabilitation) should be identified;
- Detail any existing level of soil erosion and other disturbances in the project area;
- Develop an Erosion and Sediment Control Plan for the site in consultation with an Authorised Soil Conservation Officer (Dave Waterson, Ph: 08 8951 9208).

*6.2.2.2 Potential Impacts*

- Detail the extent and implications of possible impacts to topographical, geological or landform features/sites from mining operations;
- Detail potential of mining operation to increase erosion within the project area; and
- Discuss limiting properties of landform considering erosion, rehabilitation etc. This information may be provided through the development of a landform evolution model that incorporates hydrological, topographic and sedimentological components for evaluating the likely performance of landforms proposed for rehabilitation. This would also have benefit in assisting in progressive rehabilitation over the life of the project and determining long term sustainability of post rehabilitated landforms.

*6.2.2.3 Safeguards, Management and Monitoring*

- Discuss the measures taken to avoid or minimise the impacts identified;
- Discuss management of topsoil;
- Discuss erosion and sediment control procedures and associated Erosion and Sediment Control Management Plan (ESCP) as part of the Environmental Management Plan- include how sediment would be prevented from entering into surrounding waterways – the content required for an ESCP can be found at: (http://www.nt.gov.au/nreta/natres/soil/management/index.html);
- Identify strategies to manage potential environmental impacts arising from changes in land form;
- The design and construction of roads and services needs erosion and sediment control planning requirements – refer to: (http://www.nt.gov.au/nreta/natres/soil/management/pdf/TransportCorridors.pdf) (http://www.nt.gov.au/nreta/natres/soil/management/pdf/ServiceCorridors.pdf)
- Identify the monitoring program to be implemented for each potential impact on landform, geology and soils and should provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.

## 6.3 Impacts to Air Quality

### 6.3.1 Air Quality and Noise

**Outcome**

The proponent will ensure the management and mitigation measures to control air emissions and noise are sufficient to not impact the nearby Wunara Community and users of the Barkly Highway.

#### *6.3.1.1 Information Requirements*

- Outline meteorological conditions including:
  - Prevailing wind directions and strengths;
  - Maximum wind gusts;
  - Precipitation data (maximum, minimum, average, design rainfall intensities);
  - Temperature data;
  - Evaporation data;
  - Relative humidity data; and
  - Barometric pressure data.
- Traffic volume and types of vehicles using haul roads;
- Calculate separation distances from sensitive receptors including during ore transportation and storage.

#### *6.3.1.2 Potential Impacts*

- Describe impacts on sensitive receptors from noise generated during construction and operation. Anticipated noise levels, their timing and duration should be considered in conjunction with the sensitivity of the receptor;
- Identify potential air emissions;
- Identify potential dust impacts including projected particle size and distribution; and
- Describe potential impacts on sensitive receptors to air quality resulting from the construction and operation of the project against current Northern Territory and Australian legislation, policies and standards.

#### *6.3.1.3 Safeguards, Management and Monitoring*

- Identify measures taken to avoid or minimise the impacts identified during construction and operation;
- Describe dust suppression and monitoring programs including during ore transportation;
- Identify alternative dust suppression techniques for haul roads other than water spraying in an environment with high traffic use and evaporation rates;
- Identify the monitoring program to be implemented for each potential air quality and noise impact and provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.
- Alternative dust suppression techniques for haul roads if water supply is found to be an issue.

### 6.3.2 Greenhouse Gas Emissions

**Outcome**

The proponent will adopt management measures to reduce greenhouse gas emissions. An assessment of greenhouse gas emissions for the project should be undertaken in accordance with the NT Environmental Impact Assessment Guide – Greenhouse Gas Emissions and Climate Change – Attachment B.

*6.3.2.1 Information Requirements*

- Details of potential sources of greenhouse gas emissions as a result of the project (including on site and upstream sources such as emissions arising from land clearing and the production and supply of energy to the site).
- An estimate of the emissions in carbon dioxide equivalent figures for each year of the project.
- Identification of greenhouse gas emissions on a gas by gas basis.
- Details of the project lifecycle greenhouse gas emissions and the greenhouse gas efficiency of the proposed project.
- Measures to conserve energy, improve energy efficiency and reduce fugitive emissions.
- Methods to ensure potential savings in greenhouse gas emissions are made through the use of renewable energy sources to supplement the energy requirements at the mine.
- Measures to offset greenhouse gas emissions
- Identify monitoring program to be implemented for each greenhouse gas impact and provide outcome and assessment criteria that will give early warning that management and mitigations measures are failing.

## 6.4 Impacts to Groundwater

**Outcome**

The proponent will manage the extraction and quality of ground water so that it complies with relevant standards and Guidelines such as the ANZECC and ARMCANZ 2000 and beneficial use declarations. The groundwater monitoring programme implemented will be sufficient to ensure over extraction of groundwater does not occur.

### *6.4.1 Information Requirements*

The EIS should:

- Describe relevant groundwater resources in any areas likely to be affected by the construction and operation of the mine. Description should include both confined and unconfined aquifers and identify groundwater discharge and recharge zones and ground soaks;
- Estimate the demand for potable and raw water for the operational period and discuss this in relation to the resource capacity and current use.
- Describe:
  - Current uses
  - Beneficial uses
  - Flows
  - Groundwater quality
- Describe the long-term performance of groundwater resource and the sustainability of the supply; and
- Describe the proposed bore field – the number of bores, location, extraction rates and total water required.

### *6.4.2 Potential Impacts*

- Describe how the project may impact on groundwater quality – studies on the potential of waste rock to generate leachate need to be completed before potential impacts on groundwater quality are assessed;
- Assess local aquifer supply potential and the expected draw down on local groundwater supplies and the impact on current local users and their requirements;
- Discuss potential for contamination of groundwater by chemicals or pollutants; and
- Discuss the risks associated with the proximity of the proposed project to bores or aquifer recharge zones that may supply potable water.

### *6.4.3 Safeguards, Management and Monitoring*

Details of safeguards and management strategies used to minimise the impacts of construction and operation on hydrological features should be provided. In particular:

- Measures to safeguard groundwater resources including options for the appropriate treatment and disposal of construction and operational

wastewater and stormwater runoff. Identify the preferred option and selection criteria used;
- Management of any pit water should in-flows occur;
- Proposed monitoring, reviewing and reporting of groundwater data throughout the length of the project;
- Continued water monitoring and discharge requirements following decommissioning;
- Ongoing water requirements for the maintenance of water management structures;
- Discuss any alternative water sources to supplement the groundwater sourced from borefields;
- Monitoring program to be implemented for each potential groundwater impact and provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing; and
- All groundwater data and assessment reporting should be provided to Water Resources, NRETAS.

## 6.5 Impacts to Surface Water

**Outcome**

The proponent shall manage the quality of surface water onsite and moving offsite as a result of mining operations so that it complies with relevant standards and guidelines such as the ANZECC and ARMCANZ 2000 and beneficial use declarations. The surface water monitoring programme will be sufficient to ensure surface water runoff from the mine site is not impacting downstream water quality.

### *6.5.1 Information Requirements*

- Describe the project catchments and provide maps showing the proximity of the project and associated ancillary activities (eg road transport of ore) to any waterways. All water bodies including waterholes, drainage lines, dams and wetlands should be shown on the maps;
- Describe any waterways or other wetland habitat, natural or artificial, ephemeral or permanent, including springs and mound springs that may be impacted by the project.
- Describe the size and design of sediment control structures proposed to intercept and divert surface water;
- Describe water management systems and design criteria of infrastructure in terms of return intervals (ARI), durations and intensities – include a map showing all structures and routes; and
- Provide a site water balance (all inputs and outputs) for the expected mine life, including rehabilitation.

### *6.5.2 Potential Impacts*

Discuss how the project may impact on the surface water, including:

- During flooding events
- Water quality
- Changes to surface water flows
- Aquatic flora and fauna.

### *6.5.3 Safeguards, Management and Monitoring*

Details of the safeguards and management strategies used to minimise the impacts of construction and operation on hydrological features should be provided:

- Outline management of clean, dirty and contaminated water within the proposed mineral lease;
- Detail management strategies for high/extreme rainfall events;
- Outline any water recycling;
- Measures to safeguard surface water resources including options for the appropriate treatment and disposal of construction and operational wastewater, including stormwater runoff. Identify the preferred option and selection criteria used;
- Need for a waste discharge licence.
- Proposed monitoring of surface water.
- Ongoing water requirements for the maintenance of water management structures.

The EIS should identify the monitoring program to be implemented for each potential surface water impact and should provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.

## 6.6 Rehabilitation and Decommissioning

**Outcome**

The proponent will outline a time scale for rehabilitation and decommissioning of the project and for determination of compliance with, and release from requirements of the appropriate authorities. Final rehabilitation should be as close as possible to existing landscape features.

### *6.6.1 Information Requirements*

The decommissioning and rehabilitation program is to be integrated into the mine plan and considered as part of the progression of the mining operation, rather than as a separate phase at the end of the mine life.

Specific information in the EIS should include:

- Identification of the potential for progressive rehabilitation of the project (refer 6.2.2.2);
- Identification of decommissioning and rehabilitation objectives;
- Identification of post mining land use;
- Identification of proposed completion criteria or the process for developing these criteria;
- Identification of proposed environmental indicators to measure progress in achieving the completion criteria (or the process for developing these);
- Details of the design of rehabilitated landforms, including:
  - The progressive and final rehabilitation plans for open pits, waste rock storage areas, run of mine (ROM) pad, non-direct shipping ore stockpiles, roads and other infrastructure sites;
  - The rehabilitation techniques to be used and the final topographic and drainage morphology;
  - Management of topsoil on slopes of waste rock storage areas;
  - Whether final rehabilitated landform will be level with surrounding landscape and appropriate species selection to suit those conditions;
  - Flora species appropriate for use in rehabilitation based on comprehensive baseline structural and floristic data;
  - The collection, selection and seed storage strategy for native species (native grasses and other vegetation) and optimising recruitment success of local province species;
  - Runoff and erosion control measures of rehabilitated areas to ensure runoff discharge does not erode or add to downstream siltation; and
  - Erosion and sediment control procedures.
- Description of on-going water monitoring, management and discharge requirements following decommissioning;
- Water monitoring and discharge requirements following decommissioning;
- Management of clean, dirty (ie: sediment laden) and contaminated water;
- Any long-term responsibilities of Minemakers associated with mine closure;
- Rehabilitation methodology to include:
  - Proposed staging / timing
  - Soil profile reconstruction
  - Selection and collection of local native species

- Runoff and erosion control measures
- Water supply
- Protection from fauna, including cattle and feral animals
- Weed control
- Fire management
- Contingency management against rehabilitation failure

### *6.6.2 Potential Impacts*

- Discuss impacts of rehabilitation not occurring progressively and the long term success being unknown;
- Discuss the impacts of the time lag between clearing and re-establishment of vegetation;
- Discuss the visual impacts of permanent post-disturbance landform of 15m high waste rock dumps in a predominantly flat landscape;
- Outline proposed waste dump locations, dimensions, water catchments, surface treatment and final landform (discuss alternatives) and identify associated risks and risk treatments.
- Provide a detailed description and analysis of risks for the following:

- Final post-rehabilitation topographic and drainage morphology (including waste rock storages); and
- Maintenance of water quality.

### *6.6.3 Safeguards, Management and Monitoring*

- Monitoring of vegetation establishment and stabilisation to achieve rehabilitation objectives;
- Determine whether seed bank in topsoil will be adequate and will remain viable for rehabilitation purposes;
- Conduct plant revegetation trials on stripped topsoil to determine whether natural vegetation is adequate for rehabilitation purposes;
- Detail native province seed collection program and local species that may require a research component to optimise recruitment success (eg.Spinifix seeds may have seed dormancy mechanisms that can make spinifex establishment difficult on mine rehabilitation sites)
- Integration of the rehabilitation program with mine design and operation;
- Proposed quantitative completion criteria or the process of developing these criteria;
- Proposed environmental indicators to measure progress in achieving the completion criteria (or process to develop these);
- Detailed environmental monitoring program for flora, fauna, surface and groundwater, erosion, biological aspects, sediments and other relevant

aspects pertinent to demonstrating the that disturbance incurred by the proposed action is leading towards or has achieved closure criteria
- Determine whether soil replacement methods for rehabilitation purposes are sufficient to maintain vegetation;
- A description of the methods for rehabilitating disturbed areas no longer required for mining operations, including revegetation strategies, surface stabilities and monitoring programs.

## 6.7 Traffic and Transport of Ore

**Outcome**

The proponent will assess the risks from transport related activities, including increased traffic, dust generation, accidental release of hazardous materials, human error, equipment failure, train derailment / collision or traffic accidents. The proponent is to demonstrate how risk management will mitigate or eliminate all identified risks.

### *6.7.1 Information Requirements*

- Detail existing transport networks (including road, rail and ports), telecommunications (optical fibre routes), gas and electricity infrastructure, and water supply and wastewater utilities. Details to differentiate between types of infrastructure should be provided e.g., road type, dual carriage way/single lane bitumen/gravel;
- Detail existing and potential traffic volumes for proposed transport routes sourced from existing Northern Territory Government data;
- Identify constraints with the existing infrastructure (e.g., wet season access, periods of road closure and load limits);
- Detail any new infrastructure that will be required for the project including any requirements to upgrade existing highway and ongoing maintenance. In particular, locations of new roads or tracks, lay down storage areas, turning circles and approach diversion lanes should be identified;
- List all legislation, standards, commitments and agreements applicable to traffic and transport associated with the Project, particularly the transport of ore.
- Detail transport routes, type of vehicles used and transport times for transport of ore to Tennant Creek and Darwin prior to export; and
- Describe storage shed location and size in Tennant Creek and East Arm Port in Darwin.

### *6.7.2 Potential Impacts*

- The predicted increases in traffic for all proposed transport routes, including details on the type and quantity of vehicles.
- The predicted increase in heavy vehicle transport that may cause road degradation on the Barkly Highway.
- A description of the potential impacts of the proposal on existing and future local infrastructure and transport networks during construction and operation. This should include reference to increased road usage generated by the project, as well as possible transport impacts such as increases in dust, traffic noise and risks to safety of other road users.
- From a risk perspective, examine aspects of transport and handling of ore and processing waste including, but not limited to:
  - Details of the Northern Territory's capacity to respond to a collision or derailment;
  - Details of Minemaker's capacity to respond-to / assist NT Police, Fire and Emergency Services;
  - Details of how high risk aspects will be managed (such as road intersections, river crossings, driver fatigue); and
  - Details of containerisation of ore and waste, and how risks of spillage will be managed.

### *6.7.3 Safeguards, Management and Monitoring*

- Description of proposed safeguards, management and monitoring strategies that would be implemented to minimise potential transport impacts during construction and operation including, but not limited to:
  - Methods for complying with any relevant road vehicle axis limits.
  - Methods for securing loads.
  - Measures to reduce any road traffic noise or dust impacts.
  - Measures to improve safety to other road users
  - Measures to prevent transportation of any weed species within the project area off-site via transport vehicles including shakedown areas or properly controlled truck-wash facilities.
  - Consultation with local communities affected by transport impacts.
  - Traffic management.
  - Management of driver fatigue.
- Identify the monitoring program to be implemented for each potential traffic, transport and infrastructure impact and should provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.

## 6.8 Other Potential Impacts

This section should evaluate the risks associated with relevant environmental factors and/or aspects that could be impacted by the project or with the potential to impact on the project. Baseline information for each factor/aspect must be of a sufficient scope and standard to allow assessment of potential impacts (positive and negative) and to enable the establishment of auditable management targets where applicable. Potential impacts and proposed measures to mitigate negative impacts must be described and environmental monitoring programs detailed. The proponent must fulfil all NT and Federal Government legislative requirements and should implement leading practice environmental management techniques in constructing, operating and decommissioning the project.

**The following environmental factors and aspects should be addressed:**

1. **Cultural Heritage**
2. **Socio-Economics**
3. **Weed Management** – proposed management to minimise introduction and spread of weeds on site (e.g. on site vehicle wash-down bay)
4. **Bushfire prevention, control and fighting equipment –** contact Bushfires NT to obtain guidelines with regard to firebreaks, Permits to Burn and advice to neighbours.
5. **Radiation**
6. **Biting Insects –***Guidelines for Preventing Mosquito Breeding Sites associated with Mining Sites, Guidelines for Mosquito breeding and sewage pond treatment in the Northern Territory* – Attachment C (http://www.health.nt.gov.au/Medical_Entomology/Publications/Development_Guidelines/index.aspx)

**Specific requirements and information:**

### 6.8.1 Cultural Heritage

Baseline information should include:

- Describe Indigenous and non-Indigenous sites, places or objects of historic or contemporary cultural heritage significance, including:
  - Areas nominated for listing or listed on Commonwealth and Northern Territory Heritage registers and Commonwealth and Northern Territory registers of Indigenous cultural heritage.

  - Sacred sites - provision of evidence of an Aboriginal Areas Protection Authority (AAPA) Authority Certificate under the *Northern Territory Aboriginal Sacred Sites Act.*
  - European historic sites.
- Areas with special values to Indigenous and non-Indigenous people (e.g., traditional land use).

The EIS should describe the arrangements that have been negotiated with relevant Indigenous groups in relation to archaeological surveys.

The EIS should provide:

- A description of the potential impacts on the features described in the baseline assessment.
- The identification of Indigenous cultural heritage impacts is to take place in consultation with relevant Indigenous groups. This should assess the project's effects on lifestyles, traditional practices, heritage places, the impact of increased visitation and the effects on Indigenous culture generally. All groups should be consulted in relation to the traditional subsistence economy, their natural resource use and any Native Title interests;
- A discussion of the impacts on the relationships between groups identified with traditional and/or contemporary interest in the project area.
- Details of any requirements to apply to, or applications already made to, the Minister for Environment and Heritage to disturb or destroy a prescribed archaeological place and/or object (as defined in Heritage Conservation Regulation 3) under sections 29 and 34 of the *Heritage Conservation Act.*
- A management plan should be developed to include:
  - Procedures to avoid significant areas;
  - Protection of key sites during construction, operation and decommissioning work
  - Ongoing protection measures; and
  - Procedures for the discovery of surface or sub-surface materials during the course of the project.

The EIS should identify the monitoring program to be implemented for each potential cultural heritage impact and should provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.

### 6.8.2 Socio-Economics

The Barkly Tablelands region covers a large area of the central eastern Northern Territory. The major service centre for the region is the town of Tennant Creek. The region is sparsely populated with the major sources of income for the region generated from grazing. Pastoral production within the Barkly Tablelands region accounts for 39% of the Northern Territory cattle industry. Other sources of income include mining and tourism.

The Wunara Community is the closest populated area to the project and comprises four houses and associated buildings. The population fluctuates from 2 to 30 people according to the season. The community is located adjacent to the Barkly Highway and is approximately 10 km from the proposed Mineral Lease boundary.

The EIS should describe the socio-economic characteristics of the local, regional and Northern Territory communities (including a prediction of trends over the expected operational life of the project).

The section should present a balanced broad summary of the project's impact on the local, regional and Northern Territory economies in terms of direct effects on employment, income and production.

It should outline the overall economic benefits of the project, the likely contribution of the project to the development of mining industry, regional economic development and Indigenous economic development in the Northern Territory, employment and skills development outcomes and linkages with other Northern Territory business and sectors, including suppliers and other service providers.

The EIS should specify:

- Estimated value of expenditure during the construction and operation, highlighting the proportion to be spent in the Northern Territory.
- Estimated value of annual expenditure on goods and services from the Northern Territory.
- Estimated quantity and value of production/exports.
- Anticipated markets for products.
- Estimated royalties and taxes to be paid to the Northern Territory Government.
- Opportunities for local industry and Indigenous workforce participation in the construction and operation of the mine. Identify how potential local business and employment opportunities will be identified and involved.

- Relevant opportunities to contribute to Indigenous economic development and wider regional development in the surrounding area, specifically Tennant Creek
- A breakdown of skills/trades required, including specific opportunities for skills development that may be of benefit to the local community, past the lifetime of the mine.
- Identification of opportunities for facilities and infrastructure development that may be of benefit to the local community, past the lifetime of the mine.
- Identification of negative impacts or potential synergies with existing land uses.
- A description of anticipated socio-economic impacts upon local residents, communities and towns, including increased availability of alcohol and drugs in the region
- Any proposals to contribute to community benefit including improved services and infrastructure for relevant communities involved
- Details on how potential local business and employment opportunities and opportunities for synergistic facilities and infrastructure development should be identified.
- Specify the mechanisms that would be utilised to inform the local business community and workers of business and employment opportunities.
- Detail the socio-economic indications that would be monitored on an ongoing basis.

The EIS should identify the monitoring program to be implemented for each potential socio-economic impact and should provide outcome and assessment criteria that will give early warning that management and mitigation measures are failing.

# 7 PROJECT ENVIRONMENTAL MANAGEMENT

Specific safeguards and controls which will be employed to prevent, manage and monitor environmental impacts are to be detailed in an Environmental management Plan or Plans (EMP) for the project. The draft EMP should be strategic, describing a framework for environmental management for construction, operational and decommissioning phases of the project. As much detail as is practicable should be provided to enable adequate assessment during the public exhibition phase. Where possible, specific management policies, practices and procedures should be included in the draft EMP. The EMP would be finalised at the conclusion of the assessment, taking into consideration comments on the EIS and incorporating the Assessment Report recommendations and conclusions.

The draft EMP should:

- Define the management structure of both the construction and operational phases and its relationship to the environmental management of the site;
- Describe the proposed measures to minimise adverse impacts (including those mentioned in Section 7) and the effectiveness of these safeguards;
- Provide performance indicators by which all anticipated and potential impacts can be measured;
- Include identification of responsibilities;
- Describe how employees and visitors will be made aware of environmental responsibilities and safeguards (including an induction process);
- Describe monitoring programs to allow early detection of adverse impacts;
- Describe how monitoring will be able to determine the differences between predicted and actual impacts;
- Describe remedial actions for any impacts that were not originally predicted;
- Include a summary table listing the undertakings and commitments made in the EIS, including clear timelines for key commitments and performance indicators, with cross-references to the text of the report; and
- Provide for the periodic review of the management plan itself.
- Include the following:
  - Soil and Land Management (Erosion and Sediment Control Plan)
  - Water Management
  - Waste Rock Management
  - Weeds and Invasive Species Management
  - Socio-economic Management
  - Air Emissions Management

Reference should be made to relevant legislation, guidelines and standards, and proposed arrangements for necessary approvals and permits should be noted. The agencies responsible for implementing and overseeing the management plan should be identified. Proposed reporting procedures on the implementation of the management plan, independent auditing or self-auditing and reporting of accidents and incidents should also be described.

# 8 PUBLIC INVOLVEMENT AND CONSULTATION

The EIS has an important role in informing the public about this proposal. It is essential that the proponent demonstrate how public concerns were identified, and will influence the design and delivery of the project. Public involvement and the role of government organisations should be clearly identified. The outcomes of surveys, public meetings and liaison with interested groups should be discussed and any resulting changes made to the proposal clearly identified. Details of any ongoing liaison should also be discussed.

An outline of negotiations and discussions with local government, the Northern Territory Government and the Australian Government should be provided.

A stakeholder communication plan should be included in the EIS to facilitate consultation, information sharing and involvement with Government and the local community during the planning, operation and decommissioning of the project.

# 9 ATTACHMENT A: REQUIREMENTS FOR MINING, CONSTRUCTION & BUSH CAMPS

**ENVIRONMENTAL HEALTH**
**INFORMATION BULLETIN No. 6**

This information bulletin has been developed to provide information to proponents of Mining, Construction & Bush Camps with regard to the Department of Health and Community Services' (DHCS) environmental health requirements. Issues covered include food business registration, boarding house registration, on-site wastewater disposal, wastewater stabilisation ponds, potable water supply, solid waste disposal, fuel storage, public health nuisances, and environmental management plans.

## Registration as a Food Business

Larger camps that are not self-catering generally incorporate a commercial food preparation area (kitchen). The *Food Act 2004* defines a food business as 'any business or activity that handles food intended for sale or selling regardless whether the business if of a commercial, charitable or community nature or whether it involves handling or selling on one occasion only'. Consequently the camp's commercial food preparation area is considered to be a food business and therefore requires registration with DHCS in accordance with the *Food Act 2004*.

Registration can be carried out on-line and does not attract a fee. The Registration period is for 12 months with renewals due on 1 July.

To register, go to the DHCS website link or contact the relevant Environmental Health Office:
http://www.transact.nt.gov.au/ths/healthmanager/HealthNotifications.nsf

The *Food Act 2004* also requires all food businesses to meet the minimum standards prescribed by the *Food Safety Standards*:

3.1.1 Interpretation and Application

3.2.2 Food Safety Practices and General Requirements

3.2.3 Food Premises and Equipment

These nationally endorsed standards have been designed to be descriptive, rather than prescriptive and provide the food industry with an increased flexibility in meeting the desired outcome of providing safe food to consumers.

Accordingly, Environmental Health Officers (EHO) are also now required to adopt a more flexible approach when assessing how businesses are able meet the criteria contained within these Standards.

Australian Standard AS 4674 *"Design, Construction and Fit-out of Food Premises"* has been developed to assist the food industry in meeting the outcomes of the Standards. It is not prescribed by law that a premises must meet the requirements contained within, however a premises that meets AS4674 is deemed to comply with the *Food Act* and *Food Safety Standards*.

A food premises that does not meet the requirements of AS 4674 may still able to meet the requirements of the relevant legislation. However, further evidence may be required to be provided to the EHO to ensure that they can be assured that the business will comply through other means. In some instances, a design issue may be able to be addressed through the development and implementation of appropriate workplace policies or procedures. This may, in turn, sometimes result in a delay of the approval process, and require the submission of more information than the typical application.

**Approval Process**

The approval process of a food business is dependent on its location, however it generally involves at least one inspection. Camps are by nature located in remote areas where Building Control in terms of the *Building Act* is not applicable. Building Control essentially means that a Building Certifier must certify all building structures to ensure compliance with the Building Code of Australia. Proponents are referred to Appendix 1 to determine if their project is located within a Building Control Area.

**Inside a Building Control Area**

Under the provisions of the *Building Act*, DHCS is a Reporting Authority and as such, Building Certifiers are required to seek the Department's comments on all building applications involving, amongst other things, new or existing food businesses. The Building Certifier must submit detailed plans to the relevant Environmental Health Office prior to the construction of works. Following assessment and approval, the premises must be registered as a Food Business with the relevant Environmental Health Office prior to operating.

*Outside a Building Control Area*

Since Building Certification does not apply then DHCS becomes the first point of contact for approval of a food business. The proponent must submit detailed plans and specification to the relevant Environmental Health Office prior to the construction of works. Following assessment and approval, the premises must be registered as a Food Business with the relevant Environmental Health Office prior to operating.

**Registration as a Boarding House**

The accommodation section of the Camp will require registration as a boarding house in accordance with the *Public Health Act and Public Health (Shops, Eating-Houses, Boarding Houses, Hostels and Hotels) Regulations.* The Registration period is for 12 months with renewals due on the 31 December. Annual Fees are applicable and are based on the number of bedrooms:

| | | |
|---|---|---|
| 3-10 | Bedrooms | $100 p.a. |
| 11-20 | Bedrooms | $125 p.a. |
| 21-40 | Bedrooms | $150 p.a. |
| > 40 | Bedrooms | $250 p.a. |

A Boarding House application form can be downloaded online or by contacting the relevant Environmental Health Office:

http://www.nt.gov.au/health/healthdev/environ_health/environ_health.shtml >application forms

Following a review of Northern Territory public health legislation, DHCS has developed *Public Health Guidelines for Commercial Accommodation 2005*. These Guidelines will eventually replace the current provisions relating to boarding houses in the *Public Health (Shops, Eating-Houses, Boarding Houses, Hostels and Hotels) Regulations* offering a less prescriptive approach and a clear set of minimum standards.

Room sizes in the Camp must comply with the provisions of *Public Health (Shops, Eating-Houses, Boarding Houses, Hostels and Hotels) Regulations* or the yet to be endorsed Guidelines. However, if the latter is chosen, it will be necessary for the proponent to make application in writing to the Chief Health Officer seeking approval to utilise the Guidelines.

**Approval Process**

The approval process of a boarding house is dependent on its location in a similar manner to food businesses, and also generally involves at least one inspection. Camps are by nature located in remote areas where Building Control in terms of the *Building Act* is not applicable. Building Control essentially means that a Building Certifier must certify all building structures to ensure compliance with the Building Code of Australia. Proponents are referred to Appendix 1 to determine if their project is located within a Building Control Area.

**Inside a Building Control Area**

Under the provisions of the *Building Act*, DHCS is a Reporting Authority and as such, Building Certifiers are required to seek the Department's comments on all building applications involving, amongst other things, new or existing boarding houses. The Building Certifier must submit detailed plans to the relevant Environmental Health Office prior to the construction of works. Following assessment and approval, the premises must be registered as a Boarding House with the relevant Environmental Health Office prior to operating.

*Outside a Building Control Area*

Since Building Certification does not apply then DHCS becomes the first point of contact for approval of a boarding house. The proponent must submit detailed plans and specification to the relevant Environmental Health Office prior to the construction of works. Following assessment and approval, the premises must be registered as a Boarding House with the relevant Environmental Health Office prior to operating.

**Sanitary Accommodation & Ablution Facilities**

Adequate numbers of ablution facilities and sanitary accommodation to be accessible for all operations in accordance with Building Code of Australia and relevant Northern Territory legislation.

**Environmental Management Plans**

The proponent shall provide the relevant Environmental Health Office with copies of Environmental Management Plans that relate to the Camp or Project Operations for initial comment.

**On-site Wastewater Disposal**

On-site wastewater disposal using septic tanks is likely to be the most suitable option for camps that have no major site constraints and comprise less than 20 staff. Larger camps may need to consider other options such as a treatment plant or waste stabilisation ponds. In all cases, the proponent should seek advice from a qualified hydraulic consultant about the most suitable wastewater disposal system. Reliability and low maintenance costs of remote on-site wastewater disposal systems should not be underestimated.

The design of septic tank systems is detailed in the Northern Territory *Code of Practice for the small on-site sewage and sullage treatment systems and the disposal or reuse of sewage effluent* (The Code). The Code was gazetted on the 11 November 1998 and is called up in Regulations 28-28B of the *Public Health (General Sanitation, Mosquito Prevention, Rat Exclusion and Prevention) Regulations.*

**The Role of Regulatory Authorities**
Local Government Authorities in the Northern Territory have no jurisdiction over on-site wastewater management, i.e. approval or monitoring of septic tank installations.

The Department of Planning and Infrastructure (DPI) administer the provisions of the *Building Act & Regulations* with respect to all septic tank installations within a Building Control Area.

DHCS administers the provisions of the *Public Health Act & Regulations* with respect to the:
type approval of septic tanks and associated products.

conventional septic tanks located outside Building Control Areas.

notification to install an Alternative Septic Tank System (ASTS) for a single residential dwelling.

site-specific design approval of an ASTS.

Conventional Septic Tanks & Alternative Septic Tank Systems

**Conventional Septic Tanks** (e.g. septic tank reticulating to absorption trenches or evapotranspiration bed) must be installed by self-certifying plumbers and drainers within Building Control Areas or by licensed plumbers and drainers outside Building Control Areas. The administrative process is dependent on whether the installation is located within a Building Control Area (urban areas and along main highways) or outside a Building Control Area (remote areas).

**Alternative Septic Tank Systems** (ASTS) are septic tank systems that treat effluent to a higher quality than that offered by conventional septic tank system. For example, these include Aerated Wastewater Treatment Systems (AWTS), Composting Toilets, Hybrid Systems and Ecomax Systems. In addition to the self-certification of the installation, ASTS require either a notification to install or site specific design approval.

Septic Tank application forms can be downloaded online or by contacting the relevant Environmental Health Office:

http://www.nt.gov.au/health/healthdev/environ_health/environ_health.shtml >application forms

**Connection to existing Septic Tank Systems**
If the proposal can utilise existing infrastructure such as septic tank systems, then the proponent will need to demonstrate that such infrastructure has adequate hydraulic capacity. This will require the proponent to engage a qualified

hydraulic consultant to provide the relevant Environmental Health Office with as-constructed drawings of the existing infrastructure.

**Trade Waste Pre-treatment Devices**

Trade waste is defined as a *"liquid or liquid borne waste generated from any industry, business, trade, manufacturing process or similar that is approved for discharge to sewer but does not include wastewater from a toilet, shower, hand basin or similar fixture".*

It is not recommended that trade waste be discharged to septic tank system, however a Camp's commercial food premises may prepare cooked food generating liquid trade waste that comprises of food scraps, detergents, fats, oils and grease. This liquid trade waste has a substantial impact on a septic tank system, and if not contained by pre-treatment equipment will cause system failure. For this reason, it is mandatory that all greasy liquid trade waste must be discharged to sewer via a pre-treatment device that has been approved by Power and Water Corporation's Trade Waste Section.

The requirements for trade waste pre-treatment devices are detailed in the following documents:

- Power and Water Corporation - *Guidelines for On-site Pre-treatment* which can be downloaded from the website at: http://www.powerwater.com.au/powerwater/business/trade_waste.html
- DHCS Information Bulletin – *Trade Waste Pre-treatment Devices* which can be obtained from the relevant Environmental Health Office.

**Waste Stabilisation Ponds**

Waste stabilisation ponds (also known as sewage ponds) are used extensively in the Northern Territory for the treatment of wastewater prior to final disposal.

There is legislation to control the reuse or disposal of treated sewage effluent. The responsibility for enforcement of such legislation is vested with DHCS and the Environment, Heritage and the Arts (EHA) Division. The discharge of treated sewage effluent to land or water may therefore occur, but only in accordance with pertinent legislation, or in its absence, to any reasonable conditions imposed by the relevant government agency.

Where treated sewage effluent is proposed to be discharged to a waterway and where the discharge does not have a potential to impact on public health, DHCS will liaise with the EHA as part of the approval process. Consideration will be given to the reuse/irrigation of treated sewage effluent in controlled public access areas, constructed and operated for this express purpose.

Approval Process

Any proposal to construct waste stabilisation ponds at a camp shall require the submittal of plans, design specifications and disposal methodology to the relevant Environmental Health Office & the EHA for approval, prior to construction.

Environmental Health Office will seek specific comment with regard to mosquito breeding from the Department's Medical Entomology Branch.

**Potable Water Supply**

The camp must have a potable that complies with the NH&MRC *Australian Drinking Water Guidelines*. The relevant Environment Health Office may set conditions on the provision of water testing results. Proponents should note that water analysis can be carried out by the Water Laboratories at:

Alice Springs – Department of Natural Resources, Environment, the Arts and Sport - located at the Tom Hare Building, phone (08) 8951 8233

Darwin – Department of Regional Development, Primary Industry, Fisheries and Resources - located at Berrimah Farm, phone (08) 8999 2346

Bore setbacks to onsite wastewater disposal shall be in accordance with the Code of Practice for Small On-Site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent.

Solid Waste Disposal

The *Waste Management and Pollution Control Act 1998* requires that certain waste management activities be licensed or approved by the EHA. An EHA approval for a landfill (rubbish dump) is not required if the landfill is for domestic waste generated on the premises or domestic waste from temporary construction camps.

An EHA licence for a landfill is required if the Camp serves a permanent population of more than 1000 persons or if the Project Operations generates hazardous waste. Further information can be obtained by contacting the EHA on (08) 8924 4139 or by going to their website > http://www.nt.gov.au/nreta/environment/index.html
Providing the landfill does not have to be licensed or approved by the EHA, then the proponent will still need to demonstrate to the relevant Environmental Health Office that the Camp's landfill meets best practice and will not cause an environmental or public health nuisance. Reference should be made to the *Guidelines for Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory 2003* which can be downloaded from the EHA website: http://www.nt.gov.au/nreta/environment/waste/codes/index.html

**Fuel Storage**

Camps and their respective operations generally have a fuel storage facility. Environmental Health does not regulate fuel storage and therefore proponents should discuss this issue with the EHA. Reference should be made to AS 1940-2004 (and amendments) *Storage and handling of flammable and combustible liquids.*

**Public Health Nuisance**

The proponent shall ensure that the construction and operation of the Camp does not create a public health nuisance, in particular from dust or other particulate matter. Environmental Health has provisions to deal with public health nuisances under the *Public Health (Nuisance Prevention) Regulations.*

# 10 ATACHMENT B: NT ENVIRONMENTAL IMPACT ASSESSMENT GUIDE: GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE[1]

## PURPOSE

The Northern Territory Government's objective for managing greenhouse gas emissions from new and expanding operations is to minimise emissions to a level that is as low as practicable. This will help fulfil the objective of minimising greenhouse gas emissions from the NT into the future.

The Northern Territory Government's objective for considering future climate change in the assessment process is to ensure projects and developments are planned taking climate change science and projections into account, to minimise future environmental, social and economic costs and take advantage of any opportunities.

This Guide aims to assist proponents in providing the information needed by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) to assess the impact of greenhouse gas emissions from proposed projects and assess other potential impacts from proposed projects under projected future climatic conditions under the Northern Territory *Environmental Assessment Act 1984*.

## GUIDANCE

### Emissions estimates

Note that the Australian Government is establishing a national greenhouse gas emissions trading system (the proposed Carbon Pollution Reduction Scheme – CPRS), which may have implications for some proponents. More information on the CPRS is available at http://www.climatechange.gov.au/emissionstrading/index.html

Proponents should detail the following in their environmental impact assessment documentation:

1. An estimate of the greenhouse gas emissions for the construction and operation phases:

(a) in absolute and carbon dioxide equivalent figures (refer to the Glossary in this Guide) for each year of the project;
(b) identified on a gas by gas basis; and
(c) by source (including on site and upstream sources such as emissions arising from land clearing and the production and supply of energy to the site).

Emissions estimates are to be calculated using the methodology developed and periodically updated by the National Greenhouse Gas Inventory Committee or another national or internationally agreed methodology. See http://www.climatechange.gov.au/workbook/index.html for access to the National Greenhouse Accounts Factors which may assist.

For emissions from clearing of vegetation, emissions estimates are to be calculated using the National Carbon Accounting System, or another nationally recognised methodology. For more information see http://www.climatechange.gov.au/ncas/index.html

2. Details of the project lifecycle greenhouse gas emissions and the greenhouse gas efficiency of the proposed project (per unit and/or other agreed performance indicators).

Lifecycle emissions and greenhouse gas efficiency should be compared with similar technologies producing similar products.

To provide an understanding of the broader impact of the proposal, proponents are encouraged to place the estimated greenhouse gas emissions from the proposal into a national and global context. Information on Australia's national emissions profile can be obtained from the Department of Climate Change at http://www.climatechange.gov.au/inventory/2005/index.html. International emissions can be seen at the United Nations Framework Convention on Climate Change (UNFCCC) website at http://unfccc.int/ghg_emissions_data/items/3800.php

**Measures to minimise greenhouse gas emissions**

Proponents must demonstrate consideration of a wide range of options and indicate the intended measures and efficient technologies to be adopted to minimise total greenhouse gas emissions from the proposed project, including:

(a) identifying energy conservation measures, opportunities for improving energy efficiency and ways to reduce fugitive emissions where applicable;
(b) indicating where potential savings in greenhouse gas emissions can be made through the use of renewable energy sources, taking into account fossil fuels used for supplementary power generation; and

(c) whilst recognising the likely commencement of an emissions trading scheme, their commitment to offsetting greenhouse gas emissions.

The design measures to maximise efficiency and minimise emissions should represent best practice at the time of seeking project approval.

**Offsets**

Emission offsets include activities that remove carbon from the atmosphere or reduce the greenhouse gas intensity (output per unit product) from current or future activities. No Australian standards for offsets currently exist, although the Australian Government is developing a National Carbon Offset Standard (see: http://www.climatechange.gov.au/carbonoffsetting/ncos/ncos.html).

Measures that offset emissions within the NT are strongly encouraged, and NRETAS staff can discuss possible options with proponents. Proposed emissions offsets projects should include an estimate of greenhouse gas emissions savings that will be achieved through implementation.

**Emissions monitoring and reporting**

Consistent with the principles of continuous improvement, a program is to be outlined in the proponent's Environmental Management Plan which includes ongoing monitoring, investigation, review and reporting of greenhouse gas emissions and abatement measures.

The Australian Government is developing a nationally consistent framework for greenhouse and energy reporting by industry. Projects with significant emissions may be required to report their emissions under the *National Greenhouse and Energy Reporting Act 2007*. Data reported through the system will underpin the proposed CPRS. For more information see http://www.climatechange.gov.au/reporting/index.html

**Impacts of climate change**

Climate change is projected to result in changes to sea level, land and sea temperatures, cyclone intensity, frequency of fire weather, and frequency of extreme weather events including storms, drought and flood.

Proponents should discuss how projected climate change has been taken into account in planning the proposal, and how climate change is expected to affect the proposal over its stated lifetime. Proponents should discuss how climate change-related risks (for example, risk of failure of project infrastructure during potential extreme weather events) will be managed.

Potential impacts of climate change on the surrounding environment including water, land, biodiversity and ecosystems, coastal zones, and the social environment should also be taken into account in proposal planning.

In assessing climate change risk, proponents should be guided by recent projections published by organisations such as the CSIRO, the Bureau of Meteorology (BoM), and the Intergovernmental Panel on Climate Change. For the latest CSIRO and BoM projections for Australia, see: http://www.climatechangeinaustralia.gov.au

## GLOSSARY OF GREENHOUSE TERMS

**Abatement:** Limiting, abating, avoiding or sequestering greenhouse gas emissions through source reduction, fuel displacement or switching, carbon stabilising techniques or sink enhancement.

**Absolute emissions:** Refers to the total emissions of greenhouse gases expressed in terms of the actual mass of each individual gas emitted over a specified time period.

**Best Practice:** A best practice is a process, technique, or use of technology, equipment or resource that has a proven record of success in minimising energy use and greenhouse gas emissions. A commitment to use best practice is a commitment to use all available knowledge and technology to ensure that greenhouse gas emissions are minimised.

**Carbon Dioxide Equivalent:** A unit of greenhouse gas emissions calculated by multiplying the actual mass of emissions by the appropriate Global Warming Potential. This enables emissions of different gases to be added together and compared with carbon dioxide (see Table 1 below).

**Greenhouse Gases:** Table 1 lists the greenhouse gases proponents are required to report on.

**Global Warming Potential (GWP):** The warming potential of a gas, compared to that for carbon dioxide. GWPs are revised from time to time as knowledge increases about the influences of different gases and processes on climate change. Refer Table 1.

**Project Lifecycle Greenhouse Gas Emissions:** Those greenhouse gas emissions measured cumulatively over a defined period. Typically this period is from the point of extraction of the raw materials to either the beginning of the consumer phase of a product or the final disposal or recycling stage of a product, depending on its nature. Proponents should justify their choice of the defined period.

**National Greenhouse Gas Inventory Committee:** A committee comprising representatives of the Commonwealth, State and Territory Governments that oversees the development of greenhouse gas inventory methods and compilation of inventories for Australia.

**Sequestration:** Removal of greenhouse gases from the atmosphere by vegetation or technological measures. Sequestration is not yet precisely defined for the purposes of recognised trading or offset schemes. Accordingly, NRETAS will take a common sense approach on a case by case basis in the interim. To assist proponents, NRETAS regards sequestration as a process that results in the isolation of carbon dioxide from the atmosphere for a period which is significant in terms of influencing the global warming effect.

**Source:** Any process or activity that releases a greenhouse gas into the atmosphere.

**Table 1: Greenhouse gases and respective Global Warming Potential (GWP) factors**

| Greenhouse Gas | Global Warming Potential |
|---|---|
| Carbon dioxide ($CO_2$) | 1 |
| Methane ($CH_4$) | 21 |
| Nitrous oxide ($N_2O$) | 310 |
| Perfluorocarbons ($CF_x$) | 6,500 – 9,200 |
| Hydrofluorocarbons (HFCs) | 140 - 11,700 |
| Sulphur hexafluoride ($SF_6$) | 23,900 |

Greenhouse gas emissions expressed in carbon dioxide equivalent ($CO_2$-e) are calculated by multiplying the actual mass of emissions for each greenhouse gas by its respective GWP factor. GWP factors listed are those published by the International Panel on Climate Change in its 4th Assessment Report, 2007, see http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch02.pdf

# 11 ATACHMENT C: GUIDELINES FOR PREVENTING MOSQUITO BREEDING SITES ASSOCIATED WITH MINING SITES AND MOSQUTO BREEDING AND SEWAGE POND TREATMENT IN THE NORTHERN TERRIORTY

## BITING INSECT ASSESSMENT – MOSQUITO MANAGEMENT PLAN

A 12-month baseline biting insect assessment is not required for this project, as the mine site will be located in an area of relatively low annual rainfall, therefore any mosquito problems arising from natural breeding sites is likely to be short term only. However, mosquito species arising from any nearby ephemeral lakes and streams would be capable of transmitting viruses such as Ross River virus, Barmah Forest virus and the potentially fatal Murray Valley encephalitis virus. Also, mine sites have the potential to create mosquito breeding sites, for example via effluent disposal, water storage and disposal, disruption of natural drainage lines, and erosion leading to sedimentation of drainage lines. Therefore a Mosquito Management Plan is required for the Wonarah Phosphate Project.

The Mosquito Management Plan should outline how the proponent would manage dams, storage ponds and other water holding structures in a manner that prevents mosquito breeding. The proponent should also outline how effluent would be disposed of in a manner that prevents the creation of mosquito breeding, and outline measures that would be taken to protect workers during periods of high mosquito abundance. Other aspects that would need management includes placement of waste rock stockpiles away from drainage lines, and preventing sedimentation of drainage lines.

For more information contact:

Medical Entomology Branch
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**GUIDELINES FOR PREVENTING MOSQUITO BREEDING SITES ASSOCIATED WITH MINING SITES**

**Peter I. Whelan & Allan Warchot**

**Medical Entomology Branch**
**Department of Health and Community Services**
**November 2005**

## General Comments

All mining operations need to include a section in an Environmental Management Plan for the monitoring and control of mosquitoes. This is necessary because of the potential of mine sites to provide extensive breeding sites for mosquitoes of pest and disease significance. Mine sites also provide the potential for the introduction of mosquito species and mosquito borne diseases into the NT that are either exotic to the NT or have previously been eliminated.

The monitoring of adult mosquitoes in any new mine should include trapping of adult mosquitoes once a month at a number of sites for the initial 12 months baseline mosquito monitoring program. The baseline mosquito monitoring program provides an indication of the seasonal distribution of the mosquito species present and the relative potential impact of mosquito borne disease to mine personnel.

The monitoring and control of mosquito larvae should be an ongoing operation for the life of the mine. Mosquito larvae must be controlled with an approved mosquito larvicide (*Bacillus thuringiensis* var. *israelensis* or methoprene) as part of an organised monitoring and control program. Any mosquito control program should be discussed with the Medical Entomology Branch of the Department of Health and Community Services with regard to methods and insecticides.

Accommodation for personnel should be sited as far as possible from the most important biting insect breeding sites and be adequately insect screened or otherwise protected to reduce the impact of mosquitoes.

The potential for artificially created mosquito breeding sites can be minimised with the appropriate design of water holding facilities and water management procedures.

## 1. WATER DAMS

All water storage dams should be constructed with relatively steep sides (45° slope minimum) to discourage the establishment of semi-aquatic vegetation (eg. *Typha* and *Eleocharis* reeds) that will provide suitable habitats for mosquito breeding.

Dam margins should be as straight as possible to minimise the linear area available for the establishment of semi-aquatic vegetation.

Where possible, any closely grouped dams should be joined together to minimise the linear margin of vegetation.

The bottom of any dam should be graded as level as possible, with a slight slope to one end to form a deeper section for periods of low water. This will remove the potential for the formation of isolated pools as the water level recedes in the dry season.

Areas surrounding any dam that will be flooded during the wet season should be graded to enable water to drain freely into the dam as the water level recedes, without the formation of isolated pools that are capable of retaining water for a period greater than 5 days.

There must be no islands formed within any dam. All areas of impounded water should have a relatively deep (2 m) wet season stabilised water level to prevent the emergence of semi-aquatic vegetation.

Any drainage line directed into a dam must be fitted with a sediment trap or erosion prevention structures just upstream from the dam. This is necessary to prevent the formation of “alluvial fans” that will promote the establishment of semi-aquatic vegetation in the area of the fan where silt will be progressively deposited.

Any overflow areas from dams should have erosion protection measures to prevent the creation of plunge pools.

Local native fish should be introduced or have access into any dams where the water quality is suitable for their survival, to provide natural predators for the control of mosquito larvae.

The margins of any water dam should be inspected annually for vegetation growth such as semi-aquatic vegetation and grass. Any dense marginal vegetation should be herbicided or physically removed, to prevent the vegetation from creation suitable mosquito breeding sites.

## 2. WETLAND FILTERS

Wetland filters have the potential to provide prolific breeding sites for mosquito species of pest and disease significance. If no other alternative is available for the treatment and disposal of waste water, a wetland filter should incorporate the ability to annually reduce the build up of any dead vegetation. Plans for wetland filter design and siting should be forwarded to the Department of Health and

Community Services (Medical Entomology Branch) at the planning stage to ensure that their potential impact on the health of mine site personnel is minimised.

Annual maintenance could be achieved by dividing a wetland filter into separate sections. A dual system will enable water to be directed into one section of the filter while vegetation is burnt or otherwise reduced in the other section. An ability to manipulate the water level in the filter to strand or drown vegetation would be beneficial for the management of vegetation and mosquito numbers.

Stocking the wetland filter with local native fish will provide a significant measure for controlling mosquito larvae. The provision of fish however will not remove the need for annual maintenance of the wetland filter.

Where appropriate, consideration should be given to the provision of a fish ladder on any overflow facility to enable the dispersal of fish into and upstream of the filter.

Wetland filters may need to be removed after mining operations are completed to enable the future development of adjacent land.

**3. WEIRS**

Any spillways must be fitted with erosion prevention structures to prevent scouring and siltation of creek lines during periods of overflow.

Fish ladders should be constructed where appropriate to enable the upstream dispersal of fish following periods of dam overflow.

**4. MINE WASTE DUMPS**

The final surface of mine waste dumps should be contoured so that the surface area is free draining and has no surface depressions.

Any runoff from a waste dump should be directed to a silt trap to prevent any siltation of natural creek lines. Siltation in creek lines can promote the formation of isolated pools or disrupt fish ecology and may lead to the subsequent establishment of mosquito breeding sites.

Mine waste dumps should be located away from natural drainage lines, to prevent the upstream impoundment of natural surface water flows. If impractical to locate mine waste dumps away from natural drainage lines, diversion drains will be required to direct surface water flows around the waste dump.

**5. SEDIMENT TRAPS**

Sediment traps need to be designed so that they are free draining within a period of 5 days after flooding.

Sediment traps should be maintained by silt and vegetation removal on an annual basis.

## 6. BORROW PITS

Borrow pits, costeans or scrapes must be rehabilitated such that they do not hold water for a period greater than 5 days. These sites can be rectified either by filling or rendering them to be free draining.

## 7. DRAINAGE PATHS

Natural drainage patterns should be maintained where possible. Access roads across drainage lines may need to be fitted with culverts of sufficient size to prevent upstream flooding for periods that will enable mosquito breeding. Culverts should be installed flush with the upstream surface level. Erosion prevention structures will need to be constructed on the downstream side of any culvert, and erosion prevention structures may also be required at the headwalls of any culvert.

Any disruption to surface drainage should be removed at the end of the mining operations.

## 8. WASTE WATER DISPOSAL

Septic tanks must be installed to DHCS guidelines and should be inspected on an annual basis by the Environmental Officer to ensure that tanks and their effluents do not breed mosquitoes.

Discharge, overflow or excess effluent from sewage treatment systems must be disposed of in a manner approved by DHCS. A sprinkler disposal system is suitable under most situations. Infiltration systems are acceptable if soil conditions are favourable. The discharge of excess effluent into ephemeral creek lines is not acceptable.

Sewage ponds should be constructed with steep sides with an impervious lining and be regularly maintained to prevent vegetative growth at the margins (see *"The prevention of mosquito breeding in sewage treatment facilities"*, available from the Medical Entomology Branch). Surface debris and algal scum should be removed on a regular basis. Monitoring of mosquito larvae should be conducted in sewage ponds on a regular basis and control treatments conducted when necessary.

Disposal of water into “Application areas” must ensure that water does not pool for a period greater than 5 days.

## 9. ARTIFICIAL CONTAINERS

Rainwater tanks must be adequately screened to prevent the entry of mosquitoes.

Any container capable of holding water, eg. machinery tyres, drums, disused tyres, tanks, pots, etc. should be stored under cover, be provided with drainage holes, emptied on a weekly basis, treated with an appropriate insecticide on an appropriate schedule, or disposed of in an appropriate dump site to prevent the formation of mosquito breeding sites.

No used tyres, machinery or other containers that have previously held rain water should be brought to the NT from Queensland unless the containers or machinery has been thoroughly treated with chlorine or an appropriate insecticide to remove the possibility of the introduction of drought resistant eggs of exotic *Aedes* mosquito species.

## 10. RUBBISH AND GARBAGE DUMPS

Rubbish and garbage dumps must be operated in such a matter that there is no ground surface or water filled receptacle pooling of water for a period greater than 5 days, to prevent the formation of mosquito breeding sites.

Rubbish and garbage dumps must be rehabilitated by filling and surface contouring to ensure they are free draining and have no surface depressions.

## 11. DECOMMISSIONING AND REHABILITATION

A decommissioning and rehabilitation plan should be in place for all mining operations to ensure no actual or potential mosquito breeding sites remain after cessation of mining operations. All disturbed areas should be rehabilitated to be free draining where practical. The proponent should consult the Medical Entomology Branch for input when preparing this document.

Aspects to consider when decommissioning and rehabilitating a mine site include removing and appropriately grading all sediment ponds, removing all bund walls created for the development, removing infrastructure and artificial receptacles that could pond water, removing water dams and reinstating existing flowpaths where practical, rehabilitating borrow pits, removing wetland filters, sediment traps, and other facilities that could pond water and breed mosquitoes.

Facilities such as open pit voids and water dams can be left as water holding pits if they are constructed with steep sides (at least 1:2 slope), and stocked with fish during the rehabilitation process.

# THE PREVENTION OF MOSQUITO BREEDING IN SEWAGE TREATMENT FACILITIES

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Published in the Bulletin Of Mosquito Control Association Of Australia Vol. 10, No. 3, November 1998, PP. 19-28.

Published in "Australian Mosquito Control Manual" by a panel of authors, Editors C. Morris and P. Dale.

Australian Mosquito Control Association, 1998, ISBN 0-646-35310-1.

## 1.0 Introduction

Sewage treatment facilities can be major sources of pest and vector mosquitoes (Whelan, 1981, 1984, 1988). Nutrient rich sewage and sewage effluent has the capacity to produce enormous numbers of mosquitoes. As treatment facilities are usually relatively close to communities, these mosquitoes can cause large and continuous pest and potential public health problems.

The mosquito breeding associated with sewage treatment facilities is usually associated with their inadequate design, operation and maintenance, or faulty methods of effluent disposal or dispersal. Some of these problems can be rectified in the planning stages, while others need consideration in the operational phase. There is a need for increased awareness of the nature of the potential problems among designers, operators and regulators of sewage treatment facilities. This paper outlines the problems, and suggests design and operational practices that can reduce mosquito breeding.

## 2.0 Mosquito Species Associated With Sewage

There are many mosquito species associated with sewage treatment or disposal facilities. The most common ones are listed below. For details of the biology of the species, and their potential to transmit disease, please refer to Whelan 1997 'Problem mosquito species in the Top End of the NT Pest and Vector Status Habitats and Breeding Sites'.

### *Culex quinquefasciatus*: 'The Brown House Mosquito'

This species usually breeds in organically polluted water near human communities. It is frequently found breeding in high numbers in unsealed septic tanks and primary sewage ponds, although it is sometimes found in organically overloaded secondary sewage ponds. This is a very significant pest species wherever favourable breeding sites exist. The females rarely travel more than 2 km from their breeding sites.

***Culex gelidus***

This species breeds in a range of fresh water sites, but is particularly prolific in sites with high organic levels such as waste water ponds associated with abattoirs, other animal husbandry facilities and sewage ponds. In sewage ponds it is frequently found in the primary ponds, or secondary ponds with high organic loads and marginal vegetation. It is found in high numbers close to waste facilities but does not appear to disperse in high numbers more than 1-2km.

***Culex annulirostris*: 'The Common Banded Mosquito'**

*Culex annulirostris* is one of the most common mosquitoes in Australia. The most prolific artificial breeding places are in secondary sewage treatment and evaporation ponds, and sewage pond effluent (Whelan 1984). The larvae are most frequently found in calm, sheltered areas where vegetation offers protection from disruptive wave action and aquatic predators. The females of this species can disperse up to 10 kilometres from the breeding site (Russell 1986), although the highest concentrations are usually found within 3 - 4 km of significant breeding sites.

***Anopheles annulipes* s.l.: 'The Common Australian Anopheline'**

This species usually breeds in open, sunlit, temporary and permanent freshwater ground pools, streams or swamps. It is not found in septic tanks and is rarely found in sewage treatment ponds, but it can frequently be found in sites of disposal of sewage effluent, particularly where the effluent flows into shallow, grassed areas. The females can disperse up to 2 km from their breeding places.

## 3.0 Mosquito Breeding and Septic Tanks

Mosquito breeding in septic tanks is entirely dependent on mosquito access into the tank, and is usually due to damaged or missing tank tops and inspection manholes or unscreened vents. *Culex quinquefasciatus* is the principal mosquito species found breeding in septic tanks, although low use or unused tanks can be prolific sources of *Ochlerotatus tremulus* and are potential breeding sites for the dengue mosquito *Aedes aegypti*. Septic tanks that overflow, or absorption trenches that are faulty or in water logged soil, can result in the pooling of untreated or partially treated sewage that can become prolific sources of *Cx. quinquefasciatus* or *Cx. annulirostris.*

In general, the close fitting inspection covers of fibreglass septic tanks are less likely to provide mosquito access than concrete prefabricated tanks. Concrete tanks with a flat concrete top slab invariably have a small space between the top slab and the tank walls that is sufficient to allow mosquito access. Inspection manholes or access points that are of faulty design or damaged can also allow mosquito entry.

Concrete tank tops and inspection manholes can be simply mosquito proofed by applying a sand and cement mixture or a silicone sealant to all joints. All vents to septic tanks including gully traps and breather vents should also be screened to prevent mosquito entry.

Mosquito breeding can be detected relatively easily by opening the inspection manhole and disturbing the interior of the tank with a stick. Any observed adult mosquito activity indicates that sealing of the tank is required. If septic tanks are correctly sealed there is no need for insecticide treatment.

## 4.0 Mosquito Breeding and Package Sewage Systems

Generally package sewage systems are relatively small facilities where the sewage treatment is carried out in tanks or chambers under an active process, rather than a large passive pond system. One of the finished products can be a variable volume of treated effluent that is usually disposed of by infiltration, sprinkler dispersal, evaporation or discharge to natural water bodies. Mosquito breeding does not usually occur within the treatment facilities, but inappropriate disposal of the effluent produced can cause pooling or ecological changes to receiving water, which results in breeding sites for *Cx. annulirostris* or *An. annulipes*. The precautions and remedies outlined below for sewage pond effluent disposal apply equally for package sewage systems.

## 5.0 Mosquito Breeding and Sewage Treatment Ponds

Sewage treatment in pond systems is one of the most common methods of sewage treatment in Australia. Usually the ponds are sited in a relatively low lying area where a gravity assisted sewerage system delivers untreated sewage. The sewage is treated in a series of ponds involving a passive or active primary pond, secondary aerobic ponds, and final evaporation or holding ponds for dispersal or disposal.

## 5.1 Design Considerations

### 5.1.1 Site Selection and Design

Disposal of Effluent

Appropriate planning for the final disposal is an important part of site selection. Disposal near the coast is relatively easy, but in inland areas can lead to major problems if appropriate techniques are not employed. These are discussed in section 5.2 of this paper.

Wind

Ideally ponds should be located in open windy areas away from steep hills or fringing tall or dense vegetation. Wind and the associated wave action plays an important part in preventing mosquito breeding by disrupting the larvae and pupae at the water surface. Wind action can also prevent the spread and hinder the growth of algae, aquatic floating ferns (*Azolla* sp.) and duck weed (*Lemna* sp.), or concentrate flotsam into discrete areas for ease of removal. These floating plants and flotsam should be regularly removed as they can shelter the larvae from both wave action and aquatic predators.

Drainage

The choice of a site should consider the necessity to drain the ponds for maintenance without thereby creating swamps or pools of stagnant water. Effluent release from the final pond is usually suitably arranged, but provision for emptying the intermediate ponds into suitable areas is often overlooked.

Site design should ensure that there is no disruption to normal site drainage pathways caused by any of the works. Diversionary drains around facilities that have seepage or dry season low flows should be constructed with concrete inverts and should discharge to suitable endpoints. The permeability of pond walls and groundwater seepage must also be considered and catered for.

Ponds or embankments constructed near tidal areas need to ensure existing tidal drainage patterns are maintained. If these are blocked, problems with salt water species of mosquitoes breeding in impounded water can be expected.

### 5.1.2 Access

Site design should allow for all weather access around the entire installation. Weed and tree growth maintenance, fire prevention, and erosion and siltation rectification in diversionary drains may require regular access. Seepage from ponds or diversion of site surface water can cause swampy conditions that require vehicle access for inspection and mosquito control.

### 5.1.3 Pond Dimensions

Pond Size

Sewage pond size is primarily determined by engineering parameters related to design flow rates, pollution loadings, and the required effluent quality. Frequently there is little consideration given to the effect of pond size on mosquito breeding. Adoption of oversized ponds, either from inaccurate predictions of sewage volume or a desire to provide for future capacity, can lead to the ponds becoming shallow, thickly vegetated swamps, capable of breeding large numbers of mosquitoes.

Consideration should be given to staging of pond construction, or the use of multiple ponds, although the use of smaller multiple ponds may inhibit wind and wave action. In most cases, it is the margins of the ponds which provide the mosquito breeding sites. Multiple small ponds can result in increased total margin length, but are preferable to having one large pond that is only shallow and has emergent vegetation. Installing peninsular barriers to reduce short-circuiting sewage flow through a large pond can also markedly increase the margin length. Increased margins require more capital expense with edge treatments, and increased maintenance costs.

Pond Depth

Selection of pond depth is usually dictated by the function of the pond, ie. primary, secondary, or evaporation. Adequate allowance must be made for solids deposition, particularly in primary ponds, otherwise excessive deposits will lead to colonisation by vegetation and the creation of mosquito breeding sites.

Profiling the pond base, with the deepest side at the pond entry, can help, particularly if there is a seasonal variation in sewage input. For evaporation ponds, particularly those with earth sides or which may be continually full, a depth of 2 m or more is recommended to prevent the intrusive growth of semi aquatic reeds such as *Eleocharis* sp. and *Typha* sp.

### 5.1.4 Construction Details

Vertical Concrete Margins

Vertical concrete margins have proven to be the most satisfactory means of controlling mosquito breeding by promoting wave action, and maintaining margins free of vegetation and debris.

Concrete walls can be precast for remote locations or constructed *in situ*, and are cost effective in the long term. The walls should be deep enough to allow for a wide variation in water level and should have a horizontal or slightly sloping bench at the base above the bottom level of the pond, to discourage establishment of vegetation and reduce silt accumulation immediately adjacent to the pond wall. Sealed verges around the top of the banks are desirable to facilitate maintenance and to prevent the erosion of soil into the pond. Walled ponds may still have problems, particularly in primary ponds, with floatables and wind blown debris in the corners, and silt accumulation near sewage entry points. Truncated or rounded corners and multiple or variable entry points can help to reduce these problems.

Unlined earth banks

Sewage ponds with unlined internal earth banks have the greatest capacity for mosquito breeding, particularly those with gentle slopes where marginal vegetation can establish at the water edge. They are accordingly not recommended, except as temporary or emergency measures, unless they are steep sided and there is a capacity to carry out regular vegetation management at the water edge and internal banks. For unlined ponds, the use of grasses for bank stabilization that are short and prostrate such as couch species are better suited than upright grass or shrubs The banks should be constructed using impervious materials such as compacted clay. If neglected, unlined internal earth banks can become either eroded, or overgrown with grass, shrubs and trees. Corrective measures can then be a major undertaking.

Other Linings

Various systems have been used to line earth banks as a temporary measure to reduce growth of vegetation, but they have not been entirely satisfactory.

Stone pitching of the margins is not satisfactory as it does not offer sufficient deterrent to vegetation growth, and mechanical maintenance is difficult. Overlapping cement or iron sheets have been used, but have problems with damage and stability, resulting in subsequent weed growth. Various types of bituminous or plastic sheeting have also been tried, and have shown promise as short to medium term solutions. Problems encountered include inadequate anchoring, weed growth, ultraviolet deterioration, and human interference. The more modern ultraviolet resistant heavy duty plastics, anchored with earth mounds back from the rim of the ponds, have been more successful.

Sloping concrete margins have been tried in a number of locations. While better than unlined ponds they have the drawback that wave action is damped by the slope. Dust and organic matter can also build up and enable vegetation to establish. It is important that the margins have a slight rim and sealed verges to prevent erosion and subsequent accumulation of soil and vegetation at the water margin.

### 5.1.5 Maintenance

Before commissioning sewage pond systems, a general survey of the whole site should be conducted to ensure that mosquito breeding sites have not been created inadvertently by borrow pits formed during pond construction, pools of water resulting from site drainage works or pooling caused by road access. Any problems should be rectified before the ponds are commissioned, so that they do not become a routine maintenance problem.

Pond maintenance is a vital part of pond management. The highest levels of maintenance will be required for earth lined primary ponds and final or evaporation ponds with low and seasonally variable effluent flow rates. Some form of maintenance will be required even for ponds with vertical concrete margins and sealed verges. Even those ponds of good design in favourable locations, with ideal effluent characteristics, must have adequate provision for people and resources to carry out a regular and defined maintenance program.

Aspects of maintenance frequently overlooked are the regular control and removal of vegetation on the margins or the pond verges, the regular removal of floatables, algal mats or aquatic plants from the pond margins, and the repair of cracks and other failures that can allow increased soil moisture levels on the banks and subsequent vegetation growth.

For some ponds, a program of water level management may be adopted which alternately floods and strands marginal vegetation or floatables. The form of

maintenance will depend heavily on the pond design, effluent parameters, and staff experience.

Regular and adequate maintenance to prevent mosquito breeding is not common in many sewage treatment facilities. If there is any anticipation that proper maintenance will not be carried out regularly, a maintenance-free design should be chosen.

## 5.2 Effluent Disposal Or Dispersal

### 5.2.1 Problems

Many sewage treatment facilities give insufficient consideration to the disposal of treated effluent. It has been assumed that effluent after 'adequate treatment' is no longer a problem, and can therefore be left to run down the nearest flow line. In fact, this effluent often forms flooded, overgrown, stagnant pools that create very productive mosquito breeding grounds.

In some situations effluent has been directed into sand dunes or sandy situations in the belief that infiltration would provide a satisfactory disposal method. This is totally inadequate because the high organic loads of the effluent and resultant algae invariably seal against infiltration and result in extensive pooling of effluent.

Even after tertiary treatment in evaporation ponds, the resulting 'treated' effluent still retains a great capacity to breed mosquitoes. It still has relatively high nutrient levels that lead to high algal and vegetative growth, and can disrupt freshwater ecology including that of the fish predators on mosquito larvae. Even high quality tertiary treated effluent with low nutrient levels may be sufficient to cause pooling, ecological change, and mosquito breeding, if not disposed of adequately.

### 5.2.2 Large Evaporation Ponds

Evaporation ponds either of intentional or 'ad hoc' design have commonly been used as an effluent disposal method. Large evaporation ponds are rarely filled to capacity for the entire year, and in many instances are just bunded areas that store effluent against escape to other areas. Because of their large area, the variable inflow, and seasonal variations, large evaporation ponds can become shallow, flooded, swamps with dense weed and reed vegetation. Evaporation ponds that dry up and are then seasonally inundated by rain or effluent release can become breeding grounds for floodwater mosquitoes.

The aspects to be considered in designing large ponds to reduce mosquito breeding, include:

- initial and regular removal of all emergent vegetation within the evaporation area,

- levelling of the floor of the evaporation area,
- division of the evaporation area into a number of smaller areas,
- constructing a sloping floor to concentrate the water in a 'sink' area at the effluent entry point;
- concrete lining of the 'sink' area on the floor of the evaporation area and concrete lining of embankments.

However, incorporating some of these aspects into the design can be prohibitively expensive. The alternatives are to have a regular maintenance program, which could be more expensive in the longer term, or to choose a more suitable method of effluent disposal.

### 5.2.3 Small Evaporation Ponds

The use of a series of small concrete lined evaporation ponds can be a very effective method of effluent disposal. The best designs incorporate a series of relatively small ponds that can progressively fill by gravity overflow. Such a system may be expensive to construct, particularly if the evaporation area required is relatively large. However, the method has the advantage of being relatively maintenance free and can cope with variations in effluent volume.

### 5.2.4 Disposal to the Sea

Disposal direct to the sea or to a daily flushed tidal area is one of the most suitable methods for effluent disposal. It is important that the disposal outlet is to the open sea or a large creek or river with considerable tidal movement. Disposal at the lower end of a relatively long, narrow or tortuous tidal creek can result in effluent build up in the creek, which can be pushed by incoming tides higher up the creek line and overflow or pool in areas where mosquito breeding sites can develop.

Disposal onto large flat, inadequately flushed, tidal areas can create breeding sites not only for freshwater species of mosquitoes, but also for salt and brackish water species.

### 5.2.5 Disposal to Rivers

The suitability of discharge to rivers depends upon the volume of flow in the river, the seasonal variability of flow, and the downstream effects of the disposal. When the flow in the rivers or creeks is small or subject to wide seasonal variation, this method can result in eutrophication or ecological and vegetation changes which lead to mosquito breeding.

### 5.2.6 Disposal to Land

Sprinkler dispersal

This method has been relatively successful in areas where there have been particular problems with other disposal methods. It is most successful onto areas with well developed stands of trees that are on soils of good permeability. In these situations the final effluent can be automatically and periodically dispersed via a system of overhead sprinkler heads. Fire damage in natural vegetation can be rectified by the construction of an underground pipe system with steel uprights and metal sprinklers. Sprinkler irrigation can also be undertaken using small volume undertree micro sprinklers in plantation settings. However weed maintenance can be a problem with smaller systems and is generally only suited to plantations or organised irrigation areas where regular maintenance is practical or cost effective.

Ideally, sites should be relatively flat but have adequate drainage to cope with rainy periods. Feeder lines to spray heads should be laid out along contours, rather than at right angles, so that effluent pressures are equal and effluent will be retained in the lines after spraying rather than permitting continued flow to the lowest spray head. This will avoid creating semi permanent pools of effluent at the base of one sprinkler head.

The area required will depend upon the volume of effluent to be disposed, and the long term absorption capacity of the soil and the vegetation. Precautions are required to ensure that effluent contaminated run off after rain episodes cannot pool in nearby depressions, flow lines or creeks.

Sprinkler dispersal can be used for tree and pasture growing or landscape watering, but the National Health and Medical Research Council Guidelines for the Reuse of Waste Water must be adhered to (NH&MRC, 1979). This can include fencing, adequate signs and chlorination. Tertiary chlorination can provide a high quality effluent for drip irrigation and recreational area watering but may need filtration.

If tertiary treated chlorinated effluent is held in open temporary storage ponds, the ponds should be constructed as for secondary sewage treatment or evaporation ponds. Algal and other microscopic growth will still occur and lead to marginal vegetation growth and ideal conditions for mosquito breeding. Reuse of tertiary treated effluent for landscape watering may require freshwater flushing of the distribution pipes immediately after effluent dispersal to prevent odour problems resulting from anaerobic action on the retained effluent in the pipes.

Sprinkler disposal using high volume spray units has been successfully used in some areas, but potential problems include regularly moving the spray units, and overwatering leading to pooling and rising water tables.

Dripper dispersal

Disposal by dripper systems requires a high standard of effluent, usually with a tertiary chlorine treatment, to prevent dripper blockage by algae. Dripper systems can be used for both small or large scale disposal, but is usually only suitable for plantation situations where the vegetation growth at each dripper site can be practically and economically maintained. Drippers held off the ground can reduce

root blockages of the drippers. Generally dripper systems are only suitable for the dispersal of small volumes of effluent per unit area or periodic release, and are prohibitively expensive because of their high maintenance requirement.

Small Furrow Irrigation

This method is useful for relatively small volumes of effluent on sandy soil in low rainfall areas. A feeder channel is used to deliver effluent to a ploughed area of small furrows that slope gently away from the feeder channel. Disposal is by infiltration into the sandy soil. When infiltration becomes less efficient, the flow is directed to an adjacent ploughed area, and the original area is allowed to dry out and is reploughed.

This system requires a considerable amount of attention and maintenance, but has a low capital cost.

Channel Infiltration

In this system, permanent infiltration channels are constructed and effluent flow is directed down a number of groups of channels which are alternatively spelled and maintained. The method can be used on less porous soils than is possible for furrow irrigation. If this method is used for the irrigation of tree or bush crops, intensive monitoring of water tables and salinity levels is required to ensure viability of the crop in the long term. Problems with larger scale use have included, high capital cost with infrastructure, high labour input, regular weed and erosion control in the channels, rising soil salinity, and elevated water tables.

Flood Bay Irrigation

The degree of land preparation for flood bay irrigation is usually considerable, as a system of correctly graded flood bays is necessary to allow for efficient flooding and to prevent pooling in or at the end of the flood bays. The bays are periodically or alternatively flooded by a distribution feeder channel and the effluent is allowed to evaporate or infiltrate in the bays over a period of 3 - 4 days. This method has been used successfully to grow irrigated pasture and tree crops.

Problems with flood bay irrigation arise during rainy periods, when extended flooding of the bays with nutrient enriched water can result in mosquito breeding. Small flood bay systems are suited for relatively small effluent volumes, arid areas where surface evaporation is high, or in situations with good soil infiltration. Some of the problems with flood irrigation systems can be reduced by using an automatic siphon and a multi discharge distribution channel to release effluent periodically and evenly over the flood bay. Generally flood systems require at least two separate bays so maintenance and spelling can be carried out.

## 5.3 Biological Control

Biological control, though not generally efficient or applicable to primary ponds, can be a very efficient means of controlling mosquito larvae in secondary and evaporation ponds.

The major biological control agents are fish, aquatic beetles and aquatic bugs. Fish can control mosquito larval numbers directly by eating the larvae, or indirectly by reducing algae which provide protection from other predators or wave action. Fish are usually only suitable for the higher oxygenated waters. Several native species have shown promise as mosquito larvae predators, including the rainbow fish, *Melanotaenia* sp., the delicate blue eye *Pseudomugil tenellus,* and gudgeons. The bony herring can survive well in secondary ponds and can assist in surface algal scum management. Wildlife regulations must be observed when considering using fish as biological control agents.

Marginal vegetation such as couch grass and reeds should be eliminated or kept to a minimum, so that fish can have physical access to the mosquito larvae. Actively growing reeds with upright stems may not restrict access. However, when these reed species die or lodge over, they prevent physical access for the fish and enable mosquito breeding.

Aquatic beetle larvae (Carabidae) and aquatic bugs (Belostomatidae) can be very efficient mosquito larvae predators in secondary and evaporation ponds. The aquatic bugs are able to live in higher organic water than the aquatic beetle larvae, and can be present in enormous numbers. Again, physical impedance by thick vegetation at the margins will reduce the effectiveness of these predators. Vegetation problem areas should be eliminated by slashing and physical removal or weedicide application. Insect predators can achieve almost total control of mosquito larvae in sewage ponds of suitable water quality with steep margins, minimal margin vegetation or vegetation free margins.

## 5.4 Chemical Control

The aim of chemical control of mosquito larvae should be to apply the minimum amount of insecticide to prevent the production of adult mosquitoes. Chemical control should not be used as a long term strategy in sewage treatment areas, in order to avoid insecticide resistance and unwanted effects on non-target organisms. Weedicide application to mosquito breeding sites often provides more efficient short to medium term control and can greatly reduce insecticide requirements. However, it may be necessary to apply insecticides during the initial operational period or when proper maintenance has not been carried out. The insecticides of choice to control mosquito larvae in sewage ponds and effluents are Temephos, methoprene, or *Bacillus thuringiensis* var. *israelensis* (Bti). Correct rates for temephos must be strictly adhered to, as overdosing can kill fish and other aquatic insects.

## 5.5 Mosquito Sampling

Regular inspections should be carried out in sewage ponds and their effluents to determine whether mosquito larvae are present and to determine the necessity for weed or chemical control. Chemical control with temephos, Bti or methoprene may be necessary at weekly or longer intervals. The presence of pupae indicates that control should have been conducted at shorter intervals. If only first and second instar larvae are present, then either biological control is quite efficient, or the

mosquitoes have just started to breed in that area, and continued monitoring is necessary.

Mosquito larval or pupal samples can be collected by dipping into sheltered vegetated zones with a soup ladle. Any larvae collected should be stored in small vials with 70 % alcohol or methylated spirits, together with information on collection locality, site, date and collector.

Adult specimens that have been collected as they bite or harbour can be killed by freezing and packed loosely in tissue paper in a small box, together with all the details of collection. Larval, pupal and adult specimens should be sent to an entomologist for identification or verification.

Chironomid midge pupae or adults are often in very high numbers near sewage treatment facilities and are frequently mistaken for mosquitoes. Their presence has often resulted in control programs being instituted where none was necessary.

## 6.0 Concluding Remarks

In the past, the design of sewage treatment and effluent disposal facilities was usually dictated solely by engineering and microbiological principles. Little attention was paid to the possibility of breeding mosquito populations close to habitations, and the resulting potential pest and public health problems. Appreciation of this potential risk, followed by the application of simple design principles and adequate maintenance can reduce these problems. Biological control can often be used to supplement good design features. Chemical control can be used under certain situations but should be reserved as a short term remedy until permanent solutions or maintenance measures can be implemented.

## References

1. NH&MRC, (1979), 'Guidelines for Re-use of Wastewater', *Australian Water Resources Council, National Health and Medical Research Council*, Department of National Development, Canberra.

2. Russell, R. C., (1986), 'Dispersal of the arbovirus vector *Culex annulirostris* Skuse (Diptera: Culicidae) in the Murray Valley of Victoria Australia', *Gen App Ent*, vol. 18, pp. 5-9.

3. Whelan, P. I., (1981), 'The vulnerability and receptivity of the Northern Territory to mosquito borne disease', *Transactions of the Menzies Foundation,* vol. 2 ,1981, Living in the North, pp. 165-171.

4. Whelan, P. I., (1984), 'Mosquitoes of public health importance in the Northern Territory and their control', Northern Territory Department of Health, Darwin.

5. Whelan, P. I., (1988), 'Mosquito breeding and sewage treatment in the Northern Territory', *'Water', J Aust Water & Wastewater Assoc*, vol. 15, no. 5, pp. 34-37.

6. Whelan, P.I. (1997), 'Problem mosquito species in the Top End of the NT-Pest and vector status, habitats and breeding sites'. Medical Entomology Branch handout, Department of Health and Community Services (minor update January 2004).

# 12 REFERENCES

*AS/NZS 4360:2004 Risk Management.* Standards Australia, Third edition 2004. Sydney and Standards New Zealand, Wellington.

*HB 436:2004 Risk Management Guidelines: Companion to AS/NZS 4360:2004 (Incorporating Amendment No. 1)*. Handbook. Standards Australia, Sydney and Standards New Zealand, Wellington.

*HB 158—2006 Delivering assurance based on AS/NZS 4360:2004 Risk Management.* Handbook. Standards Australia, Sydney and Standards New Zealand, Wellington.

*HB 203:2006 Environmental risk management - Principles and process*. Standards Australia. Handbook. Third edition 2006. Jointly published by Standards Australia, GPO Box 476, Sydney, NSW 2001 and Standards New Zealand, Private Bag 2439, Wellington 6020

TEAM NT (2004) Northern Territory Minerals Council (Inc.) and the Mines and Petroleum Management Division of the Northern Territory Government. *TEAM NT: Technologies for Environmental Advancement of Mining in the Northern Territory: Toolkit.* D.R. Jones & M. Fawcett principal authors.

US EPA 1998. *Guidelines for Ecological Risk Assessment*. EPA/630/R-95/002F. US Environmental Protection Agency, Washington DC.