KANOWNA BELLE PROJECT
STAGE II

CONSULTATIVE ENVIRONMENTAL REVIEW

PREPARED FOR

KANOWNA BELLE GOLD MINES

by

ndford & Associates Pty Ltd

July, 1993

Cover Photo

View east towards the abandoned Kanowna townsite, located in the cleared area at the end of the Yarri Road. The Kanowna Belle Mine, located where the waste rock dump is clearly visible, is about 3 km north-west of the old townsite, and approximately 18 km from Kalgoorlie.

GOLD ROASTER TO TREAT REFRACTORY ORE
KANOWNA BELLE MINE PROJECT STAGE II

NEAR KALGOORLIE, WESTERN AUSTRALIA

CONSULTATIVE ENVIRONMENTAL REVIEW

Prepared for

KANOWNA BELLE GOLD MINES

(PEKO GOLD LTD AS PROPONENT)

by

D. C. Blandford & Associates Pty Ltd
ACN 009 402 706

July, 1993

GOLD ROASTER TO TREAT REFRACTORY ORE
KANOWNA BELLE MINE PROJECT STAGE II
NEAR KALGOORLIE, WESTERN AUSTRALIA

CONSULTATIVE ENVIRONMENTAL REVIEW

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Consultative Environmental Review (CER) for the proposed Stage II of the Kanowna Belle Project has been prepared by D. C. Blandford & Associates Pty Ltd on behalf of Peko Gold Ltd in accordance with Western Australian Government procedures. The report will be available for comment for four weeks:

* beginning Tuesday , 3rd August, 1993

* finishing Tuesday, 31st August, 1993

Comments from government agencies and from the public will assist the EPA to prepare an Assessment Report in which it will make recommendations to the Government.

Following receipt of comments from government agencies and the public, the EPA will summarise these comments and forward them to the proponent and may ask for further information. The EPA will then prepare an assessment report with recommendations to Government, taking into account issues raised in the public submissions.

Why Write a Submission

A submission is a way to provide information, express your opinion and put forward your suggested course of action including any alternative approach. It is useful if you indicate suggestions which could improve the proposal.

All submissions received will be acknowledged.

Developing a Submission

You may agree or disagree, or comment on, the general issues discussed in the CER or with specific proposals. It helps if you give reasons for your conclusions, supported by relevant data.

You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the CER,

* clearly state your point of view;
* indicate the source of your information or argument if this is applicable;
* frame your queries in the form of questions; and
* suggest recommendations, safeguards or alternatives.

Points to Keep in Mind

By keeping the following points in mind, you will make it easier for your submission to be analysed.

Attempt to list points so that the issues raised are clear. A summary of your submission is helpful. Refer each point to the appropriate section, chapter or recommendation in the CER. If you discuss sections of the CER, keep them distinct and separate, so that there is no confusion as to which section you are considering.

Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Please indicate whether your submission can be quoted, in part or in full, by the EPA in its Assessment Report.

Remember to include:

Your name, address and date.

THE CLOSING DATE FOR SUBMISSIONS IS: 31ST AUGUST, 1993

SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman
Environmental Protection Authority
8th Floor
Westralia House
141 St Georges Terrace
PERTH WA 6000

Attention: Mr Shane Sadleir

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1.0 SUMMARY

The Golden Valley Joint Venture (GVJV) comprised of Peko Gold Ltd (50%) and Delta Gold NL (50%) propose to develop Stage II of the Kanowna Belle Project, located 18 km north-east of the city of Kalgoorlie-Boulder. Peko Gold Ltd is Manager of Operations for the joint venture, and has been nominated by the Environmental Protection Authority (EPA) as the Proponent responsible for the proposal.

Prior to the Stage I development, the GVJV operated the QED mining and heap leach operation immediately to the north of the Kanowna Belle project area. QED operations have almost been completed and rehabilitation of the affected area is proceeding in accordance with its Notice of Intent. The development of Kanowna Belle Stage I began in November 1992 and is due to commence ore treatment in August 1993. Stage II involves the construction and operation of a sulphide concentrate oxidation plant to treat sulphide ore prior to leaching. Stage II would be constructed adjacent to the existing Kanowna Belle operation which involves the open-cut mining and treatment of oxidised ore through a conventional carbon-in-pulp (CIP) process plant. The ability to economically treat and recover gold from sulphide ore in Stage II is a fundamental pre-cursor to the development of Stage III, an underground operation, which will extend mine life from about five years to fifteen years or more.

A number of options have been considered for the refractory process and these have been examined on the basis of engineering constraints, technology, and costs. This submission is made in respect of the roasting option.

Vegetation, flora, and fauna surveys have indicated that there are no plants or animals present that require special management strategies for their protection or conservation. A Priority 4 species, *Eremophila parvifolia* occurs in the project area. This species is known to occur in a number of locations in the Eastern Goldfields.

Emission of sulphur dioxide in the roaster off-gas will result from implementation of the Stage II project, and accordingly there are potential impacts on regional air quality, and on local vegetation.

A management programme has been developed to minimise this impact, and to ensure compliance with the Environmental Protection Policy for air quality within the Kalgoorlie-Boulder Policy Area.

This management programme has as its key elements:

(i) a sulphur dioxide monitoring network throughout the Kalgoorlie-Boulder residential area linked to a data collection facility;

(ii) monitoring of local and regional weather conditions;

(iii) a plume tracking capability;

(iv) the establishment of a predictive capability for plume behaviour; and

(v) the implementation of a roaster shut-down procedure based on wind direction vectors from Kanowna between 184° and 238° and a wind velocity of 4 m/s or less at a height of 10 m within this arc.

The relationship between atmospheric sulphur dioxide and plant health is complex and there are little data available for the Kalgoorlie area that provide a useful base on which to establish or assess effects of sulphur dioxide on vegetation.

A programme will be established to monitor the effects of sulphur dioxide on vegetation. In addition, a programme will be set in place to monitor groundwater levels and water quality in the vicinity of the tailings disposal facility.

A small quantity of arsenic trioxide (approximately 250 tonnes per year) will be produced at Kanowna Belle. This will be stored on site under cover in bulka bags or drums until such time as a suitable parcel of product has been collected for sale as a batch. Product sold in this manner will be packaged to United Nations' guidelines for transport of toxic materials.

The proponent is committed to a programme of environmental management and, during the initial period of roaster operation, will further develop and refine the predictive capability of the air quality management strategy, in conjunction with existing operations. Environmental management will include roaster shut-down when necessary. The proposed management programme will ensure that the environmental impacts and effects that have been identified will be minimised.

As a result of the overall commitment to environmental management and the location of the project, the project is considered to be environmentally acceptable.

2.0 INTRODUCTION

2.1 LOCATION

The Kanowna Belle mine is located approximately 18 km north-east of Kalgoorlie on the Yarri Road. The mine operates within mining tenements M27/92 and M27/103 within the Kanowna District of the north-east Coolgardie Mineral Field.

The general location of the project area is shown in Figure 1 and the relationship of the mine site to Kalgoorlie is shown in Plate 1.

2.2 THE PROPONENT

The Kanowna Belle project is owned and operated by the Golden Valley Joint Venture comprised of Peko Gold Ltd (50%) and Delta Gold NL (50%). Peko Gold Ltd is the Manager of Operations for the joint venture and has been nominated by the EPA under Section 38(6) of the Environmental Protection Act as the Proponent for the proposal.

The address of the Proponent is:

Peko Gold Ltd
ACN 004258979
154 Abernethy Road
Belmont WA 6104

2.3 PREVIOUS INVESTIGATIONS

Stage I of the Kanowna Belle project comprises the open cut mining of oxidised ore and treatment via a CIP process plant. A flotation concentrate is produced and stored for later processing in the refractory plant. This stage of the project was addressed in a Notice of Intent (NOI) prepared by Dames & Moore in 1992.

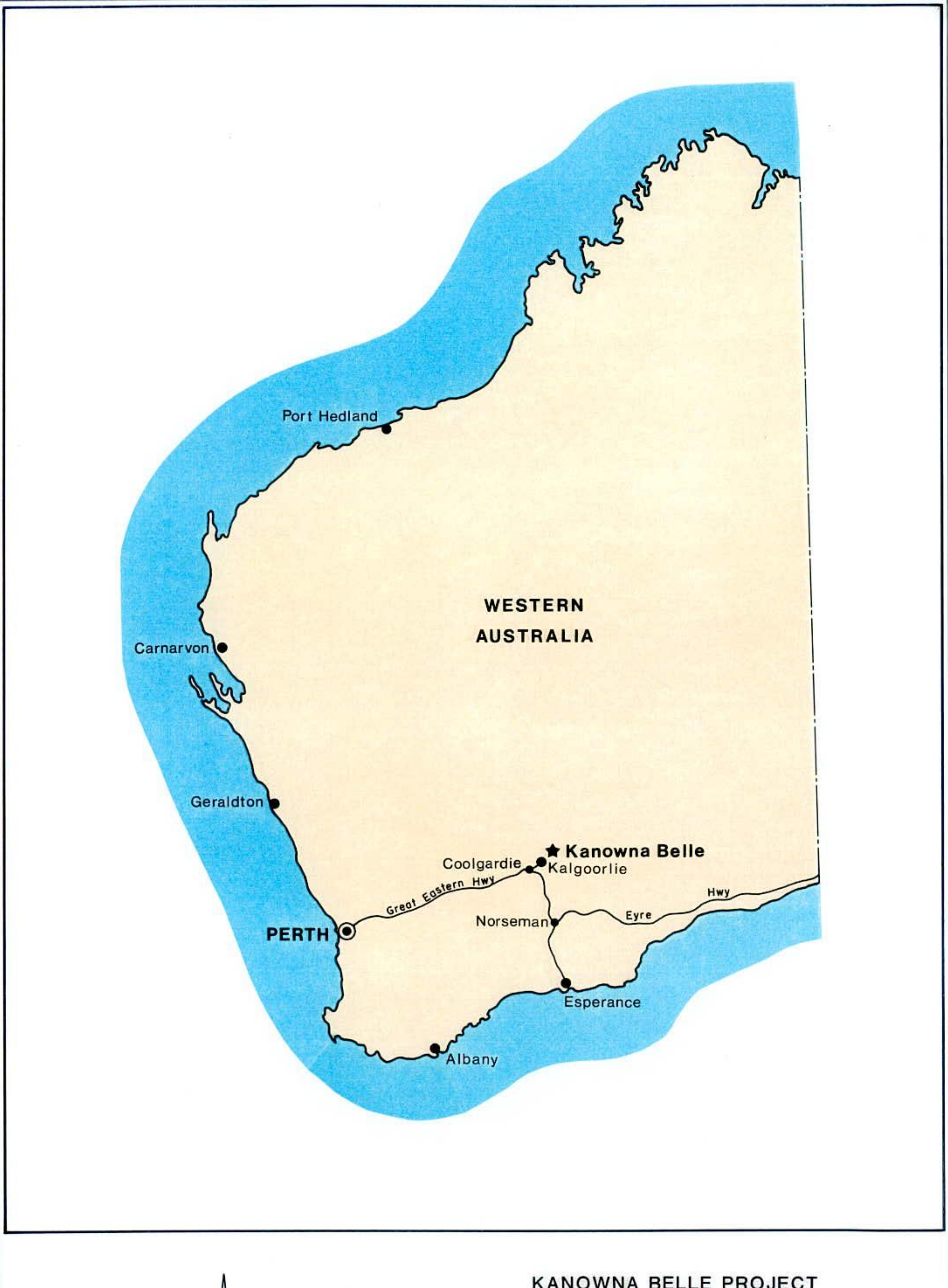
Stage II of the Kanowna Belle project comprises the construction and operation of a refractory process plant within the existing mine site infrastructure.

All aspects of the project, addressed in the NOI, prepared and submitted in accordance with statutory requirements, remain unchanged, and apply to Stage II of the project.

2.4 SCOPE OF THE CER

In the NOI, the development of Stage II was foreshadowed. However, the Golden Valley Joint Venture recognised and acknowledged the requirements for further approvals before implementation of Stage II could proceed.

This document addresses only those issues that are pertinent to the installation and operation of a conventional concentrate roaster for the processing of refractory ores at Kanowna Belle. This environmental



KANOWNA BELLE PROJECT

CONSULTATIVE ENVIRONMENTAL REVIEW

Location Map

Figure 1

DC BLANDFORD & ASSOCIATES PTY LTD

PLATE 1

Views north-east from Kalgoorlie along the Yarri Road towards the old Kanowna townsite and the Kanowna Belle Mine (arrowed) approximately 18 km distant.

review attempts to focus on the key environmental issues, and accordingly the objectives are:

(i) to place the proposal in the context of the local and regional environment;

(ii) to identify the options considered for the refractory process;

(iii) to identify potential environmental impacts resulting from the operation of the concentrate roaster; and

(iv) to detail the environmental management requirements, including monitoring, that are appropriate to avoid or minimise potential impacts.

Readers seeking additional background information are referred to the NOI, copies of which are available at the Department of Minerals and Energy in Kalgoorlie and Perth.

2.5 EXISTING FACILITIES

Stage I of the Kanowna Belle Project, currently under construction, is an oxide gold recovery plant, with an annual throughput of 1.25 mtpa, and utilising convectional cyanide leach adsorption technology. A flotation plant is included in Stage I to recover sulphide concentrate, which is stored for later processing in the refractory plant proposed for Stage II.

Stage II of the Kanowna Belle project is the construction and operation of a sulphide concentrate oxidation plant. This stage of the overall project development will be constructed adjacent to the existing Stage I facility. The mining operation and the supporting infrastructure will remain unchanged. The existing Stage I operation is illustrated in Plates 2 to 4.

2.6 STATUTORY REQUIREMENTS

The proponent has followed the statutory requirements for project environmental approval for implementation of Stage II.

The proposed project was presented to officers from the Department of Minerals and Energy, from the Environmental Protection Authority, and from the Water Authority of Western Australia (WAWA). This presentation to 'government' which constituted a formal notification of the proposed project, was followed by the submission of written material to allow the assessment level to be determined by the EPA.

The Stage II development was given a formal assessment level of Consultative Environmental Review (CER). The level of assessment was notified in the press, and final guidelines were issued by the EPA for preparation of this document. The CER is submitted for public review for a period of four weeks. At the end of this public review period, the issues raised are summarised by the EPA and forwarded to the proponent for comment and response. On receipt of the proponent's responses, the EPA prepares and releases its assessment report. Appeals may be made against the content of the report. The report is

PLATE 2

The Kanowna Belle Project with the waste rock dump in the foreground, the plant and process area beyond the dump, and the open pit to the right.

The Kanowna Belle Project with construction of the plant in progress. The concentrates storage dam and the process water dam are in the foreground.

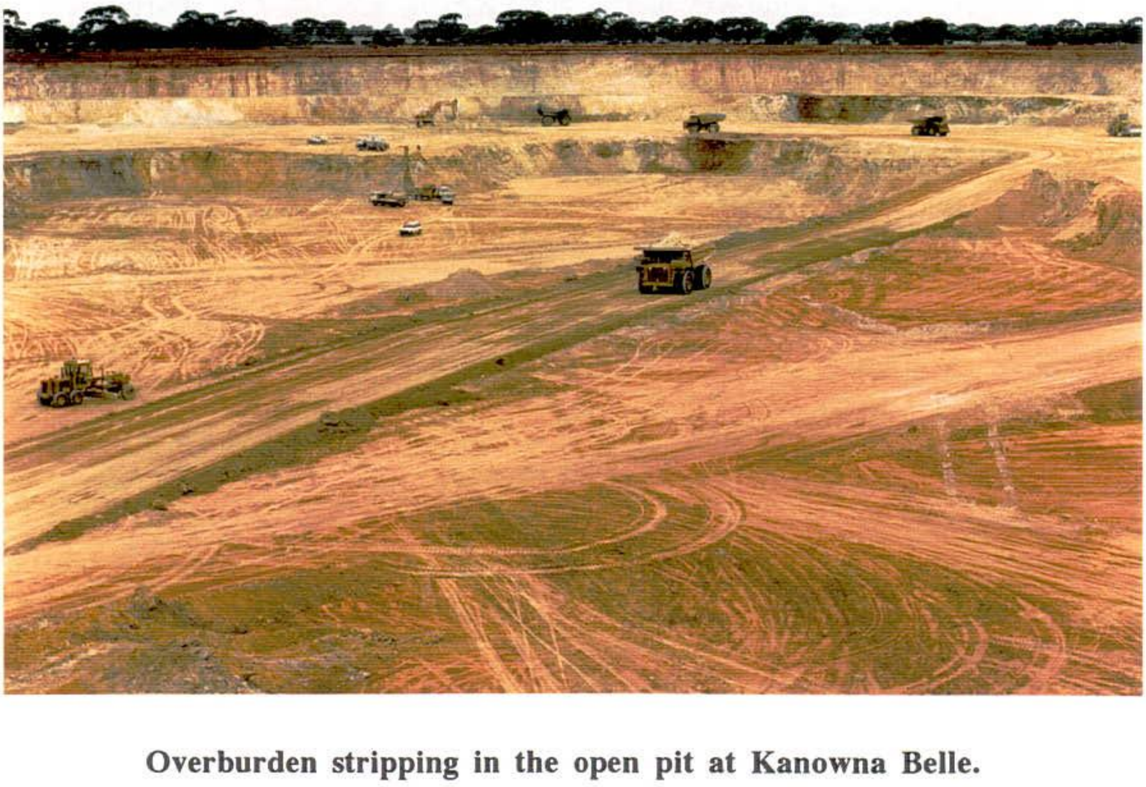
PLATE 3

The open pit at Kanowna Belle mine.

The tailings dam under construction at Kanowna Belle.

PLATE 4

Stratification in the open pit at Kanowna Belle results from a deep soil profile (3 m) overlying a transitional zone (centre) and weathering zone at base.



Overburden stripping in the open pit at Kanowna Belle.

then submitted to the Minister who sets conditions and issues a statement on the project. The proponent may also appeal against the conditions set by the Minister. A Works Approval and a Licence covered under Part 5 of the Environmental Protection Act will be applied for as part of the project approval process. A chart showing the project approval process in Western Australia is given in Appendix 5.

3.0 PROJECT DESCRIPTION

3.1 INTRODUCTION

The Kanowna Belle Project has three proposed development stages:

Stage I	-	open cut mine and CIP process plant;
Stage II	-	refractory process plant; and
Stage III	-	underground mine.

Stage I of the project is currently being constructed, and overburden stripping began in late 1992. The CIP plant is due to be commissioned in August, 1993. This initial stage of the project not only includes the open cut mine and process plant, but also encompasses all major infrastructure requirements including buildings, waste dumps, tailings dams and groundwater extraction.

Stage I utilises conventional cyanidation treatment of the gold-bearing ores, with relatively low recovery of about 45-55% from primary ores. This process route would result in the Kanowna Belle mine being limited to a relatively short-life (approximately seven years) open-cut mine.

Stage II of the Kanowna Belle Project is scheduled to commence operating in the last quarter of 1994.

As the sulphur content of the ore from Kanowna Belle declines with depth, it is unlikely that the proposed roaster capacity will require any expansion during the foreseeable future.

Stage II is designed to improve this metallurgical performance, with a predicted gold recovery of over 93%. This improvement in the recovery of gold is an essential pre-condition for the development of Stage III, an underground mine which will develop the bulk of the resource and extend the mine life to in excess of 15 years with a potential life of 20-25 years.

3.2 MINING

The Stage II development does not directly involve any additional mining activities and there will be no increase in the size of the pit as a result of the implementation of Stage II.

3.3 PROCESSING

Stage I processing comprises a conventional processing technique including crushing, milling, flotation and cyanidation (CIP). It is intended to stockpile cyanided concentrates for further treatment, whilst the bulk of the ore is discarded to a tailings dam after processing.

Figure 2 illustrates how the proposed Stage II development will be integrated with the Stage I processing plant. In summary, flotation concentrates will be washed and then roasted prior to cyanidation. Tailings from the roaster cyanidation circuit will be disposed of in a dedicated tailings dam for possible future re-processing.

Concentrate from the flotation circuit will be filtered and washed to remove the highly saline process waters. After the washed concentrate has been repulped with clean water, it will be processed at a feed rate of approximately 7.5 t/h through a fluidised-bed roaster. The purpose of roasting is to oxidise the gold-bearing sulphide minerals, which at Kanowna, are predominantly pyrite. The poor recovery of gold in conventional cyanidation is due to the locking up of the gold within the lattice of the sulphide minerals. Ignition of the concentrate is achieved using a light oil fuel (or LPG) which is only required when the roasting process is started from 'cold' conditions. The roasting process operates at elevated temperatures (+500°C) by burning the sulphide minerals in air, oxidising them and exposing the gold particles for downstream cyanidation. The gas produced in the roaster will be subjected to three cleaning processes before being emitted to the atmosphere. The first two, cycloning and electrostatic precipitation will remove fine particulate matter which may have been entrained in the gas. These dusts are recovered and, being gold bearing, will be subjected to cyanidation with the balance of the roasted concentrate.

The third cleaning process will be a filter baghouse. This is designed to remove arsenic from the gas stream, prior to emission. The arsenic will be collected as an arsenic trioxide dust which will be bagged and stored prior to being sold or chemically fixed for subsequent disposal with tailings.

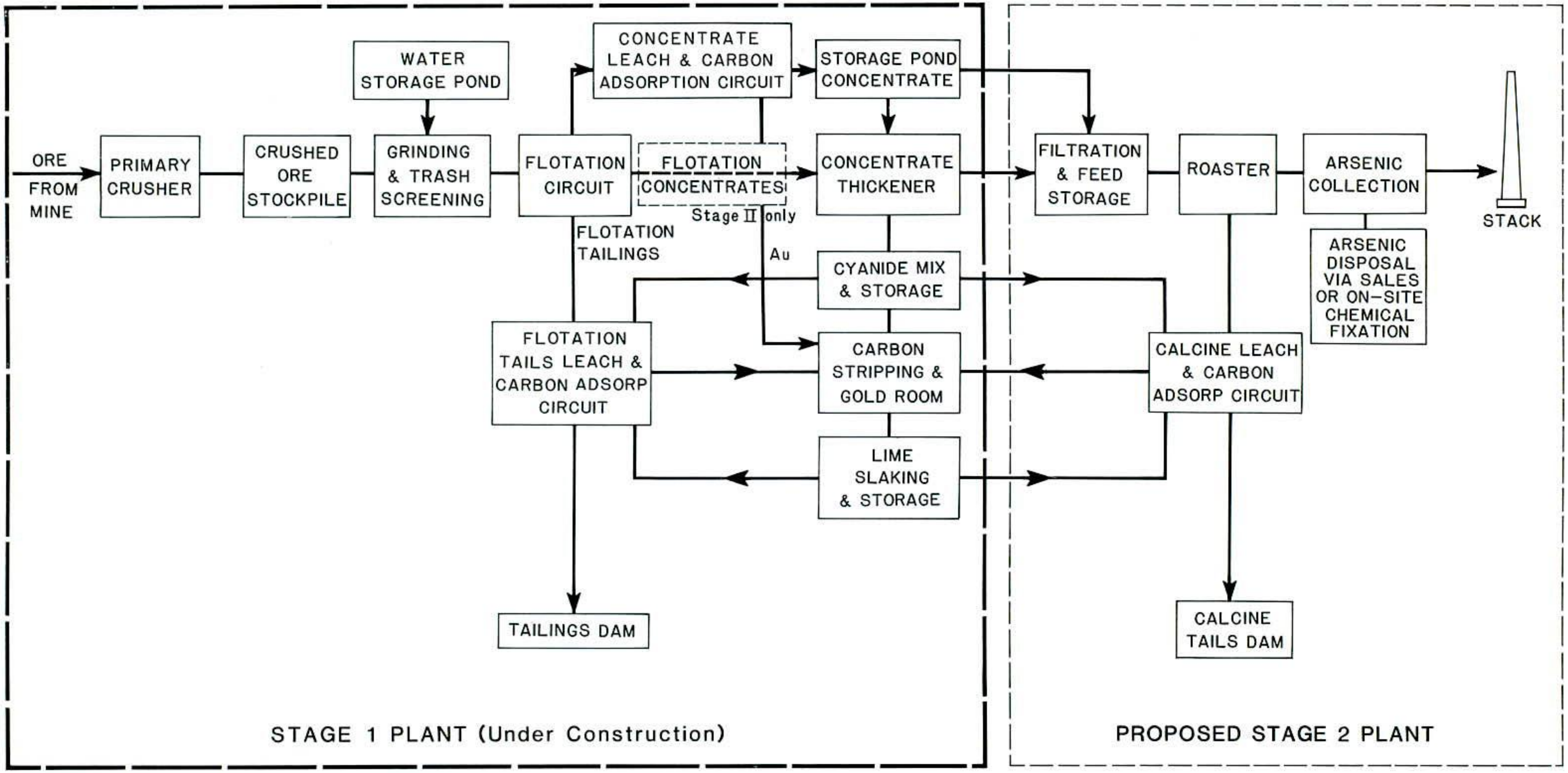
The roasted concentrate (calcine) will be collected from the roaster, cyclones and electrostatic precipitators and quenched in water to reduce its temperature to below 50°C. The slurry will then be processed using conventional cyanidation and CIP processing to extract the gold, prior to being disposed of in a dedicated tailings dam.

3.4 WASTE STREAMS

Slurry

The largest waste stream by weight, is the calcine slurry containing the oxidised concentrate after it has been processed by cyanidation. This waste will be disposed of in a dedicated calcine tailings dam located adjacent to the tailings dam currently being constructed as a part of the Stage I development. This waste slurry will contain significantly higher levels of cyanide species than Stage I waste tailings.

Supernatant water from this dam would be pumped back to the process plant for re-use. The oxidised concentrate produced during pilot plant



Source:Minproc Engineers Pty Ltd

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Plant Flowsheet

Figure 2

testing of the Kanowna Belle concentrate was subjected to the United States Environmental Protection Authority (US EPA) Toxicity Characterisation Leach Procedures (TCLP). This procedure evaluates the leachability of metallic elements from a material, relative to prescribed regulatory limits. The Kanowna Belle calcine slurry which was tested for a wide range of heavy metals, including silver, arsenic, barium, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc, satisfied the requirements of the test.

Gas

The roaster off-gas which would be expelled from an 80 m high stack located at the plant site will have the following approximate analysis:

Gas Flow	77570 Nm^3/h
Temperature	105°C
Sulphur Dioxide Concentration	1.8% SO_2 v/v
Solids Concentration	0.1 g/Nm^3 (maximum)
Heavy Metals	10.0 mg/Nm^3 (maximum)

The potential effects of the roaster discharge were modelled to predict maximum hypothetical ground-level concentrations of sulphur dioxide.

Stack height was considered in conjunction with the options for processing refractory ore. The results indicate that ground-level concentrations decrease at a fairly constant rate as the stack height is raised from 50 m to 80 m. At 80 m there is a tendency for ground-level concentrations to level off.

Arsenic Trioxide

Arsenic is present in the concentrate in the form of arsenopyrite and in concentrations of approximately 0.9%. Approximately 50% of the arsenic will volatilise during the roasting process and accordingly, will report to the roaster off-gas.

Arsenic collected from the cleaning of the roaster off-gas in the filter baghouse will be produced as an arsenic trioxide dust. This dust will be gathered on fabric filter bags which intermittently drop the dust into enclosed hoppers. Sealed conveying equipment will then feed the dust into bulka-bags or steel drums for storage and shipment.

The small quantity of arsenic trioxide produced at Kanowna Belle requires that the product is stored on site until such time as a suitable parcel of product has been collected for sale as a batch. Material sold in this manner will be packaged to United Nations' guidelines for transport of toxic materials.

Approximately 250 t of arsenic trioxide will be produced a year. It is proposed to store the arsenic trioxide product on site and under cover, in a fully concreted and bunded area 40 m x 40 m, prior to sale.

As a consequence of the need for short-term storage, the proponent proposes to store, on site, in either sealed bulka bags or drums, up to 800 tonnes of arsenic trioxide.

It is proposed to sell the arsenic trioxide product, however, other options for disposal, including chemical fixation, are being considered.

Such methods of disposal, if shown to be feasible and preferred by the proponent, would be referred to the EPA for a separate environmental assessment.

3.5 FACILITIES

Processing Facilities

The proposed Stage II processing facilities will be located adjacent to, and integral with, the Stage I process plant. These new facilities will include a vacuum filter, storage tanks, a roaster, gas train and stack, and additional cyanidation tanks.

Tailings Dam

A new tailings disposal facility will be built adjacent to the Stage I tailings dam. This new facility will be relatively small, with a total initial capacity of 270,000 tonnes, suitable for five years' operation. The detailed design of this disposal facility, which will be subject to Mines Department approval, will be provided at the time a Works Approval Application is submitted. Additional cells will be constructed as required.

Water Supply

The regional water quality is generally poor with values for total dissolved solids ranging up to 250,000 mg/l depending on the type of aquifer. There are no known supplies of better quality groundwater in the project area.

The bulk of the water utilised for Stage II will be highly saline groundwater abstracted from a borefield developed for Stage I, and located to the north of the project site. Stage II, as proposed, will not result in an increase in groundwater consumption approved for Stage I.

Groundwaters in the Kanowna Belle region are highly corrosive, and because of this, sections of the process require the use of more pure water. This will entail an increase in consumption of potable water as supplied by the WAWA. The Stage II development will include a capital contribution to the WAWA for supply of the additional scheme water to Kalgoorlie, construction of a small pipeline from Kalgoorlie to Kanowna Belle, and construction of a receival dam at the project site.

Advice received from the WAWA indicates that the water requirements for Stage II of the project, as proposed, can be met from the existing Goldfields and Agricultural Water Scheme.

4.0 STAGE II PROCESSING OPTIONS

4.1 AVAILABLE PROCESS TECHNOLOGIES

The process technology proposed for the Kanowna Belle Stage II development, namely concentrate roasting, is probably the oldest and most established technology for sulphide oxidation used in the gold industry. In Western Australia, it is used by Western Mining Corporation (WMC) at Windarra and by Kalgoorlie Consolidated Gold Mines (KCGM) at Gidji, near Kalgoorlie. However, in recent years a number of new technologies have been developed for sulphide oxidation, and these include concentrate pressure oxidation, concentrate bio-oxidation, and whole ore roasting. Bio-oxidation plants are operating at Harbour Lights and Wiluna in Western Australia.

Although concentrate roasting has been proven to be a particularly appropriate technology for gold ores from the Kalgoorlie region, the proponent determined that for the Kanowna Belle project, a comparative analysis of existing, proven technologies, would be undertaken prior to selection of a final process route. This comparative analysis was performed by Canadian consultants, Kilborn Inc.

The analysis compared the following technologies:

(i) whole ore roasting;
(ii) concentrate pressure oxidation;
(iii) concentrate bio-oxidation;
(iv) concentrate ultra-fine grinding; and
(v) concentrate roasting.

The comparison evaluated the technologies on the basis of gold recovery, capital cost, operating cost, and potable water requirements. Particular attention was paid to factors which are of particular significance to the Kalgoorlie region. These include:

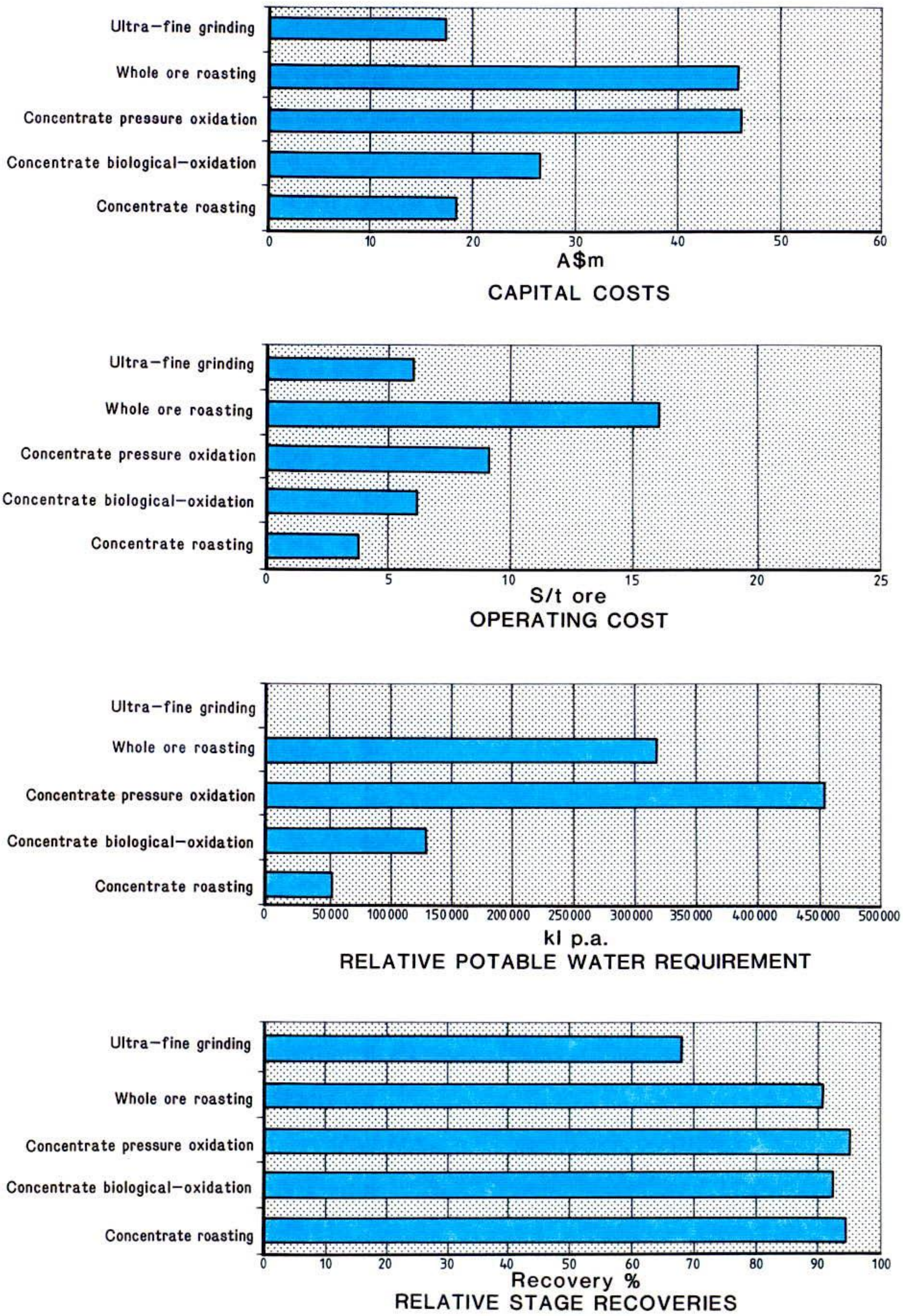
(a) high electrical power costs;
(b) extreme salinity of local groundwater;
(c) scarcity and cost of high quality water;
(d) lack of local lime or limestone resources; and
(e) high transport costs.

The results of this evaluation in terms of capital cost and operating costs are summarised in Figure 3. The significantly higher costs that would be incurred by utilising any of the relatively new oxidation technologies at Kanowna Belle are clearly demonstrated. None of the existing available technologies has been applied in a hyper-saline water environment such as is present at Kanowna Belle.

Relative potable water requirements and stage recoveries for the various process options are also given in Figure 3.

(i) Whole Ore Roasting

The process requires the ore to be dry milled to a size of 80% passing 150 microns, with the resulting product fed into a two-stage roaster. The addition of approximately 2% by mass of pulverized coal as a fuel source and oxygen as an oxidizing agent



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Comparison of Costs, Water Consumption and Relative Stage Recoveries for Process Options

Figure 3

is required to maintain the process. Operating temperature is approximately 570°C. After oxidation, the resulting calcine is quenched and thickened and is then subject to conventional cyanidation to remove the gold.

Coal handling, storage and pulverizing facilities are required to provide the necessary fuel, and a liquid oxygen plant is required to provide oxygen.

Roaster off-gas is discharged via a stack after removal of solid particles.

Whole ore roasting has a high capital cost due to the need to instal dry grinding facilities, essentially duplicating the facilities already constructed for Stage I, and to provide the necessary fuel and oxygen supply. Furthermore, whilst the process is proven in operations in the U.S., no such operations exist within Australia and a substantial programme of additional test-work would be required to verify gold recoveries if this process were chosen. Such a test-work programme would require a very large sample of underground ore that is not available without a substantial underground development.

(ii) Concentrate Pressure Oxidation

Concentrate pressure oxidation (CPOX) is a process whereby the sulphide minerals are oxidised in aqueous conditions and in an oxygen-rich environment. The process operates at elevated pressures (2000kPa) and temperatures (200°C) and at a low pH (1.5). As a result of the operating conditions, the reactor vessels, commonly referred to as autoclaves, need to be constructed from sophisticated materials. The operating conditions also require that the process water contains a very low level of chloride ions (<150 ppm Cl^-). This level is even lower than that provided by WAWA in the Kalgoorlie Scheme water (approximately 400 ppm Cl^-).

The oxidised slurry is washed and neutralised prior to conventional cyanidation. This process has no gaseous discharge to atmosphere as all waste products are contained within the tailings slurry.

The CPOX process also requires a substantial infrastructure to supply the necessary reagents and services. Included in these requirements are:

* sulphuric acid facility for pH control;
* liquid oxygen plant for process oxygen supply;
* steam generator or boiler to raise steam for process temperature control;
* lime for neutralisation; and
* large quantities of purified potable water.

The combined effect of all the above results in a process with a high capital cost and very high operating costs, negating the advantage of potential high gold recovery.

(iii) Concentrate Bio-oxidation

Biological oxidation technology is relatively new, with modern plants in Western Australia, at Wiluna and Harbour Lights, being forerunners in this emerging technology. This process utilises several different strains of bacteria to oxidise the sulphide minerals into ferric sulphate, sulphuric acid, and arsenous acid. The process operates at very low pH (1.0-1.4), at elevated temperature (45°C) and requires the addition of large quantities of air to sustain the bacteria. Whilst the bacteria are generally robust, a number of compounds, particularly cyanide, thiocyanate, and chloride compounds are toxic to bacteria at relatively low levels. Consequently, the process, if used at Kanowna Belle, could require large quantities of scheme water, as return water from tailings storage areas contains all of the above toxic species in considerable quantities.

As the bacterial oxidation process operates at very low pH levels, the slurry stream requires neutralisation with lime or limestone prior to disposal. Neutralisation is also required to fix the residual arsenic into a stable ferric arsenate. Unlike other bio-oxidation processes operating in Australia, Kanowna does not have a readily accessible source of low-cost limestone.

The combination of the toxic effects of chloride and cyanide would normally result in a process which would consume large quantities of potable water or else require a substantially new technical approach to be developed and confirmed. The process also requires substantial quantities of lime or limestone. As a result of the above, the bio-oxidation process at Kanowna Belle would require the use of some new technical innovations such as internal recycling of process water, operation at elevated chloride levels, and the use of high chloride water in the cooling circuit.

In the bio-oxidation process, all waste products are discharged with the tailings slurry to the tailings storage in a stable form and there are no gaseous discharges to atmosphere.

The proponent is evaluating the results of an extensive test-work programme undertaken to assess the feasibility of using this process at Kanowna Belle.

(iv) Concentrate Ultra-fine Grinding (UFG)

Ultra fine grinding is the simplest process evaluated, and has the lowest capital and operating cost, as well as requiring no potable water. This process uses either tower mills or vertical stirred mills of high power to reduce the concentrate to very fine size (4-6 micron). The process relies on the liberation of gold by reducing the particles to these fine sizes.

The Kanowna mineralogy does not suit this process as most of the gold is contained in sub-micron particles. As a result of this, UFG is not able to achieve recoveries better than 70% (and at times substantially lower), which is much less than that achievable by oxidation technologies.

The waste products from the UFG process are disposed of in the tailings storage facility, with no discharges to atmosphere.

(v) Concentrate Roasting

In contrast to the above process options, concentrate roasting is a well-tried and proven technology with a good level of plant reliability and very low process risk. Roasting has the added advantage of a relatively low potable water demand and there is no requirement for lime or limestone for waste stream neutralisation. An extensive test-work programme has proven that very high gold recoveries (up to 96%) can be achieved following conventional roasting.

As shown in Figure 3, oxidation technologies consistently achieve a higher recovery of gold than UFG. Of the oxidation technologies, CPOX and conventional concentrate roasting achieve the highest recoveries.

The major environmental disadvantages of concentrate roasting are the production of sulphur dioxide and the production of arsenic trioxide.

4.2 SULPHUR DIOXIDE REMOVAL SYSTEMS

The concentrate roasting process proposed for Stage II of the Kanowna Belle project will produce sulphur dioxide which will be discharged to the atmosphere in the roaster off-gas. As part of the review process, a number of systems available for the removal of sulphur dioxide from the waste gas stream were examined. These systems included:

(i) the production of sulphuric acid;
(ii) the production of sulphur;
(iii) scrubbing the off-gas using lime or limestone;
(iv) burning lime or limestone in the roaster; and
(v) scrubbing the off-gas using sea water.

The key features of each system are set out below.

(i) The Production of Sulphuric Acid

The production of sulphuric acid requires the supply of large volumes of potable water. Approximately 15 m^3/hr (equal to an annual consumption of 120 million litres) of potable water would be required for an acid plant. Capital costs required in establishing the necessary infrastructure including power supply (400 kW) are extremely high, and when combined with high yearly operating costs and high transport costs, the process does not offer an economically acceptable option.

(ii) Sulphur Production

As with the production of sulphuric acid, sulphur production requires very large volumes of potable water for cooling as a result of high heat loads generated in the process. There are currently no commercial scale plants in operation in Australia with which to draw comparisons, and sulphur production plants are known to be sensitive to changes in sulphur dioxide concentration. The production of sulphur from metallurgical gas trains is unproven. The engineering uncertainties, in combination with very high operating costs and restricted potable water supplies, make sulphur production an unacceptable option.

(iii) Off-gas Scrubbing using Lime or Limestone

Off-gas scrubbing using lime or limestone is an inherently expensive system.

The build-up of scale and salts within the scrubber constitutes a major technical problem for this option. This problem is enhanced at Kanowna by the extremely high salinity levels present in locally sourced process water. The use of high-quality water offers an alternative, however, in excess of 120 million litres of high-quality water would be required, and as with sulphuric acid production, makes this option economically unacceptable.

(iv) Burning Lime or Limestone in the Roaster

Test-work carried out on this option for the removal of sulphur dioxide from the gas stream indicates that not only is sulphur dioxide absorbed, but also volatilised arsenic is absorbed. This results in the formation of calcium arsenite which is regarded as an unstable compound. The instability of the waste raises issues for downstream environmental risk through disposal of a toxic waste. Burning lime or limestone is unproven in a gold roaster, and the effects on recovery rates are unknown. This system is currently not considered an acceptable option for the removal of sulphur dioxide.

(v) Scrubbing the Off-gas Using Sea Water

The buffering capacity of sea water offers potential to use sea water to scrub sulphur dioxide. There are, however, two major constraints to this option. First, large volumes of sea water are required, and second, the contaminated water requires disposal. The location of Kanowna Belle precludes this option for the removal of sulphur dioxide.

An examination of these sulphur dioxide removal systems indicates that there are no suitable options for the Kanowna Belle project. The two most proven options, namely sulphuric acid production, and off-gas scrubbing, require very large volumes of potable water, a resource that is not available in the Eastern Goldfields. The provision of water for either of these two options and the continued supply of potable water during operation of the roaster is not economically viable.

In summary, the very large volumes of potable water required, the engineering and processing constraints imposed by unproven technology, high power demands, high operating costs, location away from the coast, together with the small volume of sulphur dioxide to be emitted from the stack, indicates that the removal of sulphur dioxide from the roaster off-gas is neither practical nor economically feasible.

5.0 THE EXISTING ENVIRONMENT

5.1 REGIONAL SETTING

The project is located approximately 18 km north-east of Kalgoorlie and accordingly, is situated close to the boundary of the Arid and Semi-arid climatic systems. The Köppen System locates Kalgoorlie within the BS fh classification, that is, a hot, semi-arid climate in which light rain can occur during any season. Gentilli (1972) notes, however, that the BS fh region is not defined satisfactorily in Western Australia.

Climatic data, spanning 45 years for temperatures and 48 years for rainfall are presented in Figure 4. The data presented indicate that rain does occur throughout the year and falls are recorded in every month. Mean annual rainfall for Kalgoorlie is 256 mm.

5.2 GEOLOGY AND LANDFORM

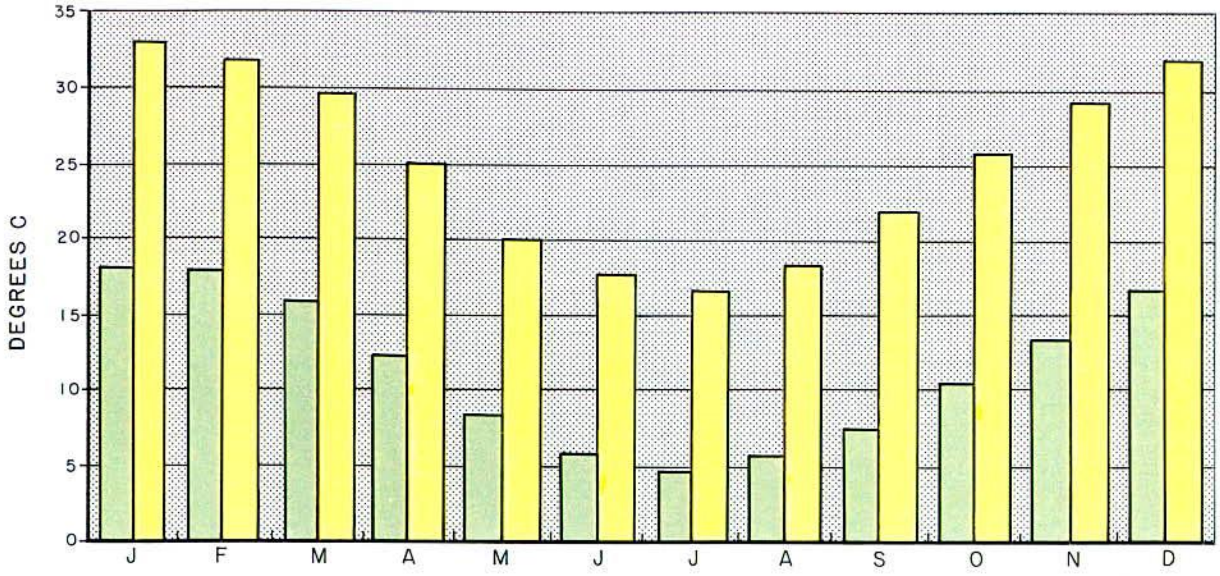
The Kanowna Belle mine is located in the Kurnalpi Terrane in the Eastern Goldfields Province of the Archaean Yilgarn Craton (Swager *et al.* 1990). This terrane, which is not well understood, in terms of regional geology, is a group of diverse tectonostratigraphic domains separated from the Kalgoorlie Terrane by the Moriaty Shear - Mt Monger Fault.

The rocks at Kanowna have been metamorphosed to lower greenschist facies and the predominant lithologies are volcaniclastic sediments. The main structure at Kanowna is the prominent Fitzroy Fault trending south-west to north-east.

The deposit contains widespread and variable carbonate-sericite-pyrite alteration. Pyrite is variably disseminated, occasionally veined, comprises between 1% and 5% of the rock, and is strongly related to gold mineralisation. Other sulphide species are only present in minor amounts. Arsenic values are mostly less than 500 ppm and the element occurs both in pyrite and as small arsenopyrite grains. Mineralogically, no significant gold association with arsenic has been detected.

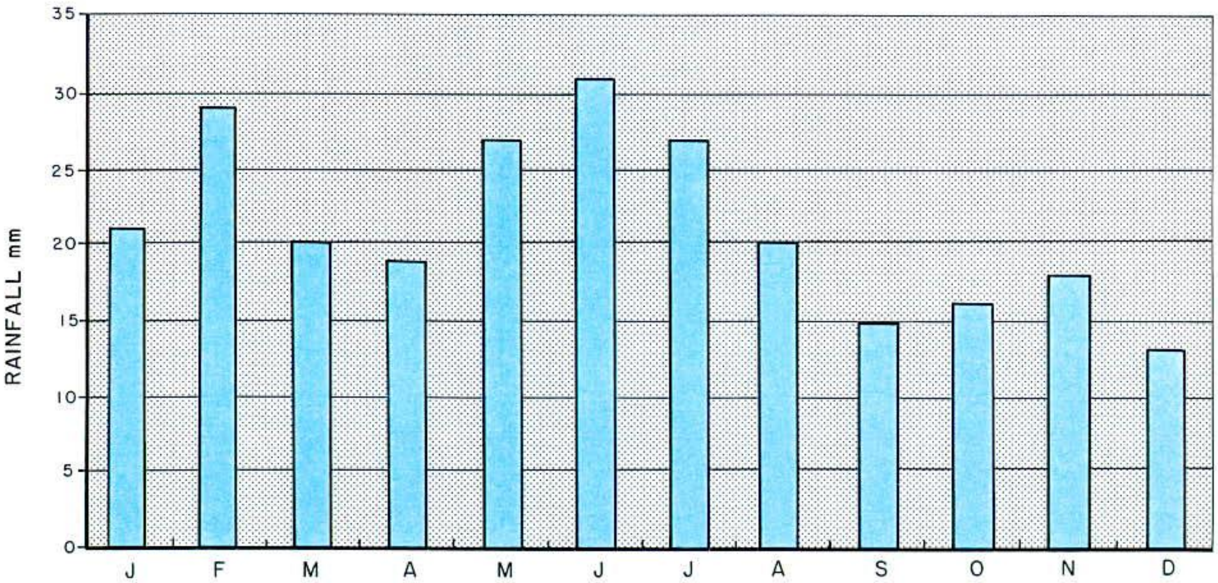
A mineralogical description of rock-chips from a representative composite of Lowes Shoot, the dominant ore body, indicated that the rock is an extensively sericitised porphyritic felsite, consisting of scattered phenocrysts of quartz, albite and occasional K-feldspar in a generally fine-grained quartz-sericite-carbonate groundmass. Ankeritic carbonate occurred in most chips, the amount being very variable but averaging 7%-10%. Pyrite was erratically distributed, averaging 1%-2%; grain sizes ranging from <5 to 200 μm (with some clusters up to 600 μm) (Dames & Moore, 1992).

The major landform in the project area is an undulating to rolling plain with local relief ranging from 6 to 30 m.



MEAN DAILY MAXIMUM & MINIMUM TEMPERATURES

SOURCE: BUREAU OF METEOROLOGY 45 YEARS OF RECORDS



MEAN MONTHLY RAINFALL

SOURCE: BUREAU OF METEOROLOGY 48 YEARS OF RECORDS

MEAN ANNUAL RAINFALL 256mm

KANOWNA BELLE PROJECT

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Kalgoorlie Climatic Data

Figure 4

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5.3 SOILS

The soils at Kanowna Belle are Calcareous Desert Soils and have a Northcote (1971) principal profile form of Gc1.22. The soils examined are strongly alkaline and calcareous throughout the profile. The deep clay horizon underlying the surface A and B horizons is not calcareous, but is still strongly alkaline in reaction.

The strongly calcareous nature of the soils at Kanowna Belle differs from the Non-calcareous Earth and Massive Red Earths found extensively east of Kalgoorlie.

The soils have a gradational texture profile with fairly distinct horizonation. The soils appeared to be structureless and the soil material becomes loose and powdery when dry.

Representative soil data are given in Appendix 3.

5.4 SURFACE HYDROLOGY

Because of the nature of local and regional landforms, there are no well-defined (incised) drainage lines in the project area. There are a number of drainage depressions mirrored by changes in vegetation, and locally, watercourses are defined by erosion.

Low-angle slopes and low-angle valley floors mean that surface ponding is common, and off-road access is virtually impossible during rain periods.

5.5 GROUNDWATER HYDROLOGY

Four types of aquifers have been identified at Kanowna Belle:

(i) shallow laterite aquifers;
(ii) aquifers developed in fractured rock;
(iii) aquifers developed in caprock over ultramafic suites; and
(iv) deep lead or palaeochannel aquifers.

In the vicinity of the mine, the standing water table is at a depth of approximately 20 m below ground level. The regional water quality is generally poor with values for total dissolved solids (TDS) ranging from 20,000 mg/l up to 250,000 mg/l, depending on the type of aquifer (Dames & Moore, 1992). Data on local mine groundwater quality are presented in Table 1.

5.6 VEGETATION AND FLORA

5.6.1 Introduction

The vegetation and flora of an area of approximately 12 km^2 surrounding the proposed roaster site was surveyed. The delineation of the survey area resulted from a review of potential environmental impacts on vegetation resulting from sulphur dioxide emissions from the roaster stack. The area of

12 km^2 equates to a circle, centred on the roaster stack, with a radius of 2 km.

The 2 km radius is significant as the data reviewed indicate that sulphur dioxide impacts on vegetation are confined to a distance within 2 km of the emission source. As the purpose of carrying out a vegetation and flora survey was not only to define the existing environment, but also to predict potential impacts, there was little to be gained by extending the survey area beyond a distance of 2 km from the emission source.

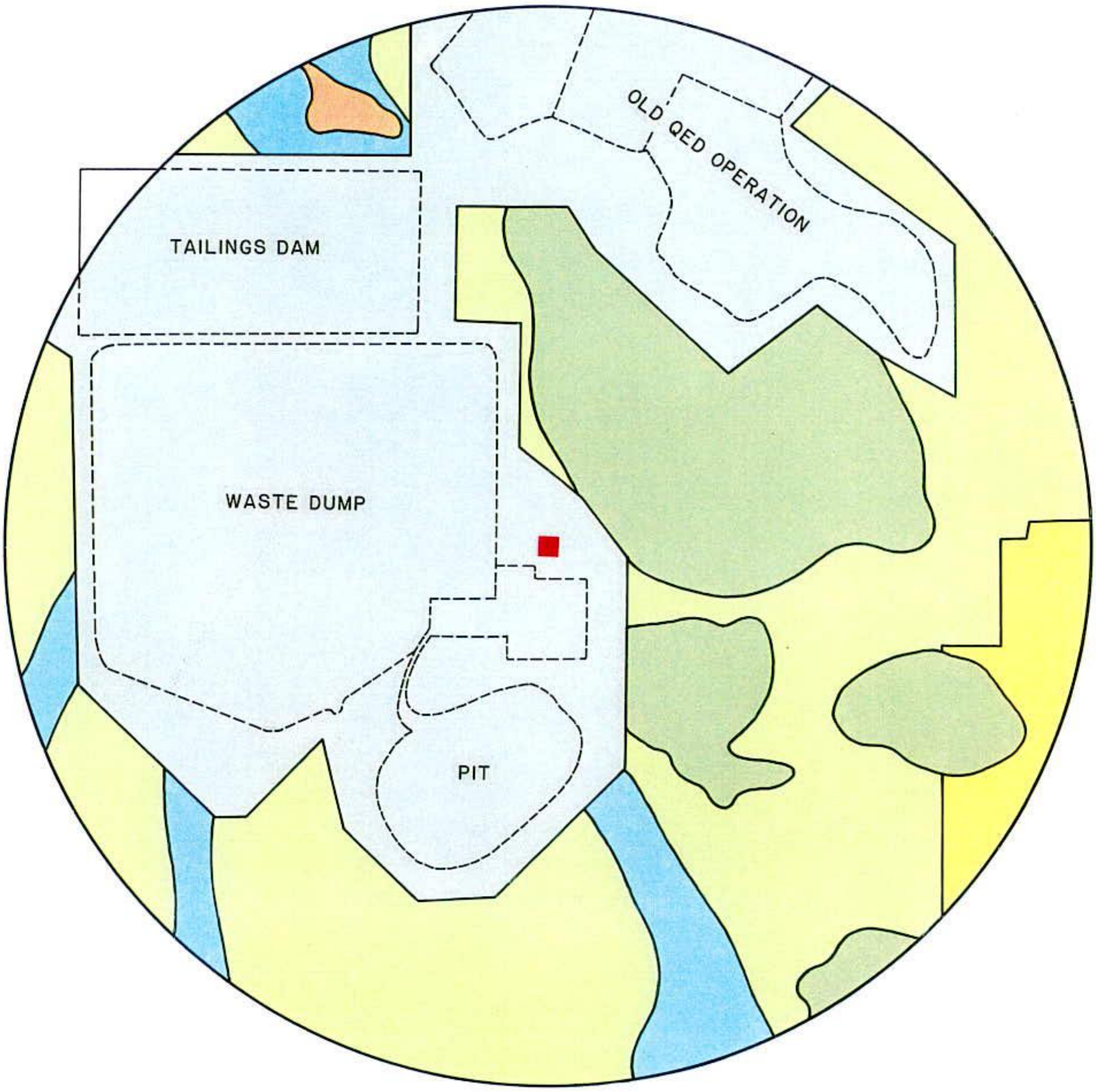
The survey was carried out by E. M. Mattiske & Associates and their modified vegetation map is given in Figure 5. The following notes are taken directly from the report prepared by the consultant, and modified to conform to the requirements of the CER.

TABLE 1

Groundwater Quality - Kanowna Belle Project Area

Parameter	Bore Number		
	KWB 62	KWB 12	KWB 79
pH	ND(1)	7.0	5.0
E_c(2)	72.0	103.0	112.0
TDS	41690.0	61080.0	67150.0
Cl	25167.0	34319.0	38241.0
Ca(3)	219.0	921.0	570.0
Mg	1931.0	2689.0	3165.0
Fe	1.4	<0.1	<0.1
Si	84.7	10.2	12.9
Na	13953.0	18482.0	21339.0
K	275.0	273.0	301.0
Al	327.0	75.3	77.1
Pb	0.118	0.163	0.074
As	<0.001	0.001	0.005
Hg	<0.001	<0.001	<0.001
Se	0.005	<0.001	0.004
Mn	0.92	6.08	4.3
Cu	<0.01	<0.01	<0.01
Zn	0.18	0.06	0.02
Cr	0.13	<0.05	<0.05

Notes:
(1) ND - Not Determined
(2) E_c - Electrical conductivity in μS/cm
(3) All values in mg/l



Eucalyptus salmonophloia open woodland over low mixed Chenopodiaceae spp.

Eucalyptus griffithsii - E. lesouefii open woodland

Open woodland of Eucalyptus salubris– E. campaspe - E. salmonophloia

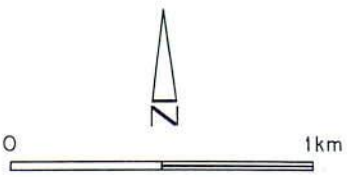
Proposed Roaster Site

Open woodland of E. salubris - E. campaspe - E. salmonophloia with Acacia and Eremophila spp.

Old Kanowna Townsite - disturbed open woodland of E. lesouefii and E. salmonophloia

Current Kanowna Belle mining operation and highly disturbed old mine and processing area

Source: E M Mattiske and Associates



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Vegetation within a 2km Radius of the Proposed Roaster Site

Figure 5

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5.6.2 Vegetation

A total of six plant communities have been defined within the survey area, and these six communities reflect underlying geology, landforms and soils. Essentially the communities can be subdivided into three main groups; those that occur on the shallow small rockier rises; the associated drainage lines; and the historically disturbed areas (see Plate 5).

The six plant communities are summarised as follows:

1. Open Woodland of *Eucalyptus salubris* - *Eucalyptus campaspe* - *Eucalyptus salmonophloia* on the main flow lines.

This woodland occurs on the series of main flow lines on the western and central sections of the survey area. The plant community is dominated by mixed *Eucalyptus* species over Chenopodiaceae shrubs and a range of annual species of the families Poaceae and Asteraceae. There is a large diversity of species, which in part appears to relate to the moister soil conditions after seasonal flow events.

2. Open Woodland of *Eucalyptus salubris* - *Eucalyptus campaspe* - *Eucalyptus salmonophloia* over dense Shrubland of *Acacia* and *Eremophila* spp. on a small section of a flow line.

This woodland which occurs on the edge of the flow line on the northern section of the survey area is similar to the previous one, but differs in the range of shrub species under the overstorey of mixed *Eucalyptus* species. The shrub species are mainly *Acacia* and *Eremophila* spp.

3. Open Woodland of *Eucalyptus salmonophloia* over low mixed Chenopodiaceae spp. on less undulating flats (see Plate 6).

This woodland occurs on the less undulating flats on the western and central sections of the survey area and is dominated by *Eucalyptus salmonophloia* over Chenopodiaceae shrubs, *Senna* (formerly *Cassia)* spp., *Acacia* spp. and a range of annual species of the families Poaceae and Asteraceae.

4. Disturbed Open Woodland of *Eucalyptus lesouefii* and *Eucalyptus salmonophloia* (old Kanowna townsite) on the small rises and less undulating flats.

This woodland occurs on the old Kanowna townsite, which on the basis of the soil and landforms would have supported a mosaic of *Eucalyptus salmonophloia* and *Eucalyptus griffithsii* - *Eucalyptus lesouefii*. All that is left at Kanowna is a mixture of shrubs and annual species as the overstorey has been removed.

5. Open Woodland of *Eucalyptus griffithsii* - *Eucalyptus lesouefii* on small rises and outcrop areas (see Plates 6 and 7).

This woodland occurs on the series of small stony rises on the central and eastern sections of the survey area. This plant community is dominated by *Eucalyptus griffithsii* - *Eucalyptus*

PLATE 5

Vegetation patterns in the vicinity of the Kanowna Belle Project.

In the foreground is an open woodland of *Eucalyptus salmonophloia*. In the centre right of the photograph is a dark-coloured pattern which is a woodland of Silver Gimlet (*E. campaspe*). On the lower rises beyond the open pit is a woodland of *E. griffithsii* and *E. lesouefii*.

The large treeless area in the centre middle distance is the old Kanowna townsite.

PLATE 7

Eucalyptus griffithsii adjacent to the project area.

Eucalyptus griffithsii open woodland with mixed chenopod shrubland north-west of the project area.

lesouefii over Chenopodiaceae shrubs, *Senna* (formerly *Cassia*) spp., *Acacia* spp. and a range of annual species of the families Poaceae and Asteraceae.

6. Disturbed old mining and processing areas.

These areas are associated with the previously disturbed, and in parts rehabilitated, waste dumps of the former QED mining operations in the northern section of the survey area. Only small remnants of the former native vegetation are left in this section of the survey area.

The plant communities differed in their composition, both floristically and structurally. Some of the less disturbed plant communities contained a large range of species which in part related to the high number of annual species present as a result of the high rainfall events throughout the Goldfields in 1992. The plant communities occurring in the survey area are well represented in the Goldfields.

5.6.3 Flora

A total of 29 families, 61 genera and 106 vascular plant species have been recorded in the survey area. Of these, 96 plant species are native and 10 are introduced. The dominant families are:

Asteraceae	-	21 species
Chenopodiaceae	-	18 species
Poaceae	-	12 species
Myoporaceae	-	8 species
Myrtaceae	-	8 species

These families contributed to 63% of the flora collected in the survey area. On the basis of previous studies in the area, this representation is typical of the contribution of these families to the flora of the Austin Botanical Province (Burbidge, 1942; Kenneally, 1968; Davies, 1970; Kenneally, 1971).

The number of species recorded is in part dependent on the survey time (seasonal conditions), the range of habitats and site conditions present and the area surveyed.

Declared Rare Flora

No declared rare plant species, which are listed in the Wildlife Conservation (Rare Flora) Notice 1992, gazetted pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act* 1950, were located in the survey area.

Priority Flora Species

One plant species listed as priority flora species in the Declared Rare and Priority Flora List for Western Australia (Department of Conservation and Land Management, 1992) was located on the Kanowna Belle Gold Mines operational area.

PLATE 6

***Eucalyptus salmonophloia* woodland over mixed chenopod shrubland.**

A *Eucalyptus lesouefii–E. griffithsii* woodland and mixed chenopod shrubland.

Eremophila parvifolia (Priority 4 species) has recently been recorded in a variety of locations from Kambalda to Kalgoorlie and therefore it appears that its priority status in part relates to a lack of knowledge of the species.

5.7 FAUNA

5.7.1 Introduction

The investigation of vertebrate fauna in the project area was carried out by Ninox Wildlife Consulting, and the following notes are taken from their report and modified according to the requirements of the CER.

The vertebrate fauna of the Eastern Goldfields has been the subject of a number of detailed studies. Of particular importance are a series of intensive, systematic fauna surveys conducted between 1978 and 1982 by the then Department of Fisheries and Wildlife, now the Department of Conservation and Land Management. The Western Australian Museum also participated in these surveys. Sampling areas were based on cells of one degree of latitude by one and a half degrees of longitude, and one study site, the Kurnalpi-Kalgoorlie Area (McKenzie *et al*. 1992) is particularly relevant to the Kanowna Belle project area.

Additional surveys have been carried out as part of other development projects in the general area, and where published information is available, these have been used as primary data sources. The fauna of the wider area surrounding the Kanowna Belle project area is therefore relatively well known. The following recent reports have also been used to assist in compiling predictive species lists: Barrett (1991), Bamford *et al.* (1991); Chapman *et al.* (1991); Ecologia (1992).

5.7.2 Regional Zoogeography

The project area lies in the faunally distinct Eyrean Sub-region as defined for birds by Serventy and Whittell (1976), and is further typified by an arid-adapted range of other vertebrates which generally follow the pattern of resident bird distributions. This faunal sub-region extends throughout the whole of inland Australia with only the northern portion of the continent (Torresian Sub-region) and the wetter south-eastern and south-western coastal and sub-coastal areas (Bassian Sub-region) excluded. The climatic extremes and size of the Eyrean Sub-region have resulted in the evolution of many specialised vertebrates and, consequently, a high proportion of endemic species. However, no endemic species are restricted to the project area, and most occur throughout the Goldfields or the Eyrean Sub-region as a whole. The project area also lies on a faunal interzone, and while mainly representative of the more arid interior (Eyrean Sub-region), it also supports an admixture of species from the wetter south-west of the State (Bassian Sub-region). Many birds are highly mobile and, depending on seasonal variations such as lack of rainfall, may not be present every year. Populations of all faunal groups in a given year are also strongly influenced by elements such as flowering and nectar-flow, local invertebrate increases and the level of seed-set on native grasses, herbs and shrubs.

5.7.3 Fauna Habitats

There are five major habitats occurring in the land surrounding the mine. These are as follows:

Habitat 1 Open Woodland of *Eucalyptus salmonophloia* over mixed Chenopods and native grasses on loamy, drainage flats. Moderate level of disturbance.

Habitat 2 Open Woodland of *Eucalyptus salmonophloia, Eucalyptus salubris* and *Eucalyptus campaspe* over mixed Chenopods on deep loamy soils in drainage lines. Relatively dense patches of mixed shrubs dominated by *Eremophila* and *Acacia* species occasionally occur. Low level of disturbance.

Habitat 3 Open Woodland of *Eucalyptus griffithsii* and *Eucalyptus lesouefii* over mixed *Eremophila* and *Acacia* species on low stony rises. High level of disturbance.

Habitat 4 Country typified by the abandoned Kanowna townsite consisting of patchy and attenuated remnants of Habitats 1, 2 and 3 but dominated by large areas of cleared land. Extremely high level of disturbance.

Habitat 5 Permanent and seasonal wetland habitats resulting from the construction of diversion drains and residue storage dams.

Although some areas of native vegetation are in relatively good condition, the project area cannot be considered as optimum fauna habitat, since overall, it shows a high level of historical and contemporary disturbance.

5.7.4 Feral or Introduced Mammals

In keeping with most other locations in the Goldfields, five feral or introduced mammals are expected to occur in the project area. Two of these (fox and rabbit) were recorded during the site inspection.

5.7.5 Amphibians and Reptiles

Cold, rainy conditions during the fauna survey resulted in very poor returns for this group with only four species being captured. Detailed survey work in the Kalgoorlie area indicates that the habitats of the lease have the capacity to support 63 species in total.

5.7.6 Rare Species

In Western Australia, rare or endangered species are covered by Schedules 1 and 2 of the *Wildlife Conservation Act* (1950 - amended November 1990). Schedule 1 species are described as 'fauna that is likely to become extinct, or is rare' and Schedule 2 species are described as 'in need of special protection'.

No rare species were recorded during the site assessment, but two birds and one reptile are expected to be present in the project area. These are:

1. Peregrine Falcon (*Falco peregrinus*)
2. Crested Shrike-tit (*Falcunculus frontatus*)
3. Carpet Python (*Morelia spilota imbricata*).

The birds will occur from time to time as vagrants or nomads, while the Carpet Python will be resident. One of the birds, the Peregrine Falcon, was recorded by Dell and How (1985) at Bungalbin Hill and the Carpet Python was observed by the Goldfields Naturalists Club at Victoria Rock Nature Reserve (Barrett, 1991). The Crested Shrike-tit has been rarely recorded in this part of the Goldfields, but its habitat preferences suggest that it may occasionally occur.

5.8 THE SOCIAL ENVIRONMENT

The city of Kalgoorlie-Boulder, with a population of approximately 27,000 is located 18 km to the south-west of the Kanowna Belle mine. The region has had a long association with gold mining since the first discovery of gold in the late 1800's, and mining and processing gold ore remains the principal industry in the region.

There has been a general trend over the years towards improving environmental standards in the Kalgoorlie-Boulder region. This trend has seen the shut-down of gold roasters near the urban areas of the city.

At the present time, KCGM operate the Gidji roaster approximately 16 km north of the city, and WMC operate their nickel smelter (KNS) approximately 13 km south of the central Kalgoorlie area.

The roasting of gold at Gidji and the smelting of nickel ore both produce large amounts of sulphur dioxide which can affect air quality in the region.

6.0 ENVIRONMENTAL IMPACT ASSESSMENT

6.1 INTRODUCTION

The main objective in an environmental impact assessment is to verify the effects and consequences of a project, and to support a decision about their management, and therefore acceptability. It is also important to understand that the validity of any study is bounded by the limitations of the models and techniques used.

It is necessary to identify and define the terms used in assessment of environmental impacts and to differentiate between the terms 'effect' and 'impact'. An 'effect' is defined by Shirley *et al.* (1985) as a change produced by some agency or cause, but its magnitude is not evaluated using a set of formal definitions. An 'impact' is an effect whose magnitude is evaluated using a set of formal definitions. Both impacts and effects may be direct or indirect.

In addition to the differences between 'effects' and 'impacts' it is appropriate to define the term 'significance' in relation to environmental impacts or effects. In this document, the term 'significant' is used to define an impact in terms of three simple thresholds. An environmental impact is significant if it crosses a legal threshold, a functional threshold, or a normative threshold. Legal thresholds are established by law or regulation; functional thresholds affect the functioning of ecosystems; and normative thresholds are established by social norms, generally at a local or sub-regional level.

While this approach may seem to be straightforward, there are difficulties with interpretation of the term 'significant' from an ecological perspective. This difficulty arises from very real problems encountered when a non-biological value is assigned to an ecosystem. The main issue relates to a loss of ecosystem components, within specified boundaries of time and space. Such an issue invokes an understanding, not only of ecosystem structure and function, but also of individual ecosystem components. Such an understanding is highly limited for the Kanowna Belle project area.

This section on environmental impact assessment identifies changes and effects on a broad scale for the project. The magnitude of these changes and effects has not been formally evaluated because of the advanced level of existing change to ecosystem structure and to ecosystem components. The term 'impact' therefore is used here in relation to the effects and changes resulting from project implementation. An impact may or may not be significant as defined above.

During the scoping process for impact assessment as part of project development, potential effects have been identified and ranked according to perceived importance or significance. These effects become integrated with conceptual design, and then final design for project operation.

However, despite scoping and the design of environmental management programmes, there still exists a level of ecological uncertainty, the fundamental cause of which is ecosystems complexity. This uncertainty is compounded by an incomplete understanding and by limited documented evidence on ecosystem response to the effects of development.

6.2 EXISTING ENVIRONMENTAL IMPACTS

This environmental review considers the proposed construction and operation of a conventional gold roaster located at the Kanowna Belle mine, and the disposal and management of the associated waste streams, specifically sulphur dioxide in the off-gas stream, and the design and development of environmental management systems.

Stage II of the project is being superimposed into an environment that has been highly modified since the turn of the century. Not only has there been a long period of modification, but also there have been changes in the type of stress imposed on the regional ecosystems. As Spencer and Mattiske (1992) point out, damage to vegetation in the goldfields has resulted from a number of factors which include drought, wildfires, grazing and pastoral activities, logging, mineral exploration activities, mining and processing, the development of transport corridors, and the use of chemicals.

It is only in recent times that attempts have been made to identify environmental impacts and to develop appropriate management strategies to minimise these impacts. Despite these recent trends, there are no significant baseline data available in terms of 'pre-disturbance' conditions.

In terms of air quality, there is a long history of sulphur dioxide emissions in the Kalgoorlie-Boulder area. Ground-level concentrations of sulphur dioxide reached such levels during the 1980's that the EPA, and the mining companies operating roasters, commenced a meteorological and sulphur dioxide monitoring programme (Riddle & Holmes, 1992).

The monitoring programme and associated studies resulted in the State Government establishing the 'Environmental Protection Policy for the control of sulphur dioxide in the residential areas of Kalgoorlie-Boulder 1987' (EPP) which defined an air quality policy area. Within the boundaries of this Policy Area, ground-level concentrations of sulphur dioxide were not to exceed 1300 $\mu g/m^3$ (three-hour average).

Following a review of the EPP, the boundary of the Policy Area has since been extended at Kalgoorlie-Boulder and additional Policy Areas have been established at Coolgardie, Kurrawang Mission, and Kambalda. The EPP of 1993 declares Protected Areas, and defines objectives for the air quality within those areas. These objectives are to be achieved and maintained by the application of licence conditions as specified in the accompanying Regulations.

The Air Quality Objectives are defined in terms of a limit and a standard. The limit represents the sulphur dioxide concentration which is never to be exceeded within a Protected Area. The standard represents the concentration which it is desirable not to exceed. The EPP Objectives for the limit and the standard are 1400 $\mu g/m^3$ and 700 $\mu g/m^3$ respectively, both averaged over one hour, (State Government 1992) and to be effective on 1st January, 1996.

Schedule 2 of the Environmental Protection Regulations sets out the maximum number of hours for which the standard may be exceeded in any 12-month period. This represents the minimum level of compliance with the ambient air quality standard. The minimum level of compliance with the standard (700 $\mu g/m^3$) in 1996 is eight hours. The limit of 1400 $\mu g/m^3$ one-hour average is not to be exceeded.

There are two major areas of environmental impact resulting from the operation of the proposed roaster at Kanowna Belle. The first is a potential impact on air quality, the second is a potential impact on vegetation and, by association, fauna. Both air quality and vegetation/fauna have been modified significantly by past activities as noted above, and accordingly, the full environmental impacts of the proposed Stage II development are very difficult to determine.

However, despite the prior changes and existing impacts, it is possible to place the project within the context of the existing environment, and to identify 'potential impacts' on the existing systems resulting from project implementation.

Table 2 sets out ambient air quality data for Kalgoorlie-Boulder, and Figure 6 shows the modelled annual average sulphur dioxide concentrations from the existing roaster and smelter on a regional scale. Hypothetical one-hour average maximum ground-level concentrations for sulphur dioxide from existing sources, without air quality management strategies, are shown in Figure 7. As the town roasters have been closed down and the KCGM roaster moved to Gidji, there has been a steady improvement in air quality in the Kalgoorlie-Boulder air shed. This improvement is indicated in Table 3 which details measured annual average sulphur dioxide concentration from 1989 to 1992. The data presented in Figure 6 should be compared with the data presented in Tables 2 and 3. The present low value for the annual average sulphur dioxide concentration is a direct result of air quality management programmes implemented by KCGM and KNS.

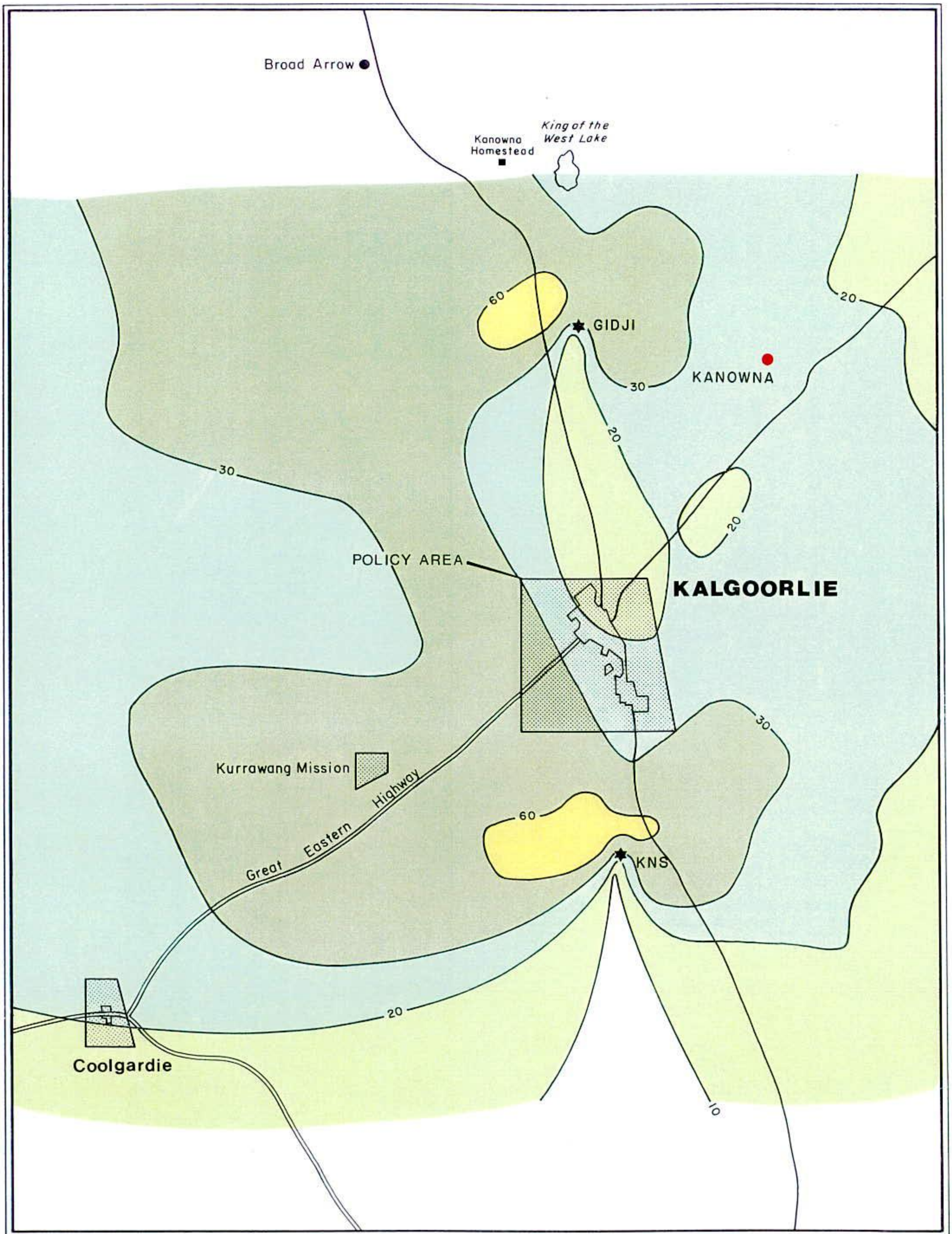
TABLE 2

Ambient Air Quality - Kalgoorlie-Boulder

Average Sulphur Dioxide Concentrations for 1992

Monitor	$\mu g/m^3$
Hannans Golf Club	11
Kalgoorlie Council Yard	12
Kalgoorlie Regional Hospital Monitor	7
Metals Exploration Monitor	13
Boulder Primary School Monitor	6
Boulder Shire Yard Monitor	13
Kalgoorlie Airport Monitor	9
Westrail Freight Yard Monitor	14

Source: Environmental Protection Authority Monitoring Reports for 1992



Source: Nigel Holmes & Associates

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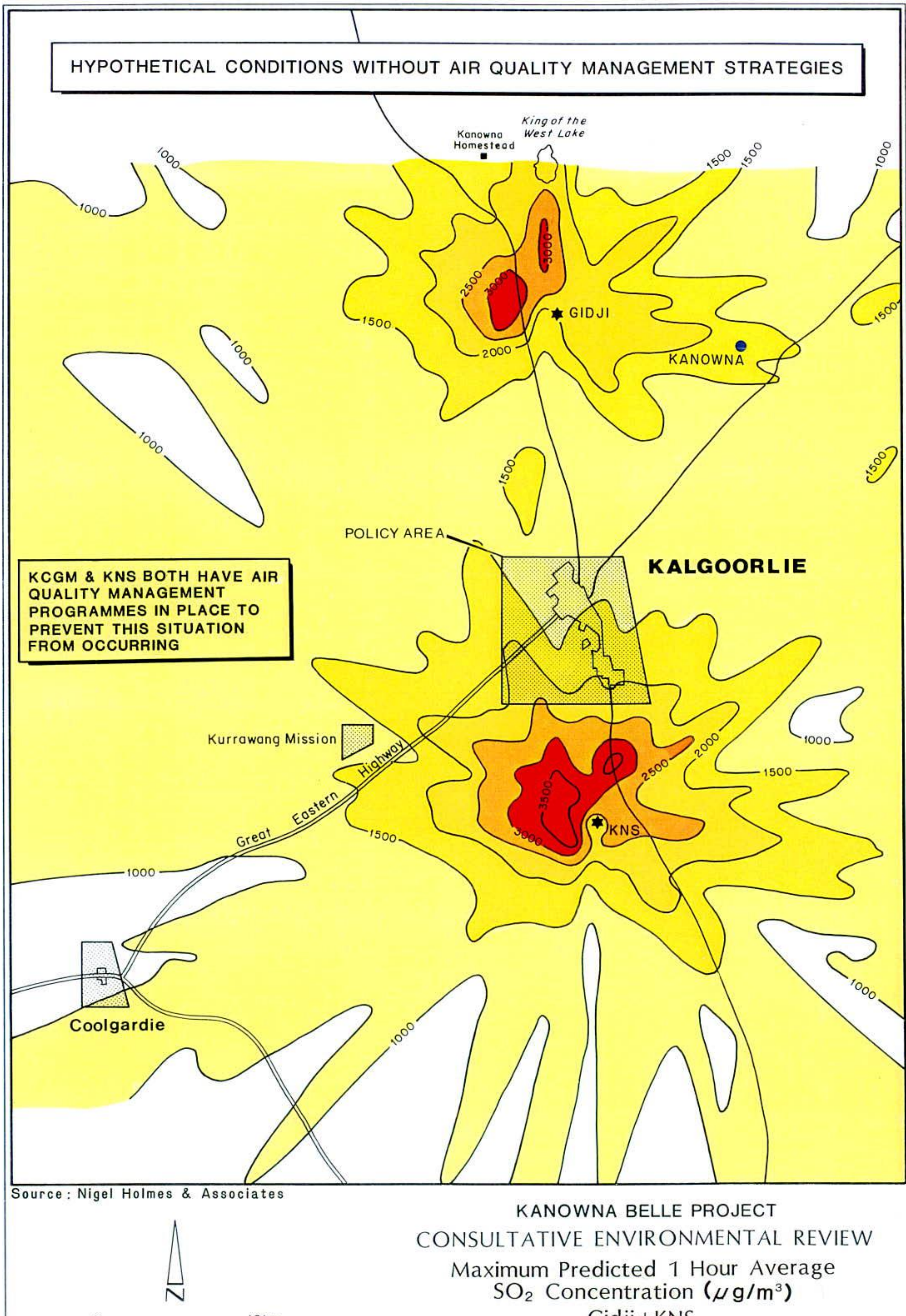
Predicted Annual Average

SO_2 Concentration ($\mu g/m^3$)

Gidji + KNS

AS MODELLED

Figure 6



Source: Nigel Holmes & Associates

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Maximum Predicted 1 Hour Average SO_2 Concentration ($\mu g/m^3$)

Gidji + KNS

AS MODELLED

Figure 7

TABLE 3

Annual Average Sulphur Dioxide Ground-level Concentrations – Kalgoorlie-Boulder

Year	$\mu g/m^3$
1989	45.4
1990	23.1
1991	11.9
1992	9.8

Source: Environmental Protection Authority Monitoring Reports

Plate 8 shows the extent of land degradation present around Kanowna Belle as a result of prior grazing, mining and exploration activities; and extensive disturbance and modification to vegetation in and around the abandoned Kanowna townsite, is illustrated in Plate 9.

6.3 ZONES OF INFLUENCE

In the determination of environmental impacts, through a process of pre-selection of the significant effects and values, a 'zone of influence' has been identified around the proposed Kanowna Belle roaster. In essence, the delineation of this reference environment included the hypothesis of some level of impact.

For this project, there are two zones of influence. The first has been defined as an area of 12 km^2 surrounding the stack of the proposed roaster. The second constitutes the Policy Areas as delineated. By analogy, the delineation of a 'Policy Area' includes the hypothesis of some level of impact on the population.

The first reference environment is shown as the circle bounding the vegetation map in Figure 5. The second reference environment is shown as the Policy Areas on Figure 6.

6.4 IMPACTS ON AIR QUALITY

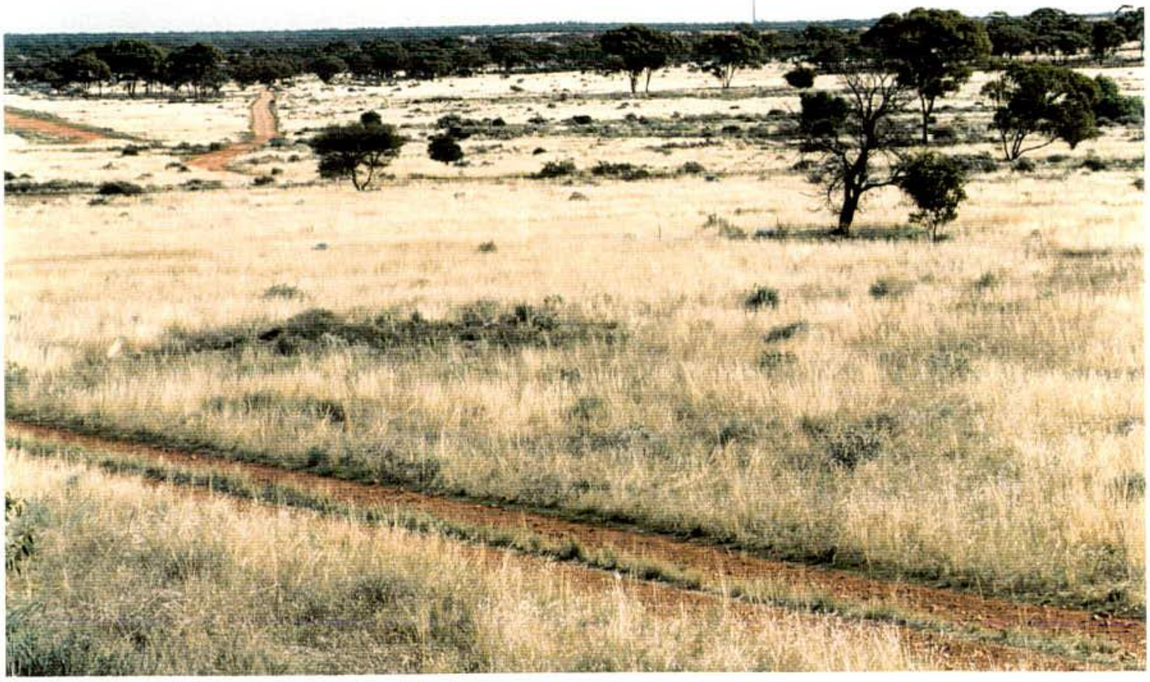
The proposed concentrate roaster for Stage II of the Kanowna Belle project will have an emission rate of sulphur dioxide of approximately 1.1 kg/second. This gas will be discharged to the atmosphere and therefore there is a potential to adversely affect air quality.

The potential impact on regional air quality can be put into perspective by reference to Figure 8 which details the existing maximum licensed contribution to atmospheric sulphur dioxide from the Gidji roaster and the nickel smelter compared to the proposed output from the Kanowna roaster.

PLATE 8

Current environmental impacts in the Kalgoorlie area include land degradation from overgrazing and old diggings and associated access tracks. These two examples are adjacent to the Kanowna Belle Project area.

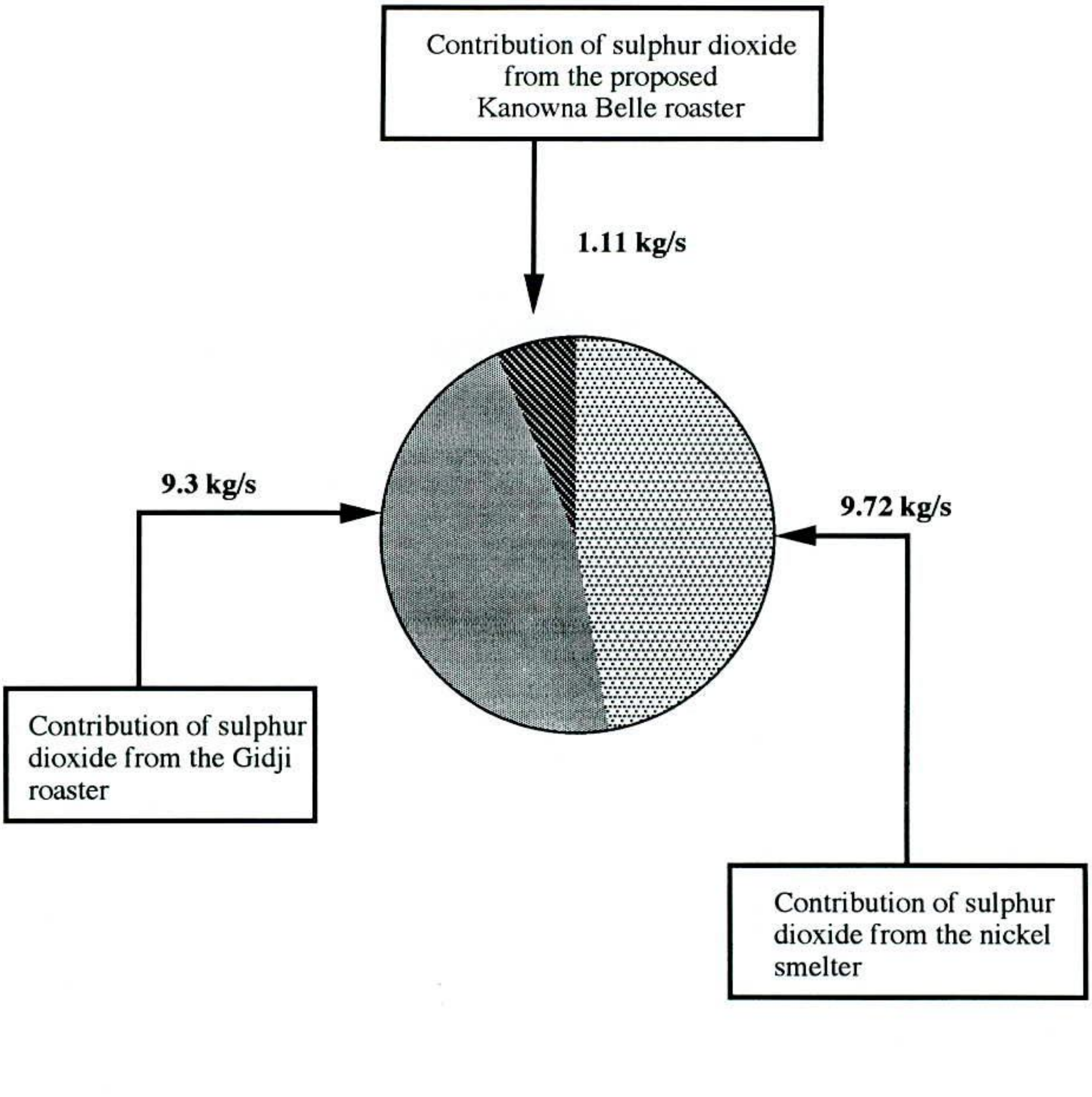
PLATE 9



View to the north-west from the old Kanowna townsite. The waste rock dump at the Kanowna Belle mine is just visible in the middle distance. The stack at the Gidji Roaster, approximately 15 km to the west is visible on the skyline.

The old Kanowna townsite is cleared of trees and contains abundant tracks and old diggings and waste dumps.

SULPHUR DIOXIDE CONTRIBUTION
TO
REGIONAL AIR QUALITY
AT
MAXIMUM LICENCED OUTPUTS



D. C. Blandford & Associates Pty Ltd

Figure 8

There is a potential impact on air quality in the Kalgoorlie-Boulder Policy Area. The wind vector that will exactly straddle the Policy Area will occur for about 7% of time. This means that for approximately 25 days of the year, winds can blow directly from the roaster towards the Kalgoorlie-Boulder Policy Area.

The dispersion of the gas plume and the assessment of resultant potential impacts has been determined using a Gaussian Model of Atmospheric Transport and Diffusion (AUSPLUME) (Nigel Holmes & Associates, 1993). The 1986 data used in the model were local area data provided by KCGM. The assessment of impacts is based on the ability of the model to predict ground-level concentrations of sulphur dioxide in the vicinity of the proposed Kanowna stack. Model runs were undertaken for the proposed operating condition. This is for a two-stage roaster with a water quench to cool the waste gas to 350°C. An electrostatic precipitator is then used to de-dust the waste gas. This is then followed by an air dilution quench, which cools the gas further to 105°C after which the gas is de-dusted with a fabric filter.

Model runs have been undertaken assuming the Kanowna roaster is operating alone, and also assuming (as will be the case in practice) that emissions from the Gidji roaster and WMC nickel smelter (KNS) occur at the same time. Both these plants emit sulphur dioxide resulting in concentrations in the same area in which the Kanowna roaster emissions will disperse.

The emission parameter for each of the sulphur dioxide sources used in the AUSPLUME model runs are given in Appendix 4.

Ground-level concentration data for Kanowna Belle alone are given in Figures 9 and 10 and the modelled change resulting from the combined effects of all three operations are shown in Figures 11 and 12. These figures represent hypothetical worst-case situations, and these data show that, for worst-case scenarios:

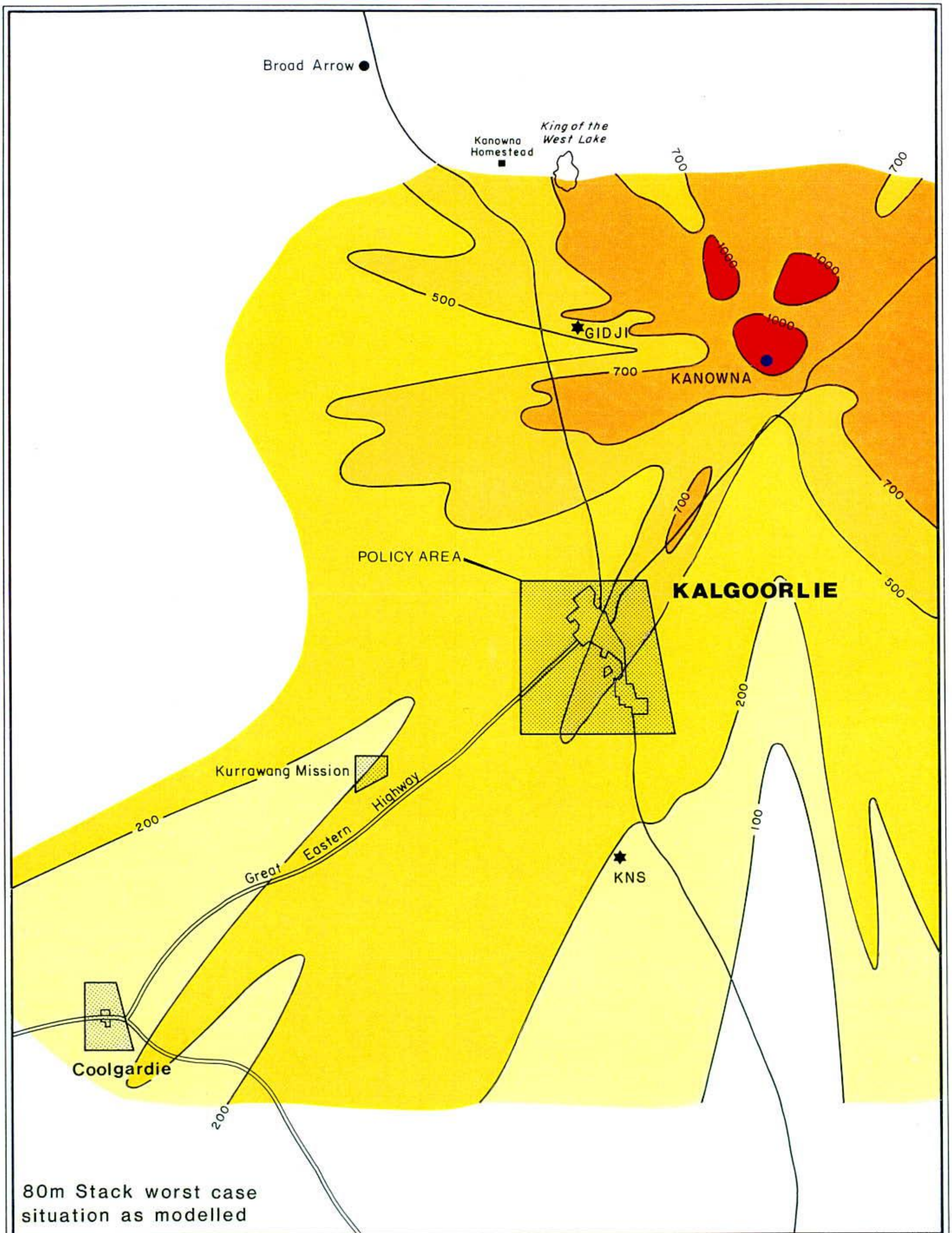
1. The modelled maximum one-hour average sulphur dioxide concentration for Kanowna Belle emissions is generally less than 600 $\mu g/m^3$ in the Policy Area (see Figure 9).

2. The modelled maximum one-hour average sulphur dioxide concentration for Gidji, KNS and Kanowna Belle combined exceeds 1400 $\mu g/m^3$ (without air quality management programmes).

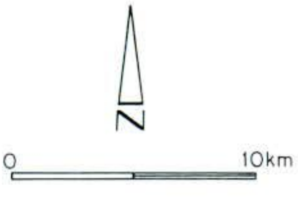
3. The modelled annual average sulphur dioxide concentration for the Policy Area from Kanowna Belle alone is from 6 $\mu g/m^3$ down to 4 $\mu g/m^3$ (see Figure 10).

4. The modelled average annual sulphur dioxide concentration from Gidji, KNS, and Kanowna Belle, is approximately 30 $\mu g/m^3$ across the Kalgoorlie-Boulder Policy Area (see Figure 11, and compare with measured concentrations in Tables 2 and 3).

Modelling ground-level concentrations allows potential impacts to be predicted. However, it is important to note that modelling is a management tool and as such, forms the basis for air quality management strategies. Both KCGM and KNS have air quality



Source: Nigel Holmes & Associates



KANOWNA BELLE PROJECT

CONSULTATIVE ENVIRONMENTAL REVIEW

Maximum Predicted 1 Hour Average SO_2 Concentration ($\mu g/m^3$)

Kanowna Belle

AS MODELLED

Figure 9

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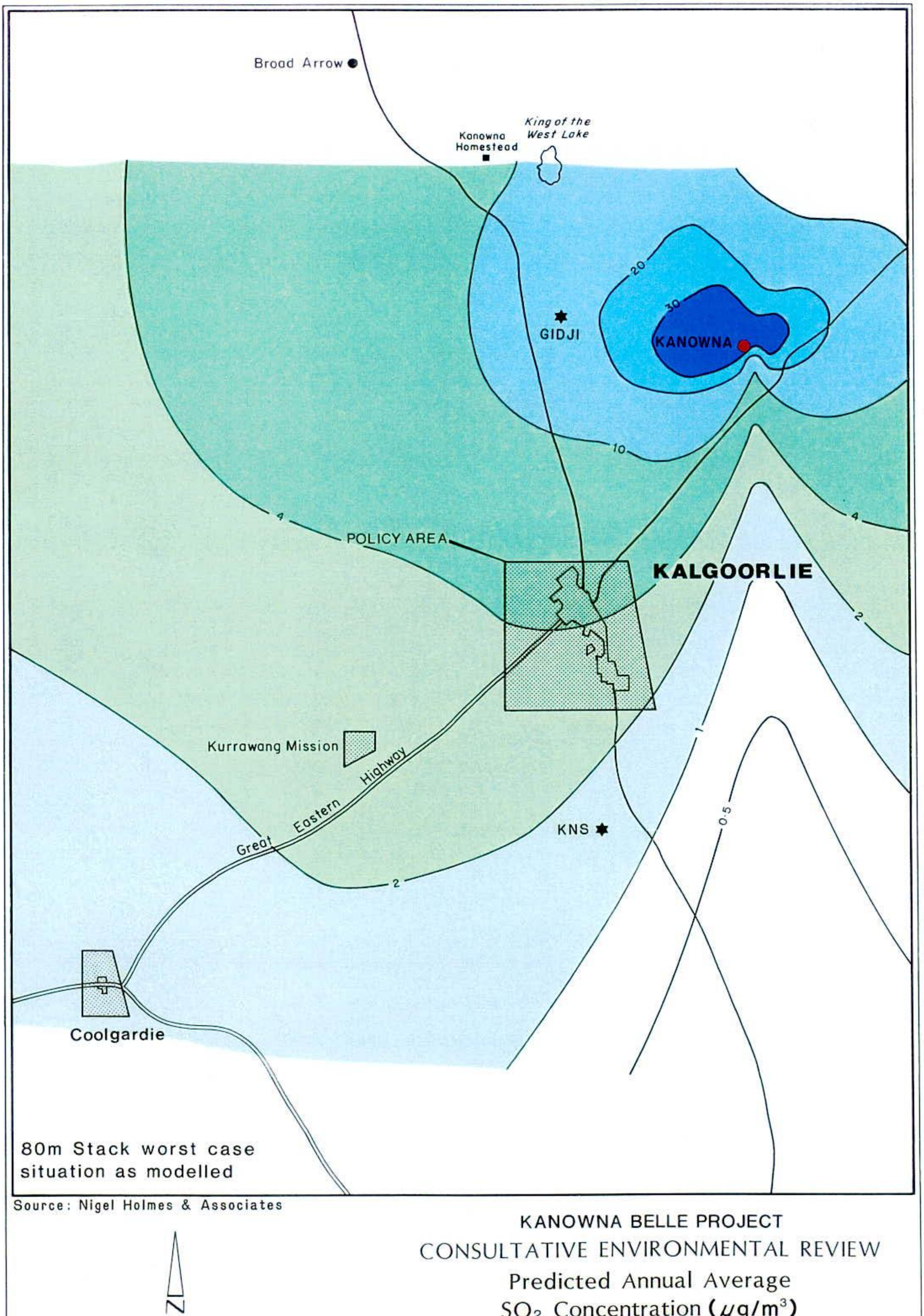
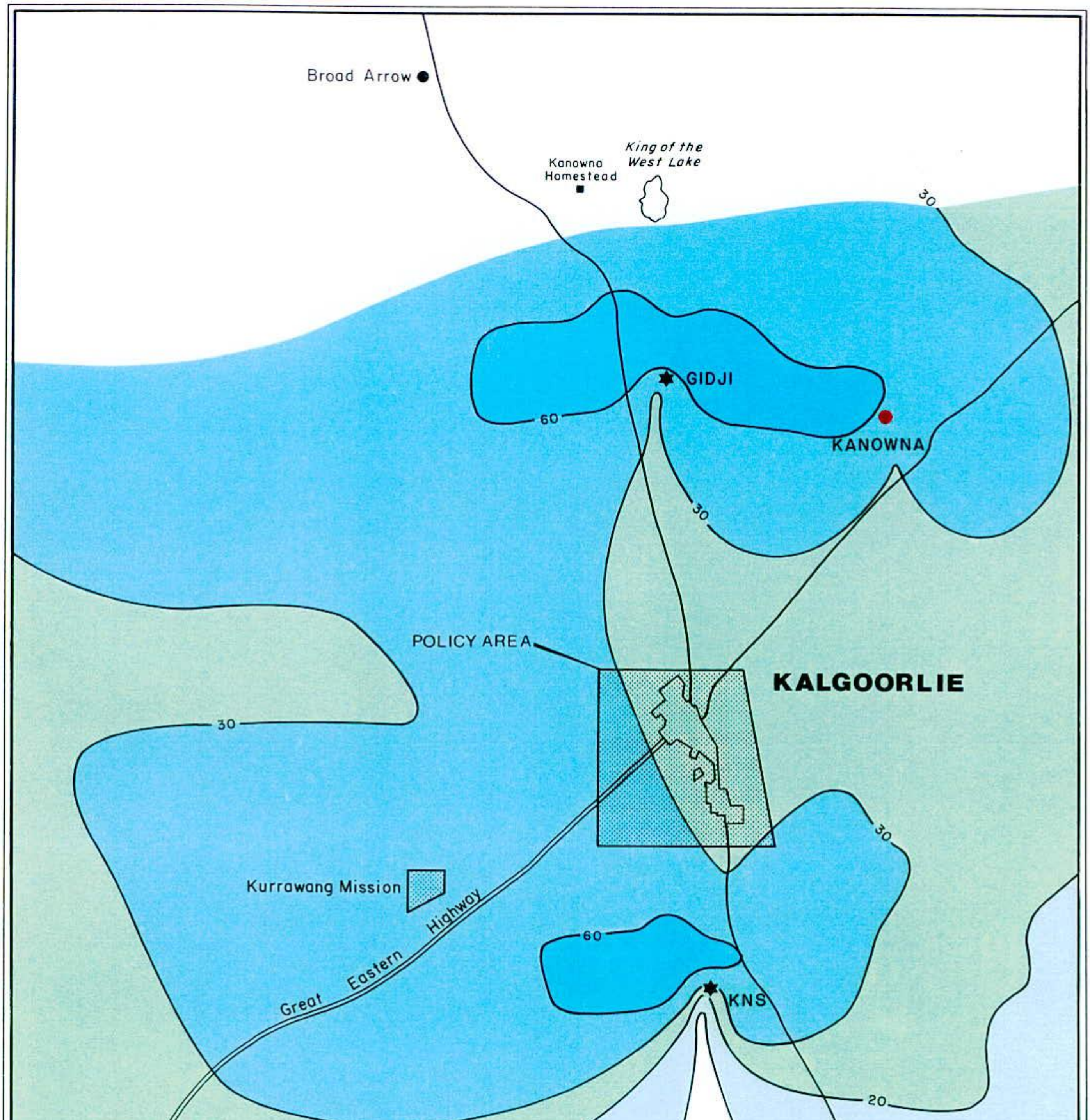


Source: Nigel Holmes & Associates

KANOWNA BELLE PROJECT
CONSULTATIVE ENVIRONMENTAL REVIEW
Predicted Annual Average
SO_2 Concentration ($\mu g/m^3$)
Kanowna Belle
AS MODELLED

Figure 10



Source: Nigel Holmes & Associates

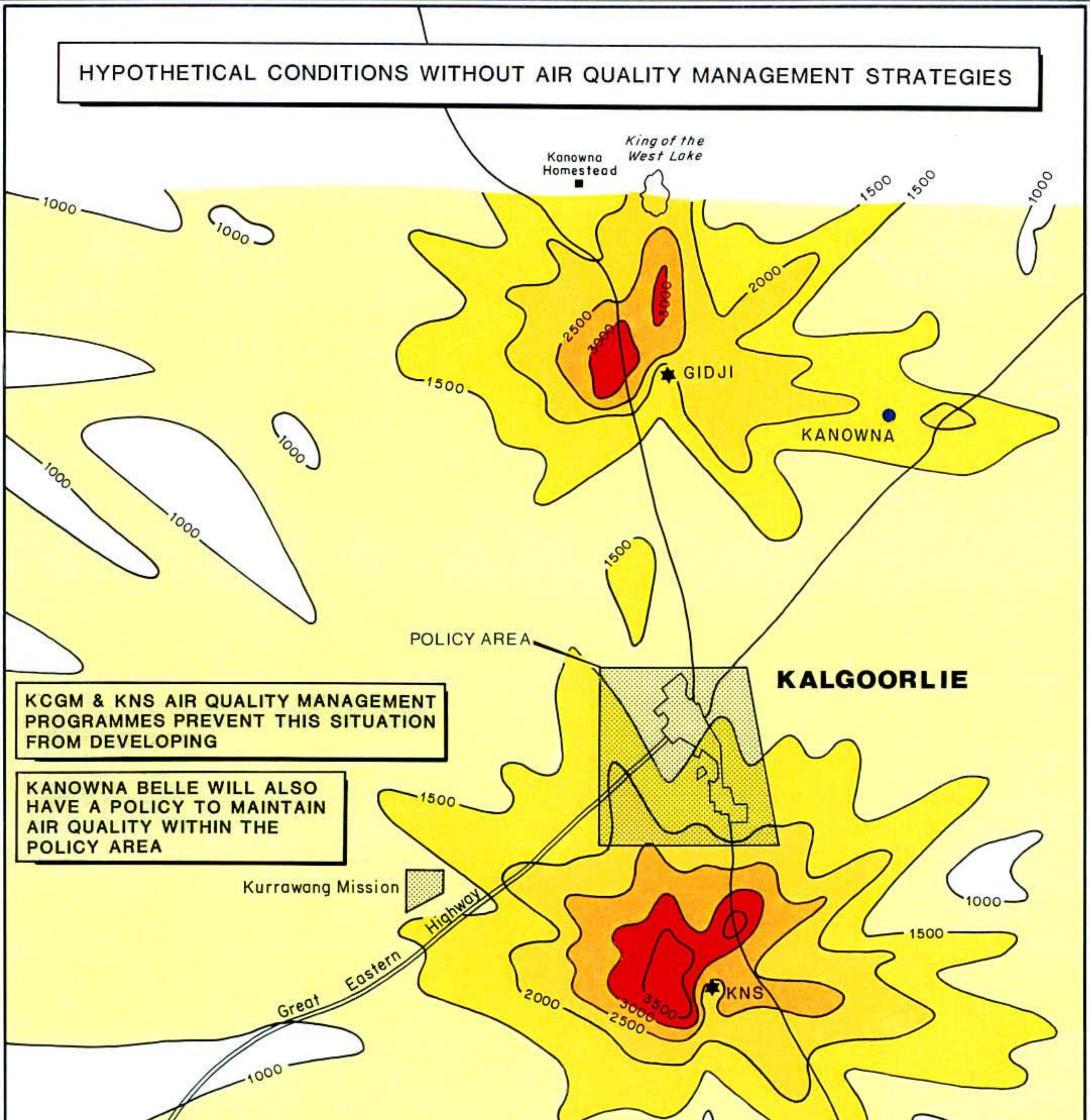
N

0 10km

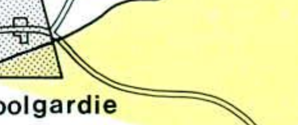
KANOWNA BELLE PROJECT
CONSULTATIVE ENVIRONMENTAL REVIEW

Predicted Annual Average SO_2 Concentration ($\mu g/m^3$) Kanowna Belle + Gidji + KNS

Figure 11



Source: Nigel Holmes & Associates



KANOWNA BELLE PROJECT
CONSULTATIVE ENVIRONMENTAL REVIEW
Maximum Predicted 1 Hour Average
SO_2 Concentration **($\mu g/m^3$)**
Kanowna Belle + Gidji + KNS
AS MODELLED

Figure 12

management programmes in place, and these programmes prevent the hypothetical worst-case situation from occurring.

The modelled maximum one-hour ground-level concentrations for Gidji and KNS without Kanowna Belle are shown in Figure 7. The modelled maximum one-hour ground-level concentrations for Gidji, KNS and the proposed Kanowna Belle roaster are shown in Figure 12. The addition of sulphur dioxide from the Kanowna roaster makes virtually no change to the pattern of ground-level concentration. **It is of paramount importance to understand that the ground-level concentrations presented in Figures 7 and 12 are hypothetical and are based on modelling only.**

6.5 IMPACTS ON VEGETATION

As noted in Section 6.3, identification of a zone of influence around the roaster included the hypothesis that there will be some type of effect on vegetation.

The selection of a 2 km radius from the stack is based on documented evidence that an impact on vegetation could be expected up to about 2 km from the source of the emission. There are, however, many factors that can influence the level and type of impact that occurs. Sulphur dioxide is recorded as being toxic to plants but little data are available on Australian Arid Zone species.

The problems and prospects for isolating toxicity and plant stress resulting from sulphur dioxide emissions are considered in more detail in Section 7.

6.6 IMPACTS ON FAUNA

An international literature search revealed that there were very little data related directly to the effects of sulphur dioxide on vertebrate fauna. This is particularly so for Australia. However, data on research carried out in Europe and North America are available and show that long-term sulphur dioxide emissions produced the following:

a) changes in relative abundance of species (Barrett & Rosenberg, 1981; Chilgren, 1978; Freedman, 1989; Puszkar, 1979);

b) increases in dominance (*c.f* Barrett & Rosenberg, 1981; Freedman, 1989; Puszkar, 1979; Rapport *et al.*, 1985);

c) decreases in species diversity (Barrett & Rosenberg, 1981; Borghi *et al.*, 1982; Chilgren, 1978; Freedman, 1989; Puszkar, 1979; Rapport *et al.*, 1985; Schaeffer *et al.*, 1988);

d) changed relationships between selected animal groups with increasing distance from the source of the emissions (Puszkar, 1979); and

e) symptoms similar to physiological stress and anaemia which lower the chances of survival of wildlife during times of natural stress, and, significant reductions in vertebrate wildlife strongly correlated with industrial air pollution (Newman, 1979).

To assume that we can effectively evaluate the impacts resulting from low yield sulphur dioxide emissions at Kanowna assumes that vertebrate fauna in the region have remained intact in terms of the structure and function of the various communities in the region. This is clearly not the case as, like the vegetation in the region, there have been very high levels of disturbance and accordingly, any assessment of impacts cannot be related to a pre-disturbance norm.

It is likely that the greatest impact on local fauna will result from human activity. The development at Kanowna Belle will result in an increase in noise level, light during night-time operations, and general site activity. An increase in road use is likely to result in an increase in road kills of a number of species.

6.7 IMPACTS ON GROUNDWATER

Test work carried out on the slurry from the oxide tailings indicates that the slurry contains relatively low concentrations of metals and cyanide (CN). Weakly complexed forms of cyanide account for about 50% of the total cyanide concentration. These forms of cyanide would be expected to decay rapidly in the decant pond and revert to stable complexes (*e.g.* iron-cyano complexes) in the entrained liquor within the tailings storage (EGI, 1993). Leachate developing from this source would not be expected to have a significant impact on groundwater quality.

The cyanide-leached calcine tailings will be deposited in a dedicated tailings dam for potential downstream re-processing. Test results indicate that these tailings contain elevated levels of TDS and a high concentration of arsenic that is susceptible to leaching under strongly oxidising, and neutral to alkaline, conditions.

The concentration of cyanide in the CN-leached calcine tailings is significantly greater than recorded from test work on the oxide and CN-leached flotation tailings. Results indicate that the slurry water from the CN-leached calcine is likely to contain relatively high concentrations of CNwad. However, such concentrations will gradually decrease through cyanide decay processes.

Accordingly, there is a potential impact on groundwater quality as a result of arsenic solubility and elevated TDS levels in leachate from the dedicated tailings dam (EGI, 1993).

7.0 DISCUSSION - SULPHUR DIOXIDE AND VEGETATION IMPACTS

Sulphur, an element required by plants for complete nutrition, is absorbed by plant roots almost exclusively as the sulphate ion, SO_4^{2}. However, some sulphur dioxide is absorbed through plant leaves and utilised by the plant (Tisdale and Nelson, 1975). These same authors also note that sulphate sulphur may be retained in the tissue and cell sap of plants in large amounts. Although the nutritional aspects of sulphur uptake by plants in the normal fashion is well understood, what is not well understood, nor has received adequate attention, is that while sulphur dioxide in abnormally high concentrations is injurious to plants, at lower concentrations it is taken in through the leaves and provides a portion of the plants' total sulphur requirement.

The average and peak-level concentrations of a pollutant, the duration of exposure, and the frequency of exposure generally dictate the type of injury produced in receptor plants. The general symptoms of injury include visible injury to foliage, alteration of metabolic processes, and decreases in plant growth, production and quality. Visible injury, *e.g.* dead or necrotic leaf tissue, is often the result of an acute exposure while a chronic exposure often results in foliar chlorosis, premature senescence, or defoliation (Barfield *et al.*, 1982).

It is very difficult to predict the specific combinations of pollutant concentration and exposure that will produce injury to vegetation. As Barfield (*op cit*) points out, pollutant susceptibility varies at the population, generic, species, and varietal levels. The presence of other pollutants, as well as environmental conditions, may also influence what might be called the visible injury threshold.

The impact of sulphur dioxide on remnant native vegetation near Pinjarra has been studied previously by Kaeding and Kidby (1986) who found that higher plant species around the refinery indicated no visible emission damage, and no changes in species numbers that could be attributed to sulphur dioxide. As a result of their findings, these authors suggest that the use of higher plants as bio-indicators for monitoring impacts resulting from sulphur dioxide emissions is not recommended. The scale of the monitoring programme is significant in that the maximum distance from the emission source at which sulphur dioxide ground level concentrations were taken was 480 m. The authors report loss of chlorophyll on species of *Eucalyptus* and *Acacia* within the grounds of the refinery, presumably within 500 m of the emission source. The results presented by Kaeding and Kidby (*op cit*) is in accord with Guderian (1977) who notes that higher plants are known to be less sensitive to sulphur dioxide than lower plants such as lichens and accordingly are less suitable for long-term monitoring, especially of low-level emissions.

Spencer and Mattiske (1992) note that both vascular and non-vascular plants near the KNS have been affected by stack emissions. These authors do not attempt to identify combined impacts, but note that impacts within 1.5 km of the emission source may be attributable to either sulphur dioxide or particulate matter. Such an observation is important in the determination of stack emission impacts on vegetation.

Sulphur deposition resulting from stack emissions at Kalgoorlie have been investigated by Carras *et al.* (1992) who make some interesting comments in relation to the impact of sulphur dioxide on crops and pastures. These authors note that annual rates of sulphur dioxide deposition (dry deposition) to vegetation and soil can be compared to fertiliser application to crops and pastures. Rates of approximately 10-12 kg/ha/y of sulphur fertiliser applied to improved pasture is equivalent to a dry deposition rate of sulphur dioxide of approximately 20-40 kg/ha/y.

As the eastern boundary of the Western Australian 'wheat belt' lies approximately 150 km west of Kalgoorlie, the potential for a regional impact (resulting from sulphur dioxide deposition) on crops and pastures is highly unlikely as the 'dry deposition' rate is less than the application rate for sulphur fertilisers recommended for plant growth.

Work carried out by Carras *et al.* (*op cit*) on the potential 'dry deposition' values around the Gidji gold roaster and the KNS suggests that values ranged from 10 kg/ha/y at 20 km distant up to 100 kg/ha/y within several kilometres of the source.

The proposed roaster at Kanowna Belle will be discharging approximately 5.5% of the maximum licensed sulphur dioxide discharged by the gold roaster and nickel smelter. Although quantitative data are not available, it is reasonable to assume an equivalence of scale for 'dry deposition' of sulphur dioxide resulting from stack emission at Kanowna.

There is a paucity of site-specific data in relation to potential impacts of sulphur dioxide on vegetation. The inference to be drawn from documented research suggests that high concentrations of sulphur dioxide close to the emission source must occur if impacts are to be identified. Given the relatively small contribution of sulphur dioxide from the proposed Kanowna Belle roaster, it is possible that impacts on vegetation may not occur, or may be too small or masked by external factors to be readily identified.

The relationship between predicted ground-level concentrations around Kanowna Belle and plant response is the subject of a proposed monitoring programme, and is discussed further in Section 8.

8.0 ENVIRONMENTAL MANAGEMENT

The aim of the Kanowna Belle environmental management programme for Stage II is to minimise effects resulting from project implementation. Accordingly, the management strategies to be adopted and put in place have their origin in potential environmental impacts identified during project formulation and design.

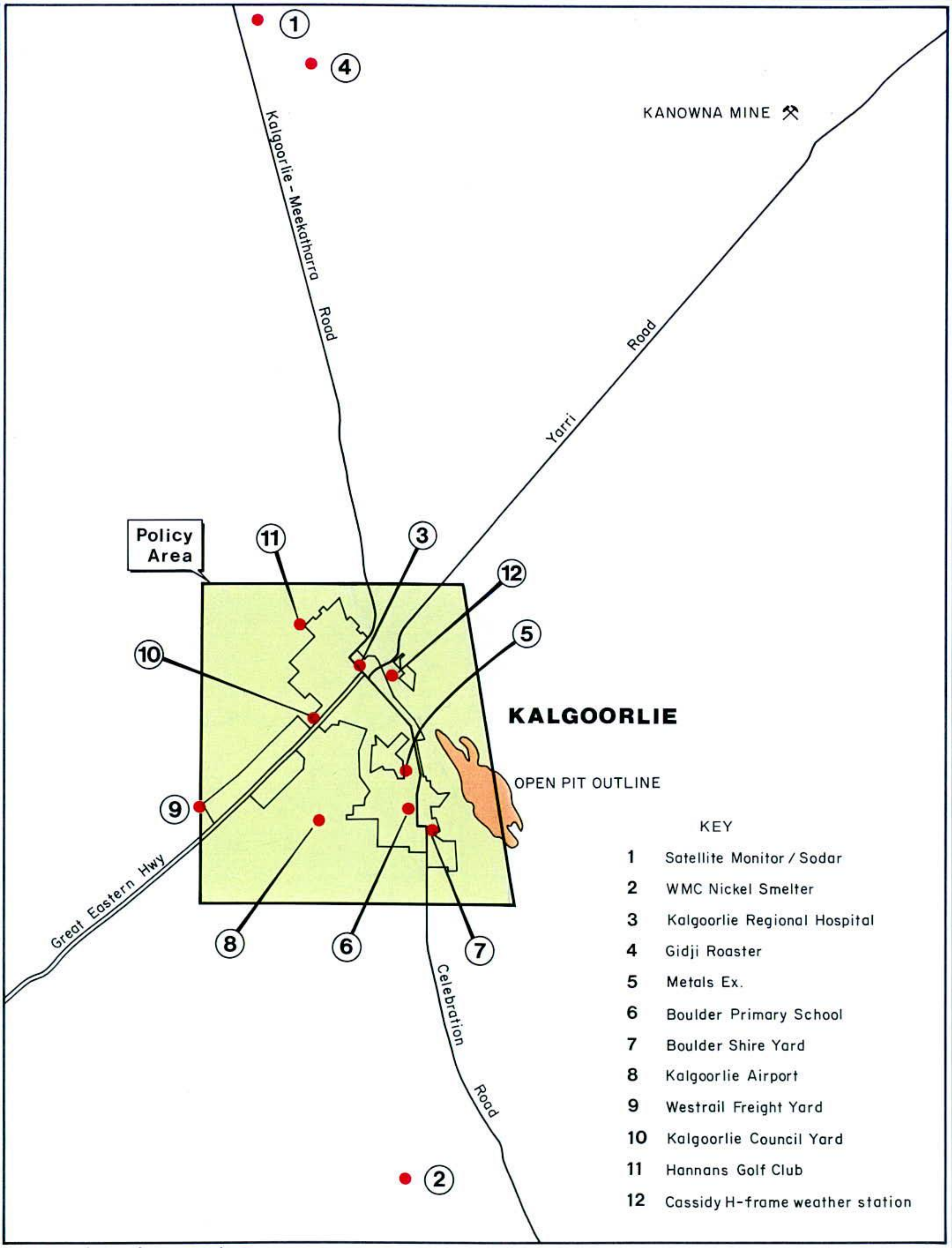
8.1 SULPHUR DIOXIDE AND AIR QUALITY

The major environmental effect resulting from Stage II will be the addition of sulphur dioxide to the atmosphere, and accordingly there is a potential to affect the human and biological environments.

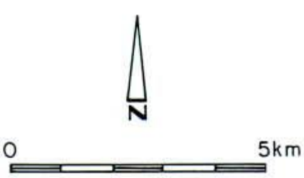
The environmental management programme is centred on the achievement of air quality objectives of the Environmental Protection (Goldfields Residential Areas) (Sulphur Dioxide) Policy 1992 and Environmental Protection (Goldfields Residential Areas) (Sulphur Dioxide) Regulations 1992.

As noted previously, the Air Quality Objective established by the Policy as from 1st January, 1996 is a limit of 1400 $\mu g/m^3$ and a standard of 700 $\mu g/m^3$, both averaged over a one-hour period. The Regulations prescribe a licence condition, and this condition will require management of emissions so that the prescribed air quality limit is not exceeded within the Policy Area.

Operators of the Gidji gold roaster and the KNS have in place a system of monitors throughout the Kalgoorlie-Boulder residential area for the detection of sulphur dioxide (see Figure 13). Monitors are also located at the roaster and smelter sites. These monitors collect data which is



After Kalgoorlie Consolidated Gold Mines



KANOWNA BELLE PROJECT

CONSULTATIVE ENVIRONMENTAL REVIEW

Location of Sulphur Dioxide Monitors

Figure 13

transferred to a central collection point from which it is accessed by the operators of the system.

The operators of the Kanowna Belle roaster have reached agreement in principle with the existing operators to use the present sulphur dioxide monitoring system and would instal an additional monitor at the roaster site to monitor on-site sulphur dioxide levels.

Management for maintenance of air quality will be based on a predictive capability for potential impacts on the Policy Area. The ground-level concentrations targeted by the proponent for this project are those levels that will be introduced on 1st January, 1996. The management programme will have the following major components:

1. A sulphur dioxide monitoring network throughout the Kalgoorlie-Boulder residential area linked to a data collection facility in the old Metals Exploration building.

2. A telecommunications line or a radio telemetry system will link the Kanowna mine site with the central data collection facility in Kalgoorlie-Boulder.

3. Weather conditions will be monitored using data from a weather station on site and data from Kalgoorlie.

4. A plume tracking capability will be installed at the mine site, and together with existing and predicted weather information, will form the basis for management.

5. The establishment of a predictive capability for plume behaviour will form the basis for management response.

6. If the tracking system indicates that there is the potential for an impact on air quality in the Policy Area to occur, the roaster will be shut down for the time required for the set of conditions generating the impact to change.

7. Shut-down criteria have been established for Kanowna and these are:

   (i) wind direction from Kanowna that straddles the Policy Area with a 10-degree buffer zone on either side; and

   (ii) wind velocity of 4 m/s or less at a height of 10 m.

   (The wind will blow from the proposed roaster towards the Policy Area for only 7% of time, and within this time, the four hours preceding sunrise are the most important.)

8. Once shut-down conditions have changed, the roaster will be re-started and normal operations resumed.

Ground-level concentrations as modelled do not represent fumigation events. Fumigation is a transient phenomena and the management strategy is therefore a fumigation protection strategy.

The proposed air quality management programme is, in reality, a combined management and monitoring programme as they are not mutually exclusive programmes. Sulphur dioxide monitoring will provide the data which, in part, will dictate management response.

8.2 GENERAL

Salinity (TDS) and arsenic are the major groundwater concerns associated with on-site containment of the CN-leached calcine. The design of the dedicated disposal facility will include an appropriate lining to restrict leachate seepage. This facility may also be equipped with an under-drainage system for leachate collection.

Salinity will be the main constraint to the direct revegetation and rehabilitation of the CN-leached calcine disposal facility, although the presence of soluble forms of arsenic may also pose constraints to plant growth. Accordingly, environmental management and rehabilitation strategies will include anti-capillarity measures to ensure that highly saline waters do not migrate to the surface.

The proponent for the proposed Stage II roaster plans to have a public display in Kalgoorlie-Boulder over two weekends. This display will present key features of the project and will give members of the public an opportunity to ask questions about the proposed roaster, including its operation and potential environmental impacts.

It is planned to conduct these public displays after release of the CER.

9.0 MONITORING PROGRAMMES

There are three areas that will be subject to a monitoring programme. These are: air quality; vegetation response to sulphur dioxide; and groundwater.

9.1 AIR QUALITY

Sulphur dioxide concentrations in the Kalgoorlie-Boulder Policy Area will be monitored using the existing monitoring system. An additional sulphur dioxide monitor would be located at the mine site.

9.2 VEGETATION

The problems associated with assessing the impact of sulphur dioxide on vegetation have been discussed previously. There is no doubt that sulphur dioxide in sufficient concentrations is toxic to plants. However, unless it can be shown that toxic air concentrations result in a significant increase in leaf tissue sulphur concentrations, then monitoring of tissue sulphur levels is of questionable value. This problem is enhanced if the differences between affected and unaffected vegetation is small in comparison with background leaf tissue sulphur levels which are high and variable.

A major problem associated with monitoring the impacts of sulphur dioxide emissions and ground-level concentrations on vegetation is an absence of definitive data on the relationship between leaf tissue sulphur levels and leaf damage. This problem is further enhanced by a lack of valid control sites around Kanowna Belle. The establishing of monitoring sites remote from the Kanowna Belle site would not solve the problem as the range and magnitude of external environmental influences would not be known.

The proponent acknowledges that it is desirable to assess the impacts of sulphur dioxide on the local vegetation communities, and accordingly proposes the following monitoring programme:

1. Ground-level concentrations, within a 2 km radius of the roaster stack, will be modelled to determine the potential pattern of dry deposition.

2. A number of quadrats (sites) will be selected to represent a range of ground-level concentrations within the dry deposition patterns as modelled. Control sites will be selected away from potential impact areas and outside the 2 km zone.

3. The vegetation within these quadrats will be assessed to determine the current state of degradation.

4. Monitoring of each site will then take the form of a visual inspection to determine plant response to stack emissions, *i.e.* the presence of symptoms resulting from a pollution event such as injury to foliage and a decrease in plant quality.

5. In the event that there is a significant impact on species within the monitoring quadrat, plant leaf tissue sulphur levels will be analysed along with other appropriate parameters in an attempt to relate these to foliar injury.

Documented evidence (*e.g.* Spencer & Mattiske, 1992) suggests that any effects will be confined to an area of 12 km^2 with the roaster stack at the centre, that is, within 2 km of the stack. The level of contemporary impacts within 2 km of the stack have been noted previously, and this factor, together with the area of disturbance resulting from the mining operation, limits the sites available for monitoring.

9.3 GROUNDWATER MONITORING

Seven monitoring bores have been installed around the perimeter of the main tailings storage dam to monitor groundwater levels. Groundwater samples will be collected on a regular basis for analysis from selected bores.

Additional bores will be located to monitor groundwater quality in the vicinity of the dedicated disposal facility.

10.0 CONCLUSION

10.1 OVERALL ENVIRONMENTAL IMPACT AND PROJECT ACCEPTABILITY

The major direct environmental impact resulting from project implementation would be the addition of sulphur dioxide to the atmosphere. Because of statutory requirements regarding air quality and the proposed management programme that includes roaster shut-down to ensure compliance with the regulations, none of the impacts identified is assessed as significant.

In conclusion, given the monitoring and management procedures outlined in this CER, the overall environmental impact of the proposed Stage II project at Kanowna Belle would be acceptable.

10.2 ENVIRONMENTAL MANAGEMENT COMMITMENTS

The major commitments to environmental management for the operation of a gold roaster at Kanowna Belle are as follows:

1. The proponent will instal a sulphur dioxide monitor at the mine site. This monitor will be linked to the current monitoring system in Kalgoorlie-Boulder.

2. An air quality management system will be developed and installed as part of operational procedure for the roaster. The system will be centred on an impact predictive capability, and will include:

   (i) a sulphur dioxide monitoring network in Kalgoorlie-Boulder;

   (ii) telecommunications link from the mine to the central data processing facility;

   (iii) an on-site weather station;

   (iv) plume monitoring and tracking capability; and

   (v) a shut-down procedure based on wind velocity and direction.

   The air quality management programme will be developed during the Stage II construction phase.

3. A vegetation monitoring programme will be implemented to assess the effects of sulphur dioxide on plant health.

4. A groundwater monitoring system will be installed and a programme carried out to monitor changes in groundwater quality.

5. Monitoring programmes will be put in place when works become available and prior to the commencement of roaster operations.

6. An Environmental Management Programme, containing these commitments will be designed and carried out by the proponent in consultation with the Mines Department to the satisfaction of the EPA.

BIBLIOGRAPHY

Bamford, M. J., Davies, S. J. F. and Ladd, P. G. (1991) - *Biological survey of Kangaroo Hills and Calooli Timber Reserves, Coolgardie, Western Australia.* Unpublished report to Dept. of Conservation & Land Management Kalgoorlie, Western Australia.

Barfield, E. T., Molley, M. O., Watts, M. C. and Kruger, S. J. (1982) - Evaluating the Impact of Sulphur Dioxide Emissions on Local Vegetation. *Tappi* 65(8) pp 71-74.

Barrett, G. (ed) (1991) - A biological survey of Victoria Rock Nature Reserve. Goldfields Naturalists Club (Inc.), Kalgoorlie, W.A.

Barrett, G. W. and Rosenberg, R. (1981) - Stress Effects on Natural Ecosystems. John Wiley & Sons Ltd, New York.

Borghi, L., Adler, D. and Schreiber, R. K. (1982) - The effects of air pollution and acid rain on fish, wildlife, and their habitats, forests. *Air Pollution and Acid Rain, Report 6.* Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Burbidge, N. T. (1942) - Notes on the vegetation of the north eastern Goldfields. *J.Roy.Soc.West.Aust.* 27: pp 119-132.

Carras, J. N., Saghafi, A. and Williams, D. J. (1992) - Model Prediction of Sulphur Deposition Arising from the SO_2 Emissions at Kalgoorlie. Invest. Rep CET/067R CSIRO Div. of Coal and Energy Technology.

Chapman, A., Kealley, I., McMillan, D., McMillan, P. and Rolland, G. (1991) - Biological surveys of four Goldfields Reserves. Dept. of Conservation & Land Management, *Landnote* 1/91.

Chilgren, J. D. (1978) - The responses of prairie deer mice to a field SO_2 gradient - In: *4th Joint Conference on Sensing of Environmental Pollutants.* American Chemical Society, Washington, D.C.

Dames & Moore (1992) - Notice of Intent. Golden Valley Joint Venture - Kanowna Belle Project.

Davies, S. J. J. F. (1970) - A list of plants and animals found at Mileura, Western Australia. C.S.I.R.O. Div. of Wildlife Research Tech. Mem. No. 3.

Dell, J. and How, R. A. (1985) - Vertebrate Fauna. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 3. Jackson - Kalgoorlie Study Area. *Rec. West. Aust. Mus.* Suppl. 23

Ecologia (1992) - Appendix VI Biological Survey Report. In: Landcorp (1992). *Consultative Environmental Review - Mungari Industrial Park.*

EGI (Environmental Geochemistry International) (1993) - Geochemistry of Process Tailings and Implications for Tailings Disposal and Environmental Management. Kanowna Belle Project Stage 2 (Roaster Option). Unpub. Report to Peko Gold Ltd.

EPA (1992) - Revised Draft Environmental Protection (Goldfields Residential Areas) (Sulphur Dioxide) Policy 1992 *and* Environmental Protection (Goldfields Residential Areas) (Sulphur Dioxide) Regulations 1992. Report to the Minister for the Environment. Environmental Protection Authority. Perth, W.A.

Freedman, B. (1989) - *Environmental Ecology: the impacts of pollution and other stresses on ecosystem structure and function.* Academic Press Inc, California.

Gentilli, J. (1972) - Australian Climate Patterns. Nelson.

Guderian, R. (1977) - Air Pollution. Springer-Verlag: Berlin.

Holmes, Nigel & Associates (1993) - Air Quality Assessment Proposed Kanowna Belle Roaster, Near Kalgoorlie, W.A. Unpub. report to Peko Gold Ltd. (Available as a Technical Appendix on request.)

Kaeding, G. F. and Kidby, D. K. (1986) - An Assessment of Low Level Sulfur Dioxide Emission from an Alumina Refinery in South-Western Australia. 1-Survey of Higher Plants. *Clean Air* 20(4) pp 119-125.

Kenneally, K. J. (1968) - An annotated list of Angiosperms of Lakeside Station, Cue, Western Australia. *West. Aust. Nat.* 10: pp 182-189.

Kenneally, K. J. (1971) - Some additions to the Angiosperm flora of Lakeside Station, Cue Western Australia. *West. Aust. Nat.* 12:20.

McKenzie, N. L. and Hall, N. J. (eds) (1992) - The Biological Survey of the Eastern Goldfields of Western Australia. Part 8. Kurnalpi-Kalgoorlie Study Area. *Rec. West. Aust. Mus.* Suppl. No. 41.

Mattiske, E. M. & Associates (1993) - Kanowna Belle Gold Mines Flora and Vegetation Studies. Unpubl. report to Kanowna Belle Gold Mines.

Newman, J. R. (1979) - The Effect of Industrial Air Pollution on Wildlife. *Biological Conservation* 15. pp 181-190.

Ninox Wildlife Consulting (1993) - Kanowna Belle Project - Stage II Vertebrate Fauna Study and Impact Assessment. Unpubl. report to D. C. Blandford & Associates Pty Ltd.

Northcote, K. H. (1971) - A Factual Key for the Recognition of Australian Soils. Rellim Tech. Publ. Glenside, South Australia.

Puszkar, T. (1979) - The effect of sulphur industry on epigeic and soil fauna. *Memorabilia zoologica,* 32, pp 101-118.

Rapport, D. J., Regier, A. and Hutchinson, T. C. (1985) - Ecosystem behaviour under stress. *American Naturalist,* 125(5), pp 617-640.

Riddle, J. C. C. and Holmes, N. E. (1992) - Management of Sulphur Dioxide Emissions from the Gidji Gold-ore Roaster near Kalgoorlie, Western Australia. Proc. Eleventh International Clean Air Conference. NZ pp 65-74.

Schaeffer, D. J., Herricks, E. E. and Kerster, H. W. (1988) - Ecosystem Health: 1. Measuring ecosystem health. *Environmental Management,* 12(4), pp 445-455.

Serventy, D. L. and Whittell, H. M. (1976). *Birds of Western Australia.* Univ. West. Aust. Press, West. Aust.

Shirley, A. M., Conover, K. T., Strong, T., Hickey, E. and Sander, F. (1985) - An Evolving Framework for Environmental Impact Analysis. 1. Methods, *Jour. Env. Mgt. 21*, pp 343-358.

Spencer, R. E. and Mattiske, E. M. (1992) - Monitoring for Effects of Air Emissions on Vegetation Surrounding the Kalgoorlie Nickel Smelter. Workshop on Rehabilitation of Arid and Semi-Arid Areas. The Goldfields Land Rehabilitation Group. pp 97-106.

Swager, C., Griffin, T. J., Witt, W. K., Wyche, S., Ahmat, A. L., Hunter, W. M. and McGoldrick, P. J. (1990) - Geology of the Archaean Kalgoorlie Terrane - An Explanatory Note. *Record 1990/12* Geological Survey of Western Australia.

Tisdale, S. and Nelson, W. (1975) - Soil Fertility and Fertilizers. Macmillan New York p 694.

GLOSSARY OF TERMS

Arsenopyrite	A mineral containing iron, arsenic and sulphur (FeAsS).
Calcine	Sulphide ore that has been burned in a roaster to oxidise the sulphide minerals.
CNwad	CN = cyanide; wad = weak acid dissociable. CNwad is a measure of the forms of cyanide which are toxic to biota.
Electrostatic Precipitator	A device that uses a high-intensity electric field to charge dust particles and other aerosols and attract them to a collector plate of the opposite charge.
Greenschist Facies	Metamorphic rocks produced under low temperature conditions.
Köppen System	A system of climate classification in Australia. The Köppen System is the best-known modern classification system for Australian climates, and the BS fh classification for Kalgoorlie is based on the following: B = Dry Climates BS = Semi-arid f = Climate with uniform rain h = Mean annual temperature is warm (>18°C)
Refractory Ore	Ore difficult to treat for recovery of the valuable metals and which responds poorly to conventional milling and leaching.
Supernatant Water	The clear water remaining on the surface of the tailings dam after settling of the solids.
Volatilise	Strictly, to be made into a vapour and therefore to pass off in the vapour form in the roaster off-gas.

APPENDICES

1. Sources of Information

2. Presentations:

   1) Kalgoorlie-Boulder City Council
   2) Public Display

3. Soil Characteristics

4. Emission parameters used in the AUSPLUME model runs

5. Chart showing project approval process in W.A.

6. EPA Guidelines

APPENDIX 1

SOURCES OF INFORMATION

Study Team

The following personnel/organizations were involved in the preparation of this document:

1. R. Dossor of Peko Gold Ltd - Stage II Project Manager.

2. D. C. Blandford & Associates Pty Ltd
   Principal Environmental Consultants and Co-ordinators for environmental studies and preparation of the CER.

3. Nigel Holmes & Associates
   Air quality investigation and plume dispersion modelling.

4. E. M. Mattiske & Associates
   Vegetation and flora investigations.

5. Ninox Wildlife Consulting
   Fauna investigations.

6. Environmental Geochemistry International.
   Investigations into the geochemistry of process tailings.

7. Engineering data on design and the roasting process was provided by Minproc Engineers Pty Ltd.

Authorities/Organizations Consulted

Environmental Protection Authority
Department of Minerals and Energy
Water Authority of Western Australia
City of Kalgoorlie-Boulder
Kalgoorlie Consolidated Gold Mines
Western Mining Corporation - Kalgoorlie Nickel Smelter

APPENDIX 2

PRESENTATIONS

1) Kalgoorlie-Boulder City Council

A presentation was made to the Kalgoorlie-Boulder City Councillors to outline the proposed project, and to provide the Councillors with an opportunity to discuss the key elements of the project.

The potential environmental impacts were identified to council, together with the proposed management programme to alleviate the impacts and monitor for effects from project implementation.

2) Public Display

The proponent proposes to hold a public display in Kalgoorlie-Boulder over two consecutive weekends. This display will outline key features of the project; identify the potential environmental impacts resulting from project implementation; and summarise the proposed environmental management programme.

The display will be staffed by the proponent or its representatives. A short handout on the Kanowna Belle Stage II project will be available.

It is planned to conduct the display immediately after release of the CER and during the formal public review period.

APPENDIX 3

SOIL CHARACTERISTICS - KANOWNA BELLE MINE AREA

Depth	Colour	pH	$CaCO_3$	Texture
0.01 m	10R 4/4 [1]	9.0	Present (NV)	Fine sandy loam
0.15 m	10R 4/6 [2]	8.5	Present (NV)	Loam
0.6 m	10R 3/4 [3]	8.5	Present (VC)	Fine sandy clay loam
0.9 m	10R 3/6 [3]	9.0	Present (VC)	Light clay
1.5 m	10R 3/6 [3]	9.0	Not Present	Light medium clay

Notes: NV = not visible
VC = visible as concretions

1 = Reddish brown
2 = Red
3 = Dark red

APPENDIX 4

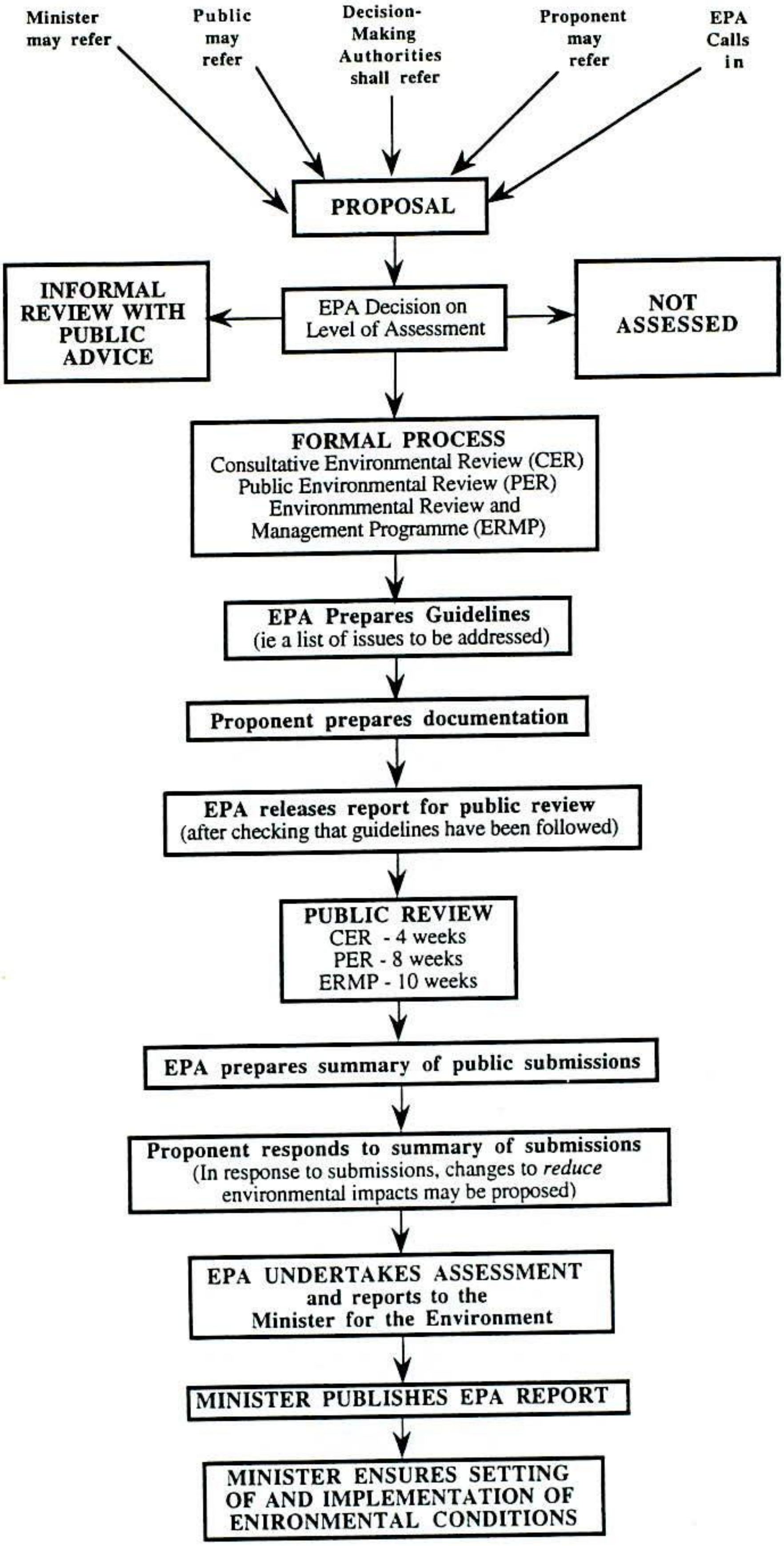
EMISSION PARAMETERS USED IN THE AUSPLUME MODEL RUNS

Parameter	Source		
	Proposed Kanowna Belle Roaster	Gidji	KNS
Stack height (m)	80	180	150
Stack diameter at top (m)	1.41	2.00	2.13
Temperature (deg. K)	378	613	549
Exit velocity (m/s)	20.0	23.9	23.0
Mass emission rate (kg/s)	1.1	9.3	9.72
AMG Easting (m)	363701	351940	354321
AMG Northing (m)	6613359	6614675	6583246

Source: Nigel Holmes & Associates

APPENDIX 5

CHART SHOWING PROJECT APPROVAL PROCESS IN WESTERN AUSTRALIA



EPA decides within 28 days. Anybody may appeal to the Minister within 14 days on level set; Minister may direct higher level but not vice versa

DMA cannot allow implementation unless either no formal assessment or the Minister Authorises. Process not suspended

Draft guidelines usually issued within 14 days of first meeting with proponent

EPA usually completes summary in 2-3 weeks

Report release often 3-5 weeks after receipt of response to submissions

Anybody may appeal on EPA report to Minister within 14 days. Minister may remit to EPA or take appeal into consideration when setting conditions

Proponent may appeal on conditions within 14 days of issue

APPENDIX 6

EPA GUIDELINES FOR

CONSULTATIVE ENVIRONMENTAL REVIEW

GOLD ROASTER TO TREAT REFRACTORY ORE, KANOWNA BELLE MINE STAGE 2, NEAR KALGOORLIE

CONSULTATIVE ENVIRONMENTAL REVIEW GUIDELINES

Overview

In Western Australia all environmental reviews are about protecting the environment. The fundamental requirement is for the proponent to describe what they propose to do, to discuss the potential environmental impacts of the proposal, and then to describe how those environmental impacts are going to be managed so that the environment is protected.

If the proponent can demonstrate that the environment would be protected from unacceptable environmental impacts, then the proposal would be found environmentally acceptable; if the proponent cannot demonstrate this, then the Environmental Protection Authority (EPA) would recommend against the proposal.

Throughout the environmental review process it is the aim of the EPA to advise and assist the proponent to improve or modify the proposal in such a way that the environment is protected. Nonetheless, the environmental review in Western Australia is proponent driven, and it is up to the proponent to identify the potential environmental impacts, and design and implement its proposal so as to protect the environment.

For this proposal, protecting the environment means that the natural and social values of the area impacted by the proposed Kanowna Belle gold roaster are protected to the greatest extent possible. Where these values cannot be protected, appropriate actions to mitigate or ameliorate the impacts are required.

Purpose of a CER

The primary purpose of a CER is to communicate clearly with the public and government agencies, so that the EPA can obtain informed comments on the proposal. This provides the basis for the EPA to assess the proposal and to advise the State Government on protecting the environment. As such, environmental impact assessment is quite deliberately a public process.

Objectives of the review

The Consultative Environmental Review should have the following objectives:

- to place this proposal in the context of the local and regional environment;
- to explain the issues, decisions and feasible alternatives which led to the choice of this proposal at this place and at this time;
- to set out the specific environmental impacts that the proposal may have; and
- for each impact, to describe any environmental management steps, including monitoring, that the proponent believes would avoid, mitigate or ameliorate that impact.

The CER should focus on the key environmental issues for the proposal and anticipate the questions that members of the public will raise. Data describing the environment should be directly related to the discussion of the potential impacts of the proposal. The discussion should then relate directly to the actions proposed to manage those impacts.

Key issues

There are a number of key issues associated with the various components of this project, and the CER should clearly identify these. The content of the succeeding sections are then determined by their relevance to these key issues.

Key issues include:

- alternative treatment technologies and criteria used to select preferred technology;
- emissions of gaseous wastes, particularly sulphur dioxide and compliance with the Environmental Protection (Goldfields Residential Areas) (Sulphur Dioxide) Policy and Regulations 1992;
- discharges of solid and liquid wastes;
- potential impacts on native flora and fauna of the area during the construction and operational phases;
- aesthetics/landscape impacts on the area;
- decommissioning and rehabilitation;
- impacts on local communities and nearest neighbours; and
- environmental monitoring (particularly sulphur dioxide in EPP areas) and subsequent changes to management to mitigate adverse impacts.

Other key issues raised during the preparation of the report should also be included.

Public participation and consultation

A description should be provided of whatever public participation and consultation activities are undertaken by the proponent in preparing and exhibiting (for four weeks) the CER. It should describe the activities undertaken, the dates, the groups and individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management for the proposal which should clearly indicate how any community concerns have been addressed.

Detailed list of environmental commitments

The commitments being made by the proponent to protect the environment should be clearly defined and separately listed. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. They should be numbered and take the form of :

what the work is;
who would do the work;
when the work would be carried out; and
to whose requirement (regulatory agency) the work would be carried out.

All actionable and auditable commitments made in the body of the document should be summarised in this list, which may be included as a condition of approval.