DARDANUP MINERAL SANDS PROJECT

CONSULTATIVE ENVIRONMENTAL REVIEW

SEPTEMBER 1991

ISK MINERALS PTY LTD
A.C.N. 008 268 826

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Prepared by ISK Minerals Pty Ltd and John Consulting Services

SUBMISSIONS ON THE PROPOSAL

Invitation

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

The Consultative Environmental Review (CER) has been prepared in accordance with the Government of Western Australia (Government) procedures. The report will be available for comment until 28 October 1991.

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

Following receipt of comments from Government agenices and the public, the EPA will discuss these comments with 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 helpful if you indicate any suggestions you may have to 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 can 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; 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 different sections of the CER keep them distinct and separate, so 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 correct.

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 THE DATE.

THE CLOSING DATE FOR SUBMISSIONS IS 28 OCTOBER 1991.

SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Ms Jane Aberdeen

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SUMMARY

INTRODUCTION

ISK Minerals Pty Ltd, which currently operates a mineral sands mine and concentrating facility at Waroona and a dry separation plant at Picton, near Bunbury, Western Australia, proposes to expand its operations through the development of a new mining operation at Dardanup, approximately 15 km east of Bunbury. The Dardanup mine would progressively replace the Waroona mine, and heavy mineral concentrate (HMC) fed to the Picton plant would ultimately be increased from the current level of 120,000 tonnes p.a. (tpa) to 200,000 tpa. The expected life of the Dardanup operation is at least 10 years.

MINING OPERATIONS

Mining at Dardanup will be effected by either sluice mining or dry mining of approximately 40 hectares p.a. For both options, a proportion of thickened clay tailings will be directly replaced in mined-out areas after mixing with dewatered sand tails and overburden; the remainder of the clay tailings will be solar-dried in conventional drying ponds before being returned to the pit as backfill.

Areas disturbed by mining and ancillary activities will be rehabilitated with the aim of returning agricultural productivity to levels at least equal to those which currently exist. Native vegetation, particularly deep-rooted species, will be included in the rehabilitation strategy to both replace existing native vegetation and to contribute to the management of high saline water tables in the area.

HMC TRANSPORT

HMC from Dardanup will be transported to the Picton plant via an extension of the existing Dowdell's Line to the South West Highway. The new road will be constructed within an existing reserve, but will not be continuous with the existing Dowdell's Line; concentrate will be loaded onto trucks at a point on private land just north of the existing northern end of Dowdell's Line. This road transport route is designed to minimise disturbance to the local community.

Four other road transport route options were examined, as were two conceptual options for slurry pipeline transport. These other options have been shown to be socially undesirable, economically unattractive or practically unfavourable.

POWER SUPPLY

Power supply to the Dardanup mine will be provided by extension and upgrading of an existing 22kV agricultural supply line which terminates approximately 3 km to the west of the proposed initial site of the concentrator. Two route options for the extension are being evaluated in consultation with the State Energy Commission and landowners potentially affected by the extension.

DRY SEPARATION

HMC from Dardanup will be treated at the existing Picton plant. Existing facilities will be expanded to accommodate the increased throughput of HMC.

ENVIRONMENTAL EVALUATION

The main environmental issues concerning the Dardanup Project are the route and method for transport of heavy mineral concentrate and the impacts of project operations on ground and surface waters in the region.

HMC Transport

The concentrate transport options included one of using a slurry pipeline to convey HMC to Picton. On both pragmatic and economic grounds, this option has been found to be decidedly unattractive.

Five road transport route options have been evaluated, and it is believed that the one proposed (extension of the existing Dowdell's Line to South West Highway) offers a realistic balance between operational requirements and social and environmental considerations.

Surface And Groundwater Management

The water question is of special importance because of the medium to long-term threat to agriculture posed by rising saline water tables in the region, particularly in areas to the west of the proposed Dardanup mine. Additionally, much of the farmland to the immediate west of the mine area provides high quality summer grazing, based on near-surface water supplies which flow from east to west in the upper (superficial) formations of the coastal plain.

Water for mining operations will be provided from mine-pit dewatering in advance of earthmoving activities, supplemented as necessary by pumping from deep bores (into the Yarragadee formation, which is essentially unconnected with the superficial formations). ISK Minerals has commissioned a detailed investigation of water supply and management for the Dardanup operation, including modelling of the effects of mine dewatering on surrounding farmland. These investigations indicate that shallow bores and other water supplies within 500 metres of the mine-pit could be affected by mine dewatering, and ISK Minerals has undertaken to consult with landowners, the Department of Agriculture and the Water Authority to pre-emptively manage these potential negative impacts.

The water studies have also evidenced a need to ensure that the backfilled mine has the capacity to transmit water from east to west at rates comparable with those which currently exist. ISK Minerals has identified at least two strategies to achieve this aim, and thereby avoid elevated water tables to the east of the mine and lowered water tables to the west; again, consultation with landowners and government instrumentalities will be used to develop optimum strategies.

Ephemeral streams crossing the mine area will at times be diverted as part of mine dewatering operations. This could reduce the agricultural productivity of areas downstream, but these areas are comparatively small and water needs can easily be met by compensatory releases from good quality mine water storage.

Water storage is estimated to require an area of 2-5 hectares to the east of the orebody. Ponds used to solar-dry the clay tailings not returned directly to the mine-pit in backfilling operations will occupy an estimated 125 hectares, again to the east of the orebody; this area would be reduced if ongoing testwork shows that more than one-third of clay tailings can be replaced directly as backfill.

Water management studies show a near-balance of requirements and supplies from dewatering and process recycling, at least on an annual basis. On a seasonal basis, a winter excess is indicated, although the amounts involved are relatively small. It is expected that good chemical and physical quality will allow excess water to be managed by diversion to the irrigation channel which runs through the mine area and ultimately reports to the Ferguson River.

PUBLIC CONSULTATION

In the development of the Dardanup Mineral Sands Project to date, ISK Minerals has promoted and actively participated in public consultation on the project, both directly and through a number of government instrumentalities. ISK Minerals has attended two meetings of local residents to answer questions and seek suggestions from the community. An Open Day was held in June 1991, with another scheduled for late September or early October, following public release of this document.

ISK Minerals intends to maintain the consultation it has established with the community and relevant government instrumentalities to date, and to extend that consultation through the construction and operational phases of the project.

1.0 *INTRODUCTION*

1.1 *Background*

ISK Minerals Pty Ltd (ISK Minerals) currently operates a mineral sands mining and concentrating plant at Waroona, about 120 kilometres (km) south of Perth. Heavy mineral concentrate from the Waroona plant (approximately 120,000 tonnes p.a.) is transported by road to ISK Minerals' dry separation plant at Picton, near Bunbury. With these facilities, ISK Minerals currently produces some 100,000 tonnes of ilmenite, 6,000 tonnes of zircon and 1,200 tonnes of leucoxene per annum. This project was assessed by the EPA in 1988 at the level of Notice of Intent, and was implemented in 1989.

Approximately half of the ilmenite produced at Picton is currently sold to a synthetic rutile producer in Western Australia, the other half being exported through the Port of Bunbury for further processing in plants owned by ISK Minerals' parent company, Ishihara Sangyo Kaisha, Ltd (ISK). Leucoxene is currently sold within Western Australia and zircon exported through both Bunbury and Fremantle Ports.

In the medium to long term, ISK Minerals plans to expand its activities and add value to its mineral products by establishing production facilities for synthetic rutile and, ultimately, titanium dioxide pigment. To justify the establishment of these "downstream-processing" facilities, it will be necessary in the shorter term to expand ilmenite production facilities to a level capable of supplying feedstock to a synthetic rutile plant of minimum economic size. To that end, ISK Minerals now proposes to develop an additional mining operation in the Dardanup area (which will ultimately replace the short-life Waroona mine), and to increase the throughput of the Picton dry separation plant to 200,000 tonnes of heavy mineral concentrate per annum.

The Dardanup operation is estimated to have a life of at least 10 years.

1.2 *The Proponent*

ISK Minerals Pty Ltd is a wholly owned subsidiary of Ishihara Sangyo Kaisha, Ltd (ISK), an international firm based in Japan. ISK is one of the world's largest producers of titanium dioxide and a major producer of magnetic iron oxide (used in the manufacture of video and audio tapes) and agrochemicals.

In addition to titanium dioxide processing facilities in Singapore and Taiwan, ISK has subsidiary and affiliate companies throughout the world. ISK is involved in mineral and chemical research in Japan, Europe and the USA.

In 1985, ISK took a minority shareholding in Westralian Sands Limited to support the establishment of synthetic rutile facilities in Western Australia.

In 1990, ISK became directly involved in the mineral sands industry in Western Australia through the purchase of Ravensthorpe Mining & Investment Pty Ltd and its wholly-owned subsidiary, Northern Metals & Oil Pty Ltd. This purchase provided ISK with the Waroona and Picton operations described in Section 1.1 above, plus mineral sands resources at Capel and mineral tenements north of Perth.

In January 1991, ISK Minerals acquired the mineral tenements which are the basis of the Dardanup Mineral Sands Project, the subject of this document.

1.3 *Proposal Scope and Timing*

It is planned that the Dardanup mining operations progressively replace the existing Waroona mine as the source of Heavy Mineral Concentrate (HMC) fed to the Picton dry separation plant. Ultimately, the capacity of the Picton plant will be increased from the current level (120,000 tpa) to 200,000 tpa of HMC. The timing of this ultimate expansion is not definite, but the depletion of resources at the high-grade but short-life Waroona mine in mid-1993 will require the lower grade Dardanup mine to be supplying HMC to the Picton plant at levels at least equal to current ones by that time.

To enable this medium-term time-frame to be met, it is desirable that approval under the terms of the Environmental Protection Act be obtained by December 1991. Construction at both Dardanup and Picton would then commence in the first quarter of 1992, with HMC being produced at Dardanup during the fourth quarter of 1992.

The Environmental Protection Authority's August 1991 preliminary schedule for assessment of this proposal indicates that this time-frame is achievable.

1.4 *Benefits of the Project*

The main benefits of the Dardanup Mineral Sands Project relate to economic, employment and agricultural matters.

The project will involve capital expenditure in excess of $40 million - approximately two-thirds of this expenditure will be at the Dardanup mine-site. It is expected that more than 90% of the expenditure will be made in Australia, a significant proportion of it in the greater Bunbury area.

At full production capacity, the Picton plant will produce some $30 million worth of ilmenite, zircon and leucoxene. Almost all of these products will be directly exported or further processed in Western Australia prior to export.

A peak on-site construction workforce of 80 is anticipated. Additional employment would be provided in workshops and other firms supplying materials and services to the construction programme. During the operational phase, 35-40 jobs will be provided at Dardanup and Picton.

At the full production level of the Dardanup mine (200,000 tpa HMC), an estimated $20 million p.a. will be spent on labour, goods and services. More than 90% of this expenditure is expected to be within Western Australia, at least half of it in the greater Bunbury region.

The Dardanup Project may also provide benefits in terms of the long-term agricultural productivity of the farmland which will be mined during the project. As part of backfilling operations during mining, sand and clay tailings from the concentrator at Dardanup will be blended, potentially removing some of the agronomic disadvantages of the existing areas of either sandy or clayey soils. Increased agricultural productivity after mineral sand mining has already been demonstrated at Capel and other locations in the South West.

On a broader scale, mining at Dardanup could assist to a limited extent in alleviating some of the hydrological problems confronting farmers in the region between the Burekup foothills and Picton. Rising water tables, with increasing salinities, especially in the west of the region, could pose long-term constraints on agricultural production (Mackie Martin & Associates, 1991). Some of these problems may be the result of seepage from the irrigation channel (known as the "South Supply Channel"), part of which is located on the western side of the proposed mining area (see Fig. 1), but the major causes are generally accepted to be irrigation with moderately saline water from Wellington Dam near Collie and reduced evapotranspiration resulting from long-term removal of deep-rooted native vegetation.

Should mining involve the replacement of parts of the irrigation channel, this could significantly reduce seepage in the area involved. Further, the extensive planting of trees as part of the mining and rehabilitation strategy (see Section 2.1.5 below) could reduce groundwater recharge in the Dardanup area.

1.5 *The Approval Process*

Late in 1990, ISK Minerals commenced discussions and negotiations with landowners in the proposed mining area at Dardanup, prior to formally acquiring the tenements. In early 1991, ISK Minerals initiated consultations with the Shire of Dardanup in relation to the development of the Dardanup Mineral Sands Project.

In April 1991, ISK Minerals commenced discussions about the project and its options with the WA Department of Mines, the EPA, other government instrumentalities and community groups.

Following these discussions, and after preliminary evaluation of project options, a Development Proposal was in June 1991 submitted through the Department of Mines, to trigger environmental assessment of the project under the terms of the Environmental Protection Act 1986.

The EPA advised, also in June 1991, that a level of assessment of Consultative Environmental Review (CER) had been set for consideration of potential environmental impacts of the project. No appeal against this decision (advertised in newspapers in Perth and Bunbury) was received by the closing date for appeals of 12 July 1991, and Guidelines for preparation of the CER were received from the EPA on 25 July 1991. (A copy of the Guidelines forms Appendix 1 of this document.)

In accordance with procedures established by the EPA, this CER is being made available to organisations (including government) and parties with a direct interest in, or likely impact from, the project. EPA procedures for CERs do not generally involve advertising in the EPA's weekly newspaper advertisement that a CER is publicly available, but sometimes do require a proponent to advertise this availability in local newspapers. ISK Minerals has lodged such advertisements in newspapers in the Bunbury region, and will make copies of this document available to landowners and community groups in the region, as well as local government authorities.

Following the Open Day held at the Dardanup Shire Hall in June 1991 (see Section 5.1), a second such forum is planned for late September or early October 1991.

Feedback from the publication of this CER may result in a series of questions which the EPA will present to ISK Minerals. ISK Minerals' responses to these questions will then enable the EPA to prepare a Report to the Minister for the Environment. Assuming approval of the project, Ministerial Conditions for its implementation will then be advised by the Minister. Subject to obtaining licences and permits from relevant decision-making authorities (e.g. the Department of Mines, the Water Authority of Western Australia), ISK Minerals would subsequently implement and operate the project.

2.0 *THE PROPOSAL, INCLUDING ALTERNATIVES*

2.1 *MINING OPERATIONS*

2.1.1 *Introduction*

The orebody proposed for mining as part of this project is located between Burekup and Dardanup, on the lower foothills of the Darling Scarp east of Bunbury (Fig. 1). The existing environment in this agricultural area is described in Section 3.

The Principal Mineralised Area (PMA) lies within a larger area of mining tenements held by ISK Minerals. The full mineral potential within these tenements has yet to be determined, and is the subject of on-going exploration; it is possible that orebodies outside the PMA could be identified.

Two options have been evaluated for mining within the PMA - dry mining and sluicing. In both cases, mine dewatering will be required prior to ore extraction, as unconfined and semi-confined aquifers are well developed in the region, and free water lies on the surface in some areas during winter. It is planned that mining operations will commence in the centre of the orebody, as shown in Fig. 1.

Overburden, almost absent at the northern end of the orebody but up to 8 metres deep towards the south, will be removed at rates of 2-2.5 million tpa at full capacity (200,000 tpa HMC production). The ore is generally 5-7 metres thick and contains, on average, 6% heavy minerals: up to 3.5 million tonnes of ore will be mined annually at full project capacity, from an area of approximately 40 hectares.

Ten farming properties are potentially affected directly by mining operations, while another 10-12 properties lie within half a km of the PMA. Some properties within the PMA will be purchased by ISK Minerals . These properties will from time to time be used as alternatives for farming operations by farmers displaced by mining operations from land not purchased by ISK Minerals.

2.1.2 *Mine Dewatering*

It is proposed that dewatering of the orebody ahead of the mining operation will be achieved by the use of drains and sumps; if necessary, bores will be developed to supplement the dewatering programme. Studies by Gutteridge, Haskins and Davey (1991) have indicated that water extraction rates of up to 1700 cubic metres per day (m3/d) will be required to dewater the mine profile; pit dewatering has the capacity to significantly affect groundwater levels up to 500 metres away.

Water from dewatering operations will be pumped to storage (earth dams or holding tanks) for use in the concentration process. The implications of this dewatering, especially in relation to farm water supplies, is discussed in Section 4.3.2.

2.1.3 *Dry Mining*

Topsoil would be removed with scrapers and used in rehabilitation, fresh material being replaced directly where practicable - alternatively, topsoil would be stockpiled for subsequent use in rehabilitation. Ore and overburden would be extracted with hydraulic excavators and/or face shovels, less commonly with front-end loaders and bulldozers. Material would be conveyed from the pits using mobile conveyors (see Fig. 2). The maximum area open for mining at any one time is estimated at 20 hectares.

Ore from the pit would be conveyed over distances up to 1000 metres to the semi-mobile concentrator, which would be relocated every 2-4 years. Between the pit and the concentrator, ore would be passed through a drum scrubber and a trommel to remove oversize material (+50mm and +2mm, respectively). Overburden would be conveyed to areas being backfilled and blended with sand and clay tailings as described in Section 2.3.

2.1.4 *Sluice Mining*

Topsoil and overburden management in a sluice mining operation would be identical with that described above for dry mining (Section 2.1.3). The area open at any one time would similarly be of the order of 20 hectares.

High pressure water guns, which would be relocated, on average, once a day, would flush ore from the working face into shallow collecting drains. These drains, surveyed in at grade, would simply be excavated trenches, terminating in a sump. A gravel pump in the sump would collect the ore slurry and pass it through a trommel (see Fig. 3) to remove oversize material (+2 mm); HMC would then be separated in the semi-mobile concentrator whose relocation was described in Section 2.1.3 above.

The sump collecting the ore slurry in the sluice mining operation would be relocated, on average, every ten days.

Water for the sluicing operation would be obtained from the dewatering operations in advance of mining (see Section 2.1.2), supplemented by a deep bore as necessary (see Section 2.7).

2.1.5 *Rehabilitation*

The primary rehabilitation strategy for the Dardanup mine will be to restore the agricultural productivity of mined land to at least its current level. Trees and other native vegetation will be included in rehabilitation prescriptions, both to replace existing vegetation and to take advantage of the opportunity created by the mining operation to increase the amount of deep-rooted vegetation in the landscape. Without sacrificing agricultural production potential, it is considered that the addition of such vegetation to the post-mining landscape could be beneficial both to the adjacent farming properties and to those agricultural areas to the west, where rising saline water tables are a medium-to long-term threat to the viability of productive agriculture (see Mackie Martin & Associates, 1991).

Dewatered sand tails from the concentrator and thickened clay tailings will be mixed with overburden and replaced in the mined-out pit (see Section 2.3 below). Dried clay tailings from solar drying dams will be mixed into this backfill or spread over backfilled areas and mixed in using conventional agricultural tillage implements.

Topsoil will then be spread from salvage stockpiles or placed directly from areas being opened up for mining, and pasture seed sown and the areas fertilized using recommended agricultural rates and techniques. Developing pastures will be maintained as necessary until agricultural productivity is established and stable.

After rehabilitation, it is ISK Minerals' intention that farmland purchased for mining be sold off - ISK Minerals has no wish to own farming properties for longer than is necessary to complete mining and rehabilitation operations. Land which is not purchased by ISK Minerals, but on which compensation is paid to the landowners, will be handed back to the landowners as quickly as is practicable.

Hydrological studies carried out for this project show that, as part of the groundwater regime which involves water in the superficial formations (10-20 metres (m) below natural surface) flowing from east to west, there exist some regions of high horizontal permeability (see Section 3.4.2). Backfilling of mine pits with a relatively uniform mix of sand tails, clay tailings and overburden could significantly reduce the permeability of the replaced profile, with consequent rises in water tables to the east of the mine. It is therefore planned that restoration operations include mechanisms to permit re-establishment of an acceptable hydrogeological regime - selective placement of permeable materials, installation of underground drains and other options are available. The methods ultimately used to restore hydrological balance will be decided in light of hydrogeological studies, drilling information, mining experience and consultation with landowners, the Department of Agriculture and the Water Authority.

Should mining operations result in any roads being affected by mining operations, ISK Minerals will consult with the Shire of Dardanup, other government instrumentalities and local landowners to develop and implement appropriate rehabilitation programmes. Should new road easements be established, similar consultation will be undertaken to facilitate establishment of roadside vegetation.

2.2 *HEAVY MINERAL CONCENTRATION*

Ore extracted by either dry or sluice mining will be subjected to standard techniques for wet separation at the Dardanup minesite to produce Heavy Mineral Concentrate (HMC). Hydrocyclones will be used to remove clay, and a series of spirals will allow the separation of high specific gravity HMC from sand tailings - a diagramatic representation of the process is shown in Fig. 4. Thickened clay tailings will be directed either to mine-pits being backfilled or to solar-drying ponds (Fig. 4, see also Section 2.3 and Figs 2 and 3).

Water will be recovered from the thickener, product cyclones, tailings cyclones, the belt filter (see below) and clay tailings ponds.

Sand tailings will be dewatered on a belt filter and mixed with clay tailings, overburden and sand tailings transported back from the Picton Dry Separation Plant. This mixture will be used as backfill, as described in Section 2.3.

2.3 *CLAY TAILINGS MANAGEMENT*

Traditionally, mineral sands operations in Western Australia have dealt with clay tailings ("slimes") from the heavy mineral concentration process by depositing thickened material in shallow (less than 2 m deep) drying ponds, re-winning solar-dried material and blending it with sand tails and overburden as part of backfilling and rehabilitation programmes. This approach is also feasible for the Dardanup Project, although the high clay content of the ore (27% by weight) would demand relatively large areas for drying ponds.

To both optimise operational efficiency and minimise areal impact, ISK Minerals plans to treat only about half of the amount of clay tailings by conventional solar drying techniques. The other half will be taken directly from the thickener (see Fig. 4) and mixed with sand tailings and overburden before being placed as backfill in the mined-out pit (see Section 2.1.5).

From the thickener, clay tailings will be mixed with sand tailings which have been dewatered on a belt filter (see Section 2.1.5 and Figs 2, 3). On an ongoing basis, it is intended that the maximum practicable amount of clay tailings will be managed in this way, with the conventional solar-drying ponds essentially being used as surge storage capacity. Testwork carried out by ISK Minerals has shown that certainly one-third, and probably at least one-half, of the total clay tailings produced can be managed by blending with sand tails and overburden to produce stable backfill material; testwork is continuing to determine the maximum amount of clay tailings that can be treated in this way.

It is estimated that approximately 120 hectares of "conventional" drying ponds will be required for the management of clay tailings which cannot immediately be combined with sand tailings and overburden for direct return to mined-out pits. These ponds will be located on farmland which ISK Minerals has purchased or intends to purchase for project development. Supernatant water from settled clay tailings and storm water in the ponds will be collected through adjustable weirs and returned to process.

Dried clay tailings from drying ponds will be re-won, transported to backfilled pits and mixed with backfill material (see Section 2.1.5).

In locating these ponds, consideration will be given to local and regional hydrogeological conditions. As necessary, ISK Minerals will consult with the Department of Agriculture and the Water Authority, as well as with its own hydrogeological consultants, when planning pond locations and construction.

2.4 *CONCENTRATE TRANSPORT*

2.4.1 *Introduction*

Two options have been evaluated for transport of HMC from the Dardanup minesite to the Picton Dry Separation plant: road transport and a slurry pipeline. A number of alternative routes have been examined for road transport, and two conceptual approaches to the slurry pipeline option have been assessed: using existing road corridors or establishing an overland corridor.

The possibility of using rail to transport HMC from Dardanup to Picton has also been evaluated. However, the economic costs of such an approach make its feasibility most unlikely - costs for sidings, handling equipment, rail wagons and freight make a rail option very much more expensive than either road transport or a slurry pipeline.

2.4.2 *Road Transport*

In response to a request from ISK Minerals, the Shire of Dardanup identified four possible routes for the road transport of HMC. These alternatives are shown in Fig. 1, and are summarised as follows:

(1) Harris Road;

(2) Dowdell's Line, extended from its existing alignment along a gazetted easement north from Edwards Road to South West Highway and thence to Picton;

(3) Harris Road to Waterloo-Dardanup Road to South West Highway and Picton; and

(4) Dowdell's Line (South) to St Helena Road to Waterloo-Dardanup Road to South West Highway and Picton.

A fifth alternative has also been identified from the northern end of the orebody via Offer and Henty Brook Roads to South West Highway and Picton.

Route distances range from 8.7 km for Harris Road (Alternative (1) above) to 18.9 km for the Offer/Henty Road alternative.

All routes would require significant capital expenditure in order to accommodate 40-tonne truck-loadings. Costs of the Alternatives (1) to (4) above have been estimated by a professional engineer at up to $1 million. Allowance was made for land resumption to remove dangerous bends in Harris Road; design conditions were a 7-metre wide two-coat hot seal pavement with 1.5-metre wide compacted gravel shoulders and a 90 kph speed limit. The fifth Alternative (Offer/Henty Roads) has not been costed in detail, but would entail costs similar to those described above.

In evaluating road transport route alternatives, considerable attention was paid to impacts on local residents. In particular, the potential for adverse effects of vehicle noise and for disruption of regular stock movements across and along roads were considered. Direct environmental impacts (e.g. disturbance or destruction of remnant vegetation) were also considered.

On this basis, ISK Minerals proposes the Dowdell's Line route (alternative 2) as the most appropriate for road transport of HMC from the Dardanup mine to Picton. This option would involve new road construction north of Edwards Road (see Fig. 1), in an existing road reserve which already contains a large drain and a rough track for a considerable part of its length. No residences are located within 500 metres of the proposed extension of Dowdell's Line.

The Harris Road option (Alternative 1), while having the lowest costs, both capital and operating, has the greatest potential for disruption of local residents. Some 11 houses are located close to Harris Road, which is also a school bus route and is regularly used for the driving of stock between paddocks. Additionally, the roadside vegetation, while relatively restricted in diversity and richness because of the narrowness of the road reserve (which contains an irrigation drain and a power line in addition to the road formation) does contain many Red Gum *(Eucalyptus calophylla)* trees which are of significant aesthetic value, especially to local residents. Thickets of *Melaleuca preissiana* and *M. rhaphiophylla* also provide valuable habitats and corridors for movement for avifauna.

A meeting held by local residents on 24 August 1991 overwhelmingly opposed the Harris Road route option, and in fact passed a motion recommending the Dowdell's Line route for HMC transport, should the project be approved.

Alternative route 3, via Harris and Waterloo-Dardanup Roads to South West Highway, would involve transport past 12 houses, and would again affect the eastern part of Harris Road - significant remnant roadside vegetation would be removed by necessary widening of this and Waterloo-Dardanup Roads.

While alternative route 4, via Dowdell's Line (South), St Helena Road and Waterloo-Dardanup Road to South West Highway, would avoid Harris Road, it offers no significant advantage over alternative 3. Seven residences lie close to this route, and significant remnant vegetation would be removed by widening of both Dowdell's Line and St Helena and Waterloo-Dardanup Roads.

The fifth alternative, via Offer and Henty Brook Roads to South West Highway, is by far the longest route. Moreover, it would bring truck traffic close to the Burekup township, with consequent risks of unacceptable noise levels from decelerating and accelerating vehicles.

Main Roads Department data show between 4700 and 5000 Average Daily Traffic (ADT) counts along South West Highway (1989 and 1990 data); 14-20% of this traffic was identified as "heavy". For the purposes of impact assessment, ISK Minerals has adopted a transport scenario of a 5-day per week operation, 24 hours a day, using 40 tonne truck-loadings; this would result in one truck movement (in one direction or the other) every 20 minutes, or 72 per day. Without allowing for the fact that this figure is based on only 5 operating days a week, HMC road transport via Dowdell's Line could increase total traffic on South West Highway by about 1.5%, and "heavy" traffic by 7.5-10.6%. However, the increase due to Dardanup-sourced HMC transport traffic will be offset by the decline of Waroona-sourced traffic, thereby reducing the overall impact of HMC transport by ISK Minerals.

In response to local concerns that construction of a road on the Dowdell's Line reserve north of Edwards Road could increase heavy traffic through the area, ISK Minerals proposes to keep the old and new sections of Dowdell's Line separate. One method of achieving this result would be to pump HMC as a slurry from the concentrator across ISK Minerals-owned land to a site north of Edwards Road, where it would be loaded onto trucks for transport to Picton using a new section of Dowdell's Line which would not be physically connected to the existing section. This and other options are being evaluated.

2.4.3 *Slurry Pipeline*

As an alternative to road transport, a long-distance slurry pipeline offers a conceptually attractive means of moving HMC from the Dardanup mine to the Picton dry separation plant.

However, financial considerations restrict the options for routing and locating the pipeline. The 8-9 km distance from Dardanup to Picton has been shown by engineering and economic studies for a 50t/hour pipeline to be at the economic limit of this means of transport, primarily because of the relatively high cost of energy required to pump the slurry and the cost of pump stations, which would be required at intervals of approximately 2.4 km. At the now-anticipated capacity of 27 tonner per hour (t/h), the pipeline option is even less attractive on economic grounds. Moreover, burying the pipeline increases costs of both installation and maintenance, making it even less competitive with road transport.

Thus, only direct routes from Dardanup to Picton have been evaluated here. The two route options are along the Harris Road reserve and on private land, either adjacent to Harris Road or directly overland.

Using the Harris Road reserve would require substantial clearing of remnant roadside vegetation, the value of which has been discussed in Section 2.4.2. Moreover, frequent crossovers for roads, driveways and other entries off Harris Road would require significant lengths of the pipeline to be buried, increasing capital and maintenance costs and elevating the risk of "sanding" of the pipeline (i.e. settling out of HMC) in low sections.

The private land option for a pipeline is considered untenable because of the complexities of land ownership and the requirement for the pipeline to be buried to ensure physical security. With possibly more than 15 landowners along a pipeline route between Dardanup and Picton, it would require only a few to resist the proposal for it to become impracticable - diverting around individual properties would quickly make the pipeline an uneconomic proposition, since increased length, as discussed above, very quickly diminishes the commercial feasibility on grounds of both capital (pump stations) and energy (pumping) expenses. As noted above, burying the pipeline in its own right makes marginal the economic feasibility of the slurry pipeline proposal.

On the basis of the above evaluation, it has been decided that the slurry pipeline alternative for HMC transport is not feasible.

2.5 *DRY SEPARATION*

With the full development of the Dardanup mine, which will replace ISK Minerals' Waroona mine as a source of HMC by mid-1993, the capacity of the Picton dry separation plant will be progressively increased from its current feed level of 120,000 tpa HMC to 200,000 tpa.

Existing facilities at Picton will be upgraded as necessary to accommodate the increased production levels. Equipment will largely be identical to that currently in place; while some new equipment may be somewhat different from existing installations, the principles of operation will be the same.

A schematic of the dry separation process is shown in Fig. 5. Separation is based on the different magnetic susceptibilities, electrical conductivities and specific gravities of the HMC components, using standard industry techniques.

An estimated 18,000 tpa of sand residues from the dry separation process will be progressively transported back to the minesite, together with the small quantity of clays produced; these residues will be included in the mine-pit backfill described in Section 2.1.5.

The Picton plant's water requirement of up to 40 cubic metres per day (at full capacity) will continue to be sourced from an on-site bore.

As is the case for HMC currently being produced at ISK Minerals' Waroona mine, HMC from Dardanup does not contain sufficient monazite to warrant its separation in the Picton plant. Testwork has shown the monazite content of Dardanup ore to be of the same order as that of Waroona ore (less than 0.03%), so that the Picton plant is expected to continue to have no radiation-related "controlled" work areas.

2.6 *PRODUCT SHIPMENT*

Ilmenite not transported to Western Australian customers would be trucked to Bunbury Harbour for bulk export. (Approximately half of the Picton plant's current production is exported.) Should ISK Minerals establish synthetic rutile production facilities in Western Australia in the future, ilmenite would be transported to those facilities.

Leucoxene and zircon may be both exported and sold locally; zircon is currently transported in "bulka bags" (woven polypropylene) and in bulk, and leucoxene in bulk.

2.7 *WATER SUPPLY AND MANAGEMENT*

2.7.1 *Dardanup Operations*

Water supply for mining and concentrating operations at Dardanup will be provided from dewatering operations, supplemented as necessary from a deep bore into the Yarragadee Formation (see Section 3.4.2 for hydrogeological discussion). Water will be stored in a surface storage dam (or several smaller dams) with a capacity of some 125million litres (ML) (approximately one month's gross water requirement); for a water depth of 6 metres, an area of 2.5 hectares would be required for this Process Water Pond (PWP).

Inputs to the PWP would come from:

(i) mine dewatering operations;

(ii) supplementary deep bore (Yarragadee) pumping (as required for make-up);

(iii) storm and decant waters from the Clay Tailings Ponds;

(iv) recycled process water; and

(v) direct rainfall on the PWP, and stormwater runoff from around the plant-site.

Offtakes from the PWP would be for:

(i) process water (hydrocyclones and concentrator feed);

(ii) dust suppression (roads and other potential sources of fugitive dust);

(iii) plant domestic consumption - potable supplies, sewerage, garden maintenance, wash-down and plant hose-down; and, as necessary

(iv) sluice mining.

The annual water balance for the Dardanup operations is shown in Fig. 6. With mine dewatering providing up to 620 ML per annum (depending on area of the orebody being worked), the water cycle for the operation is close to balance on an annual basis. However, the seasonal distribution of rainfall will likely result in a small deficiency in summer and an excess in winter (maximally 300 ML). To dispose of excess water, a number of options have been evaluated; the water would be of good quality (less than a 1000 mg/l TDS, see Section 3.4.2) and thus suitable for discharge in a number of ways, as discussed in Section 4.3.2.

The PWP will be located to the east of the orebody, and in fact may be developed by constructing smaller dams on two of the ephemeral watercourses in the north-east of the project area, on land owned by ISK Minerals (Fig. 1).

2.7.2 *Picton Operations*

The small quantity of water used at Picton (up to 40 m^3 per day at full capacity) will continue to be drawn from an on-site bore licensed as appropriate by the Water Authority.

2.8 *INFRASTRUCTURE*

2.8.1 *Power Supply*

An existing 22 kV agricultural electricity supply line currently takes power to within 1 km of the PMA, approximately 3 km west of the planned initial location of the HMC concentrator (see Fig. 1). Other alternatives for supplying electric power to the project (peak demand 8 MW) include the 132 kV Bunbury-Muja transmission line which crosses the southern end of the PMA, and a disused 66 kV line located just to the south of the South West Highway - the costs involved in energy supply via these routes would be several times that required to upgrade and extend the 22 kV agricultural supply line.

The existing agricultural supply line will need to be upgraded by at least the installation of new conductors (wires), since the existing conductors, having been designed for relatively low-draw agricultural off-takes, would not allow efficient transmission of the high-draw demands of the mining and concentrating operations.

Two alternative routes are being examined to extend the existing line to the mine-site. One is to extend the line directly to the east from its current terminus; the other is to construct a supplementary section to the east along St Helena Road from the junction of St Helena and Wireless Roads - both of these options are shown in Fig. 1. Consultations are being held with SECWA and relevant landowners to determine the most appropriate option - convenience to landowners and cost are the prime considerations.

The supplementary line option would be least expensive, since the transformers currently used to step down voltages to the six agricultural users to the east of Wireless Road could then continue to be used. The option of extending the line from the existing terminus, because it would involve larger conductors and total current, would require replacement of these transformers.

2.8.2 *Labour*

At full production capacity (200,000 tpa of HMC), the mining and concentrating facilities at Dardanup will provide employment for an estimated 20 people. If dry mining is used, the mining contractor would employ as many as 20 additional people. For sluice mining, contracting would again be involved, with 15 jobs provided. Additional indirect employment would be generated through contract maintenance.

The expanded operations at the Picton dry separation plant will employ an additional 8 people at full capacity.

Given the reservoir of semi-skilled and skilled people in the region as a result of mining and mineral processing developments established in the past, and in light of current high levels of unemployment, it is believed that the positions created by the Dardanup Mineral Sands Project will be easily filled from the Bunbury region. Indeed, ISK Minerals has already received employment enquiries from residents in the Burekup, Dardanup and Waterloo areas. The nature of much of the work, especially at the mine-site, means that practically-orientated people from farming backgrounds are ideally suited and quickly trained to become safe and efficient operators.

2.8.3 *Construction*

Because of the proximity to Bunbury, no construction camp facilities would be required for the peak on-site workforce of 80 estimated to be required for construction activities at Dardanup and Picton. Additional employment would be provided at off-site workshops and other suppliers' premises.

Construction is scheduled to take place in the second, third and fourth quarters of 1992. Access to the Dardanup minesite will depend on the residential locations of the construction workforce, but Harris Road is expected to carry the majority of the workforce traffic. Heavy traffic is likely to access the minesite via Harris Road and via Waterloo-Dardanup and Martin Pelusey Roads; unless the proposed new northern section of Dowdell's Line is made continuous with the existing roadway (see Section 2.4.3), this route will not be available for access to the mine.

Access to the Picton site will be via the currently-used route: South Western Highway and Harris Road.

2.8.4 *Operating Supplies*

Operating supplies for the Dardanup mine will be delivered by road. Depending on the geographic source of the supplies, different routes will be used: deliveries from Bunbury and from the Perth area will predominate, with all roads mentioned in Section 2.8.3 above likely to be used to varying extents.

The nature of the Dardanup operation is such that, other than for fuel delivery (in the event of dry mining being used), traffic will be of low volume (less than 10 per week) and will generally involve small loads and thus comparatively light commercial vehicles.

Operating supplies to the Picton plant will continue to be delivered via South West Highway and Harris Road. The estimated increase in numbers of deliveries from 10 per week to 15 per week is not considered to be significant in terms of overall road traffic.

3.0 *EXISTING ENVIRONMENT*

3.1 *PHYSIOGRAPHY AND LAND USE*

3.1.1 *Physiography*

The project area is located on the Pinjarra Plain, part of the Swan Coastal Plain. The Pinjarra Plain is an alluvial feature, bounded on the east and south-east by the Darling and Whicher Scarps, and on the west by the Bassendean Dune System.

No area proposed for project activities is classified as having conservation values warranting preservation via the conservation-through-reserves mechanism which operates in Western Australia.

The Collie River lies to the north of the project area, the Ferguson River to the south (see Fig. 1). Numerous swamps originally formed a sluggish drainage system for the area between these streams, but drainage ditches have been constructed as part of the agricultural development of the area, to enhance surface water removal during the wet winters. Drainage is into the Leschenault Inlet, with some small ephemeral streams also connected into the man-made drainage system.

3.1.2 *Land Use*

The project area is almost wholly cleared, privately-owned agricultural land. Some native vegetation has been retained as shelter for stock, and roadside vegetation is reasonably well preserved in some areas.

The Muja-Bunbury 132 kV power transmission line crosses the southern end of the PMA (Fig. 1), and a number of minor roads are established throughout the area. An irrigation channel (known as the "South Supply Channel") lies on the western side of the PMA.

The surface soils tend to be sandy to the east and clayey to the west, producing the problems of having intractable clays in some areas in winter and fast-drying sands in other areas in summer. Dairying is the predominant land use, with some beef cattle and sheep grazing.

3.2 *GEOLOGY*

Numerous heavy mineral sand deposits have been discovered throughout the Swan Coastal Plain in the South West of Western Australia. Apart from concentrations along the beaches and dunes of the present coastline, the majority of these deposits occur in strandlines developed on ancient shorelines within the plain.

Heavy mineral sand deposits in the Dardanup-Burekup region (including the Dardanup Project) originated from the erosion of Precambrian metamorphic and igneous rocks from the Yilgarn and Leeuwin Blocks. As these rocks eroded they released, in addition to quartz and feldspars, the heavy minerals ilmenite, zircon, rutile, monazite, garnet, tourmaline, kyanite and others. These heavy minerals, mixed with other sediments, have been transported by rivers to the Swan Coastal Plain. Over the past 200 million years, several rises and falls in the sea level have resulted in these sediments being reworked in a marine environment. The main process for concentrating the heavy mineral was the winnowing away of the lighter minerals by the sea. A combination of wave action, longshore currents and wind moved the lighter materials along the coast, resulting in a concentration of heavy minerals along the beaches and dune systems.

Once deposited, these strandlines were preserved by subsequent falls in the sea level. This accounts for the presence of heavy mineral deposits between the present sea level and elevations of around 90 metres.

The Dardanup heavy mineral sand resource is a low grade deposit and covers an area approximately 5 km in length and 0.5-1.5 kilometres in width (see Fig. 1). Mineralization is confined to a medium to light grey, fine to medium grained clayey sand layer which averages approximately 5.5 metres in thickness. The mineralized zone is at the surface in the northern part of the resource but may be covered by as much as 9 metres of alluvial overburden in some areas to the south.

Located within the broad zone of mineralization are several continuous and discontinuous north-easterly trending strandlines.

3.3 *CLIMATE AND WEATHER*

The Dardanup Mineral Sands Project area has a typical Mediterranean climate of mild wet winters and hot dry summers.

Meteorological data for Bunbury is considered to be a reasonable representation for both the Dardanup and Picton sites. Bunbury has an annual rainfall of 855 mm and an annual evaporation of 1600 mm; monthly rainfall exceeds evaporation from May to September inclusive.

Strong winds, particularly from the SE-SW sector, are common in the drier part of the year; dust management in mining operations therefore requires attention during this period.

3.4 *WATER RESOURCES*

3.4.1 *Surface Waters*

As shown in Fig. 1, the permanent streams in the general area of the project are the Collie River to the north and the Ferguson River to the south. The foothills of the Darling Scarp, particularly the region immediately east of the PMA, contain many ephemeral streams. The flatter coastal plain originally contained sluggishly-draining swamps, but many of these have been drained since European settlement. The region ultimately drains into Leschenault Inlet.

Both the Collie and Ferguson Rivers are reported to be moderately affected by agricultural and other human activities, with nutrient levels significantly greater than would be representative of a pristine stream.

Because of high water tables in the area, particularly during the winter period, a number of drains have been developed over the years to remove excess water. These drains ultimately report to the Collie and Ferguson Rivers.

3.4.2 *Groundwater*

The groundwater regime of the Dardanup Project area is well understood because of the State's interest in the regional hydrology - water for industry and potable water for domestic consumption in the Bunbury region is sourced from groundwaters. The Geological Survey of Western Australia has conducted a number of groundwater investigations in the area, with one of a line of investigation bores (the Picton Line; see Commander 1982) actually being located within the PMA of the Dardanup Project. More recently, Mackie Martin & Associates Pty Ltd reported on groundwater investigations for an irrigation strategy study in the South West, a report commissioned by the Water Authority of Western Australia (Mackie Martin & Associates, 1991) - part of this report addresses the Dardanup Project area and the irrigation area immediately to the west at Waterloo.

The superficial formations of the area have a maximum depth of 20 metres, as shown diagrammatically in Fig. 7. Groundwater flow in unconfined and semi-confined aquifers is generally westwards, with gradients decreasing with distance to the west.

The Yoganup Formation, which is overlain by the Guildford clays in the superficial formations, itself overlies the Leederville Formation. The Leederville Formation, which in the Waterloo area can be as deep as 250 m below surface, is 50-60 metres deep in the area of the Dardanup Project. The Yarragadee Formation lies beneath the Leederville, and beneath the Yarragadee is the Cockleshell Gully Formation.

Natural recharge of the superficial formations in the Dardanup Project area is through rainfall, with leakage from the irrigation channel providing additional recharge in the west of the PMA. Large downward vertical hydraulic gradients in areas close to the Darling Scarp (such as the project area) recharge the Leederville Formation; these downward gradients decrease to the west and, in the irrigation area at Waterloo, gradients can be slightly upward.

The Leederville Formation is also recharged in the area of the Blackwood Plateau, south of the project area, between the Whicher and Darling Scarps. This area is also the main recharge zone for the Yarragadee Formation.

Reflecting the salinity of the Wellington Dam water used for irrigation in the Waterloo area, salinities in the superficial formations are higher than in comparable hydrological situations on the coastal plain to the north - Total Soluble Salts (TSS) averages of 1000 mg/l are quoted by Mackie Martin & Associates (1991), and values as high as 4000 mg/l are quoted by Commander (1982).

The Leederville Formation at the project area contains water with qualities of 300-1000 mg/l TSS - the lower values occur in the sandy, uppermost part of the formation. On a regional basis, water from the Leederville Formation is used for town water supplies at Australind, Dardanup and Eaton; it is also used for some farm domestic and stock water requirements where superficial groundwater is brackish or saline. Use of water from the Leederville Formation in the region is estimated at less than 1 x 106 m^3 p.a., approximately 10% of the calculated throughflow.

Salinity in the Yarragadee Formation is generally less than 500 mg/l. Current abstraction for potable and industrial uses is estimated at 20 x 10^6 m^3 p.a., approximately one third of estimated throughflow.

The schematic hydrological arrangement in an east-west section across the Waterloo/Dardanup area is shown in Fig. 8, taken from Mackie Martin & Associates (1991). This shows the Yoganup Formation at surface in the Dardanup Project area, overlain by colluvium in some parts; it is this area where maximum groundwater recharge occurs, into both the superficial and Leederville formations.

Within the superficial formation, water moves preferentially through interleaving sandy lenses surrounded by zones of much higher clay content. While vertical hydraulic conductivities are probably comparatively high near the Darling Scarp, where the Yoganup Formation is at or near surface, and considerable recharge to the Leederville formation takes place, horizontal conductivities in the area away from the Scarp (i.e. most of the coastal plain) are considered to be 250-1000 times greater than vertical conductivities (Gutteridge Haskins & Davey, 1991).

3.5 *FLORA AND FAUNA*

A qualitative survey of the vegetation and flora of the project area was undertaken in September 1991 by E M Mattiske & Associates. No attempt was made to reconstruct the original native vegetation, because of both the degreee of disturbance and the small total area of remnant vegetation. An emphasis was placed on searching for rare or restricted plant species and broad definition of plant communities.

Because of the restricted extent of remnant vegetation in the region, it was considered that even qualitative investigations of native fauna would be of little value. All areas of remnant vegetation in the area have been affected by grazing and fire, in addition to being small in area, and thus offer restricted fauna habitats, except perhaps for avifauna.

The road corridors investigated in the vegetationa and flora survey were those along Dowdell's Line (from Guimelli Road north to the South West Highway, including the new section proposed in Section 2.4.1 for use in HMC transport), Edwards Road (as far east as the gravel pit reserve) and Simpson Road. Sections of remnant vegetation on private land at several locations in the south-eastern and north-eastern parts of the PMA were also examined.

Despite the degree of disturbance of the native vegetation of the project area, 104 plant species were recorded. Seventy-five of these were native; 29 were introduced and naturalised. No gazetted rare or restricted species were recorded within the survey area.

The predominant vegetation of the survey area prior to disturbance is considered to have been an open forest of *Eucalyptus calophylla* (Marri, or Red Gum), with *E. marginata* (Jarrah) co-occuring on higher and better-drained sites. The western and north-western parts of the mining region support a mixture of vegetation types, including a woodland of *E. rudis* (Flooded Gum) and *Melaleuca rhaphiophylla* (Swamp Paperbark), and low woodlands and thickets of Swamp Paperbark, of *M. preissiana* (Moonah) and of *Casuarina obesa* (Swamp Sheoak).

3.6 *CULTURAL AND HERITAGE CONSIDERATIONS*

3.6.1 *Historical Matters*

The Dardanup/Burekup area is a long-established farming region, with most properties having been operated by several successive generations of individual families. There are several buildings and structures of historical value and interest in the region, but none is likely to be affected by the operations of the Dardanup Project.

3.6.2 *Archaeology and Ethnography*

McDonald Hales & Associates carried out archaeological and ethnographic investigations in the Dardanup minesite area in August and September of 1991.

Archaeological field studies investigated the area using an extensive sampling technique and examination of particular locations which, from examination of aerial photographs, were considered to be prospective. No archaeological sites were found within the PMA, although three finds of quartz material were located in an eroded section of a drainage line - the finds do not formally constitute "sites" as defined in the Aboriginal Heritage Act, but have been appropriately reported to the Aboriginal Sites Department of the WA Museum.

The Dowdell's Line road reserve north of Edwards Road was traversed on foot over its entire length - no archaeological sites were discovered.

The verges of other roads which might be upgraded in the event of their being used for road transport of HMC were also investigated. However, the level of disturbance to which these areas have already been subjected made detailed evaluation of little value.

A number of Aboriginal informants have been interviewed regarding the mine area, and it would appear that no sites of contemporary ethnographic significance are located within the area likely to be affected by project activities. However, one particularly knowledgeable individual has proven difficult to locate for more than two months, and at the time of writing was believed to be interstate. On his return to Western Australia, his contribution to the understanding of the significance of the mining area will be sought.

4.0 *ENVIRONMENTAL IMPACTS AND MANAGEMENT*

4.1 *LAND USE*

Farming activities will be precluded during the period of mining, although some areas could be returned to agricultural production within four years of initial disturbance. It is ISK Minerals' strategy that agricultural land be returned to agricultural production as quickly as is practicable. Moreover, and as noted in Section 2.1.5, ISK Minerals will sell off land purchased for mining as soon as rehabilitation has stabilised the landscape.

Areas used for clay tailings drying ponds will be excluded from agricultural production for at least the life of the mining operation, unless experience proves that ponds established initially can be decommissioned because greater-than-predicted amounts of clay tailings are able to be directly incorporated with sand tails and overburden in the backfilling operation (see Section 2.3). When decommissioned, these ponds will be removed and topsoil used to re-establish productive soils.

Over the life of the project, it is expected that little if any change in topography will take place across the PMA. Dewatering of sand tails and thickening of clay tailings, and the mixture of these two components with dewatered overburden as part of the backfilling operation, have been calculated to counteract the "bulking" (increased volume and reduction in bulk density) that occurs when natural soil profiles are disturbed.

Should these expectations prove not to be fulfilled, any variation is likely to be minor, and easily accommodated by forming the final landscape in accordance with natural topography of the area. Particular attention would be paid in these circumstances to hydrogeological considerations, both locally and in relation to the Waterloo irrigation area to the west.

Groundwater impacts of mining operations on agricultural activities in areas away from the minesite are discussed in Section 4.3.2. It would appear that the mining and ancillary operations, properly planned and managed, are likely to have no perceptible effect on regional hydrogeology, or on adjacent farmland, in the longer term. Nonetheless, there are risks of significant localised short-term hydrogeological impacts, which ISK Minerals will continue to address in consultation with local landowners, the Department of Agriculture and the Water Authority.

4.2 *TRANSPORT*

4.2.1 *Concentrate Transport*

By implementing its preferred option for transport of HMC from Dardanup to Picton via a new section of Dowdell's Line to be constructed north of Edwards Road, ISK Minerals believes that no significant environmental impacts will be experienced. The vegetation in the road reserve of Dowdell's Line, north of Edwards Road, is already disturbed by a track, and a large irrigation drain exists within the corridor. Moreover, it is unlikely that road construction will necessitate removal of all vegetation from the road reserve; ISK Minerals will ensure preservation of this vegetation to the maximum practicable extent, and will enrich the roadside vegetation after road construction by planting seedlings and distributing seeds of native species.

The Dowdell's Line route is remote from residences, so that noise is not expected to be a source of disturbance. Along the South West Highway to Picton, trucks carrying HMC from Dardanup will add an estimated 1.5% to the total traffic frequency, and of the order of 10% to the "heavy" traffic frequency (see Section 2.4.2); however, the reduction in HMC transport traffic from ISK Minerals' Waroona mine will offset this impact to a large extent.

On the basis that ISK Minerals will construct the northern extension of Dowdell's Line without making it continuous with the existing road, no increase in through-traffic south on Dowdell's Line will be possible - the new Dowdell's Line will effectively be used only for HMC transport and for access to farmland adjoining the road.

Notwithstanding the current desire of some local residents that through traffic south on Dowdell's Line be avoided, the option for future connection of the new and old sections would a quick and inexpensive exercise, should circumstances change.

4.2.2 *Product Shipment*

Movement of products by road from the Picton plant to the Bunbury Harbour would be managed to minimise noise impacts on residences along the route. Current arrangements for this transport have been operating for some two years without concerns having been raised, and it is expected that increasing the number of vehicle movements by 60% will not significantly alter the situation. The City of Bunbury would be consulted to establish the expanded operation and ensure its acceptability to the local community.

4.3 *WATER RESOURCES*

4.3.1 *Surface Waters*

On a regional scale, impacts of the Dardanup Mineral Sands Project on surface waters are expected to be indiscernible. Only small amounts of water (maximally 300 ML p.a. - see Section 2.7.1) are likely to be directed from the Dardanup mine to existing water courses and thence to the Leschenault Inlet; this water would have low salinity (less than 1000 mg/l TDS), no chemical additions and extremely low turbidity.

Several options are available for this diversion of excess water from the Dardanup operation during winter months. Of these, the most logical is to use the existing irrigation channel, which ultimately reports to the Leschenault Inlet via the Ferguson and Preston Rivers. A pipeline to the Inlet or to one of the rivers would achieve the same result, but at much greater cost. The management of excess water at the Dardanup mine will be conducted in consultation with the Department of Agriculture and the Water Authority.

On a local scale, the option outlined in Section 2.7.1 to dam small ephemeral streams in the mining area to provide water storage could impact downstream users, especially during the dry summer period. These streams provide green summer grazing in areas to the west of the proposed dams and of the PMA, and a combination of damming and mine dewatering could reduce the summer productivity of this land.

The areas potentially so affected are, however, relatively small, so that small compensatory water releases into these water courses should prevent loss of valuable summer feed. A number of sources of water for such compensatory release are available (e.g. from the PWP and from deep supplementary water supply bores). ISK Minerals will consult with affected landowners, the Department of Agriculture and the Water Authority as appropriate to ensure that normal farming operations are not significantly or unreasonably affected.

Being located upslope of the PMA on ISK Minerals-owned land, process water storage facilities are considered unlikely to affect the water regimes of land lying "downstream" to the west of the PMA, other than that forming part of or lying adjacent to the watercourses detailed in the previous paragraph.

4.3.2 *Groundwater*

GROUNDWATER MODEL DEVELOPMENT

Gutteridge, Haskins and Davey Pty Ltd (GHD) were commissioned by ISK Minerals in June 1991 to carry out water supply and management studies for the Dardanup Mineral Sands Project. A report on these studies was produced in September 1991 (Gutteridge, Haskins and Davey, 1991).

Key elements of the GHD study were the modelling of the existing hydrological regime in the project area, the calibration of the model using data from bores adjacent to and near the area, and the use of the model to predict hydrological effects of mining operations, especially dewatering. Calibration of the model was enhanced by the drilling and test-pumping of three new bores in August 1991, two on Edwards Road and one on Simpson Road.

The model treated the mining area as a series of 300 m x 600 m blocks, a new block being opened up, on average, every 160 days. The three-dimensional model (MODFLOW - McDonald and Harbaugh, 1984) allows for the modelling of interactions between different aquifers and formations. Interaction between the superficial Guildford and Yoganup formations, and leakage to the Leederville Formation, were the principal elements of the modelling performed for the Dardanup Project. Vertical and horizontal hydraulic conductivities were ascribed to the different formations, based on previous work in the area by and for government instrumentalities - horizontal conductivities were 250 times higher than vertical conductivities for the Guildford formation, and 1000 times higher for the Yoganup formation.

Recharge was set at 0.15 mm/d, being the average of the summer and winter values used by Mackie Martin & Associates (1991). Evapotranspiration was taken as 5.5 mm/d for a water table at surface, reducing to zero for a water table below 2 m. An average leakage rate of 0.3 m^3 per day per lineal metre of the irrigation channel was adopted after discussions with the Department of Agriculture.

Model calibration was achieved through reference to water table elevations and piezometric levels in bores established in August 1991 by GHD and previously by the Water Authority and the Department of Agriculture. The calibrated model shows water table and potentiometric levels at the centre of each of the cells of the model. The model currently does not allow for seasonal variation in water levels (which is generally a maximum of 1.5 metres in any case), but is considered to adequately characterise and quantify the effects of mining operations, particularly dewatering. If necessary, the seasonal variations could be arithmetically added to the model results with little loss of accuracy.

DEWATERING IMPACTS

The above-described model shows that dewatering will produce between 900 m^3/d and 1700 m^3/d (330-620 ML/a), the lower figure representing a reasonably steady state situation established approximately 2 years after the commencement of dewatering.

Drawdown in the superficial formations is shown to extend approximately 500 metres to the east and west of the pit, and 300 metres to the north and south. Water levels in farm bores (domestic and stock) may decline as much as 3-4 metres in areas close to the pit. To avoid water supply problems, ISK Minerals will consult with landowners, the Department of Agriculture and the Water Authority to determine the most appropriate course of action: deepening of bores likely to be affected or providing alternative water supply are the most obvious means of pre-emptively dealing with these potential problems.

POST-MINING CONSIDERATIONS

Backfilling with mixed sand and clay tailings and overburden could result in bulk permeabilities lower than those existing prior to mining, since the sandy lenses and layers (see Section 3.4.2) which provide the existing high horizontal permeabilities would be mixed with materials of lower permeability. This could significantly reduce waterflow in the westerly direction, increasing water tables by as much as 4 metres to the east of the backfilled pit and lowering levels up to 3 metres to the west.

This potential problem can most simply be avoided by selective placement of high permeability sandy material or installation of engineered drains during backfilling operations, thereby recreating capacity to transmit water from east to west at rates similar to those currently taking place.

ISK Minerals proposes to continue hydrological and geotechnical studies, and to consult with the Water Authority and the Department of Agriculture, to ensure that the long-term bulk horizontal hydraulic conductivities of backfilled mine pits permit the transmission of water to the west without causing significant localised changes in groundwater levels.

SALINITY EFFECTS

Over the long-term, activities of the Dardanup Project could indirectly assist measures to deal with the regional salinity problem, which is largely the result of concentration by evapotranspiration of salts contained in irrigation waters. While very little water will be removed from the mining area over the life of the project, and the basic restoration/rehabilitation strategy is to re-establish the existing hydrological regime, tree planting is planned as part of the strategy - increased water use by trees would be beneficial in controlling water tables in the region.

4.4 *DUST MANAGEMENT*

As noted in Section 3.3, strong winds are a potential cause of fugitive dust from mining operations. In addition to the strength of winds caused by the general synoptic regime, the foothills location of the mine produces strong turbulence under easterly wind conditions.

Based on ISK Minerals' experience at the similarly-located Waroona mine, dust from roads at Dardanup can be effectively controlled by regular watering. Tree planting and judicious location of facilities, as well as attention to the design of stockpiles and open areas, are expected to minimise dust generation from non-traffic areas. As an overriding strategy, the area open at any one time will be restricted to the minimum consistent with safe and efficient operations.

4.5 *NOISE MANAGEMENT*

4.5.1 *Dardanup Operations*

The Dardanup mine will operate continuously, as does ISK Minerals' existing Waroona mine. Mining at Waroona has been successfully carried out within 50 metres of a rural residence, and ISK Minerals is confident that appropriate consultations with residential neighbours will similarly enable the mining and concentrating activities at Dardanup to be carried out with minimal disturbance.

Based on experience at Waroona, the siting of facilities and the timing of various operations at Dardanup is expected to provide adequate capacity to reduce noise impacts. Should problems arise, ISK Minerals will consult with affected parties and adjust operations as appropriate.

The concentrator at Dardanup will generally be located at least 500 metres from the nearest inhabitated dwellings, far enough away for noise emissions to attenuate towards background levels at the dwellings under most circumstances.

Mining industry experience has shown that mobile equipment most often causes noise nuisance through the sounds of reverse-warning devices (emitted when equipment is in reverse gear). As it has done at Waroona, ISK Minerals will approach the Department of Mines and other relevant authorities to arrange for flashing warning lights to be the sole reverse-warning measure after dark.

4.5.2 *Picton Operations*

The Picton dry separation plant is located in an industrial area, with the nearest residence approximately 300 metres to the south of the plant. The operation of additional facilities at Picton will increase the absolute noise emissions from the site, but the general nature and level of the noise is such that no problems are foreseen in either residential areas or nearby industrial facilities.

4.6 *VISUAL IMPACTS*

4.6.1 *Dardanup Operations*

Visual impacts of mining and concentration operations at Dardanup will be similar to those experienced at ISK Minerals' existing operations at Waroona. An estimated maximum of 20 ha of mine pit will be open at any time, topsoil and overburden stockpiles will be created for initial pit establishment at least, water storage facilities will be constructed and processing equipment (concentrator, thickener, trommel, drum scrubber) will be visible from certain points - the tallest facility, the concentrator, is expected to have a maximum height of about 20 metres.

Various aspects of the Dardanup operations will be visible to different extents from the various roads in the area, and from adjacent properties. A more distant but wider and more elevated view of operations will be obtainable from Henty Brook Road, several kilometres east of the PMA on the Darling Scarp.

Visual impact will be practically minimised by:

(i) restricting the size of operational areas to the minimum required for safe and efficient operation;

(ii) maintaining vegetation where it shields mining operations from view from both public and private areas;

(iii) establishing vegetation on areas, including stockpiles, to shield operations from view; and

(iv) selective location of stockpiles.

In the longer term, the re-establishment of agricultural and native vegetation on mined and disturbed areas (see Section 2.1.5) will blend the physical features of the mine area into the surrounding rural landscape.

4.6.2 *Picton Site*

Expansion of the Picton dry separation plant will be effected without additional clearing at the site; new facilities will most likely be constructed immediately to the south of and adjacent to existing facilities. The visual impact of the site, which is in an industrial area, will be essentially unchanged from that which prevails at present.

4.7 *SOCIAL CONSIDERATIONS*

As noted in Sections 3.7.1 and 4.10.1, ISK Minerals is aware of and enthusiastic to maintain the long-established nature of the farming community in the project area, and its attachment to the land. To the extent that it is practicable, ISK Minerals wishes to minimise disturbance and inconvenience, both direct and indirect, to local residents. It is nonetheless recognised that disturbance and inconvenience will take place, and that for residents whose land is not directly involved in mining (and who therefore cannot receive financial compensation), the impacts are unlikely to be offset directly.

However, ISK Minerals has already discussed with community representatives means by which ISK Minerals can participate in community development programmes. While it does not wish to simply underwrite local programmes in a financial sense, it does wish to work with the community as a member of it.

ISK Minerals believes that, because purchases of land for mining will probably mean that some farming residents may leave the area or permanently cease farming operations, remaining farm operators will have opportunities to expand their existing operations. As stated in Section 2.1.5, ISK Minerals does not intend to retain farmland after its post-mining rehabilitation has stabilised the land surface and productive agricultural systems are re-established.

4.8 *WASTE MANAGEMENT*

Inert solid waste from the Dardanup operations (other than tailings) will either be buried at the bottom of the mine pit before backfilling, or disposed of, in consultation with the local authority, at the local landfill site. Office waste at Dardanup will be disposed of in accordance with the requirements of the Shire of Dardanup: landfill, either on-site or at the Shire facility, will be used.

Waste from Picton will continue to be disposed of at the local landfill site, in accordance with relevant regulations.

Sewage at both sites will be managed with septic tanks, which will be constructed and operated in accordance with local government requirements.

Waste oil at both sites will be collected and removed from site by a licensed contractor for re-use, generally as a fuel or for recycling.

4.9 *BIOLOGICAL IMPACTS*

The Dardanup Mineral Sands Project has the potential to disturb restricted areas of remnant but highly modified vegetation located along road reserves and on private land. The report on the vegetation and flora study by E M Mattiske & Associates, discussed in Section 3.5, noted that all potentially-affected plant comunities are represented in other areas on the coastal plain, although the stands of *Casuarina obesa* are not well represented in the conservation estate.

In ecological terms, the remnant vegetation of the project area has relatively restricted values, especially in comparison with the situation existing prior to European settlement. Nonetheless, habitats are no doubt provided for avifauna in particular and, as noted in E M Mattiske & Associates' report, the scenic value of remnant trees is significant.

ISK Minerals proposes to preserve remnant vegetation where practicable, largely by locating facilities to minimise impacts - road, track and pipelines in particular. Moreover, the inclusion of native vegetation in rehabilitation strategies and prescriptions (see Section 2.1.5), and the enrichment of roadside vegetation (see Section 4.2.1), will ensure that native vegetation is represented in the post-mining landscape to an extent at least comparable with that which presently exists.

4.10 *HERITAGE AND CULTURAL MATTERS*

4.10.1 *Historical Matters*

As noted in Section 3.7.1, ISK Minerals is aware of the long-established character of the area in which mining is proposed, especially the fact that many of the farming properties have been operated for several successive generations. Attachment to the land in general, and to individual clumps of trees in particular, is not uncommon - the desire to preserve old red gums (*Eucalyptus calophylla*) trees has been encountered by ISK Minerals on a number of occasions during discussions with local residents.

While current project planning does not include any area or place listed on the Register of the National Estate by the Australian Heritage Commission, ISK Minerals plans to continue to consult with local landowners and residents to ensure awareness of more localised heritage and historical values. Through discussion and consultation on an individual basis, ISK Minerals intends to manage and balance both the interests of landowners and the integrity of the overall mining operation.

4.10.2 *Archaeological and Ethnographic Matters*

Following the archaeological investigations carried out by McDonald Hales & Associates (see Section 3.7.2), ISK Minerals will ensure that the requirements of the Aboriginal Heritage Act 1972 are met. Should any material considered likely to be a site under the Act be encountered, operations at that site will be suspended, the WA Museum Aboriginal Sites Department contacted and the possible site investigated - operations would not re-commence until the appropriate advice was received from the Museum.

The remaining key Aboriginal informant for the region will be consulted on his return to Western Australia, and his knowledge of the traditional use and significance of the mining area sought.

5.0 *PUBLIC CONSULTATION*

5.1 *COMMUNITY CONSULTATION*

In addition to extensive dealings with individual landowners regarding access for exploration and purchase or compensation for mining, ISK Minerals has encouraged the Dardanup, Burekup and Waterloo communities to both understand and contribute to the planning and decision-making processes guiding project development. A primary focus for this consultative process has been the Shire of Dardanup.

Prior to formal submission in June 1991 of the Development Proposal used to trigger project assessment under the terms of the Environmental Protection Act 1986, an Open Day was held by ISK Minerals at the Dardanup Hall. The Open Day, which was advertised in local newspapers, was designed to allow the community to examine the options being evaluated, and to discuss potentially contentious elements of the project. The key matters in this regard were water and the impacts of mining on groundwater levels and salinity, and transport of HMC from Dardanup to Picton. These matters were then given particular attention in studies leading to the preparation of this document.

Almost 100 people attended the Open Day, at which the Social Impact Unit, the Department of Agriculture, the Environmental Protection Authority and the Water Authority were also represented.

A second Open Day is scheduled for late September or early October, to allow discussion of and feedback from this CER document.

A group of residents, primarily from the Harris Road area, held a meeting in August 1991 to discuss the transportation issue; ISK Minerals was invited to address the meeting. Some 56 people attended and by a large majority opposed the Harris Road option (Alternative 1 in Section 2.4.2). Moreover, it was suggested that the Dowdell's Line route (the one now proposed for HMC road transport) would have minimal, if any, social impact. The question of increased heavy through-traffic south on Dowdell's Line was raised as the largest potential impact.

ISK Minerals also attended an August 1991 meeting of the Burekup Progress Association, primarily to answer questions about the project by some of the 26 attendees. The major concern expressed was through-traffic south on Dowdell's Line from South West Highway - ISK Minerals' proposal for the extension of Dowdell's Line to South West Highway, where no through traffic would be possible, was well received by the meeting.

ISK Minerals will continue to consult with the Dardanup, Burekup and Waterloo communities during development of the project. The Shire of Dardanup will continue to be a vehicle for this consultation, which will also include community groups, such as a Land Conservation District Committee recently proposed for the area.

ISK Minerals has also discussed the project with the Conservation Council of Western Australia and the Australian Conservation Foundationa. Consultation with, and provison of information to, these and other special interest groups will continue as appropriate throughout project development and operation.

5.2 *GOVERNMENT LIAISON*

Since early 1991, ISK Minerals has established and maintained contact with the following instrumentalities:

- Department of Mines
- Environmental Protection Authority
- Department of Agriculture
- Department of State Development
- Social Impact Unit
- Water Authority of Western Australia
- Department of Conservation and Land Management
- South West Development Authority
- Main Roads Department
- State Energy Commission of Western Australia
- Shire of Dardanup
- City of Bunbury

Liaison with these organisations will be maintained throughout project development and operation, following ISK Minerals' policy of making information freely and openly available to all parties affected by or with a genuine interest in the project.

6.0 *SUMMARY OF ENVIRONMENTAL COMMITMENTS*

As described in the previous sections, ISK Minerals is committed to responsible management of the environmental affairs of the Dardanup Mineral Sands Project.

The major environmental commitments by the company are as follows:

(1) Consult with landowners, the Department of Agriculture and the Water Authority of Western Australia to ensure that operations at Dardanup do not unreasonably affect agricultural enterprises in neighbouring properties, especially in relation to surface and groundwater.

(2) Continue hydrogeological and technical studies, including regional monitoring of water bores, to facilitate pre-emptive prediction of impacts of mine dewatering on local and regional hydrogeology.

(3) Dispose of excess water in a manner agreed in consultation with the Water Authority of Western Australia and the Department of Agriculture.

(4) Ensure that backfilled mine areas have the capacity to transmit water from east to west in a fashion similar to that which currently occurs.

(5) Rehabilitate land disturbed by mining activities to restore agricultural productivity to levels at least equal to those which currently exist.

(6) Consult with the Department of Agriculture, the Water Authority of Western Australia and landowners to include native vegetation in rehabilitation strategies, with a view to contributing to the management of the localised and regional hydrogeological problems of high water tables and salinity.

(7) Construct facilities, stockpiles and the like with consideration to visual impact from both public and private locations in the area and region.

(8) Minimise clearing and land disturbance, consistent with safe and efficient operations.

(9) Licence all bores and other water supply and water management facilities in accordance with the requirements of the relevant legislation, particularly the Rights in Water and Irrigation Act 1914.

(10) Consult with the State Energy Commission of Western Australia and relevant landowners to determine the most acceptable means of extending the existing 22 kV agricultural supply transmission line to the mining area.

(11) Enrich and establish native vegetation alongside existing permanent public roads and roads developed or disturbed as a result of project activities.

7.0 *REFERENCES*

Commander, D P (1982). The Bunbury shallow drilling groundwater investigation. W.A. Geological Survey, Report 12:32-52.

Gutteridge Haskins & Davey (1991). ISK Minerals Pty Ltd - Dardanup Project, Water Management Study. Gutteridge Haskins & Davey Pty Ltd.

Mackie Martin & Associates Pty Ltd (1991). Groundwater investigation for the irrigation strategy study - South-West Western Australia. Report to the Water Authority of Western Australia.

McDonald, M G and Harbaugh A W (1984). MODFLOW - A modular three-dimensional finite difference groundwater flow model. U S Department of the Interior, U S G S, Reston, Virginia; 528 pp.

Appendix 1:
CER Guidelines issued by the Environmental Protection Authority.

PROPOSED DEVELOPMENT OF MINERAL SANDS MINE AT DARDANUP

ISK MINERALS

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 will be protected then the proposal will be found environmentally acceptable, if the proponent cannot show that the environment would be protected then the Environmental Protection Authority (EPA) would recommend against the proposal.

Throughout the 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 proposals which protect the environment.

For this proposal protecting the environment means that the natural and social values associated with the Dardanup area are protected. Where they cannot be protected, proposals to mitigate the impacts are required.

These Guidelines identify issues that should be addressed within the Consultative Environmental Review (CER). They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

The CER is intended to be a brief document, its purpose should be explained, and the contents should be concise and accurate as well as being readily understood by interested members of the public. Specialist information and technical description should be included where it assists in the understanding of the proposal. It may be appropriate to include ancillary or lengthy information in technical appendices.

Key issues

The important issues for this proposal are likely to be associated with the location of the proposal in almost wholly cleared privately-owned agricultural lands on the lower foothills of the Darling Scarp, east of Bunbury between Burekup and Dardanup.

The key issues for the project should be clearly identified and the content of succeeding sections determined by their relevance to these issues.

In this case the key issues should include:

- Land use issues
  - impacts on land use and tenure of the area within and adjacent to the proposed mining area;
  - location of residences in relation to the mining area and the impacts on residents;
  - devaluation of properties;
  - rehabilitation (long term land use);
  - impacts on remnant vegetation;
  - cultural and heritage issues.

- Water supply and management issues
  - groundwater impacts (predicted groundwater drawdowns, zones of influence and impacts on other users);
  - surface water impacts (relationship to groundwater, protection of ground and surface water quantity and quality, impact on irrigation channels and drains);
  - salinity considerations;
  - impacts on wetlands and estuaries.
- Transport issues
  - heavy mineral concentrate transport options;
  - product transport options;
  - workforce transport and supplies route alternatives.
- Operational management issues
  - dust and noise control;
  - radiation;
  - overburden, topsoil and slimes management, rehabilitation and final land use;
  - potential future mining scenarios;
  - impact of project workforce, during construction and operations, and attendant population on the existing communities;
  - decommissioning;
  - sand and clay tailings management;
  - waste management.

plus any other key issues raised during the preparation of the report.

Public participation and consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the CER. This section should describe the activities undertaken, the dates, the groups and individuals involved and the objectives of the activities. This section should be cross referenced with the "environmental management " section which should clearly indicate how community concerns have been addressed. Where these concerns are dealt with via other departments or procedures, outside the Environmental Protection Authority process, these can be noted and referenced here.

Monitoring programmes

The proponent should recognise that ongoing monitoring will be required for certain aspects of the proposal, especially groundwater impacts and rehabilitation, and commit to putting a programme in place to manage these issues.

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:

a) who will do the work;
b) what the work is;
c) when the work will be carried out; and
d) to whose satisfaction the work will be carried out.

All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list.

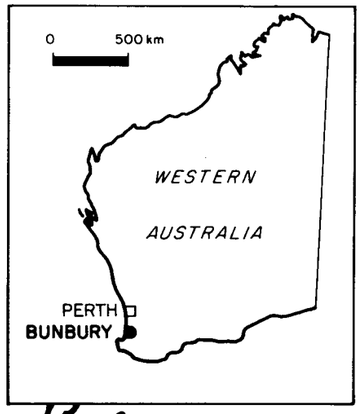
Figures

ISK MINERALS PTY LTD.

DARDANUP PROJECT

LOCATION PLAN

Author : C.D.J	Date : Sept. 1991	FIGURE 1



BUNBURY

TOWNSHIP

VITTORIA BAY

OLD COAST ROAD

PRESTON

COLLIE RIVER

MUJA - BUNBURY POWERLINE

PICTON DRY PROCESSING PLANT

22 kV TRANSMISSION LINE

TRANSMISSION LINE EXTENSION ALTERNATIVES

TERMINUS

COMMON TO ROUTES 2,3,4 & 5

E70/776

SOUTH WESTERN HIGHWAY

WIRELESS ROAD

WATERLOO ROAD

DARDANUP ROAD

ST. HELENA ROAD

HARRIS ROAD

BELL ROAD

MARTIN PELUSEY ROAD

ITALIANO ROAD

RECREATION ROAD

PHILLIPS ROAD

PARADISE ROAD

FERGUSON ROAD

DOWDELLS ROAD

EDWARDS ROAD

SIMPSON ROAD

GUIMELLI ROAD

HENTY BROOK ROAD

OFFER ROAD

BUREKUP

Henty Brook

E70/156

P70/952

P70/951

Channel Irrigation

POTENTIAL WATER STORAGE AREA

AREA OF INITIAL LOCATION OF CONCENTRATOR

PRINCIPAL MINERALIZED AREA (PRELIMINARY)

MLA/675

MLA 70/643

AIRPORT

NORTH BOYANUP ROAD

BUSSELL HIGHWAY

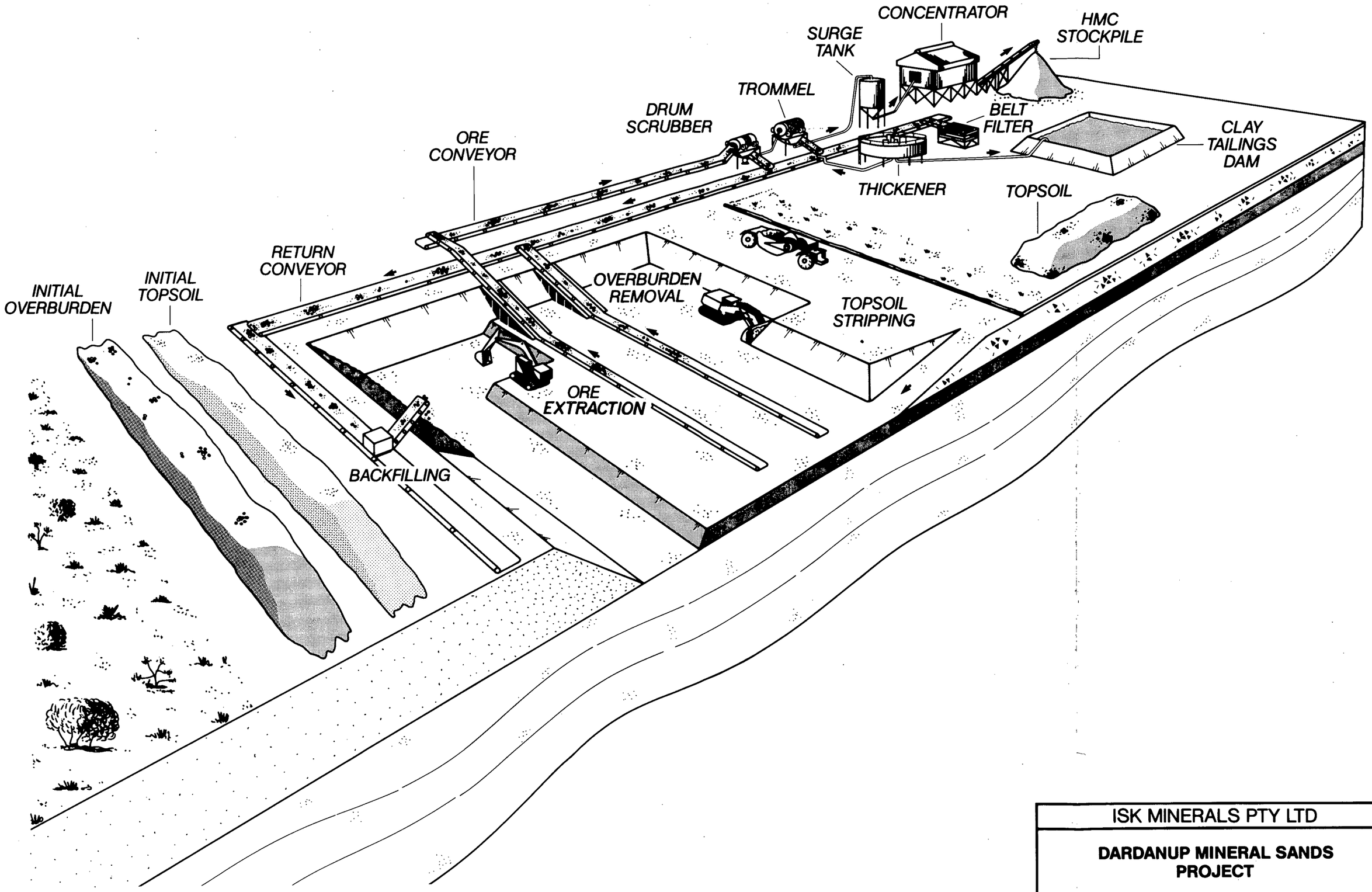
FERGUSON RIVER

N

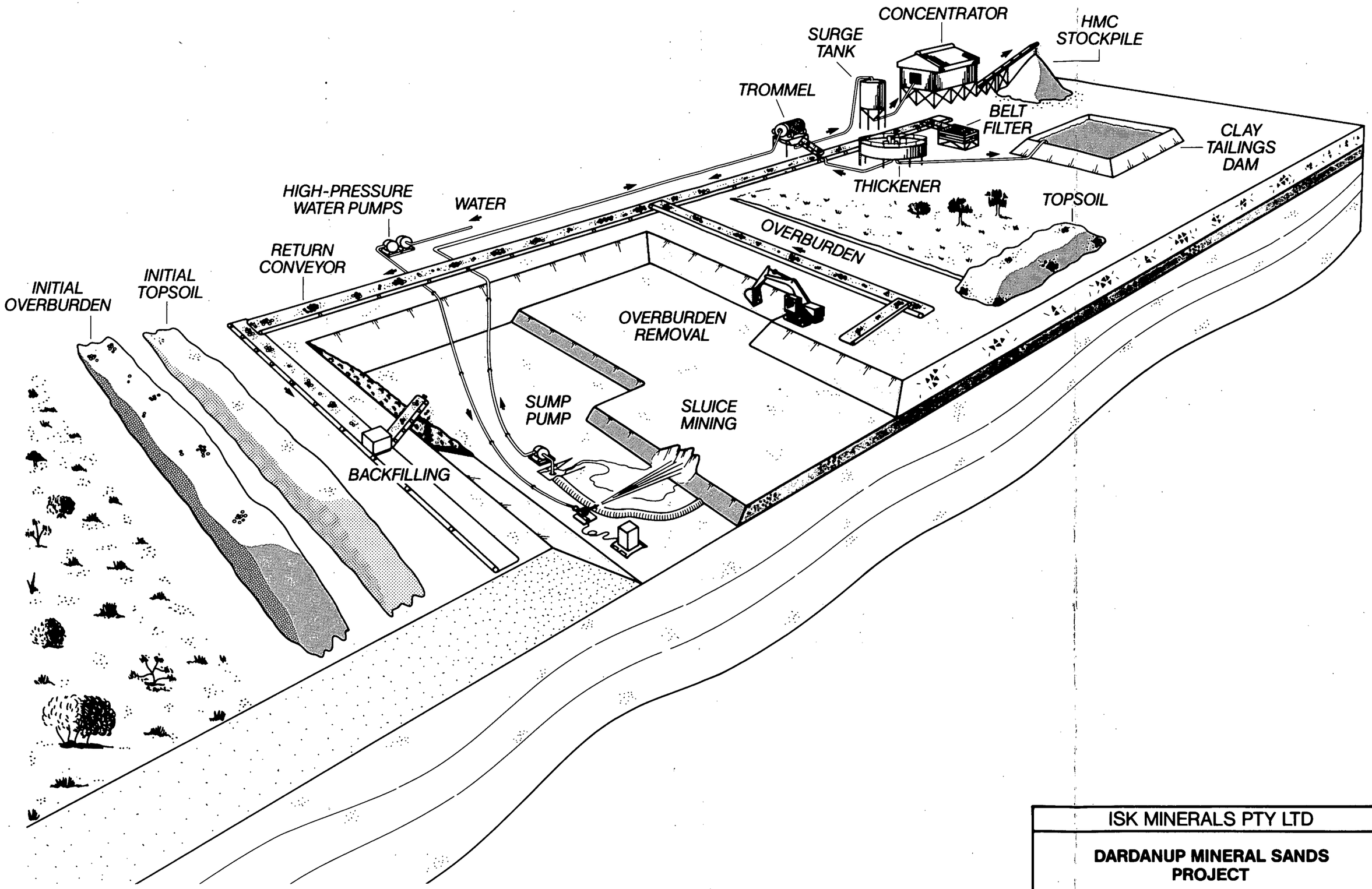
0 1 2 3 km

Scale 1:50 000

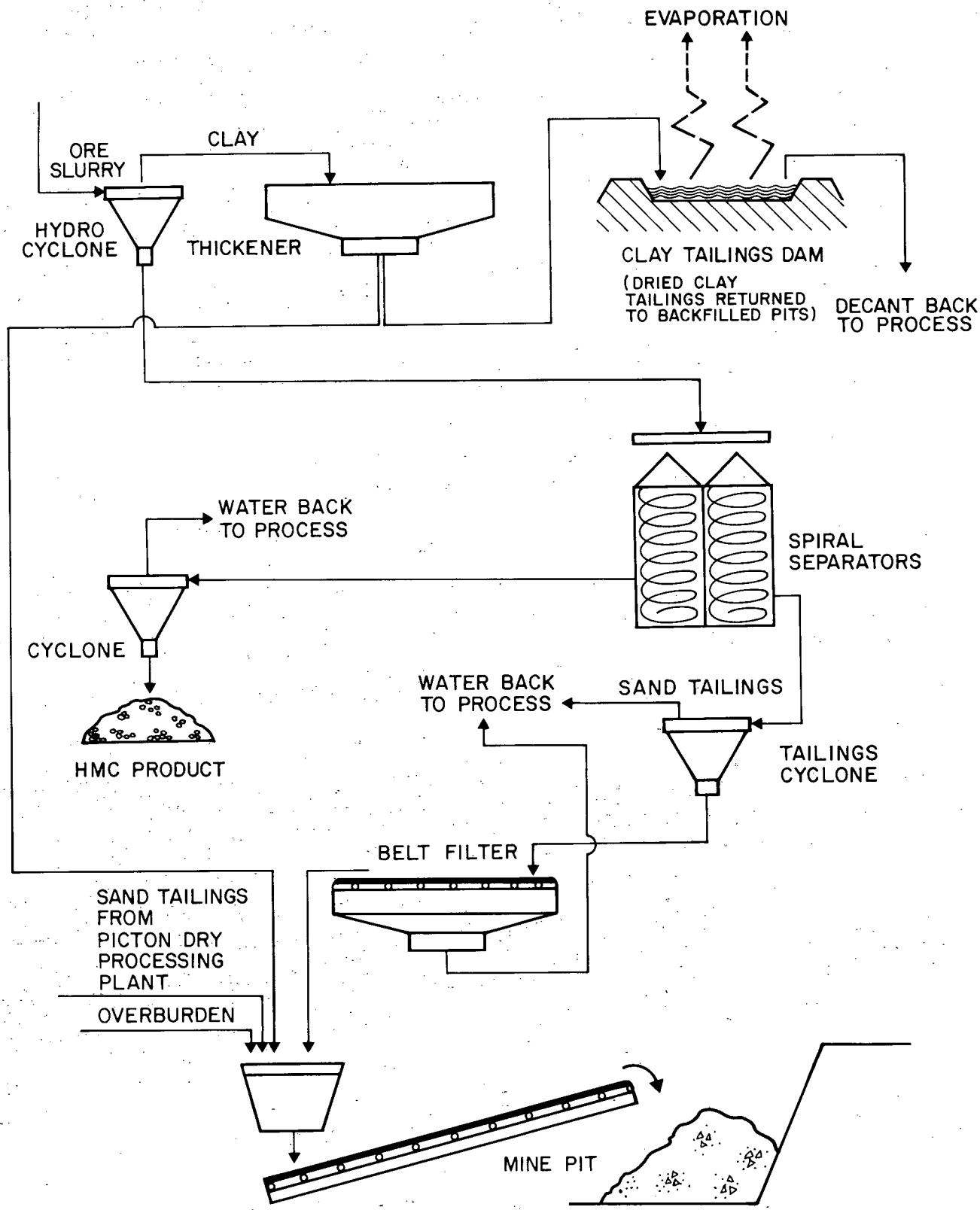
DARDANUP



ISK MINERALS PTY LTD		
DARDANUP MINERAL SANDS PROJECT **DRY MINING OPTION**		
Author: RC	Date: Sept. 1991	FIGURE **2**



ISK MINERALS PTY LTD		
DARDANUP MINERAL SANDS PROJECT **SLUICE MINING OPTION**		
Author: RC	Date: Sept. 1991	FIGURE **3**



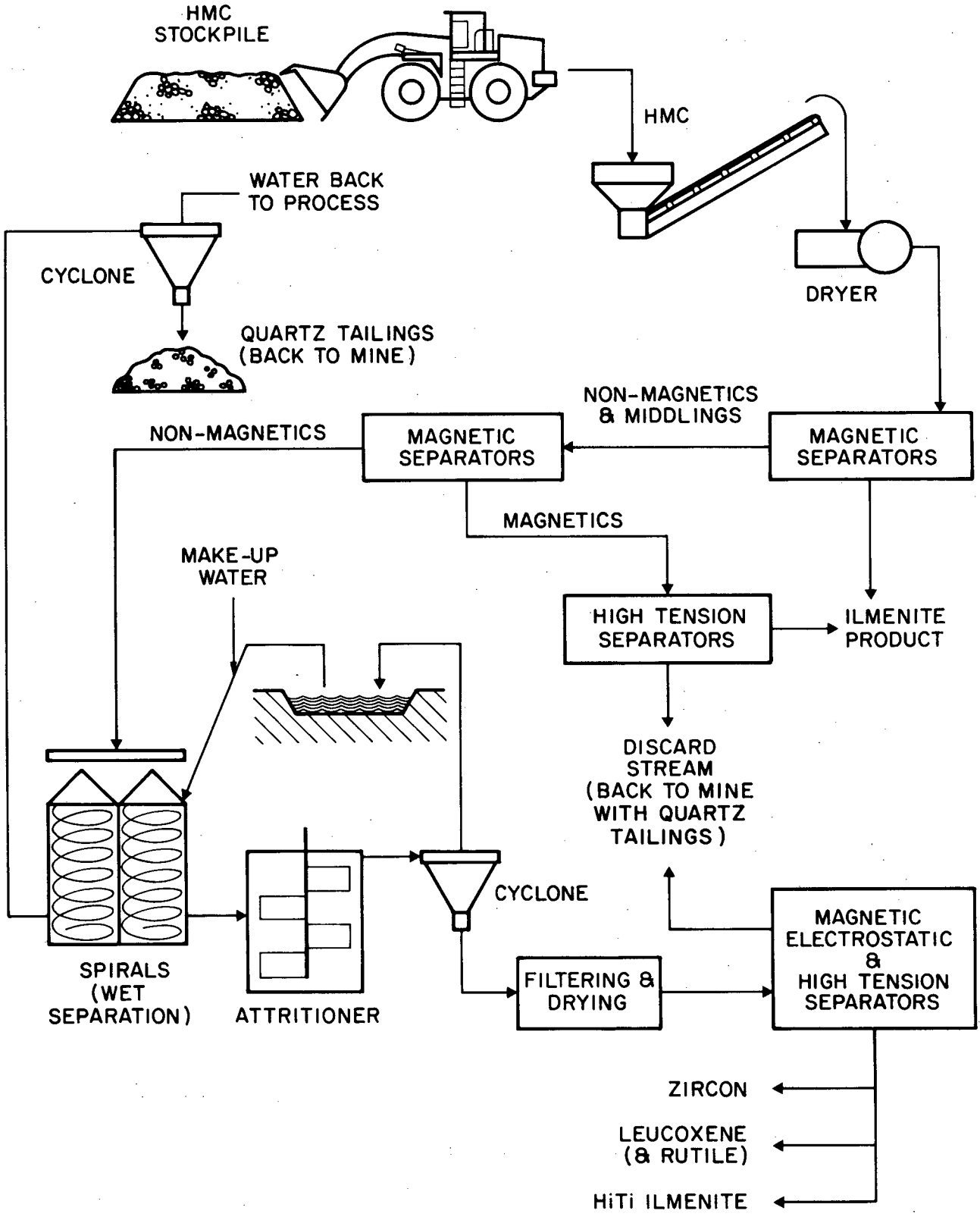
ISK MINERALS PTY LTD.

DARDANUP PROJECT

WET SEPARATION PLANT (DARDANUP MINESITE)

TYPICAL SCHEMATIC

FIGURE 4

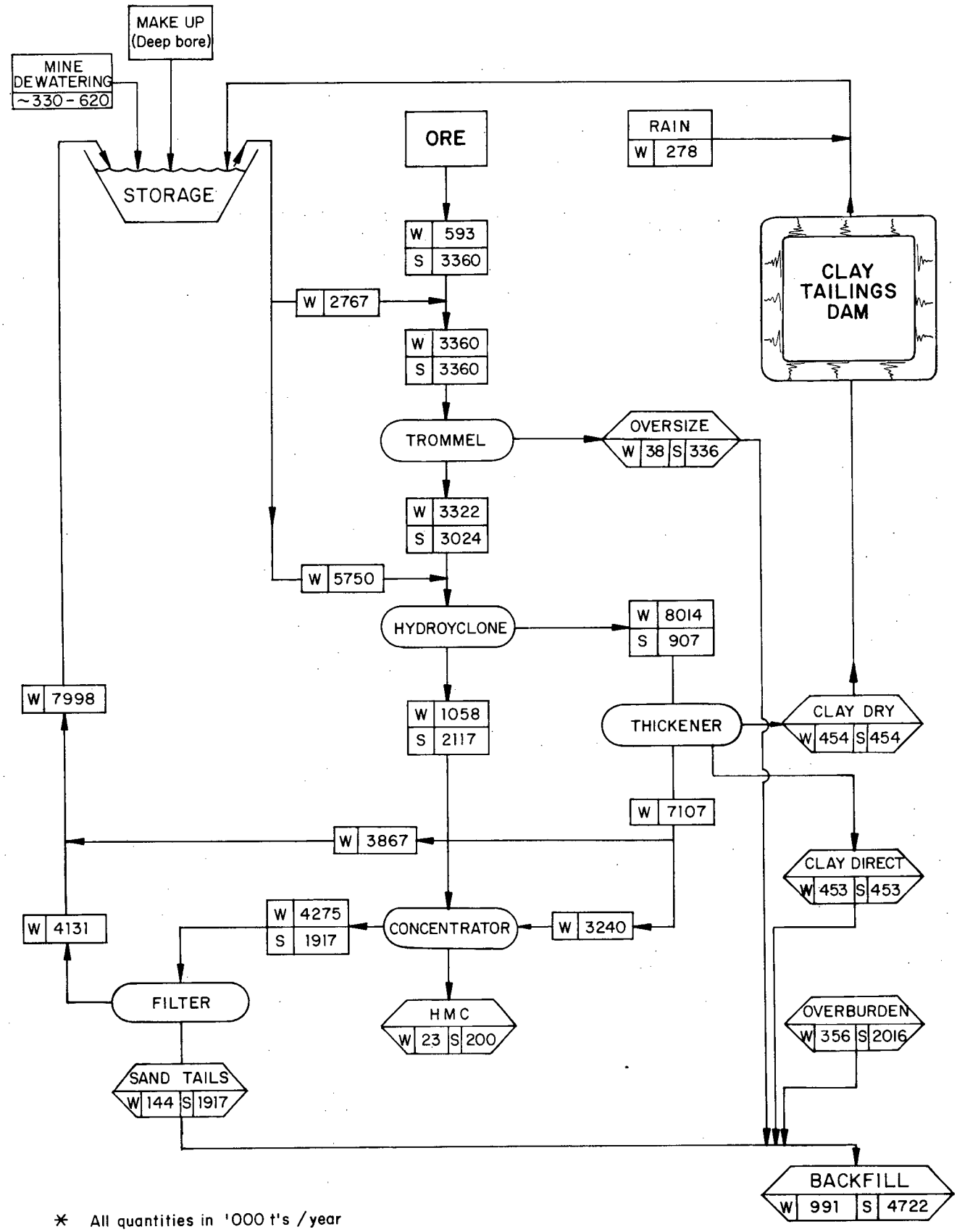


ISK MINERALS PTY LTD.

DARDANUP PROJECT

DRY SEPARATION PLANT TYPICAL SCHEMATIC

FIGURE 5

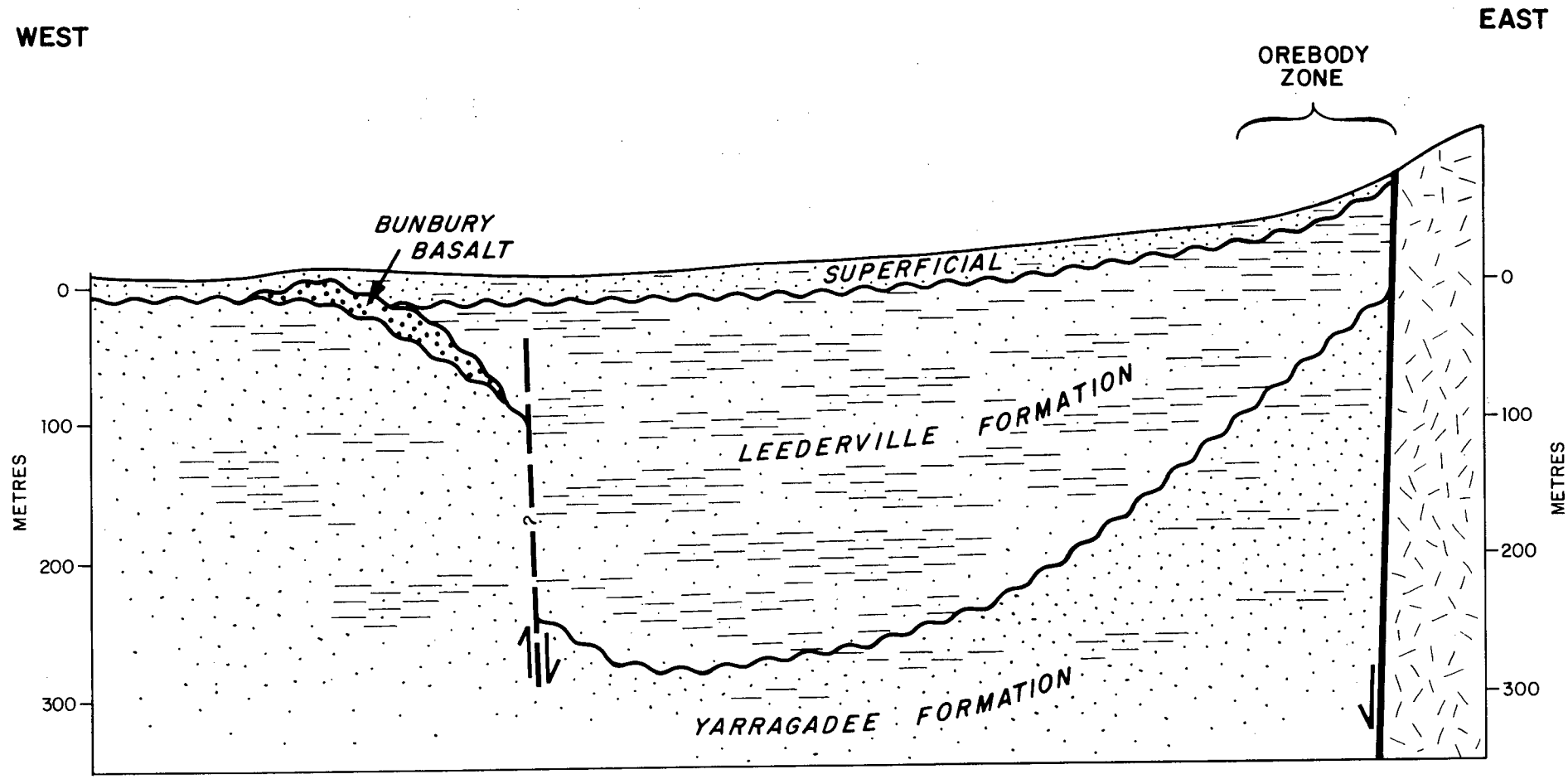


ISK MINERALS PTY LTD.

DARDANUP PROJECT

WATER MANAGEMENT
PROCESS WATER BALANCE

FIGURE 6



ISK MINERALS PTY LTD.

DARDANUP PROJECT

REGIONAL HYDROGEOLOGY

(CROSS-SECTION ON LINE OF HARRIS ROAD)

after Commander 1982

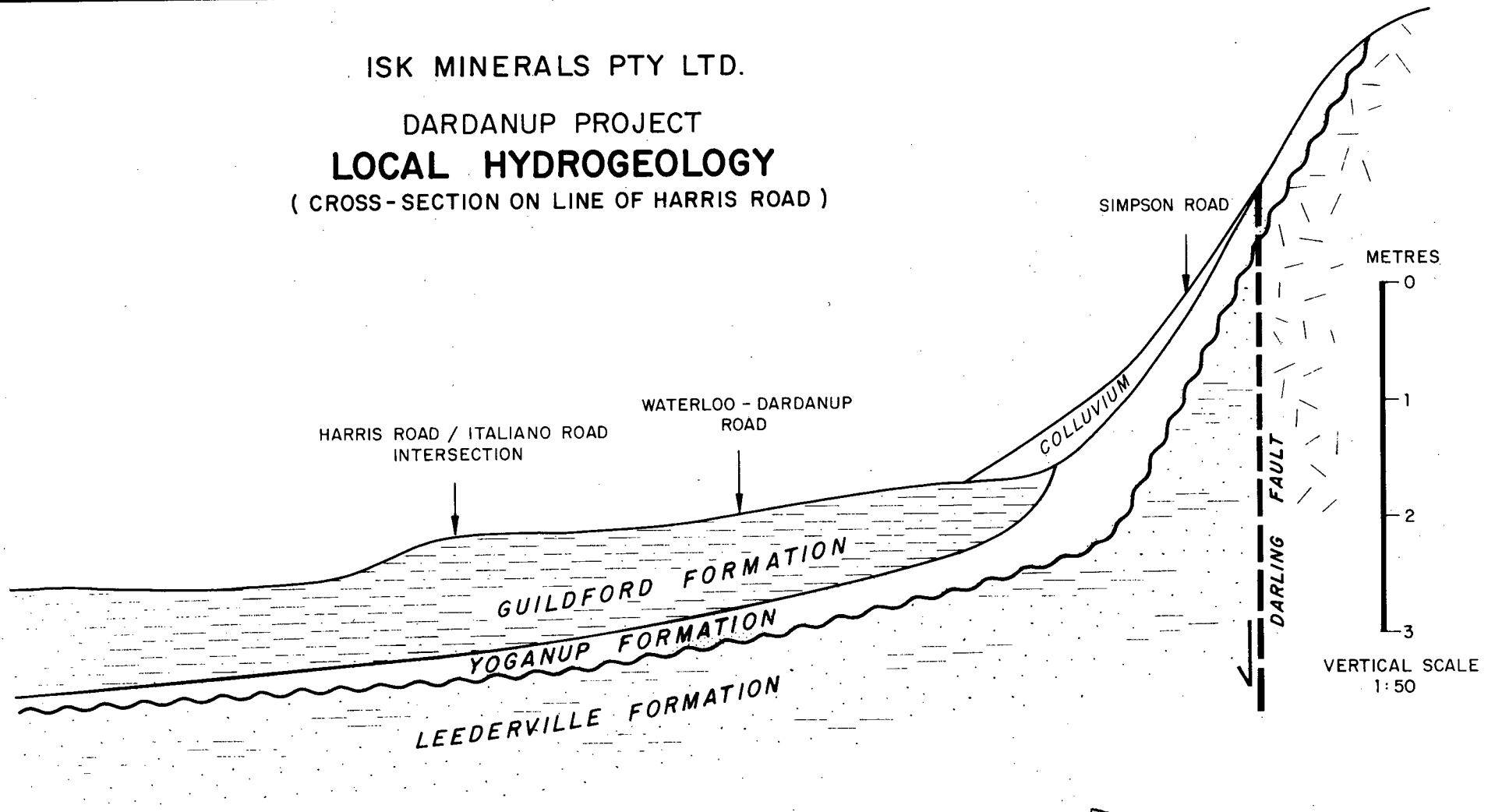
FIGURE 7

ISK MINERALS PTY LTD.

DARDANUP PROJECT

LOCAL HYDROGEOLOGY

(CROSS-SECTION ON LINE OF HARRIS ROAD)



SCALE 1:40,000

0 1 2 km

after Mackie Martin & Associates 1991

FIGURE 8