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landscape
and the
large-scale
surface mining
of lignite
a case study
landscape
and the
large-scale
surface mining
of lignite

This study is submitted in partial fulfilment for the Diploma of Landscape Architecture, Lincoln College, University of Canterbury.

by: D.G. McKenzie, B.Sc.

Lincoln College, November 1981.
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Special thanks to Peter Rough, supervisor of this study, for his advice, encouragement and criticism.
The purpose of this study is the discussion of landscape and the large-scale surface mining of lignite. The subject is approached by -

- considering surface mining and the factors that affect it, with particular reference to the New Zealand situation;

- considering landscape architecture and large-scale surface mining, with particular reference to lignite, and

- applying landscape consideration to a lignite deposit at Roxburgh East, Central Otago.
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Introduction

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"The World Conservation Strategy has established the need for the conservation of living resources for sustainable development. The way in which non-living mineral and energy resources are developed and used is also important for two reasons: firstly mineral resources and many energy resources are non-renewable. As such they cannot sustain development in the long-term and there must be an eventual transition to renewable or more abundant resources. Secondly it is also necessary to ensure that the impacts of mineral and energy resources use and development have as little effect as possible on the ability of life-support systems to sustain development." (Nature Conservation Council, 1981;29).

It is in consideration of the second of the two reasons stated above that this study has its basis. In particular, the consideration is of the 'impacts of mineral and energy resource use and development' have and have the potential of having on the landscape during the extraction of said resources. The potential extraction of the South Island Lignites by 'impact' on parts of the New Zealand landscape, so the large-scale surface mining of lignite is focused upon.
Paramount to the energy planning and mine planning necessary for the responsible use and development of the lignite resource is an understanding of landscape that will be destroyed by the surface mining of the lignite. It is on this basis of understanding landscape that the landscape architect, under the context of landscape planning has a role to play...

"Landscape planning must recognise the existence of potential mineral wealth in connection with surface extraction and deep mining operations and quarrying. Its task will be to safeguard areas where the landscape value is great and the people are concerned at the prospect of losing the amenity, or to ensure, by detailed proposals, that the landscape is not repaired unsympathetically."

(Hackett, 1971).
context of terms

LANDSCAPE -

"Landscape, used in its broadest sense of 'environment' refers to the relationships of all physical, biological and cultural components which are expressed in the visual landscape (that part of the environment that is visually perceived)" (A.Rackham & J.Darby, 1981: 1).
"Mining operations ... in connection with mining for coal ... includes -

(a) The removal of overburden by mechanical or other means to give access to the coal; and

(b) The stacking, deposit, storage, and treatment of coal; and

(c) The deposit or discharge of any overburden, material, debris, refuse, or coal produced from or in consequence of any such operations... and

(d) The erection, maintenance and use of machinery, and the construction or use of roads, races, dams, trucks, conveyors, aerial ropeways, channels, buildings, and any other works connected with such operations ... and

(e) The lawful use of land, water, rivers, streams, pools, lakes, and other natural channels or depositories of water (whether containing water or not), and tributaries, and the doing of all lawful acts incidental or conductive to such operations ...

('Coal' in the sense of the act means 'anthracite, bituminous coal, sub-bituminous coal, lignite, peat, and oil shale, and includes every other substance worked or normally worked along with coal'.)

(New Zealand Laws and Statutes, Coal Mines Act 1979; 7).
"Surface mining involves the process of removing earth, rock and other strata to uncover and remove a mineral deposit" (The American Society of Landscape Architects, 1978; 12).

The advantages of surface mining, when compared to underground mining are:-

(a) The mineral extraction can, in some cases, be 100 per cent of the deposit.
(b) Minerals can be won where ground or geological conditions prohibit underground methods.
(c) Surface mining generally has a lower cost per unit of production because of high mechanization.
(d) The extent of the operation can be more easily tailored to suit the economics of working.

The market value of a given quantity of mineral limits the quantity of non-revenue producing waste which can be excavated to obtain the mineral. This economic ratio between overburden and mineral is affected by the type of overburden, ground location, climate, the capacity of available excavating plant, and many other considerations which affect mining costs, such as environmental protection and reclamation requirements. (D.J. Harley, 1976; 34).

The disadvantage of surface mining is - its impact on the landscape - modification - destruction.
LARGE-SCALE -

As related to surface mining "... the term is a relative one: what is 'large' in the setting of one country can be 'small' in another country. The term has, therefore, to be normalised in relation to the size of a country, its population, its G.N.P., and its natural resources. The production of iron ore by large-scale surface mining in the U.S.A. is at present of the order of 100 million tonnes per year, and comes mainly from about 20 large mines. The present production of iron ore (from ironsands) in New Zealand is about 4 million tonnes per year coming from three mine sites. Normalising for the population in each country one can infer that large-scale mining of iron ore can infer that large-scale mining of iron ore in the U.S.A. is comparable with large-scale mining of ironsands in New Zealand.

Extending this approach to a few other mineral commodities, (i.e. coal, aggregate, alluvial gold) it was found that in the New Zealand setting, any removal of rocks, minerals or mineral-bearing deposits for direct economic gain at a scale of, say, more than a million cubic metres by volume, and at a rate of, say, more than a thousand cubic metres per day can be described as large-scale mining. The clause 'for direct economic gain' is important".

(M.P. Hochstein, 1981; 4).

Such is the term 'large-scale' in the context of the nation and economic gain. In this context, it would seem to relate to the expression "major work" as referred to "proposed works of national importance" or "national interest" in the National Development Act 1979 (N.Z. Laws and Statutes, National Development Act 1979; 4).
In referring the term 'large-scale' to the context of the landscape, 'large-scale' surface mining would be a scale of surface mining that, by its physical extent, dominates the natural scale of the particular landscape it is imposed upon.

From the interim estimates of the South Island lignite deposits (Isaac M, 1981; 20) the surface mining of these lignites would be 'large-scale' in the context of 'gain' and of 'landscape'.

**LIGNITE**

"Lignite is an intermediate material between peat and bituminous coal with a relatively low calorific value compared with black coal. Being such a low grade fuel, lignite has to be mined very cheaply which usually means large tonnage operations to achieve economies of scale. As it is uneconomic to transport any distance, it must be processed near the mine, and the various processes must be integrated for maximum economy.

It can be used for power generation by burning directly in boilers designed for the purpose and equipped with firing equipment incorporating pre-drying and pulverising arrangements. It can be dried, briquetted and carbonised yielding smokeless solid fuel, foundry coke and the usual products of distillation. It can be gasified and the gas used for the synthesis of nitrogenous fertilizer and synthetic fuels. (T. Atkinson, 1980; 12)."
surface mining - the process and the determinants that act upon it

In considering the landscape and the impact of large-scale surface mining, there must be an awareness of the mining process. This awareness starts by considering that which is mined - the mineral, be it a metallic, a non-metallic, or an energy mineral. There are several unique factors (Coates, 1981; 104) that set mineral resources apart from other types of resources under human use, and these factors are important in the planning and control of mineral supplies.

(a) Minerals are non-renewable. There is no second crop. Once mined out, they are gone forever.
(b) Minerals must be mined in place. Minerals do not always occur where mining is convenient.
(c) Minerals have high discovery costs. As those mineral deposits that where readily accessible for human use, have, in most cases, been already mined, the locating of minerals is becoming increasingly more expensive and difficult.
(d) Mining costs generally increase during production. As opposed to decreased unit cost with increased mass production, the cost of mining becomes greater with increased extraction. The deeper the mining extends, the more difficult it is to extract and the greater the amount of energy expended.

"Minerals and their derived products permeate all aspects of human civilization - its institutions, its businesses, its welfare, and the very quality of life ... Minerals and society are so intertwined as to be inseparable".

(Coates, 1981; 92).

As the need for minerals, and therefore the extraction of minerals would seem to be a necessary part of present human existence, the primary method of altering the impact of large-scale mining on the landscape would be to alter the human 'need' for minerals, but that avenue is beyond the scope of this study. The avenue this study is capable of proceeding along is that of discussing the secondary method of altering the impact - the extraction of minerals.

As with most human-controlled processes, the extraction of minerals is controlled by a logical sequence of events. From the available information, the most thorough sequence formulated, is that which is worked in the western states of the United States of America. Ferrante and Thor in "Predicting Events in the Development of a Coal Surface Mine in the West", 1980, have defined the norm for the process of large-scale surface mining of coal, as enacted under United States mining law and conditions. This norm could be applied to any large-scale surface mining operation, where there is some prior knowledge of the potential existence of a mineral that could be surface mined, a mining company is interested in that mineral and the nation involved has a mining law that shows some environmental and social conscience.
The sequence of events is as follows, given that all conditions are favourably met:-

* Land and Mineral Rights Obtained
  - surface and mineral ownership of reserve area mapped by mining company
  - cursory environmental, economic, and geologic analyses favourable
  - mining company landperson contacts holders of surface and mineral rights; lease or purchase or contract with option to purchase negotiated.

* Physical Exploration
  - drilling rights obtained
  - literature search to determine geology, previous discoveries, and access routes completed; information mapped
  - completion of geological reconnaissance to select best locations for detailed geological studies
  - exploration plan designed
  - exploration licence sort; obtained
  - performance bond posted
  - drilling and construction bids released and contracts awarded
  - field office established
  - access roads and buildings completed
  - drilling equipment and personnel arrive on site.

* Initial Environmental Reconnaissance
  - literature search for existing environmental information completed
  - exploration underway
  - company has qualified personnel or contracts for work.
* Economic Analysis, Feasibility Assessment
- results of drilling programme analysed, reserve is determined to be commercially mineable and marketable
- initial environmental reconnaissance of area results in favourable environmental report
- preliminary mining plan designed; in-house inventory of available equipment.

* Identification of Potential Customer
- market survey done by company
- data from drilling programme analysed for needs of customer.

* Environmental Assessment Report
- positive feasibility decision made
- field programme for environmental assessment designed
- consultant selection if needed
- baseline environmental and geological data, engineering information collected, contour maps completed
- report assembled into required format.

* Detailed Project Design
- positive feasibility decision made
- baseline environmental data collected
- best future use of land determined.

* Application for Mining Permit Submitted
- environmental assessment report completed and favourable mining and reclamation plans designed
- Board of Directors of mining company makes development commitment
- market for mineral identified and details of customers needs known
- surface rights secured.

* Mining Permit Issued
- mining permit approved by regulatory agency
- performance bond posted.
* Arrange for Labour
- permits issued or no problems foreseen
- heavy equipment arrangements made.

* Construction Begins
- construction plans approved and permits issued
- financing arranged
- construction bids released and contracts awarded
- construction equipment arrives
- construction labour arrives.

* Production Begins
- construction completed
- heavy equipment assembled
- labour arrives
- start-up phase successful.

* Completion; Performance Bond Release
- all openings and excavations closed or backfilled to mining plan
- equipment and structures related to mining removed
- areas affected by access roads graded, drained, and revegetated according to mining plan
- notice of intention to cease operations filed by mine operator with regulatory agency; mine inspected by regulatory agency to check compliance with mining plan and lease, permit, and licence stipulations
- notice of availability of proposed decision to release the bond posted.

As mentioned previously, these events are based on the western United States situation. But as large-scale surface mines have been worked in that area for many years and the United States mining law has been rewritten in step with the scale implied by these mines, this sequence of events is of relevance to other nations that have or propose large-scale surface mining.
mined landform vocabulary

- Highwall
- Embankment
- Overburden
- Mineable material
- Mounded
- Tailing, linear spoil pile or waste dump
- Trench channel
- Dike
- Sediment ponds
The actual, physical surface mining process - the extraction of the mineral and its impact and implications on the landscape and, therefore, society - is, generally, controlled by a number of determinants. These are:-

1) The surface mining method - the type of extraction.

2) The equipment - that which implements the extraction.

3) Subsurface conditions.

4) Surface conditions.

1) The Surface Mining Method:

All surface mining operations carry the potential for environmental devastation - the destruction of the landscape. Surface mining opens up the earth. It destroys the surface cover, introduces new landforms and creates contrasting lines in the landscape. Visual changes in line, form, colour and texture are radical. (Visual Management Presentations, 1981). To minimize this destruction, it is imperative that the actual surface mining method suits, not only the type of mineral and the form of its deposits, but more importantly, that the actual design of the mining operation and the inherent pre-planning that lead to that design, has as its twin goals - the efficient extraction of the mineral and the reclamation of the landscape to its original condition or better. To achieve these twin goals, they have to be aimed for throughout the stages of the mining operation. Fundamental to this is the selection of a surface mining method, which has the basis on which the detail of the particular mining operation can be designed and built.
The main methods of surface mining are:-

a) open pit.
b) area strip.
c) contour strip.
d) hydraulic.
e) dredging.

What follows is a breakdown of the various methods components and impacts commonly associated with the use of the methods.

a) **Open Pit.**

components -

A quarry operation, worked where there are non-existent to low overburden ratios, (0:1-2:1) which results in a large quantity of mineral being produced in relation to the surface area of the mine.

This method is common to the extraction of limestone, building stone such as marble, granite and basalt, and aggregate. It is used, in large-scale, for the extraction of copper, coal and iron ore.

The basic mining operation consists of drilling, blasting, loading and hauling, the mine increasing in depth as the mineral-bearing rock, be it igneous, metamorphic or sedimentary, is extracted.

There are no definite topographic constraints on this method of mining, which implies that it may be located in any landscape overlying a mineral deposit.
impacts -

The landscape above the mining prospect is destroyed and a large void is formed. The impact of plant and operations on the local landscape due to visual intrusion, noise, vibration, air and water pollution, is likely to be high.

Overburden and any tailings are dumped outside of the mine. The potential exists for the enhanced weathering and leaching of both.

There will be a lowering of the water table. There is the likelihood of sedimentation of adjacent streams.
b) **Area Strip.**

components -

A 'trenching' operation on deposits that lie near, and are usually parallel to, the surface. It includes opencast and terrace mining.

The workable overburden ratio relates to the economics of the mineral mined (up to 7.5:1 is considered the economic limit for New Zealand lignites; 10:1 for West German lignites). The quantity of mineral produced in relation to the surface area of the mine is variable, but is normally low.

This method is common to the extraction of coal phosphate, oil shales and tar sands. It is normally a large-scale operation.

The basic mining operation consists of overburden stripping, mineral extraction and backfilling, the mine progressing through the unconsolidated sedimentary "rock" that is the mineral and that, that overlies the mineral.

There are various topographic constraints on this method of mining, low slope and relief being the main ones. This implies that this mining method will be confined to such landscapes as sedimentary basins.
impacts -

The landscape above the mining prospect is progressively destroyed, as an elongated 'trench' moves through that landscape. The impact of plant and operations due to visual intrusion, noise, air and water pollution is likely to be high.

Overburden is returned to the mine as part of the mining operation, thus lowering the potential for enhanced weathering and leaching of such.

There will be a lowering of the water table, with the de-watering of the pit. There is the likelihood of sedimentation of adjacent streams.
c) Contour Strip.

components -

An operation that consists of the 'digging of a shelf' that follows the outcrop of a horizontal seam. This may involve auger mining as a part of the operation.

The overburden ratio is initially low, but increases as the mining cuts into the slope. A moderate quantity of mineral is produced in relation to the surface area of the mine. High grade coal is the mineral for which this method is commonly used.

The basic mining operation consists of the overburden being cast outslope, and the extraction of the mineral from the sedimentary rock.

Contour strip mining is topographically constrained to slopes and relief that is moderate to high. It is used in hill and valley landscapes and in mountainous terrain, (mountain top removal).
impacts -

The landscape above and below the mining prospect is destroyed, the width of the band of destruction being related to the steepness of slope, the thickness of the seam and the economic depth of extraction. A continuous high wall, shelf and spoil dump is left exposed. There will be a high impact of plant and operations on the local landscape, due to the mine's high location implying an obvious visual intrusion and increased potential for noise, air and water pollution.

Overburden is dumped outslope from the mining prospect, giving an increased potential for enhanced weathering and leaching.

The impact on the water table may be high if the coal extracted formed the aquiclude for a perched water table. Sedimentation of adjacent streams is certain.
Contour strip mining

Haulback mining
d) Hydraulic.

components -

This 'hosing-down' operation is referred to as sluicing in New Zealand.

There is usually no overburden ratio as such, the mineral being desseminated within the mineral-bearing sediments. A low quantity of mineral is produced in relation to the surface area of the mine. Alluvial gold and tin are extracted by this method.

The basic mining operation consists of the 'bank' being washed down, the slurry going to the extraction plant, the mineral being extracted, and the waste slurry being settled out downstream, normally in a settlement lagoon.

The main topographic constraint is water. Hydraulic mining is operated on sediments down slope of an adequate water supply.

impacts -

The landscape that is the mining prospect is destroyed, a water-cut bank being progressively washed-up and across the slope. There is likely to be a high impact of plant and operations on the local landscape due to the visibility of the mine and its water use and subsequent pollution.

Two grades of material are separated out by the sluicing. The heavy gravels are redistributed on the slope of the mine, the 'fines' after the mineral is extracted, are settled out of the slurry. The settlement lagoon is either abandoned when full or the solids are dug out and dumped. There is a definite potential for enhanced weathering and leaching.

The water table may rise due to water being imported to the mine. The sedimentation of adjacent streams may be possible.
e) **Dredging.**

**Components -**

This water-based operation dredges sediments in which the mineral is disseminated. The quantity of mineral produced in relation to the area worked varies with the concentration of the mineral within the sediment. The sediment may be also totally mineral, as in the case of ironsands or the mineral portion may be very low as in the case of some tin and gold placer deposits.

The basic mining operation consists of the sediment being excavated from the bottom of the flooded area, mineral extraction, the 'waste' being dumped to the rear of the dredge, forming a distinctive 'dredge tailing' topography.

The main topographic constraint is water. A water body be it - fluvial or marine, is necessary for the functioning of this form of mining.

**Impacts -**

The water-based landscape is completely altered, in the fluvial or beach situation, a dredge pond is formed round the dredge as it progresses through the sediments. There is likely to be a high impact of the plant and operations on the local landscape, due to water use and pollution, noise, dust and visual intrusion.

A high bulking factor is common in the formation of the dredge tailings. The potential for enhanced weathering and leaching exists.

The impact of dredging on the water table level may be slight, but sedimentation of adjacent water bodies may be great.
These listings of the components and impacts of the various surface mining methods are, of necessity, generalisations. The point is the scope and scale of the mining methods, not the detail. It is this scope and scale of the mining methods that implies the degree of impact the mining operation will have on the landscape - the severity of the landscape impact. The primary landscape impact of all these stated surface mining methods is that the landscape above the mining prospect is destroyed - the degree to which a new landscape may be constructed by the operation of the mining methods varies. As with the other impacts resultant from the components of the particular surface mining method, reclamation and the ability to construct that reclamation corresponds to the amount of effort and consideration given by the mining company and its planning body to enacting the reclamation or minimizing the impacts. It is impossible in a study such as this to give a grading as to the severity of landscape impact of one mining method compared to another, as the degree of impact will relate to the type of landscape on which the particular surface mining method is carried out - it suffices to say that the impact on the landscape will be severe.

As the surface mining method most likely to be used for the extraction of lignite, and in particular, the extraction of New Zealand's South Island lignites, would be that of area strip mining, some further discussion as to how this method may be deployed is called for. It is now commonplace in the United States that the area strip mining of coal is enacted as a concurrent extraction and restoration process - continuous reclamation mining. (Coates, 1973). This process has been the method of operation required by law at surface coal mines in tracts of less than 25 percent slope, which implies area strip mining as opposed to contour strip mining, in Pennsylvania since the early 1970's. (Williams 1975; 413).
Continuous Reclamation Mining.
What Williams (1975) defines as procedures typical to this process are:

a) Initial surface clearance of the mine site:
Land is cleared for the construction of access or haul roads into the area to be mined. Construction of these roads is undertaken with care so that contaminants do not enter the watershed. Where banks are created which could erode, quick-growing vegetation is planted. The area where mining is to be initiated and where appurtenant storage, maintenance, staff and on-site administration buildings are to be located is cleared of vegetation. This clearance is kept to a minimum so that as little area as possible is subjected to erosion.

b) Topsoil stripping:
Bulldozers and scrapers are used to scrape off topsoil and any needed subsoil for segregation and storage. Normally this soil is stockpiled above the highwall for easy handling after backfilling is completed. Stockpiled soil is usually not seeded because the practice of concurrent backfilling requires imminent use of this soil before erosion-controlling vegetation could be established on it.

c) Overburden removal:
The operation of overburden removal is undertaken with the spoil being placed on the 'low wall' side of the cut or sufficient distance from the highwall to permit movement of machinery in the pit - the void created by the extraction of the coal is progressing infilled, once it has been formed.

d) Acid strata segregation:
As the overburden removal operation reaches strata with acid-forming potential, this material is segregated from the clean spoil and stored in a corner of the pit or in a prepared area on the low wall where contact with water is
minimal. This is one of the most important steps in the entire surface mining operation from the standpoint of prevention of water pollution from acid discharges. (where the mineral mined or the strata surrounding the mineral has a high sulphur content, as is the case of the bituminous coal of Pennsylvania, acid formation from the oxidizing of sulphur compounds is of high risk).

e) Coal removal, then reclamation:
After the coal is exposed and removed, reclamation follows as soon as possible. In some large operations, the steps in the entire process are carried out almost simultaneously, i.e. surface clearance, topsoil segregation, overburden removal, acid segregation, coal removal and backfilling. The Pennsylvanian regulations, in 1972, did not allow the total length of open cut to exceed 500 metres, except where such was specifically approved by permit when large-size equipment was involved. This limit reportedly minimized pollution and thus practically eliminated forfeiture of bonds.

f) Reclamation:
Reclamation includes layering and compacting of the acid-forming refuse at the bottom of the pit (depending upon ground water conditions); replacement of spoil material; placement of the previously segregated topsoil and finally liming, fertilizing, and planting of the area to establish a quick-growing groundcover.
An integral part of continuous reclamation mining in Pennsylvania and a part that could be well applied to the New Zealand situation is the control of water pollution ...
Water Pollution Controls:

a) Water diversion ditches are usually required along the top of the highwall and at other appropriate locations to minimise erosion and to control the amount of water entering the pit of the mine.

b) Usually two earthen settling basins are constructed which receive all pumped water from the floor of the pit. This water must be neutralized prior to pumping if it is found to have a pH less than 6.

c) Under no circumstances may the low wall of the pit be breached to allow a gravity discharge. All water from the pit must be pumped. This is to assure that, after reclamation, no permanent acid seepage will be established at the points where the low wall was breached.

d) Erosion control basins are constructed which receive runoff from the entire disturbed area of the mine to prevent downstream siltation.

e) A barrier of undisturbed coal and overburden of at least 10 metres in width is left between the outside wall of the pit and the outcrop of the coal. This helps to promote the re-establishment of the groundwater table above the coal seam after backfilling is completed by retarding groundwater movement through the restored area. The resulting inundation of the seam and the acid-forming refuse practically eliminates acid water formation and subsequent acid seeps.

The above procedures and controls are based on a typical area strip mine in Pennsylvania where the overburden is opencast by dragline. The continuous reclamation mining described has particular emphasis placed on the two main environmental problems relative to the bituminous coal of the eastern states. This coal has a high sulphur content, and this, coupled with subsurface drainage and climatic problems, makes for a high potential for acid formation and water pollution.
Lignites with low sulphur contact do not have the same potential for acid formation. The Department of Scientific and Industrial Research has tested samples of Lignite from the Roxburgh East deposit of the South Island lignites, and found that "there is no pyrites problem associated with any of the samples (L.F.T.B. Contract No 4104/5, 1981, App.C). Pyrites is a sulphur compound and its oxidation forms sulphate acids. But as the South Island lignites involve nine separate deposits, the potential for acid formation may exist and also as many of the deposits lie in a region of relatively high rainfall and high water table, the Pennsylvanian procedures and controls in continuous reclamation mining would not be unrealistic for consideration for the mining of the South Island lignites.

Over the last ten years, many developments have been made in a form of area strip mining that has direct application to lignite extraction and the continuous reclamation process - terrace mining. The basis of continuous reclamation mining as stated in the previous list of procedures, applies to this method, but due to a dominant use of conveyors the handling and placement efficiencies of extraction and reclamation have been greatly increased. This method has been very successful in the Federal Republic of Germany, Czechoslovakia and now the western United States. (Atkinson & Carter, 1980; 191).
PARALLEL ADVANCE WITH CONVEYORS
(After Atkinson & Carter, 1980)

TERRACE MINING OPERATIONS IN STRATIFIED DEPOSITS

ROTATING PIT WITH CONVEYORS
(After Atkinson & Carter, 1980)
A knowledge of the capabilities and efficiencies of the earth-moving equipment used in the mining process is essential to the realistic planning and design of all parts of that process. Equipment currently being used in the United States includes bulldozers, front-end loaders, shovels, hoes, augers, draglines, clam shells, bucket wheel excavators, scrapers, drills, coal haulers and dredges. A system of trains, trucks, conveyers and slurry pipes transport the mineral off-site. In the Federal Republic of Germany, their large-scale surface mining of lignite is based on a linked system of bucket wheel excavators, and/or bucket chain excavators, conveyor belts, stackers and spreaders - continuous conveyance leads to their ability to obtain high mine efficiency. Smaller independent equipment is used for detailed work.
Some of the main component equipment for surface mining (A.S.L.A., 1978; 15-17) is as follows:--

a) **Bulldozers** - Bulldozers are being used for clearing terrain, constructing haul roads, levelling benches for excavating equipment, ripping overburden and reclamation grading. Sizes range from less than twelve tonnes to more than ninety tonnes.

Bulldozers are typically equipped with front-mounted blades of one of four major types: straight, angle, U-shaped or push.

Straight blades can be raised or lowered, but are fixed at right angles to the direction of travel. Tilting the top edge to the rear increases digging power, and tilting forward increases carrying capacity.

Angle blades have a smaller capacity than straight blades of the same length, but can continually carry and side cast a full load at greater speeds. This capability makes angle dozers well suited for levelling windrowed spoil banks, rough grading or making sidehill cuts.
U-shaped blades are equipped with front-curving side-wings for higher capacity in loose or free-flowing material.

Push blades are specially shaped (reinforced at the centre) for push-loading scrapers or helping trucks over adverse terrain. Push blades are not designed for production earth-moving.

Bulldozer attachments include root and rock rakes, stingers and stumpers, rippers, scarifiers, deep chisels and gougers for use in a variety of mining and reclamation operations.
b) **Stripping Shovels** - Very large stripping shovels are selected to work overburden to depths of about 30 metres. Older shovels had dipper sizes of about $4\text{m}^3$, while the newer, very large machines have dipper sizes running four times this size, up to $20\text{m}^3$. Shovel weights have increased almost nine-fold, from about 1,400 to over 12,000 tonnes.
c) **Draglines** - A significant difference in operating characteristics between draglines and stripping shovels is that draglines operate from the top of the highwall and thus can perform a greater reach and dumping radius than the shovel. This allows the removal of relatively deeper overburden. Dragline stripping is expected to account for about 80 percent of the total western states surface coal production in the foreseeable future. Bucket capacities range to over $20\,\text{m}^3$ and boom lengths are as long as 120 metres.

d) **Clamshells** - Clamshells are especially suited to vertical lifting of loose materials from one elevation to another. Various job functions may call for removal of material from below the level upon which the machine rests, or they may require carrying material above the machine. In operation, the clamshell bucket is dumped by releasing the closing line and holding it with the lowering rope.
e) Bucket Wheel Excavators (BWE) - Bucket wheel excavators are among the largest, most complicated and, under favourable circumstances, most productive excavating machines used in surface mining. They effectively remove unconsolidated overburden, such as earth, glacial till, clay and soft shale, that do not require blasting.

In one single continuous operation, a BWE will excavate material from a highwall on one side of a mine and deposit it as spoil at the rate of 150 to 200 m$^3$ per hour, up to 130 metres away on the opposite side of the pit. And it is unique among excavating machines because it is designed to operate continuously, in contrast to stripping shovels and draglines, which operate intermittently.
Bucket wheel excavator (BWE)
f) Dredges - The modern bucket-line dredge for mining placer deposits is a combined floating excavating machine and a gravity concentration system. Material is excavated at the forward end by the buckets, elevated, and discharged off the stern as coarse and small fractions. The end product is a concentrate consisting either of the valuable mineral(s) and associated heavy minerals, which are taken to a treatment plant on shore, or in the case of gold, a clean amalgam ready for the retort.

The bucket-line dredge may be adapted for purposes of directly mining valuable minerals by installing or by pumping all of the solids ashore in a pump, or for producing washed gravel in selected size fractions of which all or a selected fraction is pumped to disposal areas on shore or into side barges.
3) **Subsurface Conditions.**

"The physical characteristics of the subsurface environment form decision-making criteria for programming the process of mining, earth moving and landform design. The following physical information is required for credible decision-making:

a) Identification of the character, quality, and distribution of non-commercial material;
b) Identification of the extent, configuration, and depth, of the commercial deposit; and

Defining these three components is the science of mining geologists and engineers, and hydrologists. The ultimate definition of the components is basic to the planning of an economic and efficient mine. Once the sub-surface conditions are defined, the impact of bringing the mineral to the surface can be gauged.
4) **Surface Conditions.**

The surface conditions of any landscape can be defined by the prime biotic indicator - vegetation.

"Vegetative cover is the product of the soil, climatic conditions, landform, availability of propagules and manipulations of man. The most significant climatic influences are water, solar radiation, temperature and wind, whereas depth, fertility, texture, structure, salinity and pH are the variables affecting vegetation in soils. The landform factors of elevation, slope and aspect modify climate on both the macro and micro scale, influencing precipitation snow accumulation, exposure and run-off". (ASLA, 1978; 18).

From this biotic component of the landscape, the 'health' of the landscape can be perceived - the magnitude of each of the physical, biological and cultural components of the landscape assimilated to give the relationship that is the landscape itself.
In Summary:

These four basic and general determinants that control the impact and implications of the physical surface mining process upon the landscape are all considerations basic to the planning of the physical component of the surface mining process. The economic and social impacts and implications of the surface mining process affect the physical component as a matter of course, and in turn, the physical component affects the economic and social components. This planning must put into perspective the total of these three components.

The surface mining method, implemented by the equipment extracts from the subsurface the mineral, while modifying the surface. Such is the operation of a surface mine. Something is gained - the mineral; something is lost - the landscape. As both are requirements for human life - both present and future - a balance has to be struck. It is this question of balance that planning must address itself to. And as the landscape is a dynamic entity ... 'the countryside has always been, and presumably will always continue to be, in a constant state of change... (Tandy, 1975; 47) we must recognise mineral extraction and the landscape under the terms of landscape planning ...

"Landscape planning must recognise the existence of potential mineral wealth in connection with surface extraction and deep mining operations and quarrying. Its task will be to safeguard areas where the landscape value is great and the people are concerned at the prospect of losing the amenity, or to ensure, by detailed proposals, that the landscape is not repaired unsympathetically".

(Hackett 1971)
an overview of large-scale surface mining in New Zealand

For New Zealand, the landscape impacts and implications of large-scale surface mining are not well documented. There has been no material presented in published form, based on the New Zealand scene. The nations with large extractive industries and well-established landscape architectural professions - the United States of America, the Federal Republic of Germany and Britain - have put considerable effort into documenting the impacts and implications of surface mining on their individual landscapes. It is from these sources that a viewpoint of surface mining in New Zealand can be obtained. The employment of the components of landscape architecture has been seen by the above-mentioned nations, as essential in relating surface mining and the landscape. As for New Zealand, this working relationship is in its infancy, as is the awareness of the impacts and implications of large-scale surface mining on present day society in general. The profession of landscape architecture is being involved in the Liquid Fuels Trust Board research contract, looking at the factors affecting development of a synthetic fuels industry based on the South Island lignites. The landscape architect involved is "responsible for assessment of regional landscapes and mining impacts on landscapes". (Joint Centre for Environmental Sciences, 1981).
In relation to mining and New Zealand, the expression "large-scale surface mining" applies to any past, present or future mining activity involving the extraction of -

1) disseminated types of ore,
2) aggregates and limestones,
3) ironsands,
4) alluvial gold, and
5) coal,

- at a rate of volume production of more than a million cubic metres.

(1-5 are minerals or mineral sources that have been, are being, or are presently known to have the potential of being, surface mined, in New Zealand.)

From the accompanying table it can be seen that the large-scale surface mining has always been part of New Zealand's mining scene and based on the economy of the present, it will be part of the future scene as well. Having our past and present experience of large-scale surface mining and that of the overseas nations gives us as a nation, two sources of information from which to draw. This is essential for discussion and consideration of the future large-scale mining projects, in terms of landscape/landuse impacts and also social and economic impacts. But access to our own source - the New Zealand mining experience - may be curtailed as case histories of past and present large-scale mining activities in New Zealand (Hochstein, 1981; 4) are generally unavailable.
Past, Present and Future Large-scale Surface Mining in New Zealand:

<table>
<thead>
<tr>
<th>Type of mining/mineral source</th>
<th>Past</th>
<th>Present</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disseminated ores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strip mining</td>
<td>gold</td>
<td>•</td>
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</tr>
<tr>
<td>Hydraulic mining</td>
<td>gold</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Fluvial dredging</td>
<td>gold</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Marine dredging</td>
<td>gold</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Open pit mining</td>
<td>coal/lignite</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Strip mining</td>
<td>coal/lignite</td>
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<tr>
<td>Open pit mining</td>
<td>'heavy' sands</td>
<td>•</td>
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</tr>
<tr>
<td>Dredging</td>
<td>'heavy' sands</td>
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<tr>
<td>Open pit mining</td>
<td>aggregate/limestone</td>
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<tr>
<td>Dredging</td>
<td>aggregate</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Deep water-marine nodules</td>
<td></td>
<td></td>
<td>•</td>
</tr>
</tbody>
</table>

(after Hockstein, 1981; 51)
INDUSTRIAL MINERALS

Total production to 31.12.1978 shown for each mineral also for individual mining areas, if known, shown in brackets (tonnes)

△ Mineral production
△ Past production
X Prospecting only

Not included are building stones, clay, lime, sand, sand and gravel aggregate

Other minerals

- Obsidian
- Greenstone
- Cement works
- Proposed cement works

DIATOMITE
(cont. from North Island)
Middlemarch (1950)

SILICA SAND
(cont. from North Island)
Parapara
Cape Foulwind
Christchurch
Mt Somers
Kakahu
Hyde
Dunedin

PROSOPONITE
(183000 tonnes)
Clarendon–Melburn

LUMP SILICA
Kaitangata
Pebbly Hills

FIG. 50 Location and production of main industrial (non-metallic and bulk) minerals, to 31/12/1978
(After Thompson 1976; revised by L. J. Brown.)

industrial minerals
metallic minerals
energy minerals
Examples of large-scale surface mining in New Zealand can be discussed in terms of the minerals or mineral source mined:-

1) Disseminated Types of Ore:

In areas of volcanic activity, such as parts of the North Island, deposition of traces of minerals has taken place. These minerals have been deposited in rocks which once contained hot fluids. Such deposition still occurs today in some of our thermal systems in the Taupo Volcanic Zone (e.g. Te Ohaki). The volume percentage of disseminated ore minerals in the host rocks is always low (usually 2 percent by volume). Such ore-impregnated rocks occur, for example, in the tertiary volcanics of Coromandel and on Great Barrier Island. Minerals assemblages of these ores include, typically, gold-silver, copper-zinc-lead, and molybdenum-tungsten. Later mobilisation of these minerals resulted in some concentration in veins which were the target of past small to medium scale mining activity. (e.g. mining of gold-bearing quartz veins in Coromandel). These ore-impregnated rocks usually cannot be classed as 'ores' and it is not certain whether any economic disseminated ores occur, for example, in the Coromandel. Extensive drilling is still required to prove an economic deposit in this area. If such deposits were found, large-scale surface mining would be required to mine these ores. (Hochstein, 1981; 4). The impact of large-scale mining on the visual resource that is the Coromandel could be of a great magnitude, as could the impact on the society of the Coromandel.

2) Aggregates and Limestones:

The mining of aggregate and of limestone would normally be considered small to medium-scale, due to the factors of their economic use - location close to site of use and necessity low cost related to bulk use and transport. But in situations of large-scale use, such as the construction of the Benmore Dam, aggregate has been extracted on a large scale. And in the case of cement manufacture, for example, with the large-scale cement works planned for the Oamaru area, the extraction
of limestone can be considered large-scale. Aggregate, as it is normally deposited by sedimentation, can be displaced to give downstream sediment problems, but the ease of displacement also implies that restoration of the landscape can be accomplished with success, as is the case with the Benmore example. Limestone quarrying has a direct visual impact on the landscape due to the contrast of the mineral's light colour with the surrounding landscape colour.

3) **Ironsands:**

Titanomagnetite sands are being mined along the west coast of the North Island, at a rate of 4 to 5 million tonnes per year. Most of the production is exported to Japan. The income from one of these mines has assisted with the development of the New Zealand steel industry, which produces, at present, only about 2 percent of the mined ironsands. There are plans to increase significantly the New Zealand production of iron and steel in the near future (Hochstein, 1981; 4). The Waverley Mining Company dredging ironsands in the coastal area of South Taranaki has, via concurrent restoration increased the level of land use, in terms of agricultural production, over much of the area it has dredged. (Federated Farmers, 1981; 18). The dredging of ironsands currently has the best record in New Zealand mining scene for minimal environmental impact and productive restoration.

4) **Alluvial Gold:**

At present, a dredge is working the Taramakau River, on the West Coast, with another proposed for the Grey River. The scars left by this type of mining activity are plainly visible along many rivers of the South Island, especially the Clutha River. In terms of devastated area, alluvial gold dredging has probably caused more damage than that caused by all other types of large-scale surface mining in New Zealand. (Hochstein, 1981; 4). The view of dredge tailings lining river banks would seem to have done much to formulate the opinions many New Zealanders have about the impact of surface mining on the landscape.
With rising gold prices, the economics of gold extraction become more profitable. As only a fraction of the alluvial gold in New Zealand occurs in the young gravels of the river courses, and a significant amount occurs in the older, partly cemented gravels of the river terraces of the South Island, the potential is there for the large-scale surface mining of the terraces. (Hochstein, 1981; 4). As the extraction of alluvial gold from the terraces would involve an area strip mining method, (dredging can only be carried out in association with a body of water) moving massive amounts of material to gain a comparatively minute amount of mineral, the potential impact on the landscape could be severe, and would imply water and dust pollution, which would have a visual and physical impact.

5) Coal:

From the forecasts of the 1980 Energy Plan, Ministry of Energy, forecasts that are continued by the 1981 Energy Plan, significant expansion in New Zealand coal mining appears to be certain. This expansion will probably occur in four areas, namely Waikato, West Coast, Central Otago and Southland. Large-scale surface mining in each of these areas has potential for a marked landscape impact. Variation in the degree of impact on an area would relate to the physical and cultural 'climate' and the method of extraction used within that area.

The sub-bituminous coal of the Waikato has its bulk in a single thick seam (varying from 3 to 5 metres thick) and only a small proportion of this resource (about 50 million tonnes per year) can be extracted by surface mining. The main potential of this field can only be extracted by underground methods, and these methods will have to overcome the physical and safety problems of subsidence and flooding (Hochstein, 1981)
The West Coast areas of Buller and Grey are thought to account for 75 percent of New Zealand's known bituminous reserves. Of the 50 million tonnes in the Buller area, it is considered about 30 million tonnes could be mined by a surface method. (Birch, 1980; 57). With proposed continued and increased exporting of West Coast coal to Japan ...

"A private company with Japanese partners is considering mining the 15 million tonne Mt Davy coal reserves (part of the Grey Field) and exporting up to 500,000 tonnes per year by 1985. In addition, State Coal Mines are exploring for a suitable block of about 15-20 million tonnes with a view to the export of 70,000 tonnes per year by 1986, rising to 400,000 tonnes by 1990." (Birch, 1980; 57).

(In reference to these two 'developments' quoted above, no direct statement has been made recently as to whether they would be surface mined or not, but with the 'desired' output figures quoted, the reserves would have to be partial, if not totally surface mined to enable that degree of output). ... coupled with the fact that much of the area that could be surface mined is under native bush cover, the operational problems of surface mining in an area of high rainfall, and the 'West Coast' attitude, the exporting of coal has broad implications. There has been a notable lack of forward planning associated with past and present mining operations on the 'Coast'. (e.g. Island Block Coalmine, Reefton Field, has modified the skyline and shed debris into stream catchments on either side of the ridge, into which it cuts. (D.S.I.R. 1980; 199). Millerton Coalmine, Buller Field is presently, on fire underground and continues to pose a threat to the landscape around it.) All the above imply the potential for severe landscape impacts if ill-considered mining proceeds.

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Central Otago and Southland - the South Island Lignites are currently under research, commissioned by the Liquid Fuels Trust Board.

"Nine geographically discrete areas, three in Central Otago and six in Eastern Southland, contain sufficient lignite at shallow enough depth to warrant consideration as sources of feedstock for a coal-to-oil conversion plant." (Isaac, 1980; 32).
"The implementation of any lignite-to-liquid fuels project intended to provide a significant proportion of New Zealand's requirements would be a major undertaking on a scale as big as any industrial development in New Zealand so far. The conversion facility would occupy a significant land area, and at any time further land would be required for the mining and restoration activities." (Anderson, Wylde, 1979; 113).

To give the basis of these two quotes and to impress on the reader the scale and considered potential of the South Island lignites, it serves to quote the Lignite subsection of "Growth Opportunities in New Zealand"-

"The calorific value of the 3000 million tonne resource is estimated to be equivalent to five Maui (5700PJ) gas fields. Mining feasibility studies at present underway, and investigation into appropriate uses, have yet to define adequately how these huge reserves should be developed.

Conversion to liquid fuels appears at this stage the most promising option. Methanol synthesis and Fischer Tropsch are both commercially proven conversion processes.

From Fischer Tropsch technology, for example, the minimum size economic plant would use 500,000 tonnes of dry ash-free lignite per year to produce 200,000 tonnes of liquid fuel.

The Southland lignite, in six major blocks ranging from 200 million to 1200 million tonnes, would perhaps be mined by bucket wheel excavator - based operations. A further three blocks of lignite, each of 150 million tonnes or more, are located in Central Otago.

Seams 20 metres thick (about the average) are currently valued at $2 million per surface hectare; the surface area involved is 19,300 hectares."

(Birch, 1980; 57).
The current set of Liquid Fuels Trust Board research contracts, including that with the Joint Centre for Environmental Sciences, University of Canterbury, and associates, which is aimed at identifying the significant regional and environmental issues that would be associated with the large-scale use of the lignite, are to be used in any decision to proceed or not with planning for lignite recovery and use for liquid fuel. The Joint Centre study is also to identify the issues and information that would be needed in planning for such use. This use of the concept of contract research on this scale, is new to the New Zealand mining scene, and takes mining planning into the field of regional planning. Its use shows an awareness of the definite need for a high degree of consideration of the proposal in the pre-planning stage. Why this approach has not been used in previous mining operations may relate, in part, to there not have been considered a 'need' for such an exercise in the past, lack of the technical process for running such an exercise and to the concept of the scale and its broader implications.

The impacts and implications of large-scale surface mining developed, with its associated end-use industry, within the visually separate and unique landscapes and socially independent communities of Central Otago and Eastern Southland, will have the potential to reach proportions never seen in New Zealand before. To control, is the responsibility of those who are planning the development, as should be in the case in all mineral developments. It is the responsibility of planning - resource planning, mine planning, landscape planning, regional planning - to see that an efficient return comes to society without permanently destroying the landscape of which society is part.
Gus! Gus! Terrible news! The mining companies have been given permission to mine the wilderness! They'll wreck it!

Now look here. On behalf of lizards, snakes, scorpions, myself and other endangered species, I protest!!

I give you my categorical assurance that you will not be disturbed should any mining actually occur.

Oh, that's all right then.

Okay men, move in!

Don't believe them Gus! They are lyin'! Lyin'! Lyin'!

Not lying—just not telling the whole truth...
the law and large-scale surface mining

To put the possibilities and problems associated with the law, legislation, large-scale surface mining and the landscape into a better perspective it is necessary to look to the nations where large-scale surface mining already plays a large role as a land use.

The United States of America.

The situation in the United States, fifteen to twenty years ago was very similar to the present New Zealand situation; the mining laws which provided authority were old and unresponsive to modern technology and the scale of current and proposed mining operations. The 1872 mining law had evolved from the pressures and problems imposed by the California and Nevada mining booms of 1848 to 1866. This law was basically a general system of acquiring mining claims, and was based on hard rock mineral extraction, allowing the claimholder to develop mineral resources and to use the surface and its resources for purposes reasonably needed for mining (USDA For.Serv. 1977; 3). Our mining law would seem to have origins of similar circumstance.

In the last fifteen to twenty years, large-scale surface mining methods have undergone increased development and the environmental awareness of
many of America's citizens has also undergone increased development. New laws have been effected. The National Environmental Policy Act (NEPA) of 1969, requires all federal agencies to prepare environmental impact statements for major actions. The object of the NEPA being to "promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man". (ALSA, 1978; 8).

Linked to the N.E.P.A. are the Clean Air Act and the Federal Water Pollution Control of 1972 which require industrial compliance with air and water quality standards.

A quote from the Friends of the Earth periodical "Not Man Apart" portrays the very current and changing situation of mining policy in the United States ...

"Stripmining for coal is one of the most violent acts people inflict on the Earth, and it therefore sparked a long-running political battle over rules to mitigate the damage. Twice stripmining control bills were passed by Congress; twice they were vetoed by Gerald Ford. Finally, in 1977, Congress passed and Jimmy Carter signed the Surface Mining Control and Reclamation Act. (SMLRA). Since 1977, the Office of Surface Mining (O.S.M., set up by the Act,) has been issuing regulations and the mining industry has been challenging them in court. By the time the Carter Administration left office, some 90 percent of the OSM's regulations had been upheld by the courts, and the industry was co-operating.

Enter Ronald Reagan (elected to the office of U.S. President, November 1980) and James Watt (Reagan's Secretary of the Interior), believers in the business of doing business un-shackled. The first person to bring a lawsuit challenging the constitutionality of the SMLRA was designated as the Deputy Director of OSM. The Director-designate, James Harris, has spent years fighting implementation of the Act in
Indiana. Immediately the budget request for inspection and enforcement was halved, the regulations are being gutted and Watt is seeking to get past violators off the hook". (Webb, 1981; 2).

The purpose of the Surface Mining Control and Reclamation Act of 1977 as passed by Congress and signed into law by Carter (ASLA, 1978; 8), are:-

1. To balance the need for mining (especially surface mining) of the materials essential to the Nation's energy and economic life with human and environmental concerns;
2. To encourage the full utilization of coal resources;
3. To protect society and the environment during the surface mining process;
4. To assure that reclamation occurs to the greatest extent possible during mining operations;
5. To promote reclamation of lands mined and abandoned previous to this Act;
6. To promote research into improvement of the technology for extraction and reclamation processes; and
7. To assure procedures throughout for public participation.

This is or was being implemented by the development of state-level programmes, supported in part by federal funds.

The Act sets performance standards applicable to all surface coal mining and reclamation operations, with emphasis on the maximization of solid fuel resource recovery, so the need for remining is ruled out, and on restoration, as nearly as possible, to original or higher land use and original land contour. The Act also allows for alternative land uses and contour where practical, compatible with adjacent lands, and supported by public and private sectors. Priority as stated in the law is first to return the land to original use and contour, with consideration of alternatives only second choice.
As to the visual perception of the landscape in the legislation of American surface mining ...

"In various sections, the Act requires consideration of the visual environment through explicit language and general legislative intent. In addition, environmental standards set by the law do much to alleviate the visual impacts associated with surface coal mining. Beyond these standards, the final regulations, which translated the law into detailed procedures for implementation, only minimally express visual criteria.

Visual considerations are included in the final regulations in two categories: (1) regulation of present mining practices; and (2) reclamation of previously disturbed mine lands. Many people believe that in large part the back-to-contour reclamation provision for new mining was adopted in response to public concern for the visual impacts of surface coal mining. As such, additional visual criteria are not required in order to grant mining permits on private lands unless the land has been designated unsuitable for surface mining, nor will they be used to determine variances for post mining land uses. Each state has the discretion to include or omit visual criteria as part of the designation criteria within their Lands Unsuitable for Surface Mining Program (LUSM) and to determine reclamation priorities within their Abandoned Mine Land Reclamation Program (AMLR).

(The programmes, LUSM and AMLR, are required by the federal Surface Mining Control and Reclamation Act, but are to be effected under the law of the individual state).

Visual criteria will be considered for permitting surface mining on federal lands and to determine priorities within the U.S.D.A. Soil Conservation Service Rural Abandoned Mine Program (RAMP). It's uncertain whether visual considerations will have a role in setting priorities for distribution of research funds." (Leopold, Rowland, Stalder, 1979; 23).
This is the opinion of landscape architects who are involved with the working of this Act, an Act of 575 pages that must be the most comprehensive piece of surface mining law, as applied to a total nation, in the world.

Basic to policy and legislation is the process of change, and this is being enacted in the United States situation ...

"A fundamental change has occurred in the way natural resources policy is made. An additional set of key actors is now involved in the policy process. Judge James M. Burns of the U.S. District Court in Oregon, has described the phenomenon this way: 'The last 20 to 25 years or so have produced a significant, though largely silent, transfer or reallocation of power (perhaps a virtual revolution would not be too strong a word) in our society, a transfer of power from the executive and legislative to the judiciary. I suspect that the public generally is unaware of the fact that a good many, if not most, of the significant social, economic, and environmental decisions are now made by judges rather than by governmental Officials who are directly responsive, in an electoral sense, to the public.' (Cutler, 1979; 12).

Associated with an increased environmental awareness in various sectors of the community, has come "considerable disillusion" with the "expert wisdom of agency officials". This has induced change within the process of the courts, which has been very noticeable in the case of aesthetics. The National Environmental Policy Act (NEPA) of 1969 specifically addressed "aesthetics" as a segment of environmental quality (Cutlet, 1979; 13). And it is in the NEPA that the Surface Mining Control and Reclamation Act of 1977 finds its environmental direction.

The ability of the judge to have power over the politician is currently being put to the test in the law courts of Los Angeles, with James Watt's ill-considered decision of opening up environmentally sensitive sections
of the Californian coast for the sale of oil leases, being blocked by a federal judge (Smith, 1981; 4). With such examples, the public of the United States can see that they have the power and ability to be effective in decision-making related to their environment - the 'Voice of America' may still be heard.

Another, and a far more important factor basic to policy and legislation of the environment and surface mining, is the feeling that the people of the United States of America are gradually opening their eyes to the environment that is their country and the impact surface mining is having and can have on that environment. This is reflected in the original intent of the Surface Mining Control and Reclamation Act and by the opposition being stacked against those who seek to corrupt that intent.

The Federal Republic of Germany.

In the Federal Republic of Germany, it has long been recognised that "the multiple encroachments of mining cause deep disturbances upon the landscape, its natural balance and its visual features". (Olschowy, 1971; 1). Relating right back to the post-World War II period and the initial formation and redevelopment of the Federal Republic, effective land planning and use of their indigenous resources have been seen as key parts to their economy and society.

"Legal regulations regarding the zoning of the land-use and landscape planning during and after mining operations are prerequisites for a satisfactory recultivation and an orderly restoration of the disturbed cultivated landscapes. Recultivation and restoration plans must incorporate the changing needs of today's society ... (Olschowy, 1971; 1).

Although the Federal Republic has quite a number and variety of large-scale surface mining operations, the focus of interest for the German situation is the mines of the Lower Rhine. This concentration of interest is due to the size and depth of the pits, and also, because of the degree of town and country management and environmental planning involved. The Federal Republic has to consider the constraints placed on
its function as a controlling body, by an urban-intensive, high-energy consuming population, and the planning for this is reflected in the legislation of the mining operations - the law being detailed to a specific large-scale operation.

"The law concerning land planning in the Rhine brown coal area was passed by the State legislative of North Rhine Westphalia in 1950. Under this law a complete land use plan has to be established by the State Land Planning Commission for Rhineland. This plan was drafted by a planning committee consisting of Local Government, State Mining Agency, Land Planning Commission and Ministry of Agriculture, together with representatives of the coal mining interests, power industry and stoneware industry, farmers, mining unions and industrial unions.

A separate law established a community fund within the Rhine brown coal area to ensure the reclamation of areas adversely affected by coal mining. The fund is raised by a levy on the tonnage of raw brown coal mined but it is administered by the State Mining Office in Bonn.

The restoration of mined land is again made part of the original mining plan and the planning committee formulates land restoration requirements, based on the future use of the land, before mining permission is granted. It therefore effectively defines the conditions under which brown coal mining will take place. In this case, private enterprise undertakes the mining and restoration work according to an agreed plan. The work is supervised by a state enforcement agency." (Lindop, 1979; 28).

The Federal Republic has used its planning and mining law to bring about the opportunity to take large-scale surface mining and the exploitation of lignite and in return bring about a large-scale land usage reorganisation for agricultural and forestry purposes and for recreation.
In Review:

The scale of surface mining in the United States of America and the Federal Republic of Germany can be compared as being in the same order of magnitude, in relation to impact on the regional landscape. The culture and population densities in regard to the regions being mined are different, and this is reflected in the two nations differing approaches to mining legislation. The intent of the two forms of legislation appears to be basically similar - to remove the mineral by the most satisfactory means and with the greatest efficiency, and to return the landscape to a state of 'health' similar or better to that of the original on completion of the extraction.

The wording of the two forms of legislation read as different stories, though, in respect to the final landscape. In the United States, the priority is "first to return the land to original use and contour, with consideration of alternatives only second choice." As for the Federal Republic, the final landscape "must incorporate the changing needs of today's society". It appears that the Federal Republic sees large-scale surface mining in the context of overall land-use planning, viewing landscape modification as a means of establishing higher goals in land use. The view of the United States law has not reached this level of refinement yet, though the main direction of change has been progressive so far. The United States mining industry still views its impact as a purely temporary land use, but the reinstatement of the original landuse is now being viewed by the industry, less as the necessary evil at the end of the mining operation, and more as a concurrent part of the operation.

In both nations, large-scale surface mining of minerals is viewed as a necessary part of the nation's life. Now with the cyclic action of increasing public awareness to the environment and the cost inflicted on that environment leading to political pressure on the decision makers, and so back to the public, legislation has developed and hopefully will continue to develop, that looks to the landscape. The land-
scape afterall, is more than a passive backdrop against which we set our lives - it is the stage on which we move.

As to the direction of continuous and increasing consumption of non-renewable resources as practiced by these two nations and our own, that is another question ...

New Zealand and Mining Law:

"Our mining legislation is deficient. We have not learned from overseas examples. The mining industry, largely foreign-controlled, has free access to public resources and is subsidised to remove them. The Minister is an advocate for mining with large discretionary powers. There is no recognition of the diseconomies of mineral development nor weighing of these with the supposed benefits. Mining takes precedence and our greed is such that no place is sacrosanct. The legislation needs radical amendments but in the meantime let us try to use it to preserve our environment."

(Macfarlane, 1981; 20).

This statement defines many New Zealand feelings about our current mining law and the mining industry, in general.

New Zealand's Mining Act 1971 - "An Act to consolidate and amend law relating to mining and to provide improved facilities for the development of mineral resources" (N.Z. Laws and Statutes: Mining Act 1971; 6) is, as current statute stands, the controlling piece of legislation to guide large-scale surface mining of non-energy minerals in New Zealand (Coal is controlled by its own separate act). The development of the present government's policies of national growth related to the development of indigenous resources and industry, implies in its very nature, a development in New Zealand's large-scale surface mining.

The Mining Act 1971 is administered by the Mines Division, Ministry of Energy, and as such, the Minister of Energy is 'the advocate for mining
with large discretionary powers' mentioned above. In regard to the
government's development policies, pressure has been brought to bear on
the Minister to act and amend the current legislation.

"I was the first to concede that the Mining Act 1971 had
been overtaken by legislation during the 1970's and was
due for revision.

Farmers were concerned about the rights of the property
owner, local bodies wanted to have a greater say in the
issuing of licences, environmentalists wanted to have
stronger rights of objection and appeal and everybody
wanted somebody other than the Minister to issue the
licence." (Federated Farmers, 1981; 17).

The Mining Amendment Bill is currently before the House with the intent­
ton of being passed as by October 1, 1981.

"The challenge in upgrading this piece of legislation
was to meet those criticisms of the existing legislation
which were valid without destroying a viable mining
industry in this country. Those objectives have, I believe,
been met in this new bill..." (Federated Farmers, 1981; 17).

The Minister's objectives may have been met, but in reference to the
impacts and implications of large-scale surface mining on the landscape
very little progression in the law is apparent.

Two sections out of the 248 of the current Mining Act are directed at
what could be considered 'landscape matters' - section 82 'Conditions
relating to prevention of reduction of injury to land' and section 83
'Protection of surface of land'(refer Appendix 1). These two sections
infer that 'the Minister may impose on the licensee (the mining company)
such conditions as the Minister thinks fit' to make good disturbance or
stop disturbance to 'the surface of the land'. These two sections 82 and
83 are to be repealed by the Mining Amendment Bill, to be replaced by
sections of similar phasing and intent to those of the Act - conditions will be imposed as the "Minister thinks fit" relating to prevention or reduction of injury to land or protection of surface of land, but extending the sections to include all mining privileges, other than exploration licences and prospectors' rights. The outcome will be that the amended sections will be read as identical to the repealed sections, hardly a progressive approach to amending legislation. Some progress will be made with the inclusion of a new section - 'Protection of Land' - which is intended to provide for the territorial authority to give its views on applications for mining privileges (refer Appendix 1).

In comparison with the mining law of the United States and the Federal Republic, the current and proposed mining law of New Zealand is very light in its consideration of the landscape and the associated concerns of land-use and land-use planning. There appears to be very little offered by the New Zealand Mining Act 1971 and the proposed amendments as to the place of mineral resource planning, the impact and use of landscape modification or the context of overall land-use planning, as should be covered by a comprehensive mining law capable of dealing with the many facets of large-scale surface mining.

The National government implemented an act in 1979 to aid in the realization of its aims and strategies to accelerate the growth of New Zealand, by the development of our resources and of industry, as mentioned previously. Presently controlled by the same Minister as that of Energy, the National Development Act 1979, as it now stands and in the context of its amendment bill, enters the scene of large-scale surface mining because of its relation to the term 'large-scale'. The National Development Act is introduced as "An Act to provide for the prompt consideration of proposed works of national importance by the direct referral of the proposals to the Planning Tribunal for an inquiry and report and by providing for such works to receive the necessary consents." (N.Z.Laws and Statutes: National Development Act 1979; 1).

"Large-scale" relates to the expression "major work" in reference to "proposed works of national importance" or "national interest". The
application of this to surface mining comes from section 3(3) of the Act ...

" ... The Governor-General in Council may, if the Governor-General in Council considers that the Government work or private work is a major work that is likely to be in the national interest, and considers -

(a) That the work is essential for the purposes of

(i) The orderly production, development, or utilisation of New Zealand's resources; or

(ii) The development of New Zealand's self-sufficiency in energy...; or

(iii) The major expansion of exports or of import substitution; or

(iv) The development of significant opportunities for employment; and

(b) That it is essential a decision be made promptly as to whether or not the consents sought should be granted - apply the provision of this Act to the work or any part of it."


The potential of large-scale surface mining could be seen as work "essential for the purposes of" all four of the statements in the clause (a) above, and also relating to clause (b) above. The reference of this Act to the mining and the landscape is not the 'national interest' inference of the Act, but rather the 'speed' under which consents such as mining privileges may be considered. "Prompt consideration" by "direct referral" could possibly limit the planning period necessary for complete consideration of all the complex factors related to large-scale surface mining and the landscape.

Lignite is "coal" by legal definition, and therefore comes under the control of the Coal Mines Act 1979, "An Act to consolidate and amend the law relating to coal prospecting and mining and to regulate the
coal mining industry to ensure the proper and efficient development and use of New Zealand's coal resources." (N.Z. Laws and Statutes: Coal Mines Act 1979; 5) preliminary of the Mining Act 1971, Section 2 ...

"2 - Act not to apply to coal, etc - Nothing in this Act shall apply to -

(a) Coal or the mining of, or prospecting for, coal; ..."

But, although coal may be governed by an act separate from that governing all other minerals. This is of no relevance to so-called 'landscape matters' for section 51 (1) of the Coal Mines Act (refer Appendix 1) is identical in intent and almost identical in wording to section 82 (1) of the Mining Act 1971. Again all is left to the Minister of Energy and what he 'thinks fit'.

It is the belief of the Ministry of Energy as stated in their position paper on the lignites of Southland, 1979, that the "Coal Mines Bill (now Act) ... requires that all coal mining must be licensed by the Crown and this will ensure that the development of the resource proceeds in the best interest of the country." (pp2) It is later stated in the same paper that "large-scale exploitation of the Eastern Southland lignite deposits will involve open cast mining on a scale not seen in New Zealand to date" (pp3). This statement could be applied to the exploitation of the South Island lignites as a whole - the stated objective in the contracted report on the lignite deposits of Central Otago, filed by Lime and Marble in 1980, was to "assess the lignite bearing strata of the Central Otago region in order to establish the existence of major deposits of lignite that may be suitable for large-scale open pit mining."

"The Southland Lignite Position Paper" goes on to state that "certainly no government would permit mining to proceed without a full surface rehabilitation programme..." (pp6). "The need to provide a reclamation plan with the application for a mining license (the expression 'reclamation plan' is not actually referred to in section 42 of the Coal Mines Act - 42. Application for coal mining licence), means that if possible the land use after mining should be decided and agreed upon at the
beginning of mine planning". (pp6) and that ... "In the period before any lignite mining commences in Eastern Southland, a detailed system of reclamation planning and licensing, that will complement the existing process under the Town and Country Planning Act will be worked out. If this is done it would seem that the energy resource contained in the lignite can be mined without jeopardising the land, agricultural and water resources of the province." (pp10).

From these statements and the current consideration of planning being involved in the research contracted to the Liquid Fuels Trust Board, it would seem that the Ministry of Energy may have some intent to amend the Coal Mines Act or the implementation of that act, so as to give some legal standing to the necessary social, economic and landscape consideration that would be part of a large-scale lignite development. Much change and progression in the mining law of this country would be necessary to enact this.

To look and learn from the examples provided by the United States and Federal Republic would be a very necessary first step for all the steps involved in mineral planning and extraction. To raise the level of intent of all New Zealand's mining legislation to a level where total planning and policy making is considered an essential requirement and also a legal requirement would aid to a great degree in the consideration of the use of our non-renewable mineral resources and in the consideration of our landscape.
the future...

With a knowledge of large-scale surface mining - its determinants, its past, present and potential in New Zealand and the law that may affect it - it is possible to look to the future of such mining and its relationship to the landscape of this country.

With a continued demand for minerals that are becoming scarce and a growing demand for indigenous energy sources, a conflict potential exists within a society such as ours that has these demands and also an environmental awareness that would seem to be beginning to mature from its infancy. In New Zealand's past, surface mining has been seen as a fundamental step in our economic development, in the short-term. In the long-term the evidence that remains of this mining has shown it as a despoiler of the environment. For the future all the benefits must be long-term if we as a nation, wish to sustain our mineral resources and our environment for future generations. A balance must be struck between the demands on our minerals and those on our landscape, thus lowering the potential of conflict and avoiding the possibility of such conflict becoming kinetic.

If the potential for surface mining is implemented as part of the future of our country, the main change from the past and the present, and the
centre of any conflict that may arise, will be based on the scale of mining operations. This corresponds to the scale of the impacts and implications such mining would have upon the environment - be it natural or cultural.

Peter Steward in the "Listener" editorial of September 12, 1981 - 'Minding the Mining' - reminds us of the past and what mining brought to such regions as the Coromandel, the West Coast and Otago and the young nation of New Zealand - an influx of population that turned many local landscapes upside down in the hunt for mineral riches, making, on reflection, a colourful section of our history.

Steward also makes us aware that a second wave of 'miners' is now on our shores ...

"Today, overseas miners, garbed not in the woollen shirts of the 1860's but in corporate suits, are once more eyeing this country's potential golden wealth."

... and the scale of mining this 'second wave' envisages is not based on manpower, as with the first miners, but is based on massive machine power - the scales are in totally different orders of magnitude...

"It is this difference of scale that has to be remembered in any comparison between last century's mining activities and those proposed today."

"The miners of 120 years ago worked as individuals in the South Island, fighting the harsh landscape of Central Otago and the remote, dangerous rivers of the West Coast. The mining companies and dredges that came later were still on a modest scale (although the huge expanses of tailings on river flats are a barren reminder of the waste that can be caused). The history that was left behind was very human. The scars on the landscape frequently added their own raw
appeal. They were signs of man's struggle to establish a tenuous and temporary command over nature."

"But the massive schemes of so many of today's prospectors are beyond human scale. The tailings and the spoil of these schemes would be a very different monument to man's constant quest to recover the yellow metal..."

These comments apply equally as well to the development of large-scale projects based on energy minerals such as lignite, in terms of the impacts of scale. The responsible future for any large-scale surface mining in New Zealand should see intelligent and concerned mining activity looking to the dynamics of the landscape in which the activity is set. Through complete pre-planning the mining, the impacts of the active mine on the landscape and the community will be mitigated. A reclamation process concurrent with the efficient extraction of the mineral will lead to the re-establishment of an after-use of the exploited landscape comparable with its former use and that of the regional landscape.

Large-scale surface mining offers parts of New Zealand a potential which through creative development may lead, not only to the utilization of the mineral resource, but to the opportunity of establishing land uses of higher potential than that which can be enacted on the present landscape. This view of large-scale surface mining has been considered in Southern Arizona, U.S.A., where the demand for minerals and housing is high, and often in conflict...

"An industry that is highly equipped and skilled in the business of moving massive amounts of earth that accomplishes this task in a manner that pays for itself through the value of the ore thus extracted, is in the process of creating large-scale man-controlled landscapes. These landforms could easily serve as the replacement for the destruction of more natural areas poorly designed to meet the needs of an ever expanding housing and community development industry."

(Matter, 1977; 212).
The impact and implications of large-scale surface mining need not only be negative, for once the limits to such mining are known, the positive elements resultant from resource extraction can be developed. In terms of land use, there may be a variety of interests that could benefit not only from the mining, but in the long-term from the redevelopment of the mined area. These benefits could be in addition to satisfying the more pressing environmental issues and in fact they could be part of the solution to those environmental issues. This could see the future of large-scale surface mining viewed with a more positive attitude and the potential for conflict decreased.

In summary the future of large-scale surface mining and the relationship it will have to the New Zealand landscape is controlled by the perceived 'need' and demand for minerals. The actuality of this 'need' and demand must be determined through adequate resource and/or energy planning.

If the 'need' exists and the mineral(s) are available in New Zealand to meet this need, extraction of the mineral may follow. In planned and considered extraction, all environmental, social, economic and technological issues - the limits on mining - must be catered for. And in meeting these issues the opportunity for creation evolves. In covering these limits and opportunities the involvement of the expertise and knowledge of planning and design is essential.
landscape architecture and large-scale surface mining

an introduction...
For the reader who is not acquainted with landscape architecture, the term 'landscape' can be defined as "the relationships of all physical, biological and cultural components which are expressed in the visual landscape (that part of the environment that is visually perceived)", but yet it is more...

"... the landscape is...

... the stage on which we move. The events of life take place some where and that 'whereness' affects the perception of the event. The visual landscape, the environment we see, gives shape to our character. The objects and forms in that landscape influence our actions, guide our choices, affect our values, restrict or enhance our freedom, determine where and with what quality we will mix with each other. The perceived landscape moulds our dreams, locates our fantasies and in some mysterious way even predicts our future."

(Gussow, 1979; 7)

This emphatic statement by Gussow draws out the perspective of the term 'landscape' - "the landscape is the stage on which we move".

By "looking" at and into the landscape, we see the human interaction with that landscape - the environment. We see the lifestyles evolved from it and the physical demands made upon it - we see the depth of that landscape in relation to human experience. We will also see the change and evolution that is part of that landscape - the landscape is dynamic.

All land users interact with the landscape. And if the mine operator, by the merits of his or her operation can be seen to a 'land user', as opposed to a 'land abuser' he or she must understand natural processes, an understanding derived from a conscious and active interaction with the landscape. "The visual landscape is merely the result of this interaction, a superficial indication of the processes occurring". (Anstey, 1981).
It is at this point that a potential for conflict arises, for in reference to large-scale mining, the human-induced processes are commonly of such a magnitude as to overwhelm the natural processes associated with use of the natural surface of the land. And thereby, the landscape in total - the 'superficial indication of the natural processes occurring' - the visual landscape, and "the stage on which we move" - our human habitat - is overwhelmed. It is prior to the breakdown of the natural order of the landscape by human action that the landscape should be seen as part of nature and part of humanity.

By 'looking' at the landscape and seeing it in the perspective of its full and grand scale, we, as humans, may experience our true scale in the landscape - a scale based not on dominance and destruction, but based on tolerance and conservation. It is the landscape which we inhabit and therefore has a value to us, as a human society.

If the value placed on the mineral and its potential input to society is greater than the value placed on the landscape and its present input to society, and the decision is to mine, then the inherent landscape modification should be given great consideration.

"Landscape modifications should be viewed only as a means, never as a goal" (Gussow, 1979; 11).

The fundamental goal is the maintenance of the landscape's overall integrity and this integrity comes from the direction imposed upon it by the natural processes.
recognition of environmental ‘problems’

In the total planning and consideration of large-scale surface mining and its relationship to the landscape, it would be considered prudent to not only have a knowledge of surface mining technology, but also to have a knowledge and understanding of the impact that technology may have on the environment in which it is implemented. The purpose of this section of the study is to aid the reader's awareness of these environmental impacts, prior to the discussion of the planning aspects of large-scale surface mining.

Lignite and its extraction by an area strip mining method shall be focused on this section. The extraction of lignite is one of the largest potentials for large-scale surface mining in New Zealand, and as such, has a large potential for impact. Such a focus shall give the subject of this section greater relevance.
The environmental impact, the landscape impact, or what could be better expressed as the "environmental problems" (Down & Stocks, 1977; 10) likely to be encountered during the surface mining operation have at least four levels of influence. These levels are based on the effect of the problem upon people. Many types of environmental impact may be on more than one level, depending upon the severity with which they occur. The levels of influence, with decreasing severity are:

1) Direct hazard to human safety;
2) Indirect hazard to human well-being;
3) Damage to human possessions; and
4) Nuisance and loss of amenity.

1) Direct Hazard to Human Safety:

In this case, the hazard is that encountered while in the operating mine; those primarily at risk are the mine employees, though the general public would be at risk, if they were to gain access to the mine, or if the hazard were to move outside the mine. The potential hazards of mine operation come under the stringent legislation and control of at least three acts in New Zealand - the Mines Act, the Coal Mines Act, and the Quarries Act, the directive being to safeguard mine workers. Nonetheless, employee and public safety can be endangered on occasion through negligence or unusual or unforeseen circumstances. The principal hazards are:

a) Sudden failure of 'artefacts' - The structural collapse of topsoil dumps, drainage ditches, settlement ponds and pit walls are possibilities - the tragic potential of such catastrophes has been graphically illustrated in recent times by the Aberfan disaster in South Wales and the failure of tailings dams in the El Cobre district of Chile. The failure due to or of ill-considered major earthworks such as resulted in the Abbotsford landslip and the Ruahihi canal collapse will continue to keep the New Zealand public aware of the potential for failure in large earthworks, an awareness that may carry through to surface mining.
b) The release of toxic effluents - As mentioned previously, the potential exists in the surface mining of coal for acid formation. Whether this potential is of great import in the mining of lignite relates to the 'climate' under which the lignite was formed, which implies its sulphur content, and the climate under which it is mined. The degree of concentration of the toxic effluent, is of the greatest import. Measures should be adopted to contain and treat such substances within the operation of the mine. Danger can arise from accidental spillage of chemicals, as is possible during machine maintenance, or from unforeseen events, such as exceptionally heavy rainfall which alters the planned pattern of effluent discharge. The effects of gaseous effluents carried by the wind must be catered for also.

c) The use of explosives - Accidental initiation of explosives is very rare, but the general public is acutely conscious of the destructive potential of modern explosives. The need for the use of explosives in the extraction of lignite overlaid by loosely consolidated sediments may not be great. This would depend on the capabilities of the machinery being used for extraction. If blasting were necessary, techniques for controlling flyrock and associated risks would have to be implemented, as governed by the above-mentioned acts and the relative explosives standards.

d) Transport - Mineral transport, and particularly road traffic poses the same threat to public safety as transport arising from other sources. Most commonly this becomes an issue of importance when a mine is established in a rural area and the volume of traffic generated considerably exceeds previous levels. As for within the mine, giant trucks that can haul coal at 150 tonnes a load have little "feel" for things on the human scale.

e) Access to the mine - Adequate fencing or other security measures are normally required around any mine feature that could be the scene of an accident. This has been a particular problem related to dereliction. Active mining operations are of interest to many people and possibly the best way to contain this interest within the limits of safety is to provide adequate visitor information and view points.
2) **Indirect Hazard to Human Well-being:**

The problems in this category as with those of the next two categories are types of environmental problem for which there is no consistent and accepted techniques available to quantify the extent of the impact. This is particularly the case when loss of amenity occurs. Assessment is frequently qualitative rather than quantitative and thus contains a strong element of subjectivity. Because of the obvious and immediate nature of the threat, comprehensive measures are normally adopted to eliminate or minimize features of a mining operation which pose a direct danger to people. It is much less easy to detect and remedy those aspects which if persistent over a period of time can affect the health and safety of the general public. The most important of these are:-

a) **Air and water pollution** - Certain types of surface mining, in particular, that for base metals and that for non-metallics such as asbestos, almost invariably result in a release to the environment of toxic substances, of which the most important are metal ions and chemical reagents. This release mechanism normally continues for long periods after the mine has ceased to operate. Because of the complex combination of substances that may arise, there does seem to be some potential threat to the health, if not the life, of humans and there is the possibility that sub-lethal concentrations will be subjected to food chain magnification with consequent danger to human beings. This problem may not be encountered in the mining of lignite, but it is best to be aware of the potential.

b) **Noise and dust** - Long-term exposure to high noise levels can cause permanent hearing damage and similar exposure to dust can damage lung tissue and, in extreme cases, cause premature death. This is a problem that may have direct impact on the health of mine employees, but due to there normally being some distance separation between the mine and places of human habitation, levels of noise or dust from the mining operation are usually not sufficient to cause a public health hazard.
3) **Damage to Human Possessions:**

Many aspects of surface mining have the potential to cause damage to structures and livelihood, resulting in direct financial loss. It is inevitable also, that at the levels necessary to cause damage, nuisance and loss of amenity will also occur. Problems which affect crops or livestock may also pose an indirect threat to man by reducing or polluting sources of food. The common problems of this nature are:-

a) **Air pollution** - Both airborne dust and gaseous emissions can cause damage, the extent of which depends upon their composition and concentration. In the case of lignite extraction, dust particles of lignite are likely to be too heavy to be dispersed far from the mine, whereas dust created by machinery using the haul and access roads, plus any emissions from that machinery will have the capability of greater dispersal. This problem will be greatest during dry periods and periods of constant wind.

b) **Water pollution** - There can be a wide range of liquid effluents from surface mining which can pollute water. The effect can be that of dangerous toxicity to minor turbidity. Lignite, because of its light weight relative to water, can in particulate form, cause flocculation problems and this, depending on concentration, can be damaging. The greatest potential of water pollution from a lignite mine is that of sedimentation due to uncontrolled outwash from the mine, which can lead to silting up of steams and deposition of silt on downstream properties.

c) **Subsidence** - With the removal of large amounts of material from the ground, there is inevitably some tendency for stress readjustment which will result in ground movement. This is of importance to properties bounding the limits of the mine, in particular upslope of the mine, where ground may fail due to the support being disturbed.
d) Ground vibrations and air blast - Blasting operations give rise to ground vibrations and air blast waves which can cause structural damage. The potential diminishes rapidly with distance from the blast site, and due to the controls imposed on the use of explosives, actual damage to property is normally rare. Heavy machinery moving on external roads close to buildings can have the potential to cause vibrational damage.

4) Nuisance and Loss of Amenity:

Nuisance and loss of amenity do not threaten human existence and seldom cause a readily quantifiable pecuniary loss, therefore this area has little legislative considerations or control, but with growing environmental awareness more weight is being placed on the betterment of this area. Nuisance and loss of amenity are concerned with the quality of life and disruption of normal human activity. There is thus a strong element of subjectivity in their assessment which is inimical to quantification. The definition of the boundary between the acceptable and the unacceptable is difficult as it is affected by a wide range of factors including the nature of the impact, the location, the time of day, the duration of the impact and the susceptibilities of the individual. This makes the establishment of standards and implementation of such standards, difficult at the least.

With this level of influence of environmental problems as with the previous three, there would appear to be some correlation between the nature of the impact or problem and the number of people it affects, so each level would seem to have an equivalent weight in terms of overall impact. The first level, direct hazard to human safety - has a potential for severe impact, such as possible death by accident, but the number of people exposed to this 'impact' is limited - the employees in the mining operation. Whereas at the nuisance and loss of amenity level of influence, the actual level of impact may be low in terms of human existence but the number of people involved is potentially high, for this level affects not only those people working the mine, or those people living in the community adjacent to the mine, but potentially all those people - the travell-
ing public - who visit the area, or have or will visit the area, for surface mining has the potential to create change in the landscape and over the environment, and this change will affect the perception of that area by the people who are involved, in any capacity, in it.

The types of impact which can cause nuisance or loss of amenity are:-

a) Visual intrusion - Every aspect of mining from excavation to the surface buildings and waste disposal areas can cause visual disruption. The extent to which the mine site is visible depends principally upon the size of the operation and the nature of the surrounding topography. Visual intrusion is related mainly to the degree of visibility and the nature of the local landscape, which itself is a matter of personal value judgement. It may in general be thought advisable to reduce visibility to a minimum but this could be an oversimplification since a proportion of the general public finds interest in viewing major earthworks. What may be of more consequence, is to relate visual intrusion to the other impacts at the various other levels of influence, for when the mine and its operations are in full view, all the other factors that can be transmitted through the air, such as noise and dust, have the potential of direct impact upon the observer and the area of observation, therefore by limiting the visual intrusion, these other factors are also limited.

b) Noise and vibration - Both noise and vibration can be readily measured and therefore, in contrast to visual impact, are easily quantified. Nuisance potential seems to be related to a number of factors, principally intensity frequency, duration time of day, type of locality and individual susceptibility. Standards to control this level of nuisance must therefore relate to all of these factors to be of any effect, but again, subjectivity is the basis of contention.

c) Air and water pollution - Even at relatively low levels, air and water pollution can interfere with wildlife and natural vegetation, discolor the atmosphere and water courses, and cause contamination.
of homes and laundry by the settling of dust particles. Some contamination of household water supplies may be possible.

d) Lighting at night - Because of the massive financial cost of the equipment involved and the economics of mine operation, most large-scale surface mines of lignite operate 24 hours a day, 7 days a week. For the machine operators to have adequate visibility during the hours of darkness a lot of machine and auxiliary flood lighting is used. Though the incident light would be focussed for greatest efficiency, on the mining operation, the potential exists for reflected and scattered light to have an impact on the environment of the local inhabitants.

With nuisance and loss of amenity as with parts of the other three levels of influence, there are going to be problems as to gauging the bounds between what is acceptable and what is unacceptable in terms of impact upon the environment. Subjectivity will lead to contention, but until some fully quantifiable limits are established, the judgement of these limits may have to come from an unbiased and experienced individual or group and this judgement will have to take into account the factors influencing the nature and extent of environmental impact and the degree to which that impact may be mitigated within the landscape.

Factors influencing the nature and extent of environmental impact

In the large-scale surface mining of lignite there will be a degree of variation in both the type and severity of environmental impact from that mining (Down & Stocks, 1977; 10). This variation can be related to several factors -

1) the size of operation
2) the landscape
3) the mineral extracted
4) the method of mining, and
5) various cultural factors
1) The Size of Operation:

There must be some relationship between the scale of working and the severity of the environmental impact. And it would seem self-evident that any increase in the rate of extraction from a mine would lead to an increase in environmental impact. Increasing the size of the mine would imply the need for more fixed plant and buildings, the need for larger and possibly greater numbers of mobile plant, greater rates of lignite output and waste production and over a given period of time, the total surface area affected by mining would be greater. All these activities would normally increase the potential for some, if not all, of the main impacts including visual intrusion, air and water pollution, noise and vibration. As mentioned previously the actual ability to quantify the impacts and furthermore, the increase in impact may be difficult.

Under some circumstances an increase in output may be beneficial in reducing the overall environmental impact (Down & Stocks, 1977; 22). This may happen where the total demand for the lignite is fixed - increased output from some sites, even if at increased environmental impact, is to decrease the total number of sites required to satisfy the demand, or if the total lignite reserves at a site are fixed - any increase in output reduces the life of the mine. In both cases, it is a matter for speculation whether a higher environmental impact for a shorter time is preferable to a lower impact for a longer time.

It is apparent that no simple relationship exists between scale of working and environmental impact, and if continuous reclamation mining is implemented, the total area affected by the mining may be great, but the actual area being mined at any one time may be relatively small. It is the progression of this mining that is important, if the reclamation keeps up with the extraction, the total environmental impact may be relatively small in relation to the total area mined.
2) **Landscape:**

The individual site factors of geography and location are of extreme importance in controlling both the nature and extent of environmental impact from surface mining. (Down & Stocks, 1977; 23). These factors - be they dominated by nature or culture - come together in the expression of the landscape overlying the lignite deposit. Of the many landscape factors involved in a site, the more important are :-

a) **Topography** - The nature of the local topography and the location of the mine within it are key factors. In flat country, ground or low level features are visible for short distances only and water courses flow slowly with consequently low capacity for carrying solids in suspension. Conversely, tall features can be visible over a large area and noise and airborne dust may carry for quite long distances. In hilly or undulating countryside, the position of a feature within the landscape is most important. Hill top installations can be visually obtrusive and noise and airborne dust may travel well, whilst those in valleys are often visible only over short distances from a limited number of vantage points, and surrounding hills can form effective barriers to localise noise and dust. The carrying capacity of streams is proportional to the cube of their velocity and hence fast flowing upland watercourses can carry large volumes of sediment to be deposited in flatter lowland areas.

Topography relates the visible and physical structure of the landscape. The human experience of this implies the visual value people will place on the landscape. If the landscape is seen to comprise a region of high visual value or if it provides a habitat favourable to rare or endangered flora and fauna, the opposition to mining in that landscape is going to be intense.

b) **Climate** - Precipitation, temperature, humidity, wind and other climatic factors strongly affect the mechanisms by which pollution is transported from a mine site to the surrounding environment.
Their main influence is therefore upon the intensity of pollution and the distances over which the mine's impact is discernable. Atmospheric effects control the transmission of gaseous effluents, dust, noise and air blast whilst precipitation is of crucial importance in the dissemination of liquid effluents.

3) The Mineral Extracted:

Lignite is normally not considered toxic or polluting. Being predominantly carbon, derived from the compression and humification of wood, it is relatively inert. As mentioned previously pyrites may be present which could lead to acid formation. The rural communities and homesteads of much of Eastern Southland obtain their water supply from artesian bore. These bores are normally sunk down through clays and gravels to the lignite, which acts as an aquaclude. The groundwater is pumped from this level for household use. Though considered 'hard' the water seems to have no toxic problems.

Lignite when extracted is considered 'green' - it has a relatively high water content, which on exposure to air, will partially evaporate. Storage dumps of lignite and waste dumps containing a high proportion of lignite dross, can, if stacked, without the ability to adequately ventilate, spontaneously combust. This may lead to pit fires, machinery fires, and damage and pollution of the local environment, and possibly the regional environment if uncontrolled.

4) The Method of Mining:

The most likely method for the surface mining of lignite is area strip, the components and impacts of this method have been stated in an earlier section of this study. The open cast or terrace forms could be used on a stratified type of deposit such as lignite.

5) Cultural Factors:

The potentially dominant cultural factor would seem to be the conflict between the existing landuse and the proposed mining land use. The
potential output of lignite in nett terms would have to be balanced against the present and future output of the existing land use it will possibly disturb, plus some account has to be made of the human loss of the qualitative aspects of the land use and landscape. Further to this are the factors of:-

a) Population density - The extent to which any environmental impact may become a problem, in human terms, is very dependent upon the number of people affected by the impact. Both local indigenous population density and accessibility of the area can strongly influence environmental issues.

b) Economic and social factors - The attitude of the general public to surface mining is conditioned in part by the state of the local economy and the nature of the community. Because of factors of employment and personal income, there are normally few complaints on environmental factors from the local community, when that community is dependent on the mining operation. However, where hazard to health or safety is alleged, economic dependence does not prevent strong local reaction. This was exemplified by the Aberfan disaster in South Wales where, despite the importance of the coal mining industry, there was local pressure to remove all waste from the area following the collapse of the Aberfan top. (Down & Stocks, 1977; 23).

In concluding a discussion of the likely environmental "problems" that may be encountered in the surface mining of lignite, it can be seen that for problems - their nature and extent - the scope is wide. To focus on the actuality of these problems, one has to have more specific information from which to work. But having some idea of the total scope possible, the landscape architect can plan some form of mitigation that may lead to the minimization of these problems or impacts, and by implementing the plan, through design, may be able to combat many of the impacts with the one solution.
Paramount to the landscape architect as a person and landscape architecture as a profession, is a concern for the visual resource - a concern that is part of an overall feeling for the environment that is the visual resource and its dynamics; the landscape ...

"The visual resource, like other earth resources, must be properly managed to maintain acceptable standards of quality; whether existing quality is enhanced or degraded is a function of the nature and extent of change to the landscape. Surface mining extensively changes the landscape through removal and/or relocation of vegetation and large quantities of earth. Changes in the land's natural form, line, colour and texture that create contrast between mine and its surroundings constitute the major visual impact of surface mining." (Leopold, Rowland, & Stalder, 1979; 22).

And inherent in this appreciation of the landscape, its visual resource and surface mining is the understanding that if, landscape architects are
to be part of this short-term activity, that is mining, we must remember that the effects of mining upon people and landscape are long-term. In the words of the American Society of Landscape Architects (ASLA), taken from their publication "Creating Land for Tomorrow - a guide to Landscape Architect's participation in planning mineral development"....

"Here, then, is the essential question which gives rise to ... the landscape architect's involvement. How can surface mining be harmoniously incorporated into the land use cycle, visually acceptable, supported by the community, and enhancing, or at the very least retaining the area for future, alternative land uses? The solution can be found through creative, careful preplanning on each project, from the very beginning, designing new opportunities or preserving old ones throughout the mining process..." (ASLA, 1978:4).

And this view is in keeping with the statement of philosophy of the New Zealand Institute of Landscape Architects (NZILA)...

"The landscape reflects the cumulative effects of physical and cultural processes.

The New Zealand Institute of Landscape Architects, aims to foster and develop an understanding of these processes and to ensure that this knowledge is applied in such a manner as to conserve or enhance the quality of all natural resources and human values." (NZILA, 1980).

It is through this 'knowledge' of the landscape, that landscape architects can contribute to the solution of the 'real, complex and major problems that face the mining industry in their endeavours to extract those minerals on which this society runs.

The landscape architect has the ability to bring to the mining industry the skills of designer, planner and communicator. And these roles can be expanded to be of use to the whole of the mining operation, but it is
essential that the landscape architect has access to the complete realm of the mine planning and that the landscape architect, along with the other essential professions and sciences, be an active part of that mine planning. In relating the ability of the landscape architect to plan for people, for function and aesthetics, to the process of large-scale surface mining, the landscape architect must fully understand the mining process and be aware of the possibilities and restraints inherent in that process.

The role of the landscape architect in New Zealand is expanding into the field of landscape planning...

"Landscape planning is the examination of landscape resources, the determination and estimation respectively of the present and future demands which will have modifying effects on the landscape, and the attempted resolution of these conflicts." (Hackett, 1971).

"We can describe landscape planning as a co-operative effort aimed at integrating existing cultural and natural landscape values in the planning process. We can also describe landscape planning as the work of a specialist who is capable of inventive use of landscape factors, and is the person in the team who is able to point to potentials for development or conservation." (Vroom, 1976; 382).

As large-scale surface mining has the ability to alter completely the landscape pattern of an area, it is fundamental that landscape planning must be part of the total mine plan; in relating the mine to the current land use and landscape, and determining the land development for the long-term, after the extraction of the mineral. The inventive use of landscape factors is essential in integrating the concepts that would come from the deployment of an interdisciplinary team approach to the planning of large-scale surface mining.
In reaching to develop the mineral resource and yet maintain the landscape's overall integrity, it is paramount that the mining process must be planned, in all forms, from the outset. To deal with the scale involved and in order for sufficient depth of information to be developed, an interdisciplinary team of the professions and sciences needs to be involved. Input will be needed from at least - civil and mining engineers, geologists, hydrologists, agronomists, soil scientists, ecologists, resource planners, socioeconomists, lawyers and landscape architects. What has evolved in the United States (ASLA, 1978), as a traditional way of deploying these disciplinaries is that the sociologist and economist profile the affectes surrounding community and, with their input, help identify alternative futures; the scientific community inventories and interprets the baseline data and feasibilities. The integrator, such as the landscape architect synthesizes the information, conceptualizes and makes visible the possible alternatives.

The result of this teamwork is that the actual mining operation is planned to maximize the mineral output and minimize the impact on its natural and cultural surroundings, during the production period. And the long-term result from the mining operation will be a valid new landscape. This new landscape will be aided into being, by the visualization of alternative potential landscapes, the possibilities of these alternatives will be able to be analyzed and displayed for review by the decision-makers and the public. Visual representation can assist the planning process and aid both the mining industry and government in arriving at a decision for the long-term future use. It is when the final landscape is determined that the industry is in a capable position to assess equipment needs and operational plans.

The basis to the responsible implementation of large-scale surface mining upon the landscape is responsible and complete planning before the event. And the axis for the role of the landscape architect is the interdisciplinary team ...
"Interdisciplinary team involvement, representing the physical/natural, social/economic, and environmental design arts is the key to the full enactment of surface mining in this country". (Leopold, Rowland, Stalder, 1979; 24).

The reference "this country" applies equally as well to this country of New Zealand as it does to the country from which the above quote originates - the United States. If the "enactment of surface mining" is to be given the necessary consideration it deserves, it is necessary to fully involve all the disciplines capable of a responsive input.

Two underlying factors must be remembered throughout the period of mineral and mine planning, and they are the dynamics of the landscape and the dynamics of time. An undisturbed landscape is subject to change, induced by nature. That landscape, if totally exploited by human action, and then reinstated to a form resemblant of a balanced natural pattern, must be capable of continued evolution. The balance may be controlled by some human influence, such as agriculture or forestry, but if this influence overrides the natural influence and the landscape becomes "static" the cost of maintaining the 'static' state will be placed on the human influence.

It must be remembered, also, that, as quoted previously from the Friends of the Earth ...

"Stripmining for coal is one of the most violent acts people inflict on the Earth..."

This would apply to the surface mining of any mineral and if one is to aid in the mitigation of that "violence", one must be well aware of his or her role and capabilities, the process of surface mining, the landscape and the actions of time.
landscape architect's involvement

At this stage of the study, the direct concerns of large-scale surface mining of lignite that would come under the influence of landscape architecture will be discussed. Due to the limited resources of this study only the area stripmining of lignite will be looked at in detail - area stripmining is the method most likely to be used in the surface mining of the South Island lignites. But it will be seen that there are many parallels between this specific form of mining and its landscape concerns and the other general forms of large-scale surface mining.

As stated previously the direction of involvement of the landscape architect in the process of large-scale surface mining, would be that of landscape planning. The landscape planning input to lignite utilization could be seen as involving the landscape architect at two separate but compatible levels - energy planning and mine planning. At both levels the landscape architect would be acting as a member of an interdisciplinary team, feeding into that team, the knowledge and understanding of the landscape that has arisen from the individual's experience.
energy planning

At the energy planning level, a practising landscape architect already has an involvement in a situation that shall act as the example for the discussion of this 'level'. F.D.Boffa, of Boffa, Jackman and Associates, has the responsibility, as a member of the previously-mentioned Joint Centre for Environmental Sciences study team, "for assessment of regional landscapes and mining impacts on landscapes".

As also mentioned in a previous section of this study, the findings from the Joint Centre study, and those findings of engineering and geologic studies on the same topic - the South Island lignites - "will be used in any decision to proceed or not with planning for coal recovery and use for liquid fuel". The final planning decision will be to give the "decision-makers" the knowledgeable ability to answer the question of whether to mine or not. The answer to this question will play a direct part in the energy planning of New Zealand. (ref: "Energy Plan" 1980 and 1981).

mine planning

At the mine planning level, the actual lignite deposit will be studied as an entity and the degree of resolution for such planning shall relate to the scale of the individual deposit. The landscape architect's involvement would be in the landscape planning of the actual mining operation. This planning would be unique to each mine planned, due to the unique impacts and implications, mining would place on the local landscape overlying the lignite deposit. The landscape architect's individual "knowledge and understanding of the landscape" would be used to meet the "objectives" required to be met by an environmentally aware and socially conscious team of "planners" in developing a large-scale surface mine.
1: objectives

What are these "objectives"? There have been several groups of objectives put forward for use in other countries by various experts skilled in the knowledge of large-scale surface mining. An amalgam of these would be appropriate to lignite mining in New Zealand.

The objectives for large-scale surface mining as seen by the American Society of Landscape Architects (1978) are:

"... to harmoniously incorporate surface mining into the land use cycle; making it visually acceptable; with the support of the community; and enhancing, or at the very lease retaining the area for future, alternative land uses..."

Those of Down and Stocks (1977) from their publication "The. Environmental Impact of Mining" are:

"A landscape plan is normally intended to enable one or more of the following objectives to be attained:

1) minimum undesired visual impact throughout the life of the operation;

2) maximum benefit in respect of other environmental impacts such as noise or dust pollution; and

3) economical and effective rehabilitation of the closed mine site to a productive after-use."

Tandy (1975) in "Landscape of Industry" views the landscape objectives of surface mining as being heavily weighted towards an effective after-use of the mine site, through reclamation...
"Plans for restoration should ensure, especially in terms of landforms and texture, that the site is visually integrated into the existing landscape. They should also re-establish the basic requirements for ecological viability, physical stability and drainage equilibrium which will have been disrupted. Obviously, these elements must be mutually compatible."

Possibly the most comprehensive set of 'objectives' put forward are those stated by Coates (1973) in his article "Landscape Architectural Approach to Surface Mining Reclamation".

"1) Creation of final topography which blends with the adjoining undisturbed landscape;

2) Creation of a surface drainage pattern with no areas that promote ponding;

3) Creation of a soil condition capable of supporting plant life equal to that of the regional landscape;

4) Provision for ground cover for erosion control as soon as soil conditions allow;

5) Provision for use at some economic value; and

6) Organisation of the various steps in the operating sequence for optimum operating efficiency."

In terms of geologic time - the time scale of natural processes - surface mining would be considered a short-term land use. Even in terms of "human" time - the generations of 'man' - surface mining could be considered a short-term land use, though this time scale would vary with the scale of the mining operation. Therefore the most important phase to which any 'objectives' should be pointed would be that of subsequent long-term land use and landscape dynamics following mining. The 'objectives'
must also cover the short-term phase of mining as that is when the impact on the environment - the landscape and society - will be greatest and most apparent. So in total, any objectives based on minimizing landscape impact and social impact and on maximizing lignite extraction, for New Zealand, must first cover the operation of the mine and through that operation lead to the development of some sustainable after-use of the mine site.

By following the direction of the A.S.L.A. and the Landy "objectives" and by using the Coates "objectives" as terms to follow in the implementation of the proposed objectives, a comprehensive set of objectives for the New Zealand situation could be established. Such a set of objectives would have as its aims:

- the harmonious incorporation of surface mining into the landscape cycle;

- the visual integration of surface mining into the regional landscape;

- the social acceptance of surface mining into the society of the region; and

- the concurrent re-establishment by surface mining of a landscape capable of supporting an ongoing economic land use - a landscape containing the mutually compatible elements of ecological viability, physical stability and drainage equilibrium.

These objectives would be implemented by:

- organizing the various steps in the surface mining operation for optimum operating efficiency; with mineral disruption of the present land use; minimal disruption of the visual landscape; and minimal disruption of the regional social patterns.

- basing the surface mining operation on extraction with concurrent restoration - continuous reclamation mining; thereby re-establishing the ecological viability, physical stability and drainage equilibrium that is natural to a 'balanced' landscape.
full interaction with the social and economic needs of the society of the region.

The development of further objectives or possibly objectives considered more in line with the attitudes and needs of the nation at the time of mine planning and means of implementing them, would come with the full discussion of the "planning" team and the "decision-makers". A set of objectives such as the one above would seem to be in keeping with the present beliefs and ideals of New Zealand landscape architects.

2: stages

Having established a set of objectives that would be able to give direction for the involvement of the planning team and its landscape input, the function of the group and the individual can be developed to the full. In order to give the necessary attention to the complex relationships that operating a large-scale surface mine within a New Zealand landscape would seem likely to evolve, it will be necessary to plan the operation in simple stages. The surface mining process can be broken into three identifiable stages, the planning of each relating to that of the other two. The landscape architect would be involved in each of these stages, which are:

- Pre-mining
- Mining
- Post-mining.
Stages of mine planning

Pre-mining

A decision, based on advice from energy planning, is made to mine - the lignite will be extracted by an area strip mining method. All the factors that would affect that mine must now be detailed and a mining plan evolved that is consistent with the objectives drafted by the planning team. At the pre-mining stage, the detail planning and design of the total mining operation would be formulated. The involvement of the planning team will be at its most intense during this stage.
Landscape Assessment:

The landscape architect's involvement would be seen as landscape planning. Landscape planning, through the process of landscape assessment, would be applied in a holistic manner to the problem of defining alternative planning and design solutions, that would relate the surface mining of the lignite to the environment in which the mining is to be enacted.

The landscape assessment (Rackham, 1981) would develop in six stages:

a) Problem - the landscape and the large-scale surface mining of lignite; the two have connotations of being incompatible - the mine destroys the land.

b) Objectives - the objectives previously defined by the planning team would apply to the landscape assessment, as such objectives would be derived from the analysis of the problem.

c) Surveys - a purely quantitative stage, solely concerned with stating facts and gathering appropriate data. Such information would be derived from natural and cultural basis of the landscape and the functional requirements of the project.

d) Analyses - the collected information is interpreted to establish interrelationships between the 'parts' of the landscape. This is an aid to interpreting the landscape so as to expose its assets, potential and limitations.

e) Valuations - a value, be it objective or subjective, is placed on aspects of the relevant analyses, in terms of the requirements of the project - the mining operation, and the demand of the environment.
f) Synthesis - a summary valuation is made whereby there is a bringing together of both the site and the use - the relationship between the landscape and the large-scale surface mining of lignite is made visible. This synthesis of values leads to the formation of alternative planning and design solutions.

The landscape assessment would be the basis of the landscape input to the mining plan. Alternative planning and design solutions would consider how the mining objectives would be met and implemented, for the actual mining operation, and the environment it would affect.

With the detail of the total mining operation being considered, planned and designed for, at this pre-mining stage, the objectives of mine planning would have to be given constant notice by the members of the planning team. The objectives, being aimed toward land use incorporation; visual integration; social acceptance and reclamation of; the surface mine under the terms of efficiency, minimal disruption, socio-economic consideration and continuous reclamation mining, would give the basis for alternative solutions to the problem of the landscape and the large-scale surface mining of lignite.

Knowing the 'problem' and taking the set of 'objectives' as drafted, the next stage in the landscape assessment, the landscape survey (Rackham, 1981) would serve as an information base, it being an inventory constructed from all the landscape and project data available. The data would be derived from a variety of sources - the site, maps, aerial photos, remote imagery and literature relative to the site and its intended mining use. This data would be recorded in some readily accessible form - site information sheets, edge punch cards, written report and/or computer storage.
This information base is normally split into two areas - natural and human. The components to be considered in each are as follows -

<table>
<thead>
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<th>Natural Base:</th>
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| Climate             | - regional variations  
                      |   - local climate  
                      |   - microclimate  |
| Geology             | - rock type - permeability  
                      |     - erosion  
                      |     - strength  |
| Topography          | - type - slope  
                      |     - aspect  |
| Hydrology           | - Surface  
                      |   - Subsurface  |
| Soil                | - Type - characteristics  
                      |     - depth  |
| Flora               | - potential vegetation (ie: without human influence)  
                      |     - existing vegetation (ie: with human influence)  |
| Fauna               | - communities  
                      |     - indicators  |
Human Base:

Historic Land Use

Present Land Use
- agriculture, horticulture
- forestry
- urban
- industry
- mining
- communications
- services
- recreation

Land Values

Ownership

Existing Plans

Much of the survey information would evolve from the individual knowledge and understanding, the various members of the planning team would have of the project and the landscape. In the classification and analysis of this information specific project information would have to be incorporated. Such data for surface mining (Down & Stocks, 1977; 35) would include:-

- the mineral to be worked, so as to enable any toxicity problems to be anticipated and revegetation possibilities assessed;

- the mining method thought most economic;

- the likelihood of subsidence;

- the various details of fixed plant - type, locations, dimensions, potential for noise, dust and visual intrusion;
- the extent of waste production and surface disposal facilities required;

- the nature of waste;

- any limits and possibilities for pit design, at intervals throughout the life of the mine;

- the transport facilities needed;

- the services needed; and

- numerous other relevant aspects of the 'planned' mine.

Much of the survey information and that derived from it, could be stored upon topographic plans and sections. Depending upon the size of the project, the scale may be 1:2500 or larger, usually up to 1:5000 (Down & Stocks, 1977; 36). Any smaller scale would be inadequate for displaying the information at a degree of resolution necessary for the planning and design of a mine and its reclamation. A smaller scale may be adequate though, for gaining a 'feel' for the landscape and showing the direction for more detailed analysis.

Part of any consideration of the landscape by project landscape planning, is the visual perception of the landscape being described in terms of a visual value. As part of the landscape assessment, reference to the visual value of the existing landscape is essential. This visual value is of worth in determining the intrusion during mining and in giving a guide for the development of the aesthetics of the reclamation after mining.

The assessment of visual value is undergoing much in the way of technical development. (Clark & Fernier, 1979; 93). One technique that would be applicable to surface mining and the landscape would be the quantitative descriptive inventory (Rackham, 1981) where the visual components of the landscape is the basis to an inventory approach to the visual description and assessment of the landscape. Through such an inventory, the visual
components can be related to the other components of the landscape, as long as each component is defined on a quantitative level that is compatible. (All values placed on the components of the landscape should be able to compare; the value is giving a 'score'). From this, it is possible to define the relative value of each of the landscape components, giving an assessment of the components, based on the 'feel' the people who assess - the landscape architect, the visual 'expert' in this case - have for the components.

By completing the landscape assessment process, and especially through a full analysis - the 'taking apart' to gain a clearer understanding of the whole (Rackham, 1981) - the impacts and implications of large-scale surface mining of lignite, on the landscape will have been defined.

Responsible mine planning and landscape planning should consider the principle of efficient, economic and viable use of the land. Though surface mining may be a short-term use of land, it is a land use. For the mining operation to reach this principle, it would have to be operated so that the extraction and reclamation processes - the damage and the repair of the landscape - are a concurrent action.

"The key to success in economical, post-mining, landscape rehabilitation is the formulation and implementation of an extraction-rehabilitation operating plan, as opposed to an extraction plan which simply gets the ore out of the ground and recovers the product from it." (Williams, 1975; 409).

Aligned with landscape planning and efficient land use that could be possible with a continuous reclamation process, the mine plan would be designed to meet the objectives previously set out - harmonious incorporation, visual integration, social acceptance and concurrent re-establishment of the landscape. By considering extraction and reclamation as two phases of the same continuous process, the time to operate that process may be shortened and therefore the impact and implications of the actual mining operation on the landscape and society may be minimized.
Landscape Reclamation and Future Use:

During the valuation and synthesis stages of the landscape assessment, the landscape architect and the planning team would be considering the planning and design of the mining operation in terms of reclamation and long-term future uses of the landscape that mining would exploit. Part of this consideration would also be the mitigation of the impacts upon the environment by the active mining operation, and the role the techniques of mitigation would play, if carried into the reclaimed landscape.

"When the final landform is determined, the industry is in a better position to assess equipment needs and operational plans." (ASLA, 1978; 31).

This statement by ASLA, could be taken further to consider not only the final landform, but the total reclaimed landscape of which that landform would be part, and the use of that landscape. The alternatives for the reclaimed landscape and the associated alternatives for its future use would be postulated from the synthesis of the landscape assessment.

The design of landform is seen by many as the task of the landscape architect in the reclamation of the exploited landscape (A.S.L.A. (1978) in "Creating Land for Tomorrow - a guide to landscape architect's participation in planning mineral development". Cole, Ferraro, Mallary, Palmer and Zube (1976) in "Visual Design Resources for Surface Mine Reclamation". Downing (1977) "Landform design and grading" in Hackett's "Landscape Reclamation Practice"; and Tandy (1975) in "The Landscape of Industry"). As a composition of landforms will evolve into a physical and visual landscape, it can be seen that the landscape architect has the task of evolving the form and function of the reclaimed landscape, in co-operation with the planning team.

Downing (1977) views function as leading to a design approach that would aim to establish a landscape form that will have a maintenance liability in proportion to the profitability of the land use, or in proportion to its value to the community where direct profit is not involved. The functional approach would also result in the creation of landforms which are 'natural' in their inspiration...
"The aesthetic idea of copying nature and fitting designs into a natural pattern of the landscape is not simply a matter of bucolic fancy, but should be more soundly based on the need to create a landscape which is stable, conforms to natural drainage requirements, is low in maintenance, and has a healthy plant community related to that of the adjoining landscape." (Downing, 1977; 54).

Downing goes on to suggest that "function should be considered as a more comprehensive term, embracing the whole healthy balance of the dynamic aspects of the land in question" and that "it is important to achieve a solution that is best in economic terms and at the same time satisfactory in terms of the design, not purely as a finished product regardless of maintenance, but including the implications of continuing costs."

This leads to a classification of design constraints based on function and the limitations placed on form and function.

1) Functioning of the site after reclamation
   a) economics
   b) topographical factors
   c) aesthetics
   d) constraints of land uses

2) Limitations imposed by materials found on site

3) Limitations imposed by the technical possibilities of machinery and known reclamation techniques.

"The design solution is, in effect, the result of weighting the various constraints so as to find the optimum balance. It is unlikely that every aspect will be solved perfectly. Compromise is inevitable, but the compromise achieved must not disadvantage one aspect severely."

(Downing, 1977; 54).
In the consideration of future use of the exploited landscape that would come during the pre-mining stage, a regard to Downing's design constraints would be pertinent.

1) Functioning of the site after reclamation:

a) Economics:
The economics of landscape reclamation for future use, in terms of money and efficiency, will be felt at every stage of the planning and design process. There will be a need to establish the comparative 'costs' of the various alternatives proposed, where 'cost' will relate to the demand for and the likely productivity of the use. In terms of being 'cost' conscious, Downing suggests that two questions be answered at every planning/design decision stage...

"What is the 'cost' of the solution proposed?"

"Is this the optimum return for the money outlaid or will any increase in expenditure result in significant improvements in the overall results?"

In economic terms, it may be best if the alternative planning and design solutions for the reclaimed landscape and its use be kept open as many development options for the site as possible.

b) Topographical Factors:

In the reclaimed landscape, the topographical factors relate directly to that which will be constructed - all the 'topography' of the new landscape will be man -made. For this reason, the topographic considerations will be related directly to those of aesthetics, the deposition of the regraded material and the ecological balance of the site and the adjoining landscape.

In particular, the development of a satisfactory drainage pattern over the site requires attention to the topographical pattern of
the adjoining landscapes as well as that of the site. It is vital to achieve a stable and balanced topography so as to avoid erosion both of the surface and of the drainage channels. By re-establishing watershed characteristics that now relate to the demands of the new landscape and the adjoining landscapes, it would be possible to avoid adverse water quality effects downstream. It must be possible to make the new section of the watershed naturally free draining and thus avoid soil saturation which would lead to plant death and possible slope failure.

An important factor in relation to re-constructed topography and drainage, is the re-establishment of a water table that would meet the needs of the new landscape. The behaviour of a water table is dependent on topography, soil type, and the volume and intensity of precipitation according to the time of year. In this case, it is the topography that can be most easily controlled, so in re-grading, it is essential to be aware of the possible impact on the water table.

In the reconstruction of topography, the microclimatic factors of frost drainage and shelter must be catered for. By manipulation of the landforms, frost drainage - the unimpeded flow downslope of cold air - can be obtained. For many future uses the creation of frost pockets would be unsatisfactory. The formation of shelter by the placement of various landforms should also relate to the future use intended.

Relative to the scale of the new landscape within its regional landscape, the impact of landform shelter will vary.

Planted shelter belts may, on maturity, become topographical factors of some influence, as they have the potential of diminishing the effect of wind on the soil, both in terms of cooling effect and erosion. Shelter belts would also have an effect on the accumulation and drifting of snow, and on frost due to shading and impeded cold air drainage.
In summary of the topographical factors...

"The creation of new landforms offers unique possibilities of combining favourable arrangements of ground formation with shelter planting to create ideal climate situations. The design work is influenced by the framework of the existing topography and its consequent local climatic variations."

(Downing 1977; 55).

One further consideration in the construction of a new topography is the engineering requirements placed on it. In regrading of soil and overburden, the main engineering requirement is that imposed by the angles of repose of the various materials. The angles are modified by the degree of consolidation of the material and are affected by the general topography and drainage pattern of the area. If the design is based on natural slopes and contours, the angles of repose would not be exceeded, if even approached, so there would be no reason to fear slope failure in the reclaimed landscape due to this aspect.

c) Aesthetics:

With the increasing concern for the well-being of the environment in New Zealand and the fact that most of our landscapes are dominated by the processes of nature, it would be most acceptable to base the aesthetics of the re-constructed landscapes on naturalistic forms. Such aesthetics would blend the reclamation into the natural topography of the adjoining landscapes.

The aesthetics of the new landscape must be closely linked to the other design constraints listed. From British experience...

"Although the functional and topographical requirements of a site design may result in compromise with
the original aesthetic purpose it is the visual aspect of landscape work that causes, in the majority of cases, the most significant impact on the greatest number of people. If this is a somewhat limited reason for the subtle designs it is a more than adequate justification for the avoidance of ill-proportioned and unsightly compositions.

(Downing, 1977; 55).

Hackett (1977) sees the natural landscape as the dominant influence over the aesthetic design of a reconstructed landscape - artificial or geometric landforms being used only in the context of an environment in which man-made forms already dominate. Hackett states three principles which would govern the appearance of artificial earthworks, such as geometric landforms, so as to make them visually acceptable...

i. the containment of the form within the topographic framework;

ii. the use of simple forms resulting from primitive methods; and

iii. the relationship of the earthworks to another humanised feature.

i. and ii. relate to the placement of an artificial form within a 'natural' landscape, iii relates to the placement of an artificial form within an 'artificial' landscape. Whether a 'natural' or 'artificial' landform is used, for overall visual acceptance the new landscape must be of a scale that relates to the adjoining local landscape.

d) Constraints of land uses:

"Different land uses have different requirements for topography and its amendment. The creation of multi-purpose designs has often been expressed as a desir-
able aim by those concerned with undertaking reclamation on sites where this work is set in motion before any clear idea of the final after-use of the site has been reached. The unhappy fact is that very often the degree of flexibility required to make a site suitable, without additional work, for a range of end uses tends to reduce its usefulness for any specific purpose." (Downing, 1977; 56).

Some allowance must be made for changing circumstances during the mining operations time span, but this must not be at the loss of potential for developing the future use that was considered the ultimate during pre-mine planning.

The range of end uses for a specific site would be limited by a number of factors, such as climate, soil potential and human tradition and economics, the latter tends to imply that any new land use conforms with the pattern of development already established in the region. The possibilities for future use of the exploited landscape range from high density uses, such as industrial and urban development, through to low density uses such as agriculture and forestry, and varying density uses such as recreation. The constraints that relate to each of these uses are many and varied, but one constraint common to the satisfactory implementation of each is that of the ability of the new landscape to support plant growth. Plant growth is necessary for establishing a pleasant environment in which to work and live, and it is paramount for an healthy environment in which to play and raise animals and crops.

Where optimum plant growth is the actual functional requirement for land use, the factors that influence plant growth, such as light, mechanical support, heat, air, water and nutrients would individually or as a group, be the constraints. Such constraints can be catered for in landform design. Part of this would be the development of northern aspects, where plant production would be
highest, for the higher producing forms of agriculture, such as cropping, dairying and horticulture. The southern aspects could be minimized and used for grazing and forestry. Relative to population pressures on the new landscape, recreation, both active and passive, could be catered for. For recreation, the factors that suit optimum plant growth, suit the areas of highest use.

2) **Limitations imposed by materials found on site:**

The main limit imposed by material has already been mentioned - the angle of repose. Other limits relate to the nature of the overburden and regraded topsoil and the capability of both, separately or as a mix, to support plant growth. The relative position of the material is also important, for the ability to handle the material, and the minimization of the handling is important in landform design.

The limitations imposed on the site by the nature of the materials must be reviewed in relation to the four individual criteria for judgement enumerated for site functioning. The same is true of limitations imposed by machinery and techniques.

3) **Limitations imposed by machinery and known reclamation techniques:**

Landscape reclamation once implemented is a process of earthworking. For a landscape architect's proposals of reclamation to be carried out economically and efficiently, implies a knowledge of the machinery available to carry out major earthmoving works, and an understanding of machine operation. Particularly important is a knowledge of what can be done easily and cheaply, and what would require lengthy and highly skilled operations and hence be very costly - the feasibility of machine operation.

Various machines have different limits of use, in terms of the amount of materials that can be handled, the economic distance material can be transported, access over the site due to slope and ground conditions and allowable compaction. Much practical knowledge has been accumulated in New
Zealand in the use of earth-moving machinery and major earthworks, and this knowledge will be of use in the surface mining of lignite. As for known reclamation techniques, much has yet to be learnt...

These are the major design constraints that would affect the reclamation of the exploited landscape and its future use. The ability of the landscape architect to be successful in re-establishing a viable landscape relates to the need to work with the site rather than against it, by either suppressing its undesirable characteristics where possible, or emphasising its strong features.

New forms contrast with surrounding landscape

New rounded forms blend with surrounding landscape.
New rounded forms contrast with surrounding landscape.

Slope
Conical shaped piles

New angular forms relate to surrounding landscape.

Highwall
Terraces
Mitigation of "Problems":

In the planning and designing of reclamation and future land use during the pre-mining stage, consideration would also be given to the mitigation of the impacts imposed upon the environment by the active mining operation. The most common problems that would require landscape treatment would be those encountered in protecting the public from the visual intrusion, noise and dust mining activity could create. In the planning and design of such mitigation, various techniques would have to be developed that would comply with the potentials and limitations of the landscape that surrounds the mine.

Part of the planning would be the consideration of the role the forms of mitigation would play if they are to be kept as part of the reclaimed landscape. One of the prime considerations in staged planning and development of the lignite mine would be time. Planning must allow the necessary lead time for the establishment of the techniques so that they will be effective when mining commences. The timing of the implementation of the various techniques would relate, in most cases, to the progress of the continuous reclamation mining, which would also imply if and when the techniques would be removed, if they are not seen as part of the reclaimed landscape.

1) The Mitigation of Visual Intrusion:

"Very broadly, visual impact problems may be lessened either by concealing the obtrusive feature, or improving its appearance, or a combination of both. It is, however, unrealistic to hope that most mineral operations can be totally concealed, and thus both approaches are usually required. (Down & Stocks, 1977; 36).

This statement would hold for any large-scale surface mining of lignite where the mining operation is going to be such a dominant part of the local landscape. During the landscape assessment, a visual value would have been placed on the local landscape - its parts and the total - in which the mine will be worked. Based on the visual value, an estimate
would be made during the pre-mining stage, of the degree of visual intrusion the mining operation will bring to that landscape. From this and on the basis of the above quote, the mitigation of the visual intrusion would involve the concealment or the aesthetic improvement or both, of those parts of the mining operation that intrude.

The extent to which the mine would be visible depends primarily upon the size of the operation and the nature of the surrounding topography. Visual intrusion would relate mainly to the degree of visibility and the nature of the local landscape. The degree of visual intrusion would be controlled by the visual dominance of the intrusive feature within the local landscape and the potential effect that it would have on people.

A feature of great visual dominance has the potential to detract from the visual value of the landscape which would imply the need to reduce its dominance. Concealment would give such a reduction by blocking or screening the view to and from the feature. Aesthetic improvement works to reduce visual intrusion by making the intrusive feature an integrated part of its surroundings.
A-1 Concealment:

To develop concealment to its optimum, use should be made of any natural screening the local landscape may allow. The use of surplus, waste or stockpiled material such as topsoil stripped for re-use or overburden cast out from the first cut, would be planned so as to reinforce the natural screening. Constructed banks and mounds from excavated material must be physically stable and capable of supporting a vegetable cover, which would be necessary so as to reduce erosion of the bank and to increase the degree of concealment.

There are two areas in the surface mining of lignite where concealment could be required - concealment of the surface excavation and concealment of the fixed plant related to the mining operation...

a) Surface excavation - The flexibility in locating the actual excavation has economic constraints. Such constraints would need to be compromised if part of the landscape overlying workable lignite is needed to visually and therefore physically, conceal the excavation. In New Zealand, the surface mining of lignite would most likely be a progressive operation of extraction and reclamation, whereby any part of the landscape that is overlying lignite and acting as a natural screen could be progressed towards and worked last, if at all. This would keep the period of impact and possibly the degree of that impact, to a minimum. Related to this is the siting of access roads that enter the mine at pit floor level, by making curved access cut, direct sight-lines into the excavation can be limited.

b) Fixed plant - Much of the surface plant needed for a surface lignite mine, such as maintenance, staff and on-site administration buildings are relatively flexible in their siting. Their siting could actually be based on placement with the least visual intrusion. Any processing plant would be less flexible in its siting - the economics of movement being the controlling factor. For the concealment of fixed plant, the use of any natural landscape features for screening should be given first consideration and linked with this is the control of the height of the fixed plant so intrusion is minimized.
Techniques of Concealment:

The common forms of constructed concealment are vegetation screens or screening banks, or a combination of both. Wholly artificial means of screening, such as fencing, tall screen-fencing, hoardings and walls, could be used, but because of economics and scale, their use would be limited.

1) Vegetation Screens - If the screening function is to be fully performed it is important to realise the long-term nature of this remedy. If trees are to be used as the main component of the screen, they must be planned and designed for well in advance of commencement of the mining operation. Depending on the growth rate of the particular tree species chosen and the influence of the local climate, in excess of a decade of lead time may be required (Down & Stocks, 1977; 41). The use of semi-mature trees specially grown and transplanted for the purpose would shorten the lead time but only with the inherent disadvantage of high cost. This outlines the need for early pre-mine planning and implementation of the components of the environmental safeguards if the mine is going to be environmentally and socially acceptable.

Tandy (1975) considers the use of tree species that have a natural bush habit and dense foliage as being most appropriate where the greatest vegetative concealment is required. He suggests that such trees be used in association with screening banks and for the densest screen, the trees be planted at least 3 rows thick.
In considering the use of vegetation screens, information from the landscape survey's section on vegetation, both potential and existing, would have to be reviewed. This Section would indicate what vegetation can exist under the environmental conditions of the local landscape and therefore, what forms of vegetation would be most suitable for use as vegetation screening. Mature trees may be the most effective to obscure a view, but their use may not suit a natural tree-less environment, such as open tussock country.

ii) Screening Banks:

"The construction of screening banks of soil and overburden to conceal parts of mineral workings is an extremely common method of lessening visual impact. In Britain, a high proportion of large surface mines (notably hard-rock quarries, sand and gravel pits and open cast coal mines) construct amenity banks as a routine means of environmental improvement. The popularity of such banks is due to the relative ease of constructing them with labour and equipment already used at the mine, the fact that they form a convenient repository for waste material, and the rapidity with which the screening effect can be obtained - limited only by the earthmoving capacity which is applied to the task."

(Down & Stocks, 1977; 42).

In the design of screening banks, a choice must be made between the creation of a 'natural' or a 'geometric' landform. This choice will relate to the same aesthetic considerations given to the creation of landform in the reclaimed landscape and the permanence of the screening banks.

'Geometric' banks are the most easily formed, as the mechanical dumping of spoil leads to angular forms, without the subtle curves...
common to 'natural' forms. To achieve a 'natural' form requires the deposited spoil to be reworked by bulldozer. 'Geometric' forms may be adequate where the spoil is going to be re-distributed in a short time or when human influence is desired to be expressed in the landscape. It would seem preferable however, for large banks to be natural in form, such that they replicate and imitate the existing grades of the local landscape and obtain the advantages of physical stability and full drainage.

To design and build a screening bank of sufficient height without exceeding the amount of overburden, the space available, or the angle of repose is often difficult. Where the requirements for height can not be met, the combination of vegetation and bank may suffice.

A decision has to be made as to whether the bank should be located near the observer, or near to the feature being concealed. The former permits the same screening effect as the latter, with a smaller bank. If the bank is to be a noise baffle also, the effect on noise is greater if the bank is close to the source of the noise.

In total, the basic data required for bank design (Down & Stocks, 1977; 43) should indicate:

- the location for the bank on the basis of sight-lines between the intrusive feature and the observer.

- the location and rates of production of overburden which will be available to build the bank.

- the land area available and other site characteristics, such as drainage and air flow.

- the landform which would be most appropriate to the particular setting.
From the description of both vegetative and bank screening it can be seen that the combination of both would be most effective in terms of concealing undesirable views, while integrating the mining operation into the local landscape. With considered planning and design such screening would also act as a noise baffle because of its mass and a dust filter because of its cover. So that all three functions relate care would have to be given to the relative levels and distances between the problem source and those people it may affect.

B Aesthetic Improvement:

Because of the large-scale implied for the surface mining of lignite, total concealment would be impossible to achieve and would be considered false in its manner. Therefore, to reduce the visual intrusion of features which will remain visible, would call for design for aesthetic appeal and consideration in work methods. The components of mining which lend themselves to aesthetic improvement are:

a) Solid waste tips - Relative to the type of mining method and the landscape in which the mine is worked, tipping of waste from the pit could be necessary outside the actual confines of the mine. Conventional tipping practices create tips with the maximum visual impact, because the tip is built outwards to its final perimeter and therefore presents fresh waste surfaces throughout its life. In certain circumstances, it is possible to reduce the visual impact by regrading and establishing a temporary plant cover on the side slopes as the tip progresses.
According to Down & Stocks (1977), a technique which has considerable visual benefits is perimeter tipping, which is successfully operated in the brown coal (lignite) mines of the Federal Republic of Germany. This technique consists of the construction of a screening bank around the perimeter of the tipping area, the outer face of the bank being seeded in grass. Within the screen so formed, conventional tipping can proceed. For the success of this technique, it is important that the volumes of overburden to be tipped are known in advance, with precision, because either a shortfall or a surplus of material would reduce the benefits of a perimeter tip.

b) Settling Ponds - A number of settling ponds would have to be developed as part of the lignite mining process. Settling ponds would be necessary for the settling out of sediments from the de-watering of the pit floor along with the removal of lignite particles that may float to the surface. Separate ponds would be necessary for the removal of potentially toxic wastes, such as spent oil and anti-freeze that would collect in the oil and wash traps at the maintenance yard, and also for human wastes. All such ponds would be located away from the mine where they would receive the pumped and/or gravity flow of liquids from their points of origin. The treated water would have a potential for use in dust control, irrigation or machine wash or else be flushed into the watershed.

Choice of site for such ponds would be an important landscape consideration as would the screening of such from public view and the handling of solid waste, which, if non-toxic, could have a potential in helping to establish planting on reclaimed land and on screening banks.

c) Fixed plant - Such fixed plant as maintenance staff and on-site administration buildings are functional structures which would be built with their economic life based on the time span of the mining operation. On closure of the mine, it would be most likely that they would be demolished or transported off-site. As the basis of their design would be function, in keeping with this would be the aim to keep the actual design of the buildings simple and uncluttered and the design of their layout also simple and uncluttered.
Any structures or group of structures that are not visually 'busy' in themselves are not inclined to draw attention to themselves.

In the reduction of the visual intrusion of structures by aesthetic improvement, the colour and reflectivity of the structures will be important.

"If the design intention is to make a structure merge with its landscape background through the use of colour alone, the colour reflectivity of the structure must be similar to its background."

(Heath, 1978; 25)

And when taking into account seasonal change of the colour in the landscape...

"... it is wise to first select colours of similar reflectivity and second, to select hues which are adjacent to those predominating in the landscape background. This will minimise the colour contrast and increase the visual attachment between structural and background. Those colours selected will be compatible colours."

(Heath, 1978; 27).

Using colour to camouflage would be false and is rarely successful...

"It should be stressed, that no attempts to camouflage a structure is likely to be successful. The landscape background undergoes many seasonal colour changes, as well as colour changes due to the variable character of incident daylight. To camouflage a structure requires many colour changes to it, to correspond with these variations. This is obviously impractical. In addition camouflage colouring is likely to set up a situation of visual ambiguity to a degree which is unacceptable."

(Heath, 1978; 27).
As a design feature, the use of different but compatible colours on the structures of different function, for example, grey on convertor equipment and the processing plant to which it leads, fawn on staff and on-site administration buildings, would aid in identification and the functional unity of the structures.

If the height of the structures can be reduced, this usually reduces their visual impact. Excavation for foundations may permit buildings to be slightly sunk into the ground. In conjunction with external screening measures, lowering buildings may enable some to be concealed to a far greater degree. Some structures such as overhead convertors are not usually amenable to height reduction and in such cases, a clean, uncluttered design may be the best remedy.

The mitigation of visual intrusion would reduce the visual dominance of the offending feature. The reduction of visual intrusion would have the potential also of reducing other 'problems' such as noise and dust, especially in the case of reduction by concealment. If the view of the feature is broken down that would imply that direct impact of the other 'problems' will also be broken down. Therefore the mitigation of visual intrusion need not be developed for visual reasons alone.

2) The Mitigation of Noise:

Airborne sound is transmitted by air waves in a direct path between the source and the hearer, but it is attenuated by the distance, absorbed by various surfaces over which it passes, and deflected by physical barriers (Tandy, 1975: 89). It may seem that wind can 'carry' sound towards the listener. In fact, wind cannot increase the sound level, but it may reduce attenuation by other factors so that sound appears louder. Attenuation is also less over rising ground and across open expanses, such as lakes and valleys.

As mentioned above, the energy that is sound is dissipated by spatial attenuation, molecular absorption, and ground absorption, the first having by
far the greatest effect. Related to a point source of sound, the sound energy is approximately halved when the distance is doubled (Tandy, 1975; 89).

In application, distance is the most efficient "method" of reducing noise levels, constructed sound barriers being second to this. In a surface mine the main constant source of noise would be operating machinery. As noise from the mine would be likely to have a nuisance value to the inhabitants and users of the surrounding landscape, it would be wise to plan for the greatest separation practicable between the noise source and the hearer. If this is not adequate, constructed sound barriers would be necessary. To be effective, sound barriers must be directly between the source and the hearer, and either close to the source or close to the listener. High pitched sounds are more easily screened, low frequency sounds take the path around the obstacle with little attenuation.

When it is actually known what type of machinery will be used in the mine and their noise potential predicted, it would be possible to take action to reduce noise levels, by such measures as muffling sources of sound, building screening mounds, erecting baffles near the source or close to the nearest properties receiving the sounds or by limiting the movement, the concentration or the hours of operation, of noisy machines. If a design for mitigation has as its primary function, the reduction of noise,
the services of an acoustic engineer would be necessary.

3) The Mitigation of Dust:

Dust, a natural part of the atmosphere, can with increasing concentration become a nuisance and a pollutant. A surface mining operation, as with any other operation in which mechanical action breaks up the earth into smaller components, is going to create dust. Tandy (1975) states that excavations in cultivated agricultural soil, sub-soil, overburden, rock strata, coal, most mineral ores, sand or gravel, all give rise to comparatively large particles of 100 microns and over. (a 100 micron particle is the smallest particle discernable by the naked eye), which are harmless to plants, animals and humans, and which rarely rise above their point of origin. They tend to settle back to the ground within about 200 metres under calm conditions. On such excavation sites, dust that is fine enough to be lifted and carried by wind occurs almost solely by the drying-out of clay soil, or by the grinding down of larger particles by vehicle tyres or tracks, or by pulverization in certain machines.

Whether dust is, in fact, lifted and carried by wind, depends upon a large number of factors: (Tandy, 1975; 92), including -

- movement of the soil and/or vehicles upon the soil;
- season of the year and time of day;
- wind speed and direction;
- turbulence of air;
- soil moisture and soil temperature;
- air temperature and humidity; and
- relationship of wind direction to incidence of rainfall in the preceding few days.

In addition, roughness of the terrain, mounds, trees and other obstacles reduce the speed of the wind and cause premature deposition of the particles.

On considering the above-mentioned factors in relation to the actual
mining operation, the risk of dust as a nuisance can be established and certain precautions can be taken to minimize the risk. Solid obstructions such as mounds and sides of excavations, will, as they have in the case of noise, have a screening effect. These same obstructions may also cause turbulence and increase the dust spread. Permeable screens, such as slatted fences, trees and shrubs have greater effect (Tandy, 1975; 92) as they filter the air flow and do not cause as much turbulence as a solid mass, if the wind is not too strong.

Other ways of reducing the risk of dust as a nuisance are:

- frequent watering of dirt site roads, particularly in dry weather;
- washing the wheels of vehicles and cleaning mud off roads;
- confining vehicles to permanent site roads, spraying stocking mounds and overburden mounds with water, or better, with a plastic emulsion film;
- grass seeding on mounds with a life of more than one season; and
- re-organizing site operations at short notice to suit weather conditions and wind direction.

In continuous reclamation mining, the process of replacing and grading top soil can be the greatest dust producer, as it must be done in dry conditions. Rainfall quickly forms a 'crust' on rough ground, therefore, the soil should be left rough as long as possible, the fine tilth being produced immediately before seeding, and in the 'growing' season when rain can be expected.

It must be noted that the precautions taken against dust do not coincide with the precautions taken against noise. They may complement each other, but the optimum form and location of a noise barrier does not make it ideal as a dust filter.

In protecting the public from the 'problems' associated with the active phase of the large-scale surface mining of lignite, the landscape architect uses as tools, planning and design; as components of mitigation, vegetation and molded landform, and as an objective, the integration of the active mining operation as part of the landscape.
mining

As this stage of the surface mining process would have already been planned and designed in the pre-mining stage, the landscape architect's involvement would now be in the consideration of landscape concerns as the mine is worked. This would involve the supervision of maintenance of the various forms of impact mitigation and problem solving in regard to that mitigation and the progressive reclamation of the exploited landscape.

post-mining

This stage would also have been planned and designed in the pre-mining stage. The landscape concerns would now be that of implementing the re-establishment of the fundamentals of the landscape and the establishment of the future use activities. This would involve much in the way of 'on-the-spot' problem solving, as the plan is taken from the paper and formed in the earth.
In summing up landscape architecture and large-scale surface mining, and in particular the surface mining of lignite, it will be seen that landscape architecture has an important role to play in the potential of large-scale surface mining. This role is played both as a member of the planning team and as an individual.

The landscape architect's involvement would be seen through the implementation of landscape planning. Landscape planning would be applied to resource planning, in relation to lignite, this would mean energy planning, at a degree of resolution fitting a territorial study. The degree of resolution would be increased as the intentions of the energy planning are focussed on the detail of mine planning at the project level of landscape planning.

By being involved in the planning from the beginning, the landscape architect would be able to use the stages of mine planning to design and develop a valid new landscape from that exploited by the mine. An early involvement is necessary so that consideration can be given to all the impacts and implications of large-scale surface mining of lignite on the landscape. The result would be the mitigation of the 'problems' associated with the active mine and the development of a creative, yet functional landscape, related to the land use decided for it.
82. Conditions relating to prevention or reduction of injury to land—(1) On granting a mining licence, or at any time thereafter, the Minister may impose on the licensee such conditions as the Minister thinks fit for the purpose of preventing, or reducing, or making good, injury to the surface of the land to which the licence relates or injury to anything on the surface of the land.

(2) Without limiting the generality of the power conferred on the Minister by subsection (1) of this section, the Minister may, on granting a mining licence or at any time thereafter, impose on the licensee a condition that mining operations shall not be carried out within such distance of the surface of the land to which the licence relates as the Minister may specify.

(3) The Minister may at any time cancel or vary any condition imposed by him under this section.

Cf. 1926, No. 15, s. 105

83. Protection of surface of land, etc.—(1) In every case where an application for a mining licence specifies a method of mining proposed to be used that will disturb the surface of the land, whether by way of dredging, sluicing, or other means, the Minister shall, before granting the licence, forward copies of the application to—

(a) The Commissioner of Crown Lands for the land district in which the land is situated for a report on the nature of the land; and
(b) The Catchment Board of the catchment district, or the Catchment Commission of the catchment area, as the case may require, in which the land is situated or, if the land is situated in the Waikato Valley within the meaning of the Waikato Valley Authority Act 1956, to the Waikato Valley Authority, or, if the land is not situated within a catchment district or catchment area or the Waikato Valley, to the Soil Conservation and Rivers Control Council, for a report as to whether or not, in the opinion of the Board, Commission, Authority, or Council, the grant of a mining licence would conflict with the purposes of the Soil Conservation and Rivers Control Act 1941.

(2) If a Commissioner of Crown Lands, Catchment Board, Catchment Commission, the Waikato Valley Authority, or the Soil Conservation and Rivers Control Council, receives a copy of an application under subsection (1) of this section, he or it shall forward a report to the Minister in accordance with that subsection within one month after receiving a copy of the application or within such longer period as the Minister may in any case allow; and if the report is not received by the Minister within that period the Minister may proceed to grant the mining licence.

(3) After the consideration of any reports received by him under subsection (1) of this section and after giving the applicant an opportunity to comment on the reports, the Minister may, on granting a mining licence or at any time thereafter, specify in the licence such conditions as he thinks fit for the purpose of—

(a) Preventing, as far as is reasonably practicable, the destruction of the surface of the land;

(b) Providing, as far as is reasonably practicable, for the restoration of the surface of the land;

(c) Preventing, as far as is reasonably practicable, any conflict with the purposes of the Soil Conservation and Rivers Control Act 1941.

Cf. 1926, No. 15, s. 218; 1953, No. 89, s. 10 (1)
"Protection of Land"

"103A. Conditions relating to prevention or reduction of injury to land—(1) This section shall not apply in respect of prospectors' rights or exploration licences.

(2) On the granting of a mining privilege, the Minister may impose upon the holder of the mining privilege such conditions as the Minister thinks fit for the purpose of preventing, or reducing, or making good, injury to the surface of land to which the mining privilege relates or injury to anything on the surface of the land, or the disposal or discharge of any mineral, material, debris, tailings, refuse, or waste water produced from the exercise of the mining privilege.

(3) Without limiting the generality of the power conferred on the Minister by subsection (2) of this section, the Minister may, on granting a mining licence, impose on the licensee a condition that mining operations shall not be carried out within such distance of the surface of the land to which the licence relates as the Minister may specify.

"103B. Protection of surface of land—(1) This section shall not apply in respect of prospectors' rights or exploration licences.

(2) In every case where an application for a mining privilege specifies a method of use of the land that will disturb the surface of the land, whether by way of dredging, sluicing, or other means, the Minister shall, before granting the mining privilege, forward copies of the application to—

(a) The Commissioner of Crown Lands for the land district in which the land is situated for such report on the surface of the land as the Minister considers necessary in view of the nature of the mining privilege:

(b) The Catchment Board of the catchment district, or the Catchment Commission of the catchment area, as the case may require, in which the land is situated or, if the land is situated in the Waikato Valley within the meaning of the Waikato Valley Authority Act 1956, to the Waikato Valley Authority, or, if the land is not situated within a catchment district or catchment area or the Waikato Valley, to the Soil Conservation and Rivers Control Council, for a report as to whether or not, in the opinion of the Board, Commission, Authority, or Council, the grant of a mining privilege would conflict with the purposes of the Soil Conservation and Rivers Control Act 1941 or the Water and Soil Conservation Act 1967.

(3) If a Commissioner of Crown Lands, Catchment Board, Catchment Commission, the Waikato Valley Authority, or the Soil Conservation and Rivers Control Council,
receives a copy of an application under subsection (2) of this section, he or it shall forward a report to the Minister in accordance with that subsection within 40 working days after receiving a copy of the application or within such longer period as the Minister may in any case allow; and if the report is not received by the Minister within that period the Minister may proceed to establish the conditions to be attached to the grant of the mining privilege.

“(4) After the consideration of any reports received by him under subsection (2) of this section, the Minister may require such environmental inquiries to be undertaken as he considers necessary, and after giving the applicant an opportunity to comment on the reports and the results of any such inquiry, the Minister may, on granting a mining privilege, specify in the licence such conditions as he thinks fit for the purpose of—

“(a) Preventing, as far as is reasonably practicable, the destruction of the surface of the land;

“(b) Providing, as far as is reasonably practicable, for the restoration of the surface of the land;

“(c) Preventing, as far as is reasonably practicable, any conflict with the purposes of the Soil Conservation and Rivers Control Act 1941 and the Water and Soil Conservation Act 1967:

“(d) Preventing, as far as is reasonably practicable, the destruction of or damage to areas of scientific, wildlife, fishing, or historic interest, or special visual appeal.

“103c. Views of territorial authority—(1) This section shall not apply to prospectors’ rights or exploration licences.

“(2) In every case where an application for a mining privilege is received the Minister shall, before granting the mining privilege, forward a copy of the application to the territorial authority for the district in which the land to which the mining privilege relates is situated.

“(3) Every territorial authority, on receiving a copy of the application under subsection (2) of this section, shall cause a public notice in the prescribed form of the receipt of the application to be published in a newspaper suitable for the purpose circulating (at least once a week) in its district, and may recover the cost of the public notice from the applicant.

“(4) The territorial authority shall consider the application and shall, within 40 working days after receiving a copy of the application or within such longer period as the Minister may in any case allow, advise the Minister of its opinion, having regard to the economic, social, and environmental effects of the proposal on its district, as to—

“(a) Whether or not the application for the mining privilege should be granted; and

“(b) The conditions that should be attached to the mining privilege if it were to be granted,—
“(6) Subsequent to the giving of the notice required by subsection (5) of this section, the Secretary shall cause public notice of the proposed variation to be published in a newspaper circulating (at least once a week) in the place or district in which the land to which the mining privilege relates is situated and may, where the proposed variation was requested by the holder of the mining privilege, recover the cost of the public notice from the holder.

“(7) As soon as practical after notice has been given to the holder of the mining privilege under subsection (5) of this section, the Secretary shall cause notice of the proposed variation to be exhibited for not less than 40 working days—

“(a) In the office of the territorial authority in whose district the land to which the mining privilege relates is situated;

“(b) In the office of the Inspector of Mines nearest to the land to which the mining privilege relates.

“(8) The Minister shall not issue any memorandum of variation of conditions before the time allowed for objections to the proposed variation has expired.

“(9) Where an objection to a proposed variation of conditions has been made to the Planning Tribunal, the Minister shall not issue the memorandum of variation before the report and recommendations of the Planning Tribunal have been received.

“103e. Objections to variation of conditions—(1) Within 20 working days after the date on which public notice has been given in accordance with section 103d (6) of this Act, objections on any ground may be made to the proposed variation by any person having the right to object under subsection (2) of this section by lodging a written notice of objection in the prescribed form, stating the grounds of the objection, with the Registrar of the Planning Tribunal.

“(2) The provisions of subsections (2) to (15) of section 126 of this Act shall apply as if every reference to the applicant were a reference to the holder of the mining privilege and every reference to the proposed conditions to be attached to the mining privilege were a reference to the proposed variations.”
and if the reply is not received by the Minister within that period the Minister may proceed to establish the conditions to be attached to the grant of the mining privilege.

“(5) The Minister shall consider the reply of the territorial authority and, after giving the applicant an opportunity to comment on the reply, shall have regard to those recommendations in dealing with the application for the grant of the mining privilege.

“103b. Variation of conditions—(1) This section shall not apply to prospectors’ rights or exploration licences, or to any authorisation (including any conditions thereof) under section 80 of this Act, or any conditions suspended pursuant to section 84 (6) of this Act or to any review or reduction of the rate of royalty under section 86 of this Act or to any postponement, reduction, or remission of rent or royalties under section 131 of this Act.

“(2) The Minister may, upon such evidence as appears to him sufficient, correct errors and supply omissions in respect of any conditions attached to a mining privilege and shall thereupon forward to the holder of the mining privilege a memorandum of variation accordingly.

“(3) Subject to subsections (5) to (7) of this section and section 103b of this Act the Minister may, at any time after the grant of a mining privilege, at the request of any person who or body which proposed conditions to be attached to the grant of the appropriate licence, or at the request of the holder of the mining privilege, or of his own accord, vary the conditions subject to which the mining privilege was granted by suspending, cancelling, amending, or adding any condition, and shall thereupon forward to the holder of the mining privilege a memorandum of variation accordingly:

“Provided that where the request is made by the holder of the mining privilege or by the Minister of his own accord, the Minister shall consult with the person who or body which proposed the conditions and, if the conditions were imposed pursuant to section 26 or section 27 of this Act, also obtain the consent of that person or body to the variation.

“(4) Every memorandum of variation issued under this section shall be read with and deemed part of the mining privilege to which it relates, and, where the mining privilege has been recorded with the District Land Registrar, a memorandum of variation shall be lodged with the District Land Registrar and the provisions of this Act, with any necessary modifications, shall apply accordingly.

“(5) Before the Minister varies the conditions of a mining privilege under subsection (3) of this section of this Act, the Secretary shall cause notice of the proposed variation to be given to the holder of the mining privilege and to the appropriate territorial authority, and, if required, the appropriate body referred to in section 103b (2) (b) of this Act.
51. Conditions relating to prevention or reduction of damage to land—(1) After consideration of any reports received under section 50 of this Act and any other information or advice that the Minister considers desirable, the Minister may on granting a coal mining licence, or at any time thereafter, impose on the licensee such conditions in respect of the coal mining operations carried on pursuant to the licence as the Minister thinks fit for the purpose of preventing, or reducing, or making good, damage to the surface of the land to which the licence relates or damage to anything on the surface of that land, or preventing any conflict with the provisions of the Soil Conservation and Rivers Control Act 1941.

(2) Without limiting the generality of the power conferred on the Minister by subsection (1) of this section, the Minister may, on granting a coal mining licence or at any time thereafter, impose on the licensee a condition that coal mining operations shall not be carried out within such distance of any part of the surface of the land to which the licence relates as the Minister may specify.

(3) The Minister may at any time cancel or vary any condition imposed by him under this section.

(4) If the licensee considers that any condition (not being a condition imposed on the granting of the licence) or any variation to a condition imposed under subsection (1) of this section is unreasonable, he may serve on the Secretary a notice of objection stating the grounds of the objection. A copy of the notice of objection shall be served on the owner and occupier of the land either before or immediately after it is served on the Secretary.

(5) On the receipt of such a notice of objection, the Secretary shall forward it and all other papers and documents relating to the objection to the Registrar of the Magistrate's Court nearest to the land concerned or, with the consent of the parties to the objection, to the Registrar of any other Magistrate's Court.

(6) On receiving the notice of objection, the Registrar of the Court shall give notice of the time and place fixed for the hearing of the objection to the parties to the objection. The parties to the objection, including the Secretary, either personally or by their counsel, shall be entitled to be present and to be heard at the hearing of the objection.

(7) On hearing the objection, the Court shall allow the objection in whole or in part or decline it.

(8) The Magistrate may make such order as to costs as he thinks fit.

(9) The Registrar of the Court shall transmit to the Secretary a memorandum of the Court's decision.
(10) On receiving the memorandum of the Court's decision from the Secretary, the Minister shall amend the conditions of the licence in accordance with the Court's decision in relation to the objection.

(11) No appeal shall lie from any decision of a Magistrate under this section.

Cf. 1925, No. 39, s. 32A; 1972, No. 8, s. 37

52. Conditions relating to programme of work—(1) Every coal mining licence shall be deemed to be granted subject to the condition that the licensee shall—
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roxburgh east
and the
large-scale
surface mining
of lignite
The intent of this section of the study, "Landscape and the Large-Scale Surface Mining of Lignite", is to review the landscape consideration necessary as a planned part of a proposal to mine the lignite of the Roxburgh East deposit, Central Otago.

Detailed information on Roxburgh East, the deposit, the present land use, the social framework and other such factors that would come from a planning team's consideration of the proposal, does not currently exist. What information that does exist is inadequate for a complete and thorough landscape assessment of Roxburgh East and the large-scale surface mining of lignite. Therefore as this study is compromised by insufficient information, resources and time, the landscape assessment process will be followed through to the analysis stage with the intended outcome being the identification of the landscape issues that the large-scale surface mining of lignite would imply for Roxburgh East and its region - the problems, limitations and potentials. From this, a direction for the application of landscape architecture and the formation of a framework for further study may be established.
a landscape assessment, in part, of roxburgh east and the large scale surface mining of lignite

For an exercise in project landscape planning such as this, the landscape architect would have to act as part of a planning team, in order to cover adequately the full complexity of the proposal. The landscape architect would have a specific concern for the landscape, as part of that team. The broad range of knowledge and expertise that could be correlated from the various disciplines that make up the planning team would be essential in the total of a landscape assessment.

In making a partial landscape assessment of the Roxburgh East situation, the sophistication of such an assessment will be based on the sophistication of the information available to the landscape survey and the application of that information to the landscape analysis. The current information on the mining of the Roxburgh East lignite comes from a preliminary study of geotechnical aspects of the deposit (L.F.T.B., contract No. 4104/5, 1981). General information on the landscape of Roxburgh East can be derived from "New Zealand Land Resource Inventory Worksheet S152: Roxburgh", and this will be analysed to give a 'feel' for the landscape of the locality. The worksheet information will be reinforced by the knowledge gained from personal observation of that landscape.
Without fear of contradiction, it can be stated that implementing large-scale surface mining within the landscape of Roxburgh East would be problematical. The use of a landscape assessment as part of pre-mining planning would seek to establish the full nature of the problem and would be of application in decreasing the severity of the problem.

Objectives specific to the landscape of Roxburgh East may be necessary once all the physical, biological and cultural factors acting upon that landscape are defined by a planning team and the "decision-makers" - working with the current information and at its relative level of sophistication, the general objectives stated in the "mine planning: objectives" section of this study (pp. 103) will give an adequate basis for a preliminary discussion on the landscape aspects relative to a mining proposal such as this.

To summarise the stated objectives, the aim to decrease the severity of "the problem" may be brought about by planning the mining as part of the land use cycle, as a visually integrated part of the regional landscape, as to be socially acceptable to the society of the region and to re-establish a valid and viable landscape. Some of the stated objectives though considered necessary, will not be able to be covered in this discussion of landscape issues, as the research necessary for their fulfillment has not been given consideration yet in terms of the South Island Lignites as a group. The consideration given to the group will reflect on that given to the individual deposits.
The landscape survey in the assessment of Roxburgh East is a tabulation of natural, human, visual and mining data relevant to the mining proposal.
CLIMATE

a) Climate of the Roxburgh District

The climate of the district is directly influenced by the topography that surrounds it. The major airstreams that cover the southern part of New Zealand are from the western quarter, these airstreams cause the climate to be of a subhumid, marine nature. On striking the Southern Alps and associated uplands, the moisture-laden winds lose the greater part of their moisture, the air rises over the alps and descends into the lowlands beyond, the air warms and has a desiccating effect on the land it sweeps across. Such a rain shadow effect acts on the Central Otago region and on the district of Roxburgh. This climate pattern predominances, and results in the semi-arid climate that strengths toward the north of the district.

There is an element of uncertainty in the climate apart from dry years and wet years, hot summers and severe winters. This uncertainty includes cloudbursts, unseasonal frosts, and hailstorms. The annual rainfall for the district is approximately 530 mm, with local variation. Evapotranspiration appears to exceed precipitation leading to soil moisture stress which is reflected in the land use patterns of the district. Overall, the Roxburgh district has more available moisture than Central Otago proper.
Localized convection winds may become quite strong and frequent by day during the summer months, but they usually die down at night. Such surface winds sweep down the main valleys. Of the prevailing westerly winds, those with a northerly component are usually strong, hot and dry, while those with a southerly component are cold and often bring rain. Winds from the east are light, being deflected upwards by the mountain ranges on the east side of the district.

b) Climate of Roxburgh East

The closest source of detailed information on climatic conditions throughout the year for Roxburgh East is the meteorological station at Roxburgh Hydro. Normalized rainfall records are available for a number of recording stations in the vicinity. No sunshine data is available from Roxburgh Hydro, Alexandra data is given as a reference. The nature of the semi-arid climate of this part of Central Otago can be appreciated by contrasting the climatic data of Roxburgh Hydro with that of Dunedin.

The above-mentioned climatic data is presented on the accompanying tables, and from these it can be seen that:

- the distribution curves of rainfall and temperature follow a similar pattern; summer highs and winter lows.
- the percentage frequency of surface wind directions is dominated by winds from the north, which reflects the impact on the climate of the river gorge which contains Lake Roxburgh.

- there is a high percentage of calms which would relate to a relatively high number of ground frosts.

- a relatively low mean annual precipitation; 70 mm lower than the mean for the district, and 300 mm lower than the mean for Dunedin (from L.F.T.B. contract No. 4104/5 'Climatic data').

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The diagram illustrates the percentage frequency of surface wind directions, with Calm wind directions accounting for 47.9% of observations. The data sources are indicated as NZMS Misc. Pub. No. 109 and 109/179.
Climatic Records
Roxburgh Hydro Recording Station
### NORMALIZED RAINFALL DATA (mm)

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<th>Station</th>
<th>Number</th>
<th>Lat. S.</th>
<th>Long. E.</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
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<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year</th>
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</thead>
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<td>45 29</td>
<td>169 19</td>
<td>50</td>
<td>40</td>
<td>50</td>
<td>40</td>
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<td>169 19</td>
<td>56</td>
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<td>53</td>
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### RAINFALL IN MILLIMETRES

#### NUMBER OF DAYS WITH RAINFALL ≥ 1.0 MM

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(Source: NZMS Misc. Pub No 145, 1975)
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### CLIMATIC DATA

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<th>Av. Maxima &amp; Minima (°C)</th>
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TOPOGRAPHY

Topography of Roxburgh East

The topography of the Roxburgh district is part of the range and basin configuration of the Central Otago regional topography. The Roxburgh Basin occupies a restricted blockfault-controlled depression, situated in the Clutha River gorge system.

From the Clutha River the land of Roxburgh East rises to a plateau at an elevation of approximately 150 m above sea level. The plateau is surrounded on three sides by gently sloping gravel terraces and extends eastwards about 2.5 km, before rising rapidly into the foothills flanking the eastern margin of the basin, the Knobby Range.

To the west of the downcut course of the Clutha River is the terrace and fan topography of the Roxburgh - Coal Creek flats and the steep fault scarps of the Old Man Range, rising to 900 m above Roxburgh. To the north and south of the basin, the valley tapers into sharply incised gorges cut by the present Clutha River, the northern gorge now forms the reservoir for the Roxburgh Hydro-Electric Station at Coal Creek.

Roxburgh East has an aspect that lies well to the sun, this aspect is modified and aided in most cases, by the local relief. This relief is shown on the accompanying 'Slope' map from the inventory worksheet.
Roxburgh East, for the purpose of survey mapping, is defined as the grouping of land resource inventory factors east of the Clutha River, encompassed by the 'rock type' factor: alluvium.
The Roxburgh geologic basin consists of metamorphic rock enclosing a group of sedimentary rocks. Two major block faults of regional significance converge in the south end of the Roxburgh Basin. The fault to the west is traceable for 20 km, it trends north-south along the base of the Old Man Range, upthrown 1500 m on the west. The fault to the east is traceable for 30 km, it trends north nor'east - south sou'west, and is upthrown to the east, which has led in part, to the formation of the Knobby Range. Tertiary sediments are preserved on the down thrown side of both and at their point of convergence, the south end of the Roxburgh Basin, a large block of down faulted lignite bearing sediment has been preserved. (Bowman, 1980; 33).

The metamorphic rock is part of the Haast Schist Group. Schist forms the 'walls' and basement of the fault-controlled depression that is the Roxburgh Basin. The schist is classed as Chlorite Subzone IV; it originates from the Carboniferous and Permian periods and has been subjected to weathering during several epochs. This basement rock is now deeply weathered, coarsely foliated and highly deformed.

The schist is directly overlaid by a Tertiary sedimentary strata - the Manuherikia Group. These sediments lie unconformably on the
schist basement and reach a thickness of at least 140 m in the Roxburgh Basin. Bowman (1980) subdivides the Manukerikia Group succession into the following informal units (in ascending order):

- basal quartzose gravels and sands
- carbonaceous section (includes lignite seams)
- blue-green mudstones and siltstones.

Drilling has indicated that the basal sediments are up to 45 m thick. The main lignite seam thickness varies from 37 m in the north to 66 m in the south. The thickness of the overlying mudstones and siltstones is variable and ranges up to a maximum thickness of 50 m at the centre of the lignite deposit. (L.F.T.B., contract No. 4104/5, 1981; 11).

Quaternary gravels - glacial outwash alluvium - from 30 - 50 m thick, unconformably overlie the Manukerikia Group sediments. In parts of the Roxburgh Basin, the upper unit of the Manukerikia Group has been completely eroded prior to the deposition of the gravels, which have been deposited directly on the lignite seam.

Of the Manuherikia Group in the Roxburgh Basin, lignite is volumetrically the dominant lithology. This low ash lignite forms a deposit that has a "shallow dish" shape - the seams vary from flat lying to gently dipping. In most parts, the low ash lignite seam has several additional metres of interbedded low ash and
very high ash lignite at the bottom. The surface area of the Roxburgh East valley floor is 15 km², approximately 6 km² of this overlies potentially recoverable lignite reserves (L.F.T.B., contract No. 4104/5, 1981; 13).

b) **Engineering Geology of Roxburgh East**

Engineering geology considers such components of rock type as permeability and strength under the terms of geologic stability. The knowledge of these components at Roxburgh East, is limited due to the stage of investigation and the type of sampling method used. A complete engineering geological bore hole has been drilled, but due to mechanical difficulties, this bore was not continuously cored, which limits the evaluation of the engineering geological characteristics of the various lithologies, as does the lack of outcrops necessary for comparison with core sample.

The following is the findings on each lithology encountered by the test bore, as stated in section 4.4 'Engineering Geology' of the Liquid Fuels Trust Board's "South Island Lignite: Geotechnical Investigations: Contract No. 4104/5: Roxburgh East Deposit, Central Otago", 1981 -

"Outwash Gravels

From the (gravel) pits logged both north and south of the racecourse a general description of the gravel above the water table would be -
Brownish grey, slightly weathered, coarse to fine, GRAVEL with some cobbles with rare boulders;

- "compact"; dry well graded, faint bedding, sub-horizontal, thin to moderately thick;
- gravels, sub-rounded, schist and greywacke with some angular quartz fragments.

Data on groundwater levels in the gravels are scarce because of the drilling techniques used. However, groundwater levels measured in and adjacent to the deposit indicate that the gravels are relatively permeable and free draining. Field monitoring of the seasonal effect of irrigation water and climate variations are to verify this observation.

In gravel pits and roadside cuttings the gravels stand well in 45° slopes. However, the height of such slopes and knowledge of groundwater conditions may be insufficient to provide a basis for final design of cut slopes.

**Manuherikia Group**

Overlying Sediments:

The sediments overlying the lignite are predominantly soils, (in the engineering sense) comprising
soft to firm, moderate to high plasticity, commonly carbonaceous clayey silts and silty clays. They are generally strongly fissured probably as a result of compaction processes. Slope instability is a feature of the landscape where there are outcrops of Manuherikia Group.

**Lignite**

In the core from hole 2086 (the test bore) defects in the lignite were minimal, but extensive crushing was encountered in hole 2083 (an adjacent investigation bore) suggesting that faulting may occur locally. The lignite may also be jointed in places, judged from exposures in Harliwich pit (Coal Creek).

**Basal Quartzose Sediment**

The fine sediments and clayey gravels underlying the lignite proved difficult to drill and recovery was low. This suggests these materials might provide difficult pit floor conditions, but further drilling is required to verify this.

**Schist Bedrock**

The schist bedrock proved difficult to recover also. Core loss was high and the materials that were recovered were moderately to highly plastic, very
soft muds. There are no outcrops of such weathered schist material in the Roxburgh area. Mining operations are likely to take place on or immediately above this material."

Within the Roxburgh Basin, the lithology that forms the valley floor is alluvium - the Quaternary gravels of glacial outwash. The erosion potential of this lithology and the soils formed on it, is shown on the accompanying breakdown - "Erosion" - of the inventory worksheet. (Sheet and wind erosion for the worksheet has been assessed on an areal basis, giving the percentage of bare ground or eroding area within each unit.)

The 'Rock type' map from the inventory worksheet shows the surface geology of Roxburgh East. The geology map from L.F.T.B. contract No. 4104/5 shows the structural geology.
erosion

roxburgh east

IW  Wind  1-10% area affected
2W  Wind  11-20%
2ShW  Sheet and Wind  11-20%
ø  negligible

district

1Wsh  Wind and Sheet  1-10% area affected
1sh  Sheet  1-10%
2sh  Sheet  11-20%
2sSh  Soil slip and sheet  11-20%
rock type:

roxburgh east district

Al  alluvium
St  schist
(Lo)/St  patches of loess on schist
Al/SS  alluvium over sandstone
structural geology

Legend:
inferred fault
schist basement
alluvium

N.B.: the faulted alluvium/schist contact is inferred at depth.

There is a lack of correlation between this map and the 'rock type' map as to the position of the surface contact.

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HYDROLOGY

a) Surface Hydrology of Roxburgh East

The flow of the Clutha River dominates the hydrology of the Roxburgh area. It's flow has been utilised since the early 1950's by the Roxburgh Hydro-Electric Station which is situated on the northern boundary of the Roxburgh Basin. The Hydro dam controls the flow to a mean of $490 \text{ m}^3/\text{sec.}$, the normal level of tail water to RL 86.1 m and maximum level to RL 89.3 m. The minimum flows are in the range $50 - 100 \text{ m}^3/\text{sec.}$ and the 10 year return period flood flow is $1800 \text{ m}^3/\text{sec.}$ (L.F.T.B. contract No.:4104/5, 1981; 4). The highest flood flow known was $3300 \text{ m}^3/\text{sec.}$ during the 'Great Flood of 1878' which devastated much of Central Otago.

The Teviot River which has it's confluence with the Clutha at the southern boundary of the Roxburgh Basin, is a minor river in comparison to the Clutha, with a mean flow of $1.9 \text{ m}^3/\text{sec.}$ The Teviot supplies irrigation water to Roxburgh East, but has no other influence on the hydrology of the basin.

The local streams that drain the eastern foothills flanking the Roxburgh East plateau have been captured for use in local irrigation. The flow of these streams relates directly to the seasonal precipitation inputs. The water flow on the plateau itself is that confined to the water races and related spray and dike systems. Local swales may carry water during high rainfall.
Subsurface Hydrology of Roxburgh East

Groundwater has been considered in the L.F.T.B. contract No. 4104/5 . . .

"Groundwater investigations were limited in this study to the measurements of groundwater levels in an open hole (drilled as part of another programme adjacent to the cored engineering hole). The use of drilling mud and drilling on a 24 hour two-shift basis prevented water level measurements being taken in the cored engineering hole. The information available on groundwater levels is therefore limited but an appraisal of the groundwater regime has been made from observation of other boreholes and springs in the area.

Groundwater levels were measured in drillhole 2085 over the period November-December 1980 at RL 120 m. This is approximately 30 m below ground level.

Groundwater seeps were observed on the lower river terrace adjacent to the Clutha River at McElligot Road and Gilmour Road, ranging from RL 113 m to 115 m. The phreatic line falls by approximately 5 m over the 600 - 700 m between the drill hole and the seepage line on the terrace. Thus an appreciation
only of the ground water regime can be obtained from this rather meagre data and indicates the relatively high permeabilities of the gravels. No information was able to be gained on the ground-water regime to the east of drillhole 2085. This area covers the bulk of the lignite deposit. A stock watering pond is situated adjacent to Woodhouse Road and may indicate a perched water table, while a shallow depression which gave the appearance of carrying water at intermittent intervals was noted running from Woodhouse Road to the confluence of the Teviot and Clutha Rivers.

Discussions with local residents in the course of these limited investigations revealed that seepages and flows from springs have become more persistent since the upper terraces have been intensively irrigated. It is probable that the continued irrigation of the land has resulted in an appreciable rise in groundwater levels. It is also probable that groundwater levels would fall if the irrigation was stopped and the amount of surface runoff that was able to infiltrate the ground from the foot hills to the east of the deposit was restricted.

There is no record of artesian water pressures being encountered in drillhole 2086 or the open holes.
drilled in other programmes. This does not preclude the possibility of strong groundwater flows occurring in some of the sandy beds at depth.

The use of a heavy drilling mud would render it most unlikely that groundwater inflows (unless under high pressures) would be observed by the drillers.

Finally, the permeability of the gravels, and their ability to be dewatered by pumping or well pointing has not been verified."
a) Soils of the Roxburgh District

"Soils may be classified according to the climatic conditions assisting in their formation, or according to the nature of the underlying parent rocks, or by both. The soils are, in general, youthful and, in consequence the parent geological materials have greater influence than in mature soils. The semi-arid conditions, brought about by evaporation exceeding precipitation, result in the ground water being, in parts, deep below the surface, and between the water table and the alternately wet and dry soil there is a zone of varying and variable width which is permanently dry. This, in addition to occasional complete drying-out of the soil, precludes the growth of trees. The soils contain comparatively large amounts of soluble matter deposited as ground water is evaporated from the surface or is transpired by plants. The local soils contain relatively little humus and are therefore light-coloured; their granular structure owing to their content of soluble matter (calcium carbonate) gives them good tilth; but, fertility is related to the amount of moisture which is available and the best results will be obtained when an efficient
means of adding organic matter to the soils is found." (Webster, 1948; 2)

b) Soils of Roxburgh East

The soils of Roxburgh East are dominated by brown-grey earths. Profiles are characterised by platy, brownish-grey topsoils and pale, yellowish-brown subsoils with a distinct claypan. Accumulations of calcium carbonate are common in the deep subsoil and high concentrations of soluble salts may occur throughout the profile. Brown-grey earths occupy flat, sloping, undulating, rolling and hilly terrain on schist, colluvium and alluvium, with a thin surface layer of schist loess, under annual rainfalls of about 300-500 mm.

The brown-grey earths that cover the valley floor have all originated from the greywacke alluvium that formed the terraces. Lowburn shallow sandy loam covers the western portion of the plateau. This is a shallow soil of less than 500 mm depth and has the profile characters of sandy and gravelly textures, subsoil claypan, subsoil calcium carbonate and no structure. The Lowburn hill soils of the north west and northern terrace faces are very similar to the Lowburn shallow sandy loam.

The Ripponvale sandy loam of the south west and southern terrace faces is a moderately deep soil of over 600 mm depth. Its profile characters are sandy textures, weak platy topsoil structures and
massive subsoils. The Molyneux shallow sandy loam of the river flat terrace is shallow and has sandy and gravelly textures with subsoil calcium carbonate.

The other soil group present on the Roxburgh East valley floor are intergrades between brown-grey and yellow-grey earths formed from schist alluvium outwashed from the flanking foot hills. These are the Pigburn fine sandy loam and the Pigburn shallow sandy loam covering the eastern portion of the plateau. The Pigburn fine sandy loam is a moderately deep soil with fine sandy textures, moderate and weak nutty structures and moderate level of faunal activity. The Pigburn shallow sandy loam is a shallow soil with sandy textures moderately nutty structures and a moderate level of faunal activity.
<table>
<thead>
<tr>
<th>Soil Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Ripponvale sandy loam</td>
</tr>
<tr>
<td>ML</td>
<td>Molyneux shallow sandy loam</td>
</tr>
<tr>
<td>L</td>
<td>Lowburn shallow sandy loam</td>
</tr>
<tr>
<td>LH</td>
<td>Lowburn hill soils</td>
</tr>
<tr>
<td>PB</td>
<td>Pigburn fine sandy loam</td>
</tr>
<tr>
<td>PBs</td>
<td>Pigburn shallow sandy loam</td>
</tr>
<tr>
<td>T</td>
<td>Tailings</td>
</tr>
</tbody>
</table>

**District**

<table>
<thead>
<tr>
<th>Soil Unit</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>C</td>
<td>Convoy shallow sandy loam</td>
</tr>
<tr>
<td>CH</td>
<td>Convoy hill soils</td>
</tr>
<tr>
<td>WD</td>
<td>Waenga fine sandy loam</td>
</tr>
<tr>
<td>W</td>
<td>Waenga shallow sandy loam</td>
</tr>
<tr>
<td>CS</td>
<td>Cairnside shallow sandy loam</td>
</tr>
<tr>
<td>CSH</td>
<td>Cairnside hill soils</td>
</tr>
<tr>
<td>RX</td>
<td>Roxburgh steepland soils</td>
</tr>
</tbody>
</table>
Flora of the Roxburgh District

The native vegetation - the potential vegetation - is drought-resistant, the dominant community being lowland short tussock grassland. Where the climate will allow, such as along river banks, southern aspects of valleys and in deep gullies, shrub forms of manuka, olearia, hebe, kowhai and matagouri exist, along with raupo and tutu in the dampest areas.

The predominant vegetation community is that of introduced grassland - the grazed pasture. Lucerne is cropped as winter feed, some cereals are also cropped. The trees and shrubs of stone, pip and berry fruit production are common to the main valley floor. Willow, poplar, pine and various other exotic tree species have been planted for shelter, river bank protection and aesthetic appeal, these species being reinforced by wildings established from their wind-blown seed. Of the many introduced plants, barleygrass, sorrel, Californian thistle, ragwort, sweet briar, gorse, broom and lupin cover large areas and in many cases, are classified noxious weeds.

Flora of Roxburgh East

The potential vegetation for Roxburgh East would be the same as that for the district - lowland short tussock grassland, if
human influence was removed. The existing vegetation is very much human dominated, in terms of establishment and maintenance. The trees and grasses associated with the agricultural and horticultural land use of Roxburgh East are all exotic, and most require irrigation for their survival.

Willows and poplars are common to the river bank, along water races and around dredge ponds. Pines have been used for shelter planting and as plantations. The trees and shrubs of stone, pip and berry fruit production have been established on the south facing terrace and in scattered pockets across the eastern margin of the valley. High producing pasture dominates the plateau as shown on the accompanying 'vegetation' map from the inventory worksheet. Sweet briar, gorse, broom and mixed native shrub associations grow on unoccupied land.
vegetation

roxburgh east

P1 h 2 high producing pasture, with some orchards.
P1, 2 h 2 n.p. pasture & low producing grassland, with some rushes.
P2 low producing grassland.
P2 m 6 low producing grassland, with some mixed native scrub assns.
P2 m 10 low producing grassland, with some sweet briar.
L2 P1, 2 orchards, high producing pasture & low producing grassland.
P1 high producing pasture
P2 low producing grassland
P3 short tussock assns.
P4 snow tussock assns.
M1 Manuka

sub-dominant: pl; l l (cereals);
    l 2; m 7 (broom);
m 10; m 11 (matagouri);
a) **Fauna of the Roxburgh District**

Lacking any recent account on the fauna of the district and the time to make a personal observation, any statement on the fauna of the Roxburgh area will be somewhat limited. From a personal knowledge of the variety of bird and animal that inhabit the farmlands of Otago and Southland, it can be assumed that the farmlands of Roxburgh have a species pattern based on introduced domestic livestock - sheep, cattle, horse, pig and goat.

Common to the farmlands of the south are the endemic species of birds that have colonised the human-influenced environment. These include the black-backed gull, the black-billed gull, spur-winged plover, terns, harrier hawk, pukeko, duck, quail, blackbird, thrush, starling, sparrow, yellow-hammer, green-finch and silvereye to name the most numerous.

Associated with the habitats of the birds are feral goat, rabbit, hare, stoat and weasel. Of the animals, the rabbit would have had the greatest impact on the landscape of the Roxburgh district and great effort is still maintained to control rabbit numbers.

b) **Fauna of Roxburgh East**

It is believed that the fauna of Roxburgh East would follow that
of the district, the sheep population having the greatest influence. Horses are bred and raced, cattle are not common.

There is no record of any bird or animal population being special to this area.
HISTORIC LAND USE

a) Historic Land Use of the Roxburgh District

From A.H.H. Webster's "Teviot Tapestry - a history of the Roxburgh - Millers Flat district", published in 1948...

"The principal industry of the district is sheep-farming and it is the oldest. Gold mining, the next chronologically, has to all intents and purposes, died out. The growing of fruit as a commercial project was commenced by the early miners on their small sections and is, now, of considerable importance in the economy of the northern part of the district, where stone and pip fruits are cultivated. Small fruits are cultivated, too, but not to anything like the same extent. Many orchardists are also sheep-farmers, a fact which helps them when frosts, hail storms, or bad seasons occur. The rabbit, pest though it is, enters importantly into the commercial field because of the value of its skin and carcase. Sundry other industries are practised, one of the more recently established being a dehydrating factory, since converted to canning and pulping."
For many years coal-mining for lignite has been carried out - more particularly during the boom period when the gold dredges required large quantities of coal. The present owner of the coal pits (at Coal Creek) has been working on the open cast system, sluicing away the overburden (sic.), for a number of years. This coal has been the salvation of the district during the war period and the years since then with their labour shortages and industrial problems.

A power station on the Teviot River near Roxburgh has supplied the electrical needs of the district since 1924, and indeed, supplied the needs of a great part of Otago Central until the Roaring Meg Station (upstream from Cromwell, on the bank of the Kawarau River) came into operation in 1936. Power from the Teviot Station was carried as far as Cromwell. But by far the most important project of late years is the Coal Creek Hydro-Electric Scheme (Roxburgh Hydro) - a proposal to erect a dam across the Molyneux (Clutha) about six miles above Roxburgh and to generate some three hundred thousand kilowatts of power. This power will be carried to the large industrial areas and will not affect the local situation to any great extent, but the influx of workers with their families, and the necessary improvements to communications must have a
big effect on the region.

The district is served by a branch railway from Milton. This line was brought as far as Lawrence quite early, but it was not until 1928 that it reached Roxburgh, the matter being held up while the respective merits of the present line and an alternative route through Edievale (from Southland) were discussed. The main road to the Otago Central and the Lakes traverses the district from end to end, and with Government activity in the matter of road improvement and the speed of modern transport, is within easy distance of both the Lakes and the cities of Dunedin and Invercargill as well as the lesser towns, Gore, Balclutha and Milton. The modern motor-car and the improved roads have tended to send holiday-makers further afield, whereas, in years gone by, numbers were in the habit of holidaying in this vicinity.

The district is well served by telephones and the Post Office always has a waiting list. There are several rural mail deliveries in operation. Radio, owing to the power of the national broadcasting stations, is fairly well received, although the district is not regarded as good for radio reception." (Webster, 1948; 5-7)
This resume of Roxburgh's land use history from its conception through to the 1940's gives the basis for the historic land use of Roxburgh East.

b) **Historic Land Use of Roxburgh East**

Specific information on the land use history of Roxburgh East is limited, but from personal observation of the present land use and a knowledge of the district's history, some assumptions can be made. The first land use was sheep farming, followed by gold dredging in the river and along its banks - up to seven dredges worked the section of the Clutha between Roxburgh and Coal Creek. In 1865 lignite had been discovered at the base of north facing terrace. Known as Crossan's Pit, this mine supplied only a small quantity of coal during the dredging boom and was subsequently closed down on account of water difficulties. (Webster, 1948; 67).

Gold was followed by the development of commercial orchards on the south facing terrace and orchards were also planted on some of the sheep farms at the base of the eastern foothills. In 1931, 2,000 pine trees were planted on forty hectares of tailings, south of the main group of orchards (Webster; 163) initiating small-scale forestry in the area. The river flat terrace at the north of the area was used as construction base for the Roxburgh Hydro in the late 1940's - early 1950's.
PRESENT LAND USE

Present Land Use of Roxburgh East

There is no recent published information available on the present land use of Roxburgh East. What follows are generalisations from personal observation.

Agriculture

Semi-extensive sheep farming dominates the plateau area of Roxburgh East. The farms are run as mixed irrigated and dryland units, with some of the farms along the eastern margin of the basin having run of the foothills. Fat lamb production is the main income earner. The sheep - Crossbreds and Merino crossbreds, are 'set-stocked', pre-lamb shorn and wintered on lucerne and meadow hay. Few or no winter crops are grown. Lucerne, cocksfoot, perennial ryegrass and white clover are the exotic 'grasses' on which these farms are based. Topdressing with superphosphate is a necessary part of this farming.

Most of the farms are served by the Teviot Irrigation Scheme, a government scheme which is used to irrigate the pasture, the orchards that are part of some of the farms and to provide stock water.

Horticulture

Stone and pip fruit orchards dominate the south facing slope of the
terrace. The main fruit is the apricot, the majority of that produced going to a local processing plant. Apples are produced for the Apple and Pear Board. Some of the sheep farms have as part of their operation, commercial orchards. Berry fruits are being established in the area. All the horticulture units make use of water, for irrigation and possibly frost-fighting, from the Teviot Scheme.

Forestry

The dredge tailings along the southern margin of Roxburgh East were planted in Radiata pine. The crop has been harvested in two stages, the first stage has been replanted.

Urban

Roxburgh East has as its urban base, the township of Roxburgh (population 773 (1976). It serves the functions of local servicing, collecting and distributing, its economy is based on the resources of the land in agricultural terms. Roxburgh is the focus for local loyalties and social activities - it has three pubs.

Industry

Roxburgh East has no industry.

Mining

Two gravel pits are worked infrequently, for local use.
Communications

Road access to Roxburgh East is via a sealed county road that follows the course of the Clutha along its east bank. The Clutha is bridged at Roxburgh and dammed by the Roxburgh Hydro, giving south and north access respectively, to state highway 8, the road from Dunedin to Alexandra.

Roxburgh East has an airstrip, which is mainly used by topdressing aircraft. The rail link to Dunedin no longer exists.

Services

Roxburgh East receives the normal services provided to rural communities - electricity, television, telephone and rural mail delivery. Irrigation water comes from the Teviot Irrigation Scheme. The source of domestic water supply and the disposal method of sewage are unknown to the author.

Roxburgh East 'serves' outside communities - Four sets of high voltage transmission lines cross the basin. The cemetery for the district is on south facing slopes of the terrace. The sewage settlement ponds for Roxburgh are located on the dredge tailings.

Recreation

The Roxburgh Racecourse is located at the centre of the plateau. The
course and its associated facilities are used infrequently for
trotting trials and for the annual race day. Passive recreation
activities such as fishing and casual walking take place.

This study lacks information on land values, ownership and existing
plans (other than mining intent) for Roxburgh East.
visual data

Roxburgh East - a broad plateau surrounded on three sides by terraces, and backed on the fourth side by a range of hills; such is the structure of the local landscape. The visual character of that landscape comes from the natural and human influences upon it. The degree of visual diversity in that character and the balance of that diversity relates to the length of time over which those have been applied.

In natural terms, the terraces have been sculptured by the wash of past and present watercourses, the hills have been and are being worn by both fluvial and aeolial erosion that can be visualized as furrowed gullies, rounded ridges and the differentially eroded forms of schist tors. The natural change that is part of the visual character of this landscape can be seen to be working by the processes of erosion. This phase of the landscape cycle is based on degradation of the land to a base level formed by the Clutha River.

In human terms, man has impressed on the natural pattern the contour cuts of water races, which have initiated further change in the visual landscape of a semi-arid area. The line of the water race flowing around the face of the foothills forms a physical and visual boundary between the natural and the modified. Water brings life to this landscape - a range of vegetation grows along the banks of the race and vegetative production increases wherever that water flows and is adequate.
Water under human influence has changed the character of Roxburgh East from a lowland short tussock environment to an environment of productive agriculture and horticulture. This influence is visible in the detailed pattern of land use. The visual component of land use is expressed in the line of shelter belts, water races, border dykes, fences, roads, transmission cables and telephone wires; the patchwork of orchards, associated dwellings and packing sheds, forestry, and dredge tailings; and in the random scatter of farmsteads, livestock, dredge ponds and trees and shrubs associated with available water.

Part of the visual component that is human use of the land is the history expressed in the landscape - the stone barn on the farm known as "Kerriemuir", the white-washed cottages on Kinaston Road, the random pattern of headstones and the semi-dereliction of the old section of the cemetery on the southern terrace, the dominance of the racecourse, it's grandstand, booths and embankments, the scrub covered dredge tailings and the sweep of the main water race cutting across the flanks of the hills from the Teviot gorge.

Another visual factor representative of human history in this landscape is that of exotic trees, for people bought trees to this area and had to foster their growth in the struggle against the climate. These trees are now a dominant part of the visual detail of Roxburgh East, both in their form and their colour. The upright form of the pine and poplar brings an element of contrast to the planar form of the plateau. The rounded form of the willow ornaments the water courses. The trees of the orchards give form to the position of the
best soils. The pinks and whites of the orchards in bloom highlights the coming of spring, the golds and browns of leaf fall from the deciduous trees announces the arrival of autumn, whereas the green of the conifers is ever present. In all, this history in the landscape is part of the visual character, a landscape setting that is an integral part of the Clutha Valley.

The total of the general visual character of Roxburgh East can be seen and appreciated from any part of the surrounding basin that has a greater elevation than the crest of the terraces. Such elevated viewpoints that occur on public land are limited to areas on the northern and southern rims of the basin. The number of private dwellings that have a direct view of the Roxburgh East plateau is limited to those built in recent times on the slopes that form the western boundary of Roxburgh township (the placement of dwellings in the past was related to water supply and fertile soils that has implied lowland situations). The farmsteads on the plateau itself, and especially those on the rising land at the base of the foothills command a view of their local landscape.
visual survey: viewpoints

1. S.H.8, adj. Mt Banger Homestead.
2. Rox Hydro Observation Point.
3. Kobby Range Rd.
4. S.H.8, Coal Creek flats.
5. S.H.8, Roxburgh town boundary.
6. Roxburgh, river terrace.
7. Roxburgh, war Memorial.
Viewpoint 1:

State Highway No 8, adjacent to Mt. Banger Homestead.

Orientation: south.

State: mobile.

View: panorama.

Content: northern and central parts of Roxburgh basin

Foreground: the road, roadside, paddocks, pines

Middle ground: Clutha River, river terraces and flats, Roxburgh East terrace.

Background: Roxburgh East plateau, Knobby and Old Man Ranges.

Focus: immediate: the road.

Distant: the river.
Viewpoint 2:

orientation: south.
state: stationary.
view: panorama.
content: northern extent of Roxburgh basin.

foreground: Roxburgh Hydro village, switchyard, Clutha River pines, rock outcrop.
middle ground: Clutha River, river terraces and flats.

background: Roxburgh East terrace, Old Man Range.

focus: immediate: river and village.
       distant: skyline.

Roxburgh East

Old Man Range

Clutha River

switchyard

Roxburgh Hydro village
Viewpoint 3:

Knobby Range Road, a metalled county road.

orientation: south west.
state: mobile.
view: panorama.
content: northern and central extent of Roxburgh basin.

ground: the road, roadside, rolling paddocks

ground: gullies, northern Roxburgh East terrace and plateau.

background: Knobby and Old Man Ranges

focus: immediate: the road

distant: the racecourse
<table>
<thead>
<tr>
<th>Viewpoint 4:</th>
<th>State Highway No. 8, Coal Creek flats.</th>
</tr>
</thead>
<tbody>
<tr>
<td>orientation:</td>
<td>south east.</td>
</tr>
<tr>
<td>state:</td>
<td>mobile.</td>
</tr>
<tr>
<td>View:</td>
<td>panorama.</td>
</tr>
<tr>
<td>Content:</td>
<td>north western extent of Roxburgh basin.</td>
</tr>
<tr>
<td>Foreground:</td>
<td>the road, roadside, river terrace paddocks, trees</td>
</tr>
<tr>
<td>Middle ground:</td>
<td>river terrace and flat on east side of river</td>
</tr>
<tr>
<td>Background:</td>
<td>Roxburgh East terrace, Knobby and Old Man Ranges</td>
</tr>
<tr>
<td>Focus: immediate:</td>
<td>the road.</td>
</tr>
<tr>
<td>Distant:</td>
<td>the skyline.</td>
</tr>
</tbody>
</table>
Viewpoint 5:

State Highway No. 8, Roxburgh, northern town boundary
orientation: north east.
state: mobile.
view: panorama.
content: south eastern extent of Roxburgh basin.
  foreground: the road, roadside, river bank, pylons, trees,
  middle ground: Clutha River, tree-covered dredge tailings
  background: Roxburgh East terrace, Knobby Range.
focus: immediate: the road
distant: the skyline
Viewpoint 6:

Roxburgh, river terrace, a back street.

orientation: north.
state: mobile.
view: panorama.
content: southern extent of Roxburgh basin.
foreground: street, river bank, Clutha River.
middle ground: tree-covered river bank on far side of river
background: Roxburgh East terrace, Knobby Range.

focus: immediate: the river; the street.
distant: the skyline

Roxburgh East

Clutha River

Knobby Range
Viewpoint 7:

Roxburgh, War Memorial, on schist outcrop within town.

orientation: north.
state: stationary.
view: panorama.
content: southern extent of Roxburgh basin.

foreground: Roxburgh.

middle ground: river bank trees, dredge tailings, settlement ponds

background: Roxburgh East terrace, Knobby and Old Man Ranges

focus: immediate: Roxburgh; the settlement ponds.
distant: the skyline.
The Liquid Fuels Trust Board's "South Island Lignite Geotechnical Investigation: Contract No. 4104/5: Roxburgh East Deposit, Central Otago" (1981) contains specific information on the proposed mining of the lignite. This report discusses the stability of cut slopes, stability of spoil dumps, excavation techniques, pit floor conditions and bearing capacity, weathering characteristics of dumps and slopes, and states conclusions and recommendations relevant to mining. (A degree of analysis and valuation has been applied to their base information in the writing of the report.)

1) **Stability of Cut Slopes**

"As mining advances down to the coal geological conditions in cut slopes will be constantly changing. The coal is overlain by varying thicknesses of Manuherikia Group sediments which are in turn overlain by a mantle of gravels."

From laboratory determined strength parameters established as part of the geotechnical investigations for the various lithologies slope angles were postulated, and from these, a schematic diagram of a possible cut slope configuration can be drawn. Slope angles are as follows:
0 - 44 m  Gravels; slope angle 35°
44 - 62 m  Sands and silts; slope angle 25°
62 - 83 m  Carbonaceous silts; slope angle 20°
83 - 120 m Lignite; slope angle 60°

The lignites and gravels will probably pose the least problems during mining. The exception may be at the margins of the deposit where the lignite has been shattered or disturbed by faulting. The structure of the lignite (and the basement) is uncertain in these areas.

Insufficient data is available on the geotechnical properties of the undifferentiated Manuherikia Group sediments to be able to determine slope angles with any confidence. Also, insufficient data is available on the groundwater regime at depth to be able to use effective stress strength parameters with confidence in stability analysis.

2) **Stability of Spoil Dumps**

The stability of spoil dumps was assessed using strength data obtained from the testing of laboratory prepared specimens. These data were then used to investigate the stability of spoil dumps of varying heights.
For spoil dumps up to 40 m in height an overall slope angle of $30^\circ$ was determined, incorporating a factor of safety of 1.25 against shear failure. Beyond this height the stability of the slope decreases and benches or set backs in the dump are required to maintain stability. The stability of this slope becomes critical at a height of 60 m.

The infiltration of groundwater or surface run-off into the spoil dump has a marked effect on the stability of the dump. Saturation of the spoil heap will not only reduce effective stresses but is likely to cause a softening of the material and reduction in the cohesion able to be mobilised.

Under these conditions stability of the spoil heaps becomes critical at much lower heights. Alternatively overall slope angles may have to be reduced to $20^\circ$ to achieve comparable spoil dump heights. Drainage to control groundwater and surface run-off should be incorporated to reduce the likelihood of saturation of the spoil heaps.

The slaking properties of excavated (i.e. remoulded) materials have not been specifically investigated. It is not anticipated that material placed in spoil dumps will be subject to slaking or erosion of exposed material providing the spoil dumps are constructed with some attention to grading of permanent slopes to promote run-off of rain water and some measure of run-off
control is provided, such as contour drains.

3) **Excavation Techniques**

a) Gravels:

The gravels range in size from fine sands through to cobbles and boulders. The gravels are generally compact and in places may be lightly cemented either by weathering processes or due to the presence of clay.

It is considered the gravels could be excavated without difficulty using any form of excavation e.g. shovel, dragline, bucket wheel, etc.

b) Manuherikia Group Overburden:

These materials are essentially overconsolidated soft to firm soils. They could be excavated using any of the methods given above. In addition motor scrapers could be used with push loading and ripping where necessary. Overburden at Harliwich's pit is currently removed by motor scraper and in the past was removed by sluicing.
c) Lignite:

The lignite although massive in drill hole 2086 is generally friable and slakes quickly on exposure to air. The lignite as with the overburden could be excavated using any of the techniques listed above.

Other pits in the area use small face shovels, motor scrapers, and back hoes to win the lignite.

4) Pit Floor Conditions and Bearing Capacity

The pit floor will be composed of lignite, basal Manuherikia sediments or, in some instances, weathered schist basement. Core recovery in the basal Manuherikia sediments and the schist basement was generally poor and the information on pit floor conditions which can be inferred is limited.

Undisturbed borehole samples had field consistencies ranging from soft to hard soils. Local experience in existing lignite pits indicates that these materials are susceptible to traffic movements and degrade quickly when wet. To overcome this problem, 300 mm of lignite is generally left on the pit floor to provide a working surface which will drain freely and not degrade under mining operations. It may be
necessary to implement this practice during mining of the Roxburgh deposit with recovery of the lignite floor as mining advances.

5) Weathering Characteristics of Dumps and Slopes

Accelerated weathered tests have been carried out by the Soil Bureau D.S.I.R. Their report concludes that it is unlikely that pyrites oxidation will take place leading to acid sulphate formation or the levels of soluble salts will be harmful to plant growth.

6) Conclusions

The lignite overburden comprises Quarternary gravels and low strength Tertiary clays and silts with interbedded sands, of the Manuherikia Group. The fine sediments are mostly carbonaceous and fissured.

Observations of existing gravel slopes in the area indicate that pit slopes cut at 35° in these materials would be stable. Further investigations are required to determine the optimum angle for these materials.

Strength parameters determined in the laboratory suggest maximum cut slope angles of 25° for the Manuherikia overburden. A back-
analysis of a failed slope in Harliwich's pit indicated a cut slope angle of 15° would be appropriate in the materials overlying the lignite. In the absence of further information an average slope angle of 20° has been adopted in the fissured materials overlying the lignite.

It is considered that stable slopes in the lignite could be cut at up to 65°, with near-vertical cuts between benches. Subsequent investigations should endeavour to show that crushing due to faulting will not reduce this figure locally.

The lignite is underlain by fine sediments and clayey gravels which proved difficult to core. Unless further investigations prove otherwise these materials may prove troublesome in the pit floor, but it is clear that more detailed investigations, are required to assess optimum cut slope angles. Emphasis in future investigations should be directed more towards gaining a thorough understanding of the deposit through the coring of several drillholes less intensively sampled for testing than was specified for the drillhole reported herein.

Lack of information on groundwater conditions has considerably reduced the effectiveness of the geotechnical investigations. Groundwater investigations should be accorded high priority in future studies.
7) Recommendations

The following recommendations for further work are made:

- detailed engineering geological mapping to determine the factors involved in existing failures, particularly structural controls such as bedding.

- detailed groundwater studies to determine the in situ permeability of lithologies, the influence of the Clutha River and groundwater on mining, and the feasibility of dewatering the overburden be undertaken.

- drilling of further fully cored holes for engineering geological logging and laboratory testing. The object of these studies should be to obtain a better understanding of the material properties and their influence on the stability of cut slopes.
MINING PLAN OF THE ROXBURGH EAST DEPOSIT
INDICATING LOCATION OF DRILLHOLES

GEOLOGICAL SECTION

(source: LFTB cont. no. 4104/5, 1981)
SCHEMATIC DIAGRAM OF PIT SLOPES

(Source: LFTB conf. no. 4104/15, 1981)
From the landscape survey comes the component data of the Roxburgh East landscape and this on analysis, will be used to give a general 'feel' and understanding of that landscape. Taking the somewhat limited survey information as a base and playing the role of landscape architect, the information is interpreted to establish the inter-relationships between the components of the landscape. The inter-relationships are viewed in relation to the proposal to mine, for in the terms of the pre-mining stage of mine planning, the lignite will be mined. A use analysis such as this must look to the project requirements and identify the landscape issues implied by the large-scale surface mining of the Roxburgh East lignite.

Of the four separate data bases in the landscape survey, the natural, human and visual data shall be viewed in reference to the mining data, the mining data relating to what is currently available in terms of project requirements. The mining data gives a mapped and sectioned approximation of the physical extent of what is considered as economically recoverable lignite. Knowing the approximate three dimensions of the deposit and adding to this all the known information on subsurface conditions - the geologic components of rock type and structure, with the engineering knowledge on geologic stability, and groundwater conditions - these can be analysed in terms of mining factors and constraints.
An analysis of mining factors and constraints has been completed as part of the L.F.T.B. contract No. 4104/5, the results of this analysis are statements on slope stability (of pit walls), stability of spoil dumps, excavation techniques, pit floor conditions and bearing capacity, and the weathering characteristics of dumps and slopes. (These statements are reproduced in the Mining Data section of the landscape survey.) The reported analysis is compromised by the lack of detailed information on subsurface conditions, as stated in the report's conclusion, and it recommends that further work be carried out to define the detail of the geotechnical aspects.

Therefore, working under such constrained limits, this particular study shall proceed to draft a landscape analysis based on what is known . . .

Authors' comment

The landscape analysis as previously stated, is an aid to interpreting the landscape so as to expose its assets, potential and limitations. It is based on the knowledge of the landscape gained from the landscape survey. To gain as full a knowledge as possible of the Roxburgh East landscape, the application of an inter-disciplinary planning team would be essential to the investigation.

This study has been done in isolation, using information that is currently available, from literature and personal observation. The literature is generalised, out-dated and/or incomplete. Due to resource and time limitations, plus the complexity and scale of the landscape being dealt with, the findings from personal observation cannot be considered as fully adequate.

Therefore, the section of this study that follows is intended to be read in draft form and is written as such. The landscape analysis can only be complete when the landscape survey is complete . . .
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general observations continued

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<td>time</td>
<td>evolution</td>
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<td>land use, past and present - affected by the total of the natural components; the weight of each varies.</td>
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<tr>
<td>Present Land Use</td>
<td>plus the human influence of human geography, socioeconomics, politics, awareness and ability.</td>
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Analytic Review of the Landscape Survey

Natural Data

Climate: District
- regional topography ⇒ rain shadow ⇒ semi-arid conditions
- regional topography ⇒ wind direction

Roxburgh East
- semi-arid conditions - 'high' temperatures, 'low' rainfall, clear skies
  'high' sunshine hours.
- temperature and rainfall peaks parallel ⇒ evaporation peak
- northerly winds frequent and warm ⇒ desiccating effect
- calms common, especially at night, clear skies common
  ⇒ convection frosts common.
- annual evapotranspiration ⇒ annual precipitation
  ⇒ soil moisture deficiency

Topography: District
- part of regional range and basin configuration

Roxburgh East
- 15 km² basin within river gorge system, paralleled by
two mountain ranges.
- basin - down cut river course
  - river terraces and flats
  - terraces
  - plateau
  - foothills
- aspect: lies well to the sun
- relief; flat - gently sloping, distinctive terraces
Geology: Roxburgh East
- 2 major block faults, local convergence
  ⇒ seismic activity, record of past occurrence unknown.
- basin 'walls' and basement - Haast Schist - metamorphic
- sediments within - Manuherikia Group
  - basal gravels and sands, ⇒ 45m thick
  - lignite, 37-66 m thick, 6 km² 'recoverable'
  - dominant lithology of Man. Gp:
    - deposit - 'shallow dish' shape
  - mudstones and siltstones, ⇒ 50 m thick
- Alluvium
  - gravels, 30-50 m thick
- engineering geology
  - schist - very soft muds
  - Man. Gp. basal sediments - fine sands, clayey gravels
    - lignite - massive ⇒ jointed ⇒ highly crushed.
    - indst. siltst - clayey silts * silty clays
    - slope instability common to outcrop
- Alluvium - gravel
  - relatively permeable * free draining
  - erosion, sheet and wind erosion of exposed rock and soils

Further information necessary on:
- actual erosion potential of the lithologies on exposure
- actual geologic stability of the lithologies
- seismic activity of the faults

Hydrology: Roxburgh East
- surface - Clutha River dominates
  - flow controlled : level controlled , RL 86 m normal
- Teviot River, irrigation input
- foothill streams, captured for irrigation,
  seasonal flows.
Surface hydrology contd:

- Cross flows - confined to water races, irrigation flows
- Local swale flow, high rainfall dependent.

Subsurface:

- Plateau centre, water table: RL 120m
- Terrace, water table: RL 115m
- Ground water seeps
- Increased irrigation ⇒ increased groundwater levels

Further information necessary on:

- Actual influence of Clutha River on subsurface hydrology.
- Artesian water pressures
- Permeability of the lithologies, and the ability to be dewatered.

Soils: District

- Youthful
- Dry between active zone and water table
- Low on humus
- High soluble matter content; Calcium carbonate dominant.
- Fertility, moisture dependent

Roxburgh East:

- Brown-grey earths dominate
- Distinct claypan
- Accumulated calcium carbonate common to subsoil
- High concentration of soluble salts throughout profile

Lowburn shallow sandy loam, western portion of plateau
- Shallow, sandy & gravelly texture

Lowburn Hill soils similar

Ripponvale sandy loam, south west and southern terraces
- Moderately deep, sandy texture

Molyneux shallow sandy loam, river terrace and flats
- Shallow, sandy & gravelly texture
soils contd:
- intergrades of brown-grey or yellow-grey earths, eastern portion of plateau
  Agburn fine sandy loam, moderately deep, fine sandy texture
  Agburn shallow sandy loam, shallow, sandy texture

further information necessary on:
- actual depth of active zone
- faunal activity of soils
- productive soil moisture levels
- soluble salts limitation

**Flora**: Roxburgh East
potential vegetation - lowland short tussock grassland, drought resistant
  - native shrub associations, moisture dependent
existing vegetation - introduced grassland dominates, with crop,
  - shelter & amenity trees, all moisture dependent
  noxious weed problem

further information necessary on:
- establishment and success rates
- growth rates
- irrigation requirements

**Fauna**: Roxburgh East
domestic: sheep dominate
non-domestic: species common to Central Otago farmland

further information necessary on:
- carrying capacity/potential
- habitat types special to the area.
Human Data:

Historic Land Use: \(\rightarrow 1945\)
District:
sheep-farming
alluvial gold mining
irrigation
orcharding/sheep-farming
orcharding
fruit processing
rabbit processing
coal mining
hydro-electricity generation
servicing: road/rail
telephone/post/radio
recreation

Present Land Use: 1981

sheep-farming
irrigation
orcharding/sheep-farming
orcharding
fruit processing
coal mining
hydro-electricity generation
servicing: road

recreation

television/telephone/post/radio

Roxburgh East:
sheep-farming
alluvial gold mining
orcharding/sheep-farming
orcharding
coal mining
small-scale forestry
horse racing

further information necessary on:
- detailed land use
- land ownership, management
- land values
- potential land development
- socioeconomic conditions of Roxburgh
- etc.

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Land Use Capability Assessment

An analysis of Roxburgh East has been made by Water & Soil Division, MWD, for the assessment of the land use capability of the area, as part of the N.Z. Land Resource Inventory Worksheet s 152: Roxburgh. For this assessment of sustained productive land use, the individual factors of the 'land resource inventory' - rock type, soil, slope, erosion and vegetation - are considered, along with climate, in terms of physical limitations to land use. With this natural data, the human influence of management requirements and soil conservation needs is accounted for also.

From this assessment, the land use capability of the existing landscape is known. The land use capability assessment could prove to be a suitable base for future use determination of the reclaimed landscape, as planned for in the pre-mining stage.

Capability classification

<table>
<thead>
<tr>
<th>class</th>
<th>cropping suitability</th>
<th>general pastoral or production forestry suitability</th>
<th>general suitability</th>
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<tbody>
<tr>
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<td>III</td>
<td>low</td>
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<td>IV</td>
<td>unsuitable</td>
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<td>VIII</td>
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</table>

(source: Water & Soil Div. MWD, 1979, 33)
Land use capability assessment

Roxburgh East

IIIc3 moderate limitations to arable use, climate limit.
III S6 " " " " soil limit.
IVS9 severe limitations to arable use, soil limit.
VIe19 non-arable; moderate limitations and hazards under a perennial vegetation cover, erosion limit.
VII S9 non-arable; severe limitations and hazards under a perennial vegetation cover, soil limit.

* This is an assessment of the unit in terms of its capacity for sustained productive use, taking into account physical limitations, management requirements and soil conservation needs. The assessment is based on an interpretation of the physical information in the inventory formula as well as additional information on climate, etc." (Water and Soil Division, M.W.D. 1979, 32)
Visual Data

Roxburgh East "... a landscape setting that is an integral part of the Clutha Valley"

The visual components of Roxburgh East as the content of the view as seen from the visual survey viewpoints

<table>
<thead>
<tr>
<th>viewpoint</th>
<th>foreground</th>
<th>middleground</th>
<th>background</th>
<th>focus</th>
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<tbody>
<tr>
<td>1</td>
<td>river terrace • flats</td>
<td>plateau</td>
<td>Rox. East terrace</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>river terrace • flats</td>
<td>Rox. East terrace</td>
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<tr>
<td>3</td>
<td>Rox. East terrace</td>
<td>plateau</td>
<td>racecourse</td>
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<td>4</td>
<td>river terrace • flats</td>
<td>Rox. East terrace</td>
<td>skyline</td>
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<tr>
<td>5</td>
<td>dredge tailings</td>
<td>Rox. East terrace</td>
<td>skyline</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>river bank</td>
<td>Rox. East terrace</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>river bank trees</td>
<td>dredge tailings</td>
<td>settlement ponds</td>
<td></td>
</tr>
</tbody>
</table>

The dominance of these visual components as part of the view is relative to the breadth and depth of the view, and the elevation of the viewer relative to Roxburgh East.

The Roxburgh East terrace is a component of all the views, forming part of the background in most cases, a dominant part of the background.
where its crest forms the skyline. The Roxburgh East plateau is a significant component of the view from the two elevated viewpoints to the north of the basin, the plateau and its features dominate that seen from Knobby Range Road.

The low-lying visual components of Roxburgh East are important to the middle ground of all the views. These particular components form the middle ground due to the separation imposed between the component and the viewer by the position of the viewpoint and the river. It is due also to this separation and position of viewpoint that the visual components of Roxburgh East do not come within the foreground of any of the views.

The visual survey has considered only views onto and toward Roxburgh East. The reasoning for this being that such views would portray that seen by the most people. A visual survey and analysis for that seen within Roxburgh East and in particular, that seen on the plateau, would have limited value as the landscape of the area would be totally modified by surface mining. A knowledge of the visual elements as stated in the visual data for Roxburgh East is necessary in forecasting the degree of modification, once it is established how that modification would progress.
Mining Data

Mapped Approximations:
- areal extent of potentially recoverable lignite
  - 6 km² of the plateau and northern & southern terraces.
- cross-section of the vertical extent of the deposit
  - maximum depth, base of lignite: ~120 m
  - overburden ratio: 2:1

Stability of cut slopes:
- gravels: 35°
- lignite: 66°
  - lignite and gravels: most stable
  - least problems

Further information necessary on:
- geotechnical properties of the Manuherikia Group
- groundwater regime and its influence at depth.

Spoil dumps
- → 40 m @ 30°, then benching essential
  - 60 m height critical limit
  - saturation limit critical

Further information necessary on:
- slaking and erosion of spoil dump material

Excavation methods:
- use of conventional methods possible on all strata of overburden and lignite

At floor conditions:
- will degrade with use, degradation can be limited with drainage

Weathering of dumps/slopes
- toxin production considered unlikely
Analysis in terms of Surface Mining

Main land use - the mine

"Mining Plan" (pp 215) ~ 6 km²
"At Slopes" (pp 217) 2.3 km² (based on a 200m circumference)
8 - 9 km²

⇒ potential area of land use
⇒ potential area of direct impact on the landscape.

Additional land uses - mining auxiliaries

- roadway to mine, within mine area, and to adjacent land.
- lignite handling and processing space.
- machine maintenance and storage space.
- administration and staff space.
- topsoil and overburden dumps.
- water controls: pumping and drainage systems, treatment and settlement ponds, stream diversions.
- environmental "buffers"
- reclamation trials and implementation
- etc.

The total of the mine land uses could require the total of the plateau, parts of the northern and southern terraces and land adjacent for its functioning. This would entail the use of the vast majority of the Roxburgh East landscape. Whether the land would be required all at once or in stages would relate to the mining method used, rates of extraction, use of the lignite (i.e. processed and consumed on-site or off-site), the area necessary for environmental buffering of the mine and the techniques and implementation of reclamation.
potential area of direct impact on the landscape

"recoverable" lignite

pit slope margin
Some Landscape Considerations with reference to...

Surface Mining Operations

Climate
- potentials:
  - semi-arid ⇒ dry working conditions
- limitations:
  - north wind ⇒ dust drift toward Roxburgh
  - calm ⇒ noise transmission unhindered

Topography
- potentials:
  - sunny aspect ⇒ dry working conditions
  - low relief ⇒ ease of machine operation
  - use of landform as an environmental buffer
- limitations:
  - uncertain

Geology
- potentials:
  - lignite ⇒ economic mineral; high-grade ⇒ "recoverable"
  - alluvium ⇒ alluvial gold-bearing potential ⇒ added economic gain
- limitations:
  - faults ⇒ potential seismic activity
  - Manu Namka Group ⇒ instability

Hydrology
- potentials:
  - use of existing water races ⇒ stream diversion ⇒ lowering water table
  - Clutha River "controlled" ⇒ influence controlled
- limitations:
  - actual influence of Clutha River uncertain
  - groundwater and permeability of lithologies could be limitations
Soils

- Potentials:
  - Predominantly shallow \(\Rightarrow\) relatively limited total amount
  - \(\Rightarrow\) less cost in separation
  - \(\Rightarrow\) less space in storage

- Limitations:
  - "Light" soils \(\Rightarrow\) high erosion potential
  - \(\Rightarrow\) dust and sedimentation

Flora

- Potentials:
  - Predominantly grassland \(\Rightarrow\) ease of surface clearance

- Limitations:
  - Uncertain

Fauna

- Uncertain

Land Use

- Potentials:
  - Local knowledge of surface mining
  - Existing community structure

- Limitations:
  - Disruption of existing land uses - productive and passive.

Visual

- Potentials:
  - Possibly of the majority of the mining operation being visually contained "behind" the terrace, within the plateau.
  - Public views onto site limited/controllable

- Limitations:
  - Breaching the terrace would destroy the visual continuity of the existing landscape \(\Rightarrow\) "opening" the mine to public view
  - \(\Rightarrow\) increasing the potential of transmitting environmental "problems"
Mining
planning and design of implementation critical
use of conventional excavation methods has advantages; known
critical parameters of use and capability.

Reclamation
Climate
potentials:
semi-arid $\Rightarrow$ high plant production with adequate water and nutrients.
$\Rightarrow$ future use of horticulture has high potential
$\Rightarrow$ residential development capability
$\Rightarrow$ tourist/recreation basis
$\Rightarrow$ retirement/old-age basis
wind and sun $\Rightarrow$ alternative electricity generation

limitations:
low rainfall, heavy frosts and desiccating wind $\Rightarrow$ difficult
establishment and high maintenance of plant materials
semi-arid $\Rightarrow$ soil 'making' problems.

Topography
potentials:
sunny aspect $\Rightarrow$ advantageous to plant growth
$\Rightarrow$ advantageous to human activity
low relief $\Rightarrow$ ease of landform formation
$\Rightarrow$ slow runoff of rainfall
$\Rightarrow$ limited erosion risk

limitations:
type of topography $\Rightarrow$ design of reconstructed landform
critical
Geology

potentials:
alluvium → fine sediments
  ⇒ soil 'washing' potential, on separation from
  gravels

limitations:
manuherika group ⇒ instability
all lithologies ⇒ erosion potential on exposure unknown

Hydrology

potentials:
irrigation source Tewot River ⇒ gravity-fed supply
already existing

limitations:
reformed surface made of redistributed materials
⇒ drainage capabilities uncertain

Soils

potentials:
majority of soils over deposit arable ⇒ greater ease of
reclamation

limitations:
predominantly shallow ⇒ limited amount
  ⇒ reclamation problems
soluble salts ⇒ reclamation problems

Flora

potentials
revegetation with 'potential' vegetation ⇒ low establishment
  loss and low maintenance
revegetation with 'existing' or better vegetation possible
  with adequate water and nutrients

limitations:
noxious weed problem
Fauna
potentials:
domestic stock \Rightarrow \text{creation of grazing units and handling facilities based on efficient management requirements.}

wildlife \Rightarrow \text{creation of new habitats.}

limitations
rabbit problem

Land Use
potentials:
local skills in irrigation, agriculture and horticulture

limitations:
uncertain

Visual
potentials:
functional potential \Rightarrow \text{visual potential}

limitations:
none if planning and design thorough, complete and creative, as based on the needs of the community.

Mining
planning and design of implementation critical
Landscape architectural advice for Roxburgh East

...a framework for landscape architectural involvement...

Landscape architecture would most likely be employed by those proposing the mining development - "the mining company," and by those opposed to the mining or concerned about the nature and extent of the impact of the surface mining operation - local community members, environmental groups, federated farmers, etc.

To gain a balance from the landscape point of view, the landscape architect's of both factions, would have to identify the landscape issues that the mining proposal would imply for Roxburgh East.

Given the available information, the potentials and limitations that would be seen as landscape issues have been gathered together as part of this study in reference to surface mining operations and reclamation (see "Some Landscape Considerations with reference to... pp 234-8)

An interrelationship exists between the landscape components, (i.e. climate, topography, etc); community factors, (i.e. cultural, socioeconomic, political considerations, etc.) and the proposed mine. (area to be mined, working methods, etc) - an interrelationship which leads to the identification of the critical areas of landscape impact and the potential for reclamation. From this association comes the ability to deem necessary and locate environmental buffers and plan for the future land use.
The land overlying "recoverable" lignite, based on "potential area of direct impact on the landscape", pp. 233

Present: as seen from Knobby Range Road (land over lignite: coloured)

After mining*: in perspective

Knobby Range
levelled mine site

in cross-section

* "After mining" in these sketches implies that all recoverable lignite has been extracted, overburden levelled and pit slopes graded;
2:1 overburden ratio ⇒ up to 50 m lost in ground level
Present: as seen from Roxburgh Hydro Observation Point

After mining:

After mining: spoil from the initial mine cut used as a partial visual screen.
Old Main Range  Roxburgh East  Knobby Range

Present: as seen from Roxburgh war Memorial.

After mining: in perspective

levelled mine site

in cross-section; the removal of the southern terrace.
Specifically to Roxburgh East, the lignite underlies a plateau and its terraces to the north and south. The overburden ratio is approximately 2:1. The climate is semi-arid, and the regional topography controls the predominantly northerly wind flow. The township of Roxburgh, the local population centre is located on the east bank of the Clutha River at the southern end of the Roxburgh basin.

Taking the premise that the greater the number of people affected the greater the conflict, the most critical area of landscape impact would be that which leads to direct impact upon Roxburgh. The landscape component of climate, the community factor of location and mining involving the shifting of much overburden implies that dust would be a major environmental problem. Light at night and noise are also likely to be problems. The extent of these problems could be limited by using the southern terrace as a physical barrier to light and sound and to dust, by using a mining method that allows the settling down of the pit floor, and by planting trees to act as a visual screen and as a dust filter. The forestry on the sluice tailings situated between the terrace and the Clutha River, could be reinforced to act as a buffer through increasing the tree density and extending the planting onto the terrace face. (see pp. 245)

The success of this form of buffer would depend on sufficient lead-time being allowed for the establishment of the plantation. 10-15 years would be necessary to allow fast-growing species such as pine and poplar to grow to sufficient height and foliage density and therefore be effective as a visual screen and a dust filter.
A potential work method with the least impact on the surrounding landscape

![Sketch cross-section of the Roxburgh East lignite deposit](after Issac, 1980)

The deposit is most accessible to the north, Crossar's mine area. Lignite near surface at base of terrace, start to mine at north terrace

- spoil from the initial mine cut dumped as a 'natural' extension of the ridge line immediately north of the mine.
- final contoured form of the dump would form a partial visual screen of the mining operation, from the north.
- with tree planting, dump would give shelter to part of the reclaimed landform.

- using a continuous reclamation mining method, the mine would progress towards the south, the pit face would form a physical screen in front of the operation.
- topsoil and other soil forming material would be dumped on the undisturbed plateau to the west of the mine.
a potential mine layout (compare with pp. 233)

contoured dump for the spoil from the initial mine cut
settlement ponds for mine water treatment
topsoil dump
mine access on altered road alignment
southern terrace and dredge tailings converted to forestry function; environmental buffer

uncovered lignite

stream diversion

245
comments on reclamation

initial spoil dump with planting becomes a windbreak

settlement pond silt spread as topsoil

mine access road becomes a riverside drive

forestry milled; most fertile soils re-established as orchard, any excess topsoil spread on dredge tailings to improve production

stream diversion races become part of the irrigation scheme

access road may relate to land-use pattern
Direction for further investigation...

The potentials and limitations for surface mine operation and reclamation that have come from the landscape analysis and have been stated in terms of landscape considerations could all be followed up by further investigation. This would most likely lead to the proposal of more potentials and limitations as the information base becomes more detailed and yet, broader in scope. Further investigation is required to answer the "further information necessary on" comments raised in this landscape analysis.

With the landscape and the large-scale surface mining of lignite and the landscape planning of such, a fundamental consideration is that of time. The availability and allowance of adequate time for the planning process is essential. In implementation of that planning, a staged development of the mining and reclamation would proceed in a timed sequence, with lead time allowed for the full exploration of the deposit, study of potential social impact of surface mining on the Roxburgh District and a complete and thorough landscape assessment.
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