Impact of petroleum exploration activity on range resources and pastoral pursuits in the West Kimberley

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Impact of petroleum exploration activity on range resources and pastoral pursuits in the West Kimberley

N.M. Klepacki
S.J. Black
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DIVISION OF RESOURCE MANAGEMENT

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IMPACTS OF PETROLEUM EXPLORATION ACTIVITY ON RANGE RESOURCES AND PASTORAL PURSUITS IN THE WEST KIMBERLEY

Technical report no. 41

by

N.M. KLEPACKI
S.J. BLACK
M.H. MARCHANT

1985

1 DEPARTMENT OF AGRICULTURE
2 DEPARTMENT OF CONSERVATION AND ENVIRONMENT
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IMPACTS OF PETROLEUM EXPLORATION ACTIVITY ON RANGE RESOURCES AND PASTORAL PURSUITS IN THE WEST KIMBERLEY

SUMMARY

A survey was undertaken by the Western Australian Department of Agriculture and the Department of Conservation and Environment to identify the nature and extent of disturbances that recent petroleum exploration activities may have on environmental stability on the various landforms and soil types in the West Kimberley. The report attempts to address all facets of exploration activity such as seismic line construction, drilling operations, road building, and camp-site preparation, and the impacts such operations may have on pastoral rangelands, station lessees and other legitimate users of that resource.

Six stations were included in the survey. Their total area covers approximately 15,000 square kilometres. Of this approximately 12,800 square kilometres or 85% have been subject to recent exploration activity, including 11 drill sites. Most exploration has been undertaken within the past 15 years, but more intensively since 1980.

Ten land systems were identified in the survey area ranging from sandplain and dunefields to alluvial plains.

Detailed observations and photographs were taken at 85 sites. In addition numerous general observations were made on seismic lines during the survey. The study was concentrated in areas known to have already been subject to some degree of soil erosion. General conclusions about eroded areas and erosion susceptibility are as follows:

1. Moderate to severe gullying was active on parts of the Coonanqoody (Co) land system when the vegetative cover is removed during the cutting of seismic lines exposing the fragile shallow surface to the effects of water which washed and cut into the loamy clay subsoil.

2. Moderate water erosion was observed at four points on the lateritic soil units of the Bohemia (Bo), Myroodah (My) and Luluqul (Li) land systems.

3. Slight erosion by water was visible on sand dune crests of the Camelwooda (Cm) and Wanqanut (Wa) land systems. There was no evidence of wind erosion.

4. Only slight water erosion or none at all was observed on most of the sand plains of the Yeeda (Ye) land system.

5. The Djada (Dj), Gogo (Go) and Roebuck (Rb) land systems are not generally subject to water erosion. However, their surfaces can be subject to wind erosion after the soils become powdery from continual use by stock and vehicles.

Some explorers have been remiss in their obligations under the conditions of exploration permits covered by the Western Australian Petroleum Act 1967-1981 by not taking preventative or remedial measures to address the hazard of soil erosion in its various forms.
Recommendations in this report are made in reference to the need for:

1. Improved communication, co-operation and a continual liaison between pastoralists and explorers.

2. Consultation by the principal parties with officers of the Western Australian Department of Agriculture, Division of Resource Management (D.R.M.) when the seismic plan is finalized and before ground activities begin.

3. Immediate remedial work by some explorers on damaged areas that are a potential danger to stock, personnel, vehicles and equipment.

4. The application of techniques to prevent situations where soil erosion can be a problem.

5. The application of soil conservation techniques to remedy situations where soil erosion has been initiated.

6. General principles to be observed during and after exploration.
INTRODUCTION

The northern reaches of the Canning Basin in northern Western Australia are in the shires of Broome and Derby-West Kimberley which have a combined area of 158,700 km². Within the shires there are 50 pastoral leases with a total area of approximately 100,000 km². The remaining 58,700 km² include aboriginal reserves, vacant Crown Land, townsites and special reserves and parks.

Petroleum exploration companies have been operating in the area for over twenty years. In recent years however, exploration activity has increased dramatically, especially since the discovery of oil at Blina Station, approximately 100 km east of Derby.

The Australian Petroleum Exploration Association Ltd has drafted a Code of Environmental Practice as a supplement to existing government regulations and known as the APEA Code which provides guidelines for members to observe during exploration activities. These have not always been followed.

OBJECTIVES

The study was undertaken by N.M. Klepacki and M.H. Marchant of the Dept. of Agriculture and S.J. Black of the Dept. of Conservation and Environment (D.C.E.) with the following objectives:

1. To examine and report on the nature of any lasting disturbances created by mineral and petroleum exploration activity.

2. To report on the impact which exploration and mining has upon the station enterprise in reference to:
   (a) Interference with normal station management.
   (b) Land and pasture degradation
   (c) Effects on T B eradication programmes.

3. To relate environmental damage occurring to the type of disturbance and to the specific land system and unit of land involved.

4. To describe the techniques of conservation and rehabilitation which should be adopted in relation to the land system units affected.

5. To prepare guidelines for explorers and exploration companies which will minimize the impact of environmental disturbance.

Regional Considerations

Regions can be classified into land systems, which are broad composites of environmental units with distinctive geology, soils, topography and vegetation (CSIRO, 1964). Land units within each land system enable the identification of differences in their sensitivity to disturbance, according to the origins, depth and structure of the soils. For surveys of this nature the land system provides a convenient unit for description and comparison.

Seismic activities may be considered a short-term intrusion into the environment, but the period of time over which the effects of exploration remain depend on the sensitivity of particular land systems to the clearance of vegetation and topsoil and associated effects on natural drainage, and the methods by which the disturbance had been effected.
A better understanding of the land systems and the related soil groups within the semi-arid zones will assist the land user to appreciate the problems likely to be encountered if the soil surface is disturbed. The object should be to encourage preventative action to lessen the impact rather than to have to undertake expensive remedial work.

Major geomorphic types of land surfaces in West Kimberley

Ranges, Hills and Outcrop Plains are sensitive to unnatural disturbances because of their shallow skeletal soils overlaying impermeable sub-strata. Their elevation and degree of slopes are conducive to increased water erosion as a result of operational disturbance.

Tributary Alluvial Plains are often prone to water erosion especially where soils are texture-contrast types and where they are in close proximity to foot-hill slopes. Severe gulling can occur along seismic lines unless precautionary measures are taken.

Sand Plain and Dune Fields with their sandy soils are not as sensitive to disturbance as land systems with duplex soils because the deep sands are highly permeable and readily absorb rainfall. However, near dune crests, or areas of red calcarious earths they can be very fragile and have the potential for small, localized gulling by water and possible wind erosion.

Floodplains, Coastal Plains and Waterways are not readily prone to wind and water erosion if the topsoil and plant cover are not disturbed. However, their deep, medium or heavy textured soils are slow to revegetate following disturbance and therefore subject to damage upon continual exposure to the elements.

Local Initiatives and Responses to Exploration Activities

In 1983 and 1984 concern was expressed by pastoralists in the Derby-West Kimberley and Broome Shires over disturbance to soils, vegetation, livestock, and management practices associated with seismic surveys. In addition, in the Broome area, a danger to personnel and vehicles was caused by the collapse of seismic shot-holes creating sizeable pits along some cut-lines.

In February 1985 the Commissioner of Soil Conservation requested a study on the effects of seismic activity over two areas, one encompassing Dampier Downs Station and its neighbours Yakka Munga and Luluigui Stations, the other area being near Broome and including Thangoo, Roebuck Plains and Waterbank Stations.

A meeting in April 1985 of the West Kimberley Soil Conservation District Committee, together with representatives of three petroleum exploration companies, Mr J. O'Driscoll, Principal of Clan Contracting Pty Ltd, Mr P. De Long of Dampier Downs Station and officers of the Department of Agriculture, discussed exploration activities and their effects on pastoral management. The meeting concluded there were a number of areas requiring improvement, especially in communications and general public relations. However, the meeting agreed to the need of a detailed study on the overall effects exploration activities have on the environment and on pastoral pursuits.

METHODS

Six traverses of the survey area were made, two on Dampier Downs station (east and west), one on Thangoo/Roebuck Plains Stations, and one each on Yakka Munga, Luluigui, and Waterbank stations. Each traverse attempted to follow
and/or cross as many seismic lines on all land systems with as diverse a number of soil types as possible.

Maps were obtained showing the location of seismic lines constructed by Gulf Oil Australia, Pty Ltd, W.A.I.N.O.C.O. Australia Ltd, and International Energy Development Coporation (I.E.C.D.) in the survey area, together with 1:100,000 topographical maps with overlays of land systems and seismic lines.

Yakka Munga and Dampier Downs stations were traversed by the survey team on May 1-4 covering 830 kms. Lululiqui station was inspected May 8-10 and the three stations in the Broome area were visited May 13-15. One area on Dampier Downs was re-inspected on May 24. A total of 4900 vehicle kilometres and 32 person/days were involved in the field survey.

Eighty five detailed observation points were made so as to record vegetative cover and erosion on the cut-lines as compared to the adjacent undisturbed land. Many of the observation sites were located at intersections of cut-lines. At several crossings the lines were of different age and allowed accurate comparison of revegetation. Also, general observations were made while in transit, noting and recording changes in soil types, vegetative growth, plant associations, etc. Sites are readily identifiable by line numbers, photographic and traverse records, for re-evaluation in the future if required. Details of appropriate data collected and selected photos at some sites are found in the section covering individual station assessments. Traverse maps are also included showing the observation points. Details collected at each site included:

1. Identification of the grid line or seismic line i.e. company, year, number.
2. Width and depth of line cut.
3. Present obvious usage, i.e. nil, track, cattle pad, road, etc.
4. Land system and appropriate unit.
5. Soil group, family, type.
6. Erosion type and score. See Table 1.
7. Revegetation type and score. See Table 2.
8. General observations comparing "off-line" vegetation.

Table 1 shows the classification of erosion used in the course of the survey. In it provision is made for both wind and water erosion.

<table>
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2 Moderate
Active erosion with frequent scalds, small gullies, and thin discontinuous sheeting.

3 Severe
Active erosion with large continuous scalds; removal of soil surface, and extensive gullying.

Table 2 shows the classification used to describe the vegetative cover encountered in the survey. The scoring is based on comparison of total vegetative cover on cut-lines to the adjacent undisturbed areas at the time of the survey and is subject to re-evaluation at future points in time. Quality of vegetation as pastures was not considered in the score.

TABLE 2. REVEGETATION CLASSIFICATION

0 Nil
Very little, if any, active plant cover.

1 Slight
Some patchy ground cover present, up to 25% of the area. Mainly annual grasses with scattered forbs and perennial grasses. Very few seedlings or young plants of shrub species.

2 Fair
Ground cover more evenly distributed up to 50% of the site with annual and perennial grasses and forbs. Seedlings and young plants of shrub species evident.

3 Good
Regeneration up to 75% that of the adjacent undisturbed land with an even distribution of native grasses and moderate establishment of woody plants.

4 Complete
Regeneration 90-100% recovered. Cut-line mainly undetectable at ground level though slightly evident in the upper storey.

LAND SYSTEM DESCRIPTIONS

The land systems encountered during the survey are described below. Land systems are further divided into units with more detailed descriptions in the reference SPECK, N.H. et al. (1964).

HILL-LANDS (relief mainly less than 100 metres).

Bohemia (Bo). Lateritic plateaux and hilly sandstone country; red sands and gravelly soils; spinifex grasslands with scattered trees and shrubs.

PLAINS (relief less than 15 metres).
Myroodah (My). Extensive outcrop plains with scalded surfaces; brownish sands, reddish loams, and skeletal soils; low very open woodlands with spinifex grading into spinifex grassland.

ALLUVIAL PLAINS

Coonangoody (Co). Sandy tributary alluvial plains with broad through-going drainage floors; variable soils; low grassy woodlands with short grasses.

FLOOD PLAINS

Djada (Dj). Active flood plains comprising extensive back-plains, with juvenile cracking clays and dark cracking clays, and ribbon grass-blue grass and Mitchell grass grasslands; also less extensive levee zones, with alluvial soils, and grassy woodlands with frontage grasses.

Gogo (Go). Active flood plains with extensive levee zones, with alluvial soils, and grassy woodlands with frontage grasses; also less extensive back-plains with juvenile and dark cracking clays and ribbon grass-blue grass, and Mitchell grass grasslands.

SAND PLAINS

Sand Plain and dune fields with little organised drainage.

Yeeda (Ye). Sandplain soils; deep red sand with pindan vegetation grading to deep yellow sands with tall woodlands in higher rainfall parts.

Camelgooda (Cm). Dune fields; deep red sands and reddish sands; pindan vegetation.

Luluiqui (Li). Sand Plain and dune fields with stony surfaces and scalded plains; deep red sands, reddish sands, red and yellow loamy soils; pindan vegetation and low grassy woodlands with ribbon grass.

Sand Plain and dune fields with through-going drainage.

Wanganut (Wa). Low-lying sandplain dunes; deep red sands and yellowish sandy soils; pindan vegetation and grassy woodlands with ribbon grass.

COASTAL FLATS

Roebuck (Rb). Saline coastal flats distinguished by broad plains of salt water (or marine) couch grasslands; also samphire meadows and bare mud flats with fringing mangrove communities.
STATION ASSESSMENTS

Observation sites are indicated on the traverse maps located in each station section.

The survey team noted that several mapped seismic lines could not be located (possibly programmed but not actually cut) while others were found that were not on any available map.

Yakka Munga Station

Three sandplain land systems were covered in this traverse - Camelgooda, Wanganut and Yeeda. Six observation points were established. No erosion was evident over the entire route and revegetation was good to complete, even on the 1984 cut-line. Approximately 1600 km$^2$, or 84% of the station had been subject to exploration activity.

The total station area comprises 1894 km$^2$. The three land systems' approximate area are:

<table>
<thead>
<tr>
<th>Land System</th>
<th>Area (km$^2$)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camelgooda</td>
<td>760</td>
<td>40%</td>
</tr>
<tr>
<td>Wanganut</td>
<td>304</td>
<td>16%</td>
</tr>
<tr>
<td>Yeeda</td>
<td>830</td>
<td>44%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1894</strong></td>
<td><strong>100%</strong></td>
</tr>
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YAKKA MUNGA - Details of observation points

Traverse 1
W.N.W. on cut-line 84 - 198 approximately 2 km N. of new homestead. (See Appendix 1)

Photo: YM 01.
Cut-line 84-198: 7 m wide, Western Geophysical.
Present usage: Station access, light vehicles infrequently, some stock usage.

Land system: Cm (2), Soil red sandy loam Yabbagooddy family.

Geology: Quaternary Aeolian Sands.
Slope < 10°: Erosion score = 0 Revegetation score = 2.

Pasture plants

Ground storey: Desirable Undesirable
Chrysopegon fallax Crotalaria crispata
Eriachne obtusa Aristida browniana
Eragrostis falcata Calandrinia polyandra
Sorghum plumosum (not on line) Indigofera sp

Mid and Upper storeys:
Cassia notabilis
Grevillea striata
Acacia tumida
" pachycarpa
Photo: YM 03 4.5 km W.N.W. of site 01.

Cut-line 84-198: Western Geophysical.

Present usage: Very light station use.

Land system: Wa (3) Reddish sandy soil Yabbagoddy family.

Geology: Quaternary Aeolian Sands.

Slope < 1°: Erosion score = 0 Revegetation score = 3.

Pasture plants

Ground storey: Desirable Undesirable
Chrysopogon fallax Aristida browniana

Mid-Upper storey: Acacia pachycarpa
Photo: YM 05 S.W. along Wapet 1966 line 2.4 km from junction (with 84-198).

Present usage: Station track.

Land system: Ye (3) Reddish sandy soil, Tableland family.

Geology: Quaternary Aeolian Sands.

Slope < 1°: Erosion score = 0 Revegetation score = 4.

Pasture plants

Ground storey: Desirable

- Chrysopogon fallax
- Sorghum plumosum

Undesirable

Mid-Upper storey:

- Lysiphylhum cunninghamii
- Grevillea striata
Dampier Downs Station

Approximately 2200 km\(^2\), or 88% of the station has had exploration and drilling activities. In 1984, three seismic crews and two drilling rigs were in operation.

Traverse (2) covered the eastern portion of the station with some overlap of Luluqui Station at Gee Gully Creek. The sandplain system, Camelgooda (Cm), and the alluvial plain system, Coonangoody (Co), were crossed and twenty-six observation points were sited.

Traverse (3) entailed the western portion of Dampier Downs Station over diverse land forms such as alluvial plains, sand plains, and sandstone hills and outcrops as described respectively in the Coonangoody, Yeeda, and Bohemia land systems. An additional twenty observations were made over this area.

The station area is approximately 2521 km\(^2\). The approximate area of each land system in the station is:

<table>
<thead>
<tr>
<th>Land System</th>
<th>Area (km(^2))</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camelgooda</td>
<td>1620</td>
<td>64%</td>
</tr>
<tr>
<td>Yeeda</td>
<td>590</td>
<td>23%</td>
</tr>
<tr>
<td>Coonangoody</td>
<td>117</td>
<td>5%</td>
</tr>
<tr>
<td>Bohemia</td>
<td>194</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2521</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The Coonangoody land system comprises better pasture lands of a higher productive potential than the other systems but its area represents the least proportion of the station. This land system is also the most fragile in terms of susceptibility to erosion in that the yellowish sandy to loamy surface horizons overlie sandy loam to sandy clay loam sub-surface which occur commonly over sandstones and quartzites. Removal of the plant material and disturbance of the surface renders this land system subject to water erosion damage from which it is least likely to recover by natural means compared to the other land systems.

The majority of soil degradation resulting from seismic activity on Dampier Downs was associated with the Coonangoody land system. Refer to photos DD-03, 08, 09, 10, 33, 43. One site, DD-05 showed nil erosion and reasonable recovery.

Four sites on the Yeeda land system (Photos DD-35, 37, 38, 39) exhibited erosion. This was mainly due to the lines being used as roads, tracks or cattle pads, especially near watering points where traffic was more concentrated. Generally this land system had recovered quickly.

The Camelgooda land system was generally stable with slight soil movement evident on a few dune crests. However, where the soil in the vicinity of intense activity such as camp sites, air strips, drilling sites, roads, etc had been compacted, water run-off was accelerated and erosion was evident. Site DD-12 shows a 1982 cut-line that had been used as a road in 1983 and 1984 by I.E.D.C. and was subject to water erosion. Sites DD-01 and 11 show two different 1983 lines that have recovered very well and the soil is now stabilized.

Only a few points on the Bohemia land system were examined. The system mainly contains sandstone outcrop, laterite, plateaux, and foot-hill slopes. Site DD-30 shows a very small area of slight erosion on the lower reaches of the
Edgar Range at the end of seismic line ED-82-213. However, further downslope from this site the soils were stabilized into the Camelgooda land system and revegetation was complete. Remedial action is not required on DD-30. However, explorers should be aware of the possibility of soil damage in areas such as this.

**DAMPIER DOWNS STATION - Details of observation points**

**Traverse 2**
Commencing at Duffers Yard E. along station track. (See Appendix 1)

**Photo site:**

**Present usage:**
Not used.

**Land system:**
Cm (3) N.N.E.

**Geology:**
Quaternary Aeolian Sands (3).

**Slope < 10°:**
6 m in width. Erosion score = 0 Revegetation score = 3+

**Pasture plants**

**Ground storey:**
Desirable

- *Eragrostis eriopoda*
- *Dactyloctenium radulans*

Undesirable

- *Aristida sp*
- *Cenchrus echinatus*

**Mid-Upper storey:**

- *Melaleuca acacioides*
- *Acacia eriopoda*
From DD 01  Crotalaria crispata thick on line - less in bush. 2.5 km from DD 01 - intersection ED 83-282 with ED 83-274.

Photo site:  DD 03 E.S.E. (115°) along ED 83-282.

Present usage:  Cattle pad along 83-282.

Land system:  Co (2) red sand, Cockatoo family.

Geology:  Quaternary Aeolian Sands.

Slope < 1°:  Erosion score = 1  Revegetation score = 3. Note: cut-line has acted as firebreak in 1984.

**Pasture plants**

Ground storey:  Desirable  Undesirable

*Triodia pungens  Corchorus sidoides*

*Eragrostis (falcata?)*

Mid-Upper storey:

*Erythrophleum chlorostachys  Acacia umbellata*
Continue N.E. on ED 83-275 to intersection ED 82-218 - 1.6 km

Photo site: DD 08 erosion at intersection 1982 + 1983 lines.

Present usage: ED 82-218 used as access track by explorers in 1983.

Land system: Co (2) Red sand, Cockatoo family.

Geology: Quaternary Aeolian Sands.

Slope 1° >: Erosion score = 2 Revegetation score = 2+.

Pasture plants

Ground storey: Desirable Undesirable

Sorghum stipoideum Aristida hygrometrica
Chrysopogon fallax
Perotis rara

Mid-Upper storey: Acacia umbellata
Down 82-218 S.E. to Gee Gully crossing on ED 83-274

Photo site: DD 09 looking N.N.E. across Gee Gully on line ED 83-274.

Present usage: Some cattle usage.

Land system: Co (5) brownish sand over loam. Tarraji and Jurgurra families.

Geology: Quaternary Alluvium.

Slope - 0: Erosion = 2 (some rilling and salt coming to surface) Revegetation = 0.

Upper storey: Melaleuca acacioides.

No ground storey - some Eragrostis sp on grader spoil lines (shoulders).
Return to DD 10 on ED 83-274 1 km from DD 09.

Photo site: DD 10 looking S.S.W. Wheel track erosion.

Present use: 0, light usage as track in 1984 by exploration company (I.E.D.C.).

Land system: Co (5) (edge). Soil pinkish sand, Tarraji family.

Geology: Quaternary Aeolian Sands over Quaternary Alluvium.

Slope 1°: Erosion = 2 Revegetation = 2.

Pasture plants

Ground storey: Desirable Undesirable
Eragrostis sp Solanum sp
Eragrostis eriopoda
Eriachne obtusa

Upper storey:

Melaleuca acacioides
Lysiphyllum cunninghamii
Continue N.W. along ED 82-218 - used as track by I.E.D.C. In 1984.

Some wheel-line erosion.

From DD 07 - 1.5 km intersection ED 83-276.

Photo site: DD 11 looking N.N.E. along ed 83-276 - well grassed.

Present use: Nil.

Land system: Cm (1) Soil red sand, Cockatoo family.

Geology: Quaternary Aeolian Sands.

Slope -1° -2°: Erosion = 0 Revegetation = 3+

Pasture plants

Ground storey: Desirable

- Spermacoce breviflora
- Calandrinia sp
- Flannel weed

Undesirable

- Aristida hygrometrica
- Crotalaria crispata

Upper storey:

- Acacia sp
Continue W.N.W. along Ed 82-218 - 4 km.

Photo site: DD 12 looking W.N.W.


Land system: Cm (2) Soil red sand, Yabbagoody family.

Geology: Quaternary Aeolian Sands.

Slope 1-2°: Erosion = 1+ Revegetation = 1

Pasture plants

Ground storey: Desirable

Triodia pungens
Panicum australiense
Chrysopogon fallax
Eriachne obtusa

Mid-Upper storey:

Eucalyptus zygophylla

No Acacia revegetation.
Continue 1.7 Km S.S.W. to airstrip near Notabilis No 1 Well (I.E.D.C.) 1984.

Photo sites: DD 24 looking West down airstrip.

Note: Airstrip cultivation and Verano stylo sown by leaseholder - some legume growing - uncultivated strips quite bare.

E.S.E. from Jude's Bore (Notabilis I) on ED 82-218 which is made road 2.1 Km.

Photo site: DD 25 looking E.S.E. on 82-218.

Land system: Cm (1) Soil red sand, Cockatoo family.

Geology: Quaternary Aeolian Sands.

Erosion: 1 Minor rilling on verges. Shoulder drainage could gully.

Revegetation on road = 0 Side banks = 2.
Proceed E.S.E. on ED 82-218 for 8.1 Km.

Photo site: DD 26 intersection 82-218 with Dampier Downs access road.

Wash from road erosion 2.5 Slope estimated 3°.

Wash probably started from pushed-up loading ramp.

Bank put in by station as anti-erosion measure. Suggest dirt be piled in foreground and spur drain put in further up slope on road.
Traverse 3  Proceed S.S.W. on 82-213 4.3 Km. (See Appendix 1)

Photo site:    DD 28 on 82-213 looking S.S.W. toward Edgar Range.

Land system:  Cm (1) Soil red sand, Cockatoo family.

Geology:      Quaternary Aeolian Sands.

Present use:  Unused. Erosion score = 0  Revegetation score = 3+.

Vegetation:   Triodia pungens and Acacia holosericea.

7.5 Km from fence change to yellowish soil. Plectrachne pungens replaces
Triodia. Sorghum plumosum and Acacia holosericea.

Photo frame:  18/2 looking N.E. on 82-213.

Transition zone between Land systems Cm (1) and Bo.
Proceed on ED 82-213 S.W. 6.7 Km.

Photo sites: DD 30 = minor scalding looking S.W. (6 m wide).

Land system: Bo (5) Yellowish skeletal soil.

Geology: Permian and Jurassic age.


Slope < 1° grading to 30° on Edgar Range (off cutline). Line stops at foot of Range:

Pasture plants

<table>
<thead>
<tr>
<th>Ground storey:</th>
<th>Desirable</th>
<th>Undesirable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plectrachne pungens</td>
<td>Eriachne obtusa</td>
</tr>
<tr>
<td></td>
<td>Chrysopogon fallax</td>
<td>Aristida hygrometrica</td>
</tr>
<tr>
<td></td>
<td>Brachyachne convergens</td>
<td></td>
</tr>
</tbody>
</table>

Mid-Upper Storey:

Gossypium australe
Grevillea striata
Eucalyptus dichromophloia
Acacia holosericea
DD 33  Wheel rut erosion on station track used by W.A.P.E.T. in 1960's. S.E. of McHugh's Bore.

Land System: Co

Erosion/Revegetation: 3/1


Present use: Used by heavy traffic for 3 years (W.A.I.N.O.C.O.).

Slope 1-2° Erosion = 2 Revegetation = 0.

Land system: Yeeda
Photo site: DD 36 on road shows spur drain off roadside which water has by-passed.

Frame X: Further along access road; severe gullying.
Photo site: DD 37 along W84-17 looking S.E.

Land system: Yeeda. Red sandy soil, Cockatoo family.

Geology: Quaternary Aeolian Sands.

Present use: Some use by cattle.

Slope 1-2° Erosion = 1 Revegetation = 1+

Pasture plants

Ground storey: Undesirables only - Crotalaria crispata

Aristida hygrometrica

No upper storey vegetation.
Proceed along old road to intersection W84-15.

DD 38: shows shot hole in foreground. Photo S.W. along W84-15.

Land system: Yeeda (1) Erosion = 2 Revegetation = 1.

Slope estimated 1°.

Ground storey: Desirable

Panicum australiense

Undesirable

Aristida browniana

No regeneration of spinifex or upper storey.

Mid storey: Cassia notabilis
Continue N.E. on W84-16 4.2 Km (12.7 Km from McHughe's).

Photo sites: DD 41 end of cutline on top of Edgar range escarpment looking N.E.

Land system: Bo (4) (Sandstone outcrop, reddish gravelly skeletal soils).

Present use: Unused.

Geology: Permian and Jurassic age.

Erosion = 0  Revegetation = 2.

Only annuals regenerating on track - no spinifex regeneration.

East of McHughe's. Intersection 84-22 with E.W. track.

Photo site: DD 42 and DD 42a. Shows shothole on intersection - hat indicates size. Hole capable of breaking leg of horse or bullock.
South east of McHughe's.

Photo sites: DD 43. Cutline W84-22 - wheel track erosion looking N.W..

Land system: Coonangoody (CO1) Soil - pale loam, Tablelands family

Geology: Quaternary Alluvium.

Slope 1°. Erosion score = 1 Revegetation score = 1.

Present use: Some cattle use.

Pasture plants

Ground storey: Desirable

Desirable
Chrysopogon fallax
Aristida latifolia
Eriachne obtusa
Corchorus sidoides

Undesirable
Crotalaria crispata
Aristida hygrometrica

Mid-Upper storey:

Acacia platycarpa
Continue south of McHughes's along W84-22 S.E.

Photo site: DD 44 looking east on old 1960's (W.A.P.E.T.) line at intersection with W84-22.

Photo site: DD 45 looking N.W. along W84-22 - showing lack of revegetation.

Land system: Co (1) Soil pale loam, Tablelands family.

Geology: Quaternary Alluvium.

Slope < 1° Erosion score = 3 Revegetation score = 0.

Vegetation off cutline - Plectrachne pungens and Triodia pungens.
Continue along W84-22 S.E.

Severe gullying into Mad Creek.

Photo frames 17, 18, 19.

Cutline ends 100 m beyond creek. (Why cross it?) (W84-22 peg 101).
Luluiqui Station

As in the case of Dampier Downs Station, approximately 88%, or 2466 km², of the station's area of 2816 km² has had some exploration activity over recent years.

The fourth traverse of the survey team covered seven of the nine land systems identified on the station. These were Luluiqui (Li), Myroodah (My), Camelgooda (Cm), Coonangoody (Co), Djada (Dj), Bohemia (Bo), and Gogo (Go) land systems. The other land systems, Yeeda (Ye) and Wanganut (Wa) were not traversed because they have been covered on other routes and did not warrant further investigation.

Approximate breakdown of land systems in relation to the total station area is:

<table>
<thead>
<tr>
<th>Land System</th>
<th>Area</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luluiqui (Li)</td>
<td>380 km²</td>
<td>13%</td>
</tr>
<tr>
<td>Myroodah (My)</td>
<td>250 km²</td>
<td>9%</td>
</tr>
<tr>
<td>Camelgooda (Cm)</td>
<td>1310 km²</td>
<td>47%</td>
</tr>
<tr>
<td>Gogo (Go)</td>
<td>156 km²</td>
<td>6%</td>
</tr>
<tr>
<td>Bohemia (Bo)</td>
<td>60 km²</td>
<td>2%</td>
</tr>
<tr>
<td>Yeeda (Ye)</td>
<td>210 km²</td>
<td>8%</td>
</tr>
<tr>
<td>Coonangoody (Co)</td>
<td>180 km²</td>
<td>6%</td>
</tr>
<tr>
<td>Djada (Dj)</td>
<td>90 km²</td>
<td>3%</td>
</tr>
<tr>
<td>Wanganut (Wa)</td>
<td>180 km²</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2816 km²</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

In addition a very small portion of the Calwynyardah (Cy) land system was located in the south-east corner of the station.

Observation sites were located on four land systems, being Luluiqui, Camelgooda, Myroodah, and Gogo. The Coonangoody land system had been surveyed along Gee Gully from the Dampier Downs traverse. General observations were made when travelling over the Djada and Bohemia land systems. No soil damage was sighted to warrant closer investigation.

Sites LG-01 and 02 show intersection of two 1982 seismic lines on the Luluiqui land system. LG-01 had good revegetation though there had been light station traffic in the past. Site LG-02 shows moderate erosion and only light plant cover on the line which had not been used in recent years, but evidence of past usage may have been the cause of soil movement. Sites LG-06, 07, 08, 09 also show water erosion.

Sites LG-03 and 04 on Line 82-217 on the Myroodah land system indicate severe and moderate erosion respectively with nil to slight revegetation at LG-03 and good plant cover where erosion was not as great as shown in LG-04. The Myroodah land system was not significant in total area. However, the main land units containing soil-covered plains and stony surfaces were sensitive to the effects of water when the natural vegetation was removed and the surface disturbed.

Sites LG-11 and 14 on the Camelgooda land system show excellent recovery and no erosion as was to be expected of sandplain soils having little or no traffic following the initial cutting of the line.

Sites LG-12 and 13 taken on the Gogo land system reveal no erosion on the relatively flat terrain. However, revegetation was slow as indicated even though the line was cut in 1982 and had three wet seasons since that time. Compare photos with LG-14 taken on the same line approximately 1.5 km away on the Camelgooda land system.
LULUIGUI STATION - Details of observation points

Traverse 4  From Luluiqui homestead 12.8 Km. Intersection cutline 82-217 and 82-209. (See Appendix 1)

Photo sites:  LG 01 looking N.E. on 82-217 (25°).

Photo site:  LG 02 looking S.W. on 82-209 (205°).

Present usage:  82-217 - light station traffic.  82-209 - no present use.

Land system:  Luluiqui (4) Red brown sandy loam, Tippera family.

Geology:  Quaternary Aeolian Sands.

Slope < 1°.  Erosion scores 82-217 = 0 Revegetation score = 3.

82-209 = 2  "  "  "  = 1.

Pasture plants

Ground storey:  Desirable  Undesirable

Sorghum stipoideum  Crotalaria crispata
Chrysopogon fallax
Gomphrena canescens
No Triodia pungens regeneration

Upper storey:

Acacia tumida
Continue S.E. down 82-217 - 4.2 Km.

Photo site: LG 03 looking S.E. Drainage wash accelerated by cutline.

Present usage: Some cattle use (pad).

Land system: Myroodah (l) Brownish sands and loam, Moonah family.

Geology: Quaternary Aeolian Sands with small surface lateritic gravel.

Slope < 1°. Erosion score = 3 Revegetation score = 0 at site -
 Xerochloa laniflora up track.

Triodia pungens off line.
1.8 Km from LG 03 line 82-217.

Photo site: LG 04 looking S.E. along 82-217 - some soil wash.

Present usage: Nil.

Land system: Myroodah (1) Brownish soil and loam, Moonah family.

Geology: Quaternary Aeolian Sands.

Slope 1°. Erosion score = 2 Revegetation score = 3+.

Pasture plants

Ground storey: Triodia pungens, Sorghum stipoideum, Crotalaria crispata.
Continue 5 Km N.N.E. on 82-210 - some erosion in patches.

Photo site: LG 06. Old track crosses 82-210 looking N.N.E., wash and rilling.

Present usage: Some station traffic.

Land system: Li (2). Red sandy soil, Yabbagooddy family.

Geology: Quaternary Aeolian Sands.

Slope < 1°. Erosion score = 1 Revegetation score = 1+

Pasture plants

Ground storey: Desirable Undesirable

Sorghum stipoideum
Eriachne obtusa
Sorghum plumosum

Mid storey:

Cassia notabalis

Upper storey:

Not regenerated
S.W. along 81-15 2.5 Km S.S.W. - bad wash and sand deposited.

Photo site: LG 07 shows sand deposited (S.S.W. on 81-15).

Photo site: LG 08 0.3 km up slope showing source of wash, gullying, exposed roots etc.

Present usage: Very light and irregular station traffic.

Land system: Li (2). Red sandy soil, Yabbagoddy family.

Geology: Quaternary Aeolian Sands.

Slope 2-3°. Erosion score = 2+ Revegetation LG 07 = 0+, LG 08 = 1.

Pasture plants

Ground storey: Desirable Undesirable

Sorghum plumosum Aristida hygrometrica
Sorghum stipoides Panicum cymbiforme

No upper storey regeneration.
Continue S.W. along 81-15.  0.5 Km changes to Unit 3 Li Land system, strong outcrop plains.

1.6 Km > 2° slopes Unit 3 Triodia intermedia hilltop.

4.5 Km return to Unit 2, Luluigui Land system some gullying.

4 Km to end of cutline W81-15 - on to S. of River road.  Turn W.

Proceed to Gee Gully crossing and N. up station track.

Photo site: LG 09, intersection of fenceline track and cutline 82-212 looking 210° S.S.W.

Present usage: Cattle pad.

Land system: Li (2).  Reddish sandy soil, Yabbagoddy family.

Geology: Quaternary Aeolian Sands.

Slope 1° Erosion = 0  Revegetation = 3.

Pasture plants

Ground storey:

Desirable

Plectrachne pungens

Undesirable

Aristida hygrometrica

Panicum cymbiforme

Crotalaria crispata

Schizachyrium fragilis

Mid-Upper storey:

Waltheria indica
Acacia tumida
Acacia holosericea
Proceed across Gee Gully on 82-217 (W).

Intersection 82-217 with 82-212.

Photo site: LG 11 82-212 S.S.W.

Present usage: No usage W and S. Station track S.E. and N.N.E.

Land system: Cm (2). Reddish sandy soil, Yabbagooddy family.

Geology: Quaternary Aeolian Sands.

Slope < 1° Erosion score = 0 Revegetation score = 4 (100%).

Pasture plants

Ground storey: Desirable Undesirable

Eriachne sp
Panicum cymbiforme

Aristida hygrometrica
Crotalaria crispata

Mid storey: Cassia notabilis

Upper storey:

Acacia tumida
Erythrophleum chlorostachys
Lysiphyllum cunninghamii
Proceed along Udallia track to intersection cutline 82-119 (Gulf-Eagle).

Photo site: LG 12 N.E. along 82-119 (towards Fitzroy River).

Photo site: LG 13 S.W. along 82-119.

Present usage: Not used.

Land system: Gogo (3). Brownish juvenile cracking clays.

Geology: Quaternary Alluvium.

Slope < 1° Erosion = 0 Revegetation score = 1+. 

Pasture plants

Ground storey: Desirable

Eriachne glauca
Xerochloa sp (laniflora?)
Triodia pungens

No mid or upper storeys.
Proceed S. on 82-119 (6 m wide) 1 km.

Photo site: LG 14 looking S.W. on 82-119.

Present usage: Nil.

Land system: Camelgooda (1). Red sand, Cockatoo family.

Geology: Quaternary Aeolian Sands.

Slope 1-2° Erosion score = 0  Revegetation score = 3+.

Pasture plants

Ground storey: **Desirable**  **Undesirable**

Sorghum stipoideum  Crotalaria crispata

Mid-Upper storey:

Lysiphyllum cunninghamii
Acacia tumida
Roebuck Plains and Thangoo Stations

Roebuck Plains Station's 2893 km² has been subject to exploration activity over almost 100% of the area. (Note, the traverse map of the station only indicates the seismic lines which the survey team has followed or crossed.)

Thangoo Station contains an area of 1730 km² of which an estimated 83% or 1430 km² have undergone seismic surveys.

Both stations have the same three land systems, though in different proportions. The approximate areas are:

<table>
<thead>
<tr>
<th>Land System</th>
<th>Roebuck</th>
<th>Thangoo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeeda (Ye) Land System</td>
<td>1520 km²</td>
<td>1400 km²</td>
</tr>
<tr>
<td>Wanganut (Wa) Land System</td>
<td>813 km²</td>
<td>40 km²</td>
</tr>
<tr>
<td>Roebuck (Rb) Land System</td>
<td>560 km²</td>
<td>290 km²</td>
</tr>
<tr>
<td></td>
<td>2893 km²</td>
<td>1730 km²</td>
</tr>
</tbody>
</table>

The fifth traverse of the survey covered only a small portion of both Roebuck Plains and Thangoo because the main aim of investigating the area was to examine seismic shot-holes posing a physical hazard on both the silt plains of the Roebuck land system and the sand plains of the Yeeda and Wanganut land systems.

The owner of Thangoo, Mr A. Grey, was concerned over the shot-holes being left open after the seismic crews left the area. Some holes had filled in naturally (Sites RK-03,TH-01) while others remain a hazard to livestock, especially horses (Photo frame 5/7).

None of the cut-lines on either station showed any sign of erosion, whether on the silt plains or sandplain. Revegetation of the lines depended on the use they received but none appeared to be susceptible to water or wind erosion at that time. The silt plains can be prone to wind movement if the lines are repeatedly used as tracks and the surface becomes pulverized.
ROEBUCK PLAINS STATION - Details of observation points

Traverse 5

(See Appendix 1)

Photo site: RK 03 looking west along 83-183 2.3 Km from RK 02 0.7 Km west of intersection 83-183 83-185.

Photos show shot-hole 1.5 m in diameter, 45 cm deep.

Regrowth of Sporobolus virginicus, Sporobolus australasicus. No erosion. Regeneration on cutlines on Roebuck Plain 2+ to 4.

Traverse 5 (cont) THANGOO STATION

Intersection 82-125 and 82-135.

Photo site: TH 01 shows depression left by shothole on Rb (1) Land system.
Photo site: TH 03 looking N.N.E. on 84-205.

Present usage as station track and cattle pad. No use on 82-127.

Land system: Yeeda. Soil red sand.

Geology: Quaternary Aeolian Sands.

Slope $1^\circ$ Erosion = 0 Revegetation = 1+ on line 82-127 = 4.

Ground storey: Desirable Undesirable

Chrysopogon fallax Crotalaria crispata
Corchorus sidoides
Eragrostis falcatta

Mid-Upper storey:

Grevillea sp
Acacia eriopoda
Acacia ancistrocarpa

Photo site: Not numbered, frame 5/7. Junction 82-138 and 82-135. Shows shot hole in Rb (1) and hat for size comparison.
Waterbank Station

The station area is 3159 km$^2$ of which 70%, or 2220 km$^2$ have had exploration activity.

Only three land systems are identified on the station, Wanganut (Wa) and Yeeda (Ye) being sand plains and dunes, and Carpentaria (Cr) being tidal mud flats and mangrove community. The proportion of these land system are approximately:

- Carpentaria - 119 km$^2$ - 4%
- Wanganut - 1267 km$^2$ - 40%
- Yeeda - 1773 km$^2$ - 56%

3159 km$^2$ = 100%

The owner of Waterbank, Mr D. Higgins, has sustained personal injury as did one of his sons, and vehicle damage when hidden holes have collapsed under the weight of the vehicle. One such vehicle is shown in the photo where the front end, wheels and springs, collapsed, the passenger's head broke the windscreen, the radiator was smashed, and the left rear spring bracket broke.

The survey team made the sixth and final traverse over a large proportion of Waterbank and its findings are summarized in the traverse photos.

Site WB-01 is a 1982 cut-line on the Wanganut land system that had complete vegetative cover at that site.

Site WB-02, on the same line 26 km from WB-01, shows a shot-hole that was 'dozed in' in 1984 but had collapsed after the 1985 wet season.

Site WB-03 taken on an intersection of the line ex WB-02 and 82-100 shows considerable scouring.

Site WB-04 shows a shot-hole caved-in which had been missed by the ripping method undertaken by Higgins. The next unmarked photo (5/18) shows a shot-hole that had been ripped in 1983 by Higgins which had filled when water was allowed to wash soil into it leaving a shallow depression which will not be a hazard.

Photo site WB-07 was at the intersection of 82-102 and 82-113. The team progressed south wards on 82-113 which was completely grown over. However over the distance travelled, 27 kms, 9 shot-holes were seen, some barely discernable in the grass.

Site WB-08 shows a dead cow in one shot hole which emphasizes the size of the hole, which was large enough to cause considerable damage should vehicles unexpectedly sink into something similar.

Overall, very little evidence of erosion existed on the cut-lines. The lines having the problems of sinking shot-holes appeared to be limited to those lines on the Wanganut land system cut by Gulf Oil in 1982.
WATERBANK STATION - Details of observation points

Traverse 6 (See Appendix 1)

Photo in workshop area at homestead shows damage to vehicle in shot hole accident.
Turn off Beagle Bay road on Pt James Price road.

Photo site: WB 01 junction P.J.P. road and 82-101 0.6 Km from turnoff looking north.

Present use: Light station traffic. 82-101 and others - Gulf Oil.

Land system: Wanganut (1) Soil red sand, Cockatoo family.

Geology: Quaternary Aeolian Sands.

Slope < 1° Erosion score = 0 Revegetation score = 4.

Pasture plants

Ground storey: Desirable

Aristida hygrometrica
Calandrinia sp

Mid-Upper storey:

Lysiphillum cunninghamii
Acacia tumida
Proceed north along 82-101. Holes ripped and graded.

Photo site: WB 02 (2 frame) 26.2 Km from WB 01 looking south on 82-101. Show shot hole which was filled in by dozer, but subsequently fell-in because not ripped. Hole 2 m across, 1 m deep.
Proceed north along 82-101 6.1 Km to junction with line 82-100 (E.W.).

Photo site: WB 03 looking south along 82-101. Shows wash along wheel tracks.

Land system: Wa (1).

Slope 1° Erosion 2+ on corner. Regen = 0 on corner, 2 up track.

Pasture plants

Ground storey: Desirable

Sorghum stipoideum
Aristida browniana
Corchorus sidoides
Schizachyrium fragile

Mid-Upper storey:

Acacia tumida
Acacia eriopoda
Proceed east along 82-100 1.3 Km.

Photo site: WB 04 - shot hole collapsed (unripped). Square sided hole approximately 1.5 m diameter and 1 m deep.

Land system: WA (1).

Proceed east 2 Km along 82-100.

Photo site: WB 05 shows a ripped shot hole - now a depression 2.5 m across and 30-40 cm deep.

Water has flowed down rip-furrow and filled hole with sand.
Frame 18 [unmarked WB-06] shows depression of hole ripped in 1983. 6.4 Km east of WB 05.

Land system: Wanganut.

Continue to intersection 82-102 and 82-113.

Photo site: WB 07 shows entrance to 82-113 and high annual Sorghum grass (Sorghum stipoidum). Shotholes are not visible in this.
Photo site: WB 08 shows dead beast in shothole. The ninth shothole along 82-113 going S.S.W. from 82-102 junction - 11.7 Km.
DISCUSSION

General Impacts of Exploration Activities

Developmental and exploration activities such as seismic lines, drill sites, camp sites, access roads, air strips etc, differ in extent from place to place, but they have a common result - the clearing of native vegetation and topsoil and the disturbance of the ground surface. The intensity of the impacts by these operations are dependent on the sensitivity of the environmental unit subject to such actions.

Exploration companies have provided additional access for tourists and others as well as pastoralists to previously undeveloped areas in the Kimberley. As a result of this increased activity there is an increasing awareness in the community at large of the need to conserve the intrinsic values of arid ecosystems.

Pastoral Pursuits

Petroleum exploration activities undertaken on land subject to pastoral leases have been met with a range of reactions varying from complete acceptance by pastoralists through indifference to hostility, largely depending on personalities and attitudes of the parties concerned and the type of impact such activities have on station management.

Beneficial effects of exploration activity have been reported by pastoralists and include:

1. Old drill holes may provide additional stock water supplies.
2. Seismic lines provide greater means of access to a larger proportion of the property.
3. Lines act as firebreaks when initially cleared and can be maintained as such according to management policy.
4. Lines can also be instrumental in initial clearing for new fencelines.
5. Lines can be used for the introduction of improved pasture species.
6. Some contract work occasionally is available to the pastoralist.

Detrimental impacts upon station operations by oil exploration operations have been reported by pastoralists, and in many cases, sighted by the survey team. These negative effects vary in degree and may not all be in evidence on all properties at any given point of time. In any case they may have a disruptive influence on station operations by the demands they may place on management to make alterations to the seasonal program. However, too often the complaints voiced by pastoralists to the Department of Agriculture were after a considerable lapse of time since the cessation of exploration activities thereby rendering it difficult to organize a meeting of parties concerned for conciliation and rectification of any damages.

Adverse reports include:

1. Increased numbers of people and vehicular activity increase the likelihood of uncontrolled bush fires.
2. Camps made too close to stock yards and watering points restrict normal movements of livestock.

3. Excessive use of cut-lines and access roads by heavy equipment increase the possibility of erosion and limits ease of access by station personnel in the course of their work. Also, increased track usage creates an extra problem of dust spreading over a wide area and settling on forage plants thereby detering their acceptability by grazing animals.

4. Seismic lines may be cut too deeply thus removing valuable topsoil, seeds of native flora and organic matter thereby retarding revegetation and encouraging soil erosion.

5. Lack of attention to slopes during the initial cutting of seismic lines to ensure that off-shoot drains were constructed to minimise water erosion.

6. Rubbish has been left unburied at some camp sites.

7. Seismic shot-holes on some cut-lines on pindan soils have caved in and pose an extreme hazard.

In addition to the above points, it is noted that fences have been cut to allow the passage of heavy machinery and have not always been repaired to a satisfactory standard. This may have a greater detrimental effect on stations which are undergoing a TB eradication program and which are attempting to isolate tested "clean" cattle from untested stock.

Mr D. Collopy, District Veterinary Officer, Western Australian Department of Agriculture, Derby, states ....

"Stations in the West Kimberley contain the highest prevalence of T.B. in Western Australia. The owners of these stations have contracted to deal with the disease under approved eradication programmes. These programmes have a profound effect upon normal management procedures and are costly to run. A basic part of each programme is to ensure that cattle are subject to strict movement regulations and infected cattle are kept in secure areas to prevent spread of disease.

"Fencing is the most expensive and the most effective means of maintaining this security. A $200,000 fence is worthless unless its integrity is maintained at all times."

It is of utmost importance that oil explorers recognize that livestock management (and therefore, the pastoralist's livelihood) is dependent upon maximum cattle control which can only be achieved by water and fence management. Any disruption to these two key factors may undo the efforts of a year or more by the pastoralist in his endeavour to achieve a disease-free status for his herd.

In summation, perhaps the most common complaint received from pastoralists was the lack of advance notice that exploration crews were coming onto the property. A proper liaison between all parties involved or affected by exploration activities would go a long way to overcoming the impacts such explorations have on the station enterprise.
Landforms

Observations made of damage caused by seismic activity are summarized and discussed under the heading of each land form.

Hills and Outcrop Plains

Seismic line construction on the Bohemia land system has generally resulted in minimum damage on the units of rocky plateaux and summit remnants because of the relatively stable nature of the soils. However, on foot-hill slopes below breakaways the shallow, stony skeletal soils are slow to regenerate when disturbed and therefore subject to water erosion. It is noted that plant re-growth consisted mainly of annuals with little evidence of perennial regeneration.

The Myroodah land system contains units which can be described as plains of duplex soils (sands and loams over clay) and outcrop areas of ferruginized strew with loamy skeletal soils. Both units are prone to water erosion along seismic lines, even on the more gently slopes (0.5%) because of the channelling effect the lines contribute to rainfall run-off. Natural revegetation is slow because of the shallow soil remnants and the loss of organic matter along the cut-lines.

Alluvial Plains

Units of the Coonangoody land system surveyed in this study varied from plains with yellow sandy soils, sand plain islands with deep red or yellow sands, to drainage floors with duplex soils of sands and loams over heavy loams or clays.

Seismic lines cut across the island and drainage units resulted in the most obvious damage. It would appear the vehicle operators found the subsoils of these units conducive to improved wheel traction following removal of the topsoil and they have continually used the lines as access tracks. Even when given complete freedom from disturbance, this land system is still the slowest to regenerate when compared to the other units within the survey area. Traffic, even by cattle, contributes to active water erosion.

Sandplains

These land forms were shown to have suffered very little damage from seismic lines. The pindan soils revegetate quickly if the topsoil is not completely removed. However, in areas where considerable depths of topsoil have been removed such as dune crests on seismic lines and access roads, or areas which have had the soils compacted such as drilling sites, camp sites and air strips, some erosion is evident. Other problem areas of these land forms are the units of sand covered plains of the Luluqui land system which consist of sands/loams over clay subsoils and are shallow and stony and prone to water erosion on the slopes.

Flood Plains and Coastal Plains

These land forms are relatively flat and the clay soils are not generally subject to water erosion. However, continual use by vehicles and stock over cut-lines distinigrtes the soil structure and powders the soil which is subject to blowing. Revegetation rate varies from moderate on the coastal plains to slow on the flood plains.

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Conservation and Rehabilitation Techniques

The areas covered by exploratory activity have encompassed a variety of environmental districts, each having its own degree of sensitivity to unnatural disturbance. The type and intensity of exploration operations on a particular land system will also have varying effects on the environment.

Water erosion was the most serious form of erosion encountered on the survey. It starts as a result of the cutting of seismic lines, roadworks and clearing for campsites and gravel borrow pits, where water is channelled and collected.

The other major land degradation problem was that of the collapse of red sandy soils of the Wanganut land system at shot points on Waterbank Station. The deep narrow shot holes on the Roebuck land system were also a major safety hazard.

Techniques for coping with an existing environmental problem are similar to those actions which may be taken in anticipation of a problem arising - differing only in time and degree. It can be stated that preventative measures are those remedial techniques applied prior to the first "wet" season following the exploration operations. Anticipating the problem is better than having to cure it later.

Hence we have recommended certain restoration measures for controlling or diverting water flow and erosion in reference to specific activities over the specific land systems in the survey. In those instances where a major problem currently exists, it is recommended that immediate remedial action be implemented. Further preventative policy recommendations are discussed under "Guidelines".

1. Bohemia Land System

The shallow stony soils of this system was seen to have only posed a problem where seismic lines are directed down slopes and alluvial fans where water run-off was accelerated and resulted in gullying. Minimizing the depth of cut to remove unwanted vegetation and strew would prevent a portion of the problem from arising.

Re-spreading the topsoil, constructing earth blocks and spur drains, and contour ripping across the cut-line on the slopes are recommended.

2. Myroodah Land System

As previously stated in the section on Land Forms, this system contains fragile soil units of duplex soils and outcrops with laterite on shallow loams, both units being prone to water erosion when the topsoil is removed.

Recommended action to overcome or prevent unnecessary damage is to re-spread the top soil and construct earth blocks and spur drains. These soils should not be ripped because of the danger of exposing erodible layers of the soil to water erosion.

3. Coonangoody Land System

The duplex soil unit of this fragile system is the most likely to incur damage from disturbance. As regrowth along seismic lines is slower than the deeper soils of the plains it is suggested that clearance of lines be accomplished by means other than a grader or bulldozer blade, perhaps a
slasher is all that is required to clear the vegetation to allow the acoustic vibrators to perform their task.

Water erosion is active on lines already cleared over this land system. Re-spraying the topsoil and possibly re-seeding with perennial soil-binding grass species may be necessary to rectify the problem.

Roads crossing this land system are the cause, or potential cause, of severe gully erosion. If it is deemed necessary to use tracks across this system for continual access, then it is necessary to gravel the road surface and construct contour drains to minimize water flow.

The soils of this land system should not be ripped in the restoration process for the same reasons as given for the Myroodah land system.

4. Yeeda, Camelgooda, Wanganut Land Systems

Seismic lines cut on the sand plains of the Yeeda land system appear to have caused little damage and the native vegetation has satisfactorily recovered.

As previously noted, the shot-holes located on cut-lines on the Wanganut land system have posed the biggest problem because of the uncertain stability of the holes. Cave-ins may occur at any time. All shot-holes should be ripped with a large chisel tyne to allow water penetration into the cavity and natural re-fill of soil. This action should be taken immediately following detonation of the explosive charges.

On the sand dunes of these land systems an earth block with spur drains should be placed either side of the dune part way up the slopes. Wherever possible sand dunes should be approached at right angles to minimize length of crossing. Dune flanks of the Camelgooda land system may be compacted by clay in the sand matrix. In such cases the slopes should be cross-ripped above and below the earth blocks.

Campsites, drill sites, air-strips, etc., located on these land systems have generally been graded, thus removing the topsoil and vegetation. The grading operation is generally followed by watering the surface and compacting the soil to allow heavy equipment and other vehicles to obtain firmament and to reduce the dust problem in the immediate area. When these sites are no longer required by the exploration permittee, consultation should be sought with the pastoralist to determine if the lessee will have any use for the site in the future. If the site is not required, the original topsoil and organic matter should be re-spread over the area and deep-ripped along the contour to aid root and water penetration and incorporate the topsoil and seed stock into the subsoil to prevent its loss.

5. Luluiqui Land System

The unit of this system most likely to suffer damage from surface disruption consist of plains with soils of brownish sands and loams over clay. These duplex soils react to disturbance similar to that described for the Myroodah and Coonangoody land system. This unit consists of much bare ground with patches of native grasses and scattered low shrubs and trees.
Seismic lines should be cut only to remove unwanted vegetative cover and rocky strew, and in many cases over bare ground, the blade would not be required. Lines cut on the slopes of this system should have the top soil re-spread and earth blocks and drains constructed immediately following the acoustical operations. In some cases, re-seeding may be warranted and should be discussed with officers of the Department of Agriculture.

6. Djada and Gogo Land Systems

These flood-plain systems consist of deep, compact clay soils that are relatively flat. They are fairly stable and do not generally suffer from water erosion, however when the surface is disturbed the soils become powdery and are then subject to blowing.

Seismic lines across these land systems showed very little damage. However, they also displayed very little regeneration of plant life. Because of the hummocky terrain of these systems, seismic lines cut through them have tended to produce windrows. These windrows should be re-spread after the lines' usefulness is over in order to allow the loosened soil to act as seed traps. In some cases, it may be necessary to re-seed the area with native or exotic perennial plant species to hasten recovery.

7. Roebuck land system

The saline coastal plains vegetated by samphire and salt-water couch are flat and not subject to water erosion, though the powdery nature of the soils are liable to wind erosion.

Regeneration of plant life on seismic lines is relatively slow compared to the deeper sandy soils of other land systems. Reclamation techniques of this land unit is similar to that suggested for the Djada and Gogo land systems, i.e. re-spread windrows and re-seed, but with saline-tolerant plant species.

The major problem on this land system is the safety hazard created by shot-holes along seismic lines. The holes are deep and narrow (approximately 30 cm in diameter). Though they are not prone to cave-in as those found on the sands of the Wanganut land system, their danger lies in their stability, thus posing a trap for livestock.

It is recommended that all shot-holes on this and similar land systems (compacted clay soils) should be marked and rectified by a mound of soil over the hole which will gradually fill in.

GUIDELINES FOR EXPLORERS

The APEA code was drafted by the Association's Environmental Affairs committee as a consensus of recommended practices for the petroleum industry supplementary to existing governmental regulations. It is significant that the code provides for members of the Association to observe all the environmental safeguards required in exploration activity. An interpretive summary of the Code is given for consideration by exploration companies.

1. Study and plan prior to operational activities so as to minimise unnecessary disturbance to the land.
(a) Consultation with managers of pastoral leases and officers of appropriate government departments, such as the W.A. Department of Agriculture, of the proposed operational area.

(b) Consideration to access and siting of the operation as to the sensitivity of the environment as well as to any long term effects on the landscape which will affront other legitimate users of the land.

2. Recognise and consider the intrinsic sensitivity of the environmental regions within the area of operations so as to minimise the potential for wind and water erosion.

(a) Restrict clearing of sand dunes to a minimum width.

(b) Restrict unnecessary traffic in dunefields because of the scarifying effects when soil is dry and the compacting effects on wet soils, especially if they contain clay. Vehicular traffic should be restricted to marked roadways.

(c) Site access roads to by-pass or minimise the traversing of long slopes.

(d) Clay or gravel capping of dune crests to afford access should have bars across the line parallel to the ridges to drain water runoff.

(e) Caps should be ripped along the contours when the line is abandoned.

(f) Original vegetation that had been removed in line clearing should be re-spread on crests of dunes displaying duplex soils.

3. Conserve the topsoil.

(a) Select naturally cleared areas, if possible, for major earthworks operations such as camp sites, drill sites, borrow pits, air strips, etc.

(b) If clearing is unavoidable conserve the top soil with its stored seed stock and organic matter for re-spread upon abandonment of the site.

(c) Consider alternate methods of constructing seismic lines such as rolling or slashing of low vegetation, however, if grading is only method, the cut should be kept to a minimum depth.

(d) Re-spread windrows on sensitive areas.

(f) Avoid clearance of vegetation along margins of streams.


(a) Avoid undue obstruction of natural drainage systems to prevent water ponding in one area to the deprivation of water in another.

(b) Prevent artificial channelling of water down slopes of seismic lines and roads by cambering and/or lateral diversion of runoff by blocks and spill-drains.
(c) When site is abandoned, any disturbance to the natural drainage channels should be restructured to their original condition.

5. Tree and shrub preservation.

(a) Minimise the clearance of older trees and shrubs, especially in areas such as flood plains and channel country which is composed of multiple layers of vegetation which take longer to regenerate than salt lakes or open plains.

6. Restore and rehabilitate abandoned land.

(a) Consult with any other legitimate long-term user of the land (eg: pastoralist) as to any possible benefits which may be derived if any operational site is to be left intact ie: airstrip, bore, etc.

(b) Rip or pit compacted soil (except red duplex soils) so as to provide seed and water catchments for natural revegetation.

(c) On fragile soils, replace original top soil and vegetation.

(d) Avoid re-use of vehicles on restored areas.
GENERAL RECOMMENDATIONS

The following areas should be addressed by all parties connected with or affected by petroleum exploration:

Communication

1. It is recommended that petroleum exploration companies should accept the responsibility of initiating and maintaining a continual liaison between all parties involved in or affected by exploratory activity.

2. It is recommended that exploration companies, when submitting their seismic proposals to the Department of Mines, give copies of the maps to the affected pastoralist and to the Division of Resource Management of the Department of Agriculture so that site and line management programmes can be devised.

Pastoral Leases

3. It is recommended that the problem of real or potential damages to station access roads, tracks, waters, fences and other improvements should be dealt with in accordance with the APEA code.

4. It is recommended that all seismic shot-holes, whether now existing or planned for the future, be rectified by either mounding soil as on the silt plains or by ripping as in the case of sand plain soils.

5. It is recommended that all seismic lines should be constructed in such a way that environmental damage does not occur during and subsequent to exploration. The guidelines in this report should be followed.

6. It is recommended that appropriate remedial and rehabilitative treatment should be applied to operational sites and notifications of intended abandonment of the sites must be given to the lessee concerned and the Western Australian Department of Agriculture.

Legislation

7. The laws currently in force in Western Australia which pertains to land usage appear to discriminate against the occupier of a pastoral lease in favour of the comparatively short-term intrusions of petroleum exploration companies.

It is recommended that legislation be enacted to remove the anomalies currently contained in the various Acts concerning the multiple usage of the land resource. However, adherence by exploration companies to existing legislation would halp alleviate some of the problems expressed in this report.

8. The level of geophysical activities in pastoral areas has been, and is likely to remain high for some time to come. It is appreciated that with the number of permits and licences issued by the Department of Mines, monitoring each operation as to adherence to the conditions imposed by the appropriate Act would be monumental, if not impossible task.

It is recommended that the various State Government agencies concerned with the land resource and environment should consider the deputization of personnel to act as monitoring agents in areas subject to exploration activities.

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9. It is recommended that a condition of all exploration permits and development licenses contain the directive in Section 5 (1) of "Direction as to Geological and Geophysical Survey" of July 1, 1982 of the Petroleum Act, 1967-1981 which states that "the permittee or licensee shall ensure that all employees and contractors comply with environmental requirements and in the absence of specific Regulations or directions, that operations are, where practical, carried out in accordance with the APEA Code of Environmental Practice, October 1977".
APPENDIX 1 Traverse Maps

YAKKAMUNGA

TRAVERSE 1

KEY:
TRAVERSE . . . . . .
CUTLINES CROSSED ———
STATION TRACK ————
WINDMILL ¶
No's - PHOTO SITES
LAND SYSTEMS ~
Ye Yeeda
Cm Camelgooda
Wa Wanganut

SCALE 1:250 000

↑ N
THANGOO

TRAVERSE 5 (cont’d)

KEY:
TRAVERSE · · · · · ·
CUTLINES CROSSED ———
STATION TRACK — — — —
WINDMILL ♂
No’s - PHOTO SITES
LAND SYSTEMS ~
Ye Yeeda
Wa Wanganut
Rb Roebuck

SCALE 1:400 000

↑N
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