

Ashers-Waituna and Hawkdun lignite deposits: their resources and use potential

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Abstract

The Otago and Southland lignite deposits represent by far the largest known fossil energy resources in New Zealand. Despite their size they have remained virtually untouched since exploration in the 1970s and 1980s defined their extent. In total there is an estimated 10.9 billion tonnes of lignite in 13 defined fields in Otago and Southland. Much of the exploration work only targeted seams at shallow depth and it is highly probable that there are further resources at depth in the fields that have been explored to date.

L&M Lignite Limited (L&M) holds exploration permits over a number of lignite deposits and is currently engaged in pre-feasibility studies to investigate the potential of the lignites for gasification. L&M is focussing its studies on the Hawkdun and Ashers-Waituna deposits. Coal quality in these deposits, particularly Ashers-Waituna, is highly suitable for gasification. In total the two deposits contain 1,647Mt of potentially recoverable lignite. L&M has engaged a variety of consultants to progress this project. The Hawkdun and Ashers-Waituna deposit databases have been re-evaluated and the resources re-modelled. Further drilling has been carried out and the coal quality database has been expanded.

The baseline project is develop a mine to feed a plant that will produce liquids, specifically low-sulphur diesel and naphtha, using the Fischer-Tropsch process. The project anticipates a staged development of 10,000 barrel per day units, each requiring mining at the rate of 12,700 tonnes of lignite per day. The production of other products including ammonia-urea, methanol, hydrogen and electric power is also under study.

Keywords: *lignite, resources, Hawkdun, Ashers-Waituna, gasification, synfuels*

Introduction

Investigation of the South Island lignites (Figure 1) extends over more than 50 years, although their enormous resources were not known until the Ministry of Energy included lignite exploration in its NZ Coal Resources Survey (NZCRS) through an extensive drilling programme between 1976 and 1979. In the early 1980s, the New Zealand Government established the Liquid Fuels Trust Board (LFTB) which investigated the South Island lignites as a source of transport fuel. The work included clarification of the deposit geology, lignite resource and reserve estimates, mining assessments, lignite quality studies, conversion methods, infrastructure requirements, and environmental issues, all described in various reports. LFTB subsequently carried out more detailed investigations of three of the deposits: Benhar, Ashers-Waituna and Hawkdun.

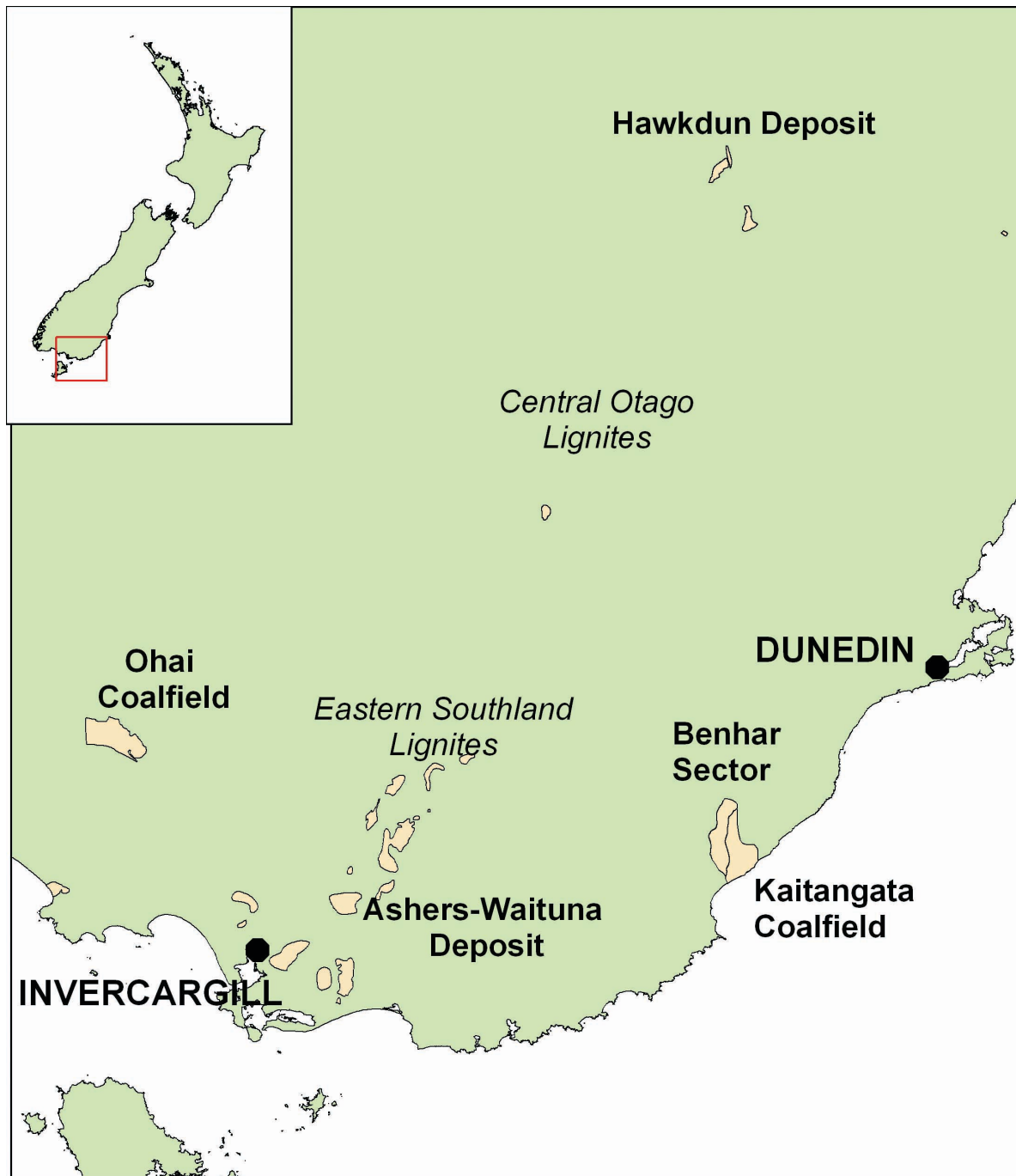


Figure 1. Location of South Island lignite deposits.

Since the LFTB studies were completed there has been little interest in the lignite fields until relatively recently. During the past five years the resources have been re-evaluated as a feed-stock for thermal electric power generation, and detailed investigations have been carried out to determine their potential to produce coal seam gas.

L&M Lignite Limited (L&M) holds exploration permits over all or part of seven deposits (Ashers-Waituna, Waimatua, Morton Mains, Edendale, Matura, Benhar and Hawkdun). L&M's involvement in the lignites commenced in the late 1970 when the company was heavily involved in exploration under the NZCRS. Since the late 1990s L&M and its associated company Kenham Holdings Limited (Kenham) has held exploration permits over various fields and has carried out a number of investigations into their potential uses. During the past 12 months the company has initiated studies into the potential of the fields as a chemical feedstock to produce liquid fuels, fertiliser and electric power.

L&M has carried out initial scoping studies and has focussed attention on the Ashers- Waituna and Hawkdun fields. Pre-feasibility studies are scheduled to be completed by mid 2006.

This paper discusses the mining and exploration history of the fields, and their resources, coal quality and utilisation potential.

Mining and exploration history

General

Other than surface mapping, mining from outcrop, and shallow boreholes drilled by DSIR in the 1950s to early 1970s, the Eastern Southland lignite fields were virtually unexplored until NZCRS drilled 450 exploration holes between 1976 and 1979. Drillhole spacing was initially 2 to 2.5 km, intended to intersect any lignite resource greater than 50Mt. Where significant lignite intersections were made, short infill lines were drilled and the more promising prospects were then drilled down to 750 m spacing.

Isaac & Lindqvist (1990) provide details of the production of lignite from the East Southland lignites since mining began in the 1870s. In total the fields have produced less than 10Mt, mainly from the Newvale and Goodwin pits (Croydon-Waimumu) and the Paper Mills mine at Matura. The Newvale mine is still operating and a small mine is worked intermittently at Ashers-Waituna.

The Central Otago lignite fields were similarly known only from outcrop and small-scale mining until explored by NZCRS drilling between 1978 and 1979 which established major deposits at Roxburgh, Home Hills and Hawkdun. A small opencast currently works the Roxburgh deposit.

In the Kaitangata Coalfield, the Benhar area was mined from the 1860s to feed the McSkimmings Pottery. There is no current production, and total output was less than 1Mt. Following mapping of the Kaitangata Coalfield by Harrington (1958), lignite deposits in the Benhar Sector of the coalfield were drilled by State Coal Mines in 1965 and by NZ Cement Holdings between 1969 and 1972. NZCRS exploration of the coalfield began in 1981 when interest in discoveries of lignite resources in Eastern Southland and Central Otago led to a planned assessment of the Kaitangata Coalfield being brought forward to determine whether there were large-scale opencastable resources that should be included in LFTB investigations. These resulted in selection of Benhar, along with Hawkdun and Ashers-Waituna, for further assessment by the LFTB.

Current total lignite production in New Zealand is about 240,000 tpa.

Hawkdun

The Hawkdun deposit is a sector of the St Bathans Coalfield (Barry et al. 1994). While there has been small scale mining from the St Bathans Coalfield, the Hawkdun deposit was not discovered until 1978 during reconnaissance exploration as part of the NZCRS. Five holes were drilled during this early programme (Bowman 1980). A second investigation was carried out in 1980-81 for the LFTB in which a further nine holes were drilled (Bowman 1981). Two holes were fully cored for the purposes of lignite sampling and analysis. NZ Geological Survey (NZGS) prepared an interim summary of the geology and estimates of lignite-in-ground (Isaac 1981) based on the 13 drillholes within the estimation area. In association with the LFTB programme, the Geophysics Division of the DSIR conducted seismic refraction and high resolution seismic reflection profiling in the field. Additional structural mapping of the deposit area was carried out by NZ Geological Survey (Bishop 1981). Other LFTB investigations of the Hawkdun deposit included preliminary geotechnical and mining assessments in 1980-81 (Anon 1981). The preliminary mining assessment considered the development of three mining options with annual production rates of 2.5Mt/year, 9.5Mt/year and 12.5Mt/year. A mining concept was developed for each mining option, together with associated mine design work. The post-1980 exploration collectively constituted Phase I of the ongoing LFTB programme (Anon. 1982).

Following screening of the lignite deposits, Hawkdun was selected for Phase II exploration and evaluation. The Phase II Hawkdun resource definition study was essentially a mining orientated study. It was integrated with associated geotechnical and hydrological field programmes to provide base data for conceptual mine planning and costing. The Phase II programme involved geological mapping, geophysical surveying, drilling and logging, core sampling, lignite analysis and computerised evaluation of the target resource. An additional 16 holes were drilled. The LFTB objective was a production rate of 11.1Mt over a designed mine life of 30 years, requiring a defined resource of 333Mt. The modelled resource was based on the 9.6 Mt/year pit area of the Phase 1 study expanded to meet the LFTB production target (Anon 1986a).

Between 2003 and 2004, Kenham drilled three holes in the central part of the deposit. All drilling was by wireline and all lignite core was sampled. Kenham commissioned a mining study (Coleman 2003), and also a study into the feasibility of construction of a small thermal power station on site (Clemens et al. 2003). L&M has recently commissioned a resource evaluation of the deposit in conjunction with an evaluation of their coal permit portfolio (Sphere and others 2004). Golder Associates (NZ) Ltd subsequently modelled the deposit and prepared a new resource estimate (Golder 2005a) for L&M. The various available estimates were then compared in detail (Geosphere 2005).

Ashers-Waituna

Initial resource estimates for Ashers-Waituna were prepared independently by the NZCRS contractors (Carr 1979) and by NZ Geological Survey (Isaac 1980). These were based on 47 drillholes, 26 of which were geophysically logged. Further work in two phases was carried out on individual lignite deposits by the LFTB. The LFTB Phase I programme included additional drilling of two fully cored holes for refining some reserve estimates, calibration of electric logs, estimation of lignite ash content in geophysically logged open drillholes, and detailed analysis of lignite. Geotechnical, hydrological and environmental considerations were investigated and a preliminary mining feasibility study undertaken (Anon. 1982).

Following screening of the lignite deposits, Ashers-Waituna was selected for Phase II exploration and evaluation. The Phase II resource definition study was similar to that conducted at Hawkdun. An additional 37 holes were drilled during the programme. The LFTB objective was a production rate of 12Mt over a designed mine life of 30 years, requiring a defined resource of 359Mt (Anon 1986b).

Under Exploration Permit 40 539, L&M has drilled three holes and commissioned several reports. CRL Energy Ltd evaluated the potential of the lignite resource for use in power generation plants (Pope 2003a). CRL also reviewed the mining potential of the deposit (Pope 2003b). Sphere and others (2004) carried out a resource evaluation of the deposit in conjunction with a review of L&M's coal permit portfolio. Golder Associates (NZ) Ltd subsequently modelled the deposit and carried out a new resource estimate (Golder 2005b). The various available estimates were then compared in detail (Geosphere 2005).

Lignite resources

Regional

Until 25 years ago, lignite resources of the South Island were poorly defined. Prior to the NZCRS, 1970s estimates of Eastern Southland lignites ranged from 358 to 1,238Mt (Taylor 1999). Following the NZCRS exploration, a total of 4,400Mt of lignite in-ground was identified in six deposits with opencast mining potential at Croyden, Waimumu, Matura, Morton Mains, Waimatua and Ashers-Waituna. By the end of the LFTB studies this figure had increased to 8,722Mt.

Early estimates of lignite resources in Central Otago ranged between 15.25 and 100Mt (NZ Mineral Resources Council 1973). The current figure is 1,398Mt. At Benhar, Harrington (1958) estimated that there was in the order of 50Mt in the Benhar Sector. The current figure is 887Mt.

Thus the total the estimates for South Island lignites prior to the NZCRS were between about 400 and 1,400Mt, indicative of their considerable uncertainty at the time. The NZCRS and subsequent LFTB investigations established in-ground resources of nearly 11,000Mt. The main purpose of the LFTB investigations was to establish a resource of sufficient size to meet LFTB objectives, although deposit models were constructed that allowed estimation of coal-in-ground resources. Barry et al. (1994) summarised resources and reserves for the South Island lignites (Table 1). Hawkdun and Ashers-Waituna estimates are discussed in more detail below.

Table 1: South Island lignite resources. All estimates are from Barry et al. (1994) except Hawkdun and Ashers-Waituna which are from recent L&M studies.

Coalfield	Resource Status			Total
	Measured	Indicated	Inferred	
Hawkdun		771.00		771.00
Home Hills		289.00	64.00	353.00
Roxburgh		197.00	51.50	248.50
Benhar	0.01	887.00		887.01
Gore		255.40	49.00	304.40
Croyden		434.50	49.00	483.50
Waimumu	7.44	243.00	35.00	285.44
Mataura	1,633.30	790.70	516.00	2,940.00
Edendale		362.70	256.00	618.70
Morton Mains		754.70	471.00	1,225.70
Waimatua		962.00		962.00
Ashers-Waituna		876.00		876.00
Makarewa		703.80	323.00	1,026.80
TOTAL	1,640.75	7,526.80	1,814.50	10,982.05

Hawkdun

There are several sources of coal resource estimates for the Hawkdun deposit, including Isaac (1981), Otto Gold (Anon. 1986a) and Golder (2005). They were made by different groups using different criteria and cannot be directly compared. Their variation is not an indication of uncertainty of resource quantities.

L&M engaged Geosphere to prepare a resource statement for the Hawkdun deposit (Geosphere 2005). The report states that the resource risk is extremely low, and although some structural and stratigraphic discontinuities can be expected to be revealed by additional drilling, these will not materially affect gross in-ground resource estimates. Geosphere (2005) considered that the 1986 Otto Gold estimate of 649Mt and the 2005 Golder resource estimate of 771Mt should be classified as Indicated Coal Resources according to the JORC Code (2004). Geosphere (2005) noted that the 2005 Golder resource estimate of 771Mt is an in-ground estimate that does not take account of mining losses and therefore includes substantial waste, and that the 1986 Otto Gold estimate of 649Mt allows for mining losses based on minimum seam thickness, parting thickness and ash cutoff criteria, and so is close to a potentially recoverable coal figure. Within the Otto Gold estimate, a production target resource of area of 329Mt was calculated to have a waste:coal ratio of 3.8:1, including very conservative batter angles.

There is no estimate which considers the current drillhole database in the areas peripheral to the Golder estimate area. These additional resources would be classified as Inferred Inventory Coal under the JORC Code.

Ashers-Waituna

There are several sources of coal resource estimates for the Ashers-Waituna deposit including Isaac (1990), Otto Gold (Anon. 1986b) and Golder (2005). As with Hawkdun, they were made by different groups using different criteria and most cannot be directly compared. Their variation is not an indication of uncertainty of resource quantities.

L&M engaged Geosphere to prepare a resource statement for the Ashers-Waituna deposit (Geosphere 2005). Based on previous classifications and drillhole spacings of about 750 to 1500 m in what by New Zealand standards is fairly simple seam geometry allowing fairly reliable seam correlation, the Golder modelled resource of 876Mt was classified by Geosphere (2005) as Indicated Coal Resources according to the JORC Code. Within the LFTB target resource, a production target resource of 359Mt was calculated to have a waste:coal ratio of 2.3:1, including batters (Anon. 1986b). Beyond the LFTB target resource, a less well explored resource estimated by Golder at 398Mt is poor Indicated.

Lignite quality

Coal quality in both the Hawkdun and Ashers-Waituna deposits has been assessed from several generations of core sampling and analysis since 1978, including several fully cored drillholes. All analysis was by the Coal Research Association of New Zealand, now CRL Energy Limited. The current coal quality dataset allows broad characterisation of variations of coal properties within the deposits and these have been reported in various technical reports. The range of most properties is well established, and general lateral and vertical trends of key properties are known. The suitability of the resource for either thermal fuel or conversion utilisation is understood in general terms. However, more coal quality investigations will be required to reliably establish coal quality trends over all or part of the deposits. Variation of coal type that could influence design of conversion processes will need to be better described.

Both the Ashers-Waituna and Hawkdun coals are classified as Lignite B rank and average in-situ properties (Anon, 1986a&b) are compared with lignites from around the world (Table 2). Full geochemical assays are available from some drillholes, from which a representative Ultimate Analysis can be derived (Table 3).

Table 2: Comparison of coal quality data for Ashers-Waituna, Hawkdun and other lignite deposits (in-situ basis).

Parameter	Ashers-Waituna	Hawkdun Germany	Rhineland, USA	Louisiana, Australia	Leigh Creek, Australia	Morwell,
Moisture %	54.3	46.5	50 - 60	30.0	28.0	60.1
Ash %	5.0	10.74	1.5 - 8.0	16.1	27.0	3.3
Calorific Value MJ/kg	10.72	11.5	7.8 - 10.5	8.0	13.7	-
Sulphur %	0.47	0.40	0.15 - 0.50	0.64	0.70	0.40
Fixed Carbon %	17.7	18.25				
Volatile Matter %	22.9	24.53	-	-	-	48.2

Table 3: Representative Ultimate Analysis data for Ashers-Waituna and Hawkdun deposits.

Ultimate analysis, %wt (d.a.s.f)		
	Hawkdun	Ashers-Waituna
Samples	103	97
Carbon	68.10	68.27
Hydrogen	5.38	5.003
Oxygen	25.66	25.95
Nitrogen	0.84	0.75

Holes drilled by Kenham at both deposits in 2004 were fully cored. Composite samples from seam plies were analysed for proximate analysis, calorific value and total sulphur. Seam composites were also analysed for Hardgrove Grindability, ash fusion temperature, ash composition and spontaneous combustion potential (for Ashers-Waituna). The results of these analyses are similar to previous results. The propensity of the Ashers-Waituna lignite to spontaneous combustion had not been analysed previously, and results from the 2004 programme indicate the lignite is very prone to spontaneous combustion.

Utilisation potential

The South Island Lignites have to date been used for domestic heating and in local industry. Utilisation options considered in the past have included thermal power generation and liquid fuel production. Since 2000 L&M has investigated both these options and has engaged CRL Energy Limited, CAE, and HCP to carry out utilisation studies.

Lignites typically have high moisture and oxygen contents, low heating values and variable ash contents. Because of these factors, the conventional boilers used in electricity generation are large and have low thermal efficiency. The consequent high cost of plant is offset by relatively low mining costs which enable the production of economically competitive electricity. The environmental cost is similar to that of higher ranked coals in all respects other than the CO₂ emissions which, due to the low conversion efficiency as a result of having to dry the coal, is high (L&M 1998).

Lignite can be readily converted to electrical energy or gaseous products using a number of processes. CAE (2004) carried out a review of world gasification trends and identified a significant number of operating gasification plants. CAE also noted that, because of dwindling gas supplies, it is likely that New Zealand will soon be entirely dependant on imported nitrogenous fertiliser, and that lignite offers a potentially viable feedstock for synthesis gas production and urea.

CAE (2004) identified gasification is the preferred option for conversion of the Southland lignite to meet New Zealand's future energy needs. Gasification offers proven technology and the cost basis can be established with confidence. CAE noted that in the near- to medium-term, the production of synthesis gas for conversion to petrochemicals is seen as a potentially viable option, and that L&M's primary focus should be given to the use of the lignites to meet future chemical and fuels supply needs, with electricity generation treated as a by-product of the process to attain improved economies of scale.

Following the study by CAE, L&M engaged HCP of Perth, Australia to carry out more detailed studies into the production of synthesis gas and downstream products.

HCP (2005) advised that coal gasification opens coal to wider markets. It affords the diversity to produce commodities such as methanol, fertilisers, chemicals or liquid fuels in conjunction with power

generation. HCP noted that several quite recent advances in technology have given this process a leading edge for a major energy development using low-cost coals.

In the gasification process, the coal is not burned but is heated under pressure to extreme temperatures of around 1400°C in which the coal is metamorphosed to synthesis gas (a mixture of carbon monoxide and hydrogen) and vitreous slag. There are several very important benefits of having the coal in the form of syngas:

With the coal in gaseous form, the high efficiencies associated with gas turbine combined cycle performance then become accessible to coal. This is the rationale behind the Integrated Coal Gasification Combined Cycle (IGCC) concept. However, the synthesis gas that is produced is generally more valuable as a feedstock for producing other commodity products such as methanol, ammonia fertilizers, ultra-clean Fischer-Tropsch (F-T) fuels, chemicals, or hydrogen in addition to electric power. Co-production of commodity products in conjunction with electric power offers greater utilization efficiency than either IGCC electricity generation or syngas/chemicals production alone.

Following analysis of the options, L&M has decided to commence studies into the development of the Hawkdun and/or the Ashers-Waituna lignite deposits for gasification. The broad parameters for the project are for a 60,000 barrel per day production of F-T liquids, specifically low sulphur diesel and naphtha. The study anticipates a staged development of 10,000 barrel per day units, each requiring mining at the rate of 12,700 tonnes of lignite per day. The production of other products including ammonia-urea, methanol, hydrogen and electric power is also being studied.

Conclusions

The South Island lignites represent New Zealand's largest known fossil energy resource, which has so far been little used. Current resource estimates indicate that there are approximately 11 billion tonnes of coal-in-ground in fields in Otago and Southland.

The Ashers-Waituna and Hawkdun lignite fields contain upward of 1.6 billion tonnes of lignite that is potentially recoverable by opencast methods. This lignite is similar in quality to lignites in other countries that is being exploited for use in electric power generation and as a chemical feedstock.

L&M has commenced studies into the development of a large-scale lignite-to-liquid fuel facility at one or both deposits. Scoping studies have recently been completed and pre-feasibility studies are underway. These are expected to be completed by mid 2006.

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Alan Sherwood is a consultant geologist and technical editor. After graduating BSc from Auckland University and MSc (Hons) and MPhil from University of Waikato, he worked for NZ Geological Survey for 15 years on coal resource evaluation. Since returning in 1995 from five years with the South Pacific Applied Geoscience Commission in Suva, Fiji, he has worked mainly on geological and energy-related projects for a range of clients including GNS, Crown Minerals, and Centre for Advanced Engineering. Several projects have involved close association with GeoSphere, including work for CAE, MoRST, Oceans Policy Secretariat and L&M.