



# **Solid Energy's environmental management systems and performance**

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Stockton mine, August 1998. Photo copyright Institute of Geological and Nuclear Sciences Limited. GNS Science/ Photographer: Lloyd Homer

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## Preface

Mining, first gold and then increasingly coal, has been an integral part of New Zealand's development since the middle of the 19th century. For the first 50 years of the 20th century coal mining dominated the economy of the South Island's West Coast. The President of the Institute of Civil Engineers in London described the region's coal as "fully equal, if not superior, to the best description from any part of the world" (McKinnon, 1997).

In terms of local employment and the wider economy, coal remains important to New Zealand today. Our coals are still recognised for their high quality and they command premium prices on world markets. However, there is now much great recognition of the environmental impacts of coal's extraction and, on a global scale, of the CO<sub>2</sub> released when it is used. It is the impacts of mining, particularly on the West Coast, that have led to this scoping study of the environmental performance of Solid Energy's mining operations.

Solid Energy is the largest mining company in New Zealand. As a state owned enterprise it has a particular responsibility to demonstrate leadership in environmental management in the mining sector. The company is forecasting that it will produce approximately 100 million tonnes of coal over the next 20 years – much of it from terrain and in local climates that are very challenging from an environmental management perspective. This challenge is recognised by Solid Energy – it has recently acknowledged that some of its mining activities have fallen well short of environmental best practice and it has made a public commitment to improve them.

Over the last few years Solid Energy has introduced a company environmental policy and an associated Environmental Management System, site plans, and other procedures that acknowledge environmental management as a core business activity. However, because the various plans and procedures are being gradually implemented it is too early to assess how effective they are in improving environmental performance on all the company's mining sites – particularly given the magnitude of mining impacts at sites such as the Stockton mine. This is Solid Energy's largest opencast mine, and it produces the biggest environmental challenges in terms of water quality and site rehabilitation.

My team and I conclude this scoping study by making a commitment to audit Solid Energy's environmental management performance at the Stockton mine in 2008. We outline the areas our audit will focus on by way of 'serving notice' on the aspects we consider need substantive improvement in environmental performance. Dedicated commitment to, and investment in, the current Environmental Management System is a good platform for progress. We hope to be able to report positively on it achieving its full potential.



**Dr J Morgan Williams**  
**Parliamentary Commissioner for the Environment**

## 1 Introduction

### 1.1 Purpose of the report

This report discusses the findings of a scoping study into Solid Energy New Zealand Limited's (Solid Energy) environmental management systems and performance. The study was undertaken by the Parliamentary Commissioner for the Environment (PCE) in the second half of 2005 and first half of 2006.

The purpose of the scoping study was to provide the Commissioner with sufficient information to determine whether Solid Energy's environmental management systems and performance at any of Solid Energy's mining operations, or any aspect of them, warrant a more detailed investigation by the PCE.

The Commissioner initiated this work in response to a number of complaints from the public and as a result of independent PCE monitoring of media reports, which indicated that some of Solid Energy's coal mining activities on the West Coast of the South Island had resulted in adverse environmental effects. People had expressed concern to us about whether these effects were being adequately managed.

### 1.2 The scoping process

In the second half of 2005 and the first half of 2006 we visited some of Solid Energy's mines and associated sites on the West Coast, and interviewed Solid Energy staff and a range of stakeholders (see Appendix A for details). We also visited Solid Energy's operations in the Waikato and met with Environment Waikato and Waikato District Council to enable us to make some comparisons between Solid Energy's West Coast operations and Waikato operations.

In addition, we obtained documents and reports from Solid Energy about their environmental management policies and plans for several sites. We also examined published literature on studies of the impact of coal mining on the New Zealand environment and reviewed other documents provided to us by councils. Details of the material we received and analysed have been documented and may be used in a later investigation.

As part of the scoping study we considered the environmental regulatory framework controlling coal mining. The PCE previously investigated this framework in 1992 in the *Environmental management of coal mining*.<sup>1</sup> That study identified a number of issues with the environmental regulatory framework.

Over the past three years, concerned citizens have approached the PCE about mining being carried out under mining licences and coal mining licences potentially having adverse environmental impacts.

We consider that the adequacy of the environmental regulatory framework controlling mining and coal mining is an issue that does warrant further investigation by the PCE in the future. However, this report does not contain any consideration of these issues, as the focus of this scoping study was instead on Solid Energy's environmental management systems and performance.

### **1.3 Authority for the scoping study**

The scoping study was undertaken pursuant to section 16(1) of the Environment Act 1986.

The study's purpose and scope were outlined in an information sheet provided to all the people, groups, and organisations interviewed by the PCE (See Appendix B).

### **1.4 What we have not investigated**

We did not consider the implications of the use of coal as it relates to the production of greenhouse gases as these issues are more appropriately addressed through the PCE's current work on energy issues and any future work on climate change issues the PCE may undertake.

We did not focus in detail on Solid Energy's historical environmental performance. However, we have considered elements of it, to the extent that it impacts on current operations and performance.

## 2 Solid Energy

### 2.1 Solid Energy's current mining operations

Solid Energy is a state owned enterprise and is New Zealand's major coal producer.<sup>2</sup> At 18 August 2006 Solid Energy held 14 coal mining licences (issued under the Coal Mines Act 1979) covering approximately 13,165 hectares,<sup>3</sup> and 10 coal mining permits (issued under the Crown Minerals Act 1991) covering approximately 5,648 hectares.<sup>4</sup>

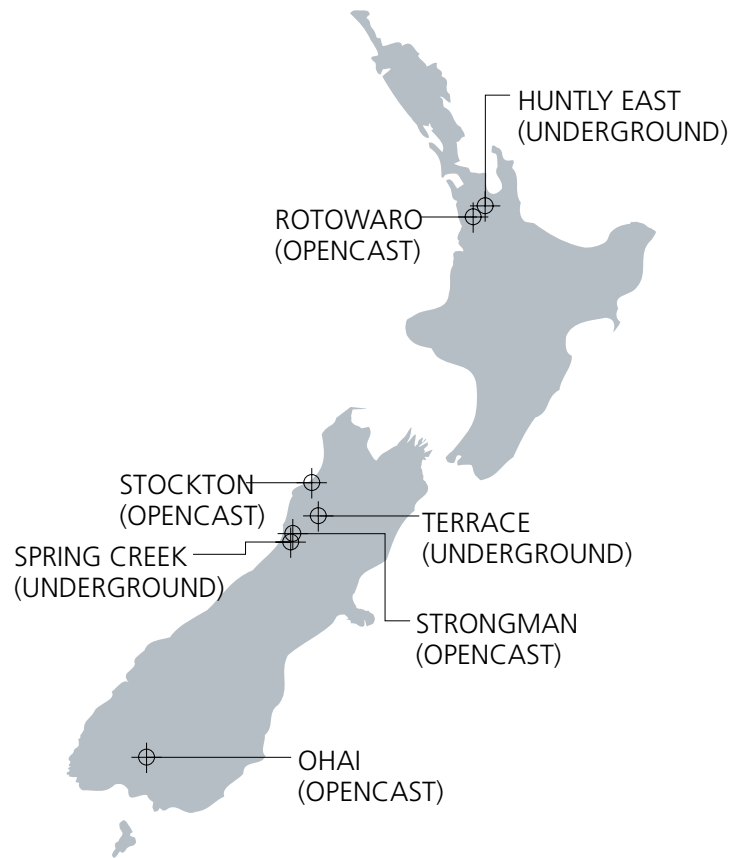
Solid Energy estimates that it has about 5.14 billion tonnes of coal resources, of which about 3.3 billion tonnes is South Island lignite.<sup>5</sup> Solid Energy estimates that it currently has approximately 36 million tonnes of coal reserves.<sup>6</sup> A coal resource is not the same as a coal reserve. Reserves are those coal holdings that, with a fairly high degree of certainty, can be recovered and sold economically, whereas a resource is "...all the coal that is contained in seams within specified limits of thickness and depth from the surface".<sup>7</sup> Solid Energy is currently spending considerable sums on exploration and prospecting.<sup>8</sup>

As at 18 August 2006 Solid Energy held 28 exploration permits covering approximately 75,364 hectares, and one prospecting permit covering approximately 1,311 square kilometres.<sup>9</sup>

Solid Energy employs more than 630 people.<sup>10</sup> In addition, its opencast mining operations at Rotowaro, Stockton, Strongman, and Ohai employ approximately 400 contractors.<sup>11</sup> Solid Energy's mines currently operating are:

- Huntly East (underground)
- Rotowaro (opencast)
- Stockton (opencast)
- Terrace (underground)
- Strongman (opencast)
- Spring Creek (underground)
- Ohai (opencast) (see Figure 1).

Additionally, a very small amount of production occurred in 2005 at the Island Block opencast mine near Reefton.<sup>12</sup> Solid Energy also operates a number of coal handling and storage facilities such as at Huntly West, Rapahoe, Reefton, Ngakawau, and the port at Westport. In 2005 Solid Energy obtained resource consents to enable it to operate an opencast mine (Cypress) in the Waimangaroa Valley, on the West Coast.



**Figure 1: Solid Energy's currently operating mines**

Source: Solid Energy, 2004a: 17

Over the past five years Solid Energy has significantly increased sales and, accordingly, production of coal. Table 1 shows annual coal sales in millions of tonnes over the past six years.

Solid Energy aims to achieve 4.9 million tonnes of coal sales in the 2005/06 financial year and 5.1 million tonnes in the 2006/07 financial year.<sup>13</sup> The company is forecasting that it will produce approximately 100 million tonnes of coal over the next 20 years.<sup>14</sup> Solid Energy states that its significant increase in production over the past five years is in response to increased demand for coal.<sup>15</sup> If current trends continue, in the medium term, Solid Energy's coal production will increase and the potential for environmental impacts will also grow.

**Table 1: Solid Energy coal sales 2000–2005**

Year	2000	2001	2002	2003	2004	2005
Coal sales (million tonnes)	2.81	2.97	3.35	4.09	4.21	4.46

Source: Solid Energy, 2001: 5; Solid Energy, 2003b: 5; Solid Energy, 2004a: 3; Solid Energy 2005a: 4

## 2.2 Environmental regulatory framework within which Solid Energy's coal mines operate

The environmental regulatory framework that controls Solid Energy's mining operations is complex. The mining operations are regulated by a combination of:

- coal mining licences, issued under the Coal Mines Act 1979
- mining permits, issued under the Crown Minerals Act 1991
- resource consents issued under the Resource Management Act 1991 (RMA)
- water rights and clean air licences from earlier legislation that are now deemed resource consents under the RMA.

Coal mining operations operate under either a coal mining licence or a mining permit, depending on when the application to mine was made. In all cases there will be resource consents required, although the type of resource consents required will depend on whether a coal mining licence or mining permit is held.

Solid Energy advises that it is currently not carrying out any mining under a mining permit, although the company does hold a number of mining permits.

## 2.3 Solid Energy and environmental sustainability

In recent years Solid Energy has stated that it is putting a lot of effort into developing and implementing its company-wide environmental management policies and procedures, acknowledging that:

*In the past, some of our mining activities have fallen well short of environmental best practice. We have to improve our environmental performance across all our mine sites if we are to continue to earn and retain our right to mine.<sup>16</sup>*

Some of the biggest challenges for Solid Energy are dealing not only with the environmental impacts of current mining operations, but also with the legacy of past mining practices that have left it with some major remediation and mitigation measures to implement.

State owned enterprises, such as Solid Energy, operate in accordance with their Statement of Corporate Intent, which must be prepared on an annual basis and approved by the shareholding ministers.<sup>17</sup>

Solid Energy's most recent Statement of Corporate Intent contains a section headed *Key Objectives of Solid Energy*:

## **2. KEY OBJECTIVES OF SOLID ENERGY**

*Solid Energy's principal objective is to maximise shareholder value by generating a sustained long-term return greater than the market cost of capital for businesses with a similar risk profile. This is supported by the following key objectives:*

- (a) Enhancing our reputation as a good employer, retaining skilled, motivated and committed staff and providing:
 
  - *Safe working conditions based on best practice health and safety systems and processes.*
  - *Training and development programmes to enhance individual abilities of employees.*
  - *Equal employment opportunities.**
- (b) Environmental sustainability of operations through an overall environmental objective of ensuring the cumulative result of all the activities we undertake has a positive net effect on the New Zealand environment.*
- (c) Exhibit social responsibility having regard to the interests of all relevant stakeholders.<sup>18</sup>*

Solid Energy has included in its Key Objectives an explicit recognition of the need for environmental sustainability of its operations.<sup>19</sup> It seeks to achieve this goal by ensuring that the cumulative effect of all of its activities has a "positive net effect on the New Zealand environment". "Positive net effect on the New Zealand environment" (sometimes also referred to as a 'net positive effect') is not defined in the policy statement, but Solid Energy's Annual Report for 2005 devotes a section to it (see pages 30-33). We understand it to mean 'off-setting' unavoidable environmental damage created by mining activities (especially opencast operations) by enhancing environmental quality or biodiversity either on-site or, if this is not feasible, at another location. The intention appears to be to 'compensate' for the environmental effects resulting from mining by engaging in an activity that will provide an off-setting environmental benefit. An example of this is the recently created Millerton Heritage and Ecological Park which opened in August 2005.<sup>20</sup>

Solid Energy has developed and implemented an Environmental Management System, which is intended to manage the environmental effects of their mining operations (the Environmental Management System is discussed further in Appendix C).

## 3 Results of the scoping study

### 3.1 Background

The purpose of the scoping study was to provide the Commissioner with sufficient information to determine whether Solid Energy's environmental management systems and performance, or any part of them or other matter related to them, warrant a more detailed investigation by the PCE.

All mining operations have the potential to impact on the environment and Solid Energy's mining operations are no exception. The extent to which environmental impacts occur depends on the interactions between the sensitivity of the environment in which the operation is located, the nature of the operation being carried out, and how well it is managed. Thus, all mining sites will have site-specific environmental issues that need to be addressed in site-specific ways to avoid adverse environmental effects, although there are likely to be common environmental issues across sites. At some sites, some environmental issues may be more difficult to manage than at others – for example water management issues may be more difficult at a site with high rainfall, and noise may be more difficult to manage at sites close to residential areas.

Planning for closure and post-closure management of coal mines is an issue for all mine sites. Some environmental issues, for example acid mine drainage (which is further discussed in Appendix D) can require active management during all phases of the mine life, including post closure.

As part of the scoping study we visited the following Solid Energy mines and coal handling facilities:

- Rotowaro mine
- Huntly East mine
- Spring Creek mine
- Strongman mine
- Rapahoe coal handling facility
- Rocky Creek coal handling facility
- Reefton coal handling facility
- Terrace mine
- Island Block mine
- Stockton mine
- Ngakawau coal handling facility.

These mines and coal handling facilities are operated in different areas of New Zealand, all with very differing environmental characteristics and environmental effects – in both nature and scale. The location of the mine and the way mining is carried out determines whether the environmental effects of the mining operation are confined within the mine's boundaries or whether there are environmental effects off-site.

As part of the scoping study we considered the range of environmental effects occurring at the mines and coal handling facilities. The environmental effects have varying degrees of impact from significant (e.g. an underground fire burning in the Strongman No 2 mine) to comparatively minor (e.g. the tracking of dust by coal transport vehicles on roads at the Ngakawau coal handling facility).

As a result of the scoping study we have formed the view that the environmental management at the Stockton mine may require closer scrutiny. We recognise that there are environmental issues at other mines that are also important, but we have chosen to focus on Stockton for a number of reasons:

- it is Solid Energy's largest mine
- there is public concern about a wide range of issues at the mine
- it is likely that further mining in adjacent areas will occur
- it is a very difficult physical environment in which to mine
- Solid Energy is putting a considerable amount of money into improving their environmental performance at the mine
- it is a good site at which to assess the effectiveness of Solid Energy's Environmental Management System as it has both Solid Energy staff and contractors operating at it
- historical and current mining activities have, in our view, resulted in Stockton having the greatest range of actual and potential environmental effects of all Solid Energy's mines.

### **3.2 Stockton mine**

The Stockton Coal Mining Licence is 2,310.3 hectares in area, which makes it the largest coal mine in New Zealand and thus Solid Energy's largest coal mine.<sup>21</sup> The Stockton mine, which is an opencast mine, is located north of Westport on a plateau between 600 and 1,100 metres above sea level in the Buller Coalfield.<sup>22</sup> The mine area receives an annual rainfall of approximately 6,000 mm and is often shrouded in cloud and mist.<sup>23</sup> In the past year Solid Energy has extracted record amounts of coal from the mine (2.03 million tonnes in the 2004/05 year<sup>24</sup>).

In the course of interviews we carried out for the scoping study, a number of people expressed concern about the impact that they felt the Stockton mine was having on

the environment, not only within the coal mining licence boundaries, but beyond. People were concerned about the impact of the mining operation within the coal mining licence boundaries in relation to issues such as:

- mining of the Mt Augustus ridgeline
- translocation of a population of endemic giant land snails (*Powelliphanta* 'Augustus').

People were also concerned about:

- the impact of the mine outside the mine boundaries on water quality and aquatic life in streams and rivers draining the mine
- the potential impact of drainage from the mine on the marine environment.

In particular, they were concerned about acid mine drainage from the mining operations, and sediment and coal fines<sup>25</sup> discharged into waterways.

The issues that the PCE has identified at the Stockton mine are discussed in the sections below.

### **3.2.1 The future assessment of the effectiveness of the Environmental Management System**

Solid Energy has developed and implemented an Environmental Management System, which is intended to manage the environmental effects of their mining operations (the Environmental Management System is discussed further in Appendix C). The critical test of any company's environmental management system is the environmental performance of the company on the ground. Solid Energy's Environmental Management System is relatively new, being developed in 2003, and some aspects of it are still being developed such as Site Environmental Management Plans for all mines.

We are aware that Solid Energy has had independent audits of its Environmental Management System carried out at some of its mining operations.

Rather than investigating the operation of the Environmental Management System across all of Solid Energy's mining operations, we consider that it would be useful to focus on one site in particular – the Stockton mine. This is because Stockton is currently the largest of Solid Energy's mines, and it also has the greatest range of actual and potential environmental impacts,<sup>26</sup> thus it is critical for good environmental outcomes that the Environmental Management System is being effectively implemented at Stockton. Therefore, we consider that Stockton mine is a good test case for the effectiveness of Solid Energy's Environmental Management System.

***Potential issues for the Commissioner to consider***

The potential issues relating to Solid Energy's Environmental Management System that the Commissioner could consider in a future investigation are:

- whether the Environmental Management System covers all the environmental effects of Solid Energy's mining operations at Stockton
- the extent to which the Environmental Management System is being implemented at Stockton
- the extent to which the Environmental Management System is being adhered to by Solid Energy staff and contractors at Stockton
- the effectiveness of the Environmental Management System in dealing with all environmental effects of mining operations at Stockton including whether it deals adequately with issues of biodiversity and the requirements under the Wildlife Act 1953.

**3.2.2 Management of water quality**

One of the biggest challenges facing the mining industry in general, and opencast coal mines in particular, is the control of off-site effects of mining activities on water quality. The geological nature of the area being mined, the rainfall patterns of the area, and how well the water on-site is managed largely determine the impact that the mine will have on water bodies that receive drainage from it. In some cases, acid mine drainage and associated dissolved metals will be the major types of contamination that have to be managed. In addition, sediments and coal fines can get washed into streams and rivers if systems established to capture and retain them in sediment ponds do not succeed.

The impacts on water quality at the Stockton mine come from a combination of acid mine drainage and associated dissolved metals, and sediments and coal fines entering waterways.<sup>27</sup> Management of water quality is further complicated by the very high rainfall at Stockton, about 6,000 mm annually.<sup>28</sup> There are also periods of high rainfall over relatively short periods – for example, up to 300 mm in 24 hours.<sup>29</sup> This pattern of rainfall can lead to large amounts of surface water run-off carrying sediment and coal fines into waterways.

The two main catchments in the Stockton mine drainage system are the Waimangaroa River and the Ngakawau River. "These consist of six medium-sized sub-catchments: Herbert Stream, Waimangaroa River, Plover Stream, Fly Creek, Mangatini Stream, and Granity Creek. The first five sub-catchments are sourced in areas of active mining... whereas the Granity Creek sub-catchment contains some small-scale, old mine workings".<sup>30</sup> Streams draining the mined area on Stockton Plateau have low pH<sup>31</sup> and high conductivity<sup>32</sup> and associated elevated levels of aluminium, iron and nickel.<sup>33</sup>

Mining at Stockton has involved the excavation of between 60 million and 80 million tonnes of Brunner Coal Measures overburden sandstones and mudstones since 1950.<sup>34</sup> Waste rock piles on the plateau are at altitudes from 600 to 1,100 metres above sea level. Acidic drainage from this overburden and from historic underground mines has contributed to depressed pH levels and elevated levels of metals in streams draining the Stockton Plateau.

It is important to note that natural acid drainage (referred to as acid rock drainage<sup>35</sup>) "...can occur where the hydrogeological environment is conducive with enough sulphides having access to sufficient water".<sup>36</sup> It can be difficult to distinguish between natural and mine contributions to acid drainage. Campbell *et al.* (2001) point out that streams in the Stockton area have pH values as low as 3 due to both acid rock drainage and acid mine drainage.

Acid mine drainage, acid rock drainage, and organic acid (derived from rotting vegetation) have been leaching into two main streams (Mangatini and St Patrick's streams). These streams carry elevated loads of acidity, iron, aluminium, and sulphate into the Ngakawau River (see Table 2). Solid Energy staff point out that additional acid mine drainage also enters the Ngakawau River from historic mines on the Stockton/ Millerton Plateau and from Charming Creek.<sup>37</sup> The Ngakawau River discharges into the sea at Ngakawau. We were unable to locate any studies looking at whether there were any adverse effects on the marine environment due to the river discharging low pH water with elevated levels of metals.

**Table 2: Estimated mean flow (cumecs) and annual total metal, acid, sulphate and suspended solids loads (tonnes) on Stockton waterways**

Site	Mean flow (cumecs)	Aluminium (T/yr)	Iron (T/yr)	Nickel (T/yr)	Sulphate (T/yr)	Zinc (T/yr)	Acidity (T/yr)	Suspended solids (T/yr)
Charming Creek	2.4	34	45	0.2	1,589	9	454	454
Mangatini Stream	1.7	756	300	3.6	7,398	23	6,274	2,949
St Patrick's Stream	5.3	602	167	2.5	7,689	22	12,368	4,947
Upper Ngakawau River	15.9	50	150	0.5	1,504	29	3,009	6,660
Lower Ngakawau River	25.3	1,247	987	5.6	15,919	103	12,736	15,123
Mine Creek	1.2	276	198	1.2	5,866	6	9,461	197

Source: Lindsay *et al.*, no date: 5

In addition to acid mine drainage and dissolved metals in the streams draining Stockton Plateau, there have also been incidents of coal fines and other sediments getting into streams. As can be seen from Table 2, approximately 8,000 tonnes of sediment annually enter the Ngakawau River from the Mangatini and St Patrick's streams. It is unclear how much Solid Energy's mining is contributing to this. Solid Energy estimates that before mining, between 4,500 and 22,500 tonnes of sediment would have entered the Ngakawau River from the Mangatini and St Patrick's streams, annually.<sup>38</sup>

More detailed information on water quality studies carried out in the Stockton mine vicinity are discussed in Appendix D.

### ***Solid Energy's intention to improve water quality at Stockton***

On 16 September 2005 Solid Energy announced its intention to spend \$20 million over the following three years on a series of measures to improve the quality of water discharged from the Stockton mine.<sup>39</sup> The series of measures, subject to resource consent and other approvals, are designed to improve the quality of water discharging into the Mangatini Stream and from there to the Ngakawau River. Measures are aimed at reducing the amount of suspended solids and coal fines in mine water draining into the Mangatini Stream and Ford Creek. They include separating mine water from clean water, stockpiling coal in covered bunkers to minimise coal fines in mine water, and installing new dams and water treatment facilities in working areas of the mine to feed into a centralised water treatment facility. Alkaline dosing is also proposed to raise the pH level of mine water affected by acid mine drainage. To improve water clarity and trap any residual fine rock material, Solid Energy proposes to build a series of dams in the Mangatini catchment.

### ***Potential issues for the Commissioner to consider***

The potential issues relating to water quality that the Commissioner could consider in a future investigation are:

- the effectiveness of measures that Solid Energy is taking to minimise the production of acid mine drainage from its mining operations at the Stockton mine
- whether Solid Energy is disposing of waste rock and overburden in a manner that minimises the production of "acid drainage", as required by its coal mining licence<sup>40</sup>
- the measures that Solid Energy is taking to minimise the amount of sediment and coal fines from their mining operations entering waterways, and the effectiveness of those measures.
- the effectiveness of the \$20 million investment to improve water quality at Stockton
- the effectiveness of Solid Energy's resource consent and coal mining licence conditions to prevent adverse impacts on water quality.

### **3.2.3 Rehabilitation**

The Stockton mine represents Solid Energy's largest challenge and liability in terms of rehabilitation.<sup>41</sup> Because of both past and relatively recent mining practice, large areas of the mine are yet to be rehabilitated, although progressive rehabilitation is required by the Stockton Coal Mining Licence.<sup>42</sup> The Stockton mine is approximately 2,310 hectares in size.<sup>43</sup> Approximately 698 hectares have been mined or are currently open

for mining and 33 hectares have been rehabilitated. Some areas of the Stockton mine have been completely mined, others partially mined, and others not yet mined. Coal from different parts of the Stockton plateau is of various grades and is blended to meet customer specifications. Therefore different areas are being mined concurrently to provide this coal.

Coal has been mined in different areas of the plateau over a long period, and the mining technology available and coal prices have changed over time. Thus, coal in an area that was only partially mined five years ago may now be physically and economically viable for Solid Energy to extract. In practice this has meant that some areas of the mine that have been rehabilitated are now being reopened and mined again.

One of the key causes of acid mine drainage at the Stockton mine is the amount of potentially acid-forming rock that has been exposed in the process of mining and remains exposed to surface water run-off and rain. Rehabilitation helps to reduce the production of acid mine drainage from the mine. We note that the Stockton Coal Mining Licence requires Solid Energy to "...undertake to dispose of waste rock and overburden in a manner that minimises the production of acid drainage from these materials".<sup>44</sup>

Rehabilitation at the Stockton mine is complicated by a number of environmental factors. The Stockton mine is at altitude and has a high rainfall. The soils at the site tend to be thin and of low nutrient value.<sup>45</sup> This is further complicated by the geology of the site, in particular the issues associated with acid rock drainage and acid mine drainage. All of these factors make plant growth and the development of characteristic ecosystems slow, which can make rehabilitation difficult.

In 2003, Solid Energy produced the Stockton Mine Rehabilitation Guidelines. These guidelines form the basis of the Rehabilitation Management Plan and the Earthworks and Landform Management Plan contained in the Stockton Site Environmental Management Plan.<sup>46</sup> The Rehabilitation Management Plan sets out the rehabilitation methods and procedures, as well as how the rehabilitation will be monitored. Solid Energy has been carrying out research and trial work to assist in determining the best methods and procedures for rehabilitation. An example of this has been a trial of saturated cover technology to neutralise acid mine drainage from potentially acid-forming overburden.<sup>47</sup>

### ***Potential issues for the Commissioner to consider***

The potential issues relating to rehabilitation that the Commissioner could consider in a future investigation are:

- how much rehabilitation has been undertaken by Solid Energy at Stockton
- the effectiveness of rehabilitation currently undertaken by Solid Energy at Stockton

- whether Solid Energy's rehabilitation efforts satisfy the coal mining licence requirement for progressive rehabilitation.

### **3.2.4 Community consultation**

As part of the scoping study we interviewed a number of stakeholders about Solid Energy's community consultation. Some stakeholders, particularly on the West Coast, had strongly expressed concerns about the adequacy of Solid Energy's community consultation, especially in relation to the Stockton mine. In particular strong concerns were expressed about the consultation process used for the mining of the Mt Augustus ridgeline.

#### ***Potential issues for the Commissioner to consider***

The potential issue relating to community consultation that the Commissioner could consider in a future investigation is:

- whether Solid Energy's current community consultation processes meet best practice and are effective.

### **3.2.5 Compliance monitoring and enforcement**

Effective compliance monitoring by both regional councils and territorial authorities is necessary to ensure that Solid Energy is complying with the conditions of their mining licences and resource consents, and that their operations are not having effects on the environment outside those permitted by their various licences, consents, the Resource Management Act, and the Coal Mines Act. Compliance monitoring also provides information to councils on whether resource consents and mining licence conditions are effective in controlling the environmental effects of mining operations. We note that although this scoping study did not focus on council monitoring and enforcement of Solid Energy's coal mining licences and resource consents, these were issues that we discussed with relevant stakeholders and have considered.

We were concerned to discover as a result of interviews with council staff in 2005, that both Buller District Council and Grey District Council had only recently become aware that they had any role in monitoring the conditions of Solid Energy's coal mining licences.<sup>48</sup> However, both councils had been monitoring resource consents held by Solid Energy. It is possible that staff turnover at these councils may have contributed to this lack of awareness. We were also advised by council staff that Solid Energy was not forwarding annual work programmes to Buller District Council, Grey District Council or Waikato District Council as required under the coal mining licences held by Solid Energy. Solid Energy advised us that it does send its annual work programmes to the Buller District Council and Grey District Council. It also advised us that it has had discussions with the Waikato District Council about this.

The West Coast Regional Council informed us that, until about three years ago, its monitoring of Solid Energy's compliance with resource consents was generally poor. More recently the Council has improved its monitoring capacity. The Council advised us that over the past year they have begun routine monitoring of water quality of streams and rivers that pass through or nearby Solid Energy's mines and coal handling facilities. With funding from Solid Energy, the Council began in 2004 to produce quarterly monitoring reports of Solid Energy mining activities on the West Coast.<sup>49</sup> The purpose of these reports is to assess Solid Energy's compliance with, and the environmental effects of, its various coal mining licences and resource consents.

Although the West Coast Regional Council quarterly monitoring reports are still in the early stages of development, we consider that there is scope to improve the reporting so that the level of compliance with consent conditions and the overall environmental performance of each facility can be clearly understood. In addition, the usefulness of reports could be improved by including information such as pressures on, and state of, water quality in streams and rivers draining mining areas, and how the West Coast Regional Council has responded to water quality issues that have arisen. Our impression from a review of the reports that have been published so far is that they pose more questions than they answer about water quality.

We consider that West Coast Regional Council needs to carry out environmental monitoring of Solid Energy's resource consents and coal mining licence environmental conditions to enable them to create benchmarks against which to assess Solid Energy's performance and also as a basis against which to compare environmental trend information.

### ***Potential issues for the Commissioner to consider***

The potential issues relating to compliance monitoring that the Commissioner could consider in a future investigation are:

- how Solid Energy works with councils to progress compliance monitoring
- how clear consent authorities and Solid Energy are about all environmental conditions that must be complied with from coal mining licences and resource consents, and who is responsible for monitoring and enforcing which conditions
- the effectiveness of compliance monitoring and enforcement of coal mining licence conditions and resource consent conditions by both regional and district councils that have jurisdiction over the Stockton mine
- the quality of reporting of compliance monitoring by councils and Solid Energy.

## 4 Conclusions

As a result of this scoping study and subject to other priorities that may arise, the Commissioner proposes to investigate Solid Energy's environmental management at Stockton in 2008. This detailed investigation has been deferred as a result of Solid Energy's commitment to improve the water quality at Stockton over the next two to three years, and the significant expenditure that Solid Energy has indicated will be allocated to that process.

At this stage, the Commissioner proposes that the investigation will focus on Solid Energy's environmental management and performance at the Stockton mine and, in particular:

- the integration of the Environmental Management System into mining operations, the extent of compliance with the Environmental Management System, and whether the Environmental Management System provides for the effective management of environmental effects of the mining operation
- water quality
- site rehabilitation
- compliance monitoring and enforcement
- whether Solid Energy's community consultation meets best practice
- any other issues identified as relevant during the course of the investigation.

We note that although these are the current intended areas of the 2008 investigation, the situation at Stockton may have changed by 2008. Therefore, before beginning an investigation the Commissioner will consider whether the proposed investigation is still warranted and whether the proposed focus is still relevant, or whether new issues have arisen at Stockton or any other Solid Energy mining operation that would be more appropriate to focus on.

## Endnotes

- 1 PCE, 1992.
- 2 Solid Energy, 2005a.
- 3 [www.crownminerals.govt.nz/minerals/permits/current\\_inc.asp](http://www.crownminerals.govt.nz/minerals/permits/current_inc.asp) [Accessed 8 November 2006].
- 4 [www.crownminerals.govt.nz/minerals/permits/current\\_inc.asp](http://www.crownminerals.govt.nz/minerals/permits/current_inc.asp) [Accessed 8 November 2006].
- 5 Solid Energy, 2005a.
- 6 *ibid.*, 2005a.
- 7 *ibid.*, 2005a: 18.
- 8 *ibid.*, 2005a. Solid Energy states that it spent more than \$11 million on exploration in the 2004/05 financial year.
- 9 [www.crownminerals.govt.nz/minerals/permits/current\\_inc.asp](http://www.crownminerals.govt.nz/minerals/permits/current_inc.asp) [Accessed 8 November 2006].
- 10 Solid Energy, 2005a.
- 11 *ibid.*, 2005a.
- 12 *ibid.*, 2005a.
- 13 Solid Energy, 2005b.
- 14 Solid Energy, 2005a.
- 15 *ibid.*, 2005a.
- 16 Solid Energy, 2004a: 26.
- 17 See section 14 State Owned Enterprises Act 1986.
- 18 Solid Energy, 2005b: 2.
- 19 We note that the key objective relating to environmental sustainability is not required by the State Owned Enterprises Act 1986.
- 20 Solid Energy, 2005a. Solid Energy entered into an agreement with the Millerton and Plateau Protection Society, under which 300 ha of the Stockton coal mining licence area was designated as a reserve. This effectively created a 'buffer zone' between the Millerton township and the mine. Subsequently the Department of Conservation has added a further 200 hectares to the reserve.
- 21 Stockton Coal Mining Licence 37 150.
- 22 Mischker and Lindsay, no date.
- 23 Solid Energy, 2005d.
- 24 Solid Energy, 2005a.
- 25 Coal fines are very small particles of coal.
- 26 These include ongoing acid mine drainage, impacts on water quality from sediment and coal fines, large amount of mined area unrehabilitated, and the large area of land disturbed by mining and hence impacts on flora and fauna.
- 27 Water quality is discussed in more detail in Appendix D.
- 28 Solid Energy, 2005d.
- 29 *ibid.*, 2005d.
- 30 Alarcón León and Anstiss, 2002: 84. Solid Energy has advised us that the Miller stream which is one of the two main tributaries of Granity Creek flows through the old Millerton underground mine and that the water quality in Granity Creek is impacted as a result.
- 31 pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 0 to 14.0. Acidity increases as the pH gets lower.
- 32 Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in streams is affected by the geology of the area through which the water flows. The presence of inorganic dissolved solids such as sulphates and metals increases conductivity. Organic compounds do not conduct electrical current very well and therefore have a low conductivity when in water.

- 33 James, 2003.
- 34 Lindsay *et al.*, no date; Mischker and Lindsay, no date.
- 35 Acid rock drainage arises where acidity of drainage water occurs naturally as a result of oxidation of sulphide materials. Acid mine drainage is a form of acid rock drainage caused by disturbance and exposure of sulphide-bearing rocks by mining activities.
- 36 Alarcón León and Anstiss, 2002: 81.
- 37 Lindsay *et al.*, no date.
- 38 *ibid.*, no date: 10.
- 39 Solid Energy, 2005c.
- 40 Stockton Coal Mining Licence 37 150, condition A7(9), see section 3.2.3.
- 41 Rehabilitation is discussed in more detail in Appendix E.
- 42 Stockton Coal Mining Licence 37 150 conditions A5(1)(f) and 5(1)(d).
- 43 Stockton Coal Mining Licence 37 150.
- 44 Stockton Coal Mining Licence 37 150 condition A7(9).
- 45 Solid Energy: 2005d.
- 46 Site Environmental Management Plans are discussed in Appendix C.
- 47 See Solid Energy, 2006: 19 for further details of this trial.
- 48 This conflicts with the position in the 1992 PCE report on the *Environmental management of coal mining*, where it appears that Grey District Council and Buller District Council were aware that they had a role in the administration of the coal mining licences. We have further been advised that these councils were previously aware that they had a role.
- 49 The first report published by the West Coast Regional Council was in February 2005 and covered the period October to December 2004. The second report was published in April 2005 and covered the period January to March 2005.
- 50 Solid Energy, 2004b.
- 51 *ibid.*, 2004b: 1-1. We note that "best practice in the mining industry" is not defined in the Environmental Management System documentation, nor is any reference made to any sources of guidance on best practice.
- 52 Solid Energy, 2003a.
- 53 Solid Energy, 2004c: 7. This refers to external independent audits.
- 54 Solid Energy, 2003a: 5.
- 55 Solid Energy, 2004b.
- 56 This consists mostly of senior managers in the company (see p 3-1 of Solid Energy, 2004b).
- 57 Since our site visits in August/September 2005 the environmental management group has been restructured. See back cover of Solid Energy, 2006 for a list of the current Environmental team at Solid Energy.
- 58 Solid Energy, 2004b.
- 59 Solid Energy, 2004c: 7.
- 60 *ibid.*, 2004c.
- 61 Campbell *et al.*, 2001: 163.
- 62 James, 2003.
- 63 Environment Australia, 1997.
- 64 A description of animals that live on or near the bed of a stream or river.
- 65 With high concentrations of organic acids derived from decomposing plants and animals.
- 66 The earlier study referred to in Winterbourn and McDiffett (1996) is Campbell, P. and Stokes, P. 1985. Acidification and toxicity of metals to aquatic biota. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 2034-2049.
- 67 James, 2003.
- 68 Solid Energy, 2006.

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## **Appendix A: Sites visited and people talked to by PCE staff during the scoping process**

As part of the scoping study staff from the Parliamentary Commissioner for the Environment (PCE) visited some of Solid Energy's more significant coal mining and handling facilities.

### **West Coast sites visited:**

- Spring Creek underground mine
- Terrace underground mine
- Island Block opencast mine
- Rapahoe coal handling facility
- Rocky Creek coal handling facility
- Reefton coal handling facility
- Strongman No. 2 underground mine and Strongman opencast mine
- Ngakawau coal handling facility
- Stockton opencast mine.

### **Waikato sites visited:**

- Rotowaro open cast mine
- Huntly East underground mine.

## **Groups and individuals interviewed during the scoping process**

The PCE scoping team visited and interviewed a range of stakeholders and interested parties, in addition to visiting Solid Energy's operational sites.

### **South Island meetings:**

- Solid Energy staff at the Christchurch head office and at each of Solid Energy's operational sites visited on the West Coast
- Te Runanga o Ngai Tahu
- Ngati Waewae
- West Coast Regional Council staff and councillors
- Grey District Council staff
- Buller District Council staff
- Department of Conservation – West Coast Tai Poutini Conservancy staff
- Peter Ewen – in a personal capacity

- Buller Conservation Group
- Ngakawau Riverwatch.

**Wellington meetings:**

- Royal Forest and Bird Protection Society of New Zealand Inc
- Crown Minerals staff.

**Waikato meetings:**

- Solid Energy staff at Rotowaro and Huntly East mines
- Environment Waikato staff
- Professor Barry Barton, School of Law, University of Waikato.

**Telephone interviews:**

- Waikato District Council staff
- Richard Anstiss, Faculty of Health and Environmental Sciences, Auckland University of Technology
- Three members of the West Coast Tai Poutini Conservation Board (Hamish MacBeth, Di Hooper, and Rob Brown speaking in individual capacities, as the Board had not met and formed an agreed position of its views on Solid Energy).

## Appendix B: Information sheet for interviewees

### Possible PCE investigation into Solid Energy's environmental management of their coal mining operations

August 2005



#### Introduction

Since 2003, PCE staff have been monitoring Solid Energy's environmental management. This has been as a result of a number of complaints received by the PCE about the adequacy of Solid Energy's environmental management and about adverse environmental effects resulting from Solid Energy's coal mining operations on the West Coast.

#### Scope

At this stage, **only** scoping is being carried out. The objective of scoping is to gather sufficient information about Solid Energy's environmental management to determine the need for and focus of any further investigation. Should we determine that an investigation is required, terms of reference and a detailed project plan will be prepared for a later investigation which will be carried out pursuant to section 16 of the Environment Act 1986.

The aim of the project is to assess the effectiveness of Solid Energy's environmental planning and management systems carried out in relation to the following issues:

- 1 Solid Energy's procedures for assessing environmental effects of its proposed and existing mining activities – general and site specific
- 2 In particular, how Solid Energy assesses environmental impacts such as:
  - Impacts on landscape
  - Impacts on biodiversity
  - Erosion
  - Noise, blasting and vibration
  - Dust
  - Transport
  - Fires
  - Discharges to water
  - Mine wastes – overburden, waste rock, tailings and discharges.

- 3 Key environmental issues at each mine site
- 4 What, if any, environmental codes(s) of practice Solid Energy adheres to in addition to any consent conditions or other legal requirements
- 5 What policies and practices Solid Energy has in relation to rehabilitation of mine sites
- 6 What environmental monitoring programmes Solid Energy has set up at each site and how these programmes align with councils' consent monitoring
- 7 The history of compliance with environmental conditions at each site
- 8 The requirements that Solid Energy place on its contractors to ensure compliance with environmental conditions, and how Solid Energy monitors any such requirements
- 9 The adequacy of mining legislation to prevent adverse environmental effects from Solid Energy's mining operation
- 10 How Solid Energy responds to complaints about its environmental performance
- 11 How Solid Energy responds to, manages and reports on environmental incidents
- 12 How Solid Energy manages its internal and external communications on environmental issues.

### Timing

This scoping project is programmed to run to the end of January 2006. Broad stages include:

Interviews, and site visits	August/September/October 2005
Research and identify investigation options	October/November 2005
Decision on whether an investigation will be carried out	March 2006

### For further information contact the project team:

Michael Moodie (project leader) (04) 495-8354 Michael@pce.govt.nz

Bruce Taylor

Philippa Le Couteur

## **Appendix C: Solid Energy's Environmental Management System and Structure**

### **Solid Energy's Environmental Policy Statement**

In its July 2003 Environmental Policy Statement the company states that:

*Solid Energy recognises that to be a sustainable business all our activities must be undertaken in an environmentally responsible manner that is also recognised externally.*

*Therefore:*

*Solid Energy's overall environmental objective is for the cumulative result of all the activities we undertake to have a positive net effect on the New Zealand environment.*

*To achieve this we will:*

- *Consider environmental planning and management a core business activity and provide adequate resources for environmental management, for environmental enhancement projects, and for relevant research*
- *Achieve continuous and demonstrable improvement in environmental performance*
- *Reasonably minimise the adverse local environmental effects that may be an unavoidable part of operating coal mines*
- *Rehabilitate mine sites and address environmental impacts as soon as practicable, both during mining and upon completion of mining*
- *Carry out appropriate non-mining projects that have significant positive benefits for the New Zealand environment*
- *Ensure our staff and contractors are sufficiently trained and informed to fulfil their environmental management responsibilities*
- *Measure and report our performance against our environmental objectives regularly, consistently, openly and honestly*
- *Undertake regular and open communication with our stakeholders.*

The company sets out a number of ways in which it will achieve this, including:

- acknowledging environmental management as a core business activity for the company
- continually improving its environmental performance
- measuring and reporting its environmental performance.

### **Solid Energy's Environmental Management System**

Solid Energy has developed an Environmental Management System, which is outlined in its 2004 Environmental Management System Description.<sup>50</sup> It is based on its overarching Environmental Policy Statement. The aim of the company's Environmental Management System is to "...Ensure a high standard of environmental management at all of the company's operations as benchmarked against best practice in the mining industry..."<sup>51</sup> The Environmental Management System is intended to integrate with other management systems used by the company, such as health and safety and project management.

The Environmental Management System provides general direction on a wide range of matters including roles and responsibilities within the company, consents documentation, procedures for setting (and reviewing) objectives and targets, internal and external communications, auditing of the Environmental Management System, and training requirements. Among other things it requires each Solid Energy site to develop its own Site Environmental Management Plan (SEMP).

### **Site Environmental Management Plans**

Solid Energy has produced an internal document<sup>52</sup> as guidelines for the development and maintenance of SEMPs. These plans are intended to be site specific, addressing the key environmental risks for each Solid Energy site, targets to be achieved, programmes to achieve those targets, supporting documentation (including resource consents), and identification of responsibilities for environmental management at each site. Solid Energy points out that "...SEMPs are the main documents against which our performance is audited".<sup>53</sup>

SEMP targets are intended to be "...challenging, but achievable, encouraging a stepwise improvement in the level of environmental management and outcomes at all sites".<sup>54</sup>

Some programmes are recognised as being common to all sites. These include programmes to manage water, noise, dust, land stability, hazardous substances, waste, visual impact, fire prevention, communications, and emergency planning. Specific guidance is given on each of these elements. In addition, guidance is

provided on setting objectives for rehabilitation and closure plans to encourage progressive rehabilitation and, thereby, decrease the company's liability for remediation works on a consistent and ongoing basis.

SEMPs are reviewed annually along with the annual review of each site's operating plan.<sup>55</sup> It is unclear what these reviews involve or how they are conducted.

### **Other relevant plans and procedures**

The company prepares Life of Mine Plans for each mine site as a means of integrating production and rehabilitation objectives over the life of each project. It represents an approach to mining in which rehabilitation occurs on an on-going basis rather than just at the end of the productive life of the mine. The plans are designed to ensure that rehabilitation and environmental impacts are addressed as soon as practicable during mining. Standard procedures exist for all sites, which ensures a consistent approach and simplifies the work of the operational staff.

An Authority to Mine is a document that operates in addition to Life of Mine Plans and standard operating procedures. It addresses specific issues that are likely to arise during the mining and rehabilitation activities. An Authority to Mine has to be signed off by all relevant people within the company, including the production, marketing and environmental sections of the company, before mining activities begin.

Environmental effects from the company's activities, and their significance, are identified through processes such as:

- use of the project assessment guidelines, which are required for all projects
- scoping and assessment of environmental effects (i.e. through resource consent applications under the Resource Management Act 1991)
- integrated risk management
- discussion at quarterly meetings of the company's Environmental Risk Forum.<sup>56</sup>
- ongoing environmental monitoring.

Solid Energy has also developed an Environmental Management Matrix, which is a system designed to assist in assigning scores and weightings to the environmental effects at each site. This allows comparison of effects within and between sites.

Environmental objectives of the company are incorporated into its environmental policy. SEMP's then become the means of implementing the policy, and progress is measured against appropriate targets set in the SEMP's. The Environmental Management System points out that both corporate and site level objectives and targets are reviewed as part of the annual management review undertaken by the Environmental Risk Forum.

The company has incident reporting and response requirements set out in its Environmental Management System, along with staff and contractor training both for general awareness of requirements and for those with specific environmental management roles.

### **Staff resources, roles, and responsibilities**

The company has appointed a number of staff with environmental responsibilities at all key sites, working with the mine managers and other staff to implement the sites' SEMP's.<sup>57</sup>

The description of the company's Environmental Management System sets out general responsibilities of all employees and contractors, including reporting any environmental incidents and identifying where environmental training might improve the company's performance.<sup>58</sup> In addition, there are specific environmental management responsibilities for the Chief Executive Officer, Environmental Risk Forum, General Counsel, National Environmental Manager, Environmental Programme Manager, regional environmental managers, environmental technicians, mine managers, and the Chief Mining Engineer.

One of the elements critical to the success of any Environmental Management System is staff training. As a result of the scoping study we were unclear as to what, if any, training in the Environmental Management System is being provided to Solid Energy staff. Solid Energy in its Environmental Report for 2004, stated that it had developed a Unit Standard registered on the New Zealand Qualifications Framework "...for environmental awareness for operators at our sites".<sup>59</sup> The Environmental Report further stated that the Unit Standard would become a prerequisite for all staff.<sup>60</sup> We were unable to find any further information as to whether this has in fact become the case. Solid Energy advised us that they "...undertake regular and ongoing staff training as reported in our Annual Environmental Reports and documented by our Environmental Team and in our HR systems".

## Appendix D: Water quality issues

In this appendix we discuss some of the key impacts on water quality that occur due to Solid Energy's coal mining activities, and outline some of the measures being taken to deal with those impacts. Where possible we refer to published scientific studies and assessments of water quality and ecosystem health in the vicinity of mining and ancillary activities (e.g. coal handling). We also refer to reports prepared by Solid Energy and those of West Coast Regional Council.

### Acid mine drainage

Acid mine drainage (AMD) is one of the most significant impacts on water quality created by mining activities in certain areas. The formation of AMD is primarily a function of the geology and hydrology of the area being mined, as well as the mining techniques used. Solid Energy's coal mines that experience AMD problems include the Stockton and Island Block opencast mines, as well as the closed Benneydale mine in the Waikato and Wangaloa mine near Balclutha.

"Acid mine drainage (AMD) is formed when sulphide minerals, notably pyrite, is oxidised on exposure to air and water in a mine or in spoil or mineral stockpiles."<sup>61</sup> It involves a series of complex geochemical and microbial reactions that occur when water comes in contact with pyrite (iron disulphide minerals) in coal or overburden (waste rock). Drainage from coal mining areas that are prone to AMD is usually high in acidity and commonly contains dissolved metals. Streams draining the mined area on Stockton Plateau have low pH and high conductivity and associated elevated levels of aluminium, iron and nickel.<sup>62</sup> Elevated levels of acidity and metals can affect water quality and the aquatic environment in such streams. The metals stay dissolved in solution until the acidity is reduced (i.e. the pH increases) to a level where precipitation occurs. AMD can have effects on receiving waters for many years after mining stops, because of water draining through areas containing exposed pyrite-containing material.

Excluding one or more of the inputs that result in oxidation can control AMD. Where it cannot be controlled in this manner it may be treated or its release regulated to a rate that will not significantly affect the receiving environment.<sup>63</sup>

Campbell *et al.* (2001) point out that Stockton's AMD problem is mainly related to the Kaiata mudstone, which contains about 5-7 percent pyrite and a very low percentage of neutralising minerals. The Kaiata mudstone is also high in aluminium and iron.

The aluminium and iron in the Kaiata mudstone becomes soluble in water with a low pH (the water has a low pH due to acid drainage). Aluminium creates turbidity in streams as the pH increases and the aluminium precipitates. Winterbourn *et al.*

(2000) note in their study of New Zealand streams that the taxonomic richness of invertebrate communities is severely reduced in stream water with low pH and high concentrations of metals.

The following sections focus in more detail on water quality issues associated with drainage from the Stockton mine.

### ***Studies of water quality in West Coast streams affected by mining activities***

Winterbourn and McDiffett (1996) carried out a study of water chemistry and benthic<sup>64</sup> invertebrate communities at 37 sites on acid streams originating on the Stockton-Denniston Plateau. Four groups of streams in the area were identified:

- naturally acid plateau streams with clear water and very low conductivity
- brown water (humic<sup>65</sup>) streams with pH less than 4 and low conductivity
- coastal plains streams with higher pH and conductivity
- streams contaminated by AMD (with higher concentrations of potentially toxic metals including aluminium).

The inclusion of humic waters in this study provided the opportunity to assess the effects of low pH on biota in the absence of the complicating effects of metal toxicity. Low pH brought about by high concentrations of organic acids are believed to render aluminium non-toxic. The study pointed out that aquatic invertebrates and fish vary greatly in their tolerance of acid water and their sensitivity to aluminium.

The study found little difference in the invertebrate fauna inhabiting the various types of low pH streams in the region, although fewer taxa were found where low conductivity acid streams are contaminated by AMD. The findings were consistent with the prediction of an earlier study that "...because of the correlation between pH and total concentrations of metals such as aluminium in surface waters, it can be assumed that organisms that tolerate low pH also tolerate elevated concentrations of metals in their environment".<sup>66</sup>

A later study by Winterbourn *et al.* (2000) of streams in the Buller coalfield area affected by AMD investigated the bioaccumulation of metals by freshwater plants and macroinvertebrates at different trophic levels. The streams examined had total iron and total soluble aluminium concentrations as high as 32.6 and 35.5 mg/l, respectively. The study found that taxonomic richness of the invertebrate communities in the streams was severely reduced at low pH and where metal concentrations in stream water were highest. Abundances were also very low at the most acidic sites and in other South Island streams contaminated by AMD. The study also noted the ability of some New Zealand stream insects, including members of groups not noted

for their pollution tolerance, to exist in streams with very low pH and high metal concentrations. This was believed to reflect an evolutionary history of exposure to naturally acidic stream environments such as the brown waters prevalent in Westland.

***West Coast Regional Council assessment of water quality in the vicinity of coal mining areas***

A West Coast Regional Council report examined the water quality of streams draining various coal measures in the north-central West Coast.<sup>67</sup> It set out to establish the condition of streams draining coal mining areas and to characterise the variability of water quality with respect to stream flow. Water quality indicators used included pH, sulphate, turbidity, conductivity, temperature, and dissolved oxygen, as well as macro-invertebrates, fish, and assessments of stream habitat. Of the 21 streams sampled, there was relatively low variability of pH (the median for most sites being between 3 and 5), conductivity, and sulphate concentrations. The report mentions significant effects on macroinvertebrate and fish populations at several sampling sites. Macroinvertebrates were mostly affected by pH. Three creeks affected by mine drainage were sampled for fish and no fish were present. The report found that fish appear to be more sensitive to acid drainage than invertebrates.

## Appendix E: Mine rehabilitation

Rehabilitation is frequently one of the key concerns of communities affected by mining operations. Effective and timely rehabilitation generally results in good environmental outcomes, and can also contribute to community confidence in the mine operator. Conversely, poor rehabilitation practices can result in long-term environmental impacts and high costs of remediation, and a loss of trust in mine operators.

The type, scale, and nature of rehabilitation that is required at any particular mine site is highly dependent on:

- the environment in which the mining has occurred (i.e. in a highly modified environment or in a relatively unmodified environment)
- the type of mining that has taken place (i.e. opencast or underground), and the nature of any ongoing adverse environmental effects that may have been caused by the mining activity (for example acid mine drainage)
- the scale of the mining operation
- community expectations and regulatory requirements of rehabilitation efforts.

Generally, greater effort has to be put into rehabilitation of opencast mines than underground mines, primarily because of the size of the disturbed area. When underground mines generate ongoing acid mine drainage or subsidence, or are subject to underground fires, ongoing rehabilitation and site management may be required.

Coal Corporation (Solid Energy's former name) was transferred some of State Coal's mines, when Coal Corporation was established as a state owned enterprise. As part of the transfer agreement between Solid Energy and the Crown, Solid Energy is responsible for the rehabilitation of the transferred State Coal mines. Solid Energy estimates its environmental liabilities (which includes the net present value of the work the company expects to carry out to rehabilitate all current and former mine sites) at \$47.8 million.<sup>68</sup>