

# Achieving an environmentally sustainable stream diversion design in an opencast mining area

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## **Abstract**

Solid Energy New Zealand Limited owns and operates the Ohai coal field (Wairaki Coal Mining Licence, CML) in western Southland. The Morley Stream passes directly through the middle of the CML and has required diversion in the past to enable open cast mining to proceed. Solid Energy is evaluating two new open cast pits at Ohai. Commissioning these new pits would necessitate further diversion of the Morley Stream. One of these potential new mines is adjacent to an abandoned State Coal Mines (State Coal) pit and there is an opportunity to substantially rehabilitate this old pit as a corollary to the new mine and the stream diversion project.

Past Morley Stream diversions were undertaken by State Coal and so they pre-dated the Resource Management Act 1991 and the degree of community environmental awareness and involvement that has become the norm these days. Not surprisingly the design and construction of the historic stream diversions was based purely upon mining (operational) and engineering considerations. This led to the stream being diverted in a manner that achieved the clinical conveyance of design volumes of water from points A and B.

Solid Energy realised that the proposed new diversions need to adopt more holistic and environmentally sustainable design principles while also including appropriate mining and engineering constraints. This project involved the design of a 1.7 kilometre diversion of the Morley Stream (median flow of about 1,000 litres/second) that would enable progressive pre-stripping and development of the new mines and would also address final rehabilitation (of the stream), geotechnical risks, hydrological and ecological issues. To address all of these factors the project required a multidisciplinary approach. Moreover, it required a clear understanding of how the mining operational constraints could be integrated with the environmental considerations. A significant aspect of the project was how to take account of fishery instream habitat needs, the resource consent requirements and most of all, the involvement of key stakeholders such as the Fish & Game Council, Department of Conservation, the Iwi and local community in the design process. This was achieved through coordinated consultation and stakeholder involvement in a technical design workshop.

**Keywords:** *Stream diversion, coal, open cast, environmental, rehabilitation*

## **Introduction**

Solid Energy New Zealand Limited owns and operates the Ohai mine in western Southland (Wairaki Coal Mining Licence, CML). The Morley Stream passes directly through the middle of the CML and has previously been diverted to enable open cast mining to proceed. Solid Energy has been giving consideration to two new open cast pits that would necessitate further diversion of the Morley Stream. One of these potential new mines is adjacent to an abandoned State Coal pit and there is an opportunity to substantially rehabilitate this old pit as a corollary to the new mine and the stream diversion project.

Past Morley Stream diversions were undertaken by State Coal and so they pre-dated the Resource Management Act 1991 and the degree of community environmental awareness and involvement that has become the norm these days. Not surprisingly the design and construction of the historic stream diversions was based purely upon mining (operational) and engineering considerations. This led to the stream being diverted in a manner that achieved the clinical conveyance of design volumes of water from points A and B, without taking into account environmental and ecological considerations. It is notable, however, that over the passage of time the natural flow regime has reworked the constructed stream bed to create a new equilibrium and to recover some lost habitat.

Sustainable management in a mining context involves undertaking new developments in a balanced manner. This principle need not mean that no development can occur at all. Natural and physical resources are used for the purposes of economic development in a manner that avoids, remedies or mitigates any adverse effects on the environment, safeguards the life-supporting capacity of the environment and meets the foreseeable needs of future generations. This principle is simply an abbreviated paragraph from the purpose (Section 5) of the Resource Management Act 1991. In a sustainable management context, a stream diversion project for the purposes of making way for a new open cast mine, requires much more than an engineered solution that conveys water. At first glance, the engineered solution may appear to be the most eloquent to mining engineers, managers and accountants. However, it may actually be the most expensive and time-consuming option in the long run. Any significant proposed diversion will normally require a resource consent and this process brings about a whole range of additional factors to consider and views to accommodate. The reality is that except in special circumstances, such as temporary, small or short diversions, the eloquent engineered conveyance solution will simply not be adequate to achieve the sustainable management principles of the Act.

## Hydrological considerations

The Morley Stream catchment has an area of 79 km<sup>2</sup> at the Ohai township. The catchment is rural, rolling hill country, with a cover of mostly pasture and forestry. The Morley Stream passes directly through the Wairaki CML and is in the middle of existing open cast mines. Some historic information has accumulated as a result of past stream diversion activities and stream gaugings have also been carried out in the past by NIWA. The gaugings are not continuous and they do not consistently represent flood events, and hence they have little value in determining design floods. Hydrological modeling methods were used to predict the range of flood flows in the stream and it was established that a typical annual flood event is about 10 cumecs (10,000 litres/second) in size. A 100-year flood event is 150 cumecs in size. The stream is therefore large enough to require a significant level of engineering in order to be diverted.

The design of any stream diversion is heavily related to the size of flood events. The design flood, that is, the flood event chosen for design purposes, determines the capacity of the stream channel and the size of sediment selected for the bed. The streambed must contain bed armouring of a given size otherwise a flood could scour out the channel. Once the design flood flow is selected, hydraulic modeling is carried out to examine the capacity of the channel and the water velocities that will occur in it.

Unless a diversion is designed for the Maximum Probable flood event (an event never likely to be exceeded), any design level has some risk that it will be exceeded allowing the diversion berm to be overtopped, resulting in possible environmental and mine infrastructure damage. Furthermore, there is the potential of prosecution (RMA), threat to human life, and loss of production. The selection of the design flood must consider the risks. For this project Solid Energy has a variety of risks to consider and the risk profile changes over time. For example, there will be a period when the existing pit is only partially backfilled and the high wall buttressed. This will mean that the Morley Stream will sit above the pit highwall while the pit backfilling is

completed. During this period there are additional geotechnical risks and risks to workers, infrastructure and production. Once the pit has been rehabilitated the risk profile changes and the major risks are more environmental. The risks include but are not limited to:

- overtopping of the channel and flooding
- scouring of the channel potentially giving rise to highwall failure and also overtopping and inundation of the pit
- illegal discharge/diversion of water as a result of channel failure giving rise to prosecution under the Resource Management Act 1991.

Having selected a design event that provides an acceptable risk profile, it would then be a relatively straight-forward matter to examine the hydraulic considerations (diversion channel dimensions, slope, substrate and velocities) to engineer a stream channel that conveys the appropriate volume of water. This is how past stream diversions at Ohai have been undertaken and arguably this was appropriate at the time considering the regulatory environment that then prevailed and the notion that perhaps those past channels are not permanent features. In today's circumstances there are many other factors to consider in order to make the activity "sustainable" including:

- Final rehabilitation condition – the projects provides the opportunity to create a final stream channel to satisfy end-of-mine-life considerations.
- Fish habitat – provision of habitat suitable for the key species recorded in the stream. This includes the low flow summer condition.
- Riparian habitat – provision of riparian vegetation and habitat suitable for aquatic and terrestrial fauna, and for human fisheries interests.
- Geotechnical safety – the head of water in the stream and the design of the channel liner and substrate effect seepage and geotechnical considerations.

Generally, the provision of aquatic habitat tends to result in the stream channel being wider than it might otherwise be if only conveyance principles are taken into account. In this example there is an economic trade-off because a wider stream channel corridor will result in a reduced economic mine limit. Sustainable management means considering all of these factors, understanding their risks, assigning priorities and obtaining a balance.

## **Balancing hydraulics and ecology**

The classic balance to be struck between hydraulic considerations and the needs of the aquatic ecosystem relates to the slope of the stream diversion. A hydraulically optimal diversion takes account of the average slope and finds a substrate and channel size that best conveys the water with ideal velocities during the design event. However, an aquatic ecosystem ideally needs a more naturalised channel morphology with an appropriate sequence of pool, run and riffle habitat, a range of substrate types and greater channel sinuosity. In the Morley Stream project it was relatively easy to take account of aquatic ecosystem considerations and vary the habitat types while still obtaining a suitable hydraulic outcome. This approach brought the river engineers together with the environmental organisations such as the Department of Conservation and Fish and Game. Significant value was obtained simply from the consultation process where fisheries interests were married with engineering considerations to achieve an outcome to suit all parties.

One area requiring careful planning related to the river sinuosity. While superficially it would have been desirable on environmental grounds to allow the channel to meander, the open cast economic limits and also the geotechnical considerations (highwall and stream channel) meant that in some reaches the channel had to be designed with a minimal width. There was, however, an innovative solution available to address this constraint while still satisfying all of the stakeholders. The simple solution is to design the run sections to coincide with the minimum

available corridor reaches of the stream. Run sections are those parts of the river with laminar-like flow, neither pools nor riffles. The narrow corridors are also those areas with greater geotechnical concern, hence there was also some benefit in conveying the water through relatively quickly to reduce the likelihood of seepage into the highwall.

The appropriate proportion of pools, runs and riffles was established by surveying the natural reaches of the Morley Stream and recording the habitats naturally present. The stream design need not be over-engineered and recognition can be given to the fact that natural modification will occur in the new stream channel. Important features are the in-channel rock weirs that not only give rise to the hydraulic jumps but also dictate where the riffle sections will form. Published fish habitat preference curves allowed us to consider the best channel design to achieve optimal water depth, velocity and wetted perimeter for any given fish species. The aquatic ecosystem requirements are accommodated in the low flow portion of the channel, whereas the primary hydraulic constraints, involving the conveyance of a design flood flow, are actually accommodated within the broader flood channel.

## **The benefits of the sustainable approach**

The “sustainable approach” is about making the effort to account for and balance a whole range of considerations in the proposed development. This approach takes more effort in the feasibility and design phase but does not necessarily cost more in the construction phase. Most of the costs of a stream diversion relate to the excavation and streambed lining (geotechnical) requirements and these are not greatly different for the conveyance-only channel. However, there are other cost benefits to taking a sustainable approach to the diversion.

Firstly, the up front incorporation of environmental considerations in the stream diversion design gives rise to significant benefit in the resource consent process. The affected parties are involved as stakeholders in the design process. Because they have contributed to the design they feel part of the process and they know their concerns have been taken into consideration. For the Morley Stream diversion all of the affected parties were prepared to provide their written approval for the non-notified consents, and to provide supportive submissions to those applications that were to be considered by the Regional Council under limited notification. If was not the case, then the time and subsequent costs required to obtain consents would have been significantly greater.

Secondly, the risks of the project were reduced as a result of taking account of a holistic range of variables. Flood risk can result in geotechnical consequences and both can result in regulatory consequences including prosecution under the Resource Management Act 1991. All of these outcomes were taken into direct consideration during the design of the stream diversion.

Another benefit of the approach relates to broader aspects of sustainable management. The stream diversion was designed to also account for rehabilitation issues and long-term environmental needs. There is a direct benefit to undertaking a diversion that will survive the foreseeable end-of-mine-life requirements thus avoiding additional rehabilitation costs later and reducing the end-of-life mine liability. Finally, and perhaps even most significantly, what value should be assigned to having the local community see first hand that a mining company is genuinely trying to undertake its business in a sustainable manner? The process builds strong relationships and sets a firm foundation for public consultation regarding new activities and resource consents. Approaching major projects adopting sustainable management principles, which involves balancing a range of considerations including the mining requirements, can lead to a more sustainable business overall as the community responds to the companies values.

## **Author**

**Craig Evans** is the Environmental Science and Planning Group Manager in the Dunedin Office of MWH New Zealand. Craig has a BSc (Honours) degree in geology and has worked as a hydrogeologist for the fourteen years. Craig has qualifications in environmental planning and has detailed experience with the Resource Management Act. Prior to joining MWH as a consultant Craig was the Environmental Advisor for Fletcher Challenge Energy and was involved in all aspects of their oil and gas mining operations from 2000 to 2002. With MWH Craig has continued to work for the oil and gas sector in New Zealand and overseas and for minerals companies including Solid Energy New Zealand. Craig is a member of the NZ Hydrological Society and the US National Groundwater Association.