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FLOODING AND ABANDONED MINES

for

Queensland Floods Commission

by

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INTRODUCTION

1 The author was engaged by the Queensland Floods Commission of Inquiry to provide a brief opinion on the general theme, "Flooding and Abandoned Mines". This report briefly summarises the issues raised by Susan Hedge in an email dated 31 October 2011.

ABANDONED MINES

2 Abandoned mines are also known as derelict mines. According to the NSW Department of Industry and Investment's web site:

> *derelict mines are former mining sites requiring rehabilitation where no individual or company can be held responsible for their management or rehabilitation. Neither Industry and Investment NSW (I&I NSW) nor any other Government agency has statutory responsibility for the rehabilitation of derelict mines. However, NSW Treasury provides annual funds to I&I NSW to undertake rehabilitation works through the Derelict Mines Program.*

Other descriptions in use in Australia include legacy or orphaned sites, highlighting the mine's existence in the past (but not the present) and the absence of current ownership.

3 A recent discussion paper by the Australasian Institute of Mining and Metallurgy made a distinction between the terms abandoned and orphaned mines (Unger and Krieken 2010) viz:

- Abandoned Mine – a mine where the legal owner is known but unable or unwilling to take action
- Orphaned Mine – a mine where the owner cannot be traced / identified

4 I have made an assumption for this report that the term "abandoned mine" incorporates both definitions.

5 The numbers of abandoned mine sites is considerable with over 11000 reported in Western Australia (MCMPR 2010) and "many thousands" exist in Queensland (MCMPR) 2010.

The author has personal experience in New South Wales and the Northern Territory where thousands of mines could be described as abandoned or derelict.

6 Abandoned mines in Queensland date from the 19th Century but, and many were operational as recently as the 1980s and 1990s such as the Mt Oxide mine in central Queensland. Unplanned or premature mine closure has been one of the causal factors for companies abandoning mines in more recent times. A study of more than 800 mine closures in Australia between 1981 and 2005 showed that 75% of the closures were unplanned. A significant proportion of these were due to a drop in commodity price or increase in costs and many result in companies failing (Laurence 2006).

7 Earlier abandoned mines can be blamed on a lack of environmental awareness or relevant regulations or enforcement however the same cannot be said for the later mines. Since the mid-1980s, legislation requiring appropriate mine rehabilitation and closure has existed in most jurisdictions. In addition, mining companies have been required to post security deposits or bonds, designed to be commensurate with the current day cost of rehabilitation.

8 Currently, there are strong regulations requiring companies to submit rehabilitation and closure plans during operations; significant bonds (tens of millions of dollars); environmental auditing; voluntary standards; and relevant guidelines (eg RET's leading practice handbook series).

9 Although these measures won't prevent the unplanned or early closure of a mine, the environmental legacies of that site should be reduced and there should be adequate resources available for remediation.

10 **Potential effects of flooding at abandoned mines, including effects on the environment and public health and safety, using examples of Queensland mines if possible**

The effects of flooding of abandoned mines on public health and safety and the environment can be significant, depending on the type of mine and any associated mineral processing or anciliary activity. In the case of a surface strip or open cut coal mine, due to the large expanse of disturbed, unrevegetated land, flooding can cause significant sediment issues. This was evident in the flooding that occurred in Queensland in both 2008 and 2010/11. Although these mines weren't "abandoned" there were challenges in emptying flooded pits due to the elevated salt and solids content. The impact on downstream aquatic life including fish populations would be expected to be potentially severe with reports of fish spawning being affected (ABC 2011). As far as underground coal mining is concerned, flooding can cause discharge of acidic drainage, caused by the water being in contact with sulphide mineralisation, particularly in the broken waste rock after coal extraction.

11 As far as metalliferous mines are concerned, the impacts are different to coal mining but can be very significant. This is due to the nature of the mineralisation. The ore in many gold, copper, lead and zinc mines is associated with sulphide mineralisation. The ore and mineralised waste when exposed to air and water can oxidise in the presence of bacteria to produce acid mine drainage or AMD. This can manifest in water in open pits, discharges from underground openings such as adits, drives or shafts, or waste rock dumps or even tailings storages. There is considerable literature available on the impacts of AMD but principally it results in low water quality and can devastate downstream aquatic assemblages, and riverine vegetation. It is not suitable for irrigation and stock purposes and certainly not potable.

12 There are numerous examples of AMD issues associated with abandoned mines that I am familiar with. They include the Northern Territory's Mt Todd mine site where there was significant leakage from the waste rock dump and the Mt Lyell mine in Tasmania. At the former site, cleanup was estimated at around $21 million in 1998 (the security deposit was around $100,000) while at the latter mine, around 7 tonnes per day of copper was entering the river systems.

Another example of heavy metal pollution includes the Sandy Flat copper mine (near the Qld border) where the tailings dam leaked, resulting in a blue discolouration of the creek leading into the adjoining nature reserve.
Another example that is often quoted is the Wheal Jane tin mine in Cornwall where a concrete plug designed to hold back acid drainage failed, allowing a huge amount of contaminated water to be released. This incident in 1992 caused the deaths of numerous fish and birds in and around Falmouth Bay.

13 The health and safety issues associated with flooded mines include the opportunities for drowning due to the depth of the water combined with the low water temperatures in open pit mines. Drowning can also occur by falling into abandoned mine shafts. There is also the risk of inrush or inundation from mining adjacent to flooded workings. If hazardous substances such as cyanide and other chemicals or fuels and lubricants remain on the mine site, these can all be released into watercourses during floods causing health as well as environmental problems.

14 **Brief overview of rehabilitation techniques used at abandoned mines which would ameliorate or remove the effects of flooding at abandoned mines, including an indication of the sort of time and type of costs involved in such rehabilitation techniques**

The rehabilitation techniques used at an abandoned mine are determined by many factors including:

- Post-mine land use
- Stakeholder input
- Climatic conditions
- Type of mine
- Potential severity of impact
- Resources/funding available etc

15 The techniques should be chosen after an appropriate risk assessment process has been carried out. Ideally, this should be done with a team of stakeholders with familiarity with the local conditions or relevant expertise.

16 In this case of abandoned open pit gold or copper mines, prior to any flood event, diversion and drainage works should be carried out on these sites. The aim would be to direct any clean water entering the former mining lease around the site so that it remains uncontaminated. “Dirty” water should be retained and treated if necessary on site. It might be decided to direct run off from waste dumps into the open pit or into a retention pond. If the pit is full of water then if possible this should be reduced by pumping out. The water quality is likely to be too poor for release into watercourses but may be suitable for evaporation through sprinklers. During the wet season in the tropics or during flood events, it may be possible to pump directly into the water course due to the immense dilution that occurs under those conditions.

17 Waste dumps require a particular management focus as they may leak acid after a heavy wet season or flooding. Downstream retention ponds need to be constructed with sufficient capacity to hold the discharge after flooding. Suitable spillways are required. Treatment of AMD from these dumps is a big issue on abandoned mines. Active treatment including lime is expensive and requires human intervention indefinitely. Passive systems including artificial wetlands are a better option if conditions allow their use. Covers have been used on dumps, either plastic (HDPE) as a short term option or “store and release” which are for the longer term. If cost is not an issue (which it always is), an option might be to relocate all the waste and deposit it into the open pit.

18 Tailings also need attention as they may be prone to erosion, piping or catastrophic dam failure.

19 If an underground mine, again a focus on drainage around the site and within the site will pay dividends. Flood events may result in discharges from underground workings and capping or plugging all underground openings might be considered.

20 Abandoned alluvial mines in the gold and gemfields (eg Clermont, Rubyvale or Sapphire) can suffer considerable damage from flooding including scouring and erosion of dumps and slurry ponds. It may be necessary to construct a creek diversion or clean out the existing water courses to ensure any flood waters flow easily and not enter the workings. This would also apply to any strip coal mining operation on alluvial plains.

21 All these measures can be costed and a more detailed analysis can be provided on request. There are various tools (rehabilitation calculators) available to provide reasonably accurate costs. This allows regulators in particular to be able to fix appropriate security deposits on existing mines.

22 **Opinion as to data and information which must be gathered about abandoned mines to determine how to assist in their rehabilitation**

The risk assessment process referred to earlier should identify land ownership and stakeholders. It is vital that this information is known and the input of stakeholders obtained. Local people often have the most practical and cost-effective solutions to rehabilitation of these sites. The views of those downstream also need to be ascertained. The ultimate land use needs to be determined eg whether forestry, agriculture, industrial land. Hydrological studies are vital in gaining a better understanding of both surface water and groundwater. This could be with the use of modelling and/or remote sensing techniques. The use of piezometers, lysimeters and other tools is recommended. The waste material needs to be understood or characterised especially as to its potential to produce AMD.

23 Fundamentally, and particularly in this era of high commodity prices, a resource evaluation should be carried out. Many abandoned mines are now being reviewed again by mining companies with a view to re-evaluation and possible re-opening.

24 Geotechnical data particularly on the stability and competency of the open pit walls should be gathered. If highly fractured, then water can escape from the pit into the ground water. If highly competent, then the open pit might be a suitable repository for mine wastes and tailings.

25 **Opinion as to how the abandoned mines sphere should be regulated, what should be regulated and by whom**

Operating mines and exploration projects are regulated in Australia by State governments. Legislation is generally, by world standards, comprehensive and includes environmental and safety provisions. Governments grant legal title over that land to allow exploration or exploitation.

26 Abandoned mines generally are not covered by a current title. Or if they have, the title or tenement holder might be in receivership thus lacking the means to rehabilitate the site. This lack of an identifiable owner with the resources necessary to carry out remedial work presents a major challenge for regulation. For example, there is provision in the NSW Mining Act 1992 (Section 241) for the Minister to direct the lease holder to rehabilitate at the lease holder's expense. The practicality of this action is clearly questionable.

27 Most State governments appear to administer an abandoned mines rehabilitation program. Queensland established its program in 2001. The NSW Derelict Mines Program commenced in 1974 with an annual allocation of $125,000. The current allocation for the 2010/2011 financial year is $1.95 million.

28 The most comprehensive program appears to be in Tasmania (see http://www.mrt.tas.gov.au/portal/page?_pageid=35,831282&_dad=portal&_schema=PORTAL). In Tasmania, it is reported that the mining industry has agreed to an increase in royalty payments to the State government to enable it to fund the rehabilitation of abandoned mines. This may be a model worth considering by the Queensland government.

A Trust Fund was established to fund rehabilitation of land affected by former mining or exploration activities and is defined in the Mineral Resources Development Act 1995 *as:*

a) *any money appropriated by Parliament for the purposes of this Part; and*
b) *any money received from the sale of any building, machinery or property vested in the Crown under section 105(4); and*
c) *any security deposit or part of a security forfeited by the Minister under section 198; and*
d) *any other money received for the purpose of this Part; and*
e) *any money the Treasurer directs to be paid into the Rehabilitation Trust Fund.*

*The Minister for Mines may: (*Mineral Resources Development Act 1995*, Section 180.)*

a) *cause any abandoned mining land or land affected by former exploration activities to be rehabilitated; and*
b) *enter into any contract relating to the environmental rehabilitation of any abandoned mining land or land affected by former exploration activities.*

29 All State and Territory regulators seek security deposits before mining commences and this should reflect the cost of rehabilitation at any point in time. This together with strong enforcement and auditing of rehabilitation plans may reduce the risk in the future of adding to the inventory of abandoned mines requiring government funding.

30 In buoyant conditions such as those occurring now, many abandoned mine sites are covered by an application for a mining lease or exploration licence. This is an opportunity for the Qld government for example to negotiate a partial if not full remediation to prevent adverse impacts from flooding. It might end up being a public-private partnership (see Unger 2010).

31 Any rehabilitation should be overseen by a management committee comprising relevant stakeholders from government, the local community and industry if possible. This might ensure a more systematic approach rather than acting on complaints or the “squeaky wheel” analogy which has happened in the past.

32 I thank you for the opportunity to provide an opinion in this matter.

David C. Laurence
PhD (Mining Engineering) M Eng (Mining), B Eng (Mining), B Sc (Geology), MBA

APPENDIX A

Curriculum Vitae

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CURRICULUM VITAE	David C LAURENCE

Qualifications

- PhD in Mining Engineering *UNSW 2003*
- Master of Engineering (Mining) *Syd 1990*
- Bachelor of Engineering (Mining) (Hons) *Syd 1976*
- Bachelor of Science (Geology) *Syd 1974*
- Master of Business Administration *UNE 1997*
- First Class Mine Manager's Certificate
- NSW (below ground), Northern Territory (open cut and underground)

Present Positions

Associate Professor
Oct. 1998 to present
School of Mining Engineering
The University of New South Wales
Sydney, Australia

Affiliations

- Australian Institute of Mining and Metallurgy - Fellow
- Society of Mining Engineers – Member
- Chamber of Mines of Zimbabwe – Member

Teaching Area

- Environmental management; mine safety & health; metalliferous mining methods & mine design; mining law; mine management; mineral economics; industrial minerals; alluvial mining

Research Interest

- Environmental management –mine planning; mine closure & decommissioning; waste dump design; acid drainage; mine rehabilitation; social impact; exploration programs; environmental management systems
- Safety and health – management systems; auditing; risk management; accident investigation

Prof. Interest

- Consultant to industry, government and aid organizations in mine environmental management; mine closure and decommissioning; institutional strengthening; health and safety systems; training and development; stakeholder liaison, due diligence in property acquisitions; management consultant; business plans; Australia, Asia, Africa & Pacific regions

Professional Experience

1998 – present	**Associate Professor,** The University of New South Wales
1997 & 1998	**Consultant**, Fiji Mineral Resources Department
1995-1998	**Chief Government Mining Engineer,** NT Department of Mines & Energy
1992-1995	**Principal Mining Engineer & Consultant,** Ministry of Mines/AusAID Zimbabwe
1988-1992	**General Manager, Operations** Nunan Sapphires (Great Northern Mining Co.)
1983-1988	**Regional Mining Engineer** NSW Department of Mineral Resources
1977-1982	**Mining Engineer** The Zinc Corporation Broken Hill

Safety Experience 1977 – 2004

- October 2003 – awarded PhD in the area of Improving Mine Safety Performance involving research at 33 mine sites in NSW, Queensland and other areas. Research focused on safe behaviour and attitudes and involved case studies involving remote controlled continuous miners and other equipment.
- 1999 to present – completed ~ 35 expert witness reports in the areas of mining and industry in general (both defendants and plaintiffs). Coal (open cut and underground); metal (open cut and underground); quarries, tunnels, warehouses, factories etc.
- 1999 – present – consultant in the mine safety field – projects included investigations involving the Northparkes mines fatalities in 1999.
- September 2002 – presented a paper at the NSW Mineral's Council OHS conference on "Modelling Safe Work Behaviour".
- August 2002 – presented similar paper at the Queensland's Mining Council OHS Conference.
- July 2001 – presented at the NSW Mineral's Council 2001 conference on eliminating risk taking in the industry.
- 1999 – present – conducted research into improving OHS in mining including for example field trials for a new type of material for strengthening the walls of underground excavations.

- 1998 – present – teaching undergraduate, postgraduate and industry personnel in aspects of mine safety and risk management.
- 1995 – 1998 – Chief Government Mining Engineer (~ Chief Inspector of Mines) in the Northern Territory – leading a team of professionals involved in accident investigation, reviewing mine safety management systems, policy and legislative development etc
- 1992 – 1995 – Principal Mining Engineer and Consultant to Ministry of Mines (Zimbabwe) – accident and incident investigation; training and development; policy and legislative development.
- 1988 – 1992 – General Manager with responsibility for 4 operating mines, numerous exploration projects, and construction sites – safety and health a major priority and lost time injury rate of nil in that time.
- 1977-1982 – various positions in large underground mining company in Broken Hill.

Safety Qualifications

- PhD in mine safety (2003)
- Member of Board of Examiners of Mine Manager's Certificate of Competency (NSW) (2003 to present)
- Former Member of Boards of Examiners in Northern Territory (1995-98) and Zimbabwe (1992-95)
- Holder of Mine Manager's Certificates of Competency in NSW, Northern Territory. (1982 and 1995 respectively)

Selected Publications

- Laurence, D.C., "Sapphire production in the New England region, NSW", Monograph No. 10
- Mining and Metallurgical Practices in Australasia, AusIMM, 1993.
- Laurence, D.C., "Productivity and its impact on employment and labour relations in the coal mining industry – case study: Zimbabwe, the Wankie Colliery", International Labour Organisation, Geneva, 1994.
- Laurence, D.C., "Environmental legislation and management practices in the Zimbabwean mining industry – the past, present and future", IMM, Harare, Zimbabwe, 1995.
- Laurence, D.C., "Mine environmental management initiatives in Zimbabwe – a model for developing countries", Proc. 3rd International Environmental Workshop, Minerals Council of Australia, Newcastle, 1996.
- Laurence, D.C., "The Life-of-Mine Approach to Decommissioning", Proc. Workshop on Environmental Issues in Decommissioning of Mine Sites", ACMER, Brisbane 1998
- Laurence, D.C., (ed) "Best Practice Environmental Management in the Fijian Minerals Industry" Proc. Workshop Mineral Resources Department, May 1998, Suva Fiji.
- Laurence, D.C., Carr, M. and Svotwa, R. "Environmental Protection and its Employment Effects on Miners in Small and Artisanal Mines in Zimbabwe" ILO Geneva Industrial Activities Branch 1998

- Laurence, D.C. “New Developments in Community Consultation in Mine Decommissioning” in Proc. Workshop on Environmental Issues in Decommissioning and Temporary Closure of Mine Sites”, ACMER, Townsville, 1999.
- Laurence, D.C., “Training Initiatives for Mines Inspectors and other key officials involved in Small and Medium-scale Mining” in Proc. Environmental Cooperation Workshop for Sustainable Development of Mining Activities, Cairns, 1999 (APEC)
- Laurence, D.C., Galvin, J.M., Beer, L. “Polymer Membrane Liners in Underground Coal Mines – Ground Control for the Millenium?” in Proc. 19th Conference on Ground Control in Mining, Morgantown, WVa, 2000.

APPENDIX B

References

ABC “The Drum” online < http://www.abc.net.au/unleashed/43128.html>

Laurence, D.C. 2006 “Why Do Mines Close?” Proceedings First International Seminar on Mine Closure. Australian Centre for Geomechanics, Perth, Pages 83-94. ISBN 0 975675664

Ministerial Council on Mineral and Petroleum Resources (MCMPR). 2010 Strategic Framework for Managing Abandoned Mines in the Minerals Industry

Resources, Energy and Tourism 2006 et seq Leading Practice Sustainable Development in the Mining Industry handbooks

Unger, C. and Krieken, A. 2011 A Discussion Paper on Abandoned Mine Management in Australia – AusIMM <available at http://www.ausimm.com.au/content/docs/abandoned_mine_management_in_australia.pdf>