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Research papers

Problems with the application of hydrogeological science to regulation of Australian mining projects: Carmichael Mine and Doongmabulla Springs

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ABSTRACT

Understanding and managing impacts from mining on groundwater-dependent ecosystems (GDEs) and other groundwater users requires development of defensible science supported by adequate field data. This usually leads to the creation of predictive models and analysis of the likely impacts of mining and their accompanying uncertainties. The identification, monitoring and management of impacts on GDEs are often a key component of mine approvals, which need to consider and attempt to minimise the risks that negative impacts may arise. Here we examine a case study where approval for a large mining project in Australia (Carmichael Coal Mine) was challenged in court on the basis that it may result in more extensive impacts on a GDE (Doongmabulla Springs) of high ecological and cultural significance than predicted by the proponent. We show that throughout the environmental assessment and approval process, significant data gaps and scientific uncertainties remained unresolved. Evidence shows that the assumed conceptual hydrogeological model for the springs could be incorrect, and that at least one alternative conceptualisation (that the springs are dependent on a deep fault) is consistent with the available field data. Assumptions made about changes to spring flow as a consequence of mine-induced drawdown also appear problematic, with significant implications for the spring-fed wetlands. Despite the large scale of the project, it appears that critical scientific data required to resolve uncertainties and construct robust models of the springs' relationship to the groundwater system were lacking at the time of approval, contributing to uncertainty and conflict. For this reason, we recommend changes to the approval process that would require a higher standard of scientific information to be collected and reviewed, particularly in relation to key environmental assets during the environmental impact assessment process in future projects.

1. Introduction

Globally, water management is one of the most critical environmental sustainability challenges for the mining industry (ERMITE, 2004; Amezaga et al., 2011; Northey et al., 2016), and there is increasing conflict over impacts to water resources from mining in some regions (e.g. Bebbington and Williams, 2008; Bebbington and Bury, 2009; Kemp et al., 2010; Gleick and Heberger, 2014). Recently in Australia, such conflicts have often focussed on groundwater, upon which many regional communities and ecosystems depend (Harrington and Cook, 2014). Aquifers and the springs and streams they support may be impacted by lowering of the water-table to allow open-pit or underground mining, as well as water withdrawal for mineral processing and other on-site requirements. Water contamination issues are also common.

In this context, mining companies, environmental decision makers and water management agencies must assess the likely impacts of proposed mines on groundwater and any connected surface water and ecosystems. Open-pit mining may lead to impacts that are slow to eventuate and subsequently permanent, and therefore investigations need to predict the post-mine closure hydrogeological conditions. Should a project be approved, monitoring and management strategies must be in place to recognise adverse impacts and, most importantly, remediate them if they occur. These requirements remain for prolonged periods after

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mining has ceased, given that the full impacts may take decades to eventuate (Northey et al., 2016). Scientific input, including collection and assessment of field data, development of conceptual hydrogeological models and predictive (e.g., numerical) modelling, is integral to this process.

The available methods for investigating impacts on hydrogeological systems arising from new stresses, such as mining, lead to significant uncertainties in the resulting predictions of future conditions – such as impacts on a particular groundwater-dependent ecosystem (GDE). An area which can introduce conceptual uncertainty in impact assessment models is the representation of subsurface heterogeneity. In particular, faults and other preferential flow pathways may be neglected or highly simplified. However, these types of heterogeneity may have a strong influence on groundwater flow and the hydraulic connectivity between aquifers and the land surface (Smerdon and Turnadge, 2015). Assessing model uncertainty, which can arise from various conceptual and numerical sources, is critical in guiding monitoring, management and mitigation strategies (Delottier et al., 2017).

Recently, a number of court cases have been heard in Australia where approvals to mining projects have been challenged on the basis that impacts to groundwater have not been adequately considered in the decision and/or design of operating conditions. The concept of 'adaptive management' has been employed in many of these cases, whereby resolution of key scientific uncertainties regarding groundwater has been deferred until after the mine has been approved to commence construction, on the basis that groundwater management can adapt to adverse impacts as they develop. Lee (2014), Lee and Gardner (2014) and Slattery (2016) discuss some of these cases and argue that adaptive management concepts are being misused in some cases in the context of mining approvals.

In Australia, as in many countries, companies applying for approval of a mining project must generally prepare an Environmental Impact Statement (EIS) if the project is considered by the relevant government authority to be significant. The EIS typically considers, among other things, the impact of the proposed mine on groundwater, surface water and ecosystems in the vicinity of the mine. After the EIS is released, it is reviewed by State government bodies, e.g. the Coordinator-General in Queensland (Australia). Large coal mine and coal seam gas (CSG) projects impacting on matters of national environmental significance, including water resources, are referred to the Australian Federal Minister for the Environment. The Minister must ask the Independent Expert Scientific Committee for Large Coal Mining and Coal Seam Gas Development (IESC) for advice before making a decision to approve proposals. The IESC was established due to community concern in Australia over impacts of mining and CSG projects on water resources, and provides independent scientific advice on potential water-related impacts. The EIS for a mining project, and the reviews of the EIS (including advice from the IESC), are typically released for public consultation as part of various approval processes and may be subject to objections, which can be assessed during a court hearing.

Worldwide, there are relatively few studies examining how hydrogeological science informs decisions about mining projects. Younger et al. (2005) examined how scientific and socio-economic considerations were incorporated into risk-based decisions about the treatment of polluted mine waters in the UK, exploring the trade-offs between these. Amezaga et al. (2011) and Northey et al. (2016) provide global overviews of long-term sustainability of mining with a focus on water management, stressing the importance of up-front assessment of likely water impacts through a project's life-cycle, including the post-closure phase. The Comparative Groundwater Law and Policy Program (Casey and Nelson, 2012) examined the science-policy interface in relation to groundwater issues, including the different approaches of scientists and policy makers to groundwater problems, although mining projects were not considered specifically.

In this paper, we discuss a high-profile case study involving a large coal mine proposal (the Carmichael Coal Mine) in central Queensland, examining how hydrogeological science was incorporated into its assessment. The key decision makers in the case included State and Federal government departments and the Land Court of Queensland. Throughout the approval process and design of operating conditions, large uncertainties remained unresolved regarding the conceptual hydrogeological model and numerical model for the mine. This was acknowledged in the Land Court judgement on the case, and the Federal Minister for the Environment's approval conditions for the mine specify that, prior to commencement of excavation, research and monitoring plans must be submitted that address these issues. We discuss in detail how hydrogeological disagreements and misconceptions informed the decision to approve the Carmichael Mine, and were ultimately reflected in the conditions of approval for the mine. We make targeted recommendations which we believe could address such issues in future.

2. Hydrogeological setting of the Carmichael Coal Mine

In 2010, a subsidiary of the Adani Group (Adani), an Indian resource, energy and infrastructure group, submitted a proposal to the Queensland Government to build the Carmichael Coal Mine and Rail Project to supply coal to its Indian power stations (GHD and Adani Mining, 2013a). If constructed, the mine would be the largest open-cut and underground coal mine in Australia's history, covering ~28,000 hectares and extending ~30 km along strike, producing an estimated 2.3 billion tonnes of thermal coal over 60 years. The mine is situated ~300 km inland and there is no local infrastructure; it will be necessary to construct a railway and expand port facilities to export the coal. The proposed mine is located in the catchment of the Burdekin River in an area predominantly used for beef cattle grazing.

The proposed mine is in a semi-arid environment with strongly seasonal rainfall (mean annual rainfall ~500 mm) and there are no permanent watercourses nearby except for part of the Carmichael River, which is spring-fed (see below). Two salt lakes, Buchanan and Galilee, lie in internal drainage basins west of the mine. The topography of the area is subdued, with a maximum relief of 300 m. The drainage divide of the Great Dividing Range, with a maximum elevation of ~500 m above sea level, runs north-south approximately 50 km west of the Carmichael mining lease. The area is mostly covered with open eucalypt woodland.

The Carmichael mining lease lies within the Galilee Basin, which contains a Permian siliciclastic sequence dominated by fluvial sandstones and shales; in stratigraphic order – the Joe Joe Formation, Colinlea Sandstone and Bandanna Formation (Moya et al., 2014). Overlying the Permian strata are the Triassic Rewan Formation, Dunda Beds and Clematis Sandstone, capped by Tertiary laterite (McKellar and Henderson, 2013; Fig. 2). These Triassic units form part of the Eromanga Basin sequence within the Great Artesian Basin. Coal seams are confined to the Colinlea Sandstone which outcrops or sub-crops at shallow depth along the eastern margin of the basin (Fig. 1), dipping westwards at 2–5° for 10–20 km and then becoming sub-horizontal. The Galilee Basin is yet to be developed for mining; however, a number of coal mines to the south of the Carmichael mining lease have also been proposed and granted approval in the last five years (Lee and Gardner, 2014).

The main aquifer in the mine area is the Colinlea Sandstone/Bandanna Formation; the lower sandstone beds are porous and high yielding with good quality groundwater (electrical