HYDROGEOLOGICAL CHARACTERISATION OF COAL MEASURES

AND OVERVIEW OF

IMPACTS OF COAL MINING ON GROUNDWATER SYSTEMS

IN THE UPPER HUNTER VALLEY OF NSW

by

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CERTIFICATE OF ORIGINALITY

I hereby declare that this submission is my own work and that to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of a university or other institute of higher learning, except where due acknowledgement is made in the text.

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ABSTRACT

Open cut coal mining in the Upper Hunter region of New South Wales has resulted in mine pit depths of 150 metres or more below the natural water table, and the backfilling and reshaping of more than 10 billion cubic metres of spoils waste rock.

Groundwater impact studies are a pre-requisite for mine pit regulatory approvals. Such studies often rely heavily upon computer based numerical models to simulate pit development and predict impacts. These models are sometimes poorly designed and reliant upon conjecture in prescribing strata hydraulic properties and other parameters. In addition, regional groundwater chemistry and the impacts relating thereto, are often addressed in a simplistic way while spoils leachate which is generated following pit resaturation, is poorly characterised if at all.

In order to assist groundwater practitioners in their assessments, a large amount of hydrogeological data has been consolidated as part of this research effort, hydrophysical and hydrochemical methodologies have been documented, and aquifers in the Upper Hunter region characterised.

Compilation and trend analysis of 172 packer tests conducted on coal seams (aquifers) at different locations and depths has resulted in a new and potentially useful coal seam depth versus hydraulic conductivity relationship based on coal brightness.

Testing of 180 interburden core samples comprehensively demonstrates the very low matrix conductivity (less than 1.0E-04 m/day) of non coal interburden strata. Expected ranges in compressible storage for both coal seams and interburden have been calculated directly from reported ranges in elastic moduli derived from geomechanical studies.

Groundwater qualities within the regional coal measures and the shallow alluvial aquifers have been re-assessed through the compilation of 850 laboratory ion speciated samples. Tri-linear plotting of samples lends weight to some previously defined hydrochemical provinces. However there appears to be no useful division that might support regional scale inference within the coal measures.

XRD analyses of 24 interburden core samples exhibit a remarkably common mineral regime dominated by quartz with subordinate albite, kaolinite, illite-smectite and dolomite. The presence of dawsonite is also noted.

Vertical section numerical modelling of a typical open cut pit demonstrates that coal seams, by virtue of their relatively high hydraulic conductivity, tend to preferentially depressurise the strata and induce a component of leakage from adjacent less permeable interburden. Pressure losses within shallower strata are likely be restricted to less than 2 km from a pit face while losses in deeper strata could migrate distances of 6 to 7 km over a period of 100 years.

Following pit closure, water levels will recover within a pit shell due to rainwater and groundwater contributions. A leachate will evolve from progressive re-saturation of spoils. The hydrochemistry of leachate derived from rainwater percolation has been explored by conducting batch reaction trials on 58 core samples representing different interburden lithologies in the Upper Hunter region. Trial results demonstrate leachates exhibiting Na>>Mg>Ca and HCO_3>>Cl-SO_4 ionic species distributions. TDS projections out to 100 years support a range from 500 mg/L to more than 5000 mg/L with an average of about 2150 mg/L.

Inverse geochemical modelling of leachate trials has shown ion exchange to be particularly relevant. Findings suggest rapid dissolution of halite and dolomite will occur while ion exchange will enhance the dominance of Na through the presence of Na-smectite. Reaction path modelling results demonstrate that in the absence of exchangeable Na, the leachate quality is likely to be Na-Mg>Ca (Ca is minor) and HCO_3-Cl-SO_4 (no dominant anion). Progressively increasing the availability of exchangeable Na leads to an increasing presence of Na and HCO_3.

Research findings suggest subsurface hydrophysical impacts of mining on the high value alluvial groundwater system adjacent to the Hunter River, are relatively minor at the present time and are likely to remain so providing the hydraulic conductivities of Permian strata adjacent to the alluvial system, are not enhanced by fracturing and bedding shears.

Potential hydrochemical impacts on regional high value aquifers equate largely to the long term potential for spillage/leakage of leachate from mine pits. Predictive analyses suggest this leachate is likely to be Na-HCO_3 type water with potential enhancement of Na-Cl from washery rejects if present. The pit closure design may also lead to enhancement of Na-Cl in the long term through evaporative concentration. Design of an appropriate passive pit closure scheme is especially relevant to long term groundwater quality in the region.

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