Upper Hunter Mining Dialogue

Beneficial Reuse of Voids Project

Summary Report

November 2019

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About the Upper Hunter Mining Dialogue

The Upper Hunter Mining Dialogue (the Dialogue) was established in 2011 in response to community concerns about infrastructure and services, mine rehabilitation, water and air quality. The Dialogue seeks to engage with the industry's stakeholders and the community and is a collaborative effort that seeks to understand and address the local community's concerns and then working together to develop and implement solutions.

There are currently ten coal producers and mining contractors operating seventeen sites across the Upper Hunter, who are participating industry members of the Dialogue, including:

- Bengalla Mining Company
- BHP
- The Bloomfield Group
- Glencore
- Malabar Coal
- MACH Energy Australia Pty Ltd
- Muswellbrook Coal Company
- Peabody Energy Australia
- Thiess; and
- Yancoal.

The Dialogue's progress is largely driven by the development and implementation of projects. Industry, business, community and government stakeholders participate collaboratively in the Dialogue's Joint Working Groups to develop and oversee projects that address community concerns about cumulative impacts associated with mining.

A number of community workshops were held to establish the Dialogue's initial five-year goals and determine key projects that would support those goals. As a result of these discussions, Industry and Joint Working Groups were formed under four themes: Water; Emissions and Health; Social Impacts and Infrastructure; and Land Management.

The Dialogue continues to evolve to meet the expectations of our stakeholders and ensure that this initiative remains relevant to the community. The Joint Advisory Steering Committee was established in 2015 as the key joint committee with oversight of the various Working Groups and to discuss long-term strategic mining and community matters in the region.

A further realignment of Dialogue priorities was undertaken in 2018 to consolidate all environmental themes (Water, Air, Land Management) into a single 'Environment' theme supported by a Joint Working Group. In addition, the Dialogue has established two new themes, supported by Working Groups to demonstrate their continued focus on improving stakeholder engagement and communications, as well as working to improve mining-related economic and social development issues, including increasing engagement with local small and medium suppliers for mining procurement opportunities.

Executive Summary

The Upper Hunter Mining Dialogue is an important community initiative that addresses key issues of concern amongst the Upper Hunter communities. One long-term issue that is consistently raised by the community at our meetings, forums and events is 'What will happen with mining assets once active mining ceases in the region'?

There are approximately 25 residual voids currently approved and a further 5 voids included as part of proposed projects. Recognising the need to commence planning and preparations for a region-wide approach to developing and establishing post-mining land uses in the Upper Hunter, the Dialogue held a workshop in 2016 with various key stakeholders to commence this process and inform future Dialogue work.

As a result of this workshop and subsequent meetings, a series of reports titled *Beneficial Reuse of Voids* were prepared, consisting of a literature review, potential end use review, a stakeholder workshop summary, a water quality study, and a water quality monitoring guidance note. Due to the technical and complex nature of the reports, the Dialogue sought to reformat the documents in a series of fact sheet summaries to improve stakeholder understanding of these outcomes. This summary document brings this comprehensive work together in a single report.

The Dialogue continues to be an instrumental stakeholder in refreshing the development of a review of the Hunter Valley's 'Synoptic Plan', which was originally commissioned in 1999 by the then NSW Department of Mineral Resources. A map pulling together all existing information and resources is currently being developed and led by the Department of Premier and Cabinet to guide future ongoing work in post-mining land use planning in the Upper Hunter.

The NSW Government is also working to develop a mine rehabilitation visualisation tool, which will summarise approved void locations, along with details regarding their size and the anticipated time frames involved in their future use. This will enable stakeholders to visualise how mine rehabilitation is progressing in the Upper Hunter and what it may look like at key intervals in the future.

The Upper Hunter Mining Dialogue is pleased to work collaboratively with industry, government, community and other key stakeholders to discuss and plan for the future of the Upper Hunter in a post-mining landscape. The Dialogue will continue to help facilitate and support projects that seek to secure positive long-term outcomes for the region.

Stakeholder Workshop Summary

Introduction to the Stakeholder Workshop

A Stakeholder Workshop was conducted in 2016 as a forum to bring industry and community together to begin discussions, visioning and concepts for the future use of closed mine voids in the region. The Workshop was hosted by the Dialogue and was attended by around 25 people from industry, state and local government and local community members.

The main objective of the Workshop was to collectively consider beneficial end uses of residual mine voids by engaging the community in discussion about the context, challenges and opportunities for use. The Workshop also developed a list of potential end uses for regional mine voids.

The Workshop included presentations from mine closure specialists and regulators and consisted of group activities and discussion. An overview was also made of likely pit lake water quality and closure practices elsewhere in Australia and internationally.

Workshop Discussions

Pit Lake Positives and Negatives

Residual voids are common mine closure feature of open-cut mines. Following mine closure, voids can be dry or contain water. Numerous coal mines in the Upper Hunter Valley extend below the groundwater table and will fill to some depth with water upon completion of mining. Mine pits containing permanent water are called “pit lakes”.

Workshop participants were asked to identify and then prioritise positives (strengths and opportunities) and the negatives (weaknesses and threats) of pit lakes and the region. The Workshop identified many significant positives for pit lake end use development enjoyed by mining in the Upper Hunter region, including proximity to people, access to good infrastructure and predicted good water quality of pit lakes. These positives are a strong basis for planning future diversification of the economy with potential for development of alternative industries.

There was uncertainty regarding some of the weaknesses and threats, which highlighted significant information gaps. These information gaps included risks of pit lakes to regional groundwater and surface water.

Opportunities for Residual Mine Void End Uses

An emphasis was placed on pit lake end use developments as most voids were considered as being likely to form lakes. Pit lakes also offered the most significant post-closure opportunities and end uses that require innovative approaches. Participants were presented with potential and existing end uses for pit lakes from an international mining industry closure

practice review; such as recreational use (boating, swimming, picnicking, fishing and trails), waste management (landfills), wildlife habitat, stock watering, horticulture and aquaculture.

The Workshop suggested and discussed potential end uses for pit lakes, including some innovative ideas. The ideas showed the broad range of possibilities which could become a useful resource for companies in the region to initiate more specific discussions with their own stakeholder groups.

Workshop participants voted for their three preferred options; the top 10 end uses identified were:

1. Recreation
2. Waste management
3. Hydropower
4. Bike riding and walking trails
5. Tourism
6. Wildlife habitat
7. Emergency services (firefighting resources)
8. Flood mitigation (river water storage)
9. Theme parks
10. Aquaculture

Participant Feedback

The Workshop was positively received by participants; however, participants made several suggestions to be incorporated into future planning:

- A pit lake closure planning strategy is needed going forward. The strategic approach (at a regional level) is required to understand the final landforms and potential timeframes for engaging with stakeholders regarding end use options and their development.
- More business development for end use opportunities to be realised, particularly by mining companies.
- A test case residual mine void should be identified for study and closure planning for future beneficial end use.

Outcomes

The objectives of the Workshop were achieved, and it was felt by delegates that the approach was a valuable forum for discussion. The Workshop showed that there has been a shift in public discussion about mine pits. Previously there has been a focus on the potential for the risk of a “moonscape” landscape, which would reduce available arable land and potentially leave soil and groundwater contamination issues. Participants at the Workshop expressed a view more toward active development of opportunities and were open to further discussions and ideas around pit lake closure.

The workshop highlighted a significant need for ongoing collaboration and planning incorporating industry, community and other stakeholders. Participants of the Workshop stressed that collaboration will be vital to minimising the cumulative impacts associated with the mine voids and maximising the opportunities.

Workshop participants gained a greater understanding of the timeframes associated with end use planning, and how the decisions made now will benefit future generations and are unlikely to be realised by the community members today.

Future Consultation and End Use Planning

The information collated during the Workshop will be incorporated into future end use planning and consultation for the Upper Hunter Valley. Based on the Workshop outcomes and findings, several recommendations have already been made. These include requirements to:

- Establish a regional strategic approach to mine pit closure planning that also determines beneficial uses of mine voids in the Upper Hunter. It is recommended to form a regional committee to continue discussions on the uses of mine voids and plan for further development and implementation. A key priority of the committee should be to identify and encourage collaboration between operators to achieve minimisation of impacts and maximisation of opportunities. This committee should meet three–four times a year and include representatives from industry, local government, community and local business with external expert technical assistance as required.
- Use the committee (recommended above) and external advisors to update the regional post-mining landscape vision and include details from individual projects' conditions and closure plans.
- Identify knowledge gaps common to all projects that could then be researched through collective or supportive funding arrangements.
- Seek funding support to further develop regional closure planning from state and national funding initiatives.
- Specifically investigate mining company and stakeholder interest in, and the viability of, identified preferred broad end use opportunities.
- Seek agreement from operations in the region to address mine void closure appropriately and consistently in closure plans.
- Seek a commitment from operations within the region to share key data relevant to mine void closure, such as water quality. Consider developing and using consistent data collection and analysis tools and approaches to assist with this.
- Engage with the mining community at a regional, national and international level and keep abreast with industry practice across these other regions and commodities to identify, achieve and demonstrate leading industry practices in end use development.
- Develop plans and execute closing a mine void as a beneficial end use as an example for stakeholders.

The Dialogue continues to work to implement recommendations from the Workshop and continue to work together with industry, Government and community members on mine void end use planning. Scoping processes, such as this workshop, will also be used to identify relevant matters or issues for consideration in planning work including Environmental Impact Statements (EIS) and the level of detail to which they should be assessed.

Potential Beneficial End Use Review

Introduction

A literature review which examined national and international examples of residual mine void end uses was commissioned by the Dialogue to assist stakeholders in identifying sustainable, practical and beneficial opportunities for the Upper Hunter region following mine closures.

The review focused on collaborative approaches to residual mine void development that apply to regions with multiple mine operations. Collaboration is important to minimise the cumulative impacts associated with numerous voids and maximise the opportunities for the region.

End Use Opportunities

Mine closure guidelines increasingly require post-mining land uses to be of equivalent value to pre-mining conditions to ensure no net loss of value to stakeholders and the environment.

Residual mine voids are often not fully considered in mine closure planning to include beneficial end use of residual mine void land or pit lakes. However, around the world there are residual mine voids that have been used for beneficial activities post closure, such as recreation and sport, aquaculture, wildlife habitat, housing developments and entertainment areas.

Recreation

Many abandoned mine sites have been rehabilitated and are used as general walking areas. One of the most famous is Butchart Gardens, a sunken garden developed in a closed limestone quarry near Victoria, Canada. The Eden Project is a reclaimed pit and now popular visitor attraction in Cornwall, England, UK. There are two biomes, which contain plants that are collected from many diverse climates and environments, and also serves as a popular concert and conference venue.

Other Uses

Other examples of using dry open pits include housing developments, such as in Salt Lake City, USA, and as film sets, such as “Mad Max”, filmed in Homebush Bay in the old clay workings and “Schindler’s List”, filmed in Krzemionki Podgorskie, Poland.

Pit Lake Case Studies

The following are examples of leading practice mine pit closures from around the world. Incorporating a holistic approach to closure they were planned early in the life of the mine with mining companies engaging with local communities on end uses.

Recreation

There are many examples of pit lakes used for recreation, including Lake Kepwari in Western Australia (WA), Rother Valley Country Park in the United Kingdom (UK), Golden Cross in New Zealand (NZ) and the Lusatian region in Germany. Lake Kepwari is located near Collie, WA, in a former open-cut coal mine pit. The lake was planned as a recreation resource for water skiing and swimming. However, lake opening was delayed due to poor water quality. The current lake use is research, wildlife habitat and technical diver training.

Although there were outstanding concerns regarding water quality, the lake is a good example of the potential of a pit lake for recreational end uses. A revised closure strategy means that lake water quality now also meets planned recreational end uses.

Rother Valley Country Park is a former coal mine in the UK. Planning occurred very early through a Joint Committee of five county councils and included community consultation. The pit lake was planned and rehabilitated to become a recreational facility. Rother Valley incorporates world's leading practice in rehabilitation such as early planning, community and local council involvement and a long-time frame for development. The park has now developed strong commercial outcomes through tourism-based activities.

Golden Cross gold and silver mine is in Waihi, NZ. A joint venture partnership between Coeur d'Alene mines and Viking Mining established a 'Joint Task Force' to examine sustainable post-mining land uses, with the process involving community consultation. The final rehabilitation has seen the mine site become a wetland and native wildlife habitat, as well as being used for grazing and recreation.

The Lusatian region was the centre of East Germany's energy production until closure of most mining in 1990. The rapid closure of lignite mining resulted in socio- economic impacts for the region. A plan was developed to convert the area to a rehabilitated Lake District for tourism and recreation. Multiple lakes would be connected by canals and provide recreational facilities such as boating, windsurfing, sailing and water skiing. There are also plans to incorporate nature conservation areas. Each lake has been slowly filling over the past decade and many are approaching their expected implementation dates.

Aquaculture

The Ngalang Boodja Mine Lake Aquaculture Project near Collie, WA, was set up in 2008 by the Ngalang Boodja Council Aboriginal Corporation (NBCAC) in partnership with Premier Coal and the Aquaculture Council of WA. The project is a former coal mining area and research was conducted on the biological feasibility of pit lakes. This research was successful, and a commercial-sized marron farm was constructed. The first harvest was successfully completed in 2011 and the second harvest in 2012. The project is a good example of turning a liability into an asset. The farm also provides job opportunities and creates a sustainable enterprise for the community.

Urban Development

Batesford Quarry is a limestone quarry near Geelong, Victoria, which is planned to become a lake surrounded by urban development. Planning has been initiated ten years before mining ceases and an expert team used to assess the constraints, opportunities and feasibility of the plan. In addition, areas will also be developed as an ecological riverine corridor. Rarely do opportunities arise allowing closure of a mine site to be planned as a key beneficial land use asset within a new urban growth area. However, this case study demonstrates that a former mine site could become a valued home to 40 000–45 000 people.

Wildlife Habitat

The Enterprise gold mine pit in the Northern Territory, Australia was closed in 1992 with a major stream partially diverted into the residual mine void making the Enterprise Pit a flow-through lake along the stream's course.

Rapid pit lake filling was used to firstly improve, and then maintain water quality. After the first wet season the lake was half full, and late in the second wet season it was about two thirds full. The lake is now regarded as an off-stream storage that is recharged each wet season as Pine Creek experiences seasonal peak flows. All year round, but particularly during the dry season, the lake provides habitat to regional waterfowl.

Collaborative Approach

The Athabasca oil sands region in Alberta, Canada consists of over ten open-pit mines. At completion of mining for current planned projects, there are expected to be around 30 pit lakes in the region, which will create a Lake District.

Guidance for pit lake closure was developed by the Cumulative Environmental Management Association (CEMA). Industry guidelines were produced under the supervision of the association's Reclamation Working Group's End Pit Lake Guide Task Group (EPLGTG). The EPLGTG includes representatives of oil sands miners, Aboriginal stakeholders and federal, provincial, and regional government agencies.

The guide provides detailed technical information to develop pit lake designs early in mine closure planning, as well as a framework for the lake district over the next century. The guidance material will be updated regularly to incorporate new information. The approach of multiple operations collaborating is vital to minimise the cumulative impacts of residual mine voids in a region.

Dry Pit Case Studies

Closed “dry” pits are rare because large-scale modern mining often extends below the groundwater level. Consequently, most dry pits are from smaller quarries. Dry void end uses may be achieved if operations are able to distribute waste rock material to partially fill in pits. Most of the end use examples reviewed were not designed for the end use, rather the end use was developed by stakeholders well after the sites were abandoned.

Theatres

There are two quarry theatres in Perth, WA. The Belvoir and the Quarry were developed in old limestone quarries. Around the world there are similar examples such as the concert venue at Dessau, Germany, and Opera House at Dalarna, Sweden.

Sporting Venues

Dry open pits are used as sporting venues. Examples include the Pete Dye Golf Club in Bridgeport USA, which was developed on a strip coal mine; the Gotland Ring in Sweden, which is a motor racing track in an abandoned limestone quarry; and the Municipal Stadium in Braga, Portugal, which is a football stadium in an old granite quarry. In the Czech Republic, there are several sporting venues located in abandoned lignite mines, including a horse racetrack, skating track, motor racing track and golf course.

Waste Management

Dry pits have been used as waste facilities, such as at Woodlawn. Woodlawn in NSW is a major bioreactor landfill located in a closed base metal mine. The waste facility handles a significant proportion of Metropolitan Sydney’s waste transported daily from 250 km away.

Conclusion

The review shows that many mining companies throughout the world are actively planning beneficial end uses for residual mine voids and engaging stakeholders in this closure planning. The case studies also demonstrate a collaborative approach to residual mine void development, such as in Canada's oil sands region. This demonstrates the need to collaborate across industry to minimise cumulative impacts of many operations in a region.

Coal mining operations in the Upper Hunter are collaborating with the community through Dialogue and continue to actively engage with stakeholders on potential beneficial end uses of mining voids in the region.

Water Quality Study

Many coal mine pits in the Upper Hunter Valley of New South Wales will extend below groundwater levels at mining completion; filling with water from groundwater seepage and surface inflows post-closure. Long term water quality is a key consideration in determining sustainable, practical and beneficial end uses for pit lakes.

The Dialogue commissioned a study of mine void lakes water quality to improve understanding of potential pit lake end uses. Below is a summary of the key results.

Water Quality

The Study evaluated water quality trends over time for four pit lakes in the Upper Hunter Valley. Water quality data from contributing companies were analysed for Glencore Liddell Mine (Dam 6), Glencore Ravensworth Mine (West Void) and two lakes at BHP Mt Arthur Mine (SW30 and SW31).

Graphs of key water quality parameters demonstrated water quality trends over time. Statistical analyses also determined how water quality differed between lakes and over time and what key water quality parameters were causing that difference.

Glencore Liddell Mine

Glencore Liddell Mine is located near Lake Liddell in the western area of the Upper Hunter Valley, New South Wales. The Liddell Mine Dam 6 pit lake has earthworks completed but is not yet significantly revegetated.

Some Dam 6 surface water quality data from July 2001 to April 2015 were available. From 2001 to 2015, pH (a measure of water acidity) remained slightly alkaline by having values of pH 8. This alkalinity compares well with groundwater of the area which is likely due to the void being predominantly filled by groundwater seepage.

Water quality changed from July 2002 to January 2015 with increasing salinity and alkalinity typical of brackish regional groundwater. However, metal concentrations decreased at the same time to levels below risk to aquatic ecosystems.

Glencore Ravensworth Mine

The Glencore Ravensworth Mine is located between the towns of Muswellbrook and Singleton. The West Void is an old mining area at Ravensworth that has been converted to a pit lake for water storage for operations. The lake stores around 2.5 GL (2.5 billion litres) of water and is approximately 30 m deep. In terms of pit lakes both nationally and internationally, this is not particularly large.

Water quality data was available from January 2013 to June 2015. The data indicated that pH was consistently alkaline over this period, while salinity increased to brackish water quality reflecting background groundwater.

BHP Mt Arthur Coal Mine

Mt Arthur is the largest coal production site in the Hunter Valley. SW30 and SW31 are pit lakes used for water storage at Mt Arthur Mine. After the completion of mining, BHP expects the pit lakes will be used for water storage. Studies predict that inflows of saline groundwater from rocks within the lake catchment will increase lake salinity in the short term. Longer term salinity increases will be driven by the concentration of these salts through water evaporating over dry periods.

Water quality data were available from August 2013 to April 2014 for pH, salinity, Total Suspended Solids (TSS), iron, sulfate and nitrate. Both voids had alkalinity at levels around seawater, which is typical of groundwater in the area. SW31 pH increased very slightly over time, while the pH increase in SW30 was insignificant. As a measure of salinity, electrical conductivity (EC) showed SW31 had higher salinity than SW30. However, both lakes displayed an increasing salinity trend to slightly brackish water, similar to surrounding groundwater also.

Iron concentrations were consistently below the detection limit of 0.05 mg/L, which is also below concentrations that present significant risk to aquatic ecosystems. Sulfate concentrations increased slightly over time at both sites, while nitrate concentrations generally decreased quickly; although remained above guideline levels for aquatic ecosystems during the short period of monitoring. Elevated nitrate levels appear to decrease rapidly through uptake by lake algae and other microbial decomposition pathways. Sulfate was at concentrations similar to groundwater surrounding the pit lake.

Gap Analysis

The amount and type of data available and how it has been collected were also compared to guidelines for pit lake sampling.

Only surface water samples were taken at all four pit lakes and the datasets provided were missing some parameters that would help understand pit lake end use opportunities available to the UHMD.

Conclusions and Recommendations

Water quality is a key factor in determining sustainable, practicable and beneficial end uses for pit lakes. Pit lake water quality monitoring data are important for making water quality predictions and explaining trends.

The following conclusions were made from analysis of the pit lakes data.

- Increasing salinity at all sites is similar to regional groundwater concentrations, suggesting there are brackish groundwater inflows, most likely through inflow of saline groundwater (pit acting as a groundwater sink). Water balance modelling of some voids has indicated Upper Hunter Valley pit lakes will function as groundwater sinks with evaporation rates exceeding the groundwater inflow, therefore attracting local groundwater inflow.
- Short-term salinity increases in the pit lakes are likely significantly greater than long term increases due to initially high rates of weathering and un-rehabilitated pit lake areas.
- Increases in sulfate concentration are likely due to salinity increases and are at levels similar to groundwater.
- Nitrate at the Mt Arthur voids is likely to rapidly biologically decompose over time, for example through increased lake algae.

Little information was available on water quality sample methodology and it was assumed that only surface waters were sampled for all sites. However, pit lakes are frequently stratified (layered), which means surface waters represent a minor fraction of the complete water column. Water quality data were also only sampled over short periods with limited parameters analysed, making water quality trends less clear. Consistently following the newly developed UHMD pit lake sampling protocol is recommended moving forward.

Case Study

Learning from Lusatia: An Integrated Approach to Planning for Post-Mining Land and Water Use in the Upper Hunter Valley, NSW

Upper Hunter stakeholders participated in a research project, supported by the Dialogue that examined how the Upper Hunter might benefit from sharing learnings from the Lusatia region in Germany - a region which has undertaken an integrated approach to planning for post-mining land and water use, with positive results for the surrounding communities.

The Upper Hunter is a community with a significant reliance on the local coal mining industry to support the local economy and communities. As more sites near the closure phase, increasing scrutiny of the industry's rehabilitation and closure activities from both regulators and community alike has required local operations in the Upper Hunter to more thoroughly consider planning for post-mining land use in a whole-of-region context.

The Upper Hunter has an opportunity to explore successful strategies and learnings from other mining regions in the world with a similar extent and proximity of coal mines. One similar mining region to the Upper Hunter is in Lusatia, Germany, a lignite mining region which is in the process of becoming Europe's largest artificial lake district after land was abandoned by insolvent mining companies following reunification in 1990.

In 1994, the Lausitz and Central-German Mining Administration Company (German translation: *Lausitzer Mitteldeutsche Bergbau Verwaltungsgesellschaft [LMBV]*) was established by the German Federal Government for the sole purpose to rehabilitate, recultivate and transform 1,000 km^2 of the post-mining Lusatian landscape as per the Federal Mining Act.

Planning for the management of land and water in a post-mining landscape can apply an integrated water management (IWM) approach considering the social, economic and/or environmental aspects of both Lusatia and the Upper Hunter. A contextual comparison between the two regions indicated a number of similarities and differences which were considered when identifying learnings from Lusatia.

A critical analysis of both the Lusatia and Upper Hunter regions was carried out including detailing existing legislation and planning instruments (as seen in Table 1) for each region and conducting interviews and surveys with stakeholders from each community.

Lusatian stakeholders identified key strengths in the Lusatian project as being the change in community perception of pit lakes to an opportunity to solve a region-wide problem and giving the region a sense of identity, the oversight of one steering organisation and regular communication throughout the process.

A range of Dialogue stakeholders were also interviewed, with more than half indicating that existing planning and laws are not sufficient. Most respondents think the mining industry

should pay for development of post-mining land uses, while responsibility lies with Government.

Stakeholders were most concerned about the economy and identified a lack of information or misinformation, and government disengagement as key barriers.

A number of key learnings from Lusatia that can be applied to the Upper Hunter, including:

1. A regional water balance model
    - to inform water management decisions by providing an indication of quantity, quality and associated timing of water availability to potential users of previously mined areas.

2. A social/cultural program such as the IBA (Internationale Bauausstellung - or International Architecture Exhibition)
    - to stimulate a change in perception of stakeholders regarding possible land and water uses after mining.

3. One post-mining steering organisation
    - to demarcate responsibility, assign funding and drive planning for post-mining land and water use in the region.

4. Establishment of a research centre:
    - initially to compile information, examples and lessons from other post-mining planning examples,
    - followed by instigation of relevant local studies, and
    - finally, retention of and access to knowledge gained.

To determine the transferability of the Lusatia water management strategy in the context of the Upper Hunter, a water and salt balance model was developed for an example void, and scenarios were developed based on approaches adopted in Lusatia. This modelling showed that improving the simulated salinity in a void requires ongoing commitment to the management of the water.

These commitments are an investment in the region to create a sustainable, post-mining landscape that will ultimately allow more post-mining land uses which may improve economic diversification opportunities in the region.

The acknowledgement of the challenge ahead is a key step in the development of post-mining land and water management. The perception of voids as an opportunity for the Upper Hunter can bring about a variety of beneficial post-mining options.

An awareness and understanding of key social, environmental and economic impacts related to water management of a region, including the associated impacts on land and related resources, provides a comprehensive banner under which to assess and plan for a region after mining ceases.

Note: This case study was adapted from information provided by Dayjil Buhle, whose masters research project 'Learning from Lusatia' was completed in 2017. Ms. Buhle conducted interviews with members of the Dialogue's Joint Environment Working Group and Joint Advisory Steering Committee. Please contact the Upper Hunter Mining Dialogue if this work is of interest, as Ms. Buhle is keen to continue engaging in conversations with interested stakeholders.

Table 1: Comparison between Lusatia and Upper Hunter locations across economic, social and environmental factors

LUSATIA	UPPER HUNTER
ECONOMIC	
● Mining of brown coal (lignite). ● Historically, Lusatia has contributed greatly to East Germany's economic progress. ● Physical rehabilitation of reunification mines is funded by Federal and State Government via the LMBV since 1994. Physical rehabilitation of active mines is funded by mining companies.	● Mining of soft coking coal and thermal coal. ● Historically, the UHV CMR has contributed greatly to NSW's economic progress. ● Physical rehabilitation of active mines is funded by mining companies.
SOCIAL	
Political	
● Pre-1990 German Democratic Republic. ● Post-1990 reunification and Federal Republic of Germany. ● Previous German Chancellor (Angela Merkel) introduced the 'Energiewiende' or Energy Transition from lignite and nuclear to renewables.	● Current NSW Government: Liberal. ● Current Australian Government: Liberal. ● Current Mayor of Singleton: Independent. ● Current Mayor of Muswellbrook: Labor.
Demographics	
● Population~150,000 (LS 2016). ● Employees in mining in 1990 ~80,000 to ~7,000 in 2001 (Koch et al. 2005).	● Population ~41,000 (ABS 2017a). ● Employees in mining in 2016 ~8,000 (based on 6% unemployment and 20-25% employed in the mining industry [ABS 2017b]).
ENVIRONMENT	
Proximity to a Major City	
● 100 km south-east of Berlin.	● 110 km north, north-east of Sydney.
Coal Mining Region Land Area	
● ~1,300 km2 (LS 2017).	● ~2,000 km2 (Google Earth 2017).
Average Annual Rainfall and Evaporation	
● Rainfall: ~550 mm (Koch et al. 2005). ● Evaporation: 400-500 mm (Pusch & Lorenz 2010).	● Rainfall: High spatial variability over the UHV. Approximately 600 mm at Denman (station 061016) (BoM 2017a). ● Evaporation: 1,400–1,600 mm (BoM 2017b).
Soil Type	
● Sands and gravel interspersed with silts, clays and glacial till (Krümmelbein et al. 2012).	● Singleton Coal Measures include sandstone, shale, mudstone and conglomerate (Department of Mines; 1969).
Land Use	
● Mining/industry, lakes, residential.	● Agriculture (including world class viticulture and equine industries but is spatially dominated by cattle grazing [DPI 2013]), mining/industry and residential.

Conclusion

The Upper Hunter Mining Dialogue continues to work with industry and key stakeholders to research and promote the potential beneficial reuse of voids in the Upper Hunter region.

There are many potential opportunities for beneficial post-mining land use in the Upper Hunter, and it will take a sustained and cooperative effort on behalf of all key stakeholders (including industry, local government, NSW government departments and agencies and the community) to identify and work towards achieving these outcomes.

We thank Golders Associates and Dr. Cherie McCullough for the work undertaken in preparing the Beneficial Reuse of Voids reports and revision documents on behalf of the Dialogue.

We also thank Dayjil Buhle of Hydro Engineering and Consulting (HEC) for sharing key insights with participants as to how the Dialogue can benefit from examining outcomes from similar international examples such as the Lusatia region in the context of the Upper Hunter.

Contact the Upper Hunter Mining Dialogue
Email: information@nswmining.com.au
Web: www.miningdialogue.com.au