



Independent Expert Scientific Committee
on Coal Seam Gas and Large Coal Mining Development



Australian Government

Department of the Environment

Reference list for water-related coal seam gas and coal mining research

Report 2: United Kingdom, China, Russia and India, January 2000 to June 2012

This report is the second in a series of reference lists commissioned by the Department of the Environment on the advice of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). It was prepared by the Water Research Laboratory of the School of Civil and Environmental Engineering at UNSW Australia.

October 2014

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Acknowledgements

This report was commissioned by the Department of the Environment on the advice of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). It was prepared and revised by Alexandra Badenhop, Chris Drummond, Doug Anderson, Will Glamore and Grantley Smith of the Water Research Laboratory of the School of Civil and Environmental Engineering at UNSW Australia (the University of New South Wales).

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Addendum

Changes to government departments may have occurred since the finalisation of this report by the authors. Up-to-date information should be sourced from the relevant department.

On 1 January 2013, the Queensland Water Commission (QWC) ceased operations. The Office of Groundwater Impact Assessment (OGIA) retains the same powers as the former QWC under Chapter 3 of the *Water Act 2000* (Qld).

On 1 January 2014, New South Wales Catchment Management Authorities (CMA) joined with the Livestock Health and Pest Authorities and Department of Primary Industries agriculture extension to form Local Land Services. The Namoi Catchment Management Authority (Namoi CMA) has been absorbed into the North West Local Land Services.

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Summary

This reference list is the second in a series of reports commissioned by the Department of the Environment on the advice of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). It includes summaries of research projects relating to the impacts of coal seam gas and coal mining developments on water resources, currently being undertaken or completed, in the United Kingdom, China, Russia and India during the period January 2000 to June 2012.

The objective of the reference list series is to provide a resource for the Department of the Environment's Office of Water Science (OWS) and the IESC to fulfil their respective functions in delivering the bioregional assessments, identifying research priorities and delivering research products, and providing advice on coal seam gas and coal development proposals to Australian Government regulators.

The reference list will also provide others, including state regulators and industry, with project and citation information, which will enable improved understanding of the water-related impacts of coal seam gas and coal mining.

Main findings

- A total of 80 projects relating to the impacts of coal seam gas and coal mining on water resources were identified from China, India, Russia and the United Kingdom from January 2000 to June 2012.
- The dominant research theme on which projects have been focusing was co-produced/mine water (51), followed by water supplies (29) and water-dependent ecosystems (26). Many projects were associated with multiple research themes.
- Of the 18 projects relating to the disruption of surface water supplies, 14 were completed in China.
- No projects were found relating to the impacts of seismicity on water resources, and very few relating to the water-related impacts of well integrity (3), hydraulic fracturing (2) and cumulative impact assessment (1).
- Of the 80 projects, 47 were completed in China. The main research theme of the projects was co-produced/mine water (28), followed by disruption of surface water supplies (14).
- The main centres of research in China were:
 - China University of Mining and Technology, Beijing & Xuzhou (18 projects)
 - Anhui University of Science and Technology, Huainan (6 projects).
- Only two of the 13 projects identified in India related to coal seam gas, while the other eleven (11) related to coal mining.
- In India, the Central Institute of Mining and Fuel Research, Dhanbad was the most prolific of the research organisations.

- Very little research could be recorded from Russia, as minimal research literature is published in English. The embassy indicated that most research is conducted by industry.
- In the United Kingdom, the University of Newcastle, Newcastle upon Tyne produced more than half of the 19 research projects identified.

Abbreviations

General abbreviations	Description
CBM	Coal Bed Methane
CMA	Catchment Management Authority
CMM	Coal Mine Methane
CO ₂	Carbon dioxide
CSG	Coal Seam Gas
DERM	Queensland Government Department of Environment and Resource Management (ceased operations in 2012)
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
GDE	Groundwater Dependent Ecosystem
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
IMWA	International Mine Water Association
LLS	Local Land Services
OWS	Office of Water Science
UK	United Kingdom
UNSW	University of New South Wales, Australia
US	United States of America
WOS	Web of Science
WRL	Water Research Laboratory of the School of Civil and Environmental Engineering at UNSW Australia

Glossary

Term	Description
Aquifer	rock or sediment in formation, group of formations or part of a formation, that is saturated and sufficiently permeable to transmit quantities of water to wells and springs.
Aquifer connectivity	the degree to which groundwater can transfer between two adjacent aquifers or to the surface.
Aquifer injection	the injection of liquid (for example, H ₂ O) or gas (for example, CO ₂) into an aquifer. Commonly used in Managed Aquifer Recharge schemes or groundwater remediation.
Aquitard	a saturated geological unit that is less permeable than an aquifer and incapable of transmitting useful quantities of water. Aquitards often form a confining layer over an artesian aquifer.
Bore/borehole	a narrow, artificially constructed hole or cavity used to intercept, collect or store water from an aquifer, or to passively observe or collect groundwater information. Also known as a borehole, well or piezometer.
CO ₂ sequestration	the process of capture and long-term storage of atmospheric carbon dioxide.
Co-produced water	the water that is pumped out of coal seams in order to extract coal seam gas. Also referred to as produced water and associated water. Over time, the volume of produced water normally decreases and the volume of produced gas increases.
Coal bed methane	(CBM) See coal seam gas.
Coal seam	sedimentary layers consisting primarily of coal. Coal seams store both groundwater and gas and generally contain saltier groundwater than aquifers that are used for drinking water or agriculture.
Coal seam gas	a form of natural gas (generally 95-97 per cent pure methane, CH ₄) typically extracted from permeable coal seams at depths of 300–1000 m.
Cone of depression	occurs in an aquifer when groundwater is pumped from a well. The pumping of groundwater lowers the watertable immediately around the bore, causing a dimple, called the cone of depression, to form in the watertable around the well. The cone of depression grows larger as the pumping rate is increased and wider as the length of time a well is pumped increases. But once pumping stops the watertable will eventually return to its original shape, although the water quality may have changed.
Fracking	see hydraulic fracturing.
Groundwater	water occurring naturally below ground level (whether in an aquifer or other low-permeability material), or water occurring at a place below ground that has been pumped, diverted or released to that place for storage. This does not include water held in underground tanks, pipes or other works.

Term	Description
Hydraulic fracturing	also known as 'fracking', 'fracking' or 'fracture stimulation', is the process by which hydrocarbon (oil and gas) bearing geological formations are 'stimulated' to enhance the flow of hydrocarbons and other fluids towards the well. The process involves the injection of fluids, gas, proppant and other additives under high pressure into a geological formation to create a network of small fractures radiating outwards from the well through which the gas, and any associated water, can flow.
Seismicity (induced)	refers to typically minor earthquakes and tremors that are caused by human activity that alters the stresses and strains on the Earth's crust.
Shale gas	a natural gas found in shale formations.
Solute	the substance present in a solution in the smaller amount. For convenience, water is generally considered the solvent even in concentrated solutions with water molecules in the minority.
Subsidence	usually refers to vertical displacement of a point at or below the ground surface. However, the subsidence process actually includes both vertical and horizontal displacements. These horizontal displacements, in cases where subsidence is small, can be greater than the vertical displacement. Subsidence is usually expressed in units of millimetres (mm).
Unconventional gas	a term used to encompass gas production methods apart from conventional natural gas production, including shale gas, coal bed methane and underground coal gasification.
Underground coal gasification	an underground, in-situ process carried out on un-mined coal seams in which oxidants are injected to convert carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide.
Water quality	the physical, chemical and biological attributes of water that affects its ability to sustain environmental values.
Well	a human-made hole in the ground, generally created by drilling, to obtain water (also see bore).

1 Introduction

The extractive nature of coal mining and coal seam gas (CSG) operations has the potential to result in significant impacts on water resources and water-dependent ecosystems. Environmental impacts may include: disruption of surface water pathways caused by mining, including mining-induced subsidence; aquifer contamination caused by fracking chemicals; and groundwater and ecological impacts from enhanced aquifer connectivity.

An expert scientific committee (now named the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC)) was established under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in November 2012 to provide independent, expert scientific advice to decision-makers on the water-related impacts of coal seam gas and large coal mining development. The Office of Water Science (OWS) within the Department of the Environment supports the IESC, including by commissioning research to address some of the critical gaps in the scientific understanding of water-related impacts associated with coal seam gas and large coal mining activities.

This is the second in a series of reference list reports commissioned by the Department of the Environment on the advice of IESC. The complete reference list series will include summaries of research projects relating to the impacts of coal seam gas and large coal mining developments on water resources, currently being undertaken or completed, in a number of countries including (but not limited to) Australia, the United States of America (US), Canada, China, India, Russia and the United Kingdom (UK) since January 2000.

The objective of the reference list series is to identify relevant research projects to:

- support targeted approaches to future research - that address critical gaps in the scientific understanding of water-related impacts associated with coal seam gas and large coal mining activities
- provide a resource to build the scientific capability of the OWS to effectively deliver bioregional assessments, research and support the IESC in the provision of advice on development proposals to regulators.

The reference list series will also provide others, including state regulators, with project and citation information, which will enable improved understanding of the water-related impacts of coal seam gas and coal mining.

1.1 Scope

This report (Report 2 in Table 1.1) includes summaries of research projects relating to the impacts of coal seam gas and coal mining developments on water resources, currently being undertaken or completed, during the period January 2000 to June 2012 from the UK, China, Russia and India.

Table 1.1 Scope of reports commissioned by OWS regarding water impacts of coal mining and coal seam gas

Report	Country included in review						
	Australia	United States	Canada	China	India	Russia	United Kingdom
Report 1: January 2000 – June 2012	✓	✓	✓				
Report 2: January 2000 – June 2012				✓	✓	✓	✓
Report 3: July 2012 – September 2013	✓	✓	✓	✓	✓	✓	✓
Report 4: October 2013 – September 2014	✓	✓	✓	✓	✓	✓	✓

The research themes identified by the Department of the Environment in the scope of this report were:

R1. aquifer interconnectivity:

- baseline information (water quality and quantity)
- field-based and modelling approaches for assessing connectivity
- groundwater flow and solute transport dynamics

R2. disruption of surface water flow pathways:

- subsidence
- mine cone of depression
- stream diversions
- infrastructure

R3. co-produced water and salt management (CSG) and mine water and salt management (coal mines):

- aquifer injection and/or water treatment (technologies, relative cost benefit)
- effect on land and water resources (including irrigation)
- effect on water dependent ecosystems (streams, rivers, floodplains, wetlands, groundwater-dependent ecosystems (GDE), peat swamps)

R4. seismicity

R5. integrity of wells - installation, operation, decommissioning

R6. hydraulic fracturing:

- chemical - surface and groundwater quality
- physical - aquitard disruption, borehole collapse

R7. quality and reliability of water supplies, including environmental health:

- mine site and gas field remediation, including well decommissioning and post-mining voids
- long-term impacts, including timescales for water levels to return to pre-development levels (quality/quantity)
- chemical migration and toxicity

- managing salt and heavy metals

R8. water dependent ecosystems:

- prediction of potential impacts to water dependent ecosystems (streams, rivers, floodplains, wetlands, GDEs, peat swamps)
- response and tolerances of water dependent ecosystems to changes in water regime (surface and groundwater quantity, seasonal patterns, variability, interactions) and water quality
- mitigation measures
- monitoring techniques

R9. cumulative impact assessments.

In undertaking this research project it was recognised that research undertaken in related extractive/resource industries (e.g. CO₂ sequestration, underground coal gasification or shale gas) may sometimes inform water and water dependent ecosystem knowledge gaps in the coal seam gas and coal mining sectors. For example, CO₂ sequestration researchers have been significantly more active in the examination of water well integrity and reservoir 'seals'. However, research from such industries was outside the scope of this project.

This report also does not include the following types of information:

- research outside of the United Kingdom, China, Russia and India
- research not relevant to the impacts on water resources from coal seam gas and coal mining projects
- bibliographic database of completed research
- operational and compliance monitoring reports completed by mining and gas companies
- policy, regulatory and legislative material
- critical review of the collated material
- research completed prior to January 2000 and after June 2012.

2 Method

The key outcome of this work was to collate information about research and knowledge acquisition projects, without critical analysis of the material. The following priorities for information acquisition were determined (in order of desirability):

1. project descriptions written by the project's principal investigators
2. project descriptions written in telephone or email consultation with principal investigators
3. project descriptions as documented on the websites of research organisations
4. project descriptions inferred from the reporting outputs (i.e. a report on a project)
5. project descriptions inferred from published literature outputs (i.e. journal papers, conference papers).

Based on the above hierarchy, a project survey was created for the project and sent out to all research organisations and authors of relevant literature. To obtain the contact information of research organisations and principal investigators it was necessary to use a variety of methods, including disseminating an information request through research networks, industry associations, embassies and social media, and literature searching using library databases. An iterative process was used as information gleaned from one method fed back into the other methods - for example, references found in a journal article that pointed to a particular research organisation active in the field of coal mining impacts on water.

The study methods are further described in Sections 2.1, 2.2 and 2.3.

2.1 Research project survey

Recognising that project descriptions obtained directly from principal investigators were likely to be the most accurate, a project survey form was created in Microsoft Word to email out to known researchers. A copy of the blank survey form is included at Appendix A. The survey form was also translated into Russian and sent to Russian contacts.

The survey was emailed out to clients with an introduction and followed up by telephone calls and a reminder email. A complete listing of survey recipients and their subsequent participation in the survey is included at Appendix B.

2.2 Search for research organisations/researchers

Research organisations and researchers were identified using a range of methods. These methods are outlined in the following sub-sections.

- Connecting with research networks. The authors liaised within their own research networks to connect with national and international research organisations that are or have been engaged in relevant research. Industry, government and academic connections across Australia and the world were contacted and asked to pass on the contact details of relevant researchers and research organisations or forward the research project survey form to their contacts.

- Contacting partner universities. The UNSW Australia maintains a network of exchange partner universities. Each university website was visited to determine whether they maintain relevant disciplines. Where the contact details of individual researchers involved in water impact research could be obtained, they were preferentially contacted, otherwise Heads of Schools/Faculties or generic universities were contacted, sent the survey form and followed up with a telephone call.
- Internet searches. Google searches were used to find research organisations involved in water research in each country. Each website was then interrogated to determine whether they were involved in relevant research projects.
- Industry associations. A posting was listed on the International Mine Water Association (IMWA) LinkedIn group forum (see dot point below).
- Contacting embassies. The following embassies were telephoned to request the names of researchers or research organisations involved in researching the potential impacts of coal mining and coal seam gas on water and water dependent ecosystems:
 - Embassy of the People's Republic of China
 - Embassy of the Russian Federation in Australia
 - The High Commission of India in Australia

Each embassy requested a copy of the survey form and additional information. By request of the Embassy of the Russian Federation in Australia, an official letter requesting information was sent to the Russian Ambassador.

- Social media/website. The authors called for interested parties to participate in the research project survey through the Water Resource Laboratory website on 31 March 2014 and via LinkedIn. The LinkedIn groups included:
 - Hydrogeology Forum of LinkedIn (14 033 members)
 - International Association of Hydrogeologists (1282 members)
 - Water Pros (37 933 members)
 - International Mine Water Association (1065 members¹)
- Interpreter services. Due to the difficulty of communicating with Russian researchers, a Russian interpreter and translator was hired for a day to translate the project survey form, search for Russian research organisations, make telephone calls and send out surveys to possible contacts.
- Literature searches. The research organisation websites of authors found through the literature review were investigated for further contacts and the authors directly contacted where possible. The reference list of each relevant article/report was further scrutinised for relevant literature and contacts. The literature search is described in more detail in Section 2.3.

¹ While membership to the IMWA LinkedIn group was requested 31 March 2014, membership was granted 23 April 2014 and thus the post was made on that day.

2.3 Literature search

The literature search was accomplished using the UNSW library database and electronic journal subscriptions systems, which are among the most comprehensive in Australia, in addition to contemporary search engine tools. This search resulted in over 30 000 references, which were then assessed for relevance.

The following databases were interrogated in the search for relevant literature and researchers:

- Researcher ID
- WOS (Web of Science)
- Scopus
- Science Direct
- Engineering Village
- OnePetroAustralian databases (Informit)

ProquestKeyword searches were derived from the key research areas (see Section 1.1). More detail regarding the literature search, including keywords used for searches is given in Appendix C.

As each piece of relevant literature was identified, its references were reviewed for further leads to relevant literature.

In addition to the database search, references provided in key government submission documents and publications produced by key national agencies were also reviewed in an attempt to source additional relevant literature.

3 Overview of research projects

A total of 80 research projects from the United Kingdom, China, Russia and India were found relating to the water-related impacts and coal seam gas/coal mining, either currently being undertaken or completed, in the period January 2000 to June 2012.

3.1 Research themes

The relative proportions of projects relating to each research theme are represented in Figure 3.1. Where a project was deemed to be associated with more than one research theme, it was included in the calculation of statistics for each research theme.

Research themes R3 (co-produced/mine water) and R7 (water supplies) were relevant to the majority of projects. These research themes are highly related topics in scientific research, as it is often mine water or co-produced water that is impacting on water supplies.

No projects relating to the water impacts of seismic events induced by coal mining or coal seam gas operations (R4) were found. Only a small number of projects were found relating to R5 (well integrity; 3 projects), R6 (hydraulic fracturing; 2 projects) and R9 (cumulative impact assessment; 1 project). While there were many research projects found relating to hydraulic fracturing and well integrity, very little of it was related to water impacts.

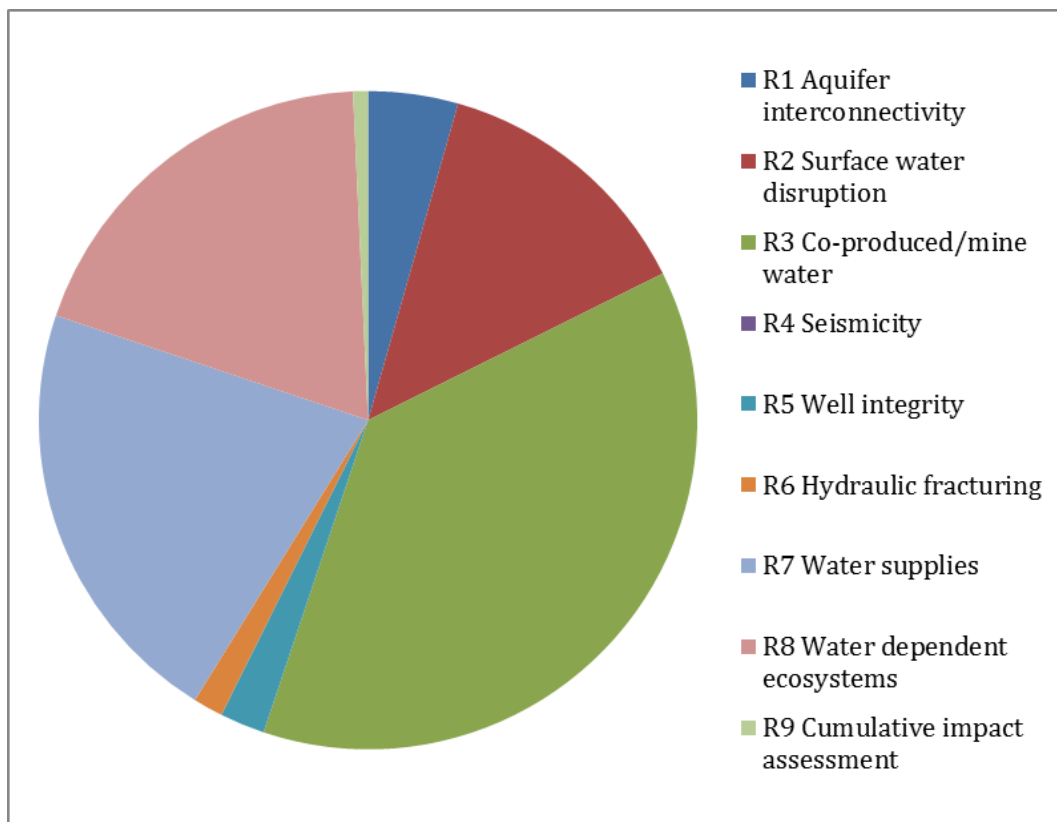


Figure 3.1 Distribution of research themes

3.2 Summaries by country

Research into the water impacts of coal seam gas and coal mining is connected to (and often largely driven by) the production of coal seam gas and coal mining in each country. According to Flores (2014), the only countries producing significant amounts of coal seam gas are China, Australia, India, US and Russia.

The relative distribution of the 80 research projects by country and research theme is displayed in Figure 3.2. More research projects were identified from China than from any other country.

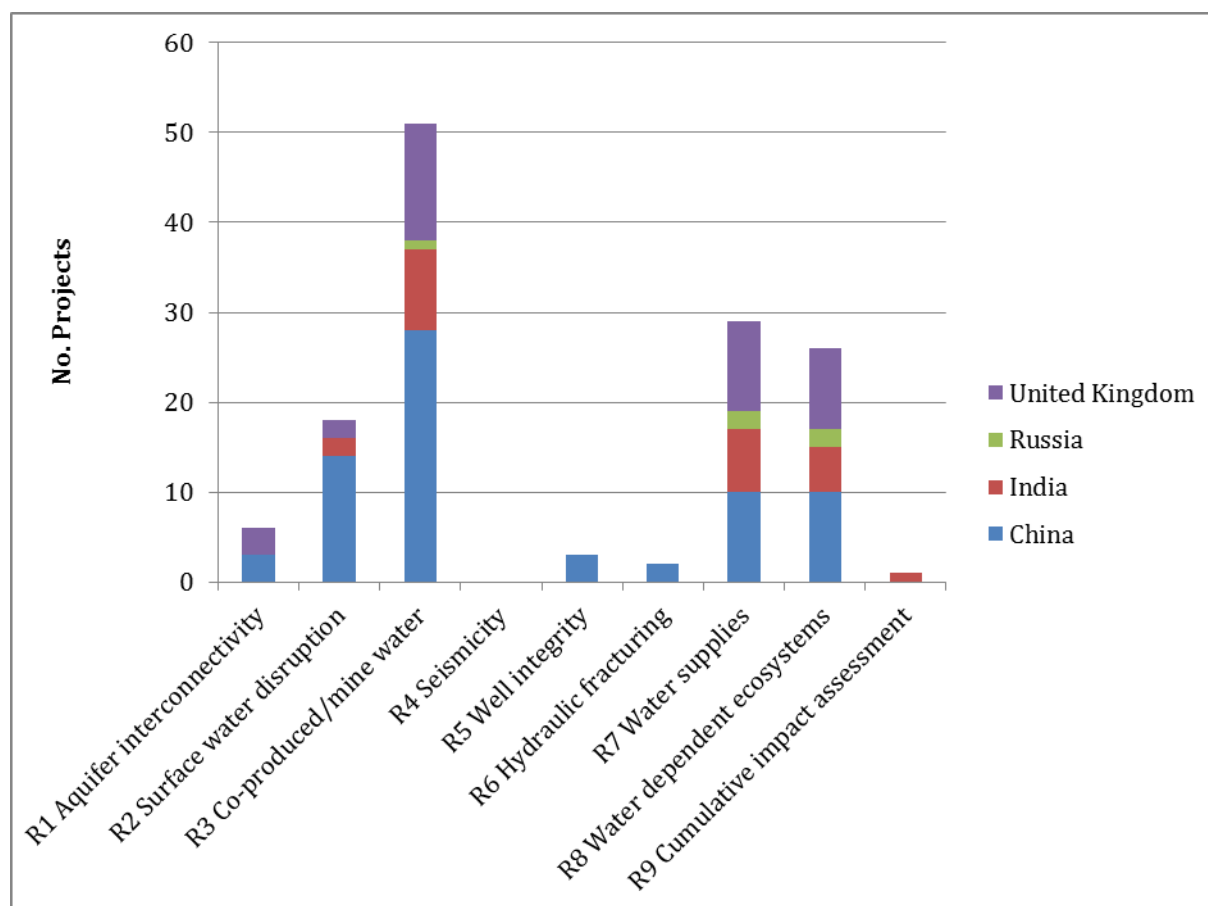


Figure 3.2 Relative proportion of projects by country and research theme

3.2.1 China

China is actively exploring coal seam gas resources and has commenced production. IEA (2012) in Flores (2014) predicts that China will greatly increase its dependency on coal by 2017. China produced twice as much coal as Australia and the US combined in 2011. Much of the coal gas currently produced is coal mine methane (CMM), which is recovered from active mines. However, coal seam gas production has been rapidly increasing since 2003, with the Qinshui and Ordos Basins found to be most commercially productive (Flores 2014).

The Embassy of the People's Republic of China provided two main contacts for acquiring research project information. Of these two bodies, only the Ministry for Environmental Protection had responded at the time of finalising this report. The Ministry of Environmental

Protection is not directing any research into water impacts of coal mining or coal seam gas (Y Zou 2014, pers. comm., 24 March).

Of the projects identified, 47 were from researchers in China. The distribution of research themes represented in these projects is displayed in Figure 3.4. As with the overall distribution of research themes amongst the research projects, the theme of co-produced/mine water dominated the research into water impacts of coal mining and coal seam gas in China.

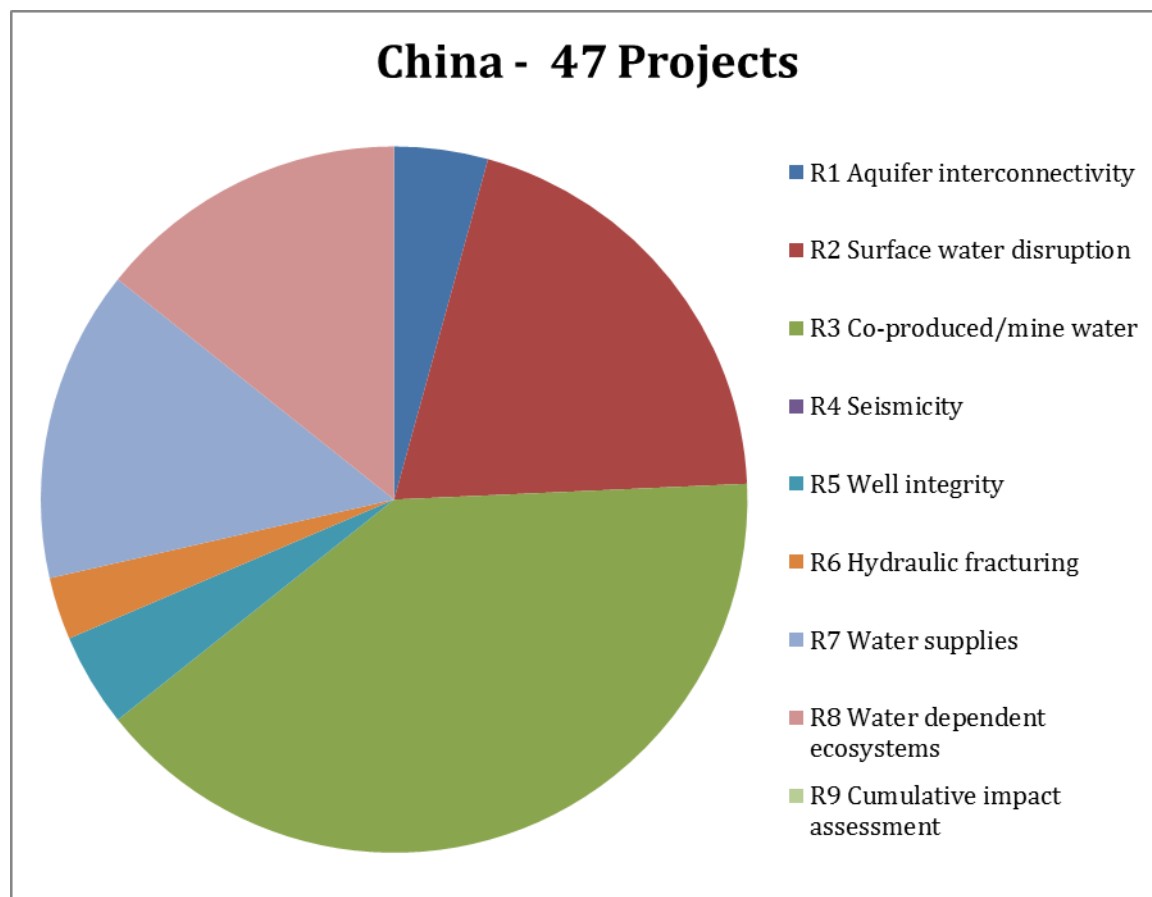


Figure 3.3 Distribution of research themes in Chinese research projects

3.2.2 India

Although there is currently no commercial production of coal seam gas (coal bed methane) in India, there is large coal bed methane (CBM) potential and one successful pilot project at Raniganj (Shah 2014). Consequently, only two of the 13 projects identified are related to coal seam gas, while the other 11 are related to coal mining. The distribution of research themes represented in these projects is displayed in Figure 3.5. As with the overall distribution of research themes among the 80 projects, the theme of co-produced/mine water dominated the research into water impacts of coal mining and coal seam gas in India. The water supplies research theme was the second most dominant theme in Indian research projects.

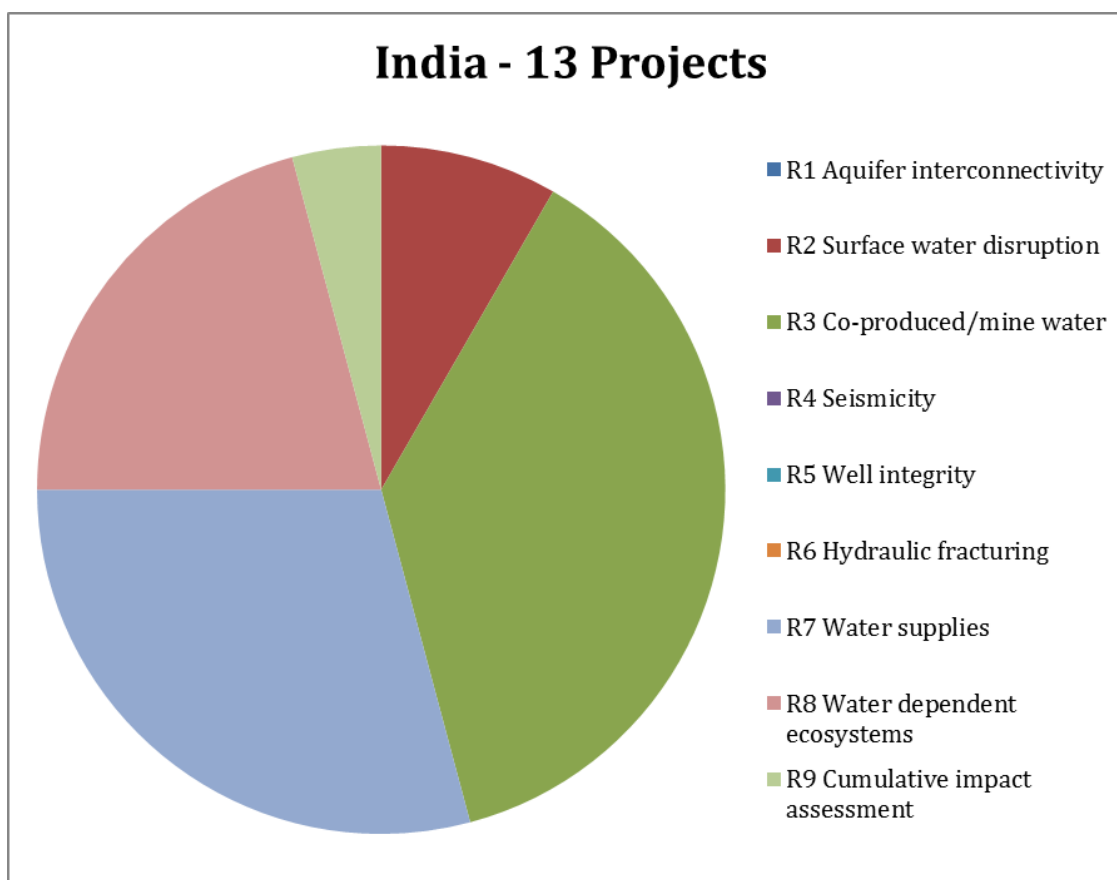


Figure 3.4 Distribution of research themes in Indian research projects

3.2.3 Russia

Russia has the second largest coal reserve in the world (Flores 2014). While Russia is also thought to have one of the largest reserves of coal bed gas in the world, it also has abundant conventional natural gas reserves and thus, less incentive to exploit coal seam gas. Russia commenced production of coal seam gas after 2010 (Flores 2014). IEA (2012) in Flores (2014) predicted that Russia will greatly increase its dependency on coal by 2017.

Only two research papers were found related to the water impacts of coal mining and coal seam gas in Russia. However, accessing Russian literature and research organisations was greatly limited by language barriers. The two research papers were related to R7 (water supplies), R8 (water dependent ecosystems) and R3 (co-produced/mine water).

3.2.4 United Kingdom

Coal mining in the United Kingdom has decreased since 1990 and subsequently, the recovery of coal mine gas has increased (Flores 2014). However, there are no commercially active sites of coal seam gas extraction in the United Kingdom. In the United Kingdom, the term 'unconventional gas' is used to encompass shale gas, coal bed methane and underground coal gasification. Most of the literature in the United Kingdom relates to shale gas, due to the presence of large shale beds. According to the Scottish Environmental Protection Agency, exploration of unconventional gas fields is in its infancy in the United Kingdom (SEPA 2014).

Nineteen (19) projects were identified from the United Kingdom between 2000 and 2012. The distribution of research themes represented in these projects is displayed in Figure 3.6. As with the overall distribution of research themes amongst the 80 research projects, the theme of co-produced/mine water dominated the research into water impacts of coal mining and coal seam gas in United Kingdom. The themes of water supplies and water dependent ecosystems also feature heavily.

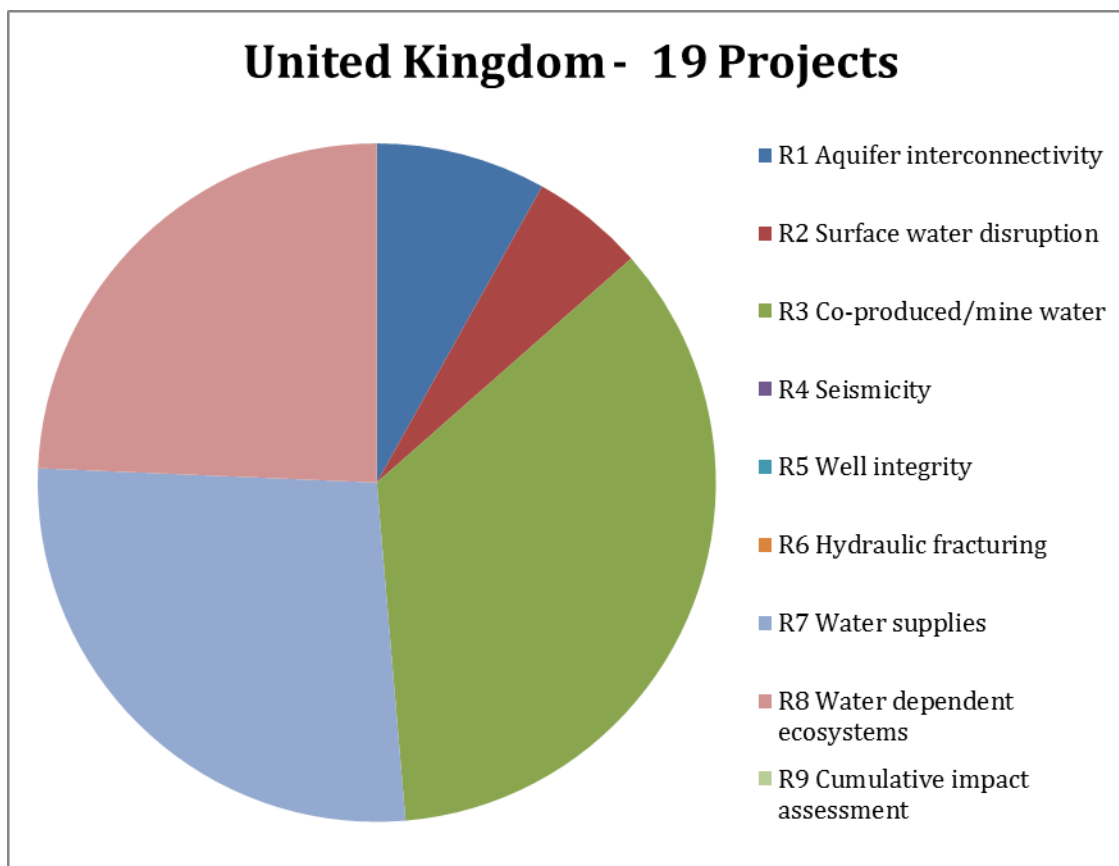


Figure 3.5 Distribution of research themes in projects from the United Kingdom

3.3 Centres of research

The number of projects completed by each research organisation are presented in Table 3.1.

The universities leading research in China are:

- China University of Mining and Technology, Beijing
- China University of Mining and Technology, Xuzhou
- Anhui University of Science and Technology, Huainan.

In India, the Central Institute of Mining and Fuel Research, Dhanbad is the most prolific of the research organisations.

In the United Kingdom, the University of Newcastle, Newcastle upon Tyne has produced more than half of the research projects identified between 2000 and 2012.

Table 3.1 Distribution of projects by research centres

Country and research organisation	No. of projects	School/department/colleges (as applicable)
China		
Anhui University of Science and Technology, Huainan	6	Department of Earth and Environment, Institute of Globe and Environment, School of Earth and Environment Science
Bureau of Hydrogeology, CNACG, Handan	1	
Changan University, Xian	1	
China University of Geosciences, Beijing	2	School of Water Resources and Environment, School of Land Science and Technology
China University of Mining and Technology, Beijing	14	Department of Geology, College of Mining Engineering, College of Geosciences and Surveying Engineering, Institute of Restoration Ecology, School of Chemical and Environmental Engineering, School of Resources and Safety Engineering, State Key Laboratory of Coal Resources and Safe Mining
China University of Mining and Technology, Xuzhou	5	Key Laboratory of Mining and Safety, Department of Mining Engineering, Faculty of Safety Engineering, School of Resources and Geoscience, Key Laboratory of CBM Resource and Reservoir-Generating Process, Ministry of Education, School of Environmental Science and Spatial Informatics
Chinese Academy of Sciences, Guiyang	1	Open Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry
Chongqing University, Chongqing	1	School of Urban Construction and Environmental Engineering
Graduate University of Chinese Academy Sciences	1	Key Lab of Computational Geodynamics of Chinese Academy of Sciences, College of Earth Science
Guizhou University, Guiyang	2	Key Laboratory of Karst Environment and Geohazard Prevention, College of Resources and Environmental Engineering
Harbin Institute of Technology, Harbin	1	State Key Laboratory of Urban Water Resource and Environment
Hebei University of Engineering, Hebei	1	
Hefei University of Technology, Hefei	1	School of Resources and Environment Engineering
Henan Polytechnic University	1	School of Resources Environment
Huailbei Mining Engineering Quality Supervision Station, HuaiBei	1	
Northeast Forestry University, Harbin	1	School of Civil Engineering

Country and research organisation	No. of projects	School/department/colleges (as applicable)
Northwest A and F University, Yangling	1	Institute of Soil and Water Conservation
Shandong University of Science and Technology	1	
Shanxi Water Conservation Professional Technology Institute, Yuncheng 044004, Shanxi	1	
South China University of Technology	1	
Taiyuan University of Technology, Taiyuan	1	
UNCRD	1	
Wuhan University, Wuhan	1	College of Resources and Environment
India		
Banaras Hindu University	1	Pollution Ecology Research Laboratory, Centre of Advanced Study in Botany
BIT Sindri, Dhanbad	1	
Central Institute of Mining and Fuel Research, Dhanbad	4	
Godda College, India	1	Life Science Research Laboratory
Indian School of Mines, Dhanbad	1	
National Environmental Engineering Research Institute	1	
North-Eastern Hill University	1	
Patna University, Patna-5 Bihar	1	Department of Geology
RTM Nagpur University	1	
Russia		
Far East Geology. Institute., FEB RAS, Vladivostok	1	
Gornyy Institut, Perm, Russian Federation	1	
United Kingdom		
Aberystwyth University, Aberystwyth	1	Institute of Geography and Earth Sciences
Environment Agency	2	
The Coal Authority	4	
The University of Wales College of Cardiff	2	
University of Birmingham	1	
University of Newcastle, Newcastle upon Tyne	10	HERO, School of Civil Engineering/ Geosciences, Sir Joseph Swan Institute

4 Research project profiles

This section profiles the recently commissioned or completed research and knowledge acquisition projects found during this review. The projects are organised by:

- research theme, then
- country, and finally
- research organisations.

Where a project is relevant to several of the identified themes, it has been categorised by its primary theme and its relevance to secondary themes also noted. No relevant projects were found with the research theme of seismicity.

The data source of each project profile is specified at the bottom of each project table. Where the information was received directly from the project survey, it has been formatted for consistency. Where the data source is directly from literature, Endnote fields have been adapted to fit the required information, where possible. Project summaries have been copied directly from abstracts rather than interpreting the project findings.

It should be noted that the year of literature publication has been used for the project duration and to categorise each project into one of the four reports in this reference list series. It may be that this does not accurately reflect the timeframe of the project, which may have finished long before the publication or may be ongoing.

Of the projects identified, seven were sourced from project surveys and the rest from literature. A complete listing of these projects is summarised in Table D1 at Appendix D, in the order they appear in this report.

4.1 Aquifer interconnectivity

The R1 aquifer interconnectivity research theme examines the water impacts of coal seam gas and coal mining due to the connections between aquifers. Topics under this category included: the collection of water quality and quantity baseline data; field based and modelling approaches for assessing connectivity; and groundwater flow and solute transport dynamics.

Two projects from the United Kingdom were collated with the primary theme of aquifer interconnectivity.

4.1.1 United Kingdom

Table 4.1 Project 1: Groundwater rebound in the South Yorkshire Coalfield; a first approximation using the GRAM model

Project characteristics	Details
Project title	Groundwater rebound in the South Yorkshire Coalfield; a first approximation using the GRAM model
Project location	United Kingdom
Principal investigator	Burke, S. P.; Younger, P. L.
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown - literature output 2000
Current status	Unknown - literature output 2000
Project summary	<p>The closures of three deep coal mines in the Rotherham area (South Yorkshire, UK), and the cessation of associated dewatering, have given rise to concerns over possible future pollution of ground- and/or surface-water resources once groundwater rebound is complete. An assessment of the legitimacy of these concerns has been made by applying the recently developed, semi-distributed computer model GRAM (Groundwater Rebound in Abandoned Mineworkings).</p> <p>The extent of workings and subsurface inter-connections relating to the three principal collieries in the Rotherham area have been identified from mine plans, augmented by testimonies of former underground workers, and assessed in terms of their hydrogeological importance. GRAM was used to predict the rate of groundwater recovery in the workings, and the timing and flow-rates of future surface discharges.</p> <p>The simulations predict that major surface discharges can be expected no sooner than the year 2005, and will eventually amount to around 3.9 Ml d (super -1). It is also predicted that around 0.4 Ml d (super -1) of water will flow from the abandoned mine-workings into nearby workings of Maltby Colliery. By analogy with discharges elsewhere associated with seams of similar sulphur content, it is considered that the "first flush" water will contain around 200 mg/l total iron (maximum estimate 600 mg/l), declining eventually to around 20 mg/l total iron.</p>
Outputs	Burke and Younger (2000). Groundwater rebound in the South Yorkshire Coalfield; a first approximation using the GRAM model. <i>The Quarterly Journal of Engineering Geology</i> . Geological Society of London, London, United Kingdom.
Key personnel	Burke, S. P.; Younger, P. L., University of Newcastle, Water Resource Systems Research Laboratory, Newcastle upon Tyne, United Kingdom
Research themes	Aquifer interconnectivity, co-produced/mine water, water supplies, water dependent ecosystems
Project information source	Literature

Table 4.2 Project 2: A strategy for modeling ground water rebound in abandoned deep mine systems.

Project characteristics	Details
Project title	A strategy for modeling ground water rebound in abandoned deep mine systems
Project location	United Kingdom
Principal investigator	Adams, R.; Younger, P. L.
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2001
Current status	Unknown- literature output 2001
Project summary	<p>Discharges of polluted water from abandoned mines are a major cause of degradation of water resources worldwide. Pollution arises after abandoned workings flood up to surface level, by the process termed ground water rebound. As flow in large, open mine voids is often turbulent, standard techniques for modeling ground water flow (which assume laminar flow) are inappropriate for predicting ground water rebound. More physically realistic models are therefore desirable, yet these are often expensive to apply to all but the smallest of systems.</p> <p>An overall strategy for ground water rebound modeling is proposed, with models of decreasing complexity applied as the temporal and spatial scales of the systems under analysis increase. For relatively modest systems (area < 200 km²), a physically based modeling approach has been developed, in which 3-D pipe networks (representing major mine roadways, etc.) are routed through a variably saturated, 3-D porous medium (representing the country, rock). For systems extending more than 100 to 3000 km², a semidistributed model (GRAM) has been developed, which conceptualizes extensively interconnected volumes of workings as ponds, which are connected to other ponds only at discrete overflow points, such as major inter-mine roadways, through which flow can be efficiently modeled using the Prandtl-Nikuradse pipe-flow formulation. At the very largest scales, simple water-balance calculations are probably as useful as any other approach, and a variety of proprietary codes may be used for the purpose.</p>
Outputs	Adams and Younger (2001). A strategy for modeling ground water rebound in abandoned deep mine systems. <i>Ground Water</i> .
Key personnel	Adams, R.; Younger, P. L. (Adams, Younger) Water Resource Systems Res. Lab., Department of Civil Engineering, University of Newcastle, Newcastle upon Tyne NE1 7RU, United Kingdom
Research themes	Water supplies, water dependent ecosystems
Project information source	Literature

4.2 Disruption of surface water flow pathways

This research theme encompasses research that describes how surface water flows may be disturbed due to coal seam gas and coal mining. This may be through mining-induced subsidence, the mine cone of depression due to dewatering, stream diversions or the physical placement of infrastructure causing disruption of surface water flows. Fourteen projects were collated with the primary theme of disruption of surface water flow pathways; from China (11), India (1) and the United Kingdom (2).

4.2.1 China

Table 4.3 Project 3: Integration of MODIS data and Short Baseline Subset (SBAS) technique for land subsidence monitoring in Datong, China

Project characteristics	Details
Project title	Integration of MODIS data and Short Baseline Subset (SBAS) technique for land subsidence monitoring in Datong, China
Project location	China
Principal investigator	Zhao, Chao-ying; Zhang, Qin; Yang, Chengsheng; Zou, Weibao
Lead institution	Changan Univ, Coll Geol Engn & Geomat, 126 Yanta Rd, Xian 710054, Peoples R China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>Datong is located in the north of Shanxi Province, which is famous for its old-fashioned coal-mining preservation in China. Some serious issues such as land subsidence, ground fissures, mining collapse, and earthquake hazards have occurred over this area for a long time resulting in significant damages to buildings and roads.</p> <p>In order to monitor and mitigate these natural man-made hazards, Short Baseline Subsets (SBAS) InSAR technique with ten Envisat ASAR data is applied to detect the surface deformation over an area of thousands of square kilometers. Then, five MODIS data are used to check the atmospheric effects on InSAR interferograms. Finally, nine nonlinear land subsidence cumulative results during September 2004 and February 2008 are obtained.</p> <p>Based on the deformation data, three kinds of land subsidence are clearly detected, caused by mine extraction, underground water withdrawal and construction of new economic zones, respectively. The annual mean velocity of subsidence can reach 1 to 4 cm/year in different subsidence areas. A newly designed high-speed railway (HSR) with speeds of 350 km/h will cross through the Datong hi-tech zone. Special measures should be taken for the long run of this project. In addition, another two subsidence regions need further investigation to mitigate such hazards.</p>
Outputs	<p>Zhao et al. (2011). Integration of MODIS data and Short Baseline Subset (SBAS) technique for land subsidence monitoring in Datong, China. <i>Journal of Geodynamics</i>.</p> <p>< http://www.sciencedirect.com/science/article/pii/S0264370710001481 ></p>

Project characteristics	Details
Key personnel	Zhao, Chao-ying; Zhang, Qin; Yang, Chengsheng; Zou, Weibao Zhao, CY Changan Univ, Coll Geol Engrn & Geomat, 126 Yanta Rd, Xian 710054, Peoples R China
Research themes	Surface water
Project information source	Literature

Table 4.4 Project 4: The effect of overlapping mining on surface water and shallow groundwater resources using numerical method

Project characteristics	Details
Project title	The effect of overlapping mining on surface water and shallow groundwater resources using numerical method
Project location	China
Principal investigator	Liu, Qimeng; Hu, Youbiao; Liu, Xiue
Lead institution	College of Earth and Environment, Anhui University of Science and Technology, Huainan, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>According to analysis of surface water distribution, supply and runoff conditions as well as water resource exploitation in Shuonan Coalfield, the effect of surface environment surface water and shallow groundwater were numerically simulated by means of the FEM software FLAC3D during overlapping mining. Then the effect on water resource as well as environment law of coal mining was summarized, and it was provided basis for the surface water and shallow groundwater protection as well as reasonable exploitation in Shuozhou.</p> <p>The results show that compared to single mining, repeat mining has more influence in the surface water and shallow groundwater. With the coal mining step by step, the coal mining effects on surface water and dive are gradually increased.</p> <p>2011 IEEE.</p>
Outputs	<p>Liu et al. (2011). The effect of overlapping mining on surface water and shallow groundwater resources using numerical method. <i>2011 International Symposium on Water Resource and Environmental Protection, ISWREP 2011, May 20, 2011 - May 22, 2011</i>. Xi'an, China: IEEE Computer Society.</p> <p>< http://dx.doi.org/10.1109/ISWREP.2011.5892953 ></p>
Key personnel	<p>Liu, Qimeng; Hu, Youbiao; Liu, Xiue</p> <p>College of Earth and Environment, Anhui University of Science and Technology, Huainan, China</p>
Research themes	Surface water
Project information source	Literature

Table 4.5 Project 5: Effects of Ca²⁺ and Mg²⁺ on the toxicity of arsenate in a high arsenic coal mine area in southwest Guizhou

Project characteristics	Details
Project title	Effects of Ca²⁺ and Mg²⁺ on the toxicity of arsenate in a high arsenic coal mine area in southwest Guizhou
Project location	China
Principal investigator	Liao, Fen; Wu, Yonggui; Zhou, Lu; Huang, Boping; Wang, Liangtao; Chen, Cheng; Shen, Wantun
Lead institution	College of Resources and Environmental Engineering, Guizhou University, Guiyang 550003, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	We studied the protective effects of Ca ²⁺ , Mg ²⁺ against the toxicity of arsenate, which is widely present in water near the high arsenic coal mines in southwest Guizhou using <i>Daphnia carinata</i> as the test organism. The results showed that with arsenate single exposure, 24 h, 48 h, 72 h and 96 h median lethal concentration (LC ₅₀) of arsenate to <i>Daphnia carinata</i> were 5.9817 mg /L-1, 5.1800 mg /L-1, 4.1884 mg /L-1 and 3.2015 mg /L-1, respectively. With Ca ²⁺ (20 mg /L-1, 60 mg /L-1 and 100 mg /L-1) and arsenate co-exposure, the LC ₅₀ after 24 h were respectively 25.8449 mg /L-1, 33.4735 mg /L-1 and 24.7439 mg /L-1 and the LC ₅₀ at 96 h were 4.9502 mg /L-1, 5.7231 mg /L-1 and 4.5072 mg /L-1, respectively. With Mg ²⁺ (5 mg /L-1, 10 mg /L-1 and 15 mg /L-1) and arsenate co-exposure, the LC ₅₀ of 24 h were 33.8412 mg /L-1, 29.7261 mg /L-1 and 25.4113 mg /L-1, respectively and the LC ₅₀ of 96 h were respectively 6.8802 mg /L-1, 4.9167 mg /L-1 and 3.0276 mg /L-1. Comparing to arsenate single exposure, the toxicity was lower at 24 h, 48 h and 72 h when <i>Daphnia carinata</i> was exposed to a solution of arsenate and Ca ²⁺ or Mg ²⁺ . After 96 h, the toxicity was relatively higher at low concentrations of arsenate (0~2.07 mg /L-1), but lower for high-concentrations of arsenate (3.70~20.72 mg /L-1).
Outputs	Liao et al. (2011). Effects of Ca ²⁺ and Mg ²⁺ on the toxicity of arsenate in a high arsenic coal mine area in southwest Guizhou. <i>Huanjing Kexue Xuebao/Acta Scientiae Circumstantiae</i> . 16 Donghuangchenggen North Street, Beijing, 100717, China: Science Press.
Key personnel	Liao, Fen; Wu, Yonggui; Zhou, Lu; Huang, Boping; Wang, Liangtao; Chen, Cheng; Shen, Wantun College of Resources and Environmental Engineering, Guizhou University, Guiyang 550003, China
Research themes	Surface water
Project information source	Literature

Table 4.6 Project 6: Current water environmental status analysis of subsided water areas and its comprehensive utilization: A case of subsided water area in Panyi Coal Mine

Project characteristics	Details
Project title	Current water environmental status analysis of subsided water areas and its comprehensive utilization: A case of subsided water area in Panyi Coal Mine
Project location	China
Principal investigator	Xu, Liang-Ji; Yan, Jia-Ping; Gao, Yong-Mei
Lead institution	Institute of Globe and Environment, Anhui University of Science and Technology, Huainan 232001, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	In order to provide the theoretical basis of comprehensive utilization of coal mine subsided water areas in Huainan Coal Mine, 39 water sampling points in the two typical subsided water areas of Panyi Coal Mine were chosen to monitor the water quality by sampling, the heavy metal were analysed and the fuzzy synthetic evaluating technique was used to analyse the water quality comprehensively. The result shows that the water quality of well closed subsided water area is declined from center to bank in the water area, the water qualities of the samples in the center are grade III. But the water qualities of most of samples in the subsided water area in the east that is connected with Nihe River are about grade IV or V. For the influence of polluting sources from mining industries, the pollution intensity of heavy metal elements in east subsided water area is more serious than the west subsided water area. The subsided water areas of Panyi Coal Mine are polluted in different degree, but they can be comprehensively utilized if the treating and protecting measures are adopted respectively.
Outputs	Xu et al. (2009). Current water environmental status analysis of subsided water areas and its comprehensive utilization: A case of subsided water area in Panyi Coal Mine. <i>Meitan Xuebao/Journal of the China Coal Society</i> . Hepingli, Beijing, 100013, China: China Coal Society.
Key personnel	Xu, Liang-Ji; Yan, Jia-Ping; Gao, Yong-Mei Institute of Globe and Environment, Anhui University of Science and Technology, Huainan 232001, China
Research themes	Surface water
Project information source	Literature

Table 4.7 Project 7: Environmental impact of coal mining subsided water area in Huainan mining area

Project characteristics	Details
Project title	Environmental impact of coal mining subsided water area in Huainan mining area
Project location	China
Principal investigator	Xu, Liang-Ji; Yan, Jia-Ping; Gao, Yong-Mei
Lead institution	Institute of Globe and Environment, Anhui University of Science and Technology, Huainan 232001, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	For the theoretical basis of comprehensive utilization about coal mine subsided water resource, the subsided water areas with different subsidence time were chosen to monitor the physicochemical indexes and heavy metal elements. By analysis and appraisal to quality of the subsided water, the results indicate that the subsided water areas are polluted in different degree, some physicochemical indexes of subsided water areas are increased with the development of the subsidence and changed with the season. The concentration of heavy metal elements in subsided water areas, except for Hg, are less than national fishery and surface water quality standard of China, and the quality of subsided water haven't been polluted by heavy metal.
Outputs	Xu et al. (2008). Environmental impact of coal mining subsided water area in Huainan mining area. <i>Meitan Xuebao/Journal of the China Coal Society</i> . Hepingli, Beijing, 100013, China: China Coal Society.
Key personnel	Xu, Liang-Ji; Yan, Jia-Ping; Gao, Yong-Mei Institute of Globe and Environment, Anhui University of Science and Technology, Huainan 232001, China
Research themes	Surface water
Project information source	Literature

Table 4.8 Project 8: Green mining techniques in the coal mines of China

Project characteristics	Details
Project title	Green mining techniques in the coal mines of China
Project location	China
Principal investigator	Xu, Jialin; Zhu, Weibin; Lai, Wenqi; Qian, Minggao
Lead institution	Key Laboratory of Mining and Safety, Department of Mining Engineering, China University of Mining and Technology, Xuzhou
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2004
Current status	Unknown- literature output 2004
Project summary	This article advances an innovative concept, explaining the connotation and technical system of "green" mining. The important theoretical foundations of "green" mining are the distribution and development characteristics of joints, fractures and bed separations, and the seepage and flow behaviour of methane and water in the broken rock strata following coal mining. The main focus of "green" mining technique includes water-preservation in mining areas, coal mining under buildings with bed separation spaces grouted to retard surface subsidence, partial extraction and backfill mining, simultaneous extraction of coal and coal-bed methane, coal roadway supporting and underground disposal of rock waste, underground coal gasification, etc.
Outputs	<i>Xu et al. (2004). Green mining techniques in the coal mines of China. Journal of Mines, Metals and Fuels.</i> Books and Journals Private Ltd.
Key personnel	Xu, Jialin; Zhu, Weibin; Lai, Wenqi; Qian, Minggao Key Laboratory of Mining and Safety, Department of Mining Engineering, China University of Mining and Technology, Xuzhou, 221008, Jiangsu, China
Research themes	Surface water
Project information source	Literature

Table 4.9 Project 9: Water quality and controlling factors of coal mining subsidence areas in Panji Huainan.

Project characteristics	Details
Project title	Water quality and controlling factors of coal mining subsidence areas in Panji Huainan
Project location	China
Principal investigator	Yan, Jiaping; Xu, Liangji
Lead institution	School of Earth and Environment Science, Anhui University of Science and Technology, Huainan 232001, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	Water quality features and controlling factors were studied in two selected subsidence water areas in Panji mining areas Huainan. The 42 sampling points distributed in the two subsidence water areas and the water quality of the sampling points were monitored and evaluated. 5 water quality indexes like pH, BOD5, DO, CODcr and some heavy metals were selected as monitored parameters. The test result showed that there are quite difference of the water quality between the two subsidence areas. Water quality in the large subsidence water area is better than that of small one. The water quality in subsidence area of coal mine were dominated by size of water area and water circulation conditions.
Outputs	Yan and Xu. (2010). Water quality and controlling factors of coal mining subsidence areas in Panji Huainan. <i>3rd International Conference on Environmental Technology and Knowledge Transfer, May 13, 2010 - May 14, 2010</i> . Hefei, China: Unavailable.
Key personnel	Yan, Jiaping; Xu, Liangji School of Earth and Environment Science, Anhui University of Science and Technology, Huainan 232001, China
Research themes	Surface water
Project information source	Literature

Table 4.10 Project 10: Coal mine subsided water quality assessment and subsided water resource comprehensive utilization analysis - a case of subsided water area in Panyi coal mine

Project characteristics	Details
Project title	Coal mine subsided water quality assessment and subsided water resource comprehensive utilization analysis - a case of subsided water area in Panyi coal mine
Project location	China
Principal investigator	Xu, L. J.; Gao, Y. M.
Lead institution	School of Earth and Environment Science, Anhui University of Science and Technology, Huainan, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	<p>In order to provide the theoretical basis for comprehensive utilization of coal mine subsided water resource in Huainan coal mine, 39 water sampling points in two typical subsided water areas of Panyi coal mine are chosen to monitor the water quality by sampling, the heavy metal elements of water body are analyzed and the fuzzy synthetic evaluation technique is used to analyze the water quality comprehensively.</p> <p>The results show that the water quality of well closed subsided water area in the west presents a decreasing tendency from the center of the water body to both banks, the water quality of the center profile is grade III; But the water quality of the subsided water area in the east that is connected with Nihe River is relatively poor and water qualities of all monitored profiles are all grade IV or V. Due to the influence of polluting sources from mining industries, the pollution intensity of heavy metal elements in the east subsided water area is more serious than the west subsided water area. The subsided water areas of Panyi coalmine are polluted in different degree, but they can be comprehensively utilized if they are protected and corresponding treatment measures are adopted.</p> <p>2009 IEEE.</p>
Outputs	<p>Xu and Gao. (2009). Coal mine subsided water quality assessment and subsided water resource comprehensive utilization analysis - A case of subsided water area in Panyi coal mine. <i>2009 International Conference on Environmental Science and Information Application Technology, ESIAT 2009, July 4, 2009 - July 5, 2009</i>. Wuhan, China: IEEE Computer Society.</p> <p>< http://dx.doi.org/10.1109/ESIAT.2009.32 ></p>
Key personnel	<p>Xu, L. J.; Gao, Y. M.</p> <p>School of Earth and Environment Science, Anhui University of Science and Technology, Huainan, China</p>
Research themes	Surface water
Project information source	Literature

Table 4.11 Project 11: Exploitation of coal resources under surface water body

Project characteristics	Details
Project title	Exploitation of coal resources under surface water body
Project location	China
Principal investigator	Wu, Xiong; Yu, Qingchun; Wang, Xiaogang; Duan, Qingwei; Li, Xinqiang; Yang, Jian; Bao, Yafu
Lead institution	School of Water Resources and Environment, China University of Geosciences, Beijing
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2006
Current status	Unknown- literature output 2006
Project summary	<p>The study on exploitation of coal resources under surface water is a comprehensive research task extending across coal mining, water conservancy, geological and environmental protection. With the promulgation and enforcement of water law of the People's Republic of China and more and more attention being paid to environmental protection, it is necessary to extend and enlarge research content and range, and to carry out study that integrates resources exploitation with ensuring security of hydro-structure and environmental protection in order to achieve multi-winning situation among systems. Issues about traversing coal measures are encountered inevitably in some large-scale water conservancy projects. For instance, main conveyance canal of middle line project of South-to-North Water Transfer traverses successively 14 mines which belong to Yuxian, Xinzheng, Jiaozuo, Xintai, etc. mining areas from the South to the North, and 1.8502 108 t coal is buried under these areas.</p> <p>So, the study on the exploitation of coal resources under surface water has great theoretical and practical significances. It is suggested that at least the following questions should be given attention to the mining coal resources under surface water:</p> <ul style="list-style-type: none"> • the influence of surface collapse due to mining on stabilization and safe operation of hydro-structure • surface water seepage caused by mining and rapid drawdown of water level • the influence of mining on change of seepage field and security of hydro-structure • environmental disruption owing to mining in research area, etc. <p>Combined with engineering example of excavating coal in expansion areas of Shenjiazhuang colliery under Yuecheng reservoir, detailed research for above questions has been done through theoretical calculation, numerical modeling, and the method of linking field survey with engineering analogue. Feasibility of exploitation of coal resources under Yuecheng reservoir has been verified; and scientific base for making policy is provided.</p>
Outputs	Wu et al. (2006). Exploitation of coal resources under surface water body. <i>Yanshilixue Yu Gongcheng Xuebao/Chinese Journal of Rock Mechanics and Engineering</i> . Academia Sinica.
Key personnel	Wu, Xiong; Yu, Qingchun; Wang, Xiaogang; Duan, Qingwei; Li, Xinqiang; Yang, Jian; Bao, Yafu School of Water Resources and Environment, China University of Geosciences, Beijing 100083, China

Project characteristics	Details
Research themes	Surface water, co-produced/mine water, water supplies
Project information source	Literature

Table 4.12 Project 12: Study on the structure model and controlling method of subsidence in flat seam and deep mining.

Project characteristics	Details
Project title	Study on the structure model and controlling method of subsidence in flat seam and deep mining
Project location	China
Principal investigator	Wang, Chongge; Chen, Weizhong; Pan, Liyou
Lead institution	Shandong University of Science and Technology, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2006
Current status	Unknown- literature output 2006
Project summary	The stratum movement and surface subsidence is considered as a whole system in the research work. The key of the surface subsidence control lies first in having thorough knowledge of the dynamic changeable of the overlaying strata movement as the face advances so as to establish the corresponding structure mechanics subsidence model in flat seam and deep mining. The common characteristic of stratum movement and the development procedure of crack arch are described in this paper. The structure constituents of subsidence and their influencing factors are also analyzed. Meanwhile, the surface subsidence is determined by the compressing of coal wall and the bending of the overlying strata. Based on the ground observation by the global positioning system, the boundary angle and the motion angle are determined. Furthermore, according to the research law, one can predict and control the surface subsidence damages for the special geologic conditions.
Outputs	Wang et al. (2006). Study on the structure model and controlling method of subsidence in flat seam and deep mining. <i>Fracture and Strength of Solids VI</i> . Trans Tech Publications Ltd.
Key personnel	Wang, Chongge; Chen, Weizhong; Pan, Liyou Shandong University of Science and Technology, Qing'dao 266510, China
Research themes	Surface water
Project information source	Literature

Table 4.13 Project 13: Impact of underground coal mining on overlying farmland in Xuzhou suburbs, China.

Project characteristics	Details
Project title	Impact of underground coal mining on overlying farmland in Xuzhou suburbs, China
Project location	China
Principal investigator	Koroma, Bashiru Mohamed
Lead institution	UNCRD, Nagoya, Japan
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2002
Current status	Unknown- literature output 2002
Project summary	<p>Coal mines in Tong Shang county by their very nature, have a finite life, which ends when the coal deposits have been fully extracted. Viewed historically, coal mines have a relatively short life, while the land as a natural resource must continue to be available for use, on an unlimited basis. Mining operators therefore have the responsibility, while deriving income from the land, to ensure that it is left in a condition whereby future generations can gain income and benefit from it, appropriately utilizing and protecting the natural environment. These expectations would eventually bring about reduced pollution and sustainable land use, thereby providing job opportunities for the vulnerable rural population.</p> <p>Environmental consequences identified in the study include surface subsidence in the overlying farmlands, leading to prevalence of disease and water quality problems, damage to, or destruction of, villages and other civil infrastructure such as roads, bridges, and canals, and the undesirable dumping of waste coal, consequently leading to shortage of farmland and spontaneous combustion during summer heat waves as well as water pollution. While most of these potential effects can be controlled by the construction, management, and maintenance of the natural environment during the existence of the mine, it would be unrealistic to suggest that any subsequent land user, specifically peasant farmers, should be solely responsible for continued management and maintenance of the damaged environment. The only satisfactory alternative, therefore, is to return the land to a stable and self-sustaining condition. Despite the fact that such consideration in mining policy and regulations may be viewed as somewhat fanciful, there are also more pragmatic and practical reasons for including reclamation in the overall management and financial plans for mining operations.</p>
Outputs	Koroma (2002). Impact of underground coal mining on overlying farmland in Xuzhou suburbs, China. <i>Regional Development Dialogue</i> . United Nations Centre for Regional Development.
Key personnel	Koroma, Bashiru Mohamed UNCRD, Nagono 1-47-1, Nakamura-ku, Nagoya 450-0001, Japan
Research themes	Surface water
Project information source	Literature

Table 4.14 Project 14: Evaluation of ground movement and damage to structures from Chinese coal mining using a new GIS coupling model.

Project characteristics	Details
Project title	Evaluation of ground movement and damage to structures from Chinese coal mining using a new GIS coupling model
Project location	China
Principal investigator	Djamaluddin, Ibrahim; Mitani, Yasuhiro; Esaki, Tetsuro
Lead institution	Department of Civil and Structural Engineering, Graduate School of Engineering, Kyushu University, Motooka 744, Nishi-Ku, Fukuoka 819-0395, Japan
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>In this paper, combining a theoretical method of predicting subsidence over time and using a geographical information system (GIS), a GIS-based dynamic model is proposed to rapid simulate the phenomenon of progressive movement distribution from large sequential mining. The theoretical method uses stochastic medium concept involving Knothe time function for basic governing equations to calculate progressive movement because this solutions have been widely developed and used in Chinese mining practice to solve the coal extraction problem under building, railways, and rivers. In order to assess the impact of progressive movement to the surface structures, a fuzzy model is suggested to identify damage classifications with contributions of subsidence calculations and building mesh data. For implementation of the GIS-based prediction and assessment model, a new GIS coupling model is established by implementing tight coupling strategy using the component object model (COM) program to overcome the problems of complex model integration for dynamic prediction and assessment. Furthermore, this paper demonstrates the effectiveness of this GIS-based model for prediction and evaluation of subsidence-induced damage from coal mining beneath surface structures in China.</p> <p>2011 Elsevier Ltd.</p>
Outputs	<p>Djamaluddin et al. (2011). Evaluation of ground movement and damage to structures from Chinese coal mining using a new GIS coupling model. <i>International Journal of Rock Mechanics and Mining Sciences</i>. Langford Lane, Kidlington, Oxford, OX5 1GB, United Kingdom: Elsevier Ltd.</p> <p>< http://dx.doi.org/10.1016/j.ijrmms.2011.01.004 ></p>
Key personnel	<p>Djamaluddin, Ibrahim; Mitani, Yasuhiro; Esaki, Tetsuro</p> <p>Department of Civil and Structural Engineering, Graduate School of Engineering, Kyushu University, Motooka 744, Nishi-Ku, Fukuoka 819-0395, Japan</p>
Research themes	Surface water
Project information source	Literature

4.2.2 India

Table 4.15 Project 15: Impact of post-mining subsidence on nitrogen transformation in southern tropical dry deciduous forest, India.

Project characteristics	Details
Project title	Impact of post-mining subsidence on nitrogen transformation in southern tropical dry deciduous forest, India
Project location	India
Principal investigator	Tripathi, N.; Singh, R. S.; Singh, J. S.
Lead institution	Central Institute of Mining and Fuel Research, Barwa Road, Dhanbad 826 001, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	The goal of our research was to assess the impact of post-mining land subsidence, caused due to underground coal mining operations, on fine root biomass and root tips count; plant available nutrient status, microbial biomass N (MBN) and N-mineralization rates of a Southern tropical dry deciduous forest of Singareni Coalfields of India. The changes were quantified in all the three (rainy, winter and summer) seasons, in slope and depression microsites of the subsided land and an adjacent undamaged forest microsite. Physico-chemical characteristics were found to be altered after subsidence, showing a positive impact of subsidence on soil moisture, bulk density, water holding capacity, organic carbon content, total N and total P. The increase in all the parameters was found in depression microsites, while in slope microsites, the values were lower. Fine root biomass and root tips count increased in the subsided depression microsites, as demonstrated by increases of 62% and 45%, respectively. Soil nitrate-N and phosphate-P concentrations were also found to be higher in depression microsite, showing an increase of 35.68% and 24.74%, respectively. Depression microsite has also shown the higher MBN value with an increase over control. Net nitrification, net N-mineralization and MBN were increased in depression microsite by 29.77%, 25.72% and 34%, respectively. There was a positive relation of microbial N with organic C, fine root biomass and root tips.
Outputs	Tripathi et al. (2009). Impact of post-mining subsidence on nitrogen transformation in southern tropical dry deciduous forest, India. <i>Environmental Research</i> . < http://www.sciencedirect.com/science/article/pii/S0013935108002442 >
Key personnel	Tripathi, N.; Singh, R. S.; Singh, J. S. Central Institute of Mining and Fuel Research, Barwa Road, Dhanbad 826 001, India.
Research themes	Surface water, co-produced/mine water
Project information source	Literature

4.2.3 United Kingdom

Table 4.16 Project 16: Impact of coal mining subsidence on groundwater resources management of the East Midlands Permo-Triassic Sandstone aquifer.

Project characteristics	Details
Project title	Impact of coal mining subsidence on groundwater resources management of the East Midlands Permo-Triassic Sandstone aquifer
Project location	United Kingdom
Principal investigator	Martin Shepley, Environment Agency
Lead institution	Environment Agency, United Kingdom
Project budget	N/A – internally funded
Source of funding	Department of Energy & Climate Change and Department of the Environment, Food and Rural Affairs, United Kingdom
Project duration	2007-2008
Current status	Completed
Project summary	Assessment of the potential impacts of subsidence associated with mine workings on water resources in the East Midlands. Case studies were used to assess the potential impacts on the near-surface environment associated with historic mining at depth beneath a major aquifer system.
Objectives	Identification and characterisation of the impact of mining-related subsidence on groundwater-surface water interactions.
Achievements	Assessment of the changes to the hydraulic characteristics of the aquifer system related to fracturing associated with mining-related subsidence.
Outputs	Characterisation of groundwater levels and flows across the aquifer system, taking into account limitations in the monitoring dataset.
Key personnel	Martin Shepley and Carl Banton
Research themes	Aquifer interconnectivity, baseline data, surface water flows, water supplies, long term impacts, water dependent ecosystems
Project information source	Survey

4.3 Co-produced water and salt management (CSG) and mine water and salt management (coal mines)

Projects in this category relate to the impacts of water produced during coal seam gas and mining operations and consequently, the need for salt management. This encompasses technologies for water disposal such as aquifer injection or water treatment, and the effects of this water on land, water resources and water dependent ecosystems due to the selected management method.

Thirty-four projects were collated with the primary theme of co-produced water and salt management (CSG) and mine water and salt management (coal mines); 22 from China, three from India and nine from the United Kingdom.

4.3.1 China

Table 4.17 Project 17: Study on related seepage problems to the exploitation of coal.

Project characteristics	Details
Project title	Study on related seepage problems to the exploitation of coal
Project location	China
Principal investigator	Bai, Guo-Liang; Liang, Bing
Lead institution	Unknown
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2007
Current status	Unknown- literature output 2007
Project summary	Coal rock mass is a kind of typical pore and fracture structure, and a lot of seepage problems are involved in the development of coal. The seepage characteristics and law of the gas in coal seam are discussed, the fluid-solid coupling interaction of gas and coal are analyzed, and the criterion of coal and gas outbursts is presented. The seepage characteristics of the water-bearing bed above the coal seam and the water-rock coupling interaction in coal mining are analyzed. The pollution of groundwater in coal production and the water-rock interaction in acidic water mine are discussed. At the same time the environmental effect of coal gangue is analyzed. With the increase of mining depth, the mine heat harm is increasing, which is paid attention to by researchers more and more, and the forming mechanism and influencing factors of the coal mine heat harm are analyzed too. The trend in the study on the seepage problems in coal mining is predicted.
Outputs	Bai and Liang (2007). Study on related seepage problems to the exploitation of coal. <i>Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/Journal of Xi'an Shiyou University, Natural Sciences Edition</i> . Xi'an, China: Xi'an Petroleum Institute.
Key personnel	Bai, Guo-Liang; Liang, Bing
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.18 Project 18: Quality and treatment of coal mine drainage water in China.

Project characteristics	Details
Project title	Quality and treatment of coal mine drainage water in China
Project location	China
Principal investigator	Guo, Jiguang; Shan, Zhongjian
Lead institution	China Univ. of Mining and Technol., Beijing, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2002
Current status	Unknown- literature output 2002
Project summary	About 71% of collieries in China are short of water resources. 2.2 billion m ³ of coal mine drainage are discharged annually. Making full use of mine water is the efficient approach for solving the shortage of water resources in coal mine areas. The authors studied field and statistical data to assess the status of discharging and utilizing coal mine water in China, mine water quality, and its distribution. In this paper the Chinese coal mine drainage systems were classified into six types. The mine water treatment technology is also summarised.
Outputs	Guo and Shan (2002). Quality and treatment of coal mine drainage water in China. <i>Proceedings of the '99 International Symposium on Mining Science and Technology, August 29, 1999 - August 31, 1999</i> . Beijing, China: shers.
Key personnel	Guo, Jiguang; Shan, Zhongjian China Univ. of Mining and Technol., Beijing, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.19 Project 19: Optimum comprehensive technic study on combination of mine water control, processing, use, recharge and eco-environment protection.

Project characteristics	Details
Project title	Optimum comprehensive technic study on combination of mine water control, processing, use, recharge and eco-environment protection
Project location	China
Principal investigator	Qiang Wu
Lead institution	China University of Mining and Technology (Beijing)
Project budget	1000 000 Yuan
Source of funding	Independent research of State Key Laboratory of Coal Resources and Safe Mining; National Natural Science Foundation of China (No.40572149)
Project duration	2006-2008
Current status	Completed
Project summary	A brand new thinking is adopted in the combination of a total of five aspects of mine water outburst fighting, i.e. mine water control, mine water treatment, mine water utilisation, mine water back filling and mine water treatment for eco-environmental protection. A well coordinated management on the five aspects produces a scheme that better copes with mine water prevention and control, water resources utilization and eco-environment protection and their interrelations. The strategy ensured the eco-environment quality surrounding the mine, realized the goal of cleaning and sustainable mining.
Objectives	Open up a way for resourceization and zero discharge of wastewater by combining mine water control-treatment-utilization-back filling and eco-environmental protection, which will protect the eco-environment as well as realize the goal of cleaning mining.
Achievements	A well coordinated management on the five aspects produces a scheme that better copes with mine water prevention and control, water resource utilisation and eco-environment protection and their interrelations. Through grouting treatment for coal face collapse column and abnormal permeation area in Wutongzhuang mine, the quantity of mine water decrease to 1580m ³ /h, eighty-five presents of the water was sealed, at the same time 2 850 000m ³ of water was saved each year which is worth 1.65 million Yuan. The establishment of mine water back filling engineering can cut down the discharge of suspended sediment by 4197 t and the CODcr by 394 t.
Outputs	<ul style="list-style-type: none"> Wu Qiang, Wang Zhiqiang, 2010, A research on an optimized five-in-one combination of mine water control, treatment, utilization, back-filling and environment friendly treatment, <i>China Coal</i>, 36(2), P109-112. Wu Qiang, Wang Zhiqiang, 2010, An innovative technique of green mining of coal resources: technical method and application of Coal Mine Water deep back-filling using ground tube well, <i>Science Technology Innovations and Brands</i>, 58(2), P55-57.
Key personnel	Qiang Wu
Research themes	Aquifer connectivity, disruption of surface water flow pathways, co-produced/mine water, well integrity, water supplies, water dependent ecosystems
Project information source	Survey

Table 4.20 Project 20: Study on treatment of mine water and its cost analysis.

Project characteristics	Details
Project title	Study on treatment of mine water and its cost analysis
Project location	China
Principal investigator	Qi, Peng;Wu, Haixia;Zhang, Yaowen
Lead institution	College of Geosciences and Surveying Engineering, China University of Mining and Technology (Beijing), Beijing, 100083, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	During the process of coal production, mine water pollution is serious. It will become a threat to ecological environment in coal mining area if this kind of water is drained away to the nature directly. Take Jialong coal mine as an example, we analyzed major qualities of mine water, provided specific process of treatment of mine water, and demonstrated the feasibility, effectiveness, cost of mine water disposal technology. The result showed to us that the process adopted is effective in removing the sewage from mine water, such as CODCr, SS, Fe, Mn. The treated water meets the standards of emission or recycling and its cost is low too. So this process has great promotional value. 2011 IEEE.
Outputs	Qi et al. (2011). Study on treatment of mine water and its cost analysis. <i>2011 International Conference on Computer Distributed Control and Intelligent Environmental Monitoring, CDCIEM 2011, February 19, 2011 - February 20, 2011</i> . Changsha, Hunan, China: IEEE Computer Society. < http://dx.doi.org/10.1109/CDCIEM.2011.128 >
Key personnel	Qi, Peng;Wu, Haixia;Zhang, Yaowen College of Geosciences and Surveying Engineering, China University of Mining and Technology(Beijing), Beijing, 100083, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.21 Project 21: Mine water pollution and acid mine water treatment.

Project characteristics	Details
Project title	Mine water pollution and acid mine water treatment
Project location	China
Principal investigator	Feng, C. C.; Han, Z. T.; Zhang, Z. Y.; Song, L.
Lead institution	College of Mining Engineering, China University of Mining & Technology, Xuzhou 221116, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	The continued exploitation of mineral resources, to the mine not only bring energy and wealth, as well as environmental pollution. Where mine water pollution is more serious, this paper describes our present situation and characteristics of mine water pollution, water pollution, one of the most serious acid mine water was highlighted and described and french limestone, lime neutralization and biological treatment treatment of acid mine water principle.
Outputs	Feng et al. (2010). Mine Water Pollution and Acid Mine Water Treatment. <i>Meitan Jishu / Coal Technology</i> . Harbin Coal Mine Machinery Research Institute.
Key personnel	Feng, C. C.; Han, Z. T.; Zhang, Z. Y.; Song, L. College of Mining Engineering, China University of Mining & Technology, Xuzhou 221116, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.22 Project 22: Stone of Village Coal Mine water recycling project design overview.

Project characteristics	Details
Project title	Stone of Village Coal Mine water recycling project design overview
Project location	China
Principal investigator	Shi, L.
Lead institution	College of Resources and Environment, Wuhan University, Wuhan 430072, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	The stone of the village coal mine water recycling project (a) evidence-based according to the national new technology of blackish water desalination, this article which is based on the example of Shicaocun coal mine pit water recycling project analyzed and compared various kinds of water treatment processes. According to the real situation of this project, this article analyzed the cost of freshwater producing as well. This water treatment process is a very good option for the western coal mine, which is lack of fresh water, to develop the fresh water that is desalinated from the high-salinity pit water as the second water resource.
Outputs	Shi. (2011). Stone of Village Coal Mine Water Recycling Project Design Overview. <i>Meitan Jishu / Coal Technology</i> . Harbin Coal Mine Machinery Research Institute.
Key personnel	Shi, L. College of Resources and Environment, Wuhan University, Wuhan 430072, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.23 Project 23: Experimental research on mine water purified treatment by modified filter media.

Project characteristics	Details
Project title	Experimental research on mine water purified treatment by modified filter media
Project location	China
Principal investigator	Xu, Guangquan; Wang, Weining; Li, Peiquan; Liu, Zegong
Lead institution	Department of Earth and Environment, Anhui University of Science and Technology, Huainan 232001, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	Iron oxide coated quartz sand and anthracite double-modified filter media have been made by high-temperature heating method. Through the filtrating experiment comparison, a variety of pollutants from coal mining water were removed effectively. After 6 h filtrating, the effluent turbidity is 0.3 NTU, and the COD _{Cr} is down to 2.5 mg/L, both of them is less than the value of the standards about drinking water limit. Besides, the removal rate of Fe and Mn is high to 88.7% and 66.7% respectively. By the reverse washing experiment, the reverse washing strength $g=16 \text{ L}/(\text{m}^2 \cdot \text{min})$ and filtration cycle $T=370 \text{ min}$. After the water quality is treated by the modified filter media filtration. It has met the desalination requirements, and it will have broad application prospects in polluted mine groundwater.
Outputs	Xu et al. (2010). Experimental research on mine water purified treatment by modified filter media. <i>3rd International Conference on Environmental Technology and Knowledge Transfer, May 13, 2010 - May 14, 2010</i> . Hefei, China: Unavailable.
Key personnel	Xu, Guangquan; Wang, Weining; Li, Peiquan; Liu, Zegong Department of Earth and Environment, Anhui University of Science and Technology, Huainan 232001, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.24 Project 24: Treatment of the mine water contained surfactant.

Project characteristics	Details
Project title	Treatment of the mine water contained surfactant
Project location	China
Principal investigator	Tian, Zhao-Jun; Wang, De-Ming; Ren, Wan-Xing; Xu, Yong-Liang; Zhong, Xiao-Xing
Lead institution	Faculty of Safety Engineering, China University of Mining and Technology, Xuzhou 221116, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	The influence of surfactant in treating the coal mine water was studied aimed at expounding the principle of foam fractionation and explained that foam fractionation coagulation precipitated combination processing craft is a new high-effective and more cost-effective mine water contained surfactant treatment. By regulating the Shaanxi Dafosi mine water processing craft, the average wipe-off of COD _{Cr} , SS, BOD ₅ and the surfactant reach 73.2%, 90.1%, 45.7% and 90.1%, finally the water quality reaches the effluent discharge standards and calibrated standards.
Outputs	Tian et al. (2009). Treatment of the mine water contained surfactant. <i>Meitan Xuebao/Journal of the China Coal Society</i> . Hepingli, Beijing, 100013, China: China Coal Society.
Key personnel	Tian, Zhao-Jun; Wang, De-Ming; Ren, Wan-Xing; Xu, Yong-Liang; Zhong, Xiao-Xing Faculty of Safety Engineering, China University of Mining and Technology, Xuzhou 221116, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.25 Project 25: Research on prevention and treatment of mine water.

Project characteristics	Details
Project title	Research on prevention and treatment of mine water
Project location	China
Principal investigator	Wang, Q. Y.
Lead institution	Huailbei Mining Engineering Quality Supervision Station, Huaibei 235000, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	Mine water damage is one of the major disasters in the mine construction and production process, which brings substantial economic loss and personal injury to our country. The coal production enterprises should therefore strengthen the work of mine water control, and relentless grip. Some aspects are researched in this paper, such as the type of mine water damage and manifestations, the foundation work of mine hydrogeology, mine water hazard control techniques, in order to guide the enterprises to carry out the water disaster prevention.
Outputs	Wang (2010). Research on Prevention and Treatment of Mine Water. <i>Meitan Jishu / Coal Technology</i> . Harbin Coal Mine Machinery Research Institute.
Key personnel	Wang, Q. Y. Huailbei Mining Engineering Quality Supervision Station, Huaibei 235000, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.26 Project 26: Characteristics of coalbed produced water in the process of coal bed methane development.

Project characteristics	Details
Project title	Characteristics of coalbed produced water in the process of coal bed methane development
Project location	China
Principal investigator	Mei, Yang; Yi-wen, Ju; Li, Tong; Xu, Guang
Lead institution	Key Lab of Computational Geodynamics of Chinese Academy of Sciences, College of Earth Science, Graduate University of Chinese Academy Sciences
Project budget	Unknown
Source of funding	National Science and Technology Major Project (No. 2009ZX05039-003, 2009ZX05039-004; 2011ZX05060-005).
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>Chemical composition data of coalbed produced water can provide information to determine the water sources, understand the evolution, select appropriate treatment processes and increase the utilization efficiency of water resources. Based on methods of hydrogeology, water chemistry and environmental chemistry, the characters of coalbed produced water in the Powder River Basin in the US and Qinshui Basin in China have been analyzed.</p> <p>Conclusions have been drawn as follows: (1) The coalbed produced water have characters of high mineralization, high salty and low water volumes in Qinshui in China, but low TDS and high water volumes in the Powder River Basin. (2) Because the two basins have different hydrological and geological conditions, so the characteristics of coalbed produced water are different from each other. (3) In the Powder River Basin, sodium and kalium ions and TDS have good correlations; While in Qinshui Basin, chloride ion, sodium and kalium ions and TDS have good correlations, calcium ion, magnesium ion, sulfate ion and TDS have bad correlations. (4) In the Powder River Basin, concentrations of sodium and kalium ions, calcium ion, ammoniumion ion and magnesium ion increase with the concentrations of TDS increased; but in Qinshui Basin, concentrations of all dissolved ions increase with the concentrations of TDS increased, chloride ion and sodium and kalium ions are easier to dissolve than others in general. It will provide useful information to select appropriate treatment to treat the wastewater from coal seam and protect the environment in different coal-bearing basins.</p> <p>Copyright of Environmental Engineering & Management Journal (EEMJ)</p>
Outputs	Mei et al. (2011). Characteristics of coalbed produced water in the process of coalbed methane development. <i>Environmental Engineering & Management Journal (EEMJ)</i> . Environmental Engineering & Management Journal.
Key personnel	Mei, Yang; Yi-wen, Ju; Li, Tong; Xu, Guang
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.27 Project 27: Geochemical distribution and removal of As, Fe, Mn and Al in a surface water system affected by acid mine drainage at a coalfield in Southwestern China.

Project characteristics	Details
Project title	Geochemical distribution and removal of As, Fe, Mn and Al in a surface water system affected by acid mine drainage at a coalfield in Southwestern China
Project location	China
Principal investigator	Wu, Pan; Tang, Changyuan; Liu, Congqiang; Zhu, Lijun; Pei, Tingquan; Feng, Lijuan
Lead institution	Key Laboratory of Karst Environment and Geohazard Prevention, Guizhou University, Ministry of Education, Caijiaguan, Guiyang, Guizhou 550003, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	<p>The chemical characteristics, formation and natural attenuation of pollutants in the coal acid mine drainage (AMD) at Xingren coalfield, Southwest China, are discussed in this paper based on the results of a geochemical investigation as well as geological and hydrogeological background information. The chemical composition of the AMD is controlled by the dissolution of sulfide minerals in the coal seam, the initial composition of the groundwater and the water-rock interaction. The AMD is characterized by high sulfate concentrations, high levels of dissolved metals (Fe, Al, Mn, etc.) and low pH values. Ca²⁺ and SO₄²⁻ are the dominant cation and anion in the AMD, respectively, while Ca²⁺ and HCO₃⁻ are present at significant levels in background water and surface water after the drainage leaves the mine site. The pH and alkalinity increase asymptotically with the distance along the flow path, while concentrations of sulfate, ferrous iron, aluminum and manganese are typically controlled by the deposition of secondary minerals. Low concentrations of As and other pollutants in the surface waters of the Xingren coalfield could be due to relatively low quantities being released from coal seams, to adsorption and coprecipitation on secondary minerals in stream sediments, and to dilution by unpolluted surface recharge. Although As is not the most serious water quality problem in the Xingren region at present, it is still a potential environmental problem.</p> <p>2008 Springer-Verlag.</p>
Outputs	<p>Wu et al. (2009). Geochemical distribution and removal of As, Fe, Mn and Al in a surface water system affected by acid mine drainage at a coalfield in Southwestern China. <i>Environmental Geology</i>. Tiergartenstrasse 17, Heidelberg, D-69121, Germany: Springer Verlag.</p> <p>< http://dx.doi.org/10.1007/s00254-008-1423-9 ></p>
Key personnel	<p>Wu, Pan; Tang, Changyuan; Liu, Congqiang; Zhu, Lijun; Pei, Tingquan; Feng, Lijuan</p> <p>Key Laboratory of Karst Environment and Geohazard Prevention, Guizhou University, Ministry of Education, Caijiaguan, Guiyang, Guizhou 550003, China</p>
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.28 Project 28: Treatment efficiency and mechanism of coal mine water with high turbidity, high concentrations of iron and manganese by modified filter material.

Project characteristics	
Project title	Treatment efficiency and mechanism of coal mine water with high turbidity, high concentrations of iron and manganese by modified filter material
Project location	China
Principal investigator	He, Xu-Wen; Zhou, Bo; Shao, Li-Nan; Huang, Jing-Hua; Li, Yan
Lead institution	School of Chemical and Environmental Engineering, China University of Mining and Technology, Beijing 100083, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	<p>A new modified manganese sand filter material was studied and prepared to improve the common filter materials concerned with the problem of low removal efficiency of manganese and excessive long maturation period. The modified filter material was characterized and its specific surface area and Zeta potential were determined. The experiments on treatment of coal mine water with high turbidity, high concentrations of iron and manganese by modified filter materials were carried out.</p> <p>The results show that more than 95% of pollutants can be removed from coal mine water by the 24 h continuous treatment experiment. The greater specific surface area of modified filter material of 8.849 m²/g resulted in its greater adsorption capacity of iron and manganese ions. The adsorptive iron and manganese ions were catalytically oxidized into soluble Fe³⁺ and MnO₂ by the filter membrane (MnxFeO·xH₂O) formed on filter material surface and were consequently removed. The -14.5 mV Zeta potential of modified filter material represents its much weaker electrostatic repulsion compared with that of quartz sand and manganese sand. The resistance of suspended substance close to the filter material surface is rather small, which makes it very easy to remove suspended substance.</p>
Outputs	He et al. (2009). Treatment efficiency and mechanism of coal mine water with high turbidity, high concentrations of iron and manganese by modified filter material. <i>Zhongguo Kuangye Daxue Xuebao/Journal of China University of Mining and Technology</i> . Xuzhou Jiangsu, 221008, China: China University of Mining and Technology.
Key personnel	He, Xu-Wen; Zhou, Bo; Shao, Li-Nan; Huang, Jing-Hua; Li, Yan School of Chemical and Environmental Engineering, China University of Mining and Technology, Beijing 100083, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.29 Project 29: Design of Xijixi Coal Mine water treatment process.

Project characteristics	
Project title	Design of Xijixi Coal Mine water treatment process
Project location	China
Principal investigator	Liu, W.H.; Li, Y.
Lead institution	School of Civil Engineering, Northeast Forestry University, Harbin 150040, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	There is a lot of mine water to be drained during coal mining, which leads to environment pollution and results in water resources waste. Xijixi mine industrial site water treatment plant adopts the combined process of pre-sedimentation equalization tank, integrated water purifier, iron removal filter by manganese sand and sodium hypochlorite disinfection to treat mine water. The finished water quality can meet the Standards for Drinking Water Quality (GB 5749 - 2006), and it can be used as life and production water in the mining area.
Outputs	Liu and Li (2010). Design of Xijixi Coal Mine Water Treatment Process. <i>China Water & Wastewater</i> . China International Book Trading Corporation.
Key personnel	Liu, W.H.; Li, Y. School of Civil Engineering, Northeast Forestry University, Harbin 150040, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.30 Project 30: Characteristics and utilization of mine water in East China.

Project characteristics	Details
Project title	Characteristics and utilization of mine water in East China
Project location	China
Principal investigator	Feng, Qi-Yan; Wang, Hua; Li, Xiang-Dong; Hao, Li-Li
Lead institution	School of Environmental Science and Spatial Informatics, CUMT, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2004
Current status	Unknown- literature output 2004
Project summary	In view of water shortage and low utilization efficiency of waste water in mining areas, water resource and water quality of coal mines in eastern China are analyzed. Four classes of mining water are divided as clear mine water, high-SS mine water, high-TDS mine water, and acidic mine water. Techniques for treating different kinds of mine water are discussed. The authors hold that to make the waste mine water an utilizable water resource can prevent the water environment system in mining area from being destructed, abate the contradiction between drainage and water resource protection, solve radically the problem of pollution of mining water, and improve the biological environment in mining areas.
Outputs	Feng et al. (2004). Characteristics and Utilization of Mine Water in East China. <i>Zhongguo Kuangye Daxue Xuebao (Journal of China University of Mining & Technology)</i> . China University of Mining and Technology, Xuzhou, Jiansu, 221008, China, [mailto:zfluo@cumt.edu.cn].
Key personnel	Feng, Qi-Yan; Wang, Hua; Li, Xiang-Dong; Hao, Li-Li School of Environmental Science and Spatial Informatics, CUMT, Xuzhou, Jiangsu 221008, China
Research themes	Water supplies, water dependent ecosystems
Project information source	Literature

Table 4.31 Project 31: Treatment of mine water and its utilization in Huainan mining area.

Project characteristics	Details
Project title	Treatment of mine water and its utilization in Huainan mining area
Project location	China
Principal investigator	Yang, Mei; Liu, Rui; Fan, Wen; Pan, Jing; Qian, Jiazhong
Lead institution	School of Resources and Environment Engineering, Hefei University of Technology, Hefei, Anhui, 230009, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	Treatment of mine water and its effective utilization are important projects for sustainable development and environment protection of mining cities. This paper introduces the main sources and the quality characteristics of mine water from Huainan Mining Area by investigating its treatment and the utilization method. The problems in the utilization processes are pointed. The corresponding countermeasures are also given.
Outputs	Yang et al. (2008). Treatment of mine water and its utilization in Huainan Mining Area. <i>2nd International Conference on Asian-European Environmental Technology and Knowledge Transfer, June 5, 2008 - June 6, 2008</i> . Hefei, China: Unavailable.
Key personnel	Yang, Mei; Liu, Rui; Fan, Wen; Pan, Jing; Qian, Jiazhong School of Resources and Environment Engineering, Hefei University of Technology, Hefei, Anhui, 230009, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.32 Project 32: Treatment mechanism of mine water with high concentration of manganese on surface-modified filter material.

Project characteristics	
Project title	Treatment mechanism of mine water with high concentration of manganese on surface-modified filter material
Project location	China
Principal investigator	Wang, Ting-Jun; Li, Fu-Qin
Lead institution	School of Resources and Safety Engineering, China University of Mining and Technology (Beijing), Beijing 100083, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	In order to achieve the goal of reusing the mine water with high manganese, this paper studies the mechanism with Surface-modified filtration media in treating the mine water from 9th-coliery of Hebei Coal Group. The experiment results show that: the quality of effluent is stable by manganese sand immersed with 3-5% KMnO ₄ , the single cycle can reach 24 hours with manganese less than 0.1mg/l, and the performance can be improved and recovered by acid; the modified filtration media can remove Mn ²⁺ efficiently under weak acid, broaden the pH scope of contact oxidation in removing manganese; the mechanism of removing manganese of modified filtration media is the autocatalytic process on the hydroxyl surface of metal oxide. 2009 IEEE.
Outputs	Wang and Li (2009). Treatment mechanism of mine water with high concentration of manganese on surface-modified filter material. 2009 <i>International Conference on Energy and Environment Technology, ICEET 2009, October 16, 2009 - October 18, 2009</i> . Guilin, China: IEEE Computer Society. < http://dx.doi.org/10.1109/ICEET.2009.455 >
Key personnel	Wang, Ting-Jun; Li, Fu-Qin School of Resources and Safety Engineering, China University of Mining and Technology (Beijing), Beijing 100083, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.33 Project 33: Revised design of the waste water treatment process for an underground mine.

Project characteristics	Details
Project title	Revised design of the waste water treatment process for an underground mine.
Project location	China
Principal investigator	Wang, De-Ming;Long, Teng-Rui;Ding, Li;Song, Chang-Hua
Lead institution	School of Urban Construction and Environmental Engineering, Chongqing University, Chongqing 400030, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	We introduce the original design and detail the process by which the waste water of a coal mine was treated. The original design is improved, based on the geographic location of the treatment station. The revised design reduces the capital investment while still meeting the design requirements and the relevant standards. The improved design lowers the capital investment by approximately 276600 RMB, reduces annual power consumption by 394450 kWh, and decreases equipment maintenance costs. This project lowers the investment cost during construction, and reduces the electrical and maintenance costs of the relevant equipment after the construction is completed.
Outputs	Wang <i>et al.</i> (2009). Revised design of the waste water treatment process for an underground mine. <i>Chongqing Daxue Xuebao/Journal of Chongqing University</i> . 174 Shazhengjie, Shapingba District, Chongqing, 400030, China: Editorial Board of Journal of Chongqing University.
Key personnel	Wang, De-Ming;Long, Teng-Rui;Ding, Li;Song, Chang-Hua School of Urban Construction and Environmental Engineering, Chongqing University, Chongqing 400030, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.34 Project 3: Environmental impact analysis of water environment in coal mining areas based on matter-element model.

Project characteristics	Details
Project title	Environmental impact analysis of water environment in coal mining areas based on matter-element model
Project location	China
Principal investigator	Wang, Qi-Liang; Wang, Lei
Lead institution	Shanxi Water Conservation Professional Technology Institute, Yuncheng 044004, Shanxi, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	In connection with the problems that coal mining accounts for water environment pollution and socio-economic development, the main factors was analysed. From water environment system, ecological system and socio-economic system, corresponding evaluation index system was perfected and became fit for factual situation. Matter-element model of water environment impact evaluation was constructed and used to evaluate four large-scale coal mining areas. The results showed that assessment model in accordance with the objective reality. Compared with other evaluation models, matter-element model is more accurate and comprehensive. By matlab, a calculating program was made and can be dynamically amended.
Outputs	Wang and Wang (2010). Environmental impact analysis of water environment in coal mining areas based on matter-element model. <i>2010 International Conference on Advanced Measurement and Test, AMT 2010, May 15, 2010 - May 16, 2010</i> . 1 ed. Sanya, China: Trans Tech Publications. < http://dx.doi.org/10.4028/www.scientific.net/AMR.108-111.403 >
Key personnel	Wang, Qi-Liang; Wang, Lei Shanxi Water Conservation Professional Technology Institute, Yuncheng 044004, Shanxi, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.35 Project 35: Field trials of aquifer protection in longwall mining of shallow coal seams in China.

Project characteristics	Details
Project title	Field trials of aquifer protection in longwall mining of shallow coal seams in China
Project location	China
Principal investigator	Zhang, Dongsheng; Fan, Gangwei; Liu, Yude; Ma, Liqiang
Lead institution	State Key Lab Coal Resource & Mine Safety, Xuzhou 221008, Jiangsu, Peoples R China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	<p>The large-scale mining of shallow coal seams has a significant impact on the overlying aquifers and surface ecological environment. To protect the aquifers and maximize the coal resource recovery, field trials were undertaken during the operation of the LW32201 in Bulianta coal mine, Shendong, China. With a severely weathered rock (SWR) layer and two key strata (KS) in the overlying strata, aquifer protection in longwall mining (APLM) relies mainly on the rapid advance. In some localized zones, special measures should be taken to achieve the APLM, including lowering mining height, backfill and slurry injection.</p> <p>To further understand the mechanism and applicable conditions of the APLM and validate the effectiveness of the APLM, variation of the water table in the aquifer was observed as the longwall face passed through the zone. This paper also discusses the mechanism and basic requirements of the APLM and the relationship between the fall of the water table and the surface subsidence. The results of the field trials indicated that APLM in shallow coal seams could be successful under suitable conditions.</p> <p>(C) 2010 Elsevier Ltd. All rights reserved.</p>
Outputs	Zhang et al. (2010). Field trials of aquifer protection in longwall mining of shallow coal seams in China. <i>International Journal of Rock Mechanics and Mining Sciences</i> .
Key personnel	Zhang, Dongsheng; Fan, Gangwei; Liu, Yude; Ma, Liqiang Fan, GW State Key Lab Coal Resource & Mine Safety, Xuzhou 221008, Jiangsu, Peoples R China
Research themes	Aquifer interconnectivity, co-produced/mine water, water dependent ecosystems
Project information source	Literature

Table 4.36 Project 36: Removal of heavy metals from mine water by cyanobacterial calcification.

Project characteristics	Details
Project title	Removal of heavy metals from mine water by cyanobacterial calcification
Project location	China
Principal investigator	Dong, Donglin; Li, Hongjiang; Zhang, Jie; Sun, Luke
Lead institution	State Key Laboratory of Coal Resources and Safe Mining, China University of Mining and Technology, Beijing 100083, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	<p>The influence of different illumination intensities on cyanobacterial calcification induced removal of heavy metals from contaminated mine water was studied. Cyanobacterial calcification experiments were performed using a growth medium intended to simulate contaminated mine water.</p> <p>The results indicate that calcification can promote the removal of heavy metal ions. As the illumination intensity became stronger calcification rates increased and the removal of Zn²⁺ and Cd²⁺ became more obvious. When the illumination intensity was 10000 lux the removal of Pb²⁺ was the largest observed: stronger or weaker illumination reduced the amount of lead removed. The removal of three different heavy metals complies with an index function. For identical illumination intensities different ions were removed to different degrees.</p> <p>2010 China University of Mining and Technology.</p>
Outputs	Dong et al. (2010). Removal of heavy metals from mine water by cyanobacterial calcification. <i>Mining Science and Technology</i> . Xuzhou Jiangsu, 221008, China: China University of Mining and Technology.
Key personnel	Dong, Donglin; Li, Hongjiang; Zhang, Jie; Sun, Luke State Key Laboratory of Coal Resources and Safe Mining, China University of Mining and Technology, Beijing 100083, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.37 Project 37: Thermophilic anaerobic digestion of Lurgi coal gasification wastewater in a UASB reactor.

Project characteristics	Details
Project title	Thermophilic anaerobic digestion of Lurgi coal gasification wastewater in a UASB reactor
Project location	China
Principal investigator	Wang, Wei; Ma, Wencheng; Han, Hongjun; Li, Huiqiang; Yuan, Min
Lead institution	State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin 150090, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>Lurgi coal gasification wastewater (LCGW) is a refractory wastewater, whose anaerobic treatment has been a severe problem due to its toxicity and poor biodegradability. Using a mesophilic (352C) reactor as a control, thermophilic anaerobic digestion (552C) of LCGW was investigated in a UASB reactor. After 120days of operation, the removal of COD and total phenols by the thermophilic reactor could reach 50-55% and 50-60% respectively, at an organic loading rate of 2.5kgCOD/(m3d) and HRT of 24h; the corresponding efficiencies were both only 20-30% in the mesophilic reactor. After thermophilic digestion, the wastewater concentrations of the aerobic effluent COD could reach below 200mg/L compared with around 294mg/L if mesophilic digestion was done and around 375mg/L if sole aerobic pretreatment was done.</p> <p>The results suggested that thermophilic anaerobic digestion improved significantly both anaerobic and aerobic biodegradation of LCGW.</p> <p>2010 Elsevier Ltd.</p>
Outputs	Wang et al. (2011). Thermophilic anaerobic digestion of Lurgi coal gasification wastewater in a UASB reactor. <i>Bioresource Technology</i> . Langford Lane, Kidlington, Oxford, OX5 1GB, United Kingdom: Elsevier Ltd.
Key personnel	Wang, Wei; Ma, Wencheng; Han, Hongjun; Li, Huiqiang; Yuan, Min State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin 150090, China
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.38 Project 38: The application of RO technology in highly mineralized mine water treatment and utilization.

Project characteristics	Details
Project title	The application of RO technology in highly mineralized mine water treatment and utilization
Project location	China
Principal investigator	Yuchuan, C.; Yaozu, P.; Ting, L.; Zenjiang, L.
Lead institution	Taiyuan University of Technology, Taiyuan 030024, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2006
Current status	Unknown- literature output 2006
Project summary	Expounding the method, process and design parameter of treating and reusing for highly mialerized mine water on the basis of practicing engineering. Presenting the conclusion of and proposal for application of RO technology in the engineering that makes domestic drinking water out of highly mineralized mine water of shanxi coal mine region.
Outputs	Yuchuan et al. (2006). the Application of RO Technology in Highly Mineralized Mine Water Treatment & Utilization. <i>Water Purification Technology</i> .
Key personnel	Yuchuan, C.; Yaozu, P.; Ting, L.; Zenjiang, L. Taiyuan University of Technology, Taiyuan 030024, China
Research themes	Co-produced/mine water
Project information source	Literature

4.3.2 India

Table 4.39 Project 39: Quality assessment of mine water in the Raniganj coalfield area, India.

Project characteristics	Details
Project title	Quality assessment of mine water in the Raniganj coalfield area, India
Project location	India
Principal investigator	Singh, A.K.; Mahato, M.K.; Neogi, B.; Singh, K.K.
Lead institution	Central Institute of Mining and Fuel Research, Dhanbad 826015, Bihar, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	In a qualitative assessment of mine water from the Raniganj coalfield, 77 mine water samples were analyzed to assess water quality and suitability for domestic, industrial, and irrigation uses. The pH of the mine water ranged from 6.5 to 8.8. Total dissolved solids (TDS) ranged from 171 to 1,626 mg L ⁻¹ ; spatial differences between the TDS values reflect variations in lithology, activities, and prevailing hydrological regime. The anion chemistry was dominated by HCO ₃ ⁽⁻⁾ and SO ₄ ⁽²⁻⁾ . On average, Cl ⁽⁻⁾ contributes 10 and 19% of the total anionic balance, respectively, in the Barakar and Raniganj Formation mine water. F ⁽⁻⁾ and NO ₃ ⁽⁻⁾ contribute <2% to the total anions. The cation chemistry is dominated by Mg ⁽²⁺⁾ and Ca ⁽²⁺⁾ in the mine water of the Barakar Formation and Na ⁽⁺⁾ in the Raniganj Formation mines. Much of the mine water, especially of the Barakar Formation area, has high TDS, total hardness, and SO ₄ concentrations. Concentrations of some trace metals (i.e. Fe, Cr, Ni) were found to be above the levels recommended for drinking water. However, the mine water can be used for irrigation, except at some sites, especially in the Raniganj Formation area, where high salinity, sodium adsorption ratio, %Na, residual sodium carbonate, and excess Mg restrict its suitability for agricultural uses.
Outputs	Singh et al. (2010). Quality Assessment of Mine Water in the Raniganj Coalfield Area, India. <i>Mine Water and the Environment</i> .
Key personnel	Singh, A.K.; Mahato, M.K.; Neogi, B.; Singh, K.K. [Singh, Abhay Kumar; Mahato, Mukesh K.; Neogi, Babita; Singh, K. K.] Cent Inst Min & Fuel Res, Dhanbad 826015, Bihar, India. Singh, AK (reprint author), Cent Inst Min & Fuel Res, Barwa Rd, Dhanbad 826015, Bihar, India.
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.40 Project 40: A simplified approach for removal of suspended coal fines from black water discharge of mining and its allied industries.

Project characteristics	Details
Project title	A simplified approach for removal of suspended coal fines from black water discharge of mining and its allied industries
Project location	India
Principal investigator	Kumar, Anjanee; Tewary, B.K.; Banerjee, M.; Ahmad, M.
Lead institution	CIMFR, Barwa Road, Dhanbad, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	Suspended fine particulate matters generated from different mining activities such as washing and crushing of coal affect large volume of natural water. The present paper highlights a simple method to improve the settlement rate of dispersed coal fine particles by incorporating them into a coarser particulate matrix. The process mentioned herein consists of three steps viz. activation of coal fine in aqueous medium, tether of activated particles to the anchor particles and pass them into straight flow stream. The activation of coal fines suspended in the effluent water may be an amine group of polymer which can link to a particle surface of metal oxide to complete the interaction for sedimentation of coal fines. The coagulated coal fine is further separated by gravitation and filtration process.
Outputs	Kumar et al. (2010). A simplified approach for removal of suspended coal fines from black water discharge of mining and its allied industries. <i>Journal of Mines, Metals and Fuels</i> . P.O. Box 7234 I.P.H.O., New Delhi, 110002, India: INSIO Scientific Books and Periodicals.
Key personnel	Kumar, Anjanee; Tewary, B.K.; Banerjee, M.; Ahmad, M. CIMFR, Barwa Road, Dhanbad, India
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.41 Project 41: Heavy metal pollution induced due to coal mining effluent on surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes.

Project characteristics	Details
Project title	Heavy metal pollution induced due to coal mining effluent on surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes
Project location	India
Principal investigator	Mishra, Virendra Kumar; Upadhyaya, Alka Rani; Pandey, Sudhir Kumar; Tripathi, B. D.
Lead institution	Pollution Ecology Research Laboratory, Centre of Advanced Study in Botany, Banaras Hindu University
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	Three aquatic plants <i>Eichhornia crassipes</i> , <i>Lemna minor</i> and <i>Spirodela polyrrhiza</i> were used in laboratory for the removal of heavy metals from the coal mining effluent. Plants were grown singly as well as in combination during 21 days phytoremediation experiment. Results revealed that combination of <i>E. crassipes</i> and <i>L. minor</i> was the most efficient for the removal of heavy metals while <i>E. crassipes</i> was the most efficient in monoculture. Significant correlations between metal concentration in final water and macrophytes were obtained. Translocation factor i.e. ratio of shoot to root metal concentration revealed that metals were largely retained in the roots of aquatic macrophytes. Analytical results showed that plant roots have accumulated heavy metals approximately 10 times of its initial concentration. These plants were also subjected to toxicity assessment and no symptom of metal toxicity was found therefore, this method can be applied on the large scale treatment of waste water where volumes generated are very high and concentrations of pollutants are low.
Outputs	Mishra et al. (2008). Heavy metal pollution induced due to coal mining effluent on surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes. <i>Bioresource Technology</i> .
Key personnel	Mishra, Virendra Kumar; Upadhyaya, Alka Rani; Pandey, Sudhir Kumar; Tripathi, B.D.
Research themes	Co-produced/mine water
Project information source	Literature

4.3.3 United Kingdom

Table 4.42 Project 42: Environmental impacts of coal mining and associated wastes: A geochemical perspective.

Project characteristics	Details
Project title	Environmental impacts of coal mining and associated wastes: A geochemical perspective
Project location	United Kingdom
Principal investigator	Younger, Paul L.
Lead institution	HERO, Sch. of Civ. Engineering/Geosciences, University of Newcastle, Newcastle upon Tyne, United Kingdom
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2004
Current status	Unknown- literature output 2004
Project summary	<p>Ever since the commencement of industrial-scale coal mining (in northeast England around 1600), substantial environmental impacts have been recorded as arising from both the mined voids and from the wastes left behind at the surface. In the early days of coal mining, complaints about such impacts were strident, as the newly established industry adversely affected long-established agricultural interests. When the coal trade had come to dominate regional economies in mining districts, its negative impacts came to be accepted as a necessary byproduct of the generation of coal-based wealth. It has only been since large-scale mine closures began to take place in the major coal-mining economies of the developed world during the last few decades that the negative impacts of coal mining have once more been deemed unacceptable.</p> <p>The environmental impacts arising from coal mining activities are fundamentally attributable to the exposure of reduced earth materials (especially coal, pyrite, siderite, and ankerite) to the oxidizing power of the Earth's atmosphere. The consequences range from the spontaneous combustion of coal to the release of acidic waters from pyrite oxidation. A typology of the known impacts arising from mine voids and wastes in coal mining districts has been developed, which recognizes many subcategories of impacts under five major headings: air pollution, fire hazards, ground deformation, water pollution, and water resource depletion.</p> <p>A robust understanding of geochemical processes is key to understanding how these impacts arise, and to developing sustainable mitigation strategies. The application of the newly developed typology is illustrated using the case of the Shilbottle Coalfield (Northumberland, UK). Although few demonstrable impacts have arisen in the categories of air pollution, fire hazards, or ground deformation, major problems of water pollution have required both preventative and remedial interventions. For the flooded underground voids, these took the form of a pump-and-treat system, whereas emissions of leachates from surface spoil heaps have necessitated the installation of an innovative 'hybrid' passive treatment system, comprising a permeable reactive barrier, oxidation ponds, and a wetland. Inverse geochemical modelling has clarified the linkages between the various types of water encountered in the coalfield, providing a baseline geochemical understanding upon which future investigations of remedial system sustainability can be based.</p>

Project characteristics	Details
	The Geological Society of London 2004.
Outputs	Younger. (2004). Environmental impacts of coal mining and associated wastes: A geochemical perspective. <i>Geological Society Special Publication</i> . Geological Society of London.
Key personnel	Younger, Paul L. HERO, Sch. of Civ. Engineering/Geosciences, University of Newcastle, Newcastle upon Tyne, United Kingdom
Research themes	Co-produced/mine water, water supplies, water dependent ecosystems
Project information source	Literature

Table 4.43 Project 43: Laboratory studies using naturally occurring 'green rust' to aid metal mine water remediation.

Project characteristics	Details
Project title	Laboratory studies using naturally occurring 'green rust' to aid metal mine water remediation
Project location	United Kingdom
Principal investigator	Bearcock, Jenny M.; Perkins, William T.; Pearce, Nicholas J.G.
Lead institution	Institute of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, SY23 3DB, UK
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>Green rust, an Fe (II) and (III) oxyhydroxy salt, can alter the aqueous oxidation state, mobility and toxicity, of inorganic contaminants and thus could have applications in water treatment. This paper discusses a series of stirred, open batch experiments designed to evaluate green rust, and its oxidised equivalent in this context comparing it to a ferrihydrite/goethite 'ochre'. Natural green rust was added to different mine waters as either a wet, reduced material or a dry, partially oxidised material. Experiments showed that the addition of either form accelerated the removal of potentially harmful elements from solution. Within one hour Fe, Al and Cu were completely removed from mine waters with initial concentrations of 80, 70 and 8.5mg/L, respectively, and Zn was reduced from 60 to <5mg/L.</p> <p>These experiments show the potential of green rust in mine water treatment, especially as it is able to remove problematic elements such as Al and Zn. The material is effective even after being dried and mostly oxidised. Changes to the pH and ORP of the mine waters and surface catalysis are the suggested mechanisms of accelerated removal of contaminants.</p>
Outputs	Bearcock et al. (2011). Laboratory studies using naturally occurring "green rust" to aid metal mine water remediation. <i>Journal of Hazardous Materials</i> . Elsevier BV.
Key personnel	Bearcock, Jenny M.; Perkins, William T.; Pearce, Nicholas J.G. Institute of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, SY23 3DB, UK
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.44 Project 44: Determination of hydraulic residence times in several UK mine water treatment systems and their relationship to iron removal.

Project characteristics	Details
Project title	Determination of hydraulic residence times in several UK mine water treatment systems and their relationship to iron removal
Project location	United Kingdom
Principal investigator	Kruse, N.A.S.; Gozzard, E.; Jarvis, A.P.
Lead institution	Newcastle Univ, Hydrogeochem Engrn Res & Outreach Grp, Sir Joseph Swan Inst, Newcastle Upon Tyne
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	<p>In the UK, the Coal Authority has more than 40 mine water treatment systems, most of which are wetland systems with settlement lagoon pretreatment. The purpose of treatment in wetlands is the oxidation of ferrous to ferric iron and the subsequent hydrolysis and precipitation of ferric hydroxide within the wetland. It is generally accepted (Hedin et al., Passive treatment of coal mine drainage, 1994, p 35; Skousen and Ziemkiewicz, Acid mine drainage control and treatment, 1996, p 362; Younger et al., Mine water: hydrology, pollution, remediation, 2002, p 442) that this process proceeds by a first-order rate law, although most systems are designed based on an areal removal rate (10 g/m(2)/day) developed by the U.S. Bureau of Mines (Hedin et al., Passive treatment of coal mine drainage, 1994, p 35); this design guideline inherently assumes a constant removal rate. Given the actual kinetics of iron removal in wetlands, it follows that residence time will control iron removal; given the wide range of system geometries and aspects, it is logical to ascertain the actual hydraulic residence time of wetlands and settlement lagoons and determine the effect this has on iron removal. To make a preliminary assessment of this link, hydraulic residence time of two Coal Authority wetlands (Lambley and Whittle) and two Coal Authority settlement lagoons (Acomb East, Acomb West and Whittle) were measured using bromide tracer tests. Water samples for iron analysis and flow measurements were taken during each tracer test. The Lambley wetland performs well in terms of residence time, and, as reeds become established and adsorptive processes increase, its iron removal performance (currently 58% removal) may improve, but the low influent iron concentration appears to be a significant impediment to meeting the original performance target. In contrast, the hydraulic performance of the Whittle wetland system is poor, which appears to be due to accumulation of dead plant material coupled with a high length to width ratio. However, performance in terms of iron removal is good (92% removal), which appears to be due to the higher influent iron concentration, and especially the fact that the iron enters the wetland largely in particulate form. The longer residence time of water within the Acomb lagoons (approximate to 12 h) resulted in far more effective iron removal (72% in the east lagoon and 85% in the west lagoon) than the shorter residence time at Whittle (24% iron removal, approximate to 5 h residence time). Performance (in terms of iron removal) of the settlement lagoon systems appears to be far more closely related to the hydraulic residence time (albeit this conclusion must be tentative, given that only three systems have been investigated, and the Acomb system receives chemical addition). Based on this study, treatment system sizing using</p>

Project characteristics	Details
	100 m(2) lagoon area per 1 L/s flow appears to be a more appropriate basis for design rather than an areal iron removal rate.
Outputs	Kruse et al. (2009). Determination of Hydraulic Residence Times in Several UK Mine Water Treatment Systems and their Relationship to Iron Removal. <i>Mine Water and the Environment</i> .
Key personnel	Kruse, N. A. S.;Gozzard, E.;Jarvis, A. P. [Kruse, Natalie A.S. Gozzard, E. Jarvis, A. P.] Newcastle Univ, Hydrogeochem Engn Res & Outreach Grp, Sir Joseph Swan Inst, Newcastle Upon Tyne NE1 7RU, Tyne & Wear, England. Kruse, NAS (reprint author), Newcastle Univ, Hydrogeochem Engn Res & Outreach G
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.45 Project 45: Design and performance assessment methodology for passive mine water treatment systems.

Project characteristics	Details
Project title	Design and performance assessment methodology for passive mine water treatment systems
Project location	United Kingdom
Principal investigator	Devin Sapsford, Cardiff University
Lead institution	The Coal Authority, United Kingdom
Project budget	N/A – internally funded
Source of funding	Department of Energy & Climate Change, United Kingdom
Project duration	2009-2011
Current status	Completed
Project summary	The Coal Authority operates over 60 mine water treatment schemes in the UK. The aim of this project was the development of a methodology for assessing the iron removal efficiency of passive mine water treatment settlement lagoons and reed beds.
Objectives	Characterise the physical and chemical processes controlling iron removal in passive mine water treatment systems.
Achievements	Assess the efficiency of operational mine water treatment schemes across the UK.
Outputs	Use the case study data to develop an empirical treatment efficiency index.
Key personnel	Devin Sapsford and Ian Watson
Research themes	Co-produced/mine water treatment, water dependent ecosystems
Project information source	Survey

Table 4.46 Project 46: The rates and mechanisms of Fe(II) oxidation in a passive vertical flow reactor for the treatment of ferruginous mine water.

Project characteristics	Details
Project title	The rates and mechanisms of Fe(II) oxidation in a passive vertical flow reactor for the treatment of ferruginous mine water
Project location	United Kingdom
Principal investigator	Barnes, A.
Lead institution	The University of Wales College of Cardiff (United Kingdom)
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	This thesis presents the methodology and results of research undertaken into the rates and mechanisms of iron oxidation both in field and laboratory environments. The field based aspects of the research entailed the collection and analysis of hydrological, hydrogeochemical, and mineralogical data from two parallel treatment systems, each treating identical ferruginous, circum-neutral, coal-mine drainage, at the Taff Merthyr site, South Wales. The two systems consist of firstly a conventional settlement lagoon, and secondly a novel pilot scale passive Vertical Flow Reactor (VFR). The second research aspect focuses on the determination of heterogeneous Fe(II) oxidation rates under laboratory conditions. Experiments were carried out under varying pH, and catalytic surface concentration and type. An analytical method was developed which allowed for the determination of both dissolved and sorbed Fe(II). The results of the field study have shown that the VFR system is capable of removing Fe at a rate greatly in excess of a conventional settlement lagoon. This therefore drastically reduces the treatment area required. In addition, due to the heterogeneous method by which the VFR operates (passing mine-water down through a bed of ochre solid), highly efficient manganese removal was also achieved. The laboratory study has shown that significant catalysis of Fe(II) oxidation can be achieved under mildly acidic pH conditions making Fe(II) oxidation (and therefore passive mine-water treatment) feasible at low pH. Evidence is also presented for the adsorption of non-oxidisable Fe(II) on to Fe(III) (hydroxy)oxides under mildly-acidic pH conditions. A conceptual model was produced to describe the observed adsorption and oxidation characteristics.
Outputs	Barnes (2008). The rates and mechanisms of Fe(II) oxidation in a passive vertical flow reactor for the treatment of ferruginous mine water. Ann Arbor: The University of Wales College of Cardiff (United Kingdom).
Key personnel	Barnes, A.
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.47 Project 47: Environmental impact of mine drainage and its treatment on aquatic communities.

Project characteristics	Details
Project title	Environmental impact of mine drainage and its treatment on aquatic communities
Project location	United Kingdom
Principal investigator	Auladell Mestre, Montserrat
Lead institution	University of Birmingham (United Kingdom)
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	An ecological and chemical analysis of eight Welsh streams impacted by mine drainage is used to discern the effects of water and sediment related variables and elucidate the most important variables in the impact of mine pollution on freshwater macroinvertebrate communities. The implications of this are to be considered for improving mine water remediation techniques and work towards the achievement of the environmental objectives set by the EU Water Framework Directive (WFD). Streams impacted by coal and metal mine drainage present a clear ecological impact in response to water and sediment related variables, demonstrating that both sediment and water are key aspects in mine drainage pollution of freshwater ecosystems. However, the WFD does not include metal concentration guidelines for sediments, neither has the UK set mandatory standards for them, and sediments are not currently being routinely monitored or remediated in the UK. To achieve the environmental objectives set by the WFD, the Coal Authority and the Environment Agency are constructing several engineered wetlands in the UK to treat mine drainage. One of these constructed engineered wetlands was seen to successfully remediate mine water removing trace metals and suspended solids and increasing pH and dissolved oxygen. However, the remediation scheme seemed to fail to improve the electrolyte status of the water and stream sediment quality. As a result, the benthic community in the receiving stream appeared to have a poor recovery.
Outputs	Auladell Mestre (2009). Environmental impact of mine drainage and its treatment on aquatic communities. Ann Arbor: University of Birmingham (United Kingdom).
Key personnel	Auladell Mestre, Montserrat
Research themes	Co-produced/mine water, water dependent ecosystems
Project information source	Literature

Table 4.48 Project 48: European Commission 5th Framework RTD Project No. EVK1-CT-1999-00021 'Passive in-situ remediation of acidic mine/industrial drainage' (PIRAMID).

Project characteristics	Details
Project title	European Commission 5th Framework RTD Project No. EVK1-CT-1999-00021 'Passive in-situ remediation of acidic mine/industrial drainage' (PIRAMID)
Project location	United Kingdom
Principal investigator	Consortium, PIRAMID
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	European Commission
Project duration	Unknown- literature output 2003
Current status	Unknown- literature output 2003
Project summary	Acidic mine drainage and similar wastewaters (such as leachates from acid-sulphate soils) are a major cause of ground and surface water pollution in the European Union. Because such pollution can persist for decades and even centuries after the cessation of industrial activity, there is a pressing need to develop cheap, sustainable remedial methods. PIRAMID has sought to harmonise research and practice efforts in Europe to create passive in situ remediation (PIR) methods for acidic drainage treatment. A key objective of this three year R&D project has been the development of these engineering guidelines for the design and installation of passive treatment systems. These guidelines are intended to provide practitioners in the field of environmental engineering with sufficient information to enable them to confidently undertake feasibility studies and develop conceptual design statements for passive mine water remediation systems
Outputs	< www.piramid.org > PIRAMID Consortium. (2003). Engineering guidelines for the passive remediation of metalliferous mine drainage and similar wastewaters. Newcastle Upon Tyne University of Newcastle Upon Tyne.
Key personnel	Consortium, PIRAMID
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.49 Project 49: Development of a methodology to aid in the prediction of minewater quality.

Project characteristics	Details
Project title	Development of a methodology to aid in the prediction of minewater quality
Project location	United Kingdom
Principal investigator	Schmolke, C.M.
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2003
Current status	Unknown- literature output 2003
Project summary	Unknown
Outputs	Schmolke. (2003). Development of a methodology to aid in the prediction of minewater quality. University of Newcastle upon Tyne.
Key personnel	Schmolke, C.M.
Research themes	Co-produced/mine water
Project information source	Literature

Table 4.50 Project 50: Mine water capture.

Project characteristics	Details
Project title	Mine water capture
Project location	United Kingdom
Principal investigator	Schmolke, Catriona; Drennan, Stewart
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2003
Current status	Unknown- literature output 2003
Project summary	The Kames No. 1 shaft discharge had been identified by the Scottish Environment Protection Agency as a priority polluting discharge. The colliery had been constructed on the flood plain of the River Ayr and Garpel Water and all that remain are two abandoned mineshafts. The discharge was emanating from the No. 1 shaft and causing pollution of the Garpel Water by direct contact, and of the River Ayr by diffuse pollution. Detailed hydrogeological studies were undertaken into the nature of the discharge. The main problems to be overcome were harnessing the discharge, managing the flow and constructing the subsequent downstream wetland treatment system, all within a flood plain scenario, without further pollution of the watercourses. This paper focuses on the engineering design and physical site works involved with the capture of the mine water from within the 330 m deep mineshaft. Successful capture of the mine water was found to be critical to engineering the downstream treatment option.
Outputs	Schmolke and Drennan. (2003). Mine water capture. <i>Land Contamination and Reclamation</i> . EPP Publications.
Key personnel	Schmolke, Catriona; Drennan, Stewart Babtie Group, 95 Bothwell Street, Glasgow G2 7HX, United Kingdom
Research themes	Co-produced/mine water
Project information source	Literature

4.4 Seismicity

Projects in this category investigate the impacts of seismic events caused by coal seam gas and coal mining operations on water resources and water dependent ecosystems. No projects were found that were relevant to this category during the period January 2000 to June 2012 from the United Kingdom, China, Russia and India.

4.5 Integrity of wells - installation, operation and decommissioning

The integrity of wells during all coal seam gas phases of installation, operation and decommissioning may impact on water resources and water dependent ecosystems. Of the research into the integrity of coal seam gas wells, only one project from China was identified that related to water impacts.

4.5.1 China

Table 4.51 Project 51: Failure characteristics of surface vertical wells for relieved coal gas and their influencing factors in Huainan mining area.

Project characteristics	Details
Project title	Failure characteristics of surface vertical wells for relieved coal gas and their influencing factors in Huainan mining area
Project location	China
Principal investigator	Hongjie, Xu; Shuxun, Sang; Liangcai, Fang; Huazhou, Huang; Bo, Ren
Lead institution	School of Resources and Geoscience, China University of Mining & Technology, Key Laboratory of CBM Resource and Reservoir-Generating Process, Ministry of Education, Xuzhou 221008, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	Based on data from through-hole and logging, we studied the failure characteristics of surface drainage wells for relieved coal gas in Huainan mining area and its influencing factors. The results show that the damaged positions of drainage wells are mainly located at the thick clay layer in the low alluvium and the lithological interface in the upper section of bedrock in west mining area. The failure depth of casing is 244–670 m and concentrates at about 270–460 m deep. These damaged positions are mainly located in the bending zone according to three zones of rock layers in the vertical section above the roof divided. Generally, the casing begins to deform or damage before the face line about 30–150 m. Special formation structure and rock mass properties are the direct causes of the casing failure, high mining height and fast advancing speed are fundamental reasons for rock mass damage. However, the borehole configuration and spacing to the casing failure are not very clear.
Outputs	Hongjie et al. (2011). Failure characteristics of surface vertical wells for relieved coal gas and their influencing factors in Huainan mining area. <i>Mining Science and Technology (China)</i> .
Key personnel	Hongjie, Xu; Shuxun, Sang; Liangcai, Fang; Huazhou, Huang; Bo, Ren
Research themes	Well integrity
Project information source	Literature

4.6 Hydraulic fracturing

Hydraulic fracturing during coal seam gas operations may impact water resources and water dependent ecosystems. Research in this area includes the effects of fracking chemicals on surface and groundwater quality, and the physical impacts of fracking such as aquitard disruption and borehole collapse. Of the large amount of research available regarding hydraulic fracturing, only two projects from China focussed on the water impacts of hydraulic fracturing.

4.6.1 China

Table 4.52 Project 52: Researches on hydro-frac induced reservoir damage to anthracite coal seams of southern Qinshui Basin.

Project characteristics	Details
Project title	Researches on hydro-frac induced reservoir damage to anthracite coal seams of southern Qinshui Basin
Project location	China
Principal investigator	Li, G.F.; Meng, Z.P.; Zhang, S.A.
Lead institution	China Univ Mining Technol, Beijing
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2007
Current status	Unknown- literature output 2007
Project summary	There are over 600 CBM wells in southern Qinshui basin, which account for more than 50% of the number in China. Anthracite ranked coal seams of southern Qinshui basin feature high adsorption capacity, low pressure and low permeability, therefore, selection of hydro-frac liquid and proportion of organic additives of the liquid are the top important things of reservoir protection. As a reference for CBM practitioners, this article outlines reservoir properties of southern Qinshui basin and research achievements on mechanism of hydro-frac induced reservoir damage, characteristics and sensitivities of the damages.
Outputs	Li et al. (2007). Researches on hydro-frac induced reservoir damage to anthracite coal seams of southern Qinshui basin. <i>Progress in Mining Science and Safety Technology, Pts A and B</i> . Beijing: Science Press Beijing.
Key personnel	Li, G.F.; Meng, Z.P.; Zhang, S.A. China Univ Mining Technol, Beijing 100083, Peoples R China. Li, GF (reprint author), China Univ Mining Technol, Beijing 100083, Peoples R China.
Research themes	Co-produced/mine water, Hydraulic fracturing
Project information source	Literature

Table 4.53 Project 53: Hydraulic fracturing after water pressure control blasting for increased fracturing.

Project characteristics	Details
Project title	Hydraulic fracturing after water pressure control blasting for increased fracturing
Project location	China
Principal investigator	Huang, Bingxiang; Liu, Changyou; Fu, Junhui; Guan, Hui
Lead institution	China University of Mining and Technology
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	<p>Traditional hydraulic fracturing techniques generally form main hydraulic cracks and airfoil branch fissures, but main hydraulic cracks are relatively few in number. Hydraulic fracturing after water pressure control blasting can transform the structure of coal and rock mass. Experiments prove that it is an effective method for increasing the number and range of hydraulic cracks, as well as for improving the permeability of coal seams. The technical principle is as follows. First, a hole is drilled in the coal seam and is injected with a gel explosive (a mining water-proof explosive). Then, water is injected into the hole to seal it, at low enough pressure to prevent cracks from forming. Third, water pressure blasting is done by detonating the explosive. The water shock waves and bubble pulsations produced by the explosion cause a high strain rate in the rock wall surrounding the hole. When the stress imposed on the rock wall surrounding the hole exceeds its dynamic critical fracture strength, the surrounding rock breaks and numerous circumferential and radial fractures propagate outward. Lastly, water injection processes, such as general injection, pulse injection, and/or cyclic injection, are carried out to promote hydraulic fracturing. Depending on the fissure water pressure, detonation fissures continue to expand and additional hydraulic fractures with a wider range are formed. Under the effect of detonation pressure, joints and fissures in the coal mass open and propagate, leading to reduced adhesive forces on structural surfaces and thereby enhancing coal cutting. Therefore, this method improves the permeability of the coal seam, effectively weakens the strength of the coal and rock mass, and reduces the surrounding rock stress of the weakened area, effectively solving the problem of having a small number of big cracks. It is a useful technical approach for improving top coal caving, preventing rock burst, preventing coal and gas outbursts, and raising the gas extraction efficiency in colliery.</p>
Outputs	Huang et al. (2011). Hydraulic fracturing after water pressure control blasting for increased fracturing. <i>International Journal of Rock Mechanics and Mining Sciences</i> (1997). Elsevier, Oxford-New York, International.
Key personnel	Huang, Bingxiang; Liu, Changyou; Fu, Junhui; Guan, Hui China University of Mining and Technology, School of Mines, Jiangsu, China
Research themes	Hydraulic fracturing
Project information source	Literature

4.7 Quality and reliability of water supplies including environmental health

Coal seam gas and coal mining may impact the quality and reliability of water supplies both during operation and long after decommissioning. Research projects into this area include mine site and gas field remediation, the long term impacts of mines and coal seam gas operations, contamination due to chemical use and salt and heavy metal management. There is significant overlap with research into R3 co-produced/mine water (section 4.3). All of the countries were involved with research projects with the primary theme of R7 quality and reliability of water supplies, including environmental health, with six projects from China, six projects from India, one from Russia and five from the United Kingdom.

4.7.1 China

Table 4.54 Project 54: Optimum combination studies on water drainage-supply and eco-environment protection in the Coal Basin of North China.

Project characteristics	Details
Project title	Optimum combination studies on water drainage-supply and eco-environment protection in the Coal Basin of North China
Project location	China
Principal investigator	Qiang Wu
Lead institution	China University of Mining & Technology (Beijing)
Project budget	410 000 Yuan
Source of funding	National Natural Science Foundation of China (No.40772162)
Project duration	2008-2010
Current status	Completed
Project summary	<p>This project presents firstly a new idea of optimum combination among water drainage, water supply and eco-environment protection. It overcomes an in-stable difficulty of water supply, caused by changeable water drainage, for the whole combination system. The new idea does not only consider a management of hydraulic techniques but also think over restraints in economy, society, ecology, environment and industrial structural adjustments, etc.</p> <p>The program breaks through traditional closed situation among departments of water drainage, water supply and eco-environment protection, and makes the different department's works done at same time step.</p> <p>This study, therefore, can avoid quite a lot of repeated works for the departments from geological survey to specific evaluation calculations, save a large amount of national investments, and raise the calculation precision for the whole combination system.</p>
Objectives	Efficient solutions for the contradiction among water drainage, water supply and eco-environment protection are thought to maintain long-term dynamic balance between input and output for the ground water basins, and to try to raise resource utilization levels of the mine-water. All solutions have to guarantee eco-environment quality for the basins.
Achievements	In this study, a groundwater management model of a coal mining area is developed to optimize mine drainage, water supply and environmental protection. New model is applied to search for the optimal management scheme

Project characteristics	Details
	at a typical site of the Jiaozuo coal mining district in North China. In the study area, multilayered, porous and karstic aquifers are connected hydraulically in the vertical direction, which is a typical hydrogeological characteristic of mines in the coal basin of North China. The optimal scenario identified from the case study is comprehensive and applicable.
Outputs	Qiang Wu, Bill X. Hu, Li Wan, Chunmiao Zheng (2010). "Coal Mine Water Management: Optimization Models and Field Application in North China", <i>Hydrological Sciences Journal</i> , 55(4),P609-623.
Key personnel	Qiang Wu
Research themes	Aquifer connectivity, disruption of surface water flow pathways, co-produced/mine water, well integrity, water supplies, water dependent ecosystems
Project information source	Survey

Table 4.55 Project 55: Environment impact assessment of open-pit coal mining in Huolinhe Coal Mine district.

Project characteristics	Details
Project title	Environment impact assessment of open-pit coal mining in Huolinhe Coal Mine district
Project location	China
Principal investigator	Dong, Bao Yan
Lead institution	China University of Mining and Technology (People's Republic of China)
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2000
Current status	Unknown- literature output 2000
Project summary	Based on the analysis of the method of coal environment impact assessment at home and abroad, the impacts and deterioration on the grassland, soil, water and air induced by the exploitation of Huolinhe Mining Area are objectively evaluated in this paper. Especially the situation of soil erosion of the solid waste by weather beaten in the dumps is deeply studied. It is considered as a very useful approach to develop the ecoenvironment area by the combining the three links of "Tree Grass mine" into a whole in the grassland mining environment such as Huolinhe mining Area for coal mine environment protection.
Outputs	Dong (2000). Environment impact assessment of open-pit coal mining in Huolinhe Coal Mine district. Ann Arbor: China University of Mining and Technology (People's Republic of China).
Key personnel	Dong, Bao Yan
Research themes	Water supplies
Project information source	Literature

Table 4.56 Project 56: Contamination of the environmental ecosystems by trace elements from mining activities of Badao Bone Coal Mine in China.

Project characteristics	Details
Project title	Contamination of the environmental ecosystems by trace elements from mining activities of Badao Bone Coal Mine in China
Project location	China
Principal investigator	Fang, W.X.; Huang, Z.Y.; Wu, P.W.
Lead institution	Open Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, 73 Guanshui Road, 550002, Guiyang, People's Republic of China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2003
Current status	Unknown- literature output 2003
Project summary	Bone coal, as a main mining object, can be used by local inhabitants as daily fuel and by local industrial enterprises as industrial fuel in Pinglin County, Shaanxi Province, China. This study reports how the environmental ecosystems have been polluted around the Badao bone coal mine. Geochemical samples (e.g. rock, water, soil, edible plant and animal) were collected. Bone coal from the Badao mine contains Se up to 75 $\mu\text{g/g}$ Se and 28 $\mu\text{g/g}$ Se in ashes after its combustion, with higher contents of other trace elements. Bone coal and its ash seem to be the main geochemical source of trace elements in soils and plants, which may cause contamination of the local environmental ecosystems. Three ways by which soils have been contaminated by these trace elements derived from bone coal are proposed in this paper. Radishes and beans have the ability to accumulate Mo and Se from soils. There is no obvious difference in concentrations of Cu, Cr and F in each plant from the two areas.
Outputs	Fang et al. (2003). Contamination of the environmental ecosystems by trace elements from mining activities of Badao bone coal mine in China. <i>Environmental Geology</i> . Springer-Verlag, < http://link.springer.de/link/service/journals/00254/bibs/3044_004/30440373.htm >
Key personnel	Fang, W.X.; Huang, Z.Y.; Wu, P.W. Open Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, 73 Guanshui Road, 550002, Guiyang, People's Republic of China, fangwuxuan@163.net
Research themes	Water supplies
Project information source	Literature

Table 4.57 Project 57: Land reclamation and ecological reconstruction in resource-exhausted mining areas.

Project characteristics	Details
Project title	Land reclamation and ecological reconstruction in resource-exhausted mining areas
Project location	China
Principal investigator	Fu, MeiChen; Zeng, Hui; Zhang, HongJie; Shi, LiPing
Lead institution	School of Land Science and Technology, China University of Geosciences (Beijing), Beijing 100083, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	Resource-exhausted mining areas are faced with an arduous task of ecological restoration. The previous studies show that the coal-based mining cities in China are mainly distributed in the middle and west parts, but the resource-exhausted mining areas are mainly in the middle and east parts. The resource-exhausted mining areas are related with different types of mineral resources, mining methods, natural conditions and production activities of "mining, dressing and smelting", which may cause various land damage types, such as, occupation, destroy, subsidence and pollution. In view of different land reclamation approaches, this paper proposes various ecological restoration programs of reclaiming damage land for the use of rural ecological agriculture, suburban wetland parks/country parks, mine parks, etc. Based on experiences both at home and abroad about land reclamation and ecological restoration in mining areas, various ecological restoration techniques are analyzed. Cropland restoration technique is to restore and construct reclaimed cropland landscape. Water resources restoration technique is to restore river system and microclimate for water cycle, and to use mine water for multi-purposes. Wetland restoration technique is to restore and create soil landscape and surface vegetation landscape, and to reconstruct road system and connect it with surrounding landscapes, and to protect and restore mining heritages. Water body restoration technique is to purify gathered water in subsidence, and to restore gathered water surface, and to allocate animals/vegetations. Village restoration technique is to protect and plan feature villages, with architecture/infrastructure. Mountain ridge restoration technique is to restore mountain ridge ecological corridors, and to restore and recover natural vegetations in mountains. And forest land restoration technique is to select and layout forest land, and to plan tree species, and to test and build anti-drought vegetation in abandoned coal waste pileups. With scientific planning and timely and effective treatment, not only the ecological environment in resource-exhausted mining areas can be restored but also a new economic growth point for sustainable development can be created in mining areas.
Outputs	Fu et al. (2009). Land reclamation and ecological reconstruction in resource-exhausted mining areas. <i>Science & Technology Review</i> .
Key personnel	Fu, MeiChen; Zeng, Hui; Zhang, HongJie; Shi, LiPing School of Land Science and Technology, China University of Geosciences (Beijing), Beijing 100083
Research	Surface water, water dependent ecosystems

Project characteristics	Details
themes	
Project information source	Literature

Table 4.58 Project 58: Mobility of heavy metals associated with the natural weathering of coal mine spoils.

Project characteristics	Details
Project title	Mobility of heavy metals associated with the natural weathering of coal mine spoils
Project location	China
Principal investigator	Dang, Zhi; Liu, Congqiang; Haigh, Martin J.
Lead institution	South China University of Technology
Project budget	Unknown
Source of funding	National Natural Scientific Foundation of China (Grant No. 49873033), National Climbing Program (Grant No. 95-P-39), Earthwatch Europe Branch
Project duration	Unknown- literature output 2002
Current status	Unknown- literature output 2002
Project summary	Knowledge of chemical mobility of heavy metals is fundamental to understanding their toxicity, bioavailability, and geochemical behavior. In this paper, two different methods, i.e. mineralogical means and sequential extractions, were employed to analyze the total contents, existing states, and chemical forms of heavy metals in coal mine spoils. The results demonstrate that the mobility of heavy metals in coal mine spoils depends not only on their existing states and the stability of their host minerals but also on the properties of the coal mine spoils. In the process of coal mine spoils–water interaction, sulfides that contain heavy metals first break down and release metals, which are then adsorbed and complexed by the iron oxyhydroxide colloid resulting from pyrite oxidization and organic matter. During the natural weathering of coal mine spoils, only a small fraction of these metals are released to the environment, and most of them still remains in the residual material
Outputs	Dang et al. (2002). Mobility of heavy metals associated with the natural weathering of coal mine spoils. <i>Environmental Pollution</i> .
Key personnel	Dang, Zhi; Liu, Congqiang; Haigh, Martin J.
Research themes	Water supplies
Project information source	Literature

4.7.2 India

Table 4.59 Project 59: Environmental concerns associated with coal mining activity - a case study.

Project characteristics	Details
Project title	Environmental concerns associated with coal mining activity - a case study
Project location	India
Principal investigator	Kumar, G.; Singh, P.K.; Deepak, Kumar
Lead institution	BIT Sindri, Dhanbad - 828 123 (Jharkhand), India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	<p>The Chasnalla block within the Jharia Basin is specially important for the coal mining activities. Consequence of mining activities involving drilling, blasting, crushing, transportation of coal etc. are the major concern for environmental pollution in the area. Mining and associated activities affect air, noise and water environment and degrades land and drainage system of the area. The extent of land degradation varies and is influenced by the topography of the area, geology, soil texture and method of mining. Damaged land adversely affects watershed and its drainage pattern, vegetation and biomass. To assess the impact of mining operation on different components of environment, monitoring of air, water, noise and soil environment as per TOR has been carried out at different pre-selected sites. Meteorological parameters are also regularly monitored at the selected site. Overall evaluation damage due to mining activity presents the qualitative result of the existing condition with and without EMP. The net environmental changes arising out of proposed mining is beneficial with the guidelines of EMP. To mitigate the adverse impacts caused due to coal mining operation at Chasnalla OCP and for overall scientific development of local habitat, Environmental Management Plan (EMP) has been formulated. The EMP is based on the base line environmental status, mining methodology and environmental impact assessment. The EMP has prescribed environmental monitoring and implementation of environmental protection measures during and after mining operations. In this paper, all technical, biological and socio-economic aspects are discussed and likely control measures are suggested in connection with air, water, noise and land and biological environment, socio-economic measures, EMP implementation and monitoring.</p>
Outputs	Kumar et al. (2009). Environmental concerns associated with coal mining activity - a case study. <i>International Journal of Chemical Sciences</i> .
Key personnel	Kumar, G.; Singh, P.K.; Deepak, Kumar BIT Sindri, Dhanbad - 828 123 (Jharkhand), India.
Research themes	Co-produced/mine water, water dependent ecosystems
Project information source	Literature

Table 4.60 Project 60: Hydrogeochemistry, elemental flux, and quality assessment of mine water in the Pootkee-Balihari Mining Area, Jharia Coalfield, India.

Project characteristics	Details
Project title	Hydrogeochemistry, elemental flux, and quality assessment of mine water in the Pootkee-Balihari Mining Area, Jharia Coalfield, India
Project location	India
Principal investigator	Singh, A. K.; Mahato, M. K.; Neogi, B.; Mondal, G. C.; Singh, T. B.
Lead institution	Central Institute of Mining and Fuel Research, Dhanbad 826015, Bihar, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	Ninety nine mine water discharge samples were collected and analyzed for pH, electrical conductivity (EC), major cations, anions, and trace metals in the Pootkee-Balihari coal mining area of the Jharia coalfield. The mines of the area annually discharge 34.80×10^6 m ³ of mine water and 39,099 t of solute loads. The pH of the analyzed mine waters ranged from 6.97 to 8.62. EC values ranged from 711 μ S cm ⁻¹ to 1862 μ S cm ⁻¹ , and reflect variations in lithology, geochemical processes, and hydrological regimes in the mines. The cation and anion chemistry indicate the general ionic abundance as: Mg(2+) > Ca(2+) > Na(+) > K(+) and HCO ₃ (-) > SO ₄ (2-) > Cl(-) > NO ₃ (-) > F(-), respectively. Elevated SO ₄ (2-) concentrations in the Gopalichuck, Kendwadiah, and Kachhi-Balihari mine waters are attributed to pyrite weathering. The water quality assessment indicated that TDS, hardness, Mg(2+), and SO ₄ (2-) are the major parameters of concern in the study area. Except for Fe, all of the measured metals in the mine water were well within the levels recommended for drinking water. With only a few exceptions, the mine water is of good to permissible quality and suitable for irrigation.
Outputs	Singh et al. (2011). Hydrogeochemistry, Elemental Flux, and Quality Assessment of Mine Water in the Pootkee-Balihari Mining Area, Jharia Coalfield, India. <i>Mine Water and the Environment</i> .
Key personnel	Singh, A. K.; Mahato, M. K.; Neogi, B.; Mondal, G. C.; Singh, T. B. [Singh, Abhay Kumar; Mahato, Mukesh K.; Neogi, Babita; Mondal, G. C.; Singh, T. B.] CSIR, Cent Inst Min & Fuel Res, Dhanbad 826015, Bihar, India. Singh, AK (reprint author), CSIR, Cent Inst Min & Fuel Res, Barwa Rd, Dhanbad 826015, Bihar, India. singhak.c
Research themes	Co-produced/mine water, water dependent ecosystems
Project information source	Literature

Table 4.61 Project 61: Study of dissolved arsenic in ground and surface waters of the Rawanwara colliery area of Pench Valley coal field (M.P.) and its impact on human health.

Project characteristics	Details
Project title	Study of dissolved arsenic in ground and surface waters of the Rawanwara colliery area of Pench Valley coal field (M.P.) and its impact on human health
Project location	India
Principal investigator	Singh, A. K.
Lead institution	Ganga Pollution Monitoring Project, Department of Geology, Patna University, Patna-5 Bihar, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2000
Current status	Unknown- literature output 2000
Project summary	In trace amount, arsenic (As) is an essential trace element for humans but toxic at higher concentration. A study has been carried out to assess the source of dissolved As in ground and surface waters of the Pench Valley coalfield. The study of data reveals that the concentration of dissolved As varies from 0.067 ppm to 0.580 ppm. The concentrations of dissolved As in waters were compared with drinking water specification laid down by ISI : 10500 (1983) to assess the toxicity limits. The majority of samples were found below the permissible level.
Outputs	Singh (2000). Study of dissolved arsenic in ground and surface waters of the Rawanwara colliery area of Pench Valley coal field (M.P.) and its impact on human health. <i>Journal of Environment and Pollution</i> .
Key personnel	Singh, A. K. Ganga Pollution Monitoring Project, Department of Geology, Patna University, Patna-5 Bihar, India
Research themes	Co-produced/mine water, Water supplies
Project information source	Literature

Table 4.62 Project 62: Geo-environmental quality assessment in Jharia coalfield, India, using multivariate statistics and geographic information system.

Project characteristics	Details
Project title	Geo-environmental quality assessment in Jharia coalfield, India, using multivariate statistics and geographic information system
Project location	India
Principal investigator	Sarkar, B. C.; Mahanta, B. N.; Saikia, K.; Paul, P. R.; Singh, G.
Lead institution	Indian Sch Mines, Dhanbad 826004, Bihar, India. Cent Mine Planning & Design Inst Ltd, Dhanbad 826005, Jharkhand, India.
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2007
Current status	Unknown- literature output 2007
Project summary	A study on geo-environmental quality assessment in Jharia coalfield, India, has been attempted using multivariate statistical analysis and geographic information system (GIS) modelling techniques. Water quality index, calculated for each sample network station in the study area to assess the suitability of water for human consumption, revealed very poor to poor quality surface water and mine water. Air quality indexing indicated that there is no sample station with clean air as per the Indian standards, which indicate the hazardous air quality. Multi-criteria evaluation (MCE), a potential GIS tool, has been applied to the delineation of various degrees of stressed villages in terms of quality of life (QoL). The role of various geo-environmental parameters such as quality of groundwater, surface water, mine water and air together with village population densities has been emphasized for delineation of the environmentally stressed villages in Jharia coalfield. The integrated cluster analysis and MCE approach provide an improved means to geo-environmental quality assessment in Jharia coalfield in terms of QoL. The assessment study is aimed to be used for future coal mining, ensuring ecologically sustainable industrial development, particularly in a coalfield.
Outputs	Sarkar et al. (2007). Geo-environmental quality assessment in Jharia coalfield, India, using multivariate statistics and geographic information system. <i>Environmental Geology</i> .
Key personnel	Sarkar, B. C.; Mahanta, B. N.; Saikia, K.; Paul, P. R.; Singh, G. Indian Sch Mines, Dhanbad 826004, Bihar, India. Cent Mine Planning & Design Inst Ltd, Dhanbad, Jharkhand, India.
Research themes	Co-produced/mine water, water supplies
Project information source	Literature

Table 4.63 Project 63: Impact of coal mine effluent on physico-chemical characteristics of pond water in coalfield area of Godda District, Jharkhand.

Project characteristics	Details
Project title	Impact of coal mine effluent on physico-chemical characteristics of pond water in coalfield area of Godda District, Jharkhand
Project location	India
Principal investigator	Mandal, N. K.; Verma, P. K.
Lead institution	Life Science Research Laboratory, Godda College, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2002
Current status	Unknown- literature output 2002
Project summary	The investigation highlights the effects of coal mine effluent on the physico-chemical environment of a fish pond, located in Lalmatia coal mine area of Godda district under Santal Pargana division of Jharkhand. The analysis of water revealed very low transparency (6.5 - 10.0 cm), higher concentration of total suspended solids (650 - 900 ppm), alkaline medium (pH 7.2 - 7.6), low dissolved oxygen (4.6 - 6.0 ppm) and low hardness (10.0 - 14.5 ppm). Besides, higher concentrations of chloride (61.0 - 68.0 ppm), sulphate (13.5 - 26.0), phosphate (0.71 - 0.94 ppm) and nitrate (0.60 - 0.79 ppm) revealed an organic loading to the pond, induced by mine effluent, cattle dumping and various human activities. Mine effluent was characterized by alkaline medium and poor dissolved oxygen content. Parameters like total suspended solids, chloride, sulphate, phosphate and nitrate were remarkably higher. Suspended particulate matter in the effluent and coal dust particles appeared to be the primary factors in destroying the biota mainly algae, macrophytes and benthic community of the pond. The mine effluent is causing a severe degradation of water quality along with biotic components and upsetting the ecological balance of the pond. The prevailing conditions adversely affect the fish production. Water has been rendered unfit for recreational and domestic purposes. Effective measures have been suggested to check the mine effluent pollution and the ecological degradation of the pond.
Outputs	Mandal and Verma. (2002). Impact of coal mine effluent on physico-chemical characteristics of pond water in coalfield area of Godda District, Jharkhand. <i>Nature, Environment and Pollution Technology</i> .
Key personnel	Mandal, N. K.; Verma, P. K. Life Science Research Laboratory, Godda College, Godda-814 133, Jharkhand, India
Research themes	Co-produced/mine water, Water supplies
Project information source	Literature

Table 4.64 Project 64: Biomonitoring of water quality in coal mining areas of Meghalaya, India.

Project characteristics	Details
Project title	Biomonitoring of water quality in coal mining areas of Meghalaya, India
Project location	India
Principal investigator	Prof. O. P. Singh
Lead institution	North-Eastern Hill University
Project budget	Rs.5,58,000.00
Source of funding	GB Pant Institute of Himalayan Environment and Development Ministry of Environment and Forests Government of India
Project duration	2002-2005
Current status	Completed
Project summary	<p>The coal is one of the extensively utilized minerals in Meghalaya. Though coal deposit in the state is found all along the southern fringe of Shillong plateau, Jaintial Hills District is a major producer of coal.</p> <p>Coal extraction is done by primitive mining method commonly known as 'rat-hole' mining. Most of the mining activities are small scale ventures controlled by individuals who own the land. Mining operation, undoubtedly has brought wealth and employment opportunity in the area, but simultaneously has led to extensive environmental degradation and disruption of traditional values in the society.</p> <p>The water bodies of the area are the greatest victims of the coal mining. Pollution of the water is evident by the colouration of water which in most of the rivers and streams in the mining area varies from brownish to reddish orange. Low pH (between 2-3), high electrical conductivity, high concentration of ions of sulphate and iron and toxic heavy metals, low dissolved oxygen (DO) and high BOD are some of the physico-chemical and biological parameters which characterize the degradation of water quality.</p> <p>Contamination of Acid Mine Drainage (AMD) originating from mines and spoils, leaching of heavy metals, organic enrichment and silting by coal and sand particles are major causes of degradation of water quality in the area.</p>
Objectives	To investigate the environmental impact of coal mining on water and associated problems including adverse impacts on aquatic biota of the area.
Achievements	Data on physico-chemical parameters of water quality showing degradation of water bodies in Jaintia Hills, Meghalaya
Outputs	<p>Sumarlin Swer and O. P. Singh, Status Of Water Quality In Coal Mining Areas Of Meghalaya, India, <i>Proceedings of the National Seminar on Environmental Engineering with special emphasis on Mining Environment</i>, NSEEME-2004, 19-20, March 2004; Eds. Indra N. Sinha, Mrinal K. Ghose & Gurdeep Singh</p> <p>Sumarlin Swer and O.P. Singh, "Coal Mining Impacting Water Quality And Aquatic Biodiversity In Jaintia Hills District Of Meghalaya", <i>ENVIS Bulletin</i> Vol 11(2):26-33.</p>
Key personnel	O. P. Singh
Research themes	<ul style="list-style-type: none"> • Disruption of surface water flow pathways - subsidence • Quality and reliability of water supplies including environmental health - long term impacts, including, timescales for water levels to return to pre-development levels (quality/quantity). • Cumulative impact assessments.

Project characteristics	Details
Project information source	Survey

4.7.3 Russia

Table 4.65 Project 65: Chemical composition of waters on the Pavlovsky coal quarry (Far East Russia) and surrounding areas.

Project characteristics	Details
Project title	Chemical composition of waters on the Pavlovsky coal quarry (Far East Russia) and surrounding areas
Project location	Russia
Principal investigator	Chudaev, O. V.; Chudaeva, V. A.; Yurcheko, S. G.
Lead institution	Far East Geol. Inst., FEB RAS, Vladivostok, Russia
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2003
Current status	Unknown- literature output 2003
Project summary	The open exploration of the Pavlovsky coal deposit which is one of the biggest in the Primorsky region (Far East Russia), has contributed to some pollution of the ground, surface, and underground waters on the Pavlovsky Coal Quarry (Far East Russia) and surrounding areas. Based on the analysis of the available hydrogeochemical data on the Pavlovsky deposit. These data include the turbidity which is in three sites of the lake (toward the exit to the river) varied insignificantly - 15.9-16.8-13.1 mg/L., Main ions and organic matter consist of sulphate, chlorine, dissolved nitrogen, dissolved phosphorus, microelements. (- Zn and Cu-), aluminum, strontium, lithium, boron, chrome, iron and manganese. From these data we draw conclusions that the action of the coal quarry is still less to the drainage system of the Razdolnaya River. The main ecological problem connected with the coal mining in this district is a significant drop of the underground water level because of the pumping-out and disturbance of the natural flow of the supra-coal water-bearing horizon resulting in mixing of waters of different composition and change of chemical composition of water-bearing horizon. This may effect not only the Abramovka River waters, located in the immediate vicinity, but the removed objects including Khanka Lake, when underground water discharged onto the lake floor.
Outputs	Chudaev et al. (2003). Chemical composition of waters on the Pavlovsky coal quarry (Far East Russia) and surrounding areas. <i>Proceedings of the 2003 International Symposium on Water Resources and the Urban Environment, November 9, 2003 - November 10, 2003</i> . Wuhan, China: China Environmental Science Press.
Key personnel	Chudaev, O. V.; Chudaeva, V. A.; Yurcheko, S. G. Far East Geol. Inst., FEB RAS, Vladivostok 690022, Russia
Research themes	Water supplies, water dependent ecosystems
Project information source	Literature

4.7.4 United Kingdom

Table 4.66 Project 66: Abandoned mines and the water environment in the UK.

Project characteristics	Details
Project title	Abandoned mines and the water environment in the UK
Project location	United Kingdom
Principal investigator	Hugh Potter, Environment Agency
Lead institution	Environment Agency, United Kingdom
Project budget	N/A – internally funded
Source of funding	Department of Energy & Climate Change and Department of the Environment, Food and Rural Affairs, United Kingdom
Project duration	2007-2009
Current status	Completed
Project summary	Abandoned mines are one of the most significant pollutant threats in the UK. This project involved the prioritisation of the UK rivers most impacted by mining and the development of a national remediation strategy. This project contributed towards the work being undertaken to achieve the requirements of the Water Framework Directive (WFD) in the UK.
Objectives	Identification of mine water discharges
Achievements	Assessment of local impacts to rivers and other water features associated with these mine water discharges, both with respect to water quality, sediment quality and ecosystem health.
Outputs	Characterise the scale of the impacts of mining on the water environment at the regional and national level.
Key personnel	Hugh Potter and Ian Watson
Research themes	Water supplies, water dependent ecosystems, co-produced/mine water, mitigation measures
Project information source	Survey

Table 4.67 Project 67: Model development for river restoration.

Project characteristics	Details
Project title	Model development for river restoration
Project location	United Kingdom
Principal investigator	Bockelmann, B. N.
Lead institution	The University of Wales College of Cardiff (United Kingdom)
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2003
Current status	Unknown- literature output 2003
Project summary	At present, very little information is available about the design and maintenance of 'natural' river restoration schemes, combining both hydraulic, morphological and ecological conditions. This combined field and numerical modelling study sought to redress this situation. A unique data set, containing hydraulic, substrate and ecological parameters was collected over a three-year period for a 3 km meandering section of the Afon Morlais. The reach as investigated commencing immediately after it had been reinstated over a disused open cast coal mine in West Wales, UK, with the aim being to evaluate the overall success of the restoration scheme and for calibration and validation of the ecohydraulic and hydro-morphodynamic model developed in this study. Surveying results showed that the river bed was stable and chemical data analysis indicated that the water quality was good. Macroinvertebrates were collected and taxa also showed good water quality, characterised by a slightly lower diversity than in an upstream "natural" reference reach. Two computer modelling tools were used and further developed to investigate the dependence of habitat creation on hydro-morphodynamic factors. Firstly, the one dimensional HECRAS model was used for predicting velocities and water depths longitudinally. An additional program was developed to determine the necessary sediment size to prevent the initiation of sediment motion. Secondly, the Research Centre's two dimensional finite difference model DIVAST was applied to several meanders, taking account of the cross-sectional velocity and depth distributions. A curvilinear computational mesh was applied, which allowed an ideal application to narrow meandering river bathymetries. DIVAST was then linked with the stream ecology, through macroinvertebrate suitability criteria and river bed changes were predicted with the model. The developed modelling tools enabled habitat predictions to be made and addressed current design guidelines for enhanced recolonisation processes in river regeneration projects.
Outputs	Bockelmann. (2003). Model development for river restoration. Ann Arbor: The University of Wales College of Cardiff (United Kingdom).
Key personnel	Bockelmann, B. N.
Research themes	Co-produced/mine water, Water supplies, Water dependent ecosystems
Project information source	Literature

Table 4.68 Project 68: Predicting temporal changes in total iron concentrations in groundwaters flowing from abandoned deep mines: A first approximation.

Project characteristics	Details
Project title	Predicting temporal changes in total iron concentrations in groundwaters flowing from abandoned deep mines: A first approximation
Project location	United Kingdom
Principal investigator	Younger, Paul L.
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2000
Current status	Unknown- literature output 2000
Project summary	<p>Discharges of contaminated groundwater from abandoned deep mines are a major environmental problem in many parts of the world. While process-based models of pollutant generation have been successfully developed for certain surface mines and waste rock piles of relatively simple geometry and limited areal extent, such models are not readily applicable to large systems of laterally extensive, interconnected, abandoned deep mines. As a first approximation for such systems, hydrological and lithological factors, which can reasonably be expected to influence pollutant release, have been assessed by empirically assessing data from 81 abandoned deep coal mine discharges in the UK. These data demonstrate that after flooding of a deep mine is complete and groundwater begins to migrate from the mine voids into surface waters or adjoining aquifers, flushing of the mine voids by fresh recharge results in a gradual improvement in the quality of groundwater (principally manifested as decreasing Fe concentrations and stabilization of pH around 7). Alternative representations of the flushing process have been examined. While elegant analytical solutions of the advection-dispersion equation can be made to mimic the changes in iron concentration, parameterization is tendentious in practice. Scrutiny of the UK data suggest that to a first approximation, the duration of the main period of flushing can be predicted to endure around four times as long as the foregoing process of mine flooding. Short- and long-term iron concentrations (i.e. at the start of the main period of flushing and after its completion, respectively) can be estimated from the sulphur content of the worked strata. If strata composition data are unavailable, some indication of pollution potential can be obtained from considerations of the proximity of worked strata to marine beds (which typically have high pyrite contents). The long-term concentrations of iron in a particular discharge can also be approximated on the basis of the proximity of the discharge location to the outcrop of the most closely associated coal seam (MCACS) and, thus, to zones of possible ongoing pyrite oxidation. The practical application of these simple predictive techniques is facilitated by means of a flowchart.</p>
Outputs	Younger. (2000). Predicting temporal changes in total iron concentrations in groundwaters flowing from abandoned deep mines: A first approximation. <i>Journal of Contaminant Hydrology</i> . Amsterdam, Netherlands: Elsevier Science Publishers B.V.
Key personnel	Younger, Paul L.
Research themes	Water supplies, water dependent ecosystems

Project characteristics	Details
Project information source	Literature

Table 4.69 Project 69: Pollution of the Permian limestone aquifer by rebounding coal measures groundwater, Co Durham, England.

Project characteristics	Details
Project title	Pollution of the Permian limestone aquifer by rebounding coal measures groundwater, Co Durham, England
Project location	United Kingdom
Principal investigator	Williams, R.
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2001
Current status	Unknown- literature output 2001
Project summary	Unknown
Outputs	Williams. (2001). Pollution of the Permian limestone aquifer by rebounding coal measures groundwater, Co Durham, England. <i>Department of Civil Engineering</i> . University of Newcastle.
Key personnel	Williams, R.
Research themes	Water supplies
Project information source	Literature

Table 4.70 Project 70: Evaluating the potential impact of opencast coal mining on water quality (Groundwater Regulations 1998).

Project characteristics	Details
Project title	Evaluating the potential impact of opencast coal mining on water quality (Groundwater Regulations 1998)
Project location	United Kingdom
Principal investigator	Younger, Paul, L.; Sapford, Devin, J.
Lead institution	University of Newcastle
Project budget	Unknown
Source of funding	Scottish Environment Protection Agency (SEPA)
Project duration	Unknown- literature output 2004
Current status	Unknown- literature output 2004
Project summary	The European Directive on Groundwater (80/68/EEC) was fully transposed into Scottish law by the introduction of the Groundwater Regulations 1998. These regulations forbid the introduction of certain substances (denoted as "List I substances") into groundwater.
Outputs	Younger and Sapford. (2004). Evaluating the potential impact of opencast coal mining on water quality (Groundwater Regulations 1998). University of Newcastle Upon Tyne.
Key personnel	Younger, Paul, L.;Sapford, Devin, J. Professor Paul Younger
Research themes	Scottish Environment Protection Agency (SEPA), water supplies
Project information source	Literature

4.8 Water dependent ecosystems

This section outlines projects researching the impact of coal seam gas and coal mining on water dependent ecosystems, such as streams, rivers, floodplains, wetlands, GDEs and peat swamps. This may include response and tolerances of water dependent ecosystems to changes in water regimes (quantity, seasonal patterns, variability, interactions) and water quality; measures for mitigating impacts and monitoring techniques. Ten (10) projects were identified with the primary theme of water dependent ecosystems, with representation from all countries.

4.8.1 China

Table 4.71 Project 71: The distribution of trace elements in various peat swamps of the No. 11 coal seam from the Antaibao Mine, Ningwu coalfield, China.

Project characteristics	Details
Project title	The distribution of trace elements in various peat swamps of the No. 11 coal seam from the Antaibao Mine, Ningwu coalfield, China
Project location	China
Principal investigator	Wang, Jinxi; Deng, Xiaoli; Kalkreuth, W.
Lead institution	Hebei University of Engineering, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	Twenty-one coal samples obtained from the Antaibao Mine, Ningwu coalfield, China, were analyzed for 46 trace elements by Inductively Coupled Plasma-Mass Spectrometer (ICP-MS), and the macerals were identified and coal facies were defined by microscopic method. Compared with the average content of trace element in the No. 11 coal, the dry forest swamp is rich in some elements (Sc, V, Cr, Ni, Cu, Zn, Rb, Sr, Nb, Mo, Cd, Sb, Cs, Ba, Ta, W, Tl, Bi, Th, U, Zr, Hf and REE). Since the provenance is dominated by the terrigenous clastic, most of the trace elements were associated with terrigenous clastic and clay. The wet forest swamp contained lower concentrations in some elements (V, Cr, Ni, Zn, Ga, Rb, Nb, Mo, Cd, Cs, Ba, Ta, W, Re, Bi, Th, U, Zr and Hf) because the elements were influenced by sea water. The low swamp was enriched in REE because of the influences of both terrigenous environment and sea water.
Outputs	Wang et al. (2011). The distribution of trace elements in various peat swamps of the No. 11 coal seam from the Antaibao Mine, Ningwu coalfield, China. <i>Energy Exploration & Exploitation</i> . Multi-Science Publishing Co. Ltd.
Key personnel 1	Wang, Jinxi; Deng, Xiaoli; Kalkreuth, W. Key Laboratory of Resource Exploration Research of Hebei Province, Hebei University of Engineering, Guangmingnan Street, Handan, Hebei 056038, China
Research themes	Co-produced/mine water, water dependent ecosystems
Project information source	Literature

Table 4.72 Project 72: Ecological risk assessment of open coal mine area.

Project characteristics	Details
Project title	Ecological risk assessment of open coal mine area
Project location	China
Principal investigator	Ma, XiJun; Lu, ZhaoHua; Cheng, JianLong
Lead institution	Institute of Restoration Ecology, China University of Mining & Technology, Beijing 100083, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	The coal mine areas in China have the serious conflicts between resources exploitation and ecology safety, therefore the coal mine ecological risk assessment is an important problem which relates to the sustainability of coal mines to regions and the whole country. In this study, open coal mine area serves as researching object, heavy metals, soil erosion and coast are screened out as risk resources, soil wireworm as the receiver of heavy metals risk, biotope ecosystem as the receiver of soil erosion and coast risk; ecological indexes are calculated with species background index, biological diversity index and natural degree index, ecological friability indexes are calculated with soil fertility index, plant coverage, plant species diversity index, soil wireworm index and maturity index, and the typical coal mine area assessment indexes system is established. In addition, the regional ecological risk assessment is conducted on the friable ecological system of Fuxin Haizhou open coal mine area. Examples are researched of Haizhou open coal mine, the coal mine risk distribution is established, and foundations are provided for the administrative decision-making.
Outputs	Ma et al. (2008). Ecological risk assessment of open coal mine area. <i>Environmental Monitoring and Assessment</i> .
Key personnel	Ma, XiJun; Lu, ZhaoHua; Cheng, JianLong Institute of Restoration Ecology, China University of Mining & Technology, Beijing 100083, China
Research themes	Co-produced/mine water, water dependent ecosystems
Project information source	Literature

Table 4.73 Project 73: Effect of coal exploitation on groundwater and vegetation in the Yushenfu Coal Mine.

Project characteristics	Details
Project title	Effect of coal exploitation on groundwater and vegetation in the Yushenfu Coal Mine
Project location	China
Principal investigator	Wang, Li; Wei, San-Ping; Wang, Quan-Jiu
Lead institution	Institute of Soil and Water Conservation, Northwest A and F University, Yangling 712100, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	Based on an overview of ecological fragility of Yushenfu Coal Mine and the significance of exploitation in China's national economy development, present situation of ecological environment in mining areas, basic characteristics of groundwater, effects of coal exploitation on groundwater and vegetation and relationship between groundwater and vegetation were illuminated. It shows that groundwater resource is an important factor that keeps the ecosystem sustainable development of Yushenfu Coal Mine. And the destroy of groundwater caused by coal exploitation will have adverse effects on vegetation restoration and reconstruction in coal mine. Lastly, some issues of research on groundwater and vegetation were put forward, and the further study and its meanings were stated.
Outputs	Wang et al. (2008). Effect of coal exploitation on groundwater and vegetation in the Yushenfu Coal Mine. <i>Meitan Xuebao/Journal of the China Coal Society</i> . Hepingli, Beijing, 100013, China: China Coal Society.
Key personnel	Wang, Li; Wei, San-Ping; Wang, Quan-Jiu Institute of Soil and Water Conservation, Northwest A and F University, Yangling 712100, China
Research themes	Co-produced/mine water, water supplies, water dependent ecosystems
Project information source	Literature

Table 4.74 Project 74: Influence of coal gas on atmosphere environment and its countermeasures.

Project characteristics	Details
Project title	Influence of coal gas on atmosphere environment and its countermeasures
Project location	China
Principal investigator	Jienan, Pan
Lead institution	School of Resources Environment, Henan Polytechnic University
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2009
Current status	Unknown- literature output 2009
Project summary	China is a country with high coal production and consumption. Being the main energy resource of China, coal has provided a reliable energy supply for the sustainable development of the countries national economy. Coal in China has made a great contribution for the national economic development, but it has also caused a negative influence on the ecological environment in China. This paper introduces the characteristics and present status of coal mining and production in China. It analyses the effect of coal gas on the atmospheric environment. It is suggested that developing and utilizing coalbed methane is not only the basic path and method to solve the air pollution and greenhouse effect of methane induced by coal gas, but also the ultimate way to reduce the safety accidents of coal gas during coal mining. 2009 IEEE.
Outputs	Jienan. (2009). Influence of coal gas on atmosphere environment and its countermeasures. <i>3rd International Conference on Bioinformatics and Biomedical Engineering, iCBBE 2009, June 11, 2009 - June 13, 2009</i> . Beijing, China: IEEE Computer Society.
Key personnel	Jienan, Pan School of Resources Environment, Henan Polytechnic University, Jiaozuo, China
Research themes	Water dependent ecosystems
Project information source	Literature

Table 4.75 Project 75: Effect of coal mining on karst groundwater in the Fengfeng coalfield.

Project characteristics	Details
Project title	Effect of coal mining on karst groundwater in the Fengfeng coalfield
Project location	China
Principal investigator	Qin, Peng
Lead institution	The 3rd Team, Bureau of Hydrogeology, CNACG, Handan 056001, China
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2011
Current status	Unknown- literature output 2011
Project summary	Based on geological survey data and detailed geological analysis results, the current article reveals the characteristics effects and role of evolution on karst groundwater caused by coal mining in Fengfeng in Hebei, China. Results indicate that long-term and large-scale mine excretion and excessive groundwater exploitation are major factors that changed the karst groundwater flow field and caused the water level to fall, the water quality to deteriorate and the water resources to decay.
Outputs	Qin. (2011). Effect of coal mining on karst groundwater in the Fengfeng coalfield. <i>Energy Exploration & Exploitation</i> . Multi-Science Publishing Co. Ltd.
Key personnel	Qin, Peng The 3rd Team, Bureau of Hydrogeology, CNACG, Handan 056001, China
Research themes	Co-produced/mine water, water supplies, water dependent ecosystems
Project information source	Literature

4.8.2 India

Table 4.76 Project 76: Algal productivity in some coal dust receiving freshwater bodies in Jharkhand State.

Project characteristics	Details
Project title	Algal productivity in some coal dust receiving freshwater bodies in Jharkhand State
Project location	India
Principal investigator	Saha, T. K.
Lead institution	Unknown
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2004
Current status	Unknown- literature output 2004
Project summary	Tests investigating the impacts of coal dust deposition on phytoplanktonic productivity were conducted during different seasons for five coal field areas in Jharkhand state, India. The strongest impacts of coal dust on phytoplankton productivity in targeted pond ecosystems were observed during the monsoon. The study documented maximum values for gross primary productivity during the winter season, while minimum values were observed during the monsoon season. Results were judged inconclusive in terms of linking coal dust with obvious impacts on phytoplankton productivity. Mathematic models were used to evaluate the roles of different net-phytoplanktonic groups in primary productivity.
Outputs	Saha. (2004). Algal Productivity in Some Coal Dust Receiving Freshwater Bodies in Jharkhand State. <i>Nature, Environment and Pollution Technology</i> . Technoscience Publications, B-34, Dev Nagar Jaipur Rajashtan 302 018.
Key personnel	Saha, T. K.
Research themes	Water supplies, water dependent ecosystems
Project information source	Literature

Table 4.77 Project 77: Impact of CBM development on environment in Jharia coal field, India.

Project characteristics	Details
Project title	Impact of CBM development on environment in Jharia coal field, India
Project location	India
Principal investigator	Verma, P.; Singh, H. V.; Wate, S. R.; Devotta, S.; Singh, R. N.
Lead institution	National Environmental Engineering Research Institute, India
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2006
Current status	Unknown- literature output 2006
Project summary	Coal Bed Methane (CBM) has emerged as a valuable energy source. Recently in India, exploration studies have been initiated to commercially exploit the methane trapped in coal beds. Despite being an environmentally friendly source of energy, several issues need to be addressed in order to understand environment impacts during its exploitation. The present work was carried out to study the impact of developmental drilling in Jharia coalfields for extracting methane gas in coal beds. Baseline data on different environmental components have been collected and analyzed. Based on the site specific conditions and technology used for developmental drilling, environmental impacts arising out of this activity have been predicted and an suitable environmental management plan is drawn in order to mitigate the adverse impacts arising out of this proposed activity.
Outputs	Verma et al. (2006). Impact of CBM development on environment in Jharia coal field, India. <i>23rd Annual International Pittsburgh Coal Conference, PCC - Coal-Energy, Environment and Sustainable Development, September 25, 2006 - September 28, 2006</i> . Pittsburgh, PA, United states: International Pittsburgh Coal Conference.
Key personnel	Verma, P.; Singh, H. V.; Wate, S. R.; Devotta, S.; Singh, R. N. National Environmental Engineering Research Institute, India
Research themes	Water supplies, water dependent ecosystems
Project information source	Literature

Table 4.78 Project 78: Coal bed methane exploration - a journey from alternative energy option to the environment polluting agent.

Project characteristics	Details
Project title	Coal bed methane exploration - a journey from alternative energy option to the environment polluting agent
Project location	India
Principal investigator	Varade, Abhay M.; Meshram, Tushar
Lead institution	RTM Nagpur University
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2010
Current status	Unknown- literature output 2010
Project summary	The occurrence of methane gas in the underground coal seams is well known since last many decades, but its pre-mining recovery in the form of CBM technology has been established in the recent times. Coal bed methane, no longer an emergent resource, is now maturing as a significant source of energy for mitigating the enhanced energy requirements of the world including India. The dual benefits of CBM recovery, other than alternate energy option include reduction in mining hazard and green house effect. But, the actual field experience of CBM exploration reveals that the technique is accompanied with many environmental difficulties like groundwater depletion, water disposal problem, air pollution, soil degradation and adverse effects on the ecosystem etc. As a result, the regulatory bodies involved in such programs are facing the challenge of balancing the need to fulfil the projected energy demand on one hand and their duties to protect the environment on the other. Present paper focuses on the environmental hazards and their possible remedial measures vis-a-vis CBM technology.
Outputs	Varade and Meshram. (2010). Coal bed methane exploration: A journey from alternative energy option to the environment polluting agent. <i>Nature Environment and Pollution Technology</i> . 2, Shila Apartment, Shila Nagar, Near T.V.Tower, Karad- 415110, Maharastra, India: Technoscience Publications.
Key personnel	Varade, Abhay M.; Meshram, Tushar Department of Geology, RTM Nagpur University, Nagpur-440 001, Maharashtra, India
Research themes	Water supplies, water dependent ecosystems
Project information source	Literature

4.8.3 Russia

Table 4.79 Project 79: Ecological conditions in the Kizelovsk Basin after closure of coal mines.

Project characteristics	Details
Project title	Ecological conditions in the Kizelovsk Basin after closure of coal mines.
Project location	Russia
Principal investigator	Nevolin, N. V.; Lykhin, P. A.; Gorshkov, V. A.; Grishchenko, G. T.
Lead institution	Rossiyskaya Akademiya Nauk, Ural'skoye Otdeleniye, Gornyy Institut, Perm, Russian Federation
Project budget	Unknown
Source of funding	Unknown
Project duration	Unknown- literature output 2008
Current status	Unknown- literature output 2008
Project summary	In the development of a coal mine, aqueduct fractures extend up to the over-coal water-bearing complex. With a stable hydraulic connection between underground and mine waters, both self-pouring out of mine water and its filtration into the horizon of underground water are possible. As a result of closure and flooding of mines, the negative influence of mine waters pouring out onto the environment greatly decreased, but a serious threat of underground water contamination by mine waters appeared.
Outputs	Nevolin et al. (2008). Ecological conditions in the Kizelovsk Basin after closure of coal mines Ekologicheskaya situatsiya v Kizelovskom bassejne posle likvidatsii ugol'nykh shakht. Izvestiya Vysshikh Uchebnykh Zavedeniy. Gornyy Zhurnal. Ministerstvo Vysshego i Srednego Spetsial'nogo Obrazovaniya Rossii, Yekaterinburg, Russian Federation.
Key personnel	Nevolin, N. V.; Lykhin, P. A.; Gorshkov, V. A.; Grishchenko, G. T. Rossiyskaya Akademiya Nauk, Ural'skoye Otdeleniye, Gornyy Institut, Perm, Russian Federation
Research themes	Co-produced/mine water, water supplies, water dependent ecosystems
Project information source	Literature

4.8.4 United Kingdom

Table 4.80 Project 80: Review of mine water monitoring in the UK.

Project characteristics	Details
Project title	Review of mine water monitoring in the UK
Project location	United Kingdom
Principal investigator	Lee Wyatt, The Coal Authority
Lead institution	The Coal Authority, United Kingdom
Project budget	N/A – internally funded
Source of funding	Department of Energy & Climate Change, United Kingdom
Project duration	2010-2011
Current status	Completed
Project summary	The Coal Authority operates a monitoring network of over 750 sites across the UK, with approximately a third relating to mine gases and the remainder being water related. This study comprised a review of the existing monitoring and sampling requirements with the aim of identifying improvements in monitoring, data management and performance.
Objectives	Review of current mine water monitoring in the UK.
Achievements	Improve internal procedures for data management, analysis and interpretation.
Outputs	Review of monitoring data to build knowledge of the local subsurface conditions to inform future risk management.
Key personnel	Lee Wyatt
Research themes	Water supplies, co-produced/mine water, aquifer interconnectivity
Project information source	Survey

4.9 Cumulative impact assessments

Cumulative impact assessments recognise that the cumulative impact of multiple industries may be far greater than that of either the individual impacts or even the sum of the individual industries. No projects were found that were relevant to this category during the period January 2000 to June 2012 from the United Kingdom, China, Russia and India.

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Appendix A - Project survey

Literature and Science Review of Coal Seam Gas and Coal Mining Recently Commissioned Research 2000-

The Office of Water Science at the Department of the Environment, Australia (<http://www.environment.gov.au>) is seeking to identify recently commissioned or completed projects researching the potential impacts of coal seam gas (coal bed methane) and coal mining on water resources and water dependent ecosystems in China, India, the United Kingdom, Russia, North America and Australia since 2000.

To be included in this important international review, please complete the following form for **each** of your projects researching the potential impacts of coal seam gas (coal bed methane) and coal mining on water resources and water dependent ecosystems. Thank you for your participation.

Return completed forms to Alexandra Badenhop

Email: a.badenhop@wrl.unsw.edu.au

Fax: +612 9949 4188

If you have any questions, please call +612 8071 9867.

Project title	Click here to enter text.	
Project location	Click here to enter text.	
Principal researcher	Click here to enter text.	
Lead institution	Click here to enter text.	
Project budget/cost	Click here to enter text.	
Source of funding	Click here to enter text.	
Project duration	Start: Click here to enter a date.	Finish: Click here to enter a date.
Current status	Choose an item.	
Project summary		
Click here to enter text.		
Objectives		
Click here to enter text.		
Achievements		
Click here to enter text.		
Outputs (Please enter references or links to available reports/journal articles/conference paper etc)		

Click here to enter text.	
Key personnel 1	
Name:	Click here to enter text.
Phone:	Click here to enter text.
Email:	Click here to enter text.
Key personnel 2	
Name:	Click here to enter text.
Phone:	Click here to enter text.
Email:	Click here to enter text.
Which of these research areas best describe your work <i>(Please check as many as are relevant)</i>	
<div style="margin-bottom: 10px;"> <input type="checkbox"/> Aquifer interconnectivity <div style="margin-left: 20px;"> <input type="checkbox"/> Baseline information (water quality and quantity) <input type="checkbox"/> Field based and modelling approaches for assessing connectivity <input type="checkbox"/> Groundwater flow and solute transport dynamics </div> </div> <div style="margin-bottom: 10px;"> <input type="checkbox"/> Disruption of surface water flow pathways <div style="margin-left: 20px;"> <input type="checkbox"/> Subsidence <input type="checkbox"/> Mine cone of depression <input type="checkbox"/> Stream diversions <input type="checkbox"/> Infrastructure </div> </div> <div style="margin-bottom: 10px;"> <input type="checkbox"/> Co-produced water and salt management (CSG) and mine water & salt management (coal mines) <div style="margin-left: 20px;"> <input type="checkbox"/> Aquifer injection and/or water treatment (technologies, relative cost benefit) <input type="checkbox"/> Effect on land and water resources (including. Irrigation) <input type="checkbox"/> Effect on Water dependent ecosystems (streams, rivers, floodplains, wetlands, GDEs, peat swamps) </div> </div> <div style="margin-bottom: 10px;"> <input type="checkbox"/> Seismicity </div> <div style="margin-bottom: 10px;"> <input type="checkbox"/> Integrity of wells - installation, operation, decommissioning </div> <div style="margin-bottom: 10px;"> <input type="checkbox"/> Hydraulic fracturing <div style="margin-left: 20px;"> <input type="checkbox"/> Chemical - Surface and groundwater quality <input type="checkbox"/> Physical - Aquitard disruption, borehole collapse </div> </div> <div style="margin-bottom: 10px;"> <input type="checkbox"/> Quality and reliability of water supplies including environmental health <div style="margin-left: 20px;"> <input type="checkbox"/> Mine site and gas field remediation, including well decommissioning and post mining voids <input type="checkbox"/> Long term impacts, including, timescales for water levels to return to pre-development levels (quality/quantity) <input type="checkbox"/> Chemical migration and toxicity <input type="checkbox"/> Managing salt and heavy metals </div> </div> <div> <input type="checkbox"/> Water dependent ecosystems <div style="margin-left: 20px;"> <input type="checkbox"/> Prediction of potential impacts to water dependent ecosystems(streams, rivers, floodplains, wetlands, GDEs, peat swamps) <input type="checkbox"/> Response and tolerances of water dependent ecosystems to changes in water regime (surface and groundwater quantity, seasonal patterns, variability, interactions) and water quality </div> </div>	

<input type="checkbox"/> Mitigation measures
<input type="checkbox"/> Monitoring techniques
<input type="checkbox"/> Cumulative impact assessments
<input type="checkbox"/> Other: Please list all

Do you know of other colleagues or counterparts involved with relevant research?

☐ Yes

☐ No

Name:	Click here to enter text.
Research Institution:	Click here to enter text.
Email:	Click here to enter text.
Phone:	Click here to enter text.

Name:	Click here to enter text.
Research Institution:	Click here to enter text.
Email:	Click here to enter text.
Phone:	Click here to enter text.

Appendix B - Project survey recipients

A listing of the personnel contacted (as of 28/05/2014) for information regarding relevant research is summarised in Table B1.

Table B1 Contacted personnel

Country	Research institution	Contact name	Response received
Australia	Alluvium Consulting QLD	Rohan Lucas	Yes
Australia	Central QLD University	Dr Claire Sellens	Yes
Australia	Mine Subsidence	Arthur Waddington	Yes - unable to provide information at this time
Australia	CSIRO	Dr Deepak Adhikary	Yes
Australia	CSIRO	Dr Peter Dillon	Yes
Australia	CSIRO	Dr Henning Prommer	Yes
Australia	CSIRO	Leif Wolf	No
Australia	CSIRO	Dr Sebastien Lamontagne	Yes
Australia	CSIRO	Dr Rob Jeffrey	Yes
Australia	CSIRO	Dr Sunil Varma	No
Australia	CSIRO	Dr Reem Freij-Ayoub	No
Australia	Curtin University	Kelly Pilgrim-Byrne,	No
Australia	Curtin University	Prof Brian Evans	Yes
Australia	Curtin University	Jeff Charrois	Yes
Australia	DNRM	Ms Joan Meecham	No
Australia	DNRM	Evan Marshall	Yes
Australia	Geoscience Australia	Kriton Glenn, Ph.D	Yes
Australia	Healthy Headwaters CSG Water Feasibility Study	Angus Veitch	No
Australia	NICNAS	Ms Sneha Satya	Yes
Australia	NSW Department of Trade and Investment, Regional Infrastructure and Services	Steve Cozens	Yes- No relevant research
Australia	Queensland University of Technology	Prof Mal Cox	No
Australia	School of Earth, Environmental & Biological Sciences,	Dr Maree Corkeron	No
Australia	Queensland Water Commission	Sanjeev Pandey	Yes
Australia	RPS	Bob Pearson	Yes
Australia	RPS	Hugh Middlemis	Yes
Australia	RPS	David Freebairn	Yes
Australia	School of the Environment, Flinders University	Prof Craig Simmons	Yes

Country	Research institution	Contact name	Response received
Australia	Stellar Corp	James Butterworth	No
Australia	Sydney Catchment Authority	Dr Jerzy Jankowski	Yes
Australia	The University of Queensland	Prof Chris Moran	No
Australia	The University of Queensland	Alistair Innes-Walker	Yes
Australia	The University of Queensland	Helen Schultz	Yes
Australia	The University of Queensland	Dr Sue Vink	No
Australia	University of Newcastle; School of Engineering	Prof Garry Willgoose	Yes
Australia	University of Newcastle; School of Engineering	Prof Stephen Fityus	No
Australia	University of Southern Queensland; Faculty of Engineering and Surveying	Prof Steven Raine	No
Australia	UNSW	Prof Bruce Hebblewhite	No
Australia	UNSW	Dr Bryce Kelly	Yes
Australia	UNSW	Dr Wendy Timms	Yes
Australia	UQ	Prof Damien Barrett	No
Australia	UQ	Prof Ling Li	No
Australia	UQ	Dr Alan Woodley	No
Australia	UQ	Dr Peter Erskine	No
Australia	UQ	Dr Andrew Fletcher	No
Canada	Alberta Environment & Sustainable Resource Development	Curtis Brock	No
Canada	Alberta Environment & Sustainable Resource Development	Richard Casey	No
Canada	Alberta University	Tayfun Babadagli	No
Canada	Coal Association of Canada	Linda Kool	Yes – no relevant research
Canada	Encana	Jay Averill	No
Canada	Environment Canada	Jim Roy	Yes – no relevant research
Canada	Geofirma Engineering Ltd	Richard Jackson	Yes – no relevant research
Canada	Laval University	John W Molson	Yes – no relevant research
Canada	University of British Columbia; Department of Chemistry	William R. Cullen	Yes- No relevant research
Canada	University of Calgary	Cathy Ryan	No
Canada	University of Guelph	Beth Parker	No

Country	Research institution	Contact name	Response received
Canada	University of Waterloo	David Rudolph	No
Canada	University of Waterloo	Ramon Aravena	No
China	China Coal Research Institute	Weiyue Hu	No
China	China University of Mining & Technology	Qiang Wu	No
China	Chinese Academy of Geological Sciences	Chen Zongyu	No
China	College of Earth Sciences, University of Chinese Academy of Sciences		No
China	College of Resources and Environment University of Chinese Academy of Sciences	WANG, Mingyu, Ph.D., CGWP	No
China	Department of Applied Chemistry, South China University of Technology,	Zhi Dang	No
China	Department of International Cooperation, Ministry of Environmental Protection	MU Zhaojing	No
China	Embassy of the Peoples Republic of China in Australia		No
China	Energy Research Institute	Liu Hong	No
China	Foreign Economic Cooperation Office (FECO)	ZOU Yueyu	Yes
China	Jiangsu Key Laboratory of Resources and Environmental Information Engineering, China University of Mining and Technology, Xuzhou, China	Ran Jin Choi	No
China	Ministry of Science and Technology		No
China	National Natural Science Foundation	Wei Quin	No
China	School of Water Resources and the Environment China University of Geosciences	Guangcai Wang	No
China	Sichuan University	Xie Heping	No
India	Advanced Center for Water Resources Development and Management (ACWADAM)	Dr.Himanshu Kulkarni,	No
India	Central Pollution Control Board	Dr. Sanjeev Aggarwal	No
India	Centre for Environmental Research and Engineering, Indian Institute of Technology, Bombay		Yes- No relevant research
India	Department of environmental Studies, North-Eastern Hill University,	Prof O.P. Singh	Yes
India	Department of Science and Technology	Dr. Sadhana Relia	No
India	Directorate General of Hydrocarbons	D. Dash	No
India	Indian Institute of Mines,	Prof Gurdeep Singh	Yes
India	Indian Institute of Technology Guwahati	Dr. Arup Kumar Sarma	No
India	Indian Institute of Technology Kanpur	Professor Rajiv Sinha	Yes

Country	Research institution	Contact name	Response received
India	Indian Institute of Technology Kanpur	Dr. Vinay K. Gupta	No
India	Indian Institute of Technology Kharagpur	Prof. Jayanta Bhattacharya	No
India	Pollution Ecology Research Laboratory, Centre of Advanced Study in Botany, Banaras Hindu University		No
India	School of Environmental Studies, University of Delhi	Dr. M.K. Pandit	No
India	School of Petroleum Technology, Pandit Deendayal Petroleum University, Gandhinagar,	Shah, Sarthak	No
India	Science and Engineering Research Board		No
India	The High Commission of India in Australia		No
India	University of Pune	Dr. Nanasaheb Parulekar Paryavaran Bhavan,	No
International	International Mine Water Association		No
Russia	Directorate of Global Energy Dialogue, International Energy Agency		No
Russia	Embassy of the Russian Federation in Australia	Alexander Odoevskiy	Yes – could not help.
Russia	Engineering Faculty, Peoples Friendship University of Russia		No
Russia	Faculty of Science, Peoples Friendship University of Russia		No
Russia	Gazprom Promgaz	Galina Nazarkina	Yes – cannot provide
Russia	Gubkin Russian State University of Oil and Gas	Professor Elena Mazlova	Yes – no relevant research
Russia	Institute of Mining Siberian branch Russian Academy of Sciences	Anwar I. Chanyshv	No
Russia	Institute of Petroleum Geology and Geophysics of Siberian Branch Russian Academy of Sciences	Sergey Kazantsev	No
Russia	InvSib Investment Agency	Taras Demidenko	No
Russia	Kemerovo Region Administration		No
Russia	Moscow State Mining University		No
Russia	Moscow State University	Viktor Antonovich Sadovnichy	No
Russia	Moscow State University of Environmental Engineering	Prof Manuk'yan David Ashikovich	No
Russia	Moscow State University of Environmental Engineering	Dr. Lagutin Natalia	No

Country	Research institution	Contact name	Response received
Russia	National Scientific Centre of Mining, Skachinskiy Institute of Mining	Alexey Leonidovich Zapadinskiy	No
Russia	Russian Academy of Sciences	V.A. Chudaeva , O.V. Chudaev	
Russia	Tomsk Polytechnic University	Olga A. Mazurina	No
United Kingdom	Environment Agency	Dr Alwyn Hart	Yes
United Kingdom	Natural Resources Wales		No
United Kingdom	Northern Ireland Environment Agency		No
United Kingdom	Scottish Universities Environmental Research Centre	Prof. Fin Stuart	No
United Kingdom	University of Cardiff	Geroni Jennifer N.	No
United Kingdom	University of Glasgow	Susan Waldron	No
United Kingdom	University of Glasgow, Systems, Power & Energy Group, School of Engineering	Professor Paul Younger	Yes
United Kingdom	University of Newcastle; School of Civil Engineering and Geosciences	Dr Jarvis Adam Paul	No
United Kingdom	British Geological Survey	Dr Jonathon Busby	Yes
United Kingdom	RPS	Gordon Taylor	No
United Kingdom	School of Earth and Environment Leeds University	Prof Simon Bottrell	No
United Kingdom	School of Earth and Environment Leeds University	Dr Nigel Mountney	No
United Kingdom	School of Earth and Environment Leeds University	Professor Joseph Holden	Yes
United Kingdom	School of Geosciences, University of Edinburgh	Simon Haunch	No
United Kingdom	Scottish Environment Protection Agency	Emma Taylor	Yes
United Kingdom	The Coal Authority	Abby Moorhouse	Yes
US	Geological Survey of Alabama	Dr Jack Pashin	No
US	Office of Research Development, U.S. EPA	Dayna Gibbons	No
US	U.S. Geological Survey	Richard W. Healy	No
US	U.S. Geological Survey	Zack Bowen	No
US	U.S. Geological Survey	William Orem	Yes
US	U.S. Geological Survey	Mark Engle, Ph.D	No

Country	Research institution	Contact name	Response received
US	University of Rio Grande	Dr. Robert Hopkins II	No
US	University of Wyoming	Scott Quillinan	Yes
US	University of Wyoming	Prof K J Reddy	No
US	USGS	Charles Cravotta	No
US	Virginia Tech	Carl Zipper	No
US	Wyoming State Geological Survey	Jim Rodgers	No

Appendix C - Literature search methodology

Search methodology

The emphasis of the searching was on a high degree of sensitivity (recall) rather than specificity. To ensure the widest 'capture' the search employed keyword searching. This involved identifying in each question relevant keywords and synonyms and word variations. Search strategies were developed for each question employing standard techniques: Boolean logic operators and truncation. Multiple keyword searches were carried out across multiple databases indexing literature from: Engineering, Geosciences, Mining, Environmental and Agricultural Sciences, Health Sciences, and Science.

The specific database search systems employed were Proquest, Web of Science, Scopus, Engineering Village (Compendex, GeoRef, Geobase), OnePetro and Informit Australian databases.

The database included references from a wide variety of information resources: journal articles, conference papers, book chapters, books, reports, etc. (see full description of database below for resource coverage). Across the different database search systems, search functionality, search syntax, indexing, field structures, sort and display options, and download options varied greatly. Limited time availability and competing work demands meant library catalogues have not been included in this search. Limiting keyword searching of the Internet to supplement database searching was also carried out by consultant engineers.

The keyword searches were performed an 'all fields' search on the databases. This approach allowed for different field structures on different search systems. A standard strategy was employed, creating groups or 'sets' of the different keyword concepts, then combining these sets which were then further limited (by countries and publication year). This strategy generally worked well in reducing the volume of search results. However, in cases where excessive numbers of records retrieved were deemed to have a high degree of irrelevance, further refinements were applied. This included:

- adding extra keywords
- excluding irrelevant topics (e.g. power stations)
- limiting keyword searching to title, abstract fields.

The ability to refine the search was based largely on the degree of functionality provided by the specific search interface.

To ensure specificity, search results were further refined by WRL consultant engineers viewing and deleting records deemed irrelevant.

Databases

The following information regarding the databases searched within this report is provided below.

Web of Science

Type: Citations/Abstracts.

Description: The Web of Science delivers web-based access to the citation indexes. Complete coverage is now provided. The citation indexes include:

- Science Citation Index 1899+
- Social Sciences Citation Index 1898+
- Arts & Humanities Citation Index 1975+
- Conference Proceedings Citation Index: Science 1990+
- Conference Proceedings Citation Index: social Sciences & Humanities 1990+

The database covers over 8000 journals across all disciplines worldwide, with about 22 000 articles being added weekly. The journals are selected as the most influential and relevant peer-reviewed titles across all disciplines.

Keywords: Anthropology; Architecture; Art; Art Education; Arts; Astronomy; Aviation; Biochemistry; Biology; Biomedicine; Biotechnology; Chemical Engineering; Chemistry; Computer; Computer Science; Criminology; Dance; Demography; Design; Digital Media; Economics; Education; Engineering; Folklore; Geography; Geomatic Engineering; History; Humanities; Industrial Chemistry; Industrial Relations; Information Science; International Relations; Language; Law; Librarianship; Life Sciences; Linguistics; Literature; Management; Marketing; Materials Science; Mathematics; Media and Mass Communication; Medicine; Mining Engineering; Multidisciplinary; Music; Optometry; Pharmacology; Philosophy; Photovoltaics; Physics; Plant Sciences; Poetry; Political Science; Psychiatry; Psychology; Public Administration; Public Health; Religion; Safety Science; Science Technology; Social Issues; Social Work; Sociology; Statistical Sciences; Substance Abuse; Surgery; Surveying; Technology Management; Theatre; Town Planning; Transportation; Urban Studies; Veterinary Sciences; Women's Studies; Zoology.

Coverage: International.

Search hints: Year can only be searched as part of a Boolean search and may provide results from different years.

ISSN/ISBN search is not supported.

Publisher: Thomson Scientific.

Additional publisher name: formerly Institute for Scientific Information (ISI).

Scopus

Type: Database.

Description: Scopus is an abstract and citation database of research literature including peer-reviewed titles, Open Access journals, conference proceedings, trade publications, patent records, scientific web pages, and seamless links to full text articles and other library resources. It is updated daily.

Search hints: External links lead to a login page that requires a Username/Password.

Author searches are done on the last name only.

Subject searches are performed in All Fields.

Publisher: Elsevier.

Science Direct

Type: Fulltext.

Description: Fulltext journal titles published by Elsevier.

Keywords: Anthropology; Architecture; Astronomy; Aviation; Biochemistry; Biology; Biomedicine; Biomedical Engineering; Biotechnology; Building; Chemical Engineering; Chemistry; Civil Engineering; Computer Science; Criminology; Design; Design Environments; Digital Media; Economics; Education; Educational Technology; Energy; Engineering; Environmental Engineering; Geography; Geomatic Engineering; Graphic Design; Humanities; Industrial Chemistry; Industrial Design; Industrial Relations; Information Science; International Relations; Landscape Architecture; Law; Librarianship; Life Sciences; Management; Marketing; Materials Science; Mathematics; Manufacturing Engineering; Marketing; Mechanical Engineering; Media and Mass Communication; Medicine; Mining Engineering; Multidisciplinary; Object Design; Optometry; Petroleum Engineering; Pharmacology; Philosophy; Photovoltaics; Physics; Plant Sciences; Political Science; Psychiatry; Public Administration; Public Health; Real Estate; Safety Science; Science Direct; Science Technology; Social Issues; Social Work; Sociology; Substance Abuse; Surgery; Surveying; Technology Management Psychology; Textile Technology; Theatre; Town Planning; Urban Studies; Veterinary Sciences; Waste Management; Zoology.

Coverage: International.

Search hints: Author searches are done on the last name only.

Subject searches are supported, but subjects are not presented within the records.

Truncation is not supported in phrases.

Publisher: Elsevier.

Additional publisher name: Elsevier Science B.V.

Publisher URL: <http://www.elsevier.com/>

Engineering Village (Compendex, GeoRef, Geobase)

Type: Database.

Keywords: Astronomy; Biomedical Engineering; Chemistry; Computer Engineering; Computer Technology; Computers; Computing; Computing Sciences; Communications Technology; Digital Media; Electrical Engineering; Electronics; Energy; Information Systems; Information Technology; Manufacturing; Manufacturing Engineering; Materials; Materials Science; Mechanical Engineering; Optometry; Photovoltaics; Physics; Statistical Sciences; Telecommunications.

Publisher: Elsevier Engineering Information.

Publisher URL: <http://www.ei.org/eicorp/>

OnePetro

Type: Database.

Description: OnePetro.org is a multi-society library that provides a simple way to search for and access a broad range of technical literature related to the oil and gas exploration and production industry. The database includes full-text from numerous organisations, including the Society of Petroleum Engineers (SPE).

Keywords: Petroleum; Resources Engineering; SPE.

Publisher: The Society of Petroleum Engineers (SPE).

Link to Database Guide: http://www.onepetro.org/search_help.htm

Australian databases (Informit)

Type: Fulltext.

Publisher: Informit.

Additional publisher name: RMIT Publishing.

Publisher URL: <http://www.informit.com.au/>

Databases searched:

- Australia's National Geosciences, Minerals and Petroleum Reference Database (AESIS)
- Australasian Medical Index (AMI)
- Agriculture and Natural Resources Index [formerly ABOA and STREAMLINE] (ANR-Index)
- Agriculture and Natural Resources Index Archive (ANR-Index Archive)
- Agriculture and Natural Resources Research (ANR-Research)
- Agriculture and Natural Resources Research Archive (ANR-Research Archive)
- Australian Public Affairs Information Service (APAIS)
- Aboriginal and Torres Strait Islander Health Bibliography (ATSIhealth)
- Australian Engineering Database (ENGINE)
- Engineering Collection (Engineering Collection)
- Environmental Abstracts (EVA)
- Health Collection (Health Collection)
- Australia's Natural Resources Database (STREAMLINE)

Proquest Databases

Type: Fulltext.

Description: ProQuest Central is the largest multidisciplinary database with over 11 000 titles, with over 8000 titles in full-text.

It serves as the central resource for researchers at all levels in all markets.

Over 160 subjects areas are covered extensively in this product including business and economics, health and medical, news and world affairs, technology, social sciences and more.

Publisher: ProQuest Information and Learning Company.

Publisher URL: <http://www.il.proquest.com/>

Databases searched:

- AGRICOLA (1970 - current)
- Aqualine (1960 - current)
- ASFA: Aquatic Sciences and Fisheries Abstracts (1971 - current)
- Biological Sciences (1946 - current)
- Dissertations & Theses @ University of New South Wales
- ebrary® e-books
- Environmental Impact Statements: Full Text (1985 - current)
- Environmental Sciences and Pollution Management (1967 - current)
- Meteorological & Geostrophysical Abstracts (1974 - current)
- ProQuest Biology Journals (1998 - current)
- ProQuest Health & Medical Complete
- ProQuest Research Library
- ProQuest Science Journals
- ProQuest Dissertations & Theses: UK & Ireland
- ProQuest Dissertations & Theses Full Text
- ProQuest Illustrata: Technology
- ProQuest Natural Science Collection (1693 - current)
- Technology Research Database (1962 - current)
- Water Resources Abstracts (1967 - current)

Search Methodology

A brief summary of the search methodology and keywords used within each database is shown in Table C1.

Table C1 Search methodology

Search method	Main Research Theme	Search terms – level 1		Search terms – level 2		Search terms – level 3		Search terms – level 4
A	Aquifer interconnectivity (R1)	csg OR cbm OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”	AND	water OR aquifer OR aquiclude OR “groundwater basin*” OR “groundwater reservoir” OR “ground water basin” OR “ground water reservoir” OR “underground basin” OR multiaquifer OR “water bearing formation*”	AND	connect* OR connexion* OR interconnect* OR interconnexion OR link*	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
B	Aquifer interconnectivity (R1)	csg OR cbm OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”	AND	“Water Quality” OR Contaminant* OR pollut* OR “Water Purity” OR “Freshwater quality” OR “Ground water quality” OR “quality of water” OR impurit* OR “Water Quantity” OR volume OR yield OR amount OR Model* OR “Field based” OR “Groundwater flow” OR “Ground water flow” OR “Ground water movement” OR “subsurface flow” OR “flow of groundwater” OR Solute* OR chemicals OR matter OR materials OR substances OR inorganic OR organic OR “Transport dynamic*” OR dispers* OR flow OR movement OR pathway*	AND	connect* OR connexion* OR interconnect* OR interconnexion OR link*	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
C	Surface water	csg OR cbm	AND	“surface water” OR stream OR	AND	Disrup* OR diversion	LIMITED	Australia OR Australian OR

Search method	Main Research Theme	Search terms – level 1		Search terms – level 2		Search terms – level 3		Search terms – level 4
	(R2)	OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”		river OR lake OR wetland OR ocean OR creek OR estuary OR dam OR reservoir OR watercourse AND (Flow OR pathway OR path OR movement)		OR divert* OR impact* OR assess* OR evaluat* OR chang* subsid* OR sink* “mine cone of depression” OR “cone of depression”	TO	England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
D	Co-produced/ mine water (R3)	csg OR cbm OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”	AND	“produced water” OR “co- produced water” OR “mine water” OR salt OR “salt management” OR saline	AND	aquifer inject* OR “water treatment” OR “water technolog*” OR “advanced Water Treatment Technolog*” OR AWTT OR Effect*OR impact* OR outcome*	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
E	Seismicity (R4)	csg OR cbm OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”	AND	seismicity OR seismic OR seismology OR earthquake*	AND	nil	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
F	Well integrity (R5)	csg OR cbm OR “coal seam gas”	AND	“well integrity” OR “integrity of well*” OR installation OR drill*	AND	nil	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR

Search method	Main Research Theme	Search terms – level 1		Search terms – level 2		Search terms – level 3		Search terms – level 4
		OR “coal bed methane” OR “coalbed methane”		OR “wellbore” OR bore*				Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
G	Hydraulic fracturing (R6)	csg OR cbm OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”	AND	surface OR water OR “Water Supply” OR River* OR lake OR stream OR ocean OR creek* OR dam OR floodplain OR wetland* OR Estuar* OR Reservoir OR Groundwater OR Aquifer OR Aquitard OR “water table”	AND	quality OR chemical* OR contaminat* OR toxic* OR chemical* OR metal* OR solute* OR “heavy metals” OR salt OR saline OR pollut* OR spill* OR “backflow” OR “back flow” OR “flow back”	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
H	Water supplies (R7)	csg OR cbm OR “coal seam gas” OR “coal bed methane” OR “coalbed methane”	AND	Quantity OR “water level” OR reliability OR depletion OR sustainability OR “aquifer stress”	AND	Remediat* OR Regenerat* OR Rehabilitat* OR “well decommissioning” OR “post mining voids” OR “Pre development” OR “Post development” OR “Pre mining” OR “Post mining” OR “Water level” OR “Water quality”	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR Canada OR Canadian OR USA OR “United States” OR US OR “United States Of America” OR China OR Chinese OR India OR Indian OR Russia OR Russian
I	Water dependent ecosystems	csg OR cbm OR “coal seam gas”	AND	Predict* OR Estim* OR Forecast* OR Respon* OR Quality OR Projection OR	AND	Ecosystem_OR Environment OR “surface water” OR	LIMITED TO	Australia OR Australian OR England OR UK OR “United Kingdom” OR

Search method	Main Research Theme	Search terms – level 1		Search terms – level 2		Search terms – level 3		Search terms – level 4
	(R8)	OR "coal bed methane" OR "coalbed methane"		Impact OR Influence OR Effect OR Affect		River* OR lake OR stream OR ocean OR creek* OR dam OR floodplain OR wetland* OR GDEs OR "Peat swamp*" OR Estuar* OR Reservoir OR "Water course" OR Water		Canada OR Canadian OR USA OR "United States" OR US OR "United States Of America" OR China OR Chinese OR India OR Indian OR Russia OR Russian
J	Cumulative impact assessment (R9)	csg OR cbm OR "coal seam gas" OR "coal bed methane" OR "coalbed methane"	AND	"Cumulative impact" OR "impact assessment"	AND	nil	LIMITED TO	Australia OR Australian OR England OR UK OR "United Kingdom" OR Canada OR Canadian OR USA OR "United States" OR US OR "United States Of America" OR China OR Chinese OR India OR Indian OR Russia OR Russian

Appendix D - Project index

Table D1 Research projects titles and themes

Project no.	Project title	Aquifer connectivity	Disruption of surface water	Co-produced/ mine water & salt management	Seismicity	Integrity of wells	Hydraulic fracturing	Water supplies	Water dependent ecosystems	Cumulative impact assessments
1	Groundwater rebound in the South Yorkshire Coalfield; a first approximation using the GRAM model, United Kingdom	✓		✓			✓	✓		
2	A strategy for modeling ground water rebound in abandoned deep mine systems, United Kingdom						✓	✓		
3	Integration of MODIS data and Short Baseline Subset (SBAS) technique for land subsidence monitoring in Datong, China		✓							
4	The effect of overlapping mining on surface water and shallow groundwater resources using numerical method, China		✓							
5	Effects of Ca ²⁺ and Mg ²⁺ on the toxicity of arsenate in a high arsenic coal mine area in southwest Guizhou, China		✓							
6	Current water environmental status analysis of subsided water areas and its comprehensive utilization: A case of subsided water area in Panyi Coal Mine, China		✓							
7	Environmental impact of coal mining subsided water area in Huainan mining area, China		✓							
8	Green mining techniques in the coal mines of China		✓							
9	Water quality and controlling factors of coal mining subsidence areas in Panji Huainan, China		✓							
10	Coal mine subsided water quality assessment and subsided water resource comprehensive utilization analysis - A case of subsided water area in Panyi coal mine, China		✓							
11	Exploitation of coal resources under surface water body, China		✓	✓			✓			

Project no.	Project title	Aquifer connectivity	Disruption of surface water	Co-produced/ mine water & salt management	Seismicity	Integrity of wells	Hydraulic fracturing	Water supplies	Water dependent ecosystems	Cumulative impact assessments
12	Study on the structure model and controlling method of subsidence in flat seam and deep mining, China		✓							
13	Impact of underground coal mining on overlying farmland in Xuzhou suburbs, China		✓							
14	Evaluation of ground movement and damage to structures from Chinese coal mining using a new GIS coupling model, United Kingdom		✓							
15	Impact of post-mining subsidence on nitrogen transformation in southern tropical dry deciduous forest, India		✓	✓						
16	Impact of coal mining subsidence on groundwater resources management of the East Midlands Permo-Triassic Sandstone aquifer., United Kingdom	✓	✓				✓	✓		
17	Study on related seepage problems to the exploitation of coal, China			✓						
18	Quality and treatment of coal mine drainage water in China			✓						
19	Optimum comprehensive technic study on combination of mine water control, processing, use, recharge and eco-environment protection, China	✓	✓	✓		✓	✓	✓		
20	Study on treatment of mine water and its cost analysis, China			✓						
21	Mine water pollution and acid mine water treatment, China			✓						
22	Stone of Village Coal Mine water recycling project design overview, China			✓						
23	Experimental research on mine water purified treatment by modified filter media, China			✓						
24	Treatment of the mine water contained surfactant, China			✓						
25	Research on Prevention and Treatment of Mine Water, China			✓						

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26	Characteristics of coal bed produced water in the process of coal bed methane development, China			✓						
27	Geochemical distribution and removal of As, Fe, Mn and Al in a surface water system affected by acid mine drainage at a coalfield in southwestern China			✓						
28	Treatment efficiency and mechanism of coal mine water with high turbidity, high concentrations of iron and manganese by modified filter material, China			✓						
29	Design of Xijixi Coal Mine water treatment process, China			✓						
30	Characteristics and utilization of mine water in East China						✓	✓		
31	Treatment of mine water and its utilization in Huainan Mining Area, China			✓						
32	Treatment mechanism of mine water with high concentration of manganese on surface-modified filter material, China			✓						
33	Revised design of the waste water treatment process for an underground mine, China			✓						
34	Environmental impact analysis of water environment in coal mining areas based on matter-element model, China			✓						
35	Field trials of aquifer protection in longwall mining of shallow coal seams in China	✓		✓				✓		
36	Removal of heavy metals from mine water by cyanobacterial calcification, China			✓						
37	Thermophilic anaerobic digestion of Lurgi coal gasification wastewater in a UASB reactor, China			✓						

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38	The application of RO Technology in highly mineralized mine water treatment and utilization, China			✓						
39	Quality assessment of mine water in the Raniganj Coalfield Area, India			✓						
40	A simplified approach for removal of suspended coal fines from black water discharge of mining and its allied industries, India			✓						
41	Heavy metal pollution induced due to coal mining effluent on surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes, India			✓						
42	Environmental impacts of coal mining and associated wastes: A geochemical perspective, United Kingdom			✓			✓	✓		
43	Laboratory studies using naturally occurring "green rust" to aid metal mine water remediation, United Kingdom			✓						
44	Determination of hydraulic residence times in several UK mine water treatment systems and their relationship to iron removal, United Kingdom			✓						
45	Design and performance assessment methodology for passive mine water treatment systems, United Kingdom			✓				✓		
46	The rates and mechanisms of Fe(II) oxidation in a passive vertical flow reactor for the treatment of ferruginous mine water, United Kingdom			✓						
47	Environmental impact of mine drainage and its treatment on aquatic communities, United Kingdom			✓				✓		
48	European Commission 5th Framework RTD Project No. EVK1-CT-1999-00021 "Passive in-situ remediation of acidic mine / industrial drainage" (PIRAMID), United Kingdom			✓						

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49	Development of a methodology to aid in the prediction of minewater quality, United Kingdom			✓						
50	Mine water capture, United Kingdom			✓						
51	Failure characteristics of surface vertical wells for relieved coal gas and their influencing factors in Huainan mining area, China					✓				
52	Researches on hydro-frac induced reservoir damage to anthracite coal seams of southern Qinshui basin, China			✓					✓	
53	Hydraulic fracturing after water pressure control blasting for increased fracturing, China								✓	
54	Optimum combination studies on water drainage-supply and eco-environment Protection in the coal basin of North China. China	✓	✓	✓		✓	✓	✓		
55	Environment impact assessment of open-pit coal mining in Huolinhe Coal Mine district, China						✓			
56	Contamination of the environmental ecosystems by trace elements from mining activities of Badao bone coal mine in China						✓			
57	Land reclamation and ecological reconstruction in resource-exhausted mining areas, China		✓					✓		
58	Mobility of heavy metals associated with the natural weathering of coal mine spoils, China						✓			
59	Environmental concerns associated with coal mining activity - a case study, India			✓				✓		
60	Hydrogeochemistry, elemental flux, and quality assessment of mine water in the Pootkee-Balihari Mining Area, Jharia Coalfield, India			✓				✓		

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61	Study of dissolved arsenic in ground and surface waters of the Rawanwara colliery area of Pench Valley coal field (M.P.) and its impact on human health, India			✓			✓			
62	Geo-environmental quality assessment in Jharia coalfield, India, using multivariate statistics and geographic information system, India			✓			✓			
63	Impact of coal mine effluent on physico-chemical characteristics of pond water in coalfield area of Godda District, Jharkhand, India			✓			✓			
64	Biomonitoring of water quality in coal mining areas of Meghalaya, India, India		✓				✓			✓
65	Chemical composition of waters on the Pavlovsky Coal Quarry (Far East Russia) and surrounding areas, Russia						✓	✓		
66	Abandoned mines and the water environment in the UK, United Kingdom			✓			✓	✓		
67	Model development for river restoration. (BL), United Kingdom			✓			✓	✓		
68	Predicting temporal changes in total iron concentrations in groundwaters flowing from abandoned deep mines: A first approximation, United Kingdom						✓	✓		
69	Pollution of the Permian limestone aquifer by rebounding coal measures groundwater, Co Durham, England, United Kingdom						✓			
70	Evaluating the potential impact of opencast coal mining on water quality (Groundwater Regulations 1998), United Kingdom						✓			
71	The distribution of trace elements in various peat swamps of the No. 11 coal seam from the Antaibao Mine, Ningwu coalfield, China			✓				✓		
72	Ecological risk assessment of open coal mine area, China			✓				✓		

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73	Effect of coal exploitation on groundwater and vegetation in the Yushenfu Coal Mine, China			✓			✓	✓		
74	Influence of coal gas on atmosphere environment and its countermeasures, China							✓		
75	Effect of coal mining on karst groundwater in the Fengfeng coalfield, China			✓			✓	✓		
76	Algal productivity in some coal dust receiving freshwater bodies in Jharkhand State, India						✓	✓		
77	Impact of CBM development on environment in Jharia coal field, India						✓	✓		
78	Coal bed methane exploration: A journey from alternative energy option to the environment polluting agent, India						✓	✓		
79	Ecological conditions in the Kizelovsk Basin after closure of coal mines, Russia			✓			✓	✓		
80	Review of mine water monitoring in the United Kingdom	✓		✓			✓			