

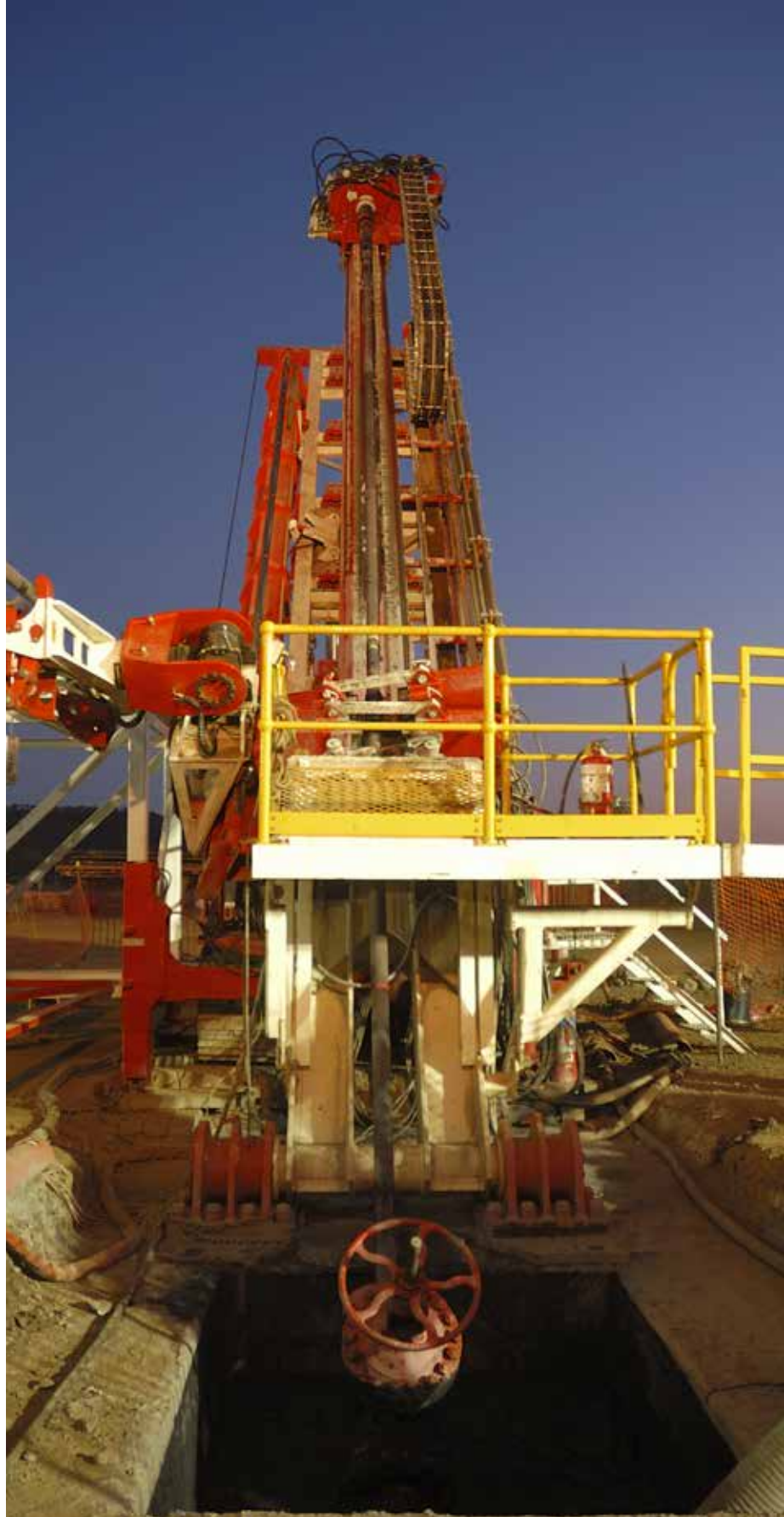


CSG, Coal and Shale Mining Associated Water Management

Water solutions for the Mining Industry



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Arris has extensive skills and offers its clients the highest level of capability in the beneficial and sustainable management of co-produced and dewatering (associated water) water management. We have 16 years experience in the treatment, assessment, regulation and beneficial reuse of a wide range of waste streams. A differentiating aspect of our service is the skill set we provide our clients, including integrated end-to-end solutions down to individual project components.

Arris provides clients and regulators a range of services in the management and beneficial reuse of associated water, including:

- 'Fit for purpose' water treatment: design, construct and operate;
- Hydrogeological services for both the extraction and reuse phases;
- Receiving environment assessment: climate, soil and landform;
- Research and development ;
- Crop suitability assessment;
- Research: water quality and environmental impacts;
- Regulatory compliance reporting and Beneficial Use Approval (BUA) development;
- Ecotoxicological assessments, site contamination and remediation;
- Education and training;
- Market for water analysis: customer analysis and assessment, capacity and willingness to pay, customer rules and agreements; and
- Stakeholder assessment and engagement.

Arris has been involved in the development of Australia's largest water reuse projects, including the 20GL per year, contracted to 300 customers, Virginia Pipeline Scheme. We have developed national guidelines for the sustainable use of recycled water and have current contracts for water treatment and environmental consulting within both the coal and shale gas industries.

We have 16 years experience in the treatment, assessment, regulation and beneficial reuse of a wide range of waste streams.





The Zetos Filter is being used for the treatment of coal seam gas (CSG) water in Central Queensland.

WATER TREATMENT

Arris provides treatment solutions for sites that have 'difficult' wastewater to manage. Characteristics of difficult wastewater may include chemical, biological or physical parameters, volumes or water generation patterns. Our integrated and experienced team develop holistic whole of system approaches to the sustainable and beneficial treatment and reuse of associated water.

Design

Arris has designed and constructed a number of treatment chains for the beneficial reuse of associated water. Our treatment and environmental experts match treatment processes with 'fit for purpose' requirements. This has significant advantages for the client as it can reduce capital and/or operational costs for treatment without compromising environmental outcomes.

Arris has designed and built reverse osmosis (RO), ion exchange, filtration, chemical addition, mechanical, biological treatment plants and no release systems.

Products

Arris has researched, developed and patented water treatment technologies and have access to the world's leading water equipment suppliers and their technical staff. We are not tied to any one brand or

solution. Our purpose designed treatment chains are designed to provide excellent value for money. The operational experience we provide allows us to select products that are robust and reliable whilst having low operational costs and maintenance requirements.

Through our research, we have developed the Zetos Filter which uses ion exchange media for the correction of water Sodium Absorption Ratio (SAR) with salinity reduction. Typically, SAR correction is made through the addition of calcium and magnesium salts, a process that lowers SAR but increases salinity. The Zetos Filter decreases SAR and salinity, a unique process that has been developed as a result of ten years research. The Zetos Filter is also effective for the removal of heavy metals, pH correction and hydrocarbons.

The Zetos Filter decreases SAR and salinity, a unique process that has been developed as a result of ten years research.

Arris can supply world leading Primozone ozone equipment which is very beneficial in treatment applications in the CSG, coal and shale gas industries. Our Canadian partners, VEK Environmental, have been using ozone in the treatment of oil and gas process waters. Ozone provides outstanding results as it oxidises hydrocarbons and can precipitate heavy metals, producing water suitable for certain types of reuse. It is a common pre-treatment stage for other technologies such as reverse osmosis. It is particularly effective at treating fracking flow back and process water.

Operation

Arris has trained water treatment plant operators who operate a variety of plants either owned or operated by Arris. A pivotal element of our offer is that we train internal water treatment operators and provide the necessary ongoing backup and support. Arris provides operation manuals and trouble shooting guidelines for our water treatment plants.

Our technical staff can optimise treatment plants designed and built by other companies. Arris engineers are currently contracted to a major coal mine to project manage the operation of their 10 ML/day RO pit dewatering plant and treatment train.

MINING CAMPS

One aspect of the design and operation of mining camps is the provision and management of potable and waste water. Often these camps are decentralised and have highly variable flows that present their own difficulties for design and operation. Arris has extensive experience in the design, construction, treatment and compliance of treatment systems for potable water and waste water.

Arris offers fit-for-purpose water treatment solutions for all aspects of the engineered water cycle. We work with the domestic, commercial, agricultural, trade-waste, government, industrial, mining and gas sectors. Our water projects have ranged from a single household to projects that use 10 million litres per day.

Potable Water

We have developed potable water treatment systems for decentralised developments including Red Rock, Sunrise at 1770, Reef Cove, Springs Beach and the Woodford Folk Festival site.

With mining camps there is a high reliance on bore feed systems that can have individual water quality issues. With our ozone and Zetos technologies we can treat 'difficult' water to meet the Australian Drinking Water Quality Guidelines standard.

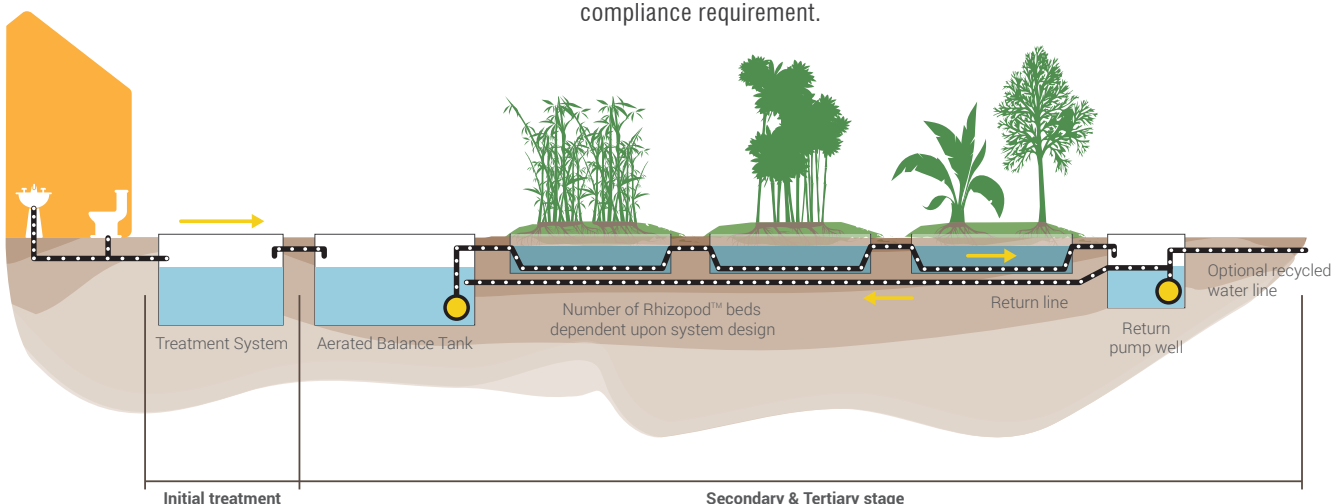
Wastewater

Arris has designed and installed a number of treatment trains that reduce the treatment and management costs of wastewater from mining camps. We have successfully retro fitted failed wastewater treatment systems to meet compliance requirements and reduce operational costs.

Arris has developed the proprietary Rhizopod™ System which has been used in a number of mining camps, commercial and domestic site. This system offer clients many advantages, including:

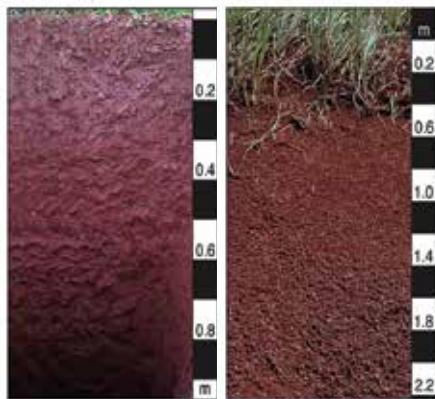
- Small foot print
- Reduced wastewater removal costs
- A solution in poor soils and difficult environments
- It is seen as 'no-release' by regulators reducing licensing and monitoring costs and requirements

Key to the Arris approach is our 'fit for purpose' design service where we achieve the best outcome for our clients regardless of the situation and the compliance requirement.



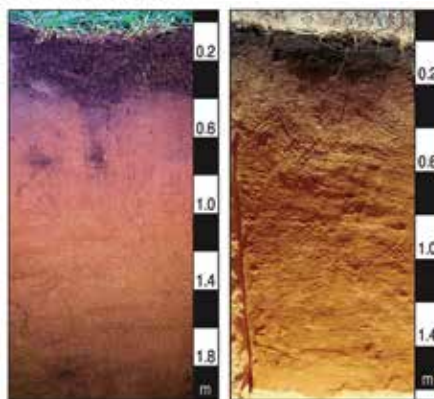
FERROSOLS

Red Ferrosol
Scottsdale, Tas



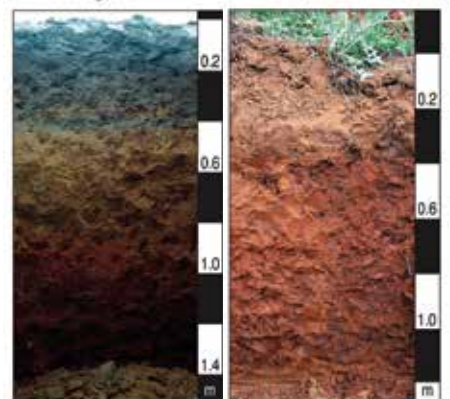
TENOSOLS

Brown-Orthic Tenosol
North Midlands, Tas



DERMOSOLS

Red Dermosol
Bundaberg, Qld



RECEIVING ENVIRONMENT ASSESSMENT

Arris is recognised nationally and internationally for its research and work in water reuse. Key staff members have been involved in research, environmental assessment and guideline development for both state and federal agencies.

We have expertise in the sodic and/or saline land and the irrigation of brackish water often with elevated SAR.

Understanding the receiving environment is critical to the development of a 'fit for purpose' water treatment train. The identification of key assets and limitations define the water quality parameters critical to system sustainability and corporate responsibility, whether discharging to natural water systems or through beneficial reuse in agricultural projects.

Land Capability and Environmental Risk Assessments

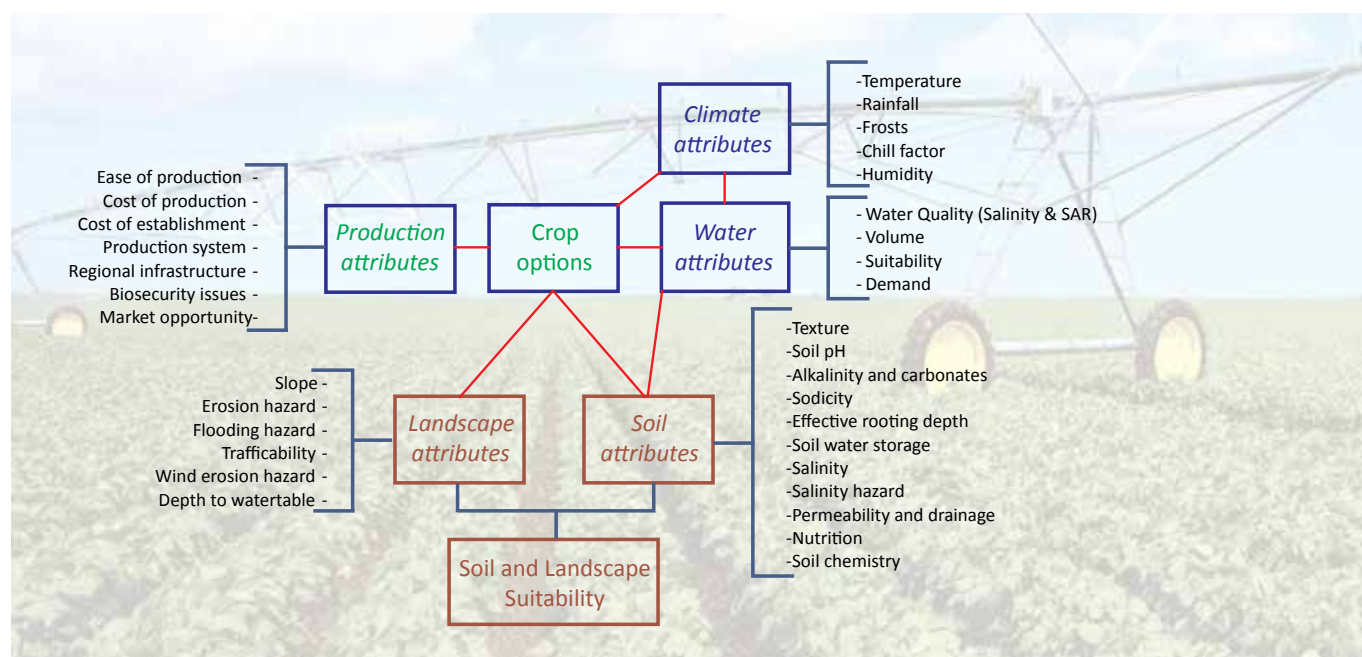
One of the most important aspects in the development and approval for the sustainable reuse of associated water is a thorough assessment of the receiving land capabilities and identification of all environmental risks. It is a requirement of a BUA and it establishes:

- Baseline conditions;
- Identifies limitations and critical control points for monitoring and management;
- Forms the basis for the Environmental Risk Assessment (ERA);
- Defines critical values for water treatment; and
- Defines crop selection criteria.

Arris is recognised nationally and internationally for its research and work in water reuse.

In the CSG, coal, shale mining and water treatment industries, Arris has undertaken more than 20 reuse water assessments including the Virginia Pipeline Scheme (South Australia) and the Western Corridor Recycled Water Scheme projects (Queensland). We have been a major contributor to the science relating to the beneficial reuse of wastewater.

SOIL AND LANDSCAPE SUITABILITY FRAMEWORK



Arris has undertaken numerous Land Capability Assessments (LCA) for irrigation with associated water. We use the information attained for the LCA to develop an integrated ***Soil and Landscape Suitability Assessment***. We understand the interaction between key environmental conditions, crop selection and water quality suitability for sustainable irrigation which adds significant value to the traditional LCA. The Soil and Landscape Suitability Framework has seen the development of a decision tree for up to 40 input parameters subject to information/data availability. Note: no two decision trees are the same as they have differently weighted attribute values depending on water quality and receiving environment conditions.

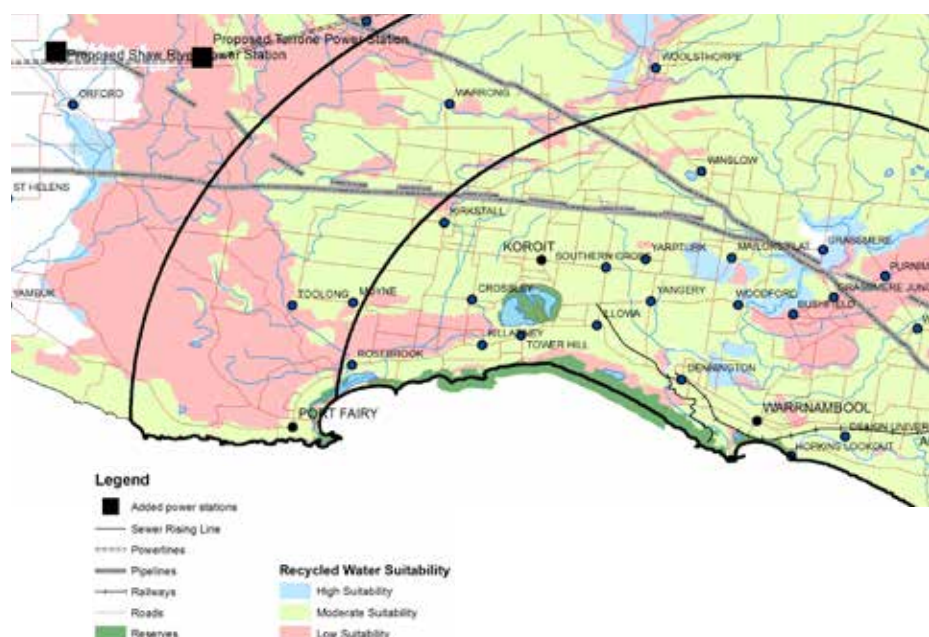
Arris is highly skilled in the management and irrigation of saline and sodic soils. We have produced a number of land management and irrigation manuals and trained irrigators and regulators in the sustainable irrigation of brackish water.

GIS Assessment of Land Suitability

The use of regional scale land suitability assessment has been valuable in the identification of potential sites suitable for irrigation with reuse water. Using

our Soil and Landscape Suitability Framework, we are able to establish the weighted critical values in the soil and landform system and undertake a suitability assessment.

This method does not replace a soil survey as the method of assessing soil suitability, but does improve efficiency and cost of site selection. It allows for the identification of potentially suitable sites for validation using field survey techniques to be followed by a full LCA.



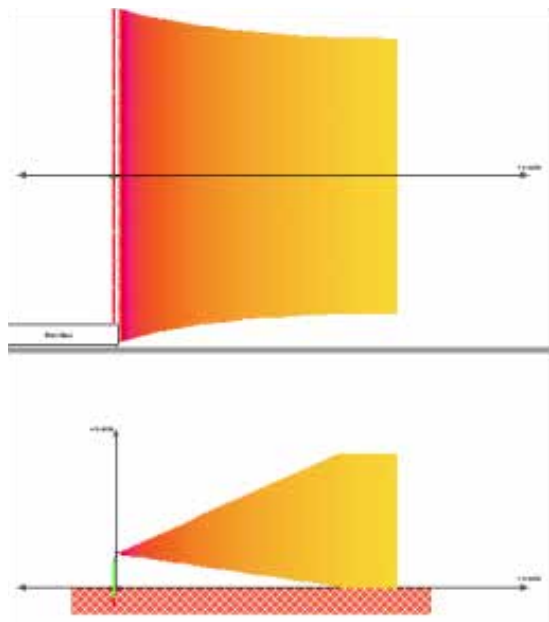
CROP SUITABILITY ASSESSMENT

Crop suitability assessment is a critical aspect to the development of the sustainable and beneficial reuse of CSG, coal and shale mine associated water. The selection of crop/s will influence the water treatment requirements, irrigation demand, leaching requirements, nutrient balances and the cost of the irrigation system setup and operation.

Arris has developed a database of over 100 economic crops, biofuel and carbon sequestration crops. These crops are semi quantitatively assessed against >30 parameters under the following broad headings:

- Soil and landform suitability;
- Climate suitability;
- Ease of farming and establishment; and
- Economic return and market potential.

This process provides clients with an opportunity to understand the reasons behind specific crop selections and to impose factors that are critical to them. The semi quantitative assessment provides a higher level of understanding of opportunities and limitations. This process is highly sought by our clients as it increases their 'ownership' of the process and selection of suitable crops and provides greater insight into the potential value of water.



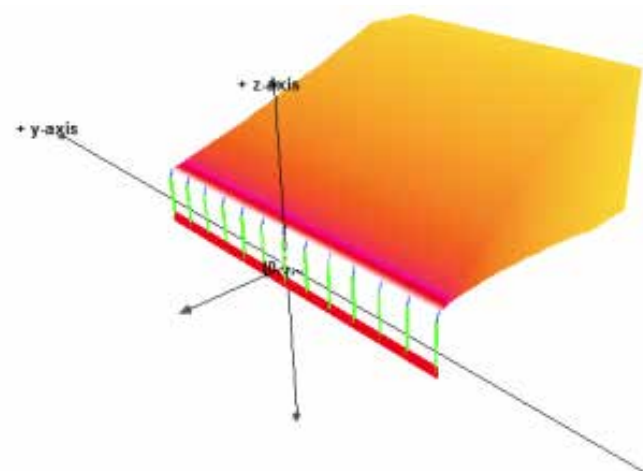
MODELLING

Management of Brine Waste

Arris has undertaken the brine wastewater strategy for a number of industries including CSG. An example is the Sundrop Farm project in South Australia, a seawater solar thermal desalination and high technology greenhouse project www.sundropfarm.com.au. The management strategy for brine wastewater is delivered in two parts: a detailed literature review and comparative analysis of brine waste management strategies specific to brine water quality and quantity, the modelled discharge plume in a marine environment for EPA approval.

In a recent example, the review covered commonly used methods of brine management and assessed new and novel technologies. A comparative analysis was undertaken under a stringent framework where prime factors that influenced the 'best fit' model included:

- Volume and nature of the brine stream: as Multi Effect Distillation was used the waste had different characteristics (as opposed to RO discharge), most significantly wastewater was 46°C;
- Sensitive marine environment: closed system with poor water exchange;



Modelling of brine discharge in a constrained marine environment using COREMIX

- Assessment of impact on sensitive ecosystems (threatened species);
- The clients 'Clean Green Credentials'; and
- Semi quantitative risk assessment.

The plume modelling was undertaken using two methodologies: computer discharge and mixing model, followed by system level box model of near, mid and far field aspect and impact assessment.

This modelling approach can be used for terrestrial waterways to understand the impact of discharge water to the system. Note: this modelling approach can be utilised for low salt, brackish and brine wastewater streams into different receiving environments.

Hydrus

A major factor in the treatment and beneficial use of associated water is the end use and potential environmental impact. Arris has undertaken 2D modelling of water flow and solute movement through the soil profiles for large scale CSG irrigation projects. The modelling allowed for an assessment of a site's suitability for irrigation; scenario testing included:

- Irrigation rates under different rainfall scenarios;
- Impact of buffer zones on solute movement;
- Differential groundwater levels and their impact; and
- Assessing impact of different soil conditions on rate of lateral movement.

In this case, the model was used to assess the movement of solutes to a river system under defined irrigation conditions.



Insitu media trials for exchange and non-exchange media. This method has been used for the assessment of salinity, SAR and pH correction of wastewaters

RESEARCH: WATER AND ENVIRONMENTAL

A key feature of Arris' work in the treatment and management of associated water is the ongoing research we undertake. Our strategic relationships with CQ University and The Waite Research Precinct has provided our clients with the highest understanding and best possible outcomes. This research is largely broken into two broad areas:

- Treatment of associated water; and
- Sustainable use of associated water.

Treatment Research

Arris is working with our clients to find sustainable cost effective treatment technologies for associated water. Arris has been at the fore of the use of zeolites as an ion exchange media for the 'fit for purpose' treatment of CSG Water.

We fund a PhD scholarship with Central Queensland University focussed on the treatment of CSG water with ion exchange and RO. This research has been undertaken at an operational scale in the field treating CSG associated water, together with trialling new treatment options in the laboratory.

A product of the research we have undertaken has been a water treatment media test bench which enables us to undertake larger scale research (relative to a typical laboratory scale experiment) to validate treatment media and sequences prior to plant scale design and construction.

provides a predictive tool to anticipate the effects of a changing water quality. It is widely understood that associated water is both spatially and temporally variable and hence, a better understanding of threshold salinity and SAR is critical to sustainable irrigation.

Having a detailed understanding of the impact of changing water quality on soil allows the management of water and treatment

A detailed understanding of the impact of changing water quality on soil stability

Environmental Research

Arris is recognised nationally and internationally as a leader in research and development into the sustainable and beneficial use of recycled water. Recently, we established a new method for the assessment of soil structural stability under irrigation with high Electrical Conductivity (EC) and SAR irrigation water. This research has led to a better understanding of the receiving environment where the client is meeting environmental conditions of their modified BUA.

The development of this methodology enables Arris to assess the impact of irrigation water on soil structural stability. As the method employed uses water with a wide range of salinities and SARs, it

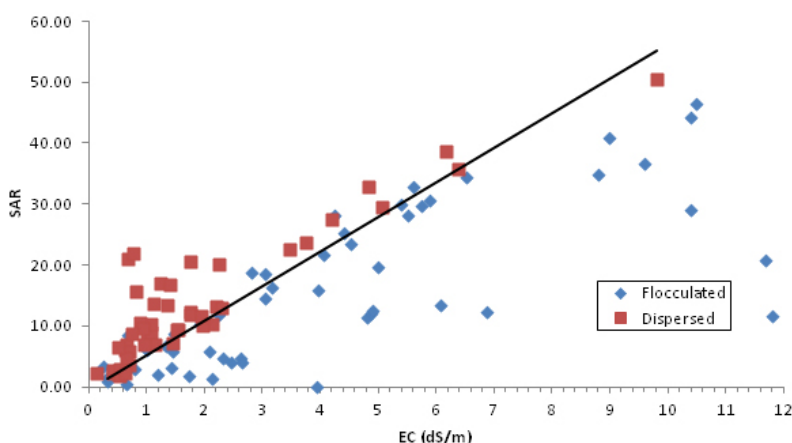
processes, ensuring that negative impact on soil does not occur and leading to reduced treatment costs.

REGULATORY COMPLIANCE, REPORTING AND BUA DEVELOPMENT

This is an important service we offer our clients. Currently, we undertake licence compliance reporting for a number of clients for over 30GL of reuse water. As discussed, we have extensive experience in the development of guidelines and the use of guidelines in the development of beneficial reuse options.

It is this experience that is sought by our clients in the development of reuse options and approvals. Our knowledge of water plant, soil and hydrogeology interactions ensures that we not only meet environmental approval conditions but also minimise the cost of regulatory compliance.

Arris recently approached the regulator on behalf of a client, at their request, for approval to use an ASPAC accredited laboratory rather than a NATA laboratory for soil assessments, improving the confidence in the results and significantly reducing the cost of analysis.



Site specific assessment of the impact of EC and SAR of irrigation water on structural stability

Arris has undertaken methodology reviews for clients who wish to have their site practices assessed for regulatory compliance. Recently, Arris conducted a review of a client's water quality assessment practices, including sample planning and frequency, field sampling practices, sample labelling, and sample transport and data handling, which assisted producing a method of site water quality assessment that met their Environmental Authority Permit conditions. Arris staff have the capability to perform these types of methodology compliance reviews for a number of environmental reporting practices/requirements.

ECOTOXICOLOGICAL ASSESSMENTS, SITE CONTAMINATION AND REMEDIATION

Arris has a broad range of skills and experience when it comes to assessing fate and behaviours of contaminants of concern in the environment. We have conducted extensive ecotoxicological risk profiles for the chemicals used in CSG production, including assessing their toxicity to organisms, mobility and persistence in soil, water and air, breakdown products, biodegradability and bioconcentration factors. Arris staff have a high level of understanding of the National Environmental Protection (Assessment of Site Contamination) Measure 1999, as well as the Australian Standard 4482.1-2005 "Guide to the investigation and sampling of sites with potentially contaminated soil". We use our knowledge of site contamination process, together with our strong soil and water chemistry knowledge, to work collaboratively with the regulators to complete full site contamination assessments and remediation solutions that satisfy all regulator requirements.

Environmental Risk Assessment

Arris developed the ERA framework for the Australian Guidelines for Water Recycling: Managing Health



and Environmental Risks. Following the writing of the environmental component of the guidelines, we trained regulators in the use of the risk assessment approach.

Rather than being limited to arbitrary threshold values, this approach assesses potential impact of water on the receiving environment. A detailed understanding of the environment is critical to the ERA where aspects and impacts are assessed and critical control points and monitoring requirements are established. This approach increases confidence in the sustainability of reuse irrigation but also matches water quality, and hence treatment requirements, with end use and environmental conditions, potentially saving significant water treatment capital and operational costs.

Provide greater insight into the potential value of water

MARKETS FOR WATER

It is well recognised that the cost of treatment of associated water can be a significant burden to the producer. It is imperative that the return (\$) of water can be maximised. However, factors that effect water pricing can include:

- Cost of competing water resources;
- Value of the crop being grown;
- Security attached to water;
- Cost of infrastructure required by the end user; and/or
- Water quality.

Arris has undertaken numerous water market analyses for reuse water for the CSG and water industries. We have identified markets for in excess of 60GL of water for predominantly irrigation of food crops. In a Victorian project, we identified an industrial user having a much higher capacity to pay. Providing significant economic benefits to the water producer.

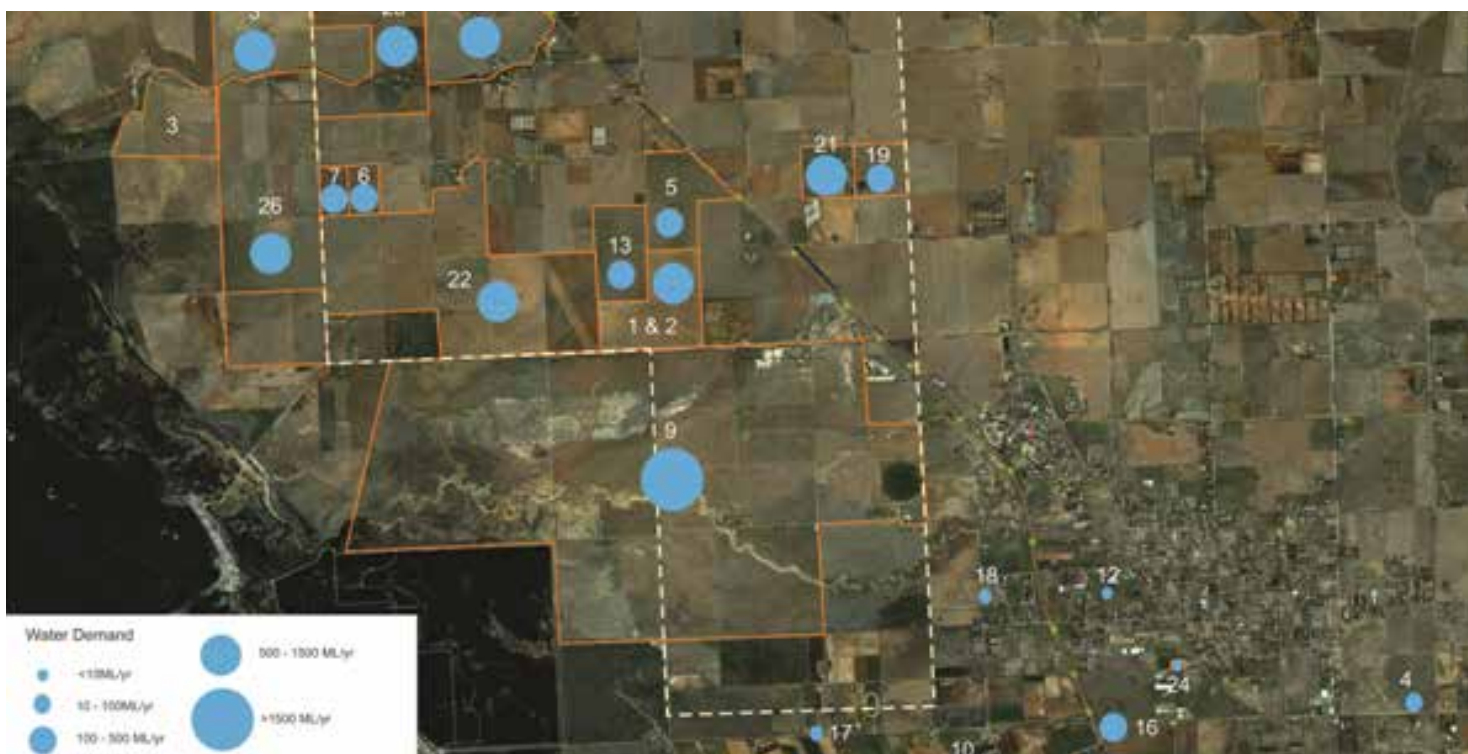
A large section of this work is the analysis of the potential customer's willingness and capacity to pay for water. In many cases, willingness can be significantly less than the customer's capacity to pay. We have developed a process which we take the customer through to increase their willingness to pay for water.

Another service offered by Arris in this space is the development of customer contracts and customer rules. It is critically important to clearly define what the offering is to the potential customer; this may change through the negotiation process but the greatest barrier to adoption is the confusion that can develop through poor communication.

STAKEHOLDER ASSESSMENT AND ENGAGEMENT

Arris has been a major player in the development of beneficial reuse of treated effluent water for food production. This commenced with a five year research project through the University of Adelaide and a subsequent seven year tenure as the National Coordinator for Recycled Water Development in Horticulture. A critical component of this work was the management of key stakeholders and the production of national communication tools promoting the benefits of recycled water use.

Able to shift stakeholders' views of reuse water from a liability to an asset





Sundrop farms community information brochure

We understand the importance of clear and effective communication with identified stakeholder groups. As with the CSG industry, the effluent reuse industry had significant barriers to the adoption of reclaimed water. Interestingly, farmers were one of the most influential stakeholder groups where preconceived concerns about potential impact to their property and markets were a major barrier.

A principal advantage of Arris is that many staff are not only scientists but are from farming backgrounds. This is a significant advantage in gaining 'trust' when interacting with landholders. We have been able to shift stakeholders' views of reuse water from a liability to an asset.

SOUTH AUSTRALIAN REGULATORY FRAMEWORK

Arris was involved in the South Australia's National Partnership Agreement (NPA) on CSG and Large Coal Mining Development for the South Australian Department of Environment, Water and Natural Resources. The purpose of this NPA program was to prepare South Australia's component of a national management regime for CSG and coal mining, through the development of improved understanding of the bioregions in which these activities take place. Members of our team managed the overall \$13M South Australian program and developed the communication and stakeholder plan.

Management of the program included overseeing the early stages of the program:

- Agreements and liaison with national partners – Office of Water Science, Geoscience Australia, CSIRO, Bureau of Meteorology, mining companies, and South Australian and Northern Territory regulatory agencies;
- Agreements and project plans with six South Australian Natural Resource Management Boards to develop and ground-truth water asset databases;
- Development of scientific and investigative programs;
- Management of communications and communications planning;
- Overseeing the development of a state bioregional database; and
- Delivering on all of the contracts associated with this significant policy development program.



HYDROGEOLOGICAL SERVICES

The operation of CSG, coal and shale mining projects require hydrogeological impact assessments. These are essential in the exploratory, extraction and beneficial water reuse phases.

Arris has recently added hydrogeological services to our suite of services. New to our staff is a highly experienced hydrogeologist who provides essential skills in the gas extraction industry. These services include aquifer storage and recovery where he has been at the fore of ASR research for reuse water.

Surface/unconfined aquifer assessment and modelling is a critical success factor in the sustainable use of co-produced water. Leaching requirements and its impact on regional hydrology must be understood in any irrigation project. Adding a respected senior hydrogeologist to our water, design and environmental science skill set provides our clients a holistic service.





CLIENTS

Arris has provided a range of services to some of Australia's most influential miners, including:

- WestSide Corporation Limited;
- AGL Energy Limited;
- AJ Lucas Group Limited;
- Santos Limited;
- Glencore Xstrata;
- The Griffin Coal Mining Company Pty Limited;
- Aligned Energy Pty Ltd
(partnered with Oil Search Limited);
- Strike Energy Pty Ltd;
- BMA;
- Bassari Resources Ltd;
- Yarrabee Coal.

KEY TEAM MEMBERS

Arris has assembled a team of speciality experts that have worked together on a wide range of integrated projects.

Water treatment

Ben Kele, Director, Water Treatment and System Design

Environmental and Beneficial Reuse

Jim Kelly, Managing Director, Senior Environmental Consultant

Hydrogeological

Zac Sibenaler, Senior Hydrogeologist

Stakeholder Management

Bruno Carrocci, Manager, Marketing Communication



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