WATER TABLE, AQUIFER & LIXIVIANTS

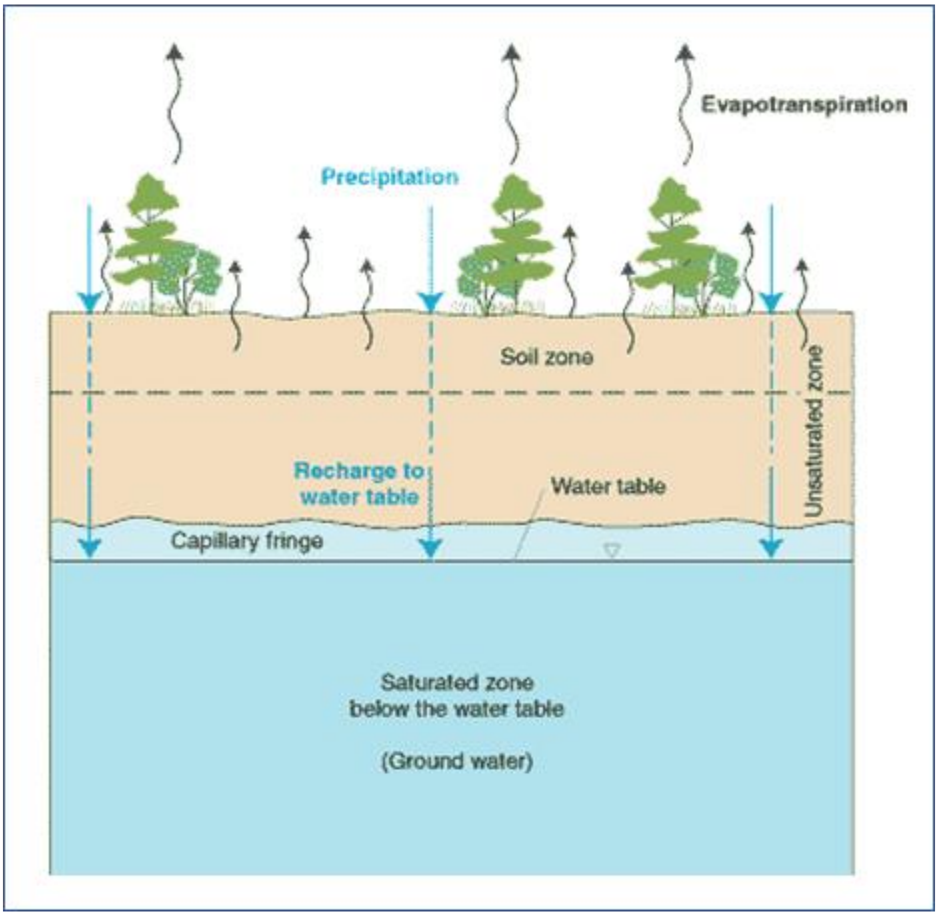
What is the difference between an aquifer and a water table?

Aquifers are storehouses of water or otherwise known as a saturated zone.

Movement of water within this zone can occur depending on the permeability of the surrounding rocks (cracks and spaces), and be can be influenced by precipitation (rainfall) and evaporation (hot summers).

The upper surface of this zone is referred to as the water table.

This water table is a measurement of the level of water within the aquifer, which is influenced by the above factors. See diagram below



LIXIVIANTS

What is the actual nature of the lixiviants?

12 Lixiviant solutions being researched with key ones listed below: -

Glycine is a colourless, sweet-tasting, non-toxic crystalline solid and occurs naturally in the human body. It is cheap, easily transportable and re-usable. Glycine is used as an additive in pet food and animal feed. For humans, glycine is sold as a sweetener/taste enhancer. Certain food supplements and protein drinks contain glycine. **Glycine is Biodegradable** breaking down quickly (few hours) into ammonia, carbon dioxide and water.

While glycine works best at higher pH values it **will extract copper at pH > 7**. It's use is being investigated because there are a range of pH settings in the ground water in the Kapunda mine site area, ranging from pH < 3 through to pH >9 . Calcareous rocks (dolostones) exist in higher pH environments so glycine would be a suitable lixiviant choice (without the addition of caustic soda), in other parts of the mine area, sulphides (mainly pyrite) have created quite acidic conditions in the ground water (pH <3). Here an investigation of another different lixiviant would be undertaken.

Sodium Thiosulphate is an odourless, white crystalline solid and has applications in water treatment, neutralizing bleach, leather tanning, gold extraction, photographic processing, and chemical heating pads. **Thiosulphate is Biodegradable** breaking down into oxy sulphur species – sulphates, sulphites and sulphur - depending on pH conditions and other material in the ground. Matching the current conditions of naturally occurring sulphides already present in the mine site.

Vinegar (acetic acid) the solution being tested is effectively diluted household vinegar.

How does the lixiviant extract the copper?

The extraction method involves injecting a lixiviant into the ore body from bores and then extracting the solution after it has reacted with the copper. The copper is dissolved to copper ions, transported in the water/lixiviant mix and the copper is then extracted at surface.

It is a closed loop system, with a net flow towards the central extraction point being obtained by pumping-out at a slightly higher rate than the cumulative pumping-in rate. The extracted solution is then pumped to a processing shed, where the copper is extracted.

See "Q&A What Will the Mine Look Like?"

If the extraction rate must be higher than the injection rate to ensure solution flow in the required direction, what is the net impact on water levels in the aquifer?

Water levels near the mine site will be lowered very slightly, however on a regional scale the impact will not be measurable. The area that is being processed at any one time will be relatively small (~75m x 75m).

The wells in the middle of this area extract a slightly higher percentage of fluid than is injected in, leading to a small hydraulic gradient flowing towards the centre rather than away from the area, in a localised effect unlikely to have a regional scale effect on the aquifer.

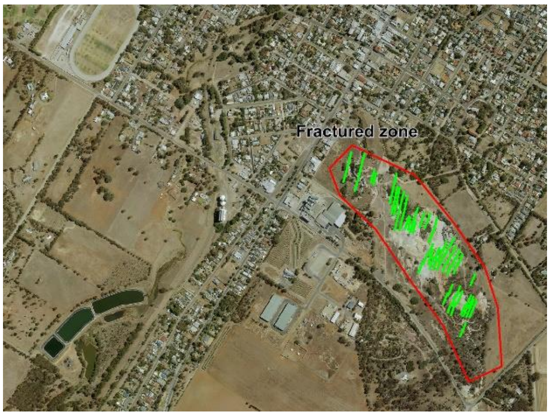
Detailed calculation of water table drawdown by CSIRO and University of Adelaide will form part of the research. The regulatory processes will be undertaken after test bores are installed and aquifer testing is completed.

What is the hydro-geology of the mine and surrounding area?

Data from historic reports indicates that there appears to be a natural "bowl" effect containing fluid within the mine area. Water moves easily within the highly fractured mine area but is constrained by the less permeable, unfractured surrounding siltstones. It appears that water does **not move quickly into the non-fractured areas**.

This suggests that fluid control is contained within the mine area and is evidenced by the fact that the elevated copper levels are not seen in the surrounding water courses e.g. Light River.

The regulatory process will involve drilling bores and conducting pump testing to ensure this is the case.



The above diagram highlights in green the exiting lodes; natural geological fractures that allow high fluid transmissivity within low permeable siltstones and therefore containing any fluid transmission.

What is the likelihood that the solution may spread to the aquifer outside the mine area, e.g. by failure of the machinery or some blockage or discontinuity that prevents the solution flowing towards the extraction point?

Due to the nature of the natural hydro-geology (see previous point) it would be extremely unlikely to escape into the surrounding area and remembering that the fluids are environmentally friendly, breaking down into the soil/water into naturally occurring elements.

However, government regulation still require us to have risk mitigation plans in place.
At a local level around the pumps the following would occur: -

a. Pipe and pumping systems are fitted with a series of flow and pressure monitoring sensors. If high flow / low pressure (pipe failure) or high pressure / low flow (pipe blockage) is detected, then the system shuts down.
b. Bores will have leak trays around pipe work fitted with leak detection sensors.
c. Well fields and storages are typically bunded (retaining wall) to control any spills of benign lixiviant.
d. Un-planned movement of mining solution outside the mining zone is detected by frequent sampling of a perimeter ring of closely spaced monitoring wells.

Having these back-up systems is a requirement of the mining application process but will be a lesser issue in the presence of new biodegradable lixiviants and the natural hydro-geology.

Maintenance of the specified water balance (extraction greater than injection) is typically a regulatory requirement for operating ISR mines. The flow rates are continuously monitored by electronic flow meters and any pump failures are addressed immediately by stopping injection until the pump is repaired and the required water balance can be maintained.

What is the actual environmental state of the surrounding aquifer and Light River?
It is important to emphasise that the present-day groundwater within the mine area has very high salinity levels and has elevated levels of dissolved copper that have leached naturally from the ore. Current salinity levels in the area are generally reported between 2,000 and 8,000 mg/L with isolated occurrences of salinity being less. These salinity levels are classified as brackish to saline and not suitable for drinking or irrigation. See next point on EPA report on Light River.

Recent measurements of dissolved copper within the main pit is 354mg/L and an historic measurement within Stockyard Shaft recorded 382mg/L. Readings in surface runoff reach as high as 1000mg/l Cu. See next point on safe copper levels.

Initial testing of the Light River shows no presence of copper. CSIRO Land & Water will further investigate existing contaminants along a larger section of the river.

According to National Drinking Water Guidelines (6) updated 2017 (NHMRC), recommended concentration of copper in drinking water should not exceed 2mg/L.

Baseline environmental studies undertaken by ECR Pty Ltd to date (as part of the regulatory process) have reviewed multiple reports available in the public domain and established that the mine site and surrounding area contain highly elevated levels of copper and heavy metals. These levels have been leached by natural processes and previous mining activities.

The Light River has been classified as “poor” by the EPA in 2 reports dated 2011 and 2016, due to high level of TDS (total dissolved salts), nitrates and phosphates from agriculture.

(EPA Report 2016)

http://www.epa.sa.gov.au/reports_water/c0474-ecosystem-2016

There appear to be no known use of the water via bores registered with Water Connect.

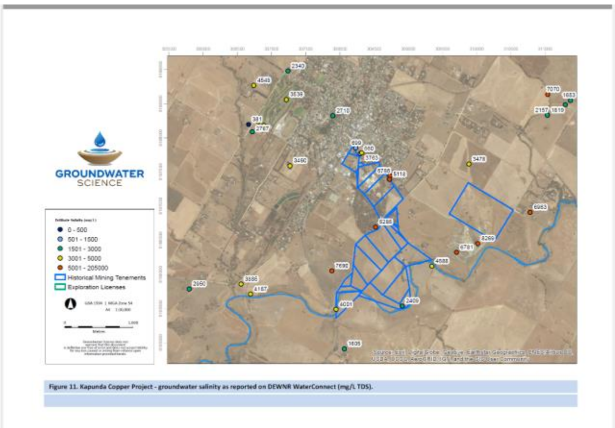


Diagram showing salinity levels as reported by DEWNR Water Connect

What will be the quality and safety level of the water left in the mining area once mining ceases?

It is envisaged that the water quality will be similar if not better after the operation, as existing high levels of copper will have been removed during processing and salinity levels may have been slightly reduced during the processing operation.