Managed Aquifer Recharge, an Australian Perspective

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Groundwater Management
Managed Aquifer Recharge (MAR) / Aquifer Storage and Recovery (ASR)

• Purposeful recharge of an aquifer for recovery or environmental benefit
• Benefits - increased water use efficiency, continue to meet agriculture needs, address environmental water requirements
• Forms of MAR
  – Aquifer Storage and Recovery (ASR)
  – Aquifer Storage Transfer and Recovery
  – Infiltration ponds/infiltration galleries
  – Soil Aquifer Treatment (SAT)
  – Bank Filtration
• Urban (recreation/potable)
• Rural Application (drought augmentation/replenish g/w levels)
Government Participation to Encourage Managed Aquifer Recharge

National Water Commission (a federal government organization) recognized that acceptance of Managed Aquifer Recharge was hindered by:

- High uncertainty of initial cost estimates compared with alternatives
- Relatively high upfront costs to evaluate feasibility
- Poor understanding of groundwater processes
- Regulatory barriers
- Lack of demonstration sites in many areas

To get more installations completed the National Water Commission did the following:

- Developed a policy design for managed aquifer recharge
- Compiled and published existing case studies
- Evaluated Managed Aquifer Recharge specifically for agriculture
- Developed maps ranking Managed Aquifer Recharge opportunities
- Established eight demonstration sites
High Level Government Support for Using Managed Aquifer Recharge (MAR)

Typical Australian MAR Project Drivers

- National Resource Management/Water Banking/Groundwater User Associations
- Strategic Resources
- Saline intrusion barriers
- Bank infiltration
- Large scale flood harvesting
- Combined infiltration-injection treatment/storage systems
- Conversion of unmanaged to managed aquifers
- Restoration of stressed groundwater and surface water systems
History / extent of MAR
1960s Burdekin Delta System - infiltration basins 100.5 MG/yr
1970s Callide and Lockyer Cks – Recharge wells
1970s Little Parra Dam – recharge release 4.0 MG/yr
1980s MAR for the Angus-Bremer irrigation region 6.0 MG/yr
1995 Gully Winds Vineyard, Barosa Valley – MAR (wells)
Three Moon Creek Water Supply scheme, 1.3 MG/yr
2000s Mining Sector, water supply and environmental 100.5 MG/yr
Typical New Project Example – Derwent Park an urbanized area with suburban and industrial land use.

Urban area
High demand for water
Opportunity for project to replace potable water use
Appropriate geologic environment
Unclear environmental regulations related to:
• water rights for source water
• water rights for recovered water
• storage rights
Where is Derwent Park?
Triggers for stormwater harvesting at Derwent Park

- Water is available in stormwater peak flow,
- Stormwater infrastructure improvements needed, and
- Federal funding available if stormwater is harvested for re-use.
Why Aquifer Storage and Recovery (ASR)?

Not enough room on the surface for tanks or reservoirs
Previous geologic investigations helped select the location – enough to identify a potential storage aquifer.

Pre-existing gravity survey indicated elongated basin of low-density sediment and basalt-filled paleovalley – potential for groundwater storage.

Glenorchy City Council (local government) needed somewhere to store peak flows and had money.

Federal funding provides additional money if water is reused.

Tasmania’s first ASR project is born
Project Description

• Stormwater yield of the catchment could supply much of the water needs of processing at the Nyrstar Zinc Refinery, replacing high-quality potable water.

• However, in order to capture peak flows, an impractically large surface storage facility would be required. So…

• Assessment of the feasibility of Aquifer Storage and Recovery (ASR)

• Started as an investigation project, to drill a few small diameter holes and see if there was an aquifer. Found thin sands over basalt, some basalt is very permeable with vesicular and flow breccia zones.
• Harvest suburban stormwater: solve flooding problems and provide water near end-user.
• Treat in large wetlands and settling ponds: lots of storage and inexpensive treatment.
• Inject in deep, confined uniform aquifers: easy to control and monitor.
• Clear regulatory environment and process: Surety of water and storage rights.
Example of an ideal stormwater ASR location - Bolivar South Australia (Ayuso et al 2010)

Open area with lots of room for wetland water treatment, drilling rigs and pipework. Regulatory acceptance of ASR.
Derwent park is not ideal

- Suburban and industrial catchment (potential for contaminants – needs regular monitoring)

- No room for wetlands (need engineered filter systems)

- Shallow and complicated aquifer (required a lot of drilling and testing) which will require a lot of monitoring

- No clear regulatory environment for ASR and very limited control on groundwater use (although regulators wanted input anyway).

- Aquifer is unconfined and shallow
Components of Derwent Park ASR System Help Resolve the Less Than Ideal Circumstances

<table>
<thead>
<tr>
<th>Component</th>
<th>Derwent Park ASR system</th>
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<tbody>
<tr>
<td>1. Capture zone</td>
<td>Stormwater from the Derwent Park catchment</td>
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<tr>
<td>2. Pre-treatment</td>
<td>Gross pollutant traps and bio-filtration</td>
</tr>
<tr>
<td>3. Recharge</td>
<td>Mostly injection wells (but possibly lots of leakage from drains)</td>
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<tr>
<td>4. Subsurface storage</td>
<td>Vesicular, fractured basalt and alluvial / lacustrine sands</td>
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<tr>
<td>5. Recovery</td>
<td>From combined injection extraction wells</td>
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<tr>
<td>6. Post-treatment</td>
<td>Micro filtration and reverse osmosis</td>
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<tr>
<td>7. End use</td>
<td>Industrial use and possibly irrigation for parks</td>
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Harvested storm water system schematic of water flow (from Page et al 2010, Managed aquifer recharge case study risk assessments. CSIRO: Water for a Healthy Country National Research Flagship)
**Sequence of Development**

- **Aquifer Testing**
  - 2010-2011 investigation identified basalt and sand aquifers in a palaeovalley of the Derwent River

- **Stage 1**
  - Entry Level Risk Assessment – viability, degree of difficulty
  - Identified vesicular basalt and sand aquifers, adequate storage capacity for the proposed short-cycle ASR usage

- **Stage 2**
  - Pre-commissioning investigations and risk assessment
  - Geochemical evaluation, clogging evaluation, water quality assessment, extraction & injection

- **Initial Operation**
  - Extraction cycles at about 630 gpm (~40L/s) with static water level and chemical monitoring. Injection cycle uses potable water until filtration system on-line.
The Aquifers

- Initially identified sand-filled palaeochannel target

- But, basalt was closer to the proposed storage areas. Permeable zones along flow breccias vesicular zones, but some massive, impermeable zones (required a lot of drilling to figure out).

- Thick clay layer at base of basalt and along eastern edge which isolates aquifer underlying basalt and more importantly saline estuary and landfill.
Drilling production wells in the ‘burbs

One of the more accessible sites
Pumping test from 50 gpm to 320 gpm (20+ L/s) extraction rate

BH30
Injection testing at ~ 150 gpm (10 L/s) per well (design target of 1,500 gpm for 10 wells)

- Constant head injection at ~3.9 m above initial SWL.
- Injection ceased at approx 380 min.
- Dropped to to within 0.3m of starting head within 20 minutes and within 0.04 m within 2 hours after injection ceased.
Completed headworks

- Injection and extraction lines. (temporary PVC for trial)
- Rather than single riser with complicated control valves, shallow depth and wide diameter of well allowed separate injection and extraction risers down hole.
- Injection rate controlled based on water elevation in well, not simple flow rate. This prevents over-injection of unconfined, shallow aquifer.
• Fairly uniform groundwater chemistry in both basalt and sand - sodium-chloride/bicarbonate type. Max 3000 ppm TDS

• Geochemically compatible with injected water and aquifer (no precipitation or dissolution)
Modelling – Calibrate existing conditions

Groundwater model developed and calibrated for existing conditions. Then use model to evaluate the effects of injection and extraction cycles.
Example of modelling injection and extraction cycles - Based on daily rainfall. For this example run, peak injection 1,500 gpm (100 L/s) and peak extraction 630 gpm (40 L/s)
Maximum drawdown over 1 (dry) year of operation.

Dark blue = 0.2 m
Impacts to Surface Water Minimal

- Examined low to and from rivulets
- Assessed drawdown near creeks and all OK.
- More analysis world be required if system expands closer to surface water bodies.
Current Status

• Approval process worked out with multiple government departments; Federal grant ($), EPA (environmental agency), DPIPW (groundwater agency), DPIPWE (surface water agency), and GCC (local government, $).

• Initial injection and extraction underway, with close monitoring of water levels and chemistry by GCC (local government).

• Remote flow control – Injection cuts off if water level too high pump shuts off if too low (all flow and water level data pushed to smartphone of operator).

• Data to be used for further numerical modelling to confirm optimum injection and extraction rates and locations and impacts along coast.

• Additional extraction/injection wells to be fitted out with extracted water used for industry.
Future Directions

• If the trial operation and further investigation confirm larger scale ASR is feasible, the injection and extraction network may be expanded with the water used for irrigation (replace potable water and without treatment).

• Operational risk assessment for basalt area will begin after review of flow, water levels and chemistry data in late 2013.

• Start all over again for sand aquifer? - With the benefit of lessons learned by the project team and regulators.
Outcomes

Key factors for project success have been identified as:

• Ability to capture short-term, high flows - Need lots of injection wells.

• Proximity of Derwent and contaminated groundwater beneath former landfill – Risk reduced by limited basalt shoreline and clay base.

• Shallow groundwater levels limiting injection rates – Monitor and automatic control to prevent over-injection of shallow aquifer.

• Urban and Industrial catchment – Close monitoring or chemistry to allow early identification of contamination.
Outcomes cont.

Key advantages of including ASR in the stormwater harvesting project are:

• Limited current groundwater use.

• Potential to improve groundwater quality.

• More cost-effective than storage tanks, thus increasing the supply of harvested stormwater.

• Limited environmental risk due to highly modified urban catchment - but still monitored.
And Finally

- Although a relatively small-scale ASR project, this project represents Tasmania’s first ASR scheme
- It has helped develop the regulatory process
- Will hopefully act as a demonstration project for further larger-scale projects in Tasmania.
- But, will need to get areas “declared” to provide security over injected water.
Questions?