Hydrogeology of the Dry Creek Salt Fields and Groundwater Flow Towards the Mangroves of St Kilda

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NGO Meeting

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SOUTH AUSTRALIA

Government of South Australia

Department for Energy and Mining

Objectives

Update on:

- Conceptual hydrogeology
- Groundwater and salt flow toward the marsh

Everything presented today is preliminary and draft and represents work in progress

Geology and Hydrogeology

Pre-salt fields:

- Thin (<4m) coastal aquifer in the St Kilda Formation
- Groundwater elevation is < 2m AHD
- Horizontal hydraulic gradient towards the west
- Water table close to ground, some waterlogging in winter
- Likely brackish to slightly saline groundwater
- Groundwater discharge to the marsh
- Thin aquifer, water table close to ground = not much space left for extra water

Salt ponds would have changed the hydrogeology:

- In general, any dam/pond that is not underlined by adequate thickness of impervious material will leak.
- This leakage creates an artificial groundwater recharge that can form a '*mound*' beneath the pond.
- Due to the elevated position of the mounded water table, there will be an increased groundwater flow to the marsh (and also towards the eastern landward side of the pond) with increased salinity.

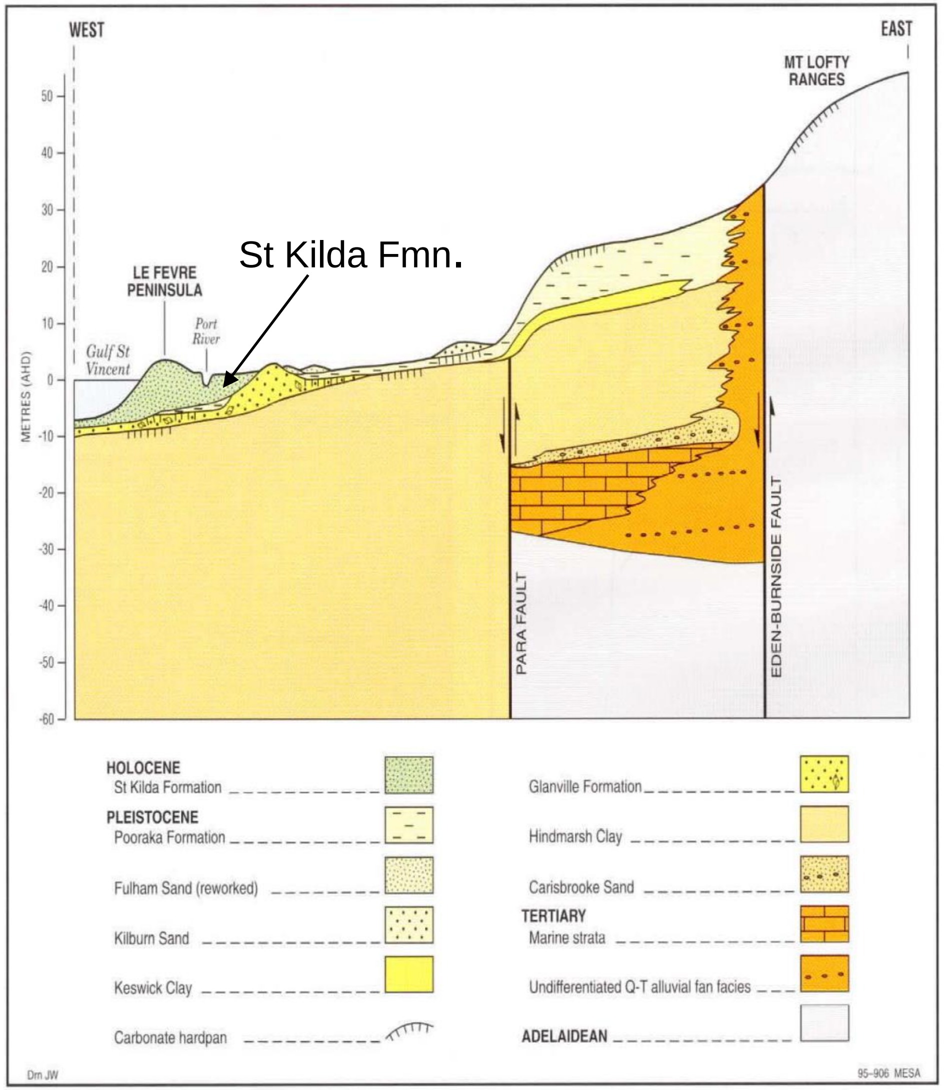
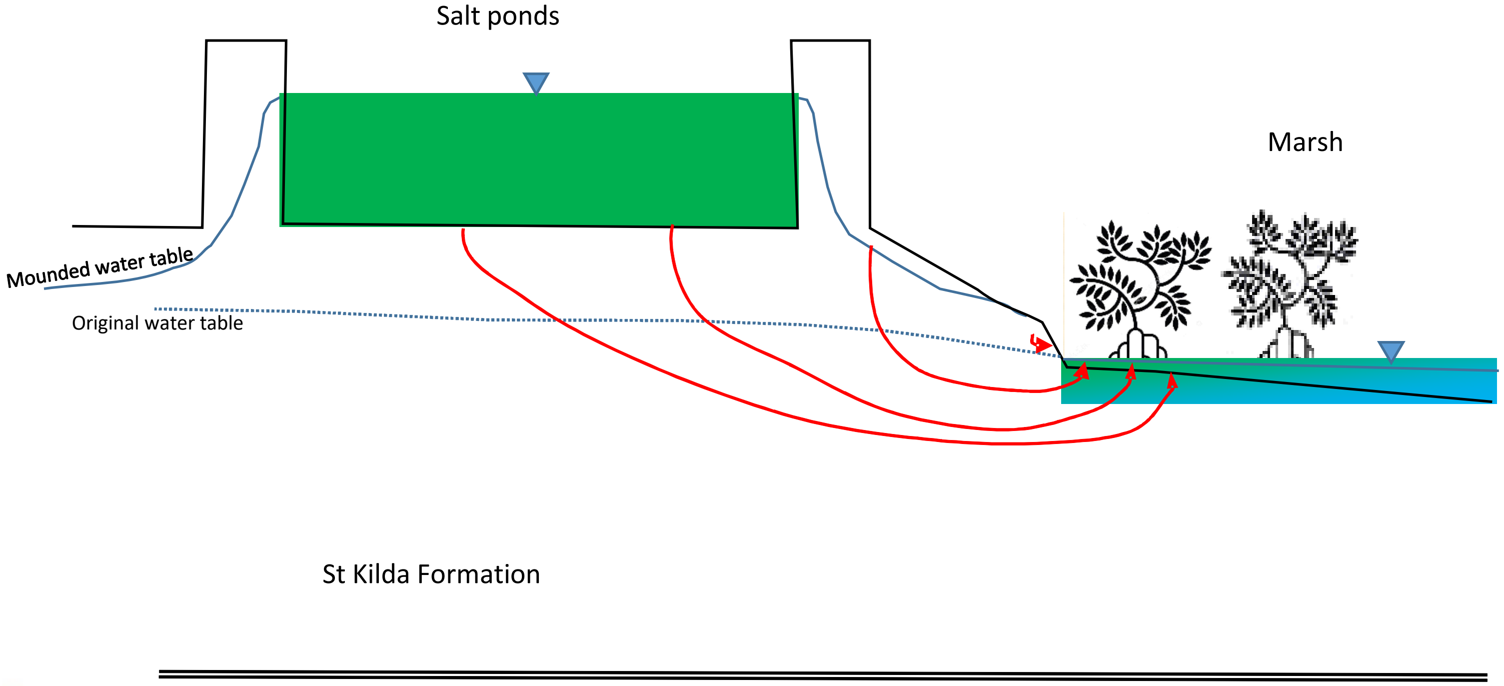


Fig. 11.12 Schematic cross-section from Le Fevre Peninsula to the Mount Lofty Ranges, showing relationships between Quaternary coastal marine and continental facies of the St Vincent Basin (after Sheard and Bowman, in prep.; Belperio and Rice, 1989). Not to scale.

Groundwater mounding and flow to marsh



Mounding causes more salt flux

- Cracked gypsum bed → increased hydraulic conductivity → more loss of brine (recharge to groundwater)
- More recharge to groundwater → higher mound
- Higher mound → more groundwater flow to marsh
- If groundwater is raised up to the pond → groundwater salinity ≈ pond salinity
- More groundwater flow @ higher salt concentration → more salt flux to marsh

Evidence to support the conceptual hydrogeology

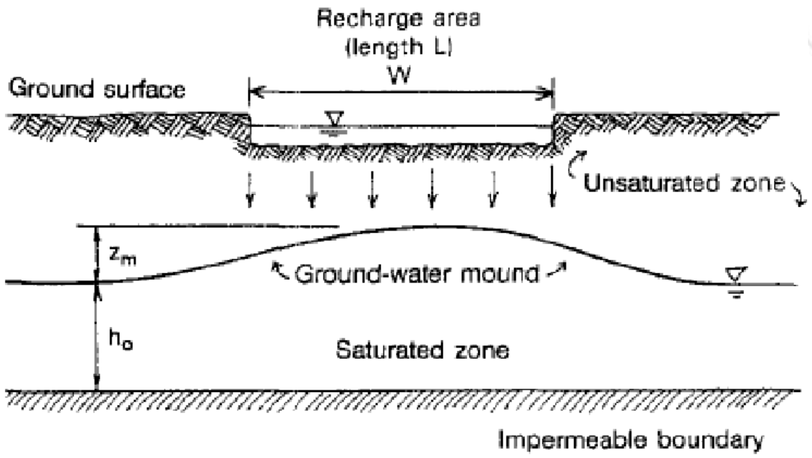
- EPA data (new wells, measurements on new and Tonkin (2015) wells, salinities, water quality)
- Tonkin Consulting (2015). Dry Creek Salt Fields Shallow Piezometers Installation and Monitoring. ARI – Ridley, 14 January 2015, Ref No. 20140089FR1.
- Coleman, P (2020). Appendices: Technical Summaries and Mapping. Mangrove deaths. Draft Appendix 6 to Report Prepared for Salisbury Council.
- Notes. Meeting with DEM, DEW, EPA on 6 October Re Salt Field Issues, by Nick Withers, 10 October 2020
- Pavelic P and Dillon P J (1993). Gillman – Dry Creek Groundwater Study, Volumes I and II. Final report to MFP Australia. Centre for Groundwater Report No. 54, December 1993.

Process 1 : Mounding

- US Geological Survey Scientific Investigations Report 2010-5102 "*Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins*" and associated spreadsheet.
- Input parameters are in part based Coleman's (2020) assessment of pond PA10
  - Recharge : 4.4 mm/day
  - Duration of infiltration period: 42 days
  - Specific yield : 0.1
  - Horizontal hydraulic conductivity: 0.1 m/d
  - Basin half dimensions: 300 by 400 m

The resulting mounding is 1.85 m (the initial water table would rise by 1.85 m).

Confirms that the loading on PA10 would easily be large enough to bring groundwater to above the gypsum bed of PA6.



https://www.semanticscholar.org/paper/Groundwater-mounding-and-contaminant-transport-Thompson-Nimmer/c8e7235b510baadb904fca2227934a6b7176091c/figure/4

Process 2 : Flow to the Marsh

Seepage through a dam, after Ritzema (2006):

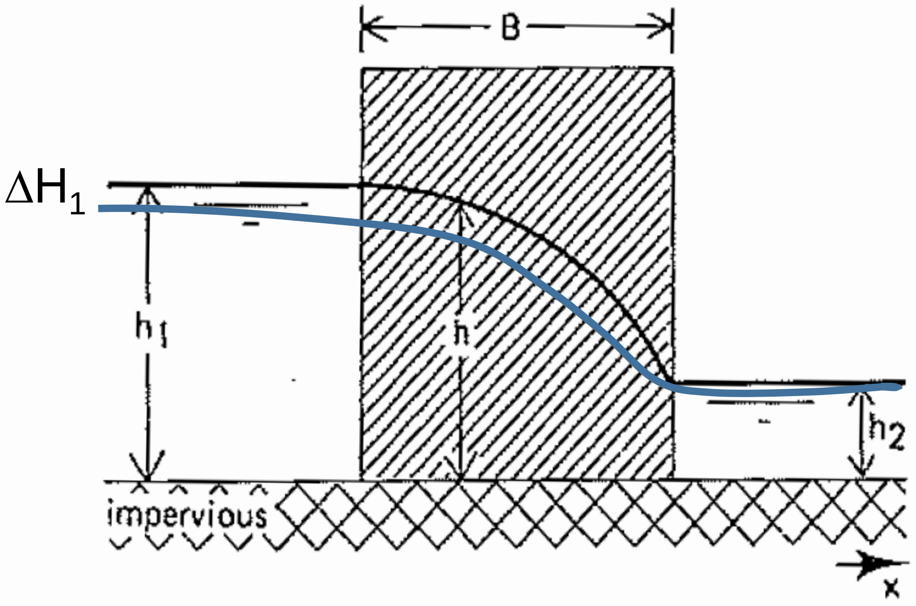
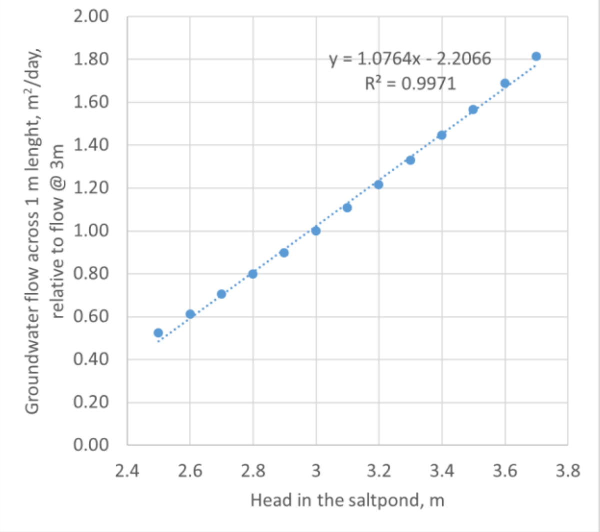


Figure 9.6 Seepage through a straight dam with vertical faces

$$Q = k\,(H_1^2 - H_2^2) / 2B$$



Where:
k is the hydraulic conductivity for the aquifer
H_1 is the groundwater head beneath the salt ponds, above the base of the aquifer, estimated as 3.3 m for 26 November 2020.
H_2 is the groundwater head in the marsh above the base of the aquifer, estimated as 2.0 m.
B is the lateral distance between the measurement points for H_1 and H_2

$$Q = Q\,(k, H_1, H_2, B) \sim Q_{norm}(H_1) \sim Q_{norm}(H_{brine})$$

Rule-of-thumb: "every 0.1 m decrease in the salt pond head would reduce the groundwater flow by about 11%" subject to several assumptions

Preliminary EPA monitoring results

1. A comparison between groundwater elevations for P02-P05 and P07-P08 near to the visitor centre indicate a +0.7 m increase in groundwater elevation from 2014 to November 2020.
2. Groundwater mounded right up to the pond and above the gypsum seal in pond PA6 in November 2020.
3. Groundwater salinity was between 164 and 295 g/L TDS in November/December 2020.
4. By 21 December 2020, the brine elevation in PA6 and PA7 declined by about 0.10 to 0.15 m from 26 November in PA6. Wells nearest to the visitor centre, P02 to P05, show about the same 0.10 to 0.15 m decrease in groundwater elevation. Negligible change occurred since 26 November in the corresponding outer western marsh wells.
5. By 18 January 2021 the wells nearest to the visitor centre, P02 to P05, show an additional 0.15 m decrease in groundwater elevation (measured from 21 December). Wells to the west of PA8 (P06-8) also show an additional 0.15 m decrease.