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

August Update

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SOUTH AUSTRALIA

Government of South Australia

Department for Energy and Mining

Reminder and Update

Reminder slides 3-7

- Based on a presentation to non government organisations (NGOs), 25 May 2021

Update slides 8-12

- Groundwater flow and salt flow (flux) towards the marsh along Transect A, through PA6, nearest transect to St Kilda mangroves visitor centre

Note presentation preliminary and draft only; work in progress

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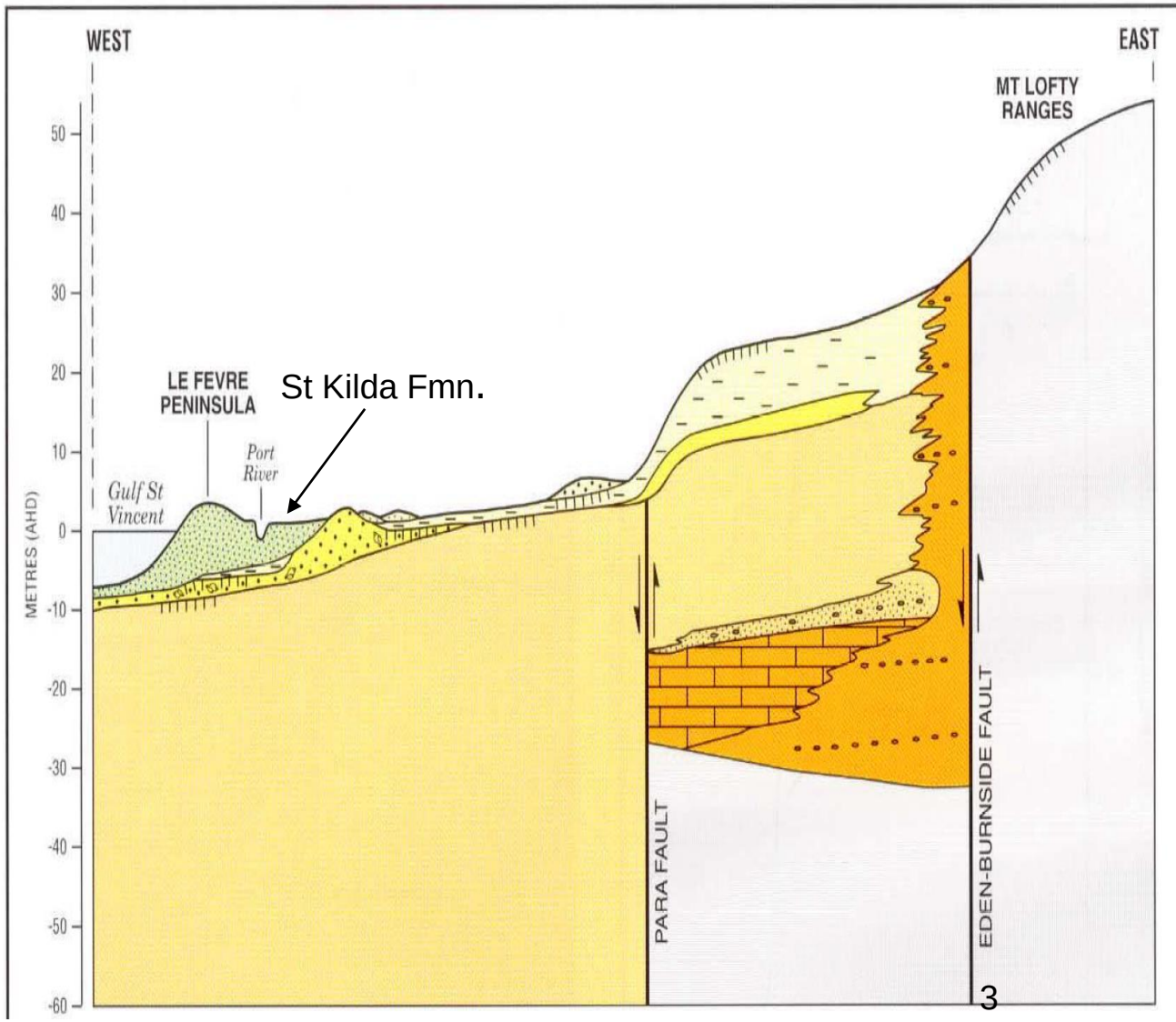
Reminder one: Geology and Hydrogeology

Pre-salt fields:

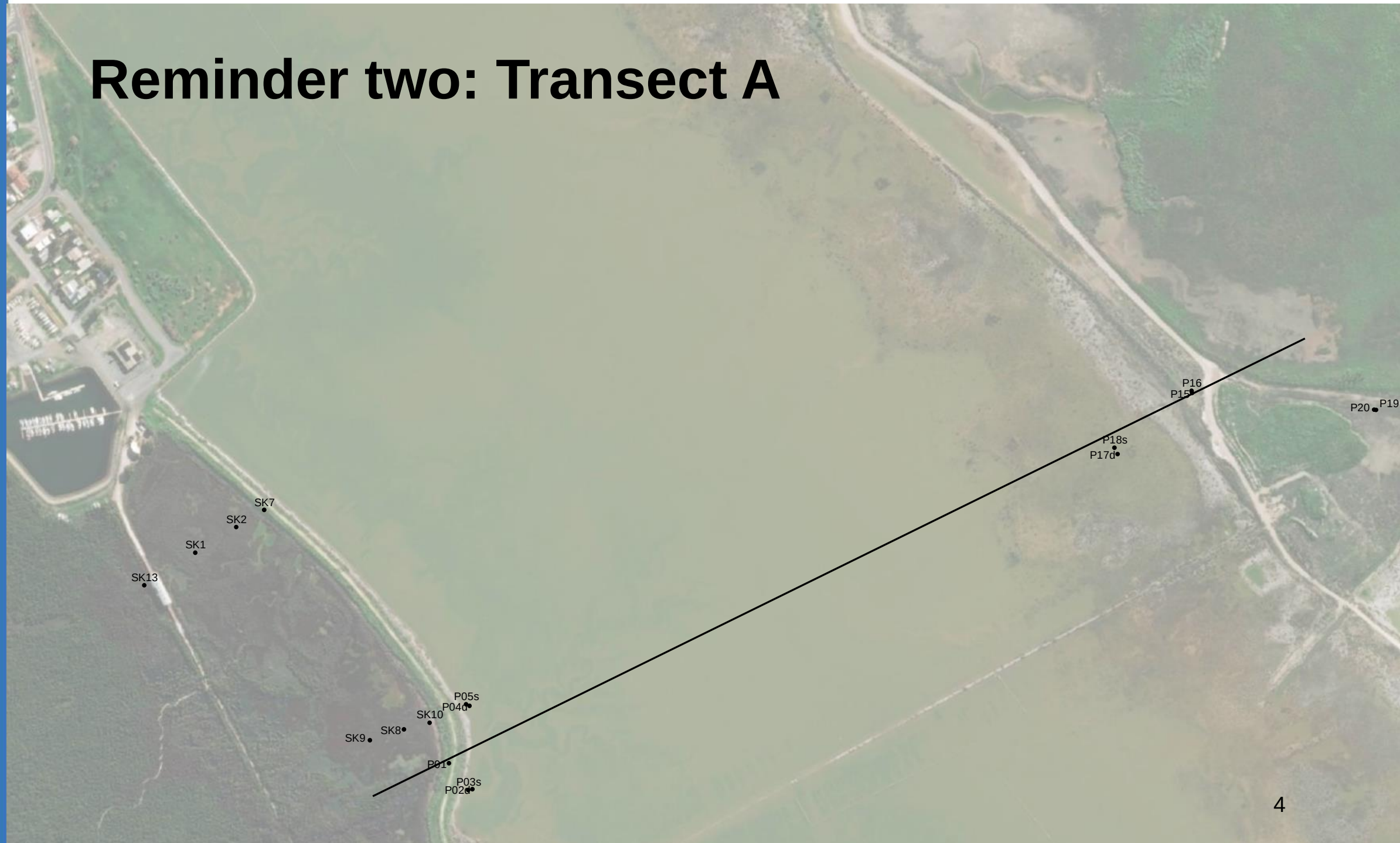
- Thin (<4m) coastal aquifer in the St Kilda Formation (Fnm.)
- Horizontal hydraulic gradient towards the west
- Water table close to ground, some waterlogging in winter
- Groundwater discharge to the marsh
- Thin aquifer, water table close to ground = not much space left for extra water

Salt ponds would have changed the hydrogeology:

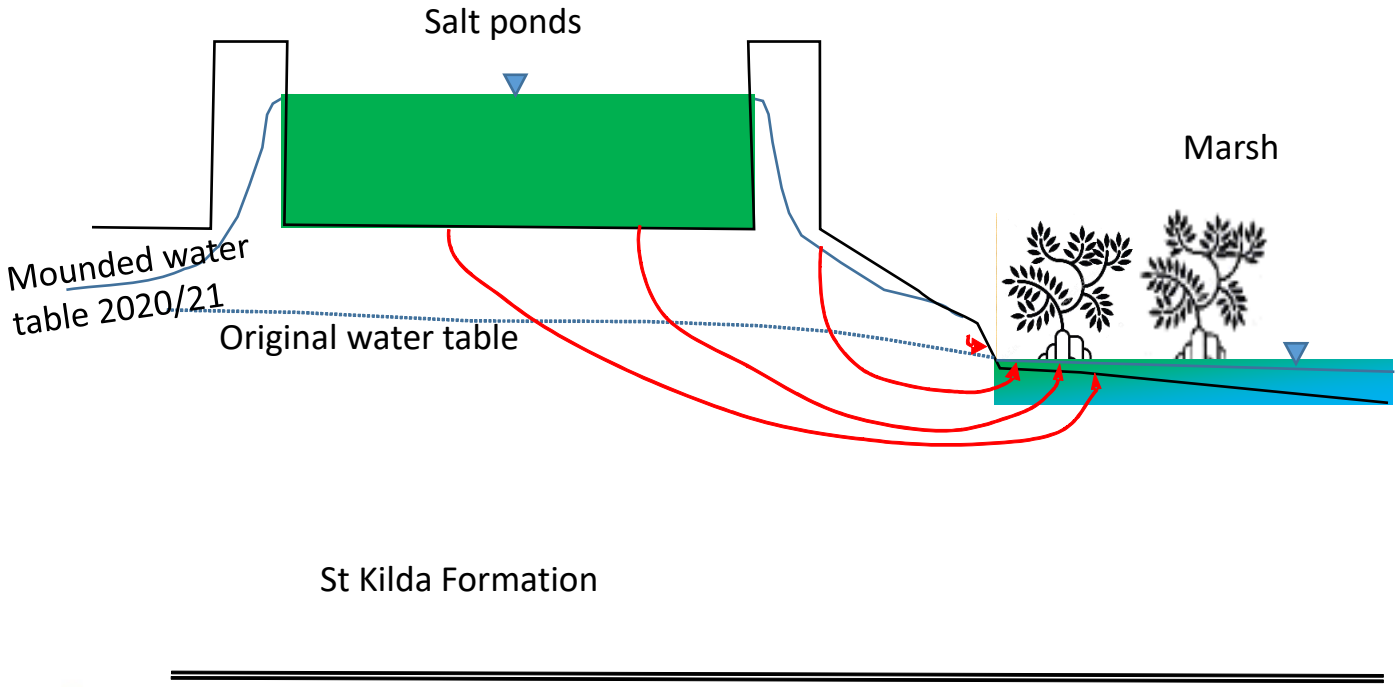
- Leakage creates an artificial groundwater recharge that can form a '*mound*' beneath the pond
- Due to the elevated position of the mounded water table, there will be an increased groundwater flow to the marsh (and also towards the eastern landward side of the pond) with increased salinity



Reminder two: Transect A



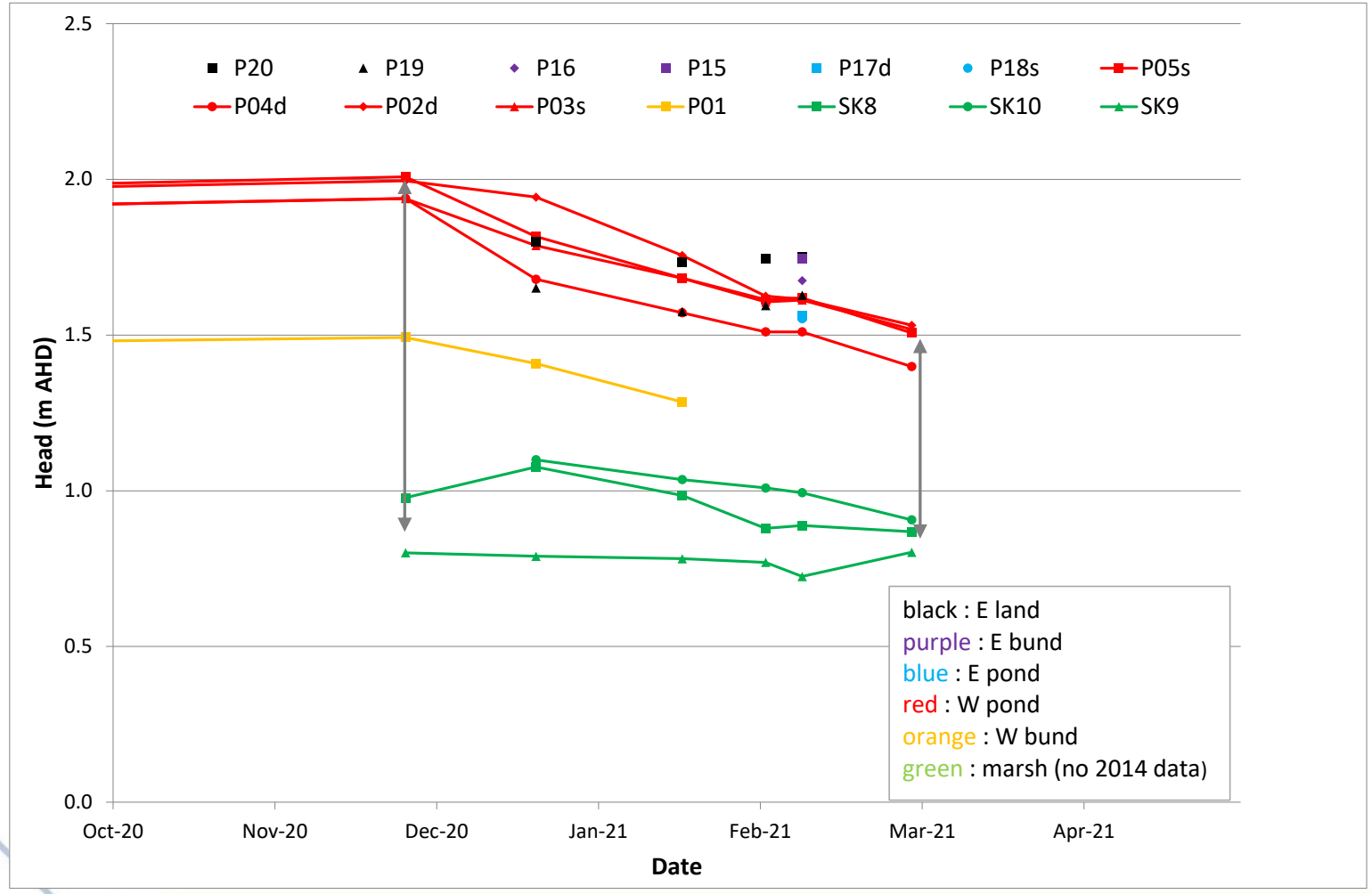
Reminder three: Conceptual hydrogeology



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**

Reminder four: Transect A –groundwater head



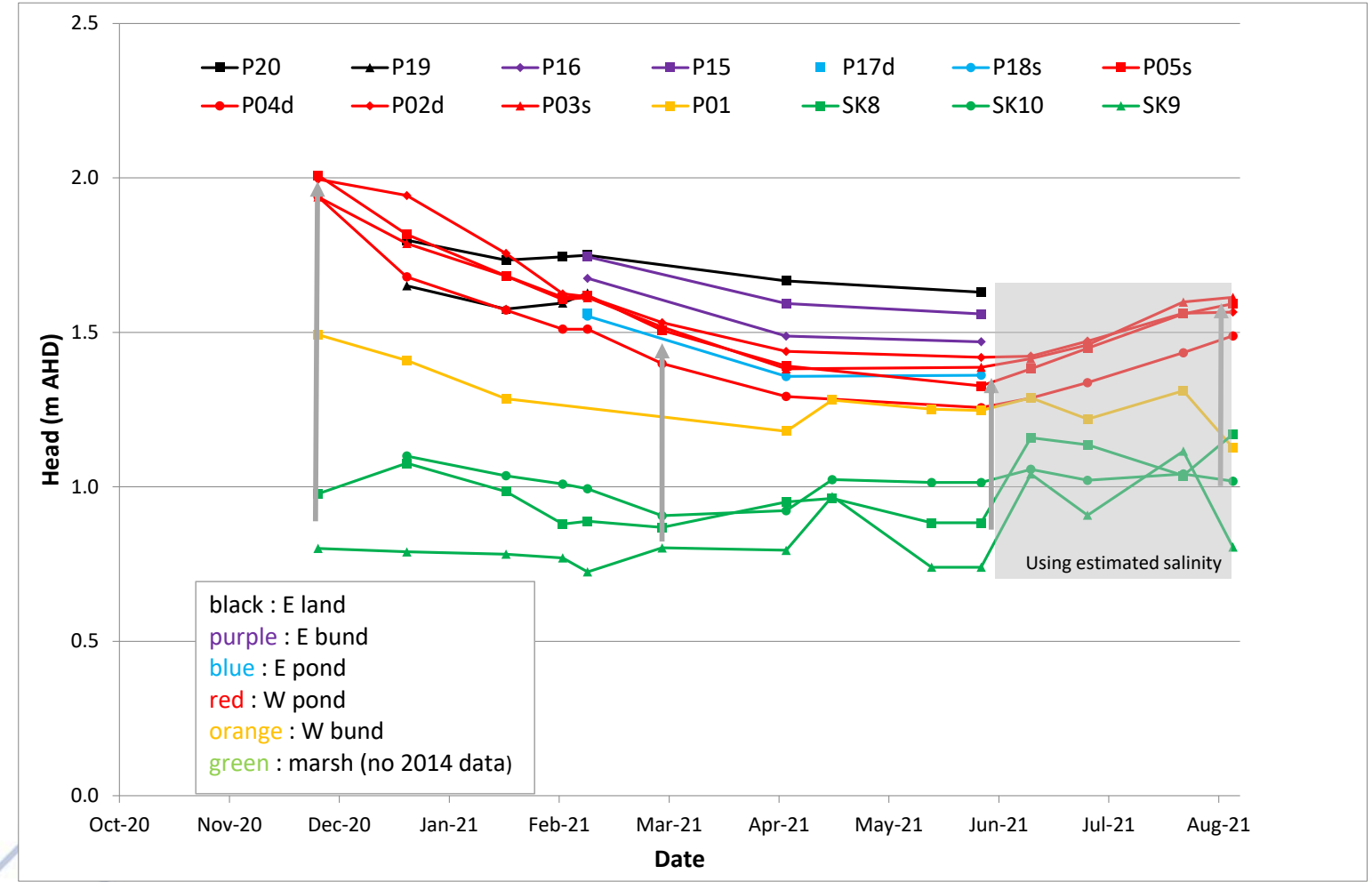
From 2020/21:

- ~ 0.15 m/months decline in W pond wells (~ 0.5 m decline from late November 2020 to early March 2021)
- much less change in marsh wells, especially SK9 (furthest from PA6)
- Late 2020 heads in the W pond > E pond (mounding > gradient)
- Hydraulic gradient has declined since November 2020 by ~ 40%

Reminder five: Conclusions to March 2021 Transect A

1. Groundwater mounded right up to the pond and above the gypsum seal in pond PA6 in November 2020
2. Groundwater heads beneath western PA6 have declined about 0.5 m since late November 2020
3. Western bund well P01 salinity tripled since 2014
4. Marsh well salinities in 2020/21 are high
5. Dilution effect that was transparent in 2014 is not present in 2020/21 to March 2021
6. The hydraulic gradient driving groundwater towards the marsh has decreased by about 40% since November 2020
7. The salt flux towards the marsh has decreased by about 35% since November 2020

Update one: Transect A – groundwater head

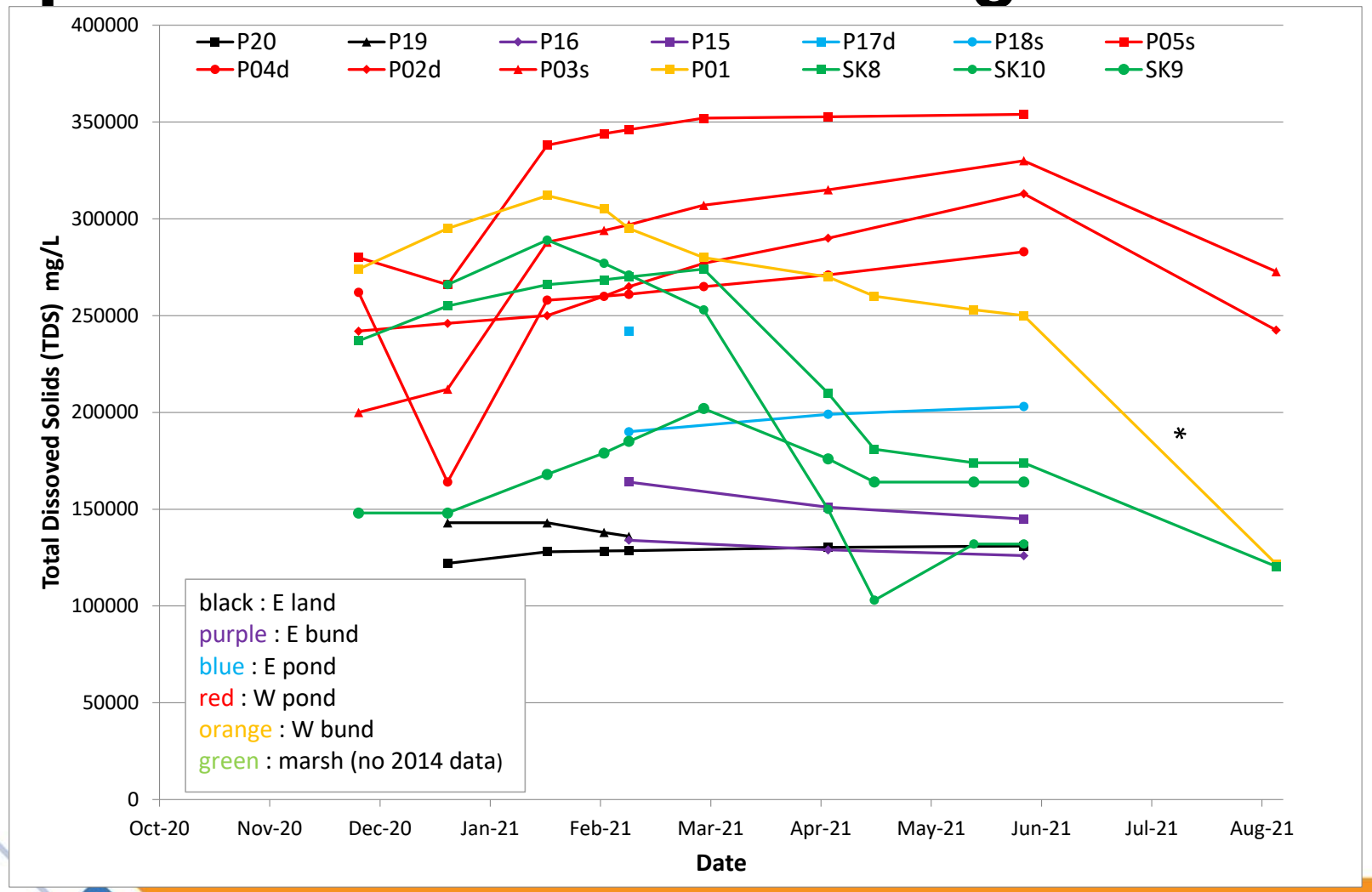


Findings:

- Hydraulic gradient is proportional to difference between head in W pond (red) and marsh wells (green)
- Hydraulic gradient has declined from November 2020 to August 2021 as indicated by the length of the grey lines
- Hydraulic gradient has increased since June 2021 but still remains below 2020 levels

Refer to Slide 12 for technical explanation of estimated salinities

Update two: Transect A – groundwater salinity

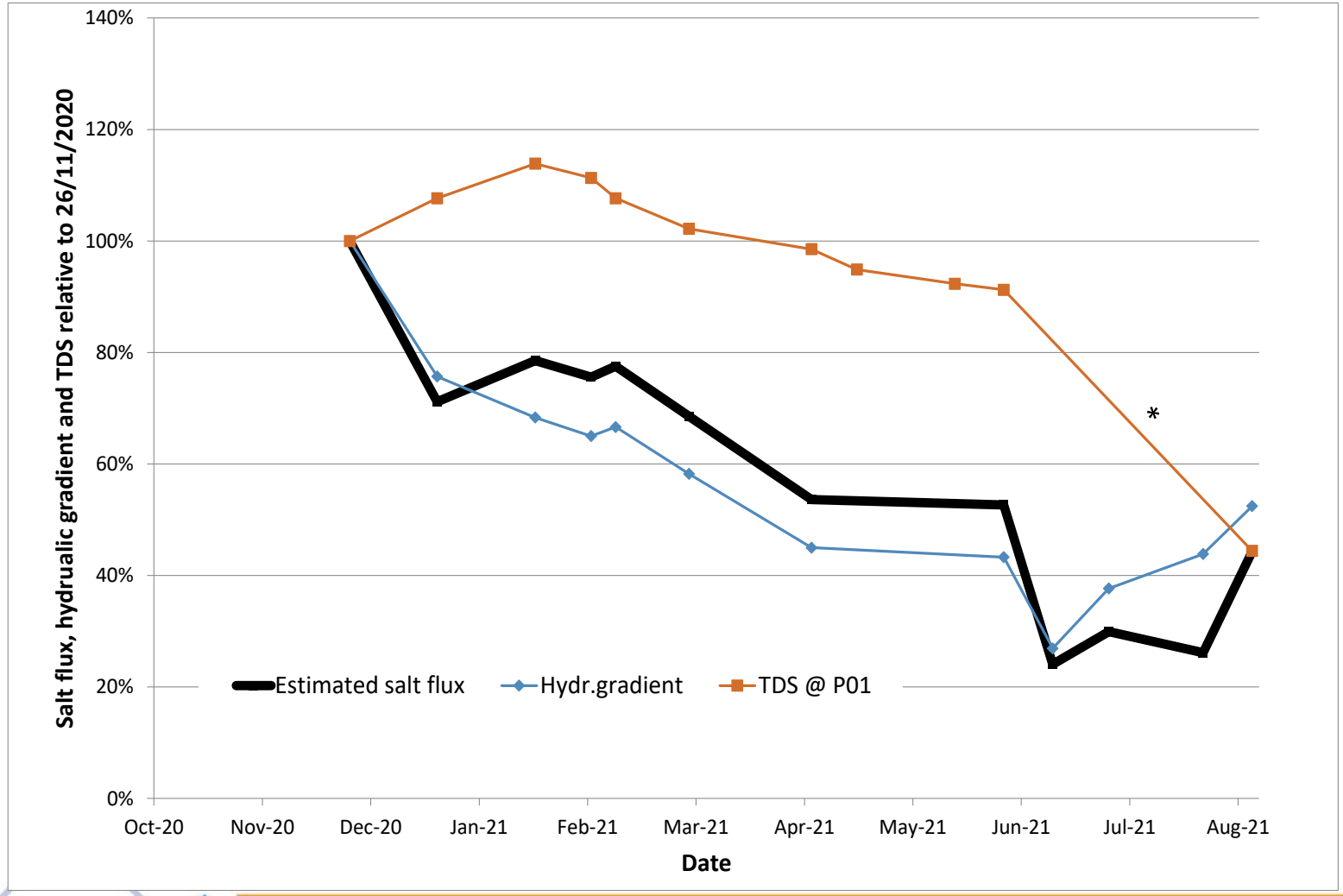


Findings:

- TDS in western pond (red) and marsh (green) wells increased from Nov 2020 to June 2021. From June to August the TDS decreased
- In bund well P01 (orange) the TDS increased to January 2021 and has decreased since, with a steep decrease since June 2021

** Steep decrease in P01 to be confirmed by September data*

Update three : Transect A – provisional salt flux



Salt flux is assumed to be proportional to the product of the hydraulic gradient and the salinity (Total Dissolved Solids/TDS).

- Hydraulic gradient is proportional to difference between the average (subject to Sept 21 data) heads in W pond and marsh wells
- Salinity (TDS) is taken @ bund well P01 between the pond and marsh
- 26 Nov 2020 = Salt flux 100%

<u>Nov 20 to June 21</u>
Salt flux ↓ because hydraulic gradient ↓

Provisional interpretation :
<u>June 21 to August 21</u>
Salt flux → because hydraulic gradient ↑ & TDS ↓

** Steep decrease in P01 to be confirmed by September data*

Update four: Conclusions to August 2021 Transect A

1. Salt flow (flux) from beneath the western PA6 pond to the marsh
2. Winter rainfall elevated the groundwater but this was also diluted (decreased the salinity)
3. Despite an increase in hydraulic gradient between June and August 2021, the estimated salt flux in August 2021 is less than half of what it was in November 2020 (subject to September salinity/TDS data confirming August field measurement)
4. New brine is not currently authorised to be pumped into PA6/PA7, hence, by spring the decline in salt flux to the marsh is expected to continue for the following reasons:
    - St Kilda winter rainfall recharge to groundwater is considerably less than recharge was from operational salt ponds
    - The brine level in the ponds is expected to have less and less relevance to the underlying groundwater heads. This is because the gypsum seal, having been saturated for some time in the western part of Pond 6, would have likely sealed most of the cracks developed under previous dry conditions and will continue to seal with time
    - Tidal influence/dilution may increase as the groundwater mound declines
5. More will be known about the effects winter had after the analysis of all the winter data, estimated Sept/Oct 2021
6. On-going monitoring of groundwater is important, as is the establishment of a salt-field wide salt budget

Update five: Technical details

Slide 8 - Using estimated salinity:

- A density correction of the groundwater elevation is required to calculate groundwater head
- To apply the density correction, both depth to groundwater and salinity are required
- Monthly monitoring often only involves measuring the depth to groundwater; and salinity is obtained only at the three monthly ‘full’ monitoring runs
- The last full run was in June, the next due in September. Salinity is normally interpolated; i.e. to July and August, from both the June and September data. In this case it was extrapolated or estimated

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