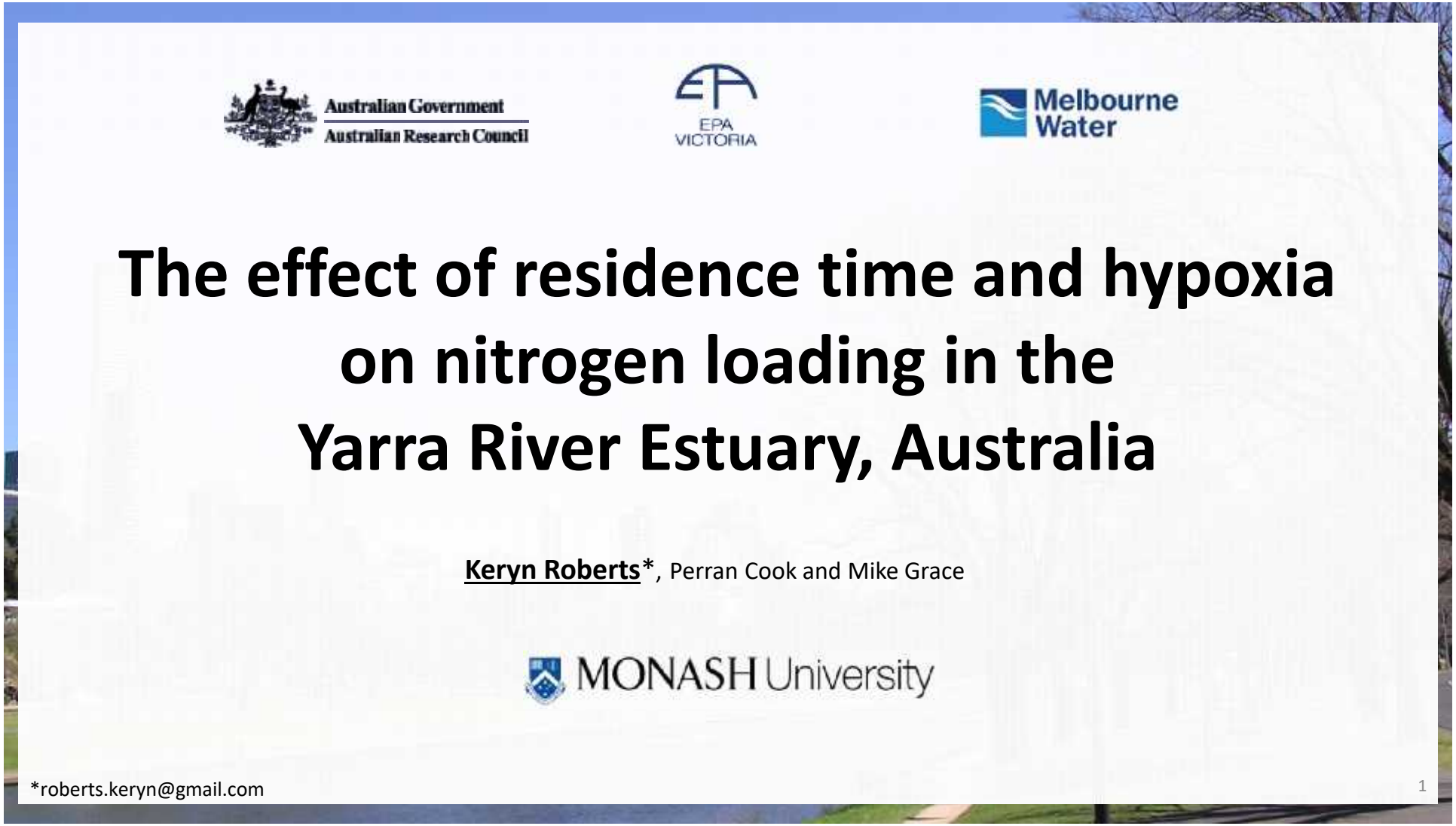


Australian Government
Australian Research Council

EPA VICTORIA

Melbourne Water

The effect of residence time and hypoxia on nitrogen loading in the Yarra River Estuary, Australia

Keryn Roberts*, Perran Cook and Mike Grace

MONASH University

*roberts.keryn@gmail.com

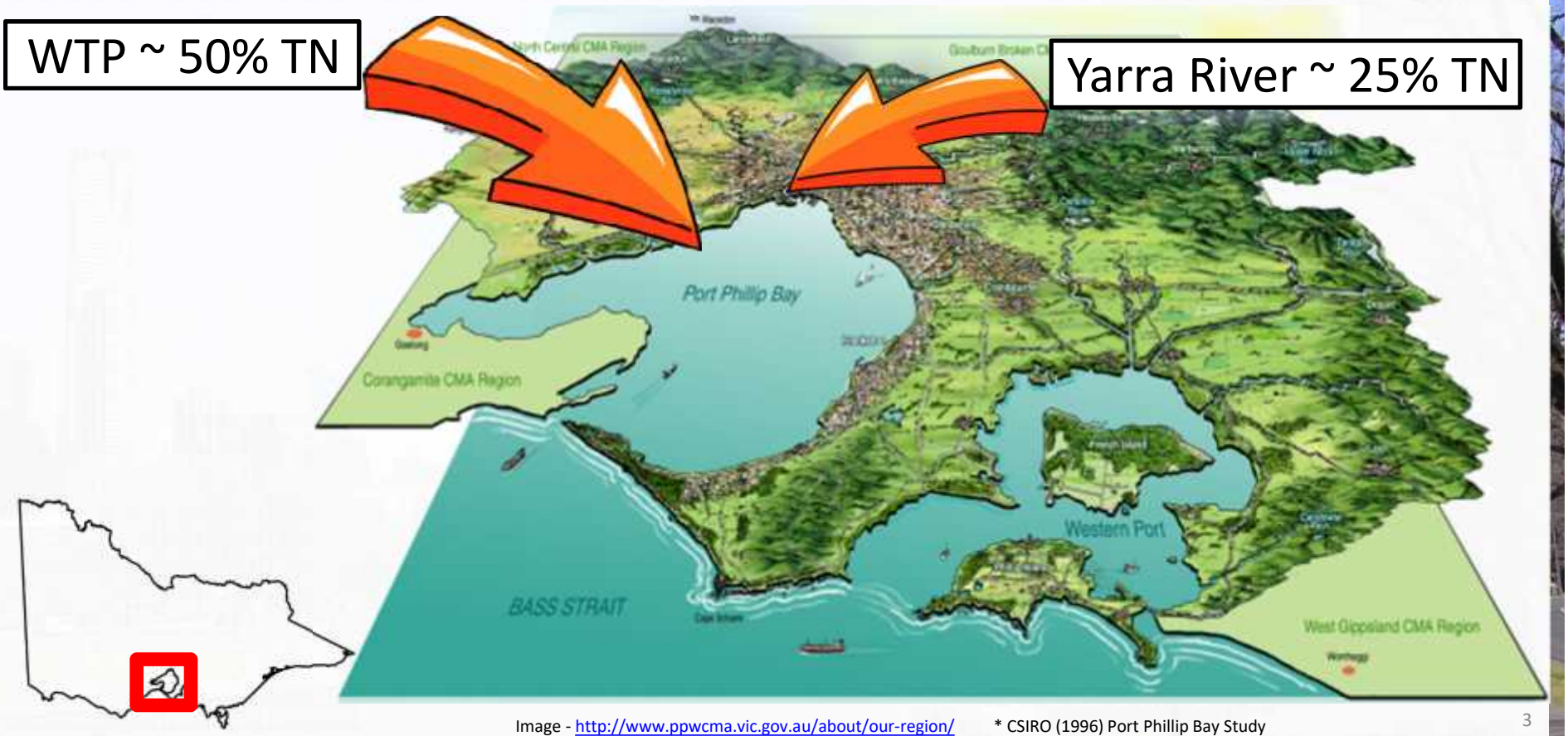
N-limited Port Phillip Bay

Image - http://www.ppwcma.vic.gov.au/about/our-region/ * CSIRO (1996) Port Phillip Bay Study

N-limited Port Phillip Bay

WTP ~ 50% TN

Yarra River ~ 25% TN



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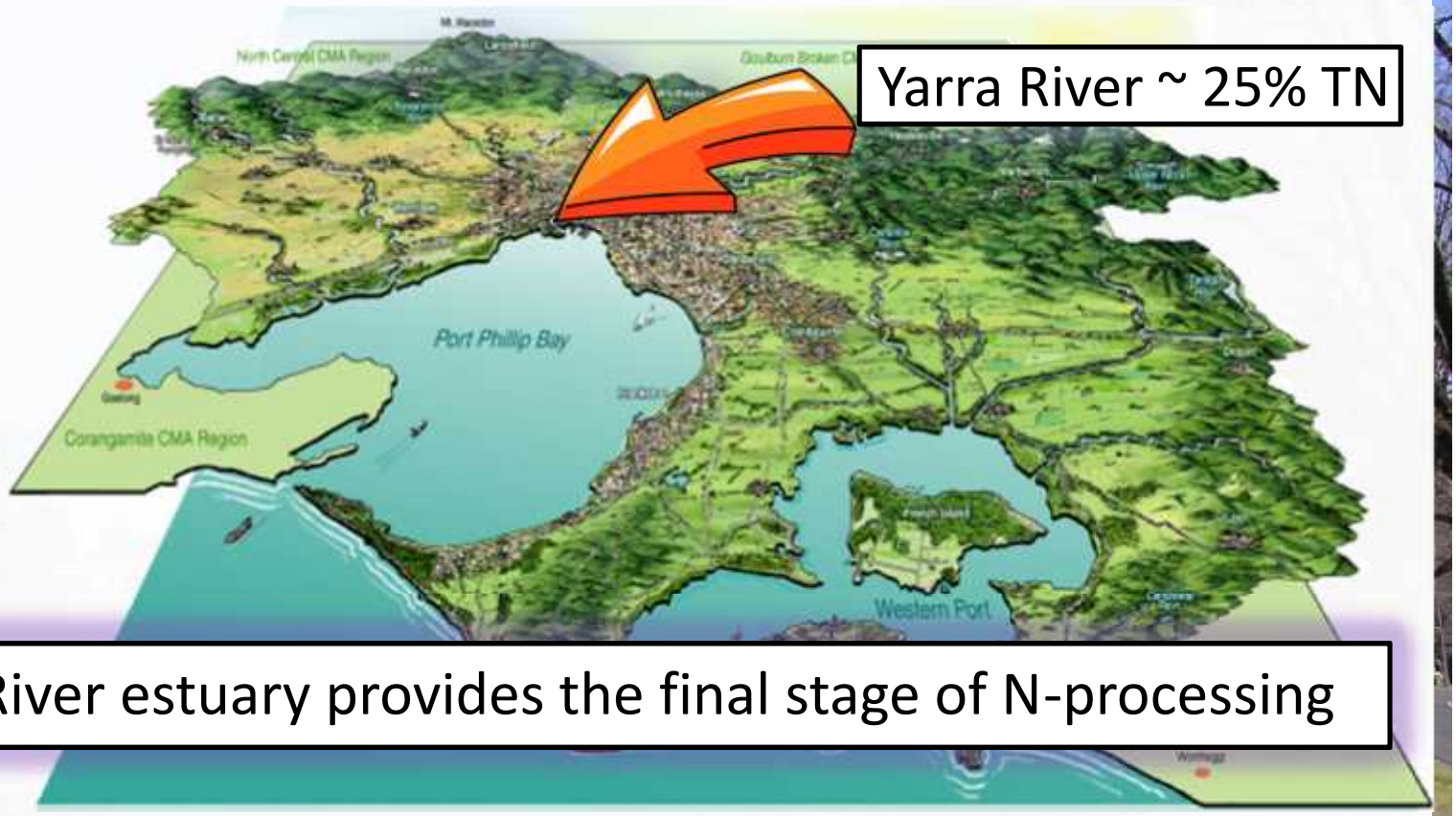
N-limited Port Phillip Bay



The Yarra River estuary provides the final stage of N-processing

Image - http://www.ppwcma.vic.gov.au/about/our-region/ * CSIRO (1996) Port Phillip Bay Study

Yarra River Estuary

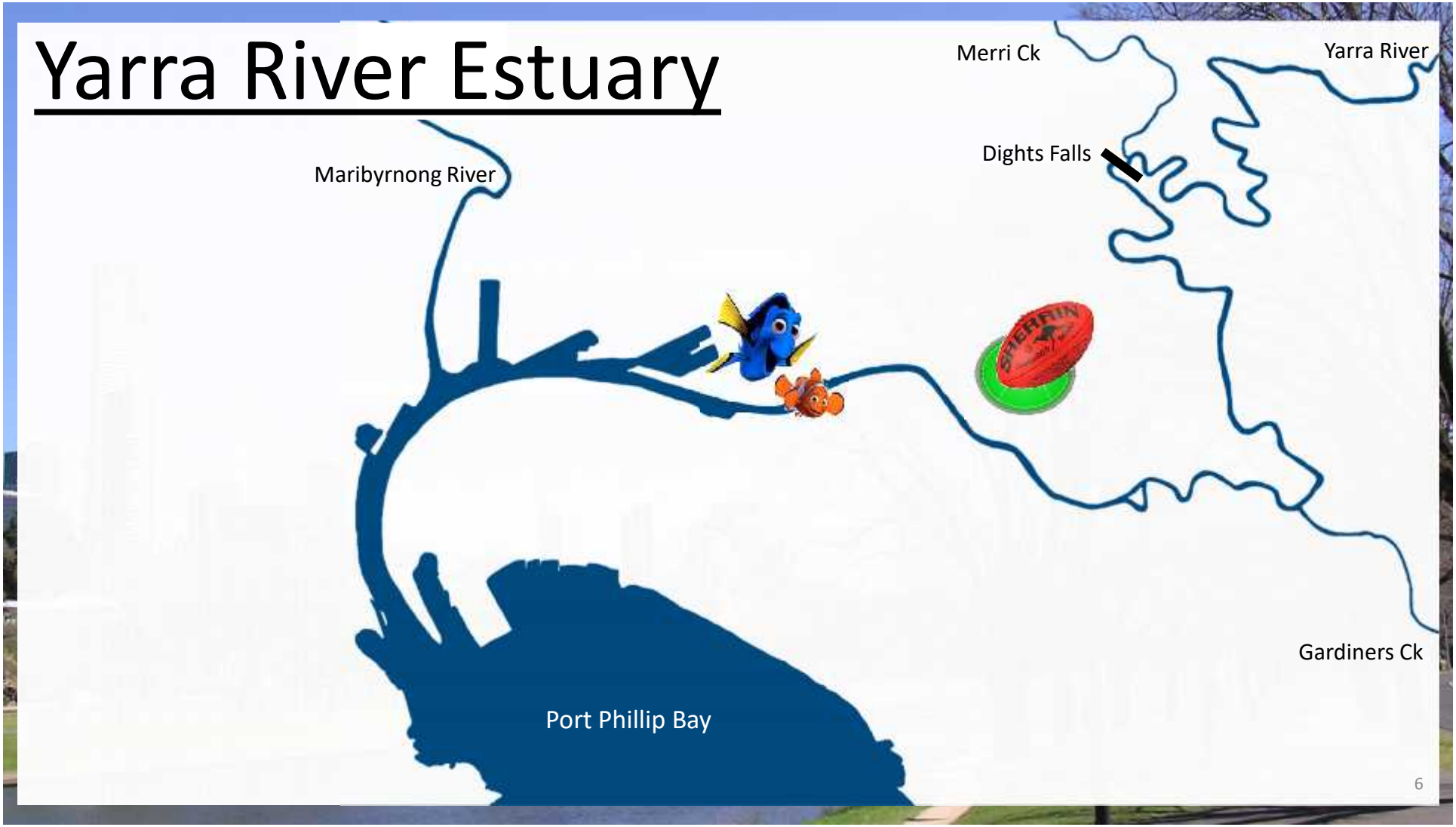
Maribyrnong River

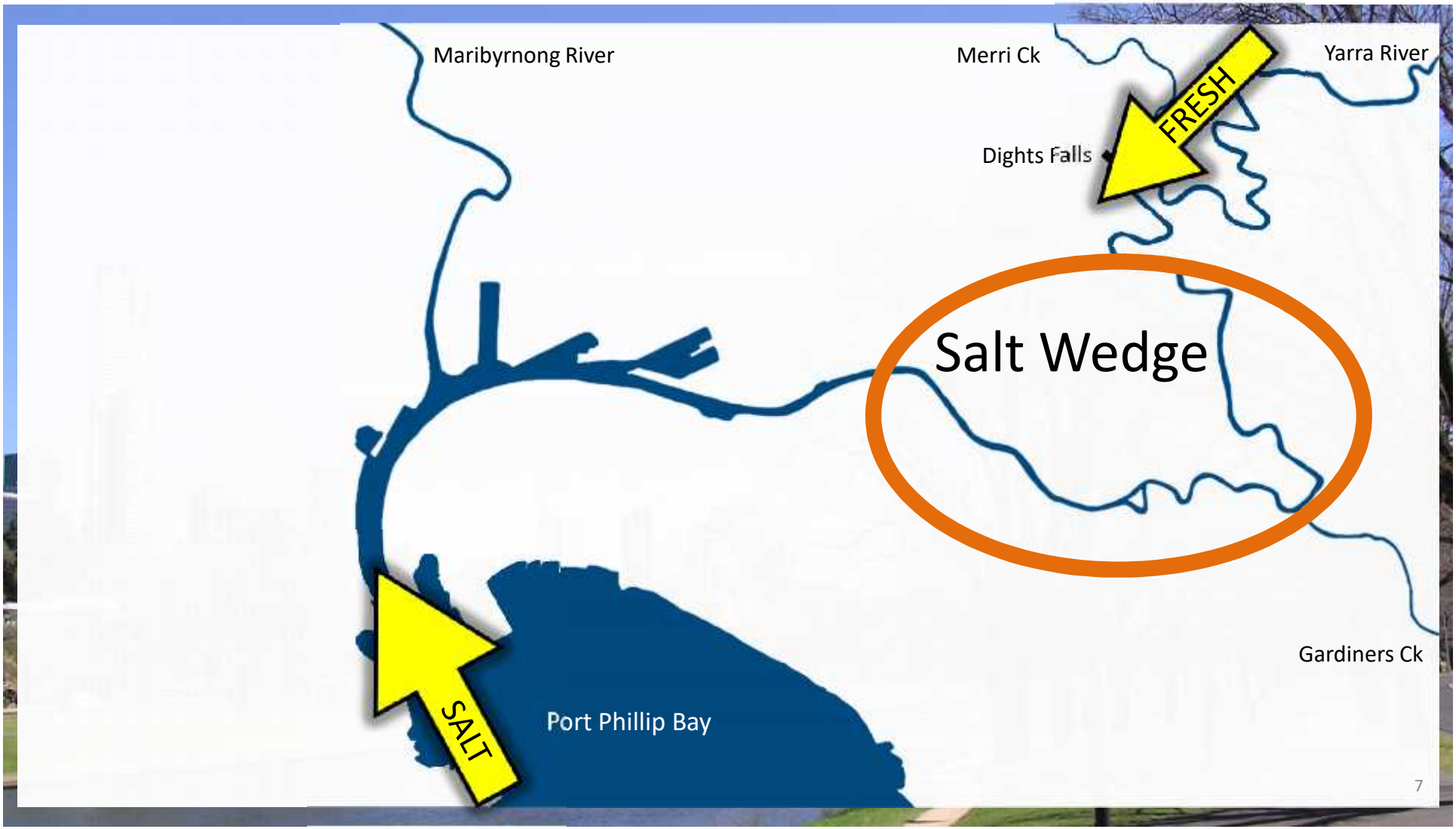
Melbourne CBD

Gardiners Ck

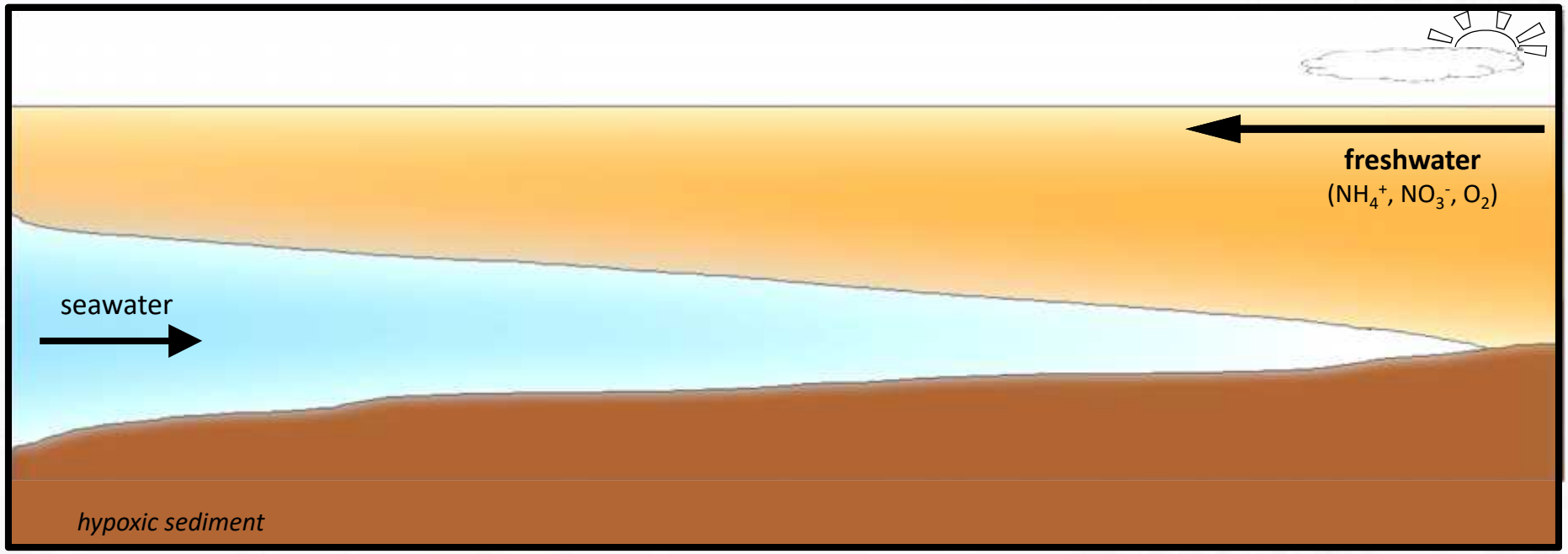
Port Phillip Bay

Yarra River Estuary

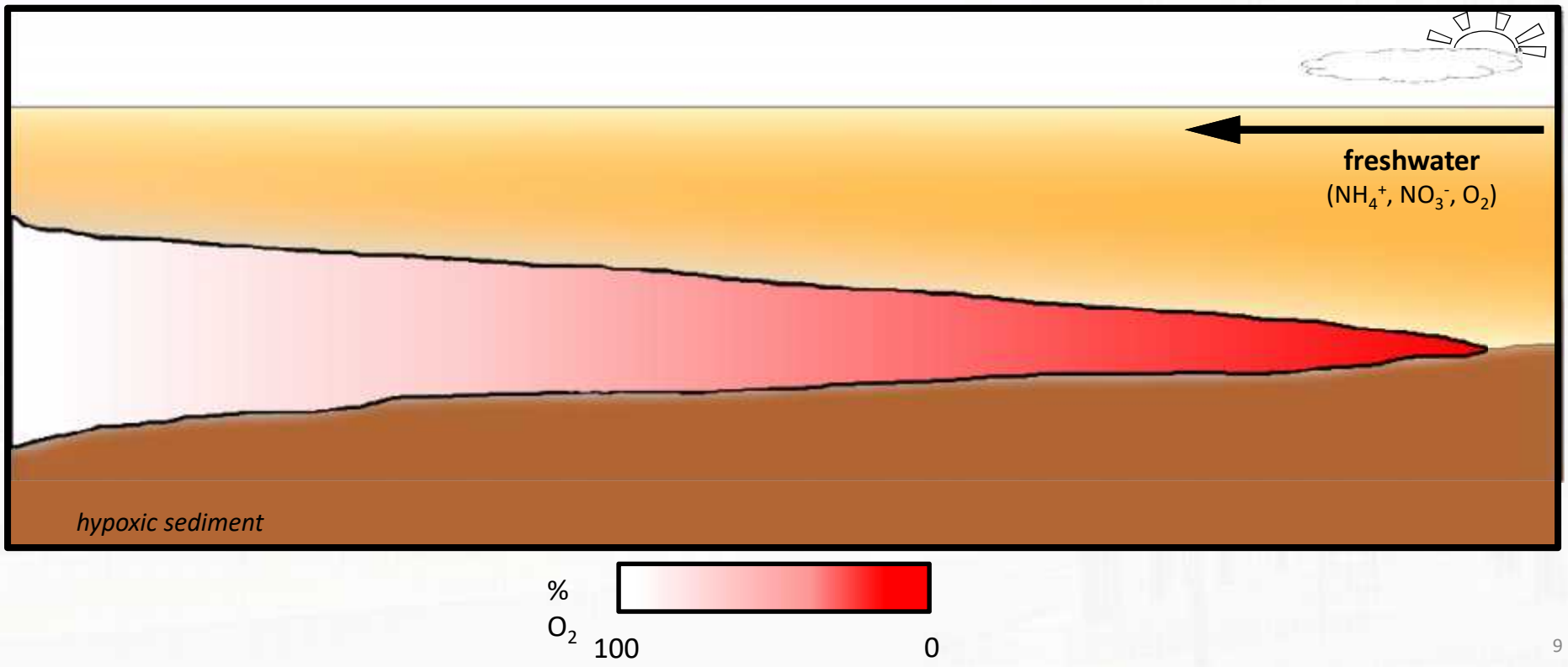



Maribyrnong River
Merri Ck
Yarra River
FRESH
Dights Falls
Salt Wedge
Gardiners Ck
SALT
Port Phillip Bay

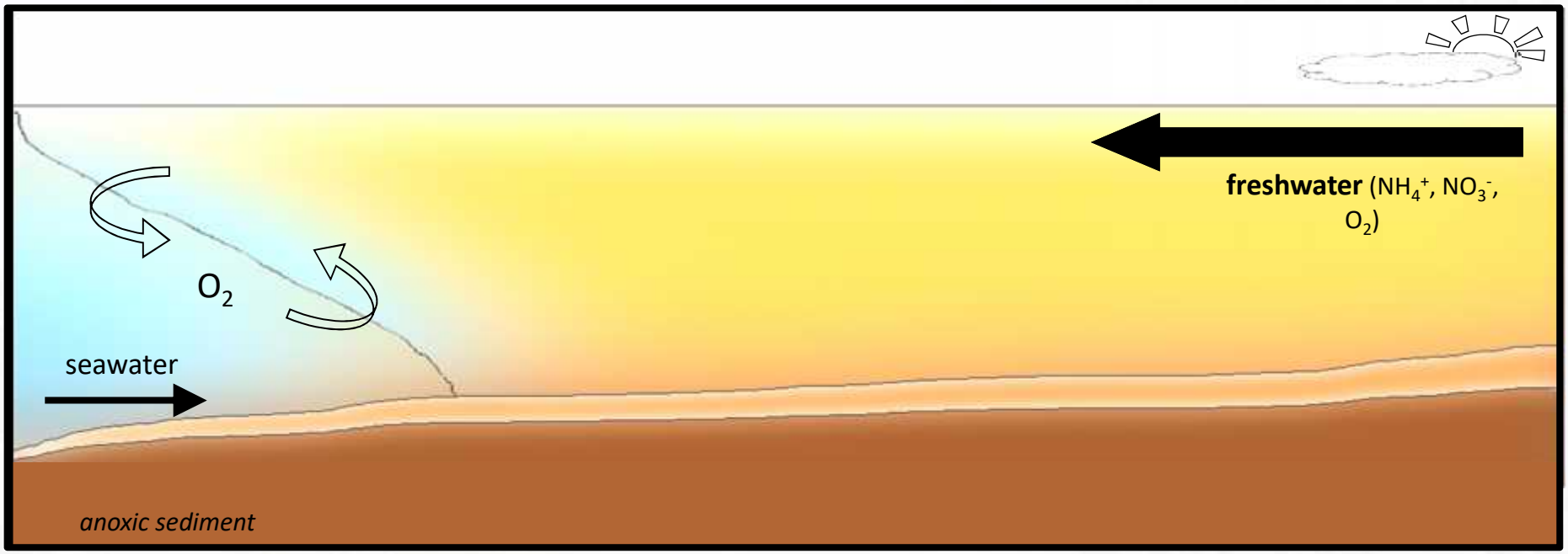
- <u>Low freshwater inflow</u>
- Residence time of bottom water can be weeks to months



- Stratification and isolation of saline bottom waters
- Depletion O_2 – hypoxic or anoxic conditions

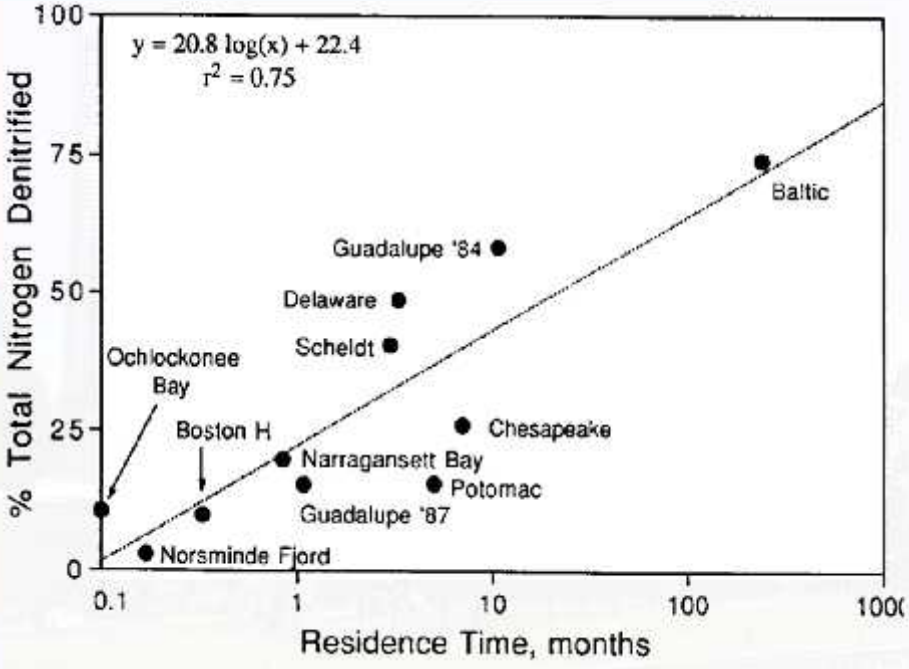


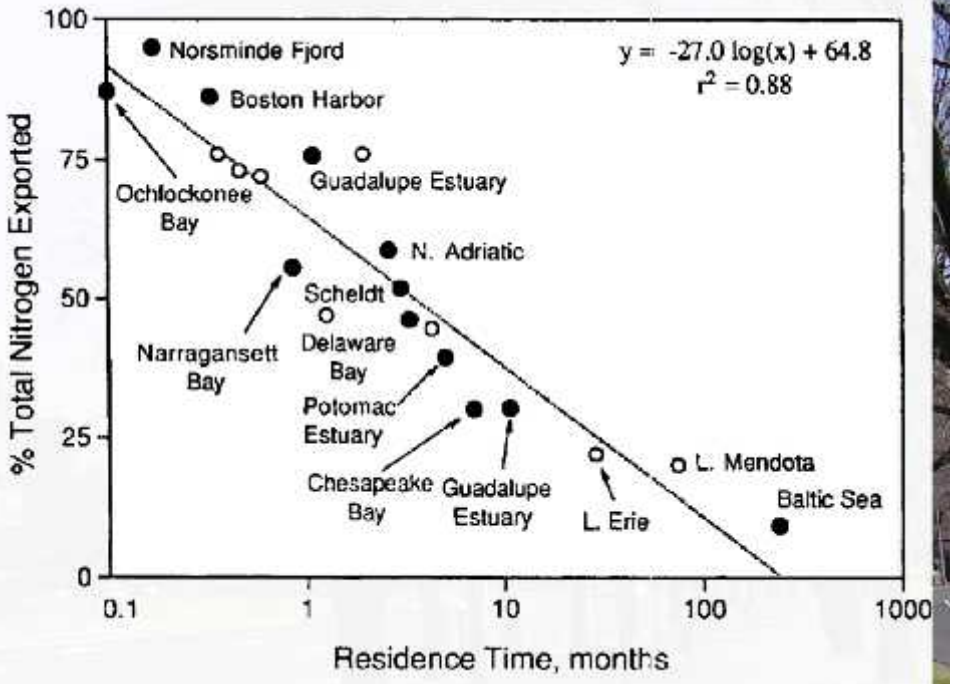
- <u>High freshwater inflow</u>
- Induces mixing, re-oxygenates bottom water, residence time hours to days



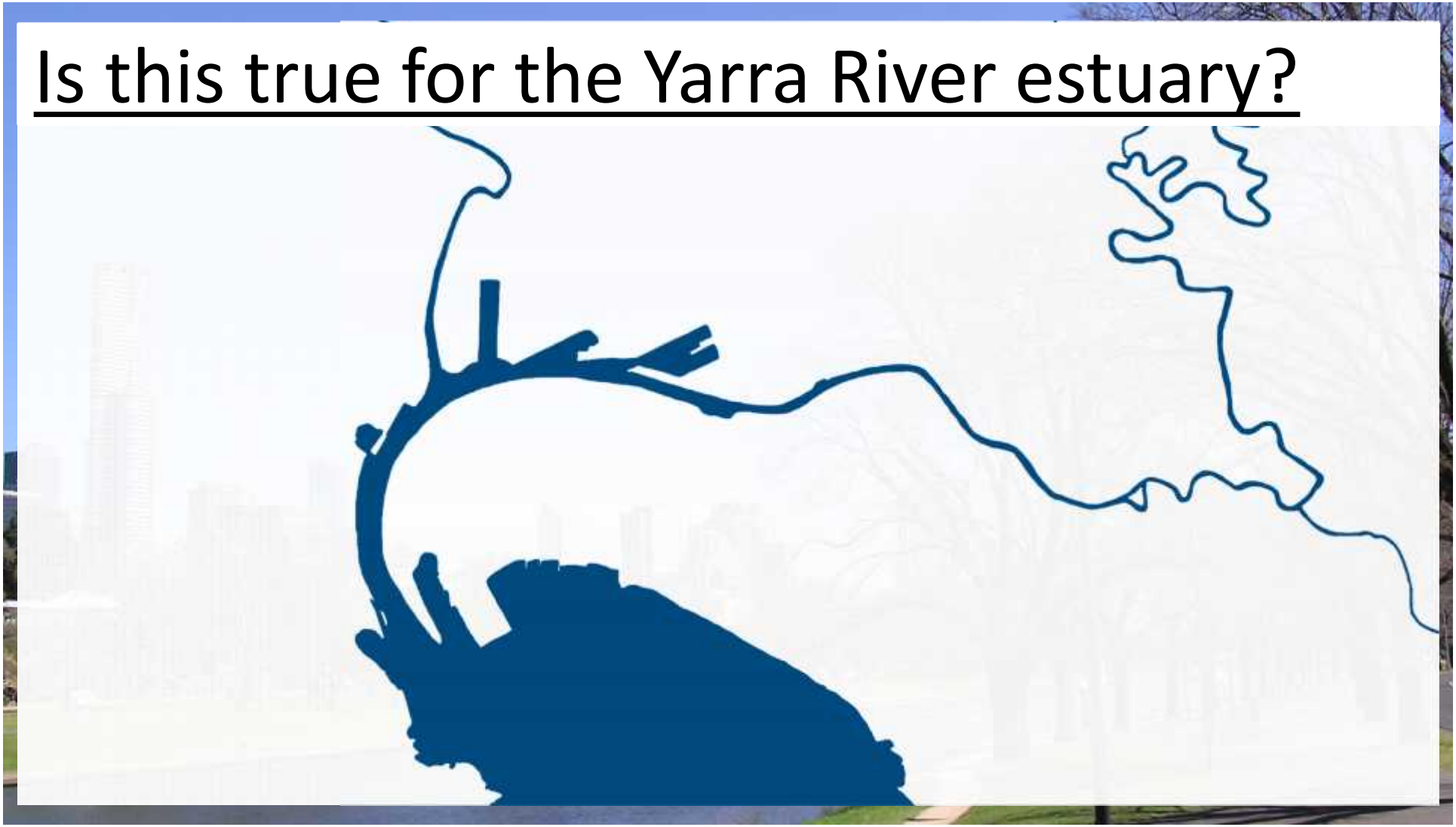
Residence time and nitrogen loads

Nixon et al (1996) *Biogeochemistry* **35**: 141-180





Is this true for the Yarra River estuary?



Calculating DIN loads

- Flow and nutrients gauged at Chandler Hwy, Merri Creek, Gardiners Ck

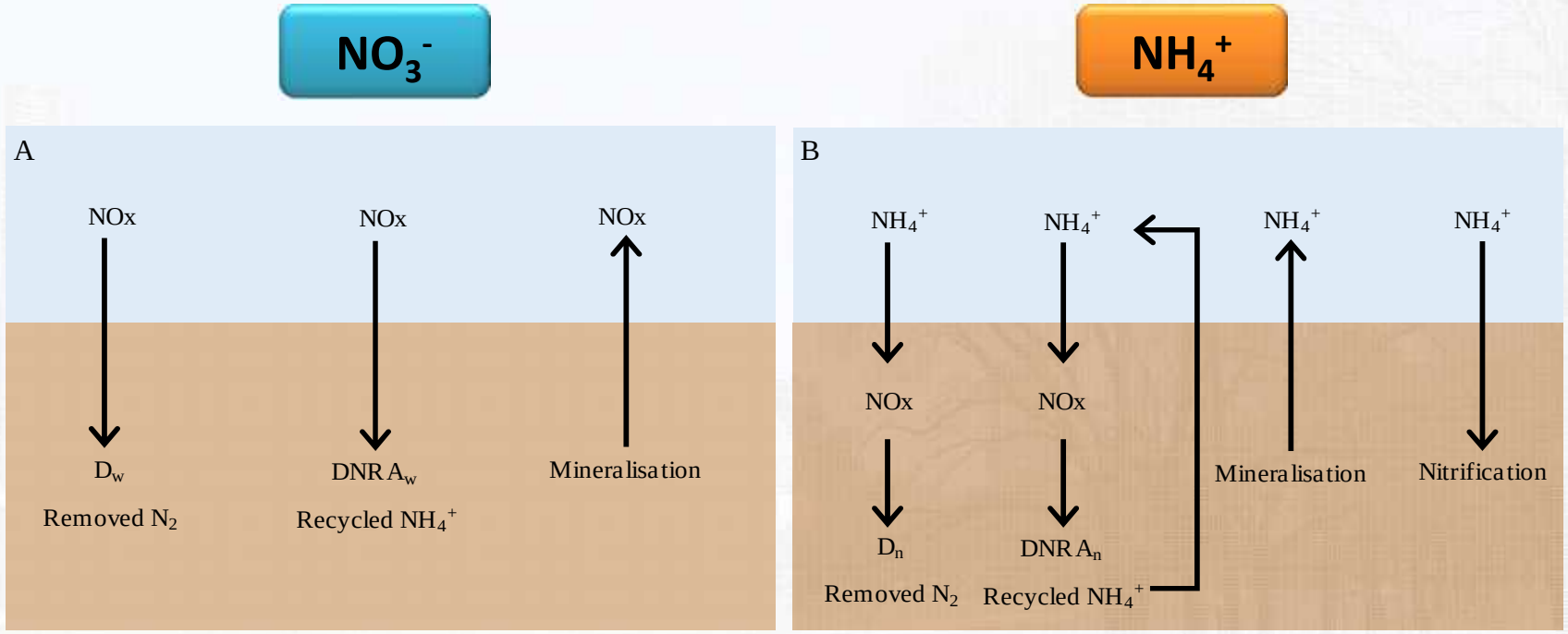
Melbourne Water

Calculating DIN loads

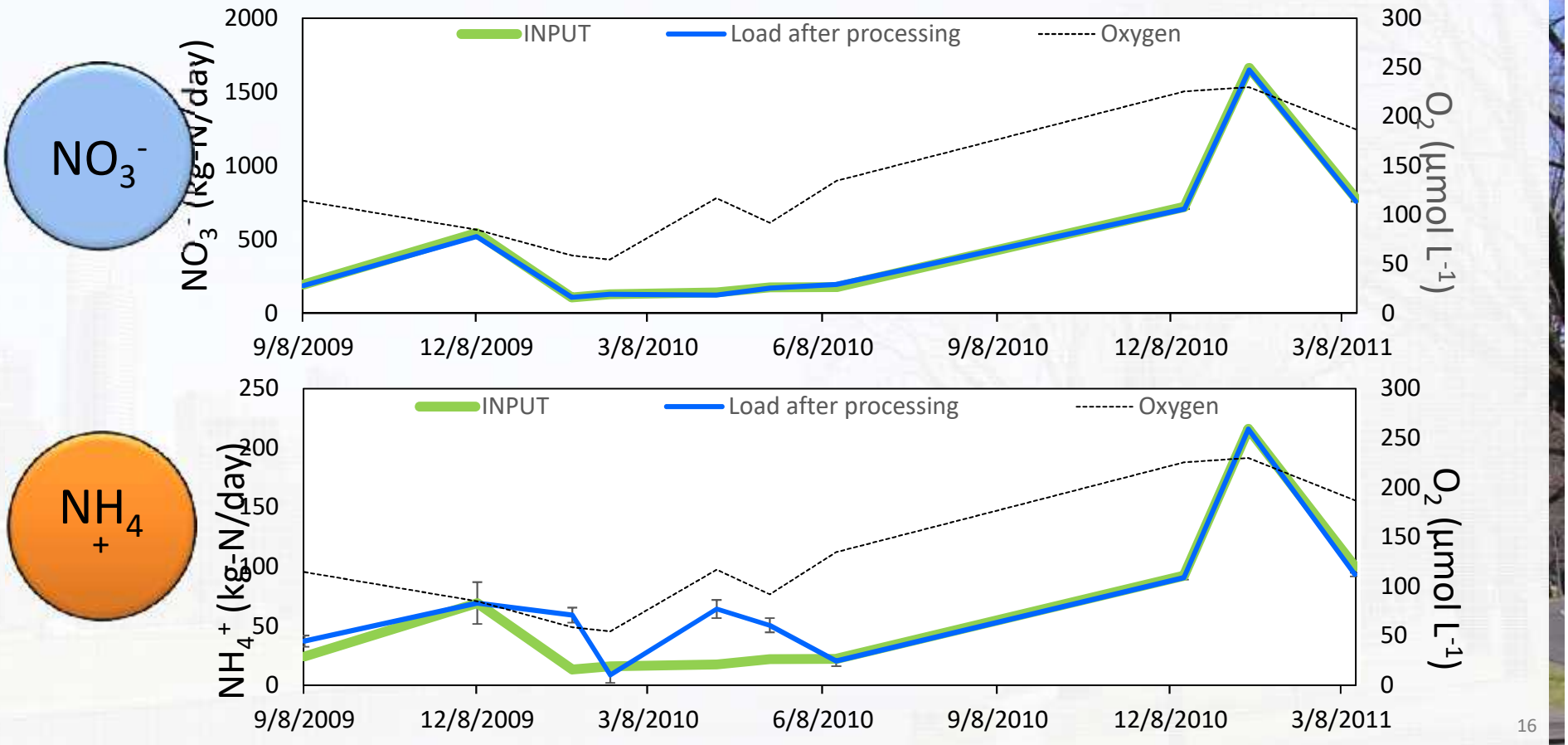
- Flow and nutrients gauged at Chandler Hwy, Merri Creek, Gardiners Ck

- Measured rates of denitrification, DNRA, fluxes of NO_3^- and NH_4^+

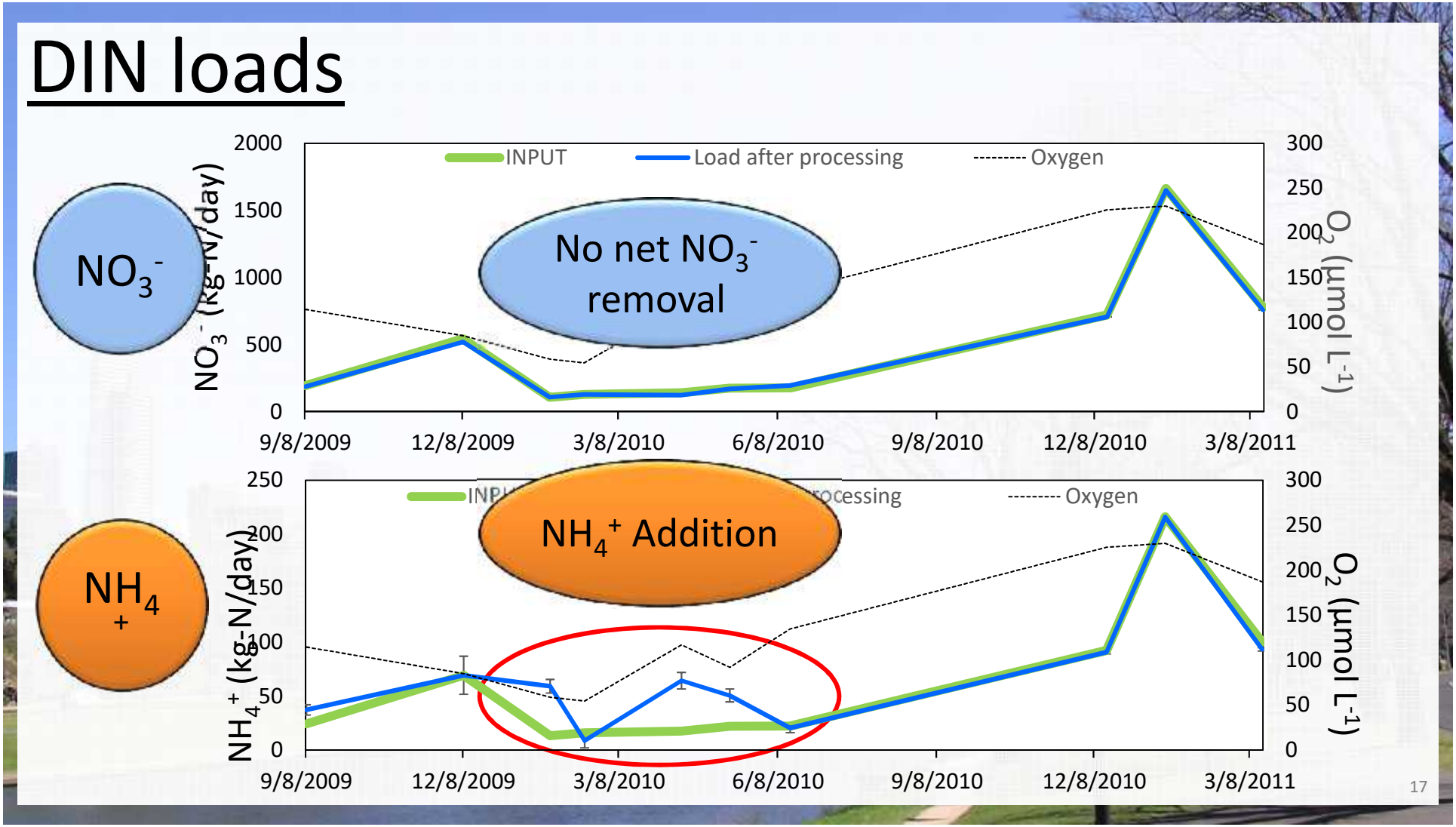
DIN pathways



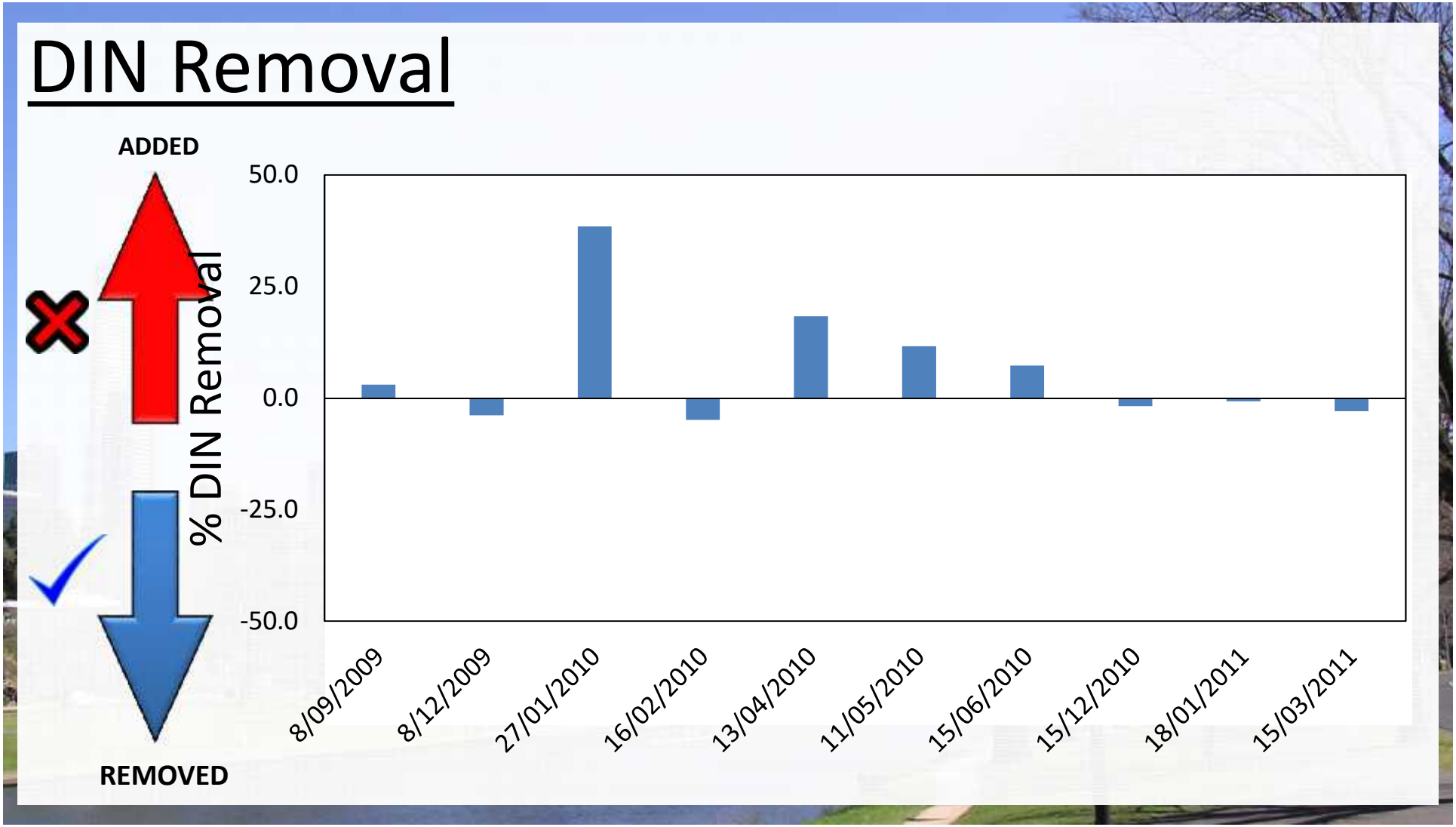
DIN loads


NO_3^-
NO_3^- (kg-N/day)
INPUT
Load after processing
Oxygen
O_2 (µmol L^{-1})
2000
1500
1000
500
0
300
250
200
150
100
50
0
9/8/2009
12/8/2009
3/8/2010
6/8/2010
9/8/2010
12/8/2010
3/8/2011
NH_4^+
NH_4^+ (kg-N/day)
INPUT
Load after processing
Oxygen
O_2 (µmol L^{-1})
250
200
150
100
50
0
300
250
200
150
100
50
0
9/8/2009
12/8/2009
3/8/2010
6/8/2010
9/8/2010
12/8/2010
3/8/2011

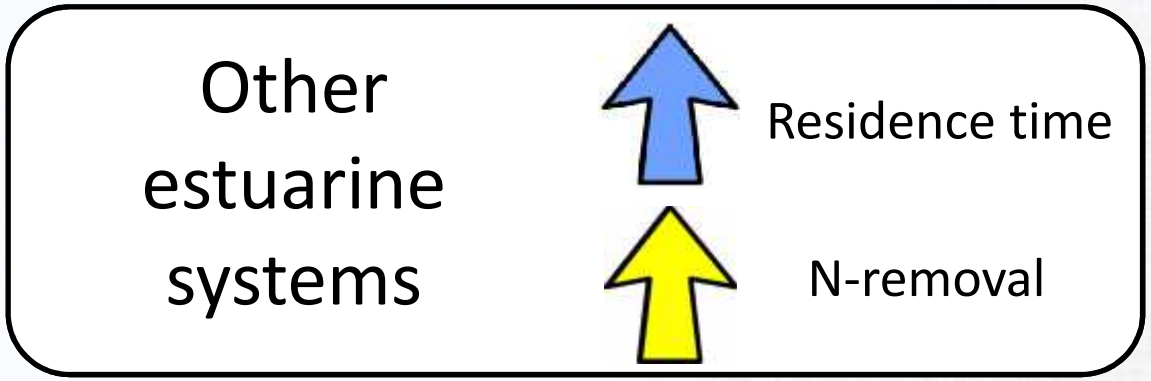
DIN loads

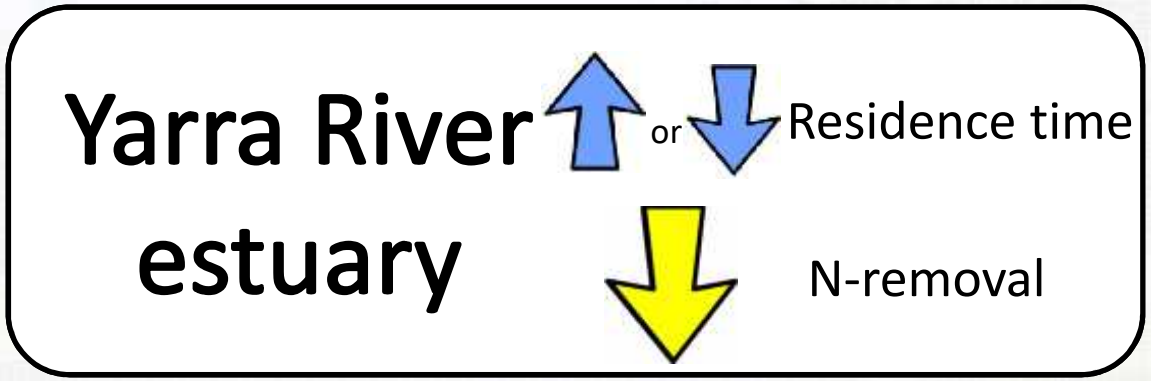

NO_3^-
NO_3^- (kg-N/day)
INPUT
Load after processing
Oxygen
No net NO_3^- removal
O_2 (µmol L^{-1})
2000
1500
1000
500
0
300
250
200
150
100
50
0
9/8/2009
12/8/2009
3/8/2010
6/8/2010
9/8/2010
12/8/2010
3/8/2011
NH_4^+
NH_4^+ (kg-N/day)
NH_4^+ Addition
250
200
150
100
50
0

DIN Removal


ADDED
REMOVED
% DIN Removal
50.0
25.0
0.0
-25.0
-50.0
8/09/2009
8/12/2009
27/01/2010
16/02/2010
13/04/2010
11/05/2010
15/06/2010
15/12/2010
18/01/2011
15/03/2011

Residence time and nitrogen loads





Why?

Why?

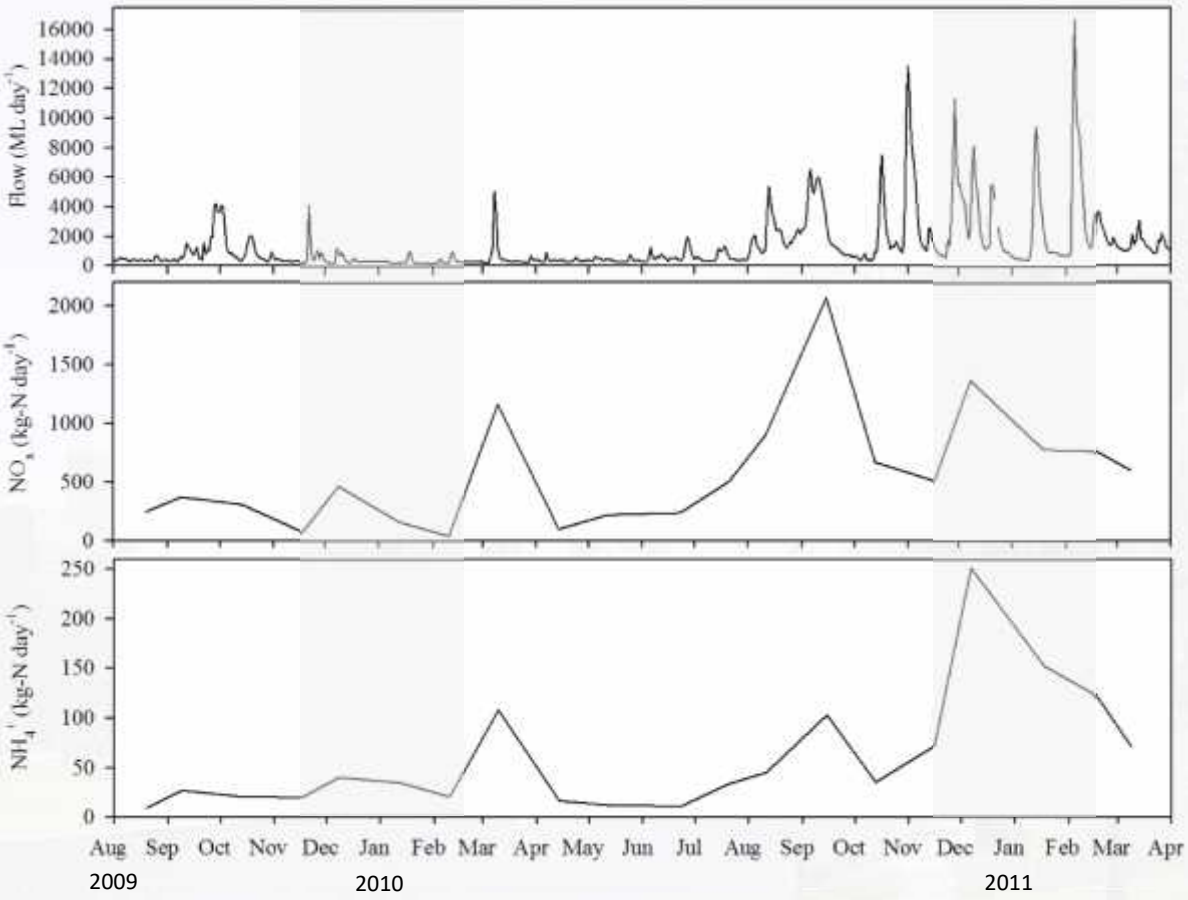
1. Freshwater inflow
2. Stratification & Hypoxia
3. Denitrification

1. Freshwater inflow N-loads

FLOW

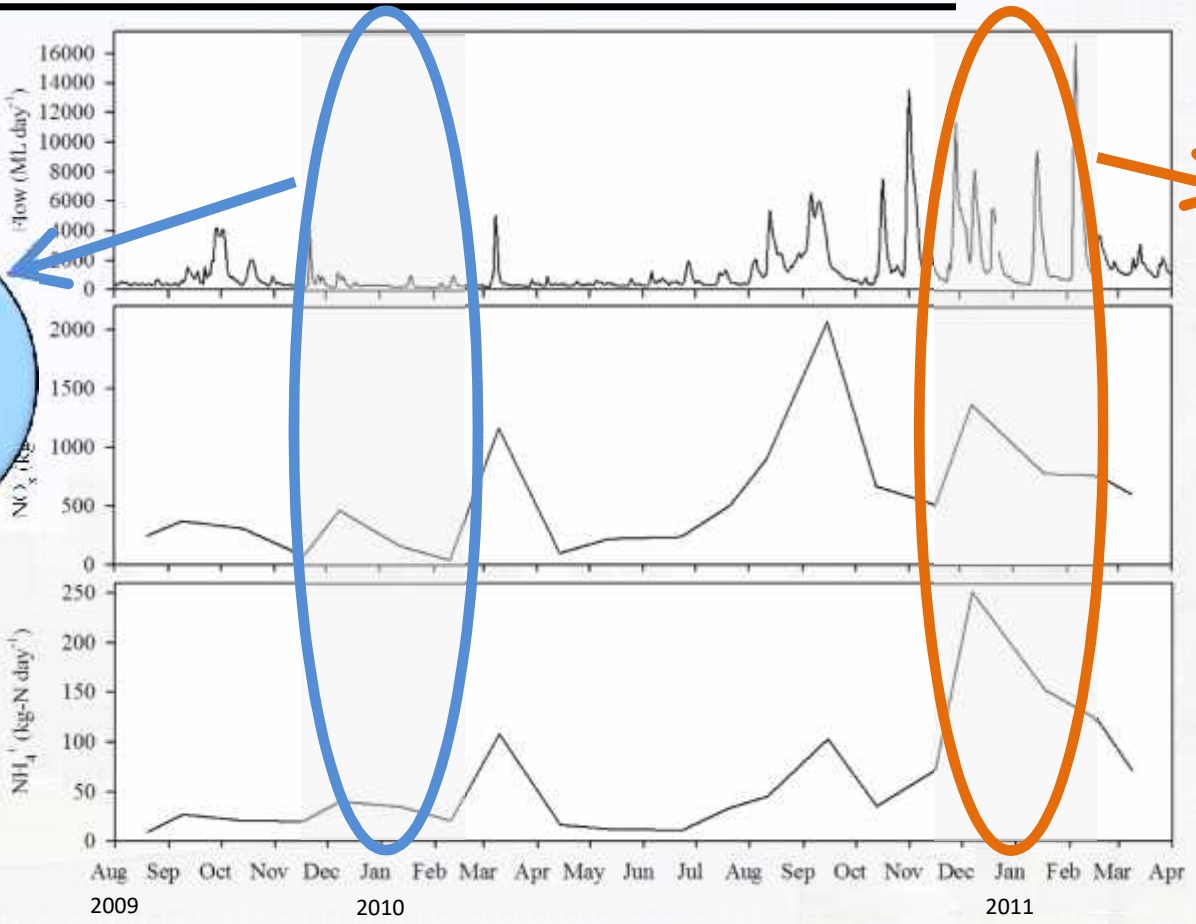
NO_3^-

NH_4^+



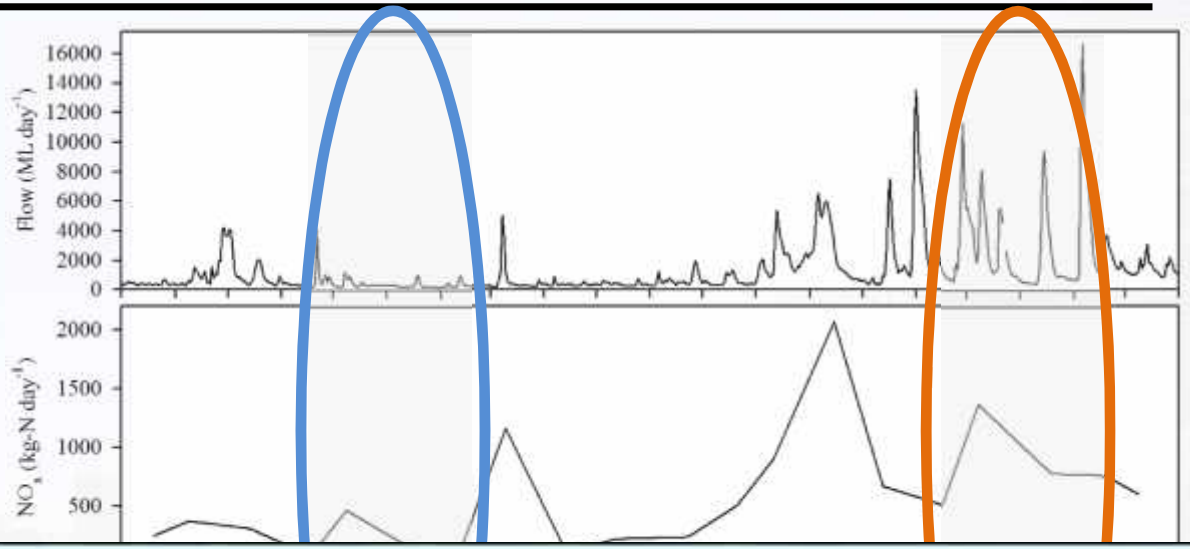
1. Freshwater inflow N-loads

LOW summer rainfall = high residence time (weeks) of bottom water leads to **HYPOXIA**



HIGH summer rainfall = low residence time of bottom water (hours to days)

1. Freshwater inflow and N-loads

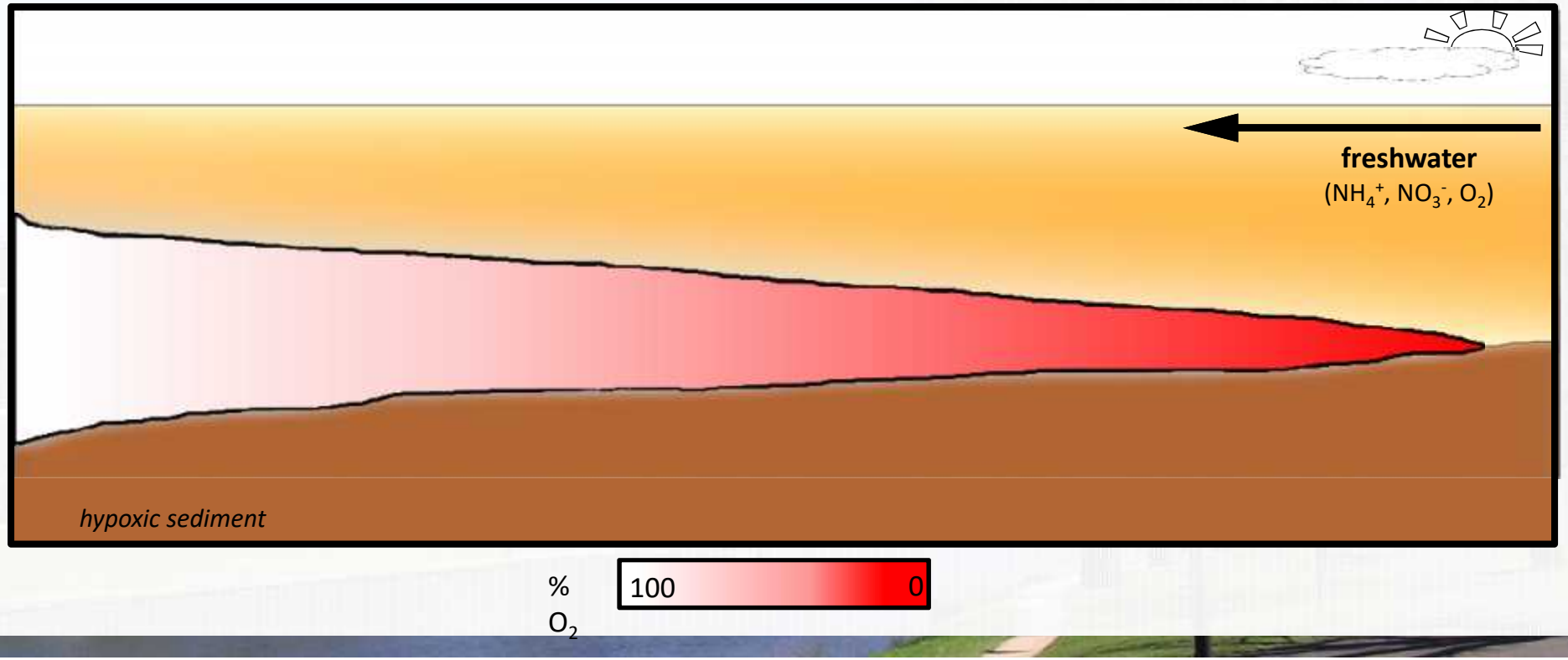


- The highest N-loads are input during high flow. The residence time under these conditions is hours to days.

NOT enough time for significant N-removal to occur.

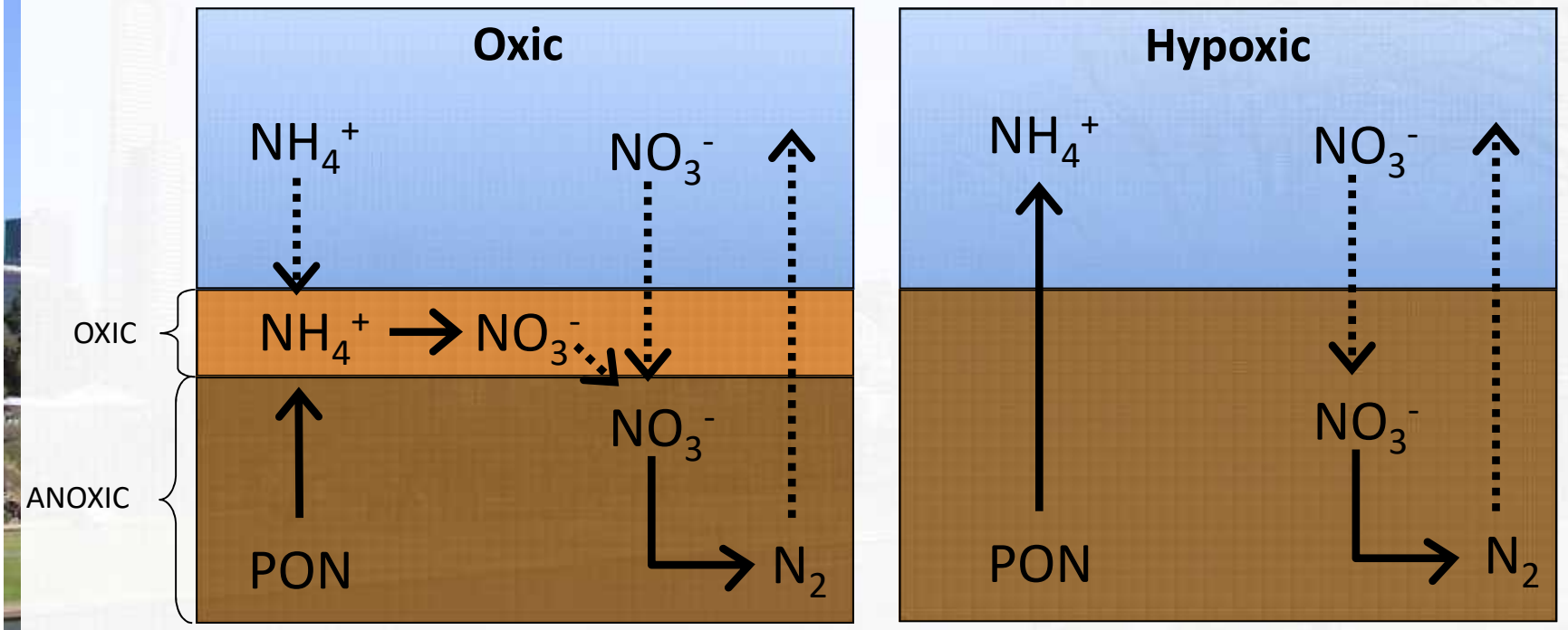
2. Stratification and Hypoxia

- Under low flow conditions the residence time is **weeks to months** leading to **low oxygen** conditions in the bottom waters



2. Stratification and Hypoxia

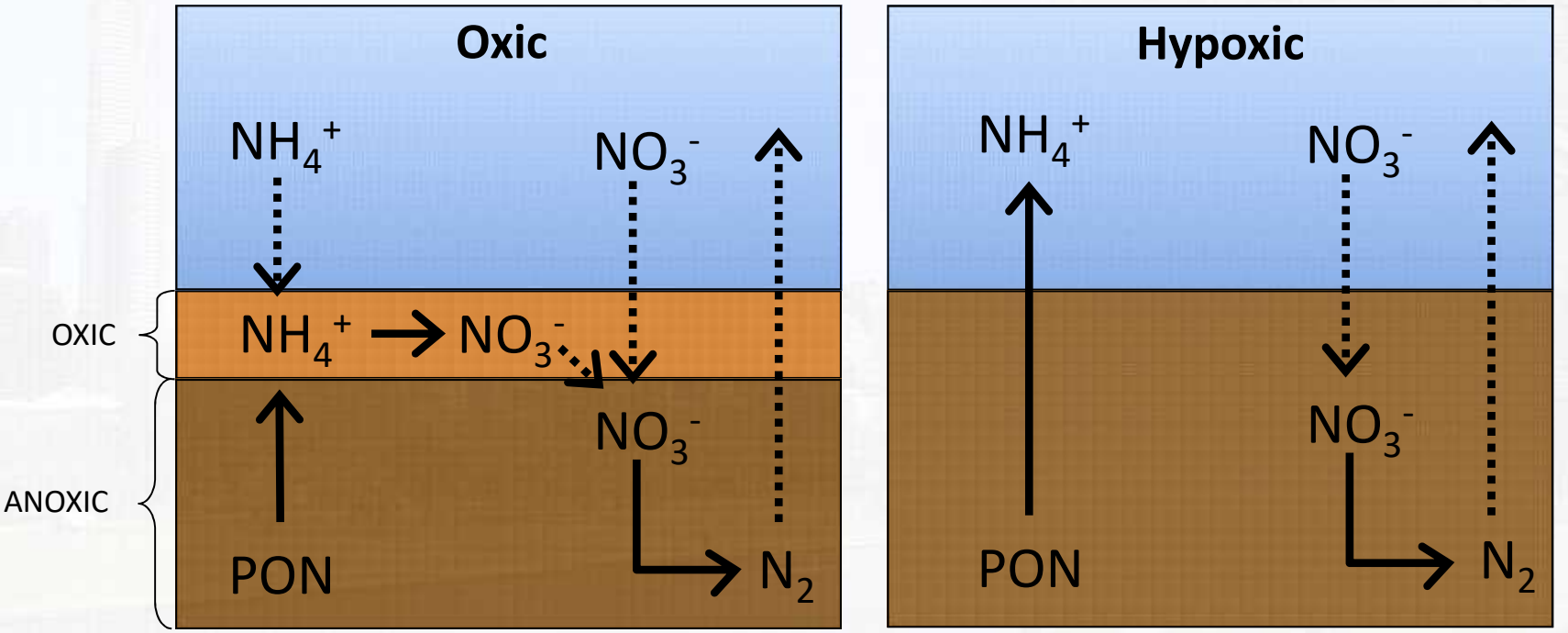
- Under low flow conditions the residence time is **weeks to months** leading to **low oxygen** conditions in the bottom waters



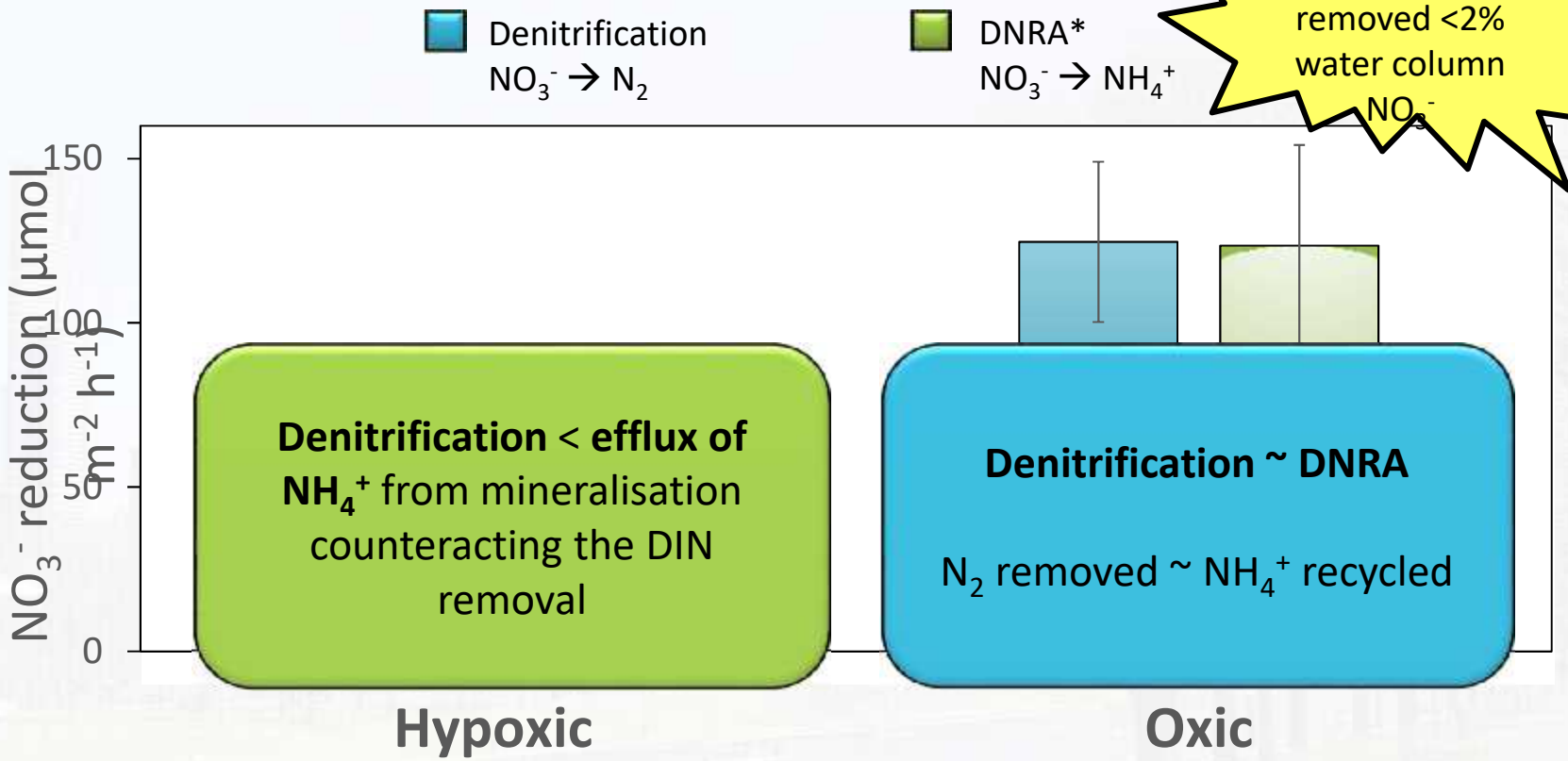
2.

Anoxic conditions disconnect between NH_4^+ produced via mineralisation and nitrification-denitrification coupling

Efflux of NH_4^+ from the sediment



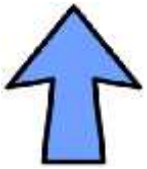
3. Denitrification



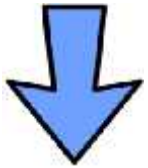
* Roberts et al (2012) Limnology and Oceanography **57**(5) 1427-1442; Roberts et al (2014) Geochimica et Cosmochimica Acta **133** 313-324; Robertson et al (2015) Limnology and Oceanography **61**(1) 365-381

CONCLUSION

Yarra River estuary



Residence time



Residence time

N-removal

N-removal

MANAGEMENT

Catchment N-loads

Reduce stratification/ hypoxia

IMPORTANT!! Consider estuarine type in the management of N-loads