Relationship between river inflows, water extractions and salinity in the Hunter River tidal pool water sources

What is the issue?

Full extraction of existing water entitlements during times of low freshwater inflows into the Hunter tidal pools would result in increased occurrence, frequency, and extent of salinity in the tidal pools, negatively impacting the quality and quantity of water available for water users and the riverine environment.

The department is proposing to amend the existing *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Source 2022* (the Plan) to include rules to minimise these negative impacts on water users and the environment. Details of the proposed changes are contained in the Proposal to Manage Salinity in the Hunter River Tidal Pool Water Sources through Available Water Determination Rules Fact Sheet.

The purpose of this fact sheet is to explain the relationship between rates of water extraction, freshwater inflows and the location and concentration of salinity in the tidal pools. This information is important to explain why the department is proposing the Plan changes as the best way to minimise negative impacts of salinity on water users, while protecting the water sources that they rely on.

Location and extractions

There are three Hunter tidal pool water sources. These are the Hunter River, Paterson River and Wallis Creek tidal pool water sources (see Figure 1). There are approximately 23,900 unit shares of water allocated to approximately 230 licences in the three tidal pool water sources (see Figure 2). These licences are located mostly upstream of the Green Rocks gauging station (#210432) and are used for a range of industries including pasture, turf, lucerne, vegetables, orchards, dairy, wedding venues/gardens and stock production.

INT24/43459 | TMP-MC-FS-V1.2

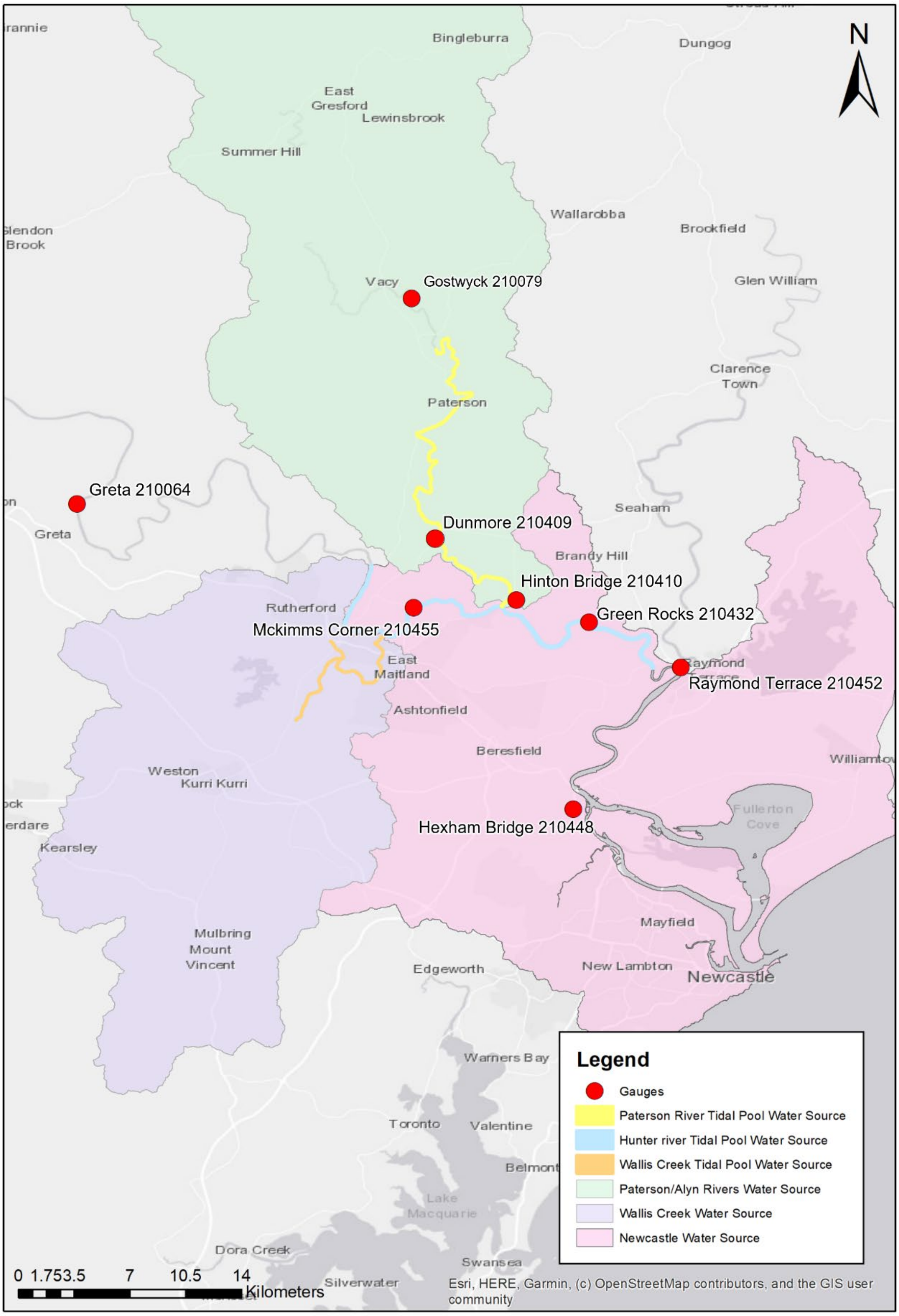

Figure 1: The three Hunter Tidal pool water sources and WaterNSW Gauging stations located in the Hunter tidal pools

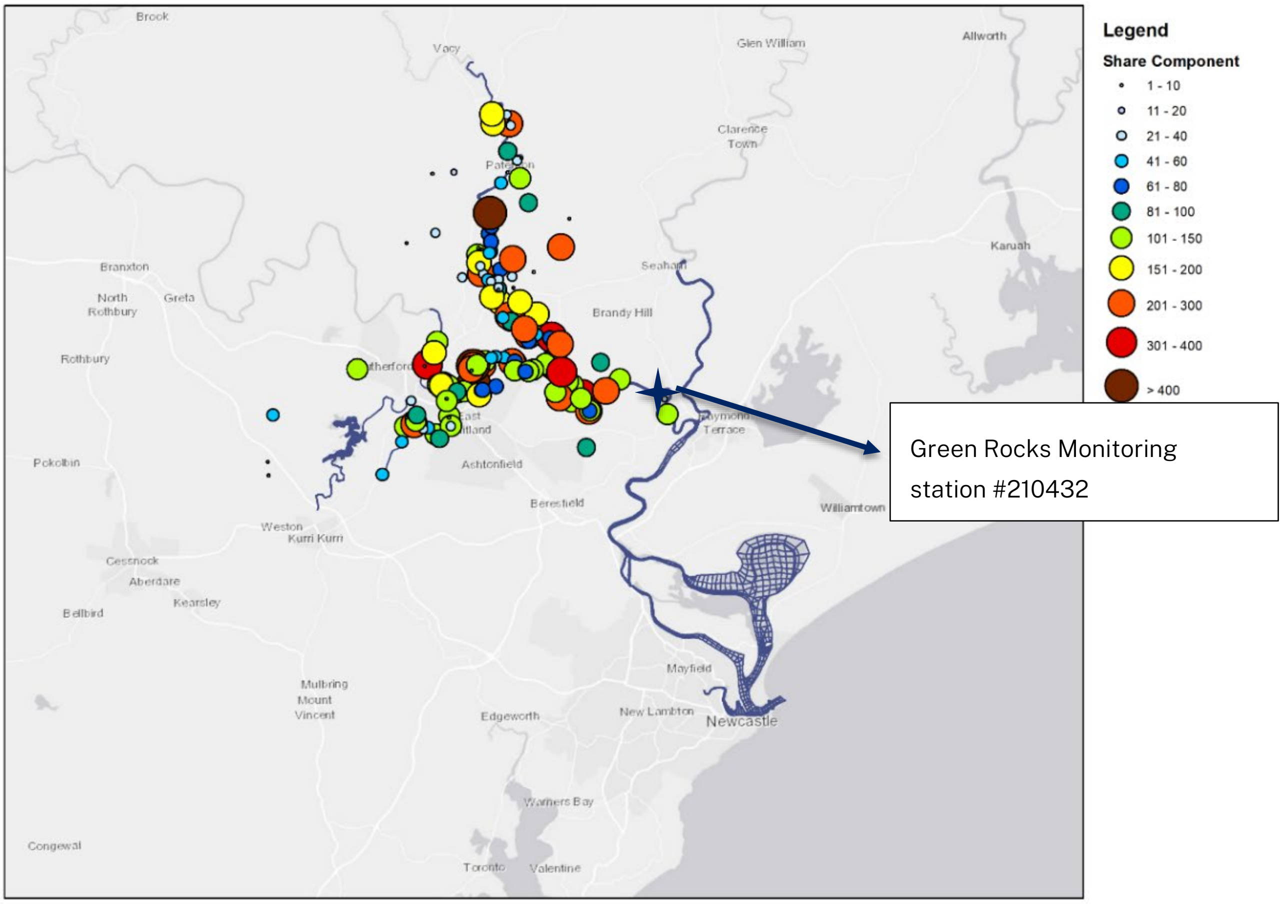

Figure 2: Water access licences in the Hunter River, Paterson River, and Wallis Creek tidal pool water sources, mostly upstream of Green Rocks monitoring station (#210432)

Impacts of salinity on agricultural and domestic and stock values

Increased salinity will affect Irrigated crops, fodder plants, pastures, fruits vegetables, stock and drinking water. Table 1 lists salinity thresholds for plants and animals grown in the Hunter tidal pool areas as adapted by NSW Department of Primary Industries 2017 (Salinity tolerance in irrigated crops (nsw.gov.au) and (Water for livestock: interpreting water quality tests (nsw.gov.au). For gardening, the Australian Native Plant Society recommends avoiding water that is more than approximately 2,000 µs/cm (Effective Watering in the Garden (anpsa.org.au). The Australian Drinking Water Guidelines recommend sodium levels shouldn't be above approx. 500 µs/cm. (Australian_Drinking_Water_Guidelines_ADWG_V3-8_Sep2022.pdf).

Table 1: Salinity thresholds for agricultural crops and stock

Plant/animal	Salinity thresholds
Beef cattle	8,000 –15,600 µs/
Dairy cattle	6,300-10,900 µs/cm
Couch grass	7,000 µs/cm
Zucchini	5,000 µs/cm
Lucerne	3,600 µs/cm
Cucumber	3,000 µs/cm
Bean	1,500 µs/cm
Strawberry	1,200 µs/cm

Impacts of salinity on ecological values

Freshwater inflows to estuaries are critical in maintaining important habitat and foraging zones for many species (Drinkwater and Frank 1994[1], Alber 2002[2], Robins et al., 2005[3]) and results of recent salinity increases as shown in Figures 3-6 would affect a number of natural ecosystem processes (dwr_1331.pdf (ca.gov)) in the Hunter tidal pool including:

- intrusion of predators and parasites,
- increased saltwater intrusion into groundwater/alluvial waters, and
- increased frequency of anaerobic (without oxygen) conditions in the benthic layers (bottom of river/waterway) of the Hunter tidal pool.

Table 2 lists the salinity thresholds for plants and animals likely to occur in the Hunter tidal pool areas, adapted from the studies of Miller et al. (2005)[4] and Peirson et al. (1999)[5]. Under these conditions, Adult Bass would be unable to inhabit the Hunter tidal pool area in/around Green Rocks

[1] Drinkwater, K.F. and Frank K.T., 1994, "Effects of river regulation and diversion on marine fish and invertebrates" *Aquatic Conservation; Freshwater and Marine Ecosystems* Vol 4: 135-151.

[2] Alber, M. 2002. "A Conceptual Model of Estuarine Freshwater Inflow Management". *Estuaries* Vol 25 No 68 p 1246-1261.

[3] Robins, J. B. et al, 2005. "Freshwater-flow requirements of estuarine fisheries in tropical Australia: a review of the state of knowledge and application of suggested approach". *Marine and Freshwater Research*, 2005: 56; 343-360

[4] Miller, B.M., K.A Bishop, A. Frazer and A. Badenhop, 2005. "Rous Water Lismore Source, Ecological Impacts of Changed Flow Regimes", WRL Technical Report 2004/19.

[5] Peirson, W.L., K. Bishop, M.J. Chadwick and R. Nittim, 1999. "An Investigation of the Potential Ecological Impacts of Freshwater Extraction from the Richmond River Tidal Pool", WRL Technical Report 1999/51. University of New South Wales-Water Research Laboratory.

when salinity levels exceed 7,905µs/cm. Freshwater macrophytes (larger aquatic plants such as reeds) and frogs such as the endangered Green and Golden Bell Frogs (Atlas of Living Australia (ala.org.au) would be affected by salinity levels above 1,500µs/cm in the Paterson River at Dunmore and the Hunter River at McKimms Corner as seen in Figures 6 and 7.

Table 2: Summary of Compiled from Miller et al (2005) and Peirson et al (1999),

Plants/animals	Salinity thresholds
Freshwater macrophytes	1,581 µs/cm
Green and Golden Bell Frog	1,560 – 3,120 µs/cm
Australian Bass outside spawning season	7,905 µs/cm

The Australian and New Zealand Environment and Conservation Council (ANZECC) has established water quality guidelines (Table 3 below) that clarify general salinity limits for waterways. Although these are general limits, they may be helpful when talking about how "salty" the water is in any specific situation and are therefore referred to throughout this Fact Sheet.

Table 3: EC limits for waterways (ANZECC 2000)

Water Type	Electrical Conductivity (EC) (µS/cm)
Freshwater	<1,500
Brackish Water	1,500 – 4,800
Saline Water	4,800 – 51,000
Saltwater	>51,000

Relationship between inflows and salinity in the Hunter tidal pools

Salinity and flow monitoring in the Hunter River tidal pool water sources shows that salinity levels at Green Rocks gauging station (#210432), in the tidal pool below the confluence of the Hunter, Paterson and Wallis Creek tidal pool water sources, remains below 4,800 µs/cm most of the time. However, salinity levels above 4,800µs/cm at Green Rocks are recorded during times of low inflows including most recently in Oct and Dec 2023 (Figure 3) and as can be seen in Figure 4, during 2013-2020.

Figures 5 and 6 show that the same relationship between inflows and salinity exist in the Paterson River (Figure 5) as well as in the Hunter River (Figure 6). Salinity levels in the Paterson River at Hinton (#210410) and Hunter River at McKimms Corner (#210455) gauging stations at the upstream end of the tidal pool water sources are mostly below 1,500 µs/cm. However, elevated salinity levels have occurred at Hinton and McKimms Corner during the periods of low inflows at similar times as shown in Figure 4 for Green Rocks.

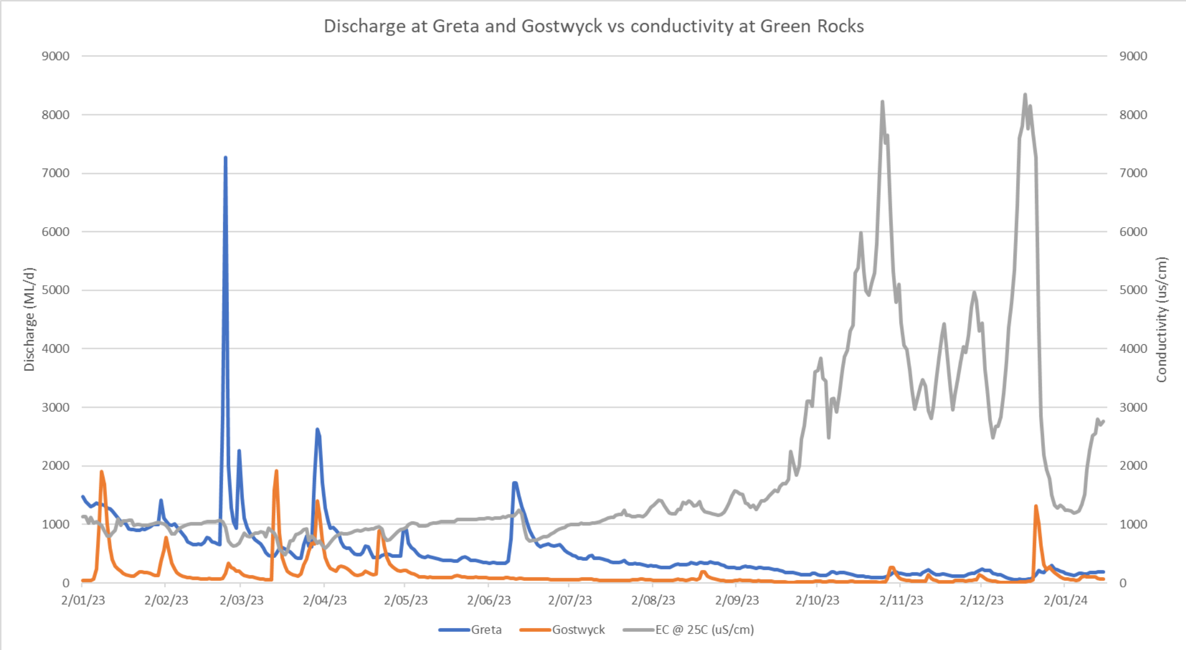

Figure 3: Discharge (inflows) measured at Greta (gauge #210064) and Gostwyck (gauge #210079) and salinity (conductivity) at Green Rocks monitoring station #210432 Jan 2023 to Jan 2024.

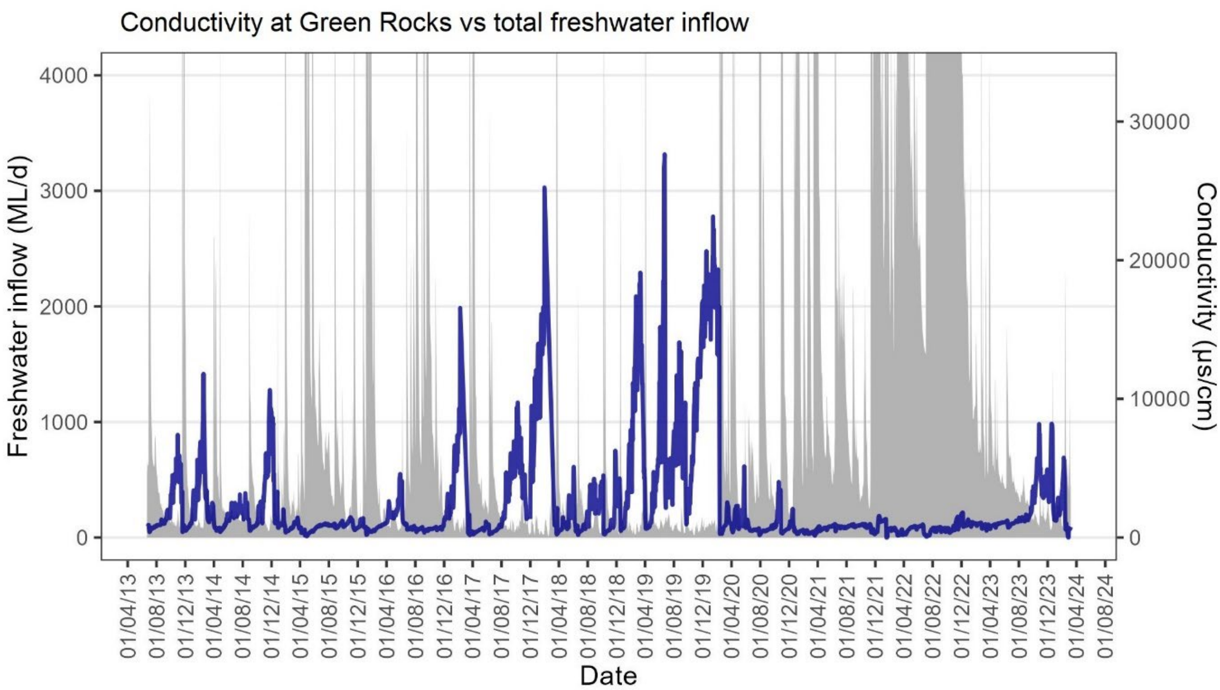

Figure 4: Combined discharge (freshwater inflows) as measured at Greta (gauge #210064) and Gostwyck (gauge#210079) (grey shaded areas) VS conductivity (salinity) at Green Rocks monitoring station #210432 (blue line) from 2013-2024.

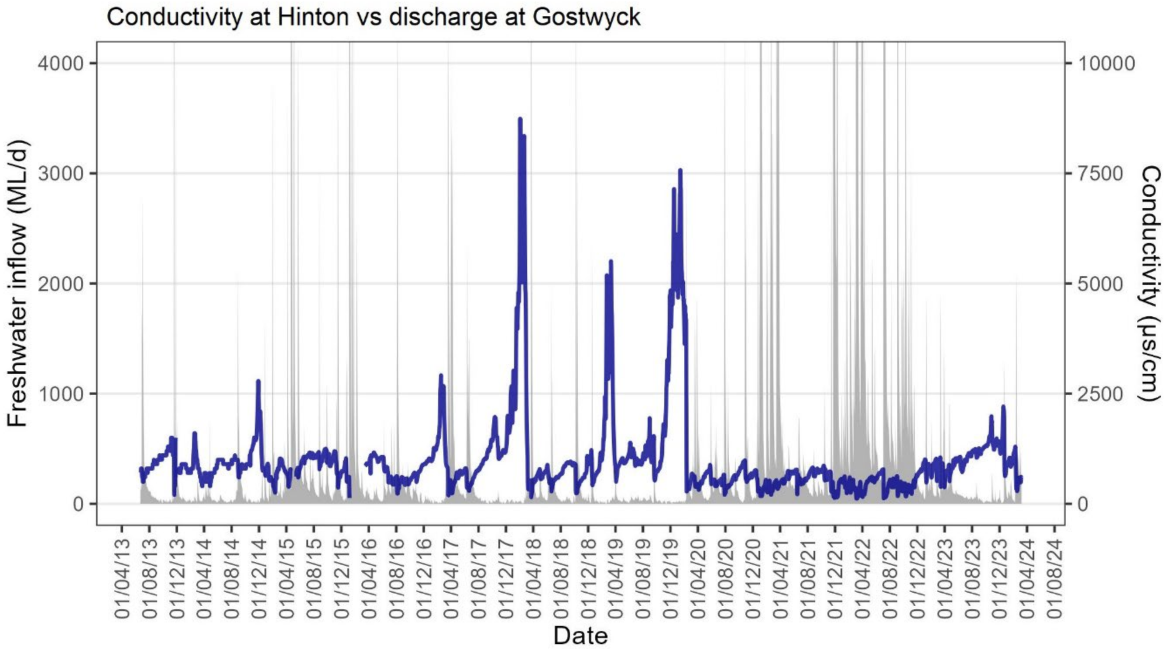

Figure 5: Discharge at Gostwyck (gauge#210079) (grey shaded area) vs conductivity at Hinton Bridge (gauge #201410) (blue line)

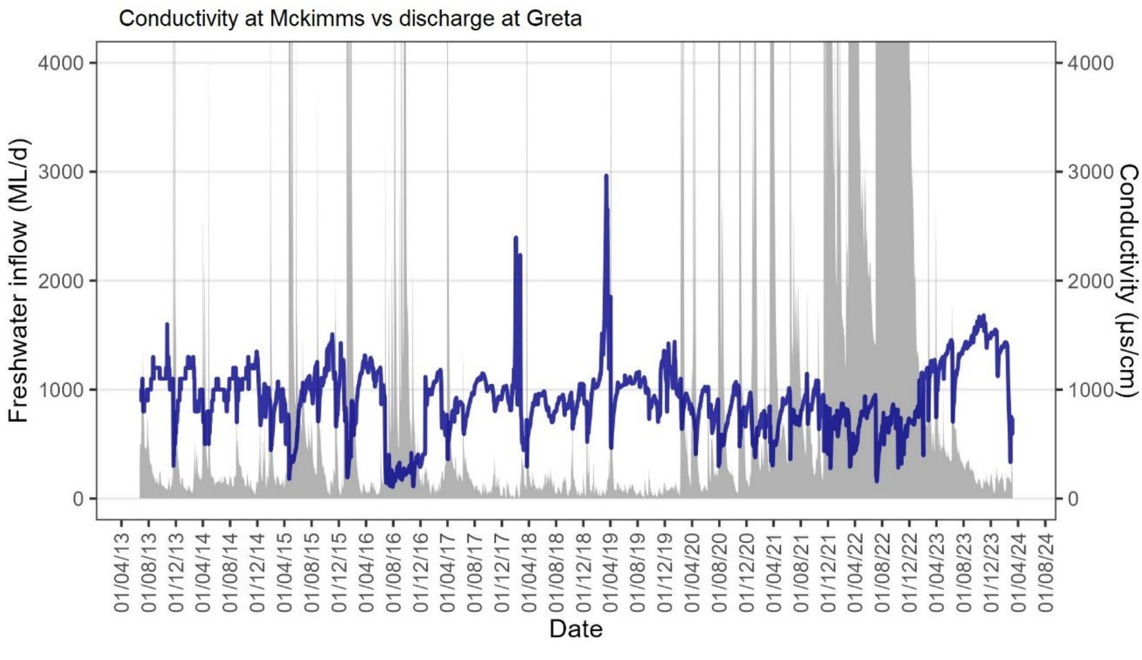

Figure 6: Discharge at Greta (gauge #210064) (grey shaded area) vs conductivity at Mckimms corner (gauge #210455) (blue line)

While salinity variation is a natural dynamic in tidal pools there is likely to be ecological impacts to tidal pool ecosystems and availability of usable water for extraction when salinity levels are consistently above, and further upstream than experienced previously.

Figure 7 plots the annual combined inflows (light blue) against the percentage of time salinity would be expected to exceed 4,000 *μs*/cm at Green Rocks (dark blue) if full entitlement was extracted. It shows a clear relationship between driest inflow years and increased frequency of high salinity. The graph shows that it is during approximately the driest 20% of the time when salinity would be high more often. The driest 20% of time represents inflows of less than 300,000 ML/yr.

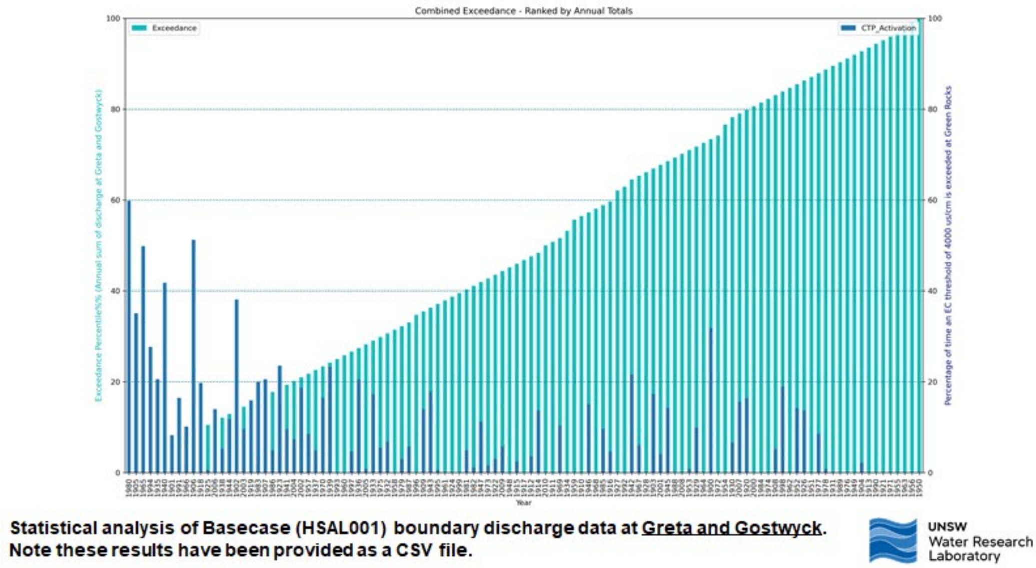

Figure 7: WRL Modelled analysis of combined inflows ranked by annual sum of inflows at Greta and Gostwyck (light blue) and % of time an EC over 4,000 μs/cm is exceeded at Green Rocks under full extraction scenario. For example, in the driest year (1980), combined inflows were 59,155 ML, in this scenario, 4000 μs/cm would have been exceeded 60% of time that year. In the wettest year (1950), total inflows 6,271,246 ML, and 4,000EC was exceeded 0% of the time.

Assessing impacts of different extraction scenarios on salinity

Modelling has been used to simulate the relationship between river inflows, extractions and salinity levels in the Hunter tidal pools.

The Department's Water Group contracted UNSW Water Research Laboratory (WRL) during 2019-2022 to run their hydrodynamic model with integrated quantity and quality (IQQM) data supplied by the department to assess several different extraction management scenarios.

The modelling scenarios indicate that during periods of low inflows water extraction from the Hunter tidal pools results in upstream migration of the salinity wedge. When full extraction is modelled the movement is up to 10 km upstream negatively impacting water users and river flora and fauna. Figure 8 shows how the brackish water, with salinity levels above 1,500μs/cm, extends upstream past the Dunmore and McKimms Corner gauging stations (see the yellow wedges in the picture on left) when there is full extraction of entitlement, whereas these levels of salinity would stop at approximately Berry Park (see yellow wedge in the picture on right) if there was no extraction. Salinity levels at Berry Park reach 4,800µs/cm under full entitlement extraction whereas these would stop at Green Rocks (blue cross) if there was no extraction.

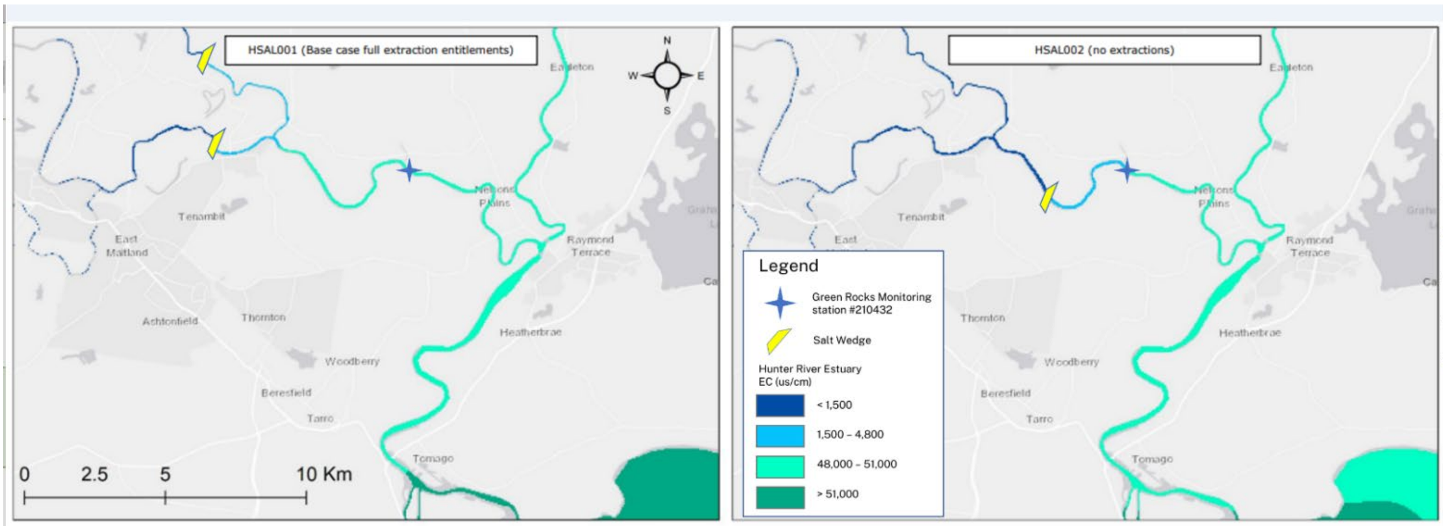

Figure 8: Location of salt wedge moving from Green Rocks Monitoring station #210432 under modelled scenarios for a dry period (March 1980) - with full extraction (left figure) vs no entitlements (right figure).

Modelling results also showed salinity levels would be reduced at various locations under reduced extraction scenarios. Figure 9 depicts the modelling results of the different extraction scenarios. It shows that if extraction is limited to 50% of licence limits (the green line), salinity at Green Rocks would be approximately 5,000 µs/cm, and just within the brackish parameter, during the driest 5% of time. This compares to a salinity level at Green Rocks approximately 8,000 µs/cm with full tidal pool extractions (blue line), and salinity level approximately 3,000 µs/cm with no tidal pool extraction (orange line).

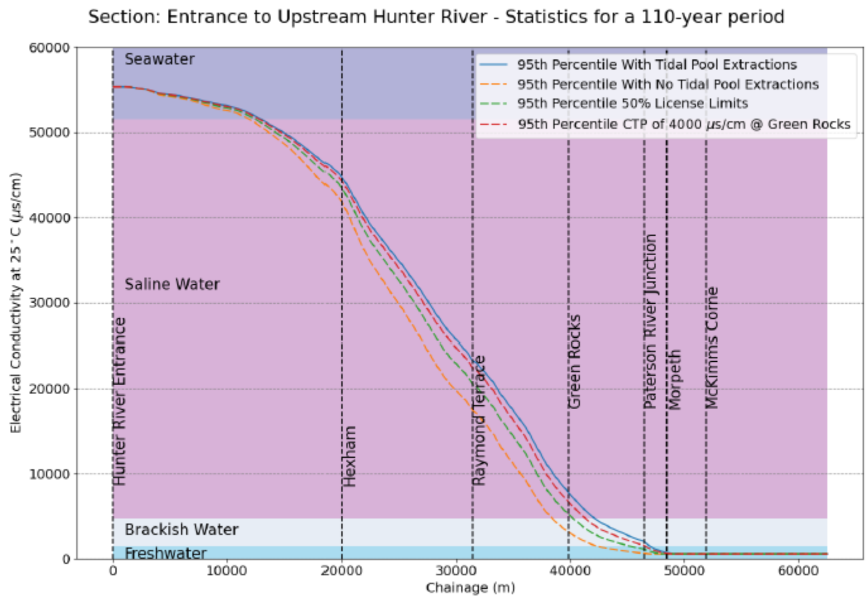

Figure 9: The 95%ile salinity at various locations upstream of the entrance to the Hunter River for various extraction rules applied to model runs

Management of upstream saltwater movement in the Hunter Tidal pools.

The department has a responsibility under the *Water Management Act 2000* s5(3) to ensure sharing of water from a water source protects the water source, it's dependent ecosystems and basic landholder rights. The department aims to find the right balance between the social, economic, and ecological needs and is considering introducing water sharing rules to the Hunter tidal pool water sources to ensure these requirements are met.

Water sharing plans for the Hunter Unregulated and Alluvial Water Sources

The first water sharing plan for the area (The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources) was gazetted in 2009 and foreshadowed the establishment of access rules in the tidal pools in order to manage salinity. In its review of the plan in 2020, the Natural Resources Commission (NRC) recommended establishing access rules in the tidal pools in order to manage salinity due to the important ecological functions they provide for fish and other biota (NRC, May 2020[6]).

During consultation of the draft replacement plan during 2020-2022, water users told the department that daily access rules based on inflows or salinity levels would result in severe economic hardship. The department then proposed to use Available Water Determinations (AWDs) to manage extraction volumes during periods of low inflows. Further analysis and consultation were

[6]Natural Resources Commission Review of the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*, May 2020

required before this could be implemented so the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water sources 2022* (the Plan) includes an amendment provision to allow establishment of available water determination (AWD) rules in the tidal pool water sources by 2024 to improve salinity management.

The amendment further stipulates that it should not result in any substantial change to the long-term average annual extraction limit or the time at which water may be extracted from the water sources.

The intent of the amendment is to limit the movement of salt water upstream during times of low inflows by capping licenced water extraction volumes at these times, via a reduced AWD. Further information on the amendment can be found in the Proposal to Manage Salinity in the Hunter River Tidal Pool Water Sources through Available Water Determination rules fact sheet.