Delineation of Seawater Intrusion in the Burdekin Delta Aquifer

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The Burdekin River Delta hosts a large unconfined aquifer that has supplied fresh groundwater for irrigation, stock and domestic use in the area for over 100 years. Typically, it provides more than 450,000 ML of groundwater per annum for sugarcane irrigation. The Delta aquifer comprises mostly unconsolidated sedimentary deposits to depths in excess of 100 metres overlying a predominantly granitic basement. The nature of sedimentation is very complex with sediments comprising a mixture of inter-bedded gravel, sand, silt, mud and clay. These sediments are rarely continuous laterally, with layers pinching out and grading with distance. The high dependence of groundwater for irrigation of crops has led to concerns about the potential encroachment of the seawater interface into the fresh groundwater. The threat of seawater intrusion is one of the major issues to the groundwater supply as well as sustainability of irrigation in the Delta.

Due to the complexity of sediment distribution, it is a great challenge for resource managers to understand how freshwater and seawater move through such a heterogeneous delta aquifer system. The boundary between the freshwater and seawater is not a sharp interface, but a transition zone whose thickness is controlled by the hydrogeological characteristics of the aquifer. In the Burdekin Delta aquifer, this zone is relatively thin. Electrical conductivity (EC) measurements greater than 5000 μS/cm are considered to be evidence of contamination by seawater, and are mapped at this concentration to define the position of the seawater interface. Delineation of this interface is achieved through a network of both continuously slotted and multi-pipe monitoring bores, installed at various locations across the delta.

Intermittent monitoring of the coastal groundwater has shown that the position of the seawater interface is not stationary, but moves in accordance with the net fresh groundwater flux. Therefore, seawater intrusion is most pronounced during years of low rainfall (low recharge) combined with the subsequent increase in groundwater extraction. Conversely, periods of high rainfall (higher recharge) reduce the need for groundwater pumping and the seawater interface movement can extend seaward. The toe of the interface extends for many kilometres inland, particularly in the North Burdekin region where the aquifer is deeper and there is a larger exposure of coastline compared to the South Burdekin.

A methodology to characterise the Delta aquifer and the nature and movement of groundwater within the Delta has been developed to assist with understanding the hydrological processes active in the aquifer. This leads to the formulation of a computer model that provides a numerical simulation of the movement of groundwater and the implications this has for the behaviour of the seawater interface, and the subsequent threat of seawater intrusion.

Discharge of freshwater to the sea occurs along the face of the seawater interface at the shoreline. Water quality monitoring data for groundwater shows that average nitrate values have increased over the last thirty years due to the continued expansion of sugarcane cultivation. This is particularly evident in the years since 1992, where average nitrate values have increased steadily from around 3 mg/L to around 13 mg/L in 1998. Recent estimations by the Queensland Department of Natural Resources have estimated that freshwater discharge to the sea in the Burdekin Delta area ranges from 1500 to 9000 ML/yr. In terms of solute mass, this would indicate that nitrate discharge to the sea could range between 4.5 and 117 tonnes of nitrate per year.