TARGETED STREAM AUGMENTATION AND MANAGED AQUIFER RECHARGE MODELLING WITHIN THE WAIMAKARIRI IRRIGATION LIMITED COMMAND AREA

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Aims

Managed Aquifer Recharge (MAR) is the infiltration of good quality water into the ground to improve groundwater quantity and/or quality and the flow and quality of springfed streams that emerge from the groundwater. Targeted Stream Augmentation (TSA) is the addition of water to improve the quantity and/or quality of a specific stream. Environment Canterbury (ECan) has projected future nitrate-N concentrations at public drinking water supply wells, private water supply well areas, and streams in the Waimakariri Water Management Zone if current management practices (CMP) continue, or if all farming changes to adopt good management practices (GMP) (Etheridge et al., 2018).

This study sought to utilise these recent and projected nitrate-N concentrations to assess the effects and feasibility of using TSA and MAR to help achieve the Plan Change 7 (PC7) recommended nitrate-N concentration limits via the application of additional fresh water available from the Waimakariri River within the Waimakariri Irrigation Limited (WIL) command area.

Method

Water availability for TSA and MAR was investigated by subtracting the irrigation water demand estimated with a daily soil moisture balance (SMB) model from the total inflow authorised by consent allocations for the Browns Rock intake. The SMB model evaluates soil moisture balance on a daily basis using input data including consented water take restrictions, river flow, storage, rainfall, potential evapotranspiration (PET), soil properties, and irrigation application decision making.

The TSA models use the current and projected in-stream nitrate-N concentrations and the calculated median flow rates from gauging data to estimate the overall increase in median flow with fresh water required for meeting the recommended PC7 limits. Similarly, each analytical MAR mixing model estimates a total MAR requirement by defining a shallow aquifer zone that encompasses active private drinking water supply well depths and applying Darcy's law to solve for long-term median groundwater throughflow and nitrate-N transport within each private water supply well area with projected exceedances. Lateral hydraulic gradients were estimated from ECan's Waimakariri long-term median, pre 2016 shallow wells, piezometric contours and ranges in shallow aquifer zone transmissivity were determined from aquifer test data. Groundwater throughflow areas were determined from interpreted long-term median groundwater flow directions that encompass the extent of active private drinking water wells within each area. Literature values for vertical dispersion informed the estimated ranges of vertical groundwater mixing, while calculated ranges of linear groundwater velocities were used to approximate timeframes to achieve positive outcomes within each area.

Data on *E. coli* concentrations within the Waimakariri River source water in the vicinity of the Browns Rock intake were applied to literature values of decay rates and the estimated linear groundwater velocities to determine the safe spacings of hypothetical MAR features from domestic wells for microbial attenuation. Long-term median and recent seasonal minimum/maximum depth to groundwater conditions were estimated in conjunction with analytics on cumulative mounding effects to assess MAR feasibility and necessary accommodation space within the very shallow aquifer zone with respect to potential drainage problems and sources of contamination such as septic systems.

Sixty potential MAR and TSA site areas were identified along water races away from domestic wells and potential sources of contamination in areas where deeper groundwater conditions with more accommodation space are expected. Seventeen of these potential MAR sites were classified as priority based on a matrix of criteria including the likelihood of positive measurable outcomes in the near future at nitrate-N impacted domestic wells and proximity to areas that, in the long-term, serve larger populations in terms of the overlapping groundwater recharge areas for public supply wells where ECan have projected nitrate-N exceedances of the PC7 targets.

Results

The SMB model underpredicted the measured total abstraction volume for the irrigation scheme over the last three irrigation seasons with a relative percent difference ranging from 4% to 10%. Based on the entire SMB modelling period (1968 – 2018), at least 3.1 cumecs (as a constant-rate) of water is potentially available each year for TSA and MAR. It is also estimated that for every 5 out of 10 years, at least 7.5 cumecs of water is potentially available for TSA and MAR.

The average estimated total current and future TSA and MAR water requirements are within the range of water available from the Waimakariri River (Figure 1). The TSA requirements do not consider improvements to groundwater quality from MAR within stream groundwater recharge zones (Figure 2), so it is possible that future TSA requirements under various MAR scenarios for private well areas (Figure 3) could be less than what are found by this study. Total water race capacities are also within the range of the estimated MAR requirements at potential sites (Figure 4). Predicted cumulative mounding effects suggest that most of the potential MAR sites could support the estimated 8-month rate requirements when water is available and running in tandem.

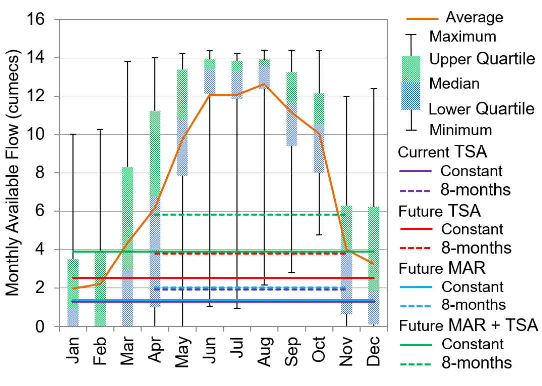

Figure 1: Water Availability and Requirements

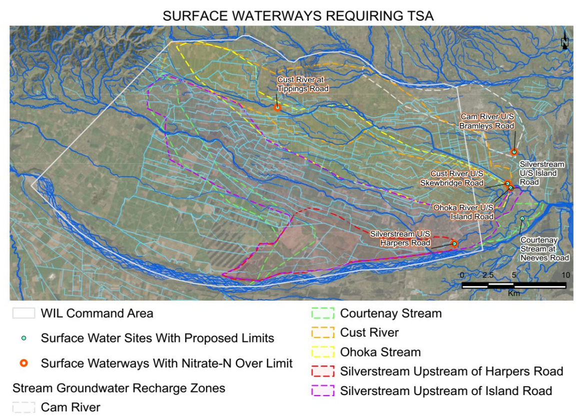

Figure 2: Waterways Requiring TSA

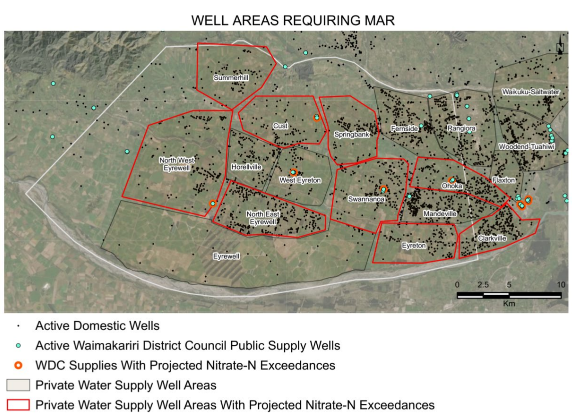

Figure 3: Private Well Areas Requiring MAR

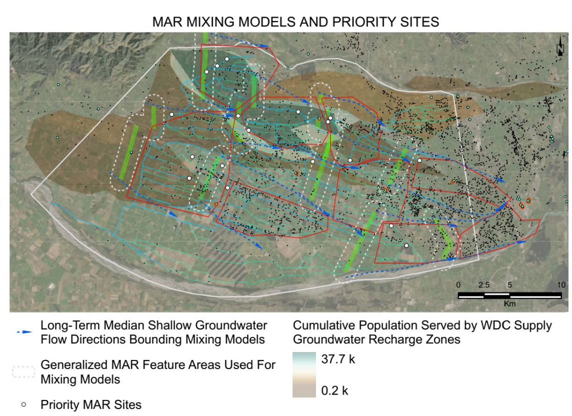

Figure 4: MAR Mixing Models and Priority Sites

Reference

Etheridge, Z., Hanson, M., Harris, S., Whalen, M., Arthur, J., Meredith, A., Holland, J. and Picken, A. (2018). Nitrate assessment for the northern Waimakariri River tributaries catchment. Environment Canterbury.