Quantifying Legacy and Future Embodied Carbon Emissions of Christchurch Water Reticulation Systems

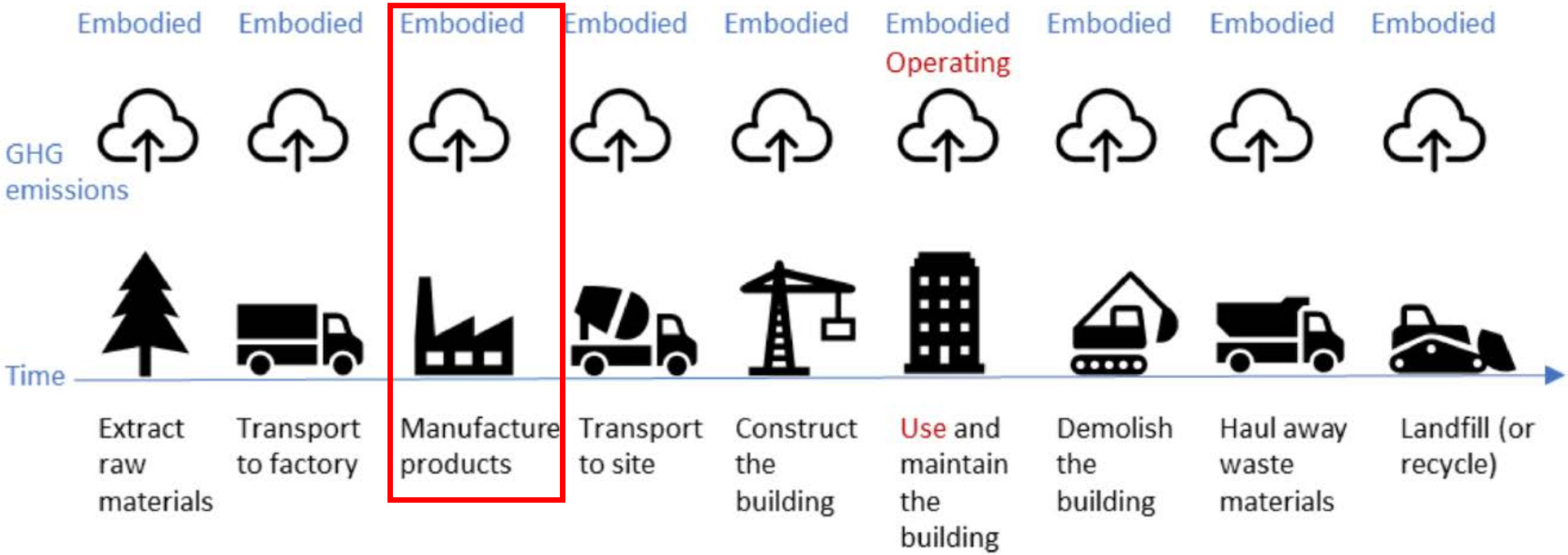
J. Z. Wu and H. P. H. Verstappen

Final Year Projects, 2020
Dept. of Civil and Natural Resources Engineering
University of Canterbury
Project supervisor(s): Dr M. W. Hughes

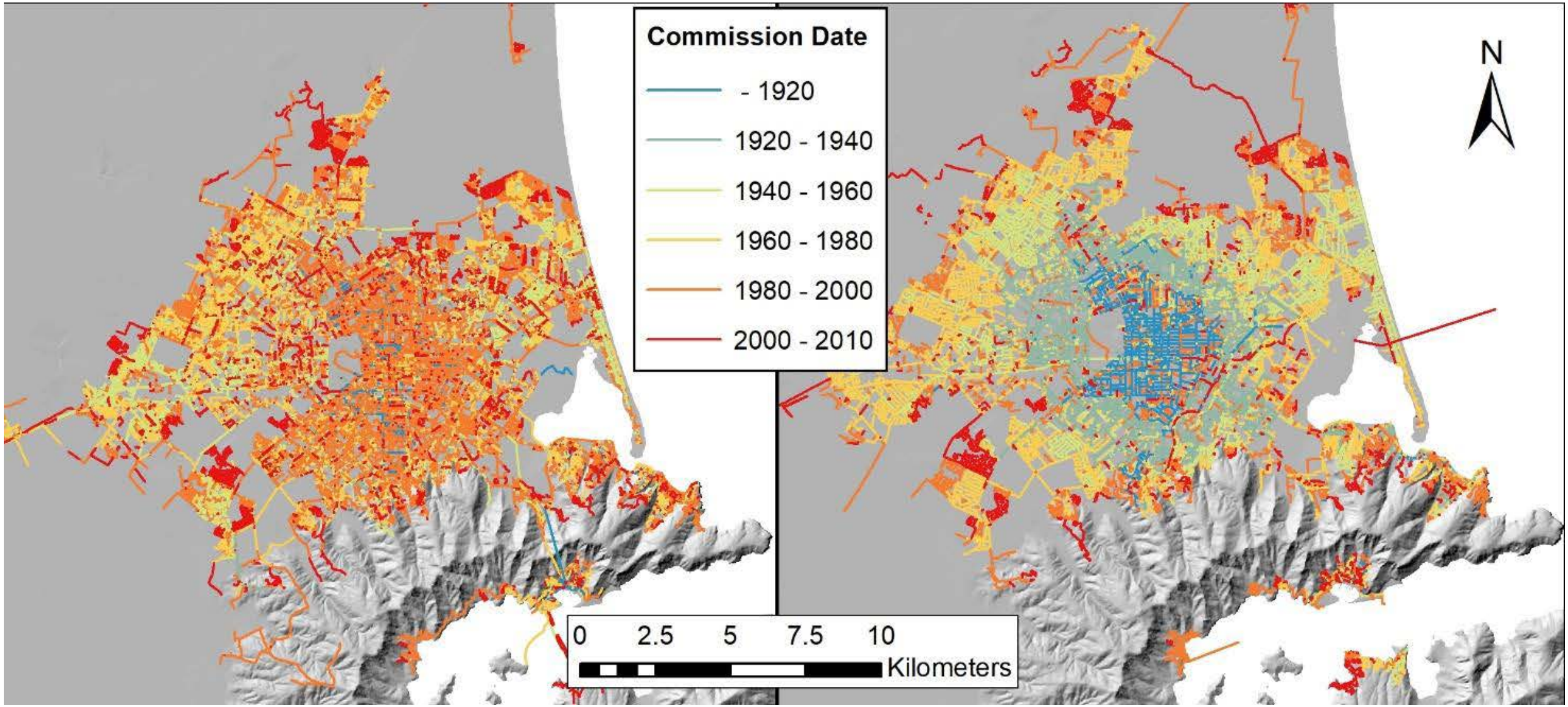
Keywords: *Embodied carbon, infrastructure, pipe network, Christchurch, climate change*

Civil & Natural Resources Engineering | Pūhanga Metarahi me te Rawa Taiao

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND



Visualisation of embodied carbon via greenhouse gas (GHG) emissions (Forestry Innovation Investment, 2017)



Christchurch water supply (left) and wastewater (right) pipe networks colour coded by commission date

Total length and percentage distribution of PE and PVC usage in CCC water supply and wastewater pipe networks

	Length (km)	Percentage (%)
Water Supply		
PE	1884	74.3%
PVC	652	25.7%
Waste Water		
PE	273	25.4%
PVC	802	74.6%

- New Zealand Standards specify the minimum and maximum wall thickness for PE and PVC pipes based on pressure class and nominal diameter;
- Maximum, minimum and mean wall thicknesses were assigned to pipe sections, and associated pipe volumes calculated.

Densities and GHG emissions factors for PE and PVC piping (ISCA 2013; Martins et al. 2009; Merah et al. 2006)

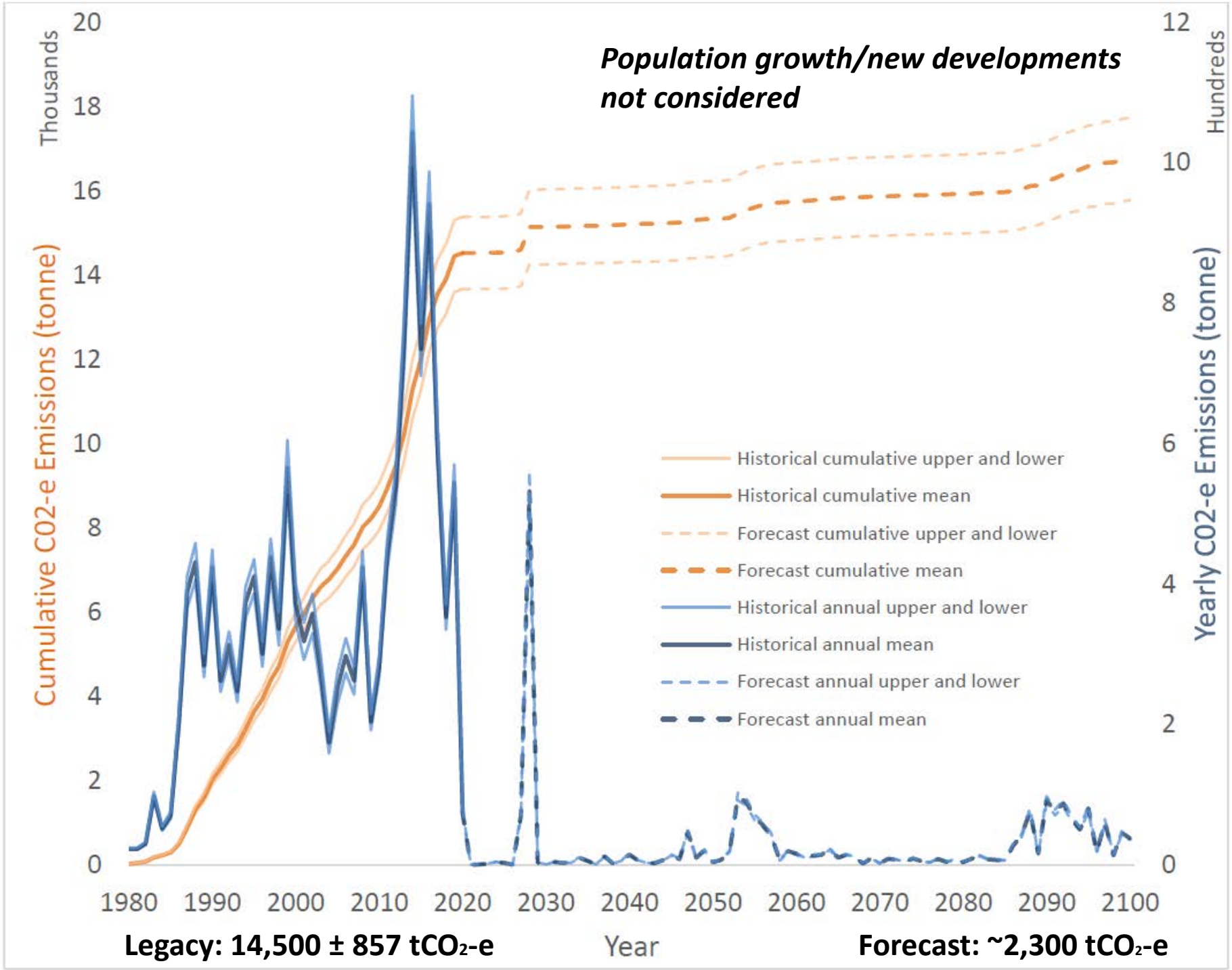
Pipe Type	Density (kg/m^3)	GHG emissions factor (tCO_2-e/t)
PVC	1,380	2.03
PE	965	2.54

- The Infrastructure Sustainability Materials Calculator (ISMC) was used to calculate embodied carbon associated with the CCC PE and PVC pipes of the wastewater and water supply networks;
- Embodied carbon factors assigned by inputting base case of 1000 tonnes of PE and PVC piping and obtaining GHG emissions factor from Australian Life Cycle Analysis (LCA) databases for materials

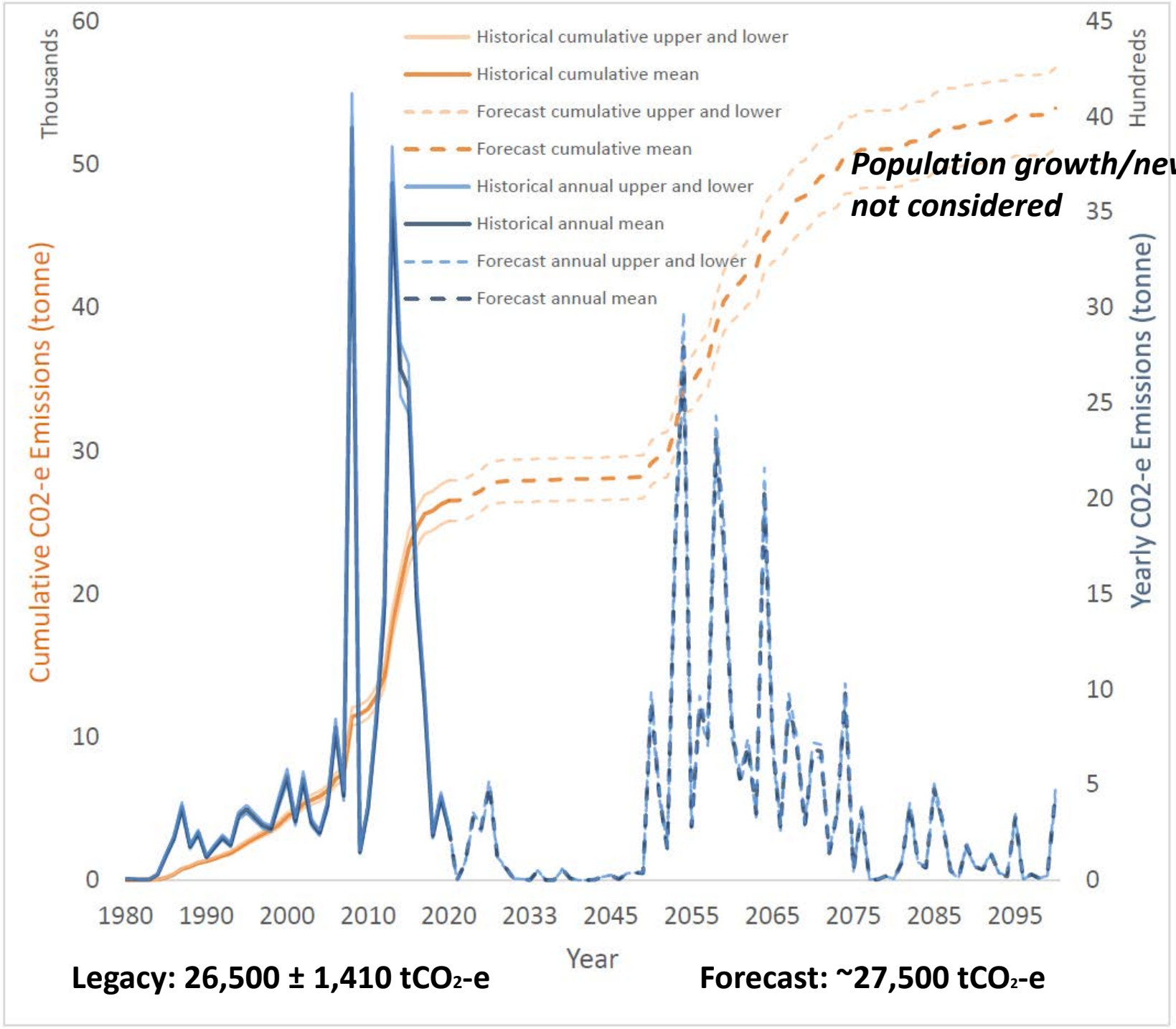
Assumptions

- A pressure class of PN12 was adopted for all pipes unless otherwise noted in the database to conform with Christchurch City Council water supply and wastewater infrastructure design standards.
- All PE pipes where assumed to be graded PE100 unless otherwise stated to align with standard material usage standards for pipe systems.
- Pipe dimensions were consistent with the relevant New Zealand Standards at the time of commission.
- When applying forecasts to pipe types, an identical inner diameter was assumed to accommodate similar flow demands.
- The inner diameter of the pipes forecasted was assumed to be identical in PE and PVC to maintain similar flows.
- Forecasted emissions of the water supply and wastewater pipe networks were assumed to follow the current usage distribution of PE and PVC piping by length of their respective networks (similar % to used currently).
- For forecasting, it was assumed that PE and PVC will be used in future pipe renewals.

Potable Water



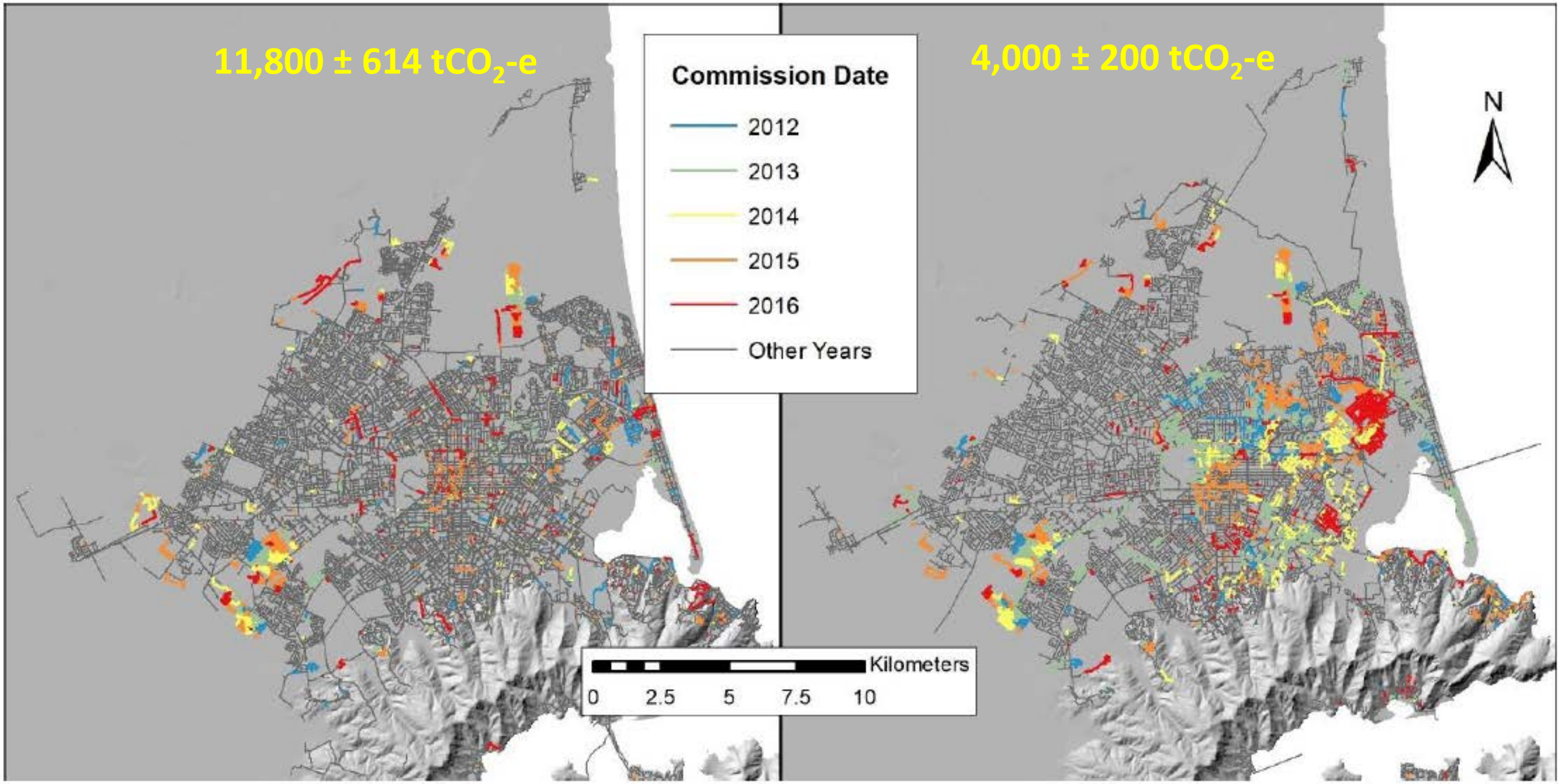
Wastewater



Population growth/new developments not considered

Legacy: 26,500 ± 1,410 tCO_2-e

Forecast: ~27,500 tCO_2-e



Pipes replaced in the wastewater (left) and water supply (right) during Canterbury Earthquake Sequence repairs