

CLUES: modelling the impacts of land-use change and farm practices on catchment water quality

NIWA's Catchment Land Use for Environmental Sustainability (CLUES) model is a GIS-based system that predicts the effects of land-use change and farm practice scenarios on water quality and a range of socio-economic indicators at the catchment scale. CLUES allows users to create scenarios and view results in map or tabular displays. It was developed as a decision support tool for catchment managers, land-use planners and regulators.

Predicting loads and concentrations

CLUES was developed by NIWA for the Ministry of Agriculture and Forestry (now part of the Ministry for Primary Industries) and the Ministry for the Environment. CLUES is an amalgamation of existing modelling and mapping procedures contributed by various research organisations including AgResearch, Landcare Research, Plant & Food Research, Aqualinc Research and Harris Consulting. It incorporates a simplified version of OVERSEER.

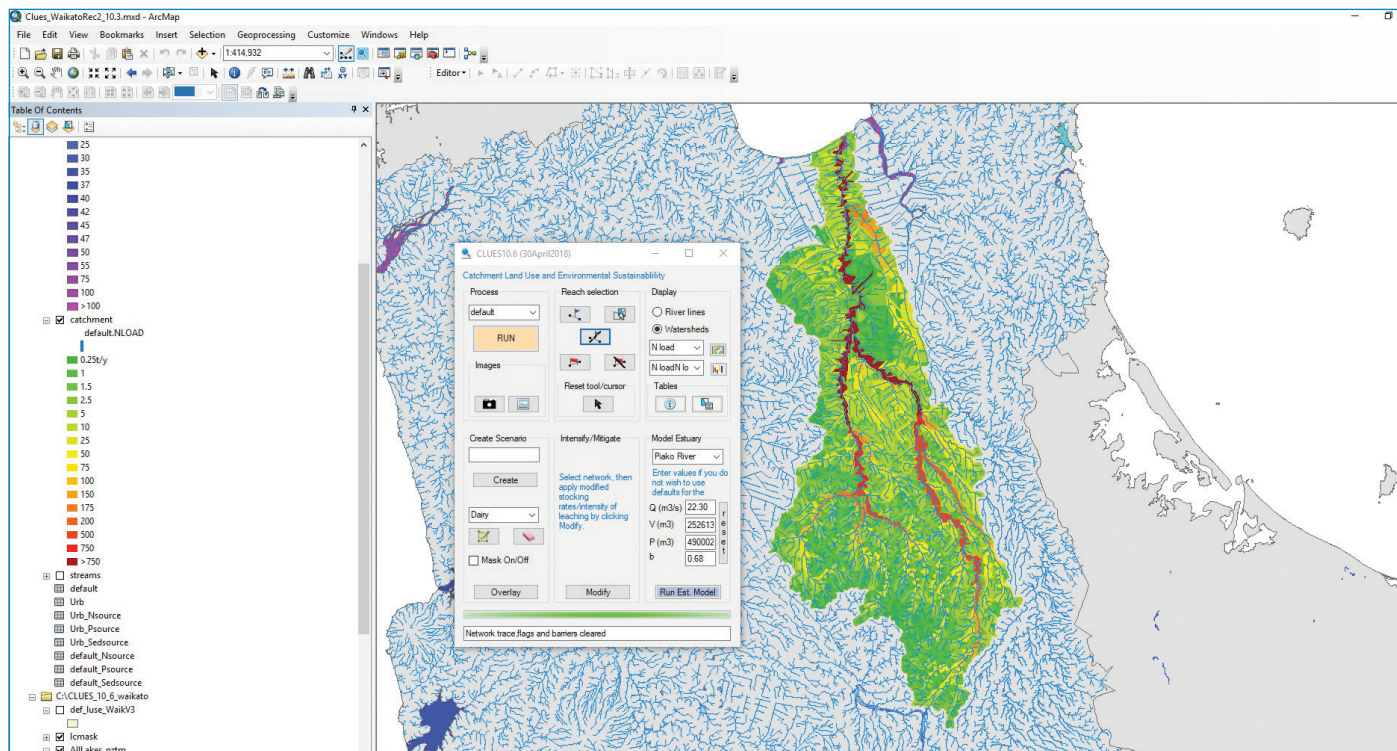
CLUES is provided to users as a front-end interface for ArcGIS, which queries a geospatial database that is provided with CLUES. The GIS platform allows input data and results to be mapped alongside other spatial data supplied by the user. This means that CLUES can be used for geo-visualisation to promote understanding and facilitate public communication. The smallest spatial unit within CLUES is the river reach from NIWA's River Environments Classification (version 2). For each river reach, CLUES predicts the annual average loads and yields of nutrients (total nitrogen and total phosphorus), total suspended solids and *E. coli*. Estimates of nutrient concentrations are also calculated.

Social economic indicators include farm revenue and employment, fuel and energy use and greenhouse gas emissions. Mitigation measures can also be accommodated.

CLUES-Estuary tool

Estuaries support sensitive ecosystems, and are the receiving environments for stream and river catchments. Deteriorating health in an estuary can be an early indicator of problems in the catchment that will eventually impact on water quality throughout. The CLUES Estuary tool has been integrated into the CLUES model system to help manage these ecosystems. This tool predicts potential nutrient (nitrates and total phosphorus) concentrations in estuarine environments, and can be run with the same scenarios as CLUES.

The CLUES-Estuary tool connects to databases containing the physical properties of all New Zealand fresh waterways and estuaries, so is capable of providing the complete picture from catchment to estuary.



Screen shot of the CLUES model interface and outputs displayed as a catchment map and as tables for a single river segment.

Contaminant tracing tables

Contaminant tracing tables were added to CLUES in 2015 and are returned for each of TN, TP and sediment. These tables contain the generated and cumulative loads and yields estimated for each corresponding contaminant by land use class for all the REC reaches selected for the model run. For each land use class and REC sub-catchment, the tables provide two sets of results; these are the sub-catchment generated and cumulative (instream) loads, areas and yields, respectively. The tables have been provided to allow users to determine the estimated contaminant load from each land use within each sub-catchment and to track loads originating from a particular land use downstream. This means that users can identify which land uses have the most impact on the estimated load within each sub-catchment and down the stream network. This information in turn can be used to support catchment scale mitigation planning – that is, which land uses should be targeted and in which sub-catchments to obtain the greatest reduction in contaminant loads at different points along the catchment.

CLUES examples

CLUES has been used for a range of studies undertaken for regional and central government at the catchment, regional and national scales. Recent examples are modelling generated nutrient yields in the Porirua Harbour catchment for Greater Wellington Regional Council and assessing the impacts of stock exclusion policies on *E. coli* at the national level for the Ministry for Primary Industries and the Ministry for the Environment.

While CLUES is available to download in ready-to-use form, NIWA can work with users to customise the model for special applications or to incorporate additional data. ECan used a modified version of CLUES to model water-quality implications in the upper Waitaki catchment. ECan's own research has provided a fine-scale analysis of soil types and leaching rates in the area, which have been built into the model. Additionally, alternative sediment modelling models (SedNet NZ and WANSY) have been integrated into the CLUES model framework for use by Auckland Council, Waikato Regional Council and Northland Regional Council.

Find out more

The CLUES model and user manual are available free-of-charge to non-commercial users. Download them at: <ftp://ftp.niwa.co.nz/clues/>

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Semadeni-Davies, A., Jones-Todd, C., Srinivasan, M.S., Muirhead, R., Elliott, A., Shankar, U., Tanner, C. (2019a) CLUES model calibration and its implications for estimating contaminant attenuation. *Agricultural Water Management*: 105853.

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