Research translation in risk-based decision making: Lessons from the Victorian Framework for High-Value Groundwater Dependent Ecosystems

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Abstract

Communication and feedback are important to any environmental risk assessment. However, results and findings are often presented in a manner with limited transparency behind the ideas and the opportunity to interrogate results. As part of the communication strategy for the recent Victorian Framework for High-Value Groundwater Dependent Ecosystems (GDEs), we adopted the use of interactive HTML dashboards as an alternative document format. Interactive HTML dashboards were tailored to the framework methodology and designed as standalone documents to be shared like traditional document formats (docx, pdf, shp). These dashboards are then used to inform policy development and decision-making.

Keywords

Dashboard
GDE
Groundwater Dependent Ecosystems
HTML
Research Translation
Spatial Data

Introduction

Groundwater dependent ecosystems (GDEs) are those that rely on groundwater for part or all of their water needs and may include estuaries, wetlands, rivers, and terrestrial vegetation (State of Victoria, 2013). GDEs face a range of threats from groundwater supply. Groundwater extraction occurs for a range of uses, such as irrigation, domestic and stock, and other consumptive uses. The proximity and volume of extraction has the potential to negatively impact on GDEs. Furthermore, changing climate may have adverse impacts on groundwater systems through changing recharge dynamics (Kløve et al., 2014). Over-extraction can lead to the degradation of GDEs through changes in water quantity, water quality and reduction of landscape features such as drought refuges and habitat (Kath et al, 2015).

Groundwater extraction across Victoria has the potential to negatively impact on GDEs. However, site specific information about the location, critical processes and threats to GDEs are limited and were only available for selected high-value sites in pockets of Victoria (e.g., regions of Melbourne Water, Goulburn Broken Catchment Management Authority (CMA) and East and West Gippsland CMAs). The majority of GDEs in the state have had no assessment of impact from groundwater extraction. While the location of many GDEs have been identified in previous studies and datasets (e.g. Victorian Government Wetland Current 2013; Bureau of Meteorology GDE Atlas, 2015), there was no existing information about risk from groundwater extraction to inform the delivery of policy objectives. To address this the Environmental Water (EW) team at Department of Environment, Land, Water and Planning (DELWP) began the Victorian GDE Framework. Key to the framework was to prepare a statewide baseline impact assessment for a shortlist of high-value GDEs. The outcome was a risk-based impact assessment with a score assigned to each high-value GDE to inform a prioritisation process for funding and management.

Risk based tools are increasingly being used to support environmental decision making. Communication and feedback are key parts of any environmental risk assessment. However, results and findings are often presented in a manner with limited transparency behind the ideas and without the opportunity to interrogate results. Recent developments in HTML (i.e. browser-based) reporting provide opportunities to overcome limitations with traditional document formats (Word docs, PFD files, GIS shapefiles). Knowledge and research translation are becoming a key metric in project design and delivery, with clear scientific communication central to sharing science.

In this paper, we present the dashboards developed for this project, insights from undertaking the process and lessons learnt. Few projects have adopted HTML as the main format in project delivery. The applications in environmental science are significant. The key difference is they are stand-alone documents, can be shared like traditional formats, and only require a web browser to operate.

Policy Setting

Since the Millennium Drought, there has been an increase in impact assessments for GDEs in Victoria.

In 2015, the Victorian Ministerial Guidelines for Groundwater Licensing and the Protection of High-Value Groundwater Dependent Ecosystems were published; enabling applications for new groundwater entitlements or trade in groundwater to be assessed against the guidelines. The guidelines establish a clear framework for considering groundwater dependent ecosystems when making groundwater licensing decisions and clarify how high-value groundwater dependent ecosystems are to be protected (State of Victoria, 2018).

The Victorian Waterway Management strategy identified that management of groundwater had historically focused on the sustainability of the resource, rather than an ecosystem's reliance on groundwater (State of Victoria, 2013). The sustainability and efficacy of GDE management is reliant on improved knowledge of the distribution, condition and environmental values of GDEs, including the relationship between groundwater and surface water.

The dashboard incorporates the risk framework approach and presents large quantities of data in an easy-to-use way. The project aligns with Policies 8.16 & 8.17 of the Victorian Waterway Management Strategy (State of Victoria, 2013); and Policy 4.3 of the Western Region Sustainable Water Strategy. These policies adopt a risk-based approach when considering groundwater-dependent ecosystems, and systems of high groundwater and surface water interaction.

This project also addresses Action 8.8 of the Victorian Waterway Management Strategy - 'Identify and prioritise types of high-value groundwater-dependent ecosystems to inform regional waterway planning processes and water allocation decisions'. Information from this program will assist in development of proposed changes to groundwater trading rules, and in reviewing Regional Waterway Strategies.

Methodology Overview

Policy 8.16 of the Victorian Waterway Management Strategy is a groundwater allocation risk-based framework for impact assessments to groundwater-dependent ecosystems. To meet this requirement, the Australian Standard for Risk Assessment was adopted, using the AS/NZS ISO 31000:2009, Risk management -

Principles and guidelines. This framework provides a structured and transparent approach toward calculating risk (Figure 1). The likelihood of groundwater extraction impacting GDEs was defined by the GDEs susceptibility and the management practices and policies in place for groundwater pumping. The consequence of groundwater extraction impacting GDEs was defined by the GDEs value and the GDEs sensitivity to declining groundwater levels. Details of the methodology are provided in CDM Smith (2018).

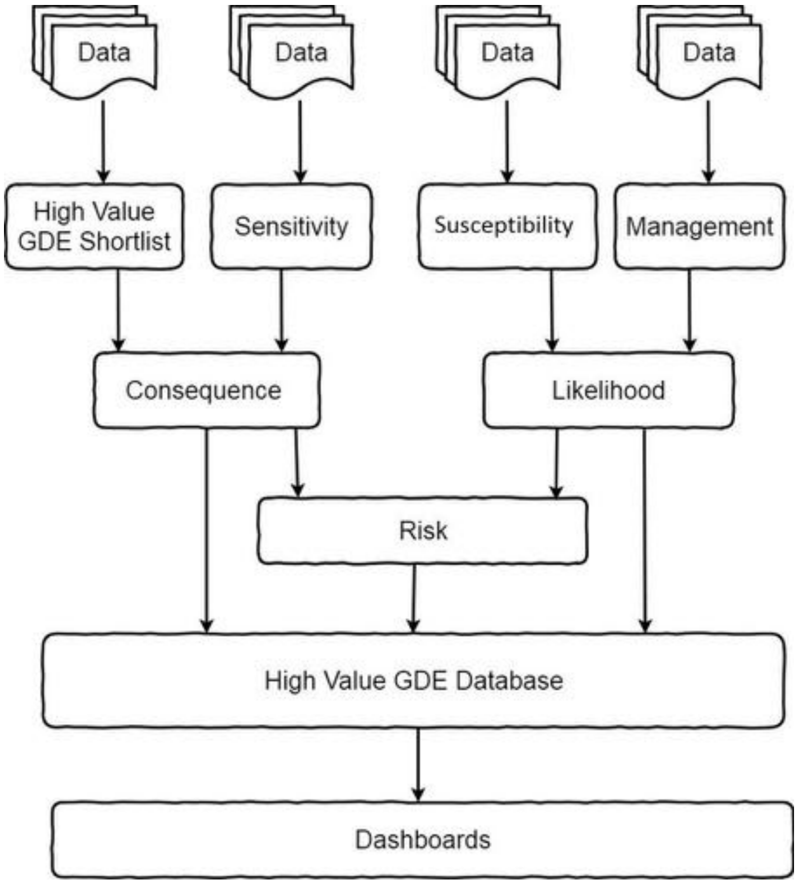

Figure 1: Work flow

Calculating a Risk Based Score

Risk is commonly communicated using a rank and score system. Previous GDE assessments used a rank-only approach to assign risk (i.e. High (H), Medium (M) and Low (L)). The limitation with this approach is that results are clustered into three groups. In this project, we use a Weighted Scoring Method (WSM) for converting ranks into a normalized score (between 0 and 1), and were assigned weights (1 or 1.5) to reflect attribute importance. High value GDEs were shortlisted through a document review and consultation process with CMAs. The high-value list was cross checked with the BOM GDE Atlas for reliability of being a GDE (High and medium potential only). Consequence and likelihood were calculated from a range of shortlisted spatial attribute layers. Due to the variety of attribute layers, three GDE classes were analysed: wetlands, rivers and terrestrial ecosystems. To account for the variability of input data layers, scores were calculated based on the relative number of data layers available at each GDE. Risk was calculated as the product of the likelihood and consequence normalized scores. A normalised scale from 0 (low impact) to 1 (high impact) was implemented to assist with informing and prioritising action (see Figure 2).

Research Translation using HTML Dashboards

Dashboard Layout and Design

Three dashboards were developed to accommodate the different types of GDEs in this study: wetland, rivers and terrestrial (Figure 2; Figure 3). As the dashboards can be shared separately to the method report, the design approach adopted was to include an interactive map, with all the results, and additional tabs which summarised the project and methodology. This approach is like having an interactive executive summary for the project, self-contained with the results and a high-level summary of the project methodology. Information is organised using tabs, with the interactive map as the first tab.

Features of the dashboards include:

- A score filter from 0 to 1, adjustable in 0.1 increments
- Reactive plots (histograms and box plots) for data displayed on screen
- Background map that can be changed. Here options for a street map and terrain map were used
- Option to show values that were not of high-value and/or data that is missing
- Filtering results based on a wetland or river's name, number and location

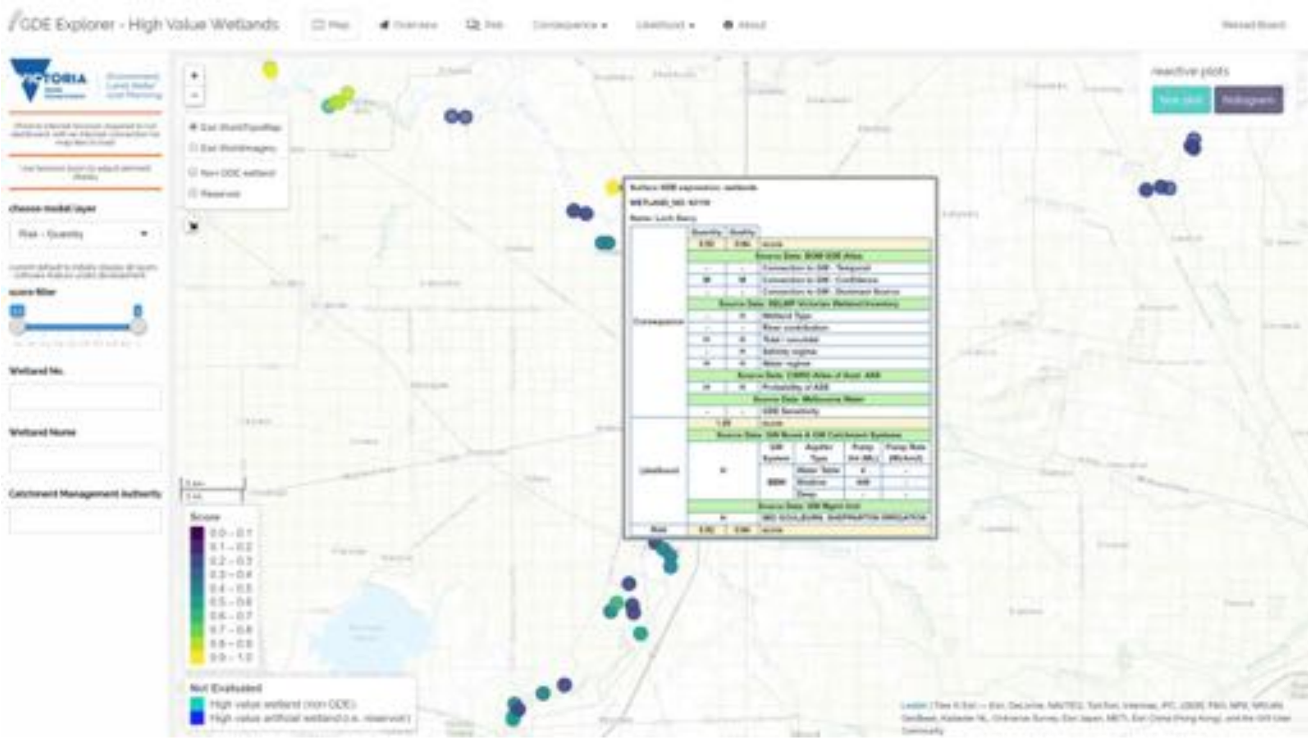

Figure 2: Screenshot of the Wetland GDE Dashboard, displaying the popup table for a wetland near Shepparton, Victoria. The popup table displays available rankings for attribute layers which intersected that particular wetland. Where a dashed line appears, no data was available or considered in the impact assessment. In addition, note the dashboard filters on the left-hand side of the screen.

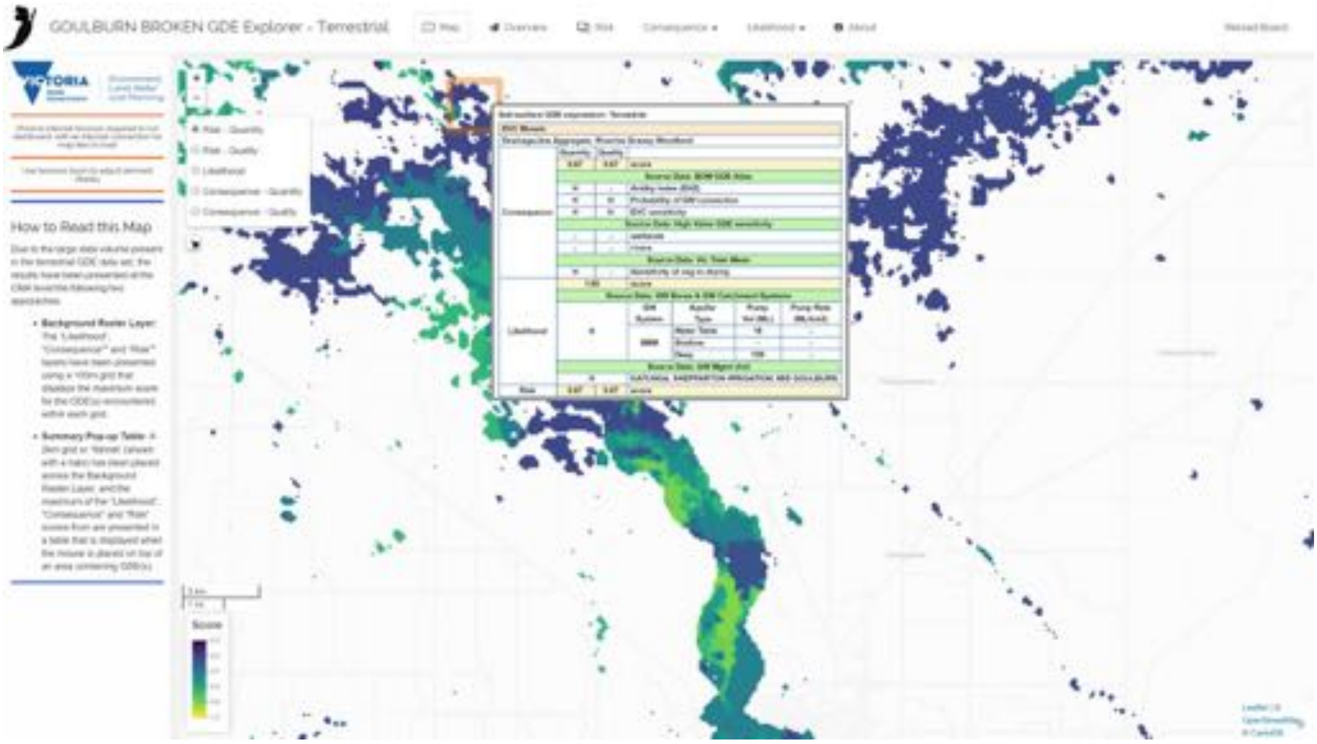

Figure 3: Screenshot of the Terrestrial GDE Dashboard for the Goulburn Broken CMA, displaying the popup table for a 2km fishnet (sample) grid near Shepparton, Victoria. The popup table displays the maximum rankings for attribute layers within that grid cell. This approach was used due to high number of polygons in the underlying EVC layer. Where a dashed line appears, no data was available or considered in the impact assessment.

So where is the data stored?

HTML is a text-based document. When it is opened by a web browser, commands in the text instruct the browser how to construct the page. As the HTML dashboards are standalone documents, the data is simply stored as additional text in the document. The more data presented the larger the file. We found files up to 15Mb worked as a rule of thumb. For our purposes, we were able to put all the results for wetlands and rivers into a single dashboard each. However, with the terrestrial vegetation, due to the large number of ecological vegetation classes (EVCs) which were used to build the BOM GDE sub-surface layer, this was not an option. To overcome this, we used a fishnet sampling method, where a 2km grid cell was placed over the landscape and the maximum value in each grid cell was reported in the dashboard. To further reduce file size, individual dashboards were presented for each CMA. Because the dashboards themselves are just a template, minimal additional coding is required to split the dashboards into an appropriate document size.

Under the Hood

The design of the dashboard as a template has several advantages. First, as information in the data sets is updated the template itself need only be regenerated using automated scripting to display the updated information. Second, as new metrics for analysing risk (or other variables) are added to the framework, these are added to the existing display and updated. Tabs and pages can be removed as needed.

The project was scripted and automated using the R language (R Core Team, 2018). R was adopted for several reasons. Firstly, all the project analysis could be fully automated. Second, R offers the ability to generate method and coding reports which greatly improve the reproducibility of R code. Third, several key packages have been integrated into the R space to generate HTML dashboards and reporting (e.g. leaflet (Cheng et al, 2018), crosstalk (Cheng, 2017), sf (Pebesma, 2018), rmarkdown (Allaire, 2018), knitr (Xie, 2018). Finally, R is open source. Combined, this allows the user to undertake data analysis and data presentation within the same coding environment.

Next Steps

The dashboards were developed using the principles of reproducible research, i.e. data processing and handling was scripted and is accompanied by scripting reports. The map was initially going to be displayed as a state-wide ArcGIS layer, but this project shifted focus and adopted a “reproducible research” approach. Reproducible research is the idea that data analyses are published with the data and software code, so that others may verify the findings and build upon them. This approach has the benefit of making the results easy to interrogate, and it creates a uniform platform to interrogate the results.

It is also possible to build other information and parameters into this dashboard over time, such as climate change scenarios. DELWP may use this to support the Ministerial Guidelines for Protection of Groundwater Dependent Ecosystems, by providing a quick indicative assessment of where areas might be susceptible to groundwater pumping. It may also be used to inform investment as part of the Victorian Water Program Investment Framework. It is being used as a criterion for investment in on-ground GDE-related projects.

This style of reporting is still undergoing testing for user experience. CDM Smith are currently developing a set of working examples using HTML for interactive reporting to be made available at the start of a project to allow stakeholders to gain a better appreciation of the final project.

As this type of project represents a new approach for all involved, there has been a considerable learning process regarding the efficient use of time and resources. It is important to have a clear, mutual understanding of the problem and the process required to turn an idea into a product. This project has helped to shape and develop a different way of reporting. DELWP will continue to work with stakeholders to refine its GDE program.

Conclusions

Communication and feedback are key parts of any risk assessment. However, results from environmental risk assessments are often delivered and presented in a manner which reduces transparency and interrogation of results. As part of the communication strategy for the recent Victorian Framework for High-Value GDEs, we adopted a novel approach to results communication using interactive HTML dashboards tailored to the framework methodology. Further, dashboards were designed as standalone documents to be shared like traditional document formats (docx, pdf, shp).

Acknowledgments

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