An evaluation of PortsE2

A water quality Decision Support System utilising the E2 (Source Catchments) framework

Sharyn RossRakesh
Simon Pierotti

Melbourne Water Technical Report Series
Report No 2011/1 - July 2011

State Government Victoria

Melbourne Water

Melbourne Water is owned by the Victorian Government. We manage Melbourne's water supply catchments, remove and treat most of Melbourne's sewage, and manage rivers and creeks and major drainage systems throughout the Port Phillip and Westernport region.

This document should be cited as:

RossRakesh, S.L. and Simon Pierotti, (2011) Technical Report No. 2011/1: An evaluation of PortsE2 A water quality Decision Support System utilising the E2 (Source Catchments) framework. Melbourne Water Corporation, Melbourne.

Report commissioned and published by Melbourne Water Corporation. For further copies, contact Melbourne Water:

Tel: +61 3 9235 7100

Fax: +61 3 9235 7200

Email: techreports@melbourneWater.com.au

Website: http://www.melbourneWater.com.au

Post: PO Box 4342, Melbourne VIC 3001 Australia

ISBN
0-7311-***-*

ISSN

DOI

Document Versions and Amendments

Document Versions

Revision	Date Issued	Issued To	Issued By
Draft 1	11 August 2011	Research and Technology, Catchment Strategies, Systems and Biodiversity, Earth Systems, eWater CRC	Melbourne Water, Catchments
Final	17 August 2011	Research and Technology, Catchment Strategies, Systems and Biodiversity, Earth Systems, eWater CRC	Melbourne Water, Catchments

Document Amendments

Amendments	Date Issued	Issued To	Issued By
Draft 1			
Draft 2			
Final			

Executive Summary

This paper has been prepared by Melbourne Water (an AUS Lake Tai Cluster Member) for the Lake Tai Water Pollution Treatment Project (hereafter 'the Project') supported under AusAID's Australia China Environment Development Partnership (ACEDP). The purpose of this paper is to provide Chinese Government partners, including the National Development and Reform Commission, Lake Tai Basin Authority, Municipalities agencies from Suzhou and Huzhou and other stakeholders involved in the management of the health and quality of Lake Tai, with practical insights into the success and challenges with the development and application of lumped models such as PortsE2 and its successor, being constructed using the Source Catchments framework.

In July 2011 the Project commenced an extension activity titled "Policy Application of Catchment Modelling and Non Point Source Pollution Management". This extension consists of the development of a "Source Catchments" demonstration model for a sub-catchment in Suzhou (Jiangsu P). The aim is to demonstrate the application of lumped models for understanding nutrient sources and processes at the catchment scale and how these models can be used to: a) identify key N and P pollution sources and priority rehabilitation areas; b) set of catchment water quality targets and land-use zoning/targets; c) design of effective water quality monitoring systems to support policy; and d) inform priority government investment needs, and information and research priorities.

This paper is intended as an important contribution to this extension activity by communicating the strengths and limitations of such models so that policy makers and practitioners alike, have a better and realistic understanding of how they can be used to inform policy, investments and management decisions for the control of non-point source (and point source) nutrient pollution at the catchment scale.

Melbourne Water has gained significant knowledge over the last 10 years from developing and using broad-scale pollutant generation models such as Source Catchments. While Melbourne Water has been involved in many modelling projects, this paper will focus on the lessons learnt from a Decision Support System (DSS) developed for Better Bays and Waterways (BBW), a Water Quality Improvement Plan (WQIP) for the Melbourne region. This model, PortsE2 – is a predecessor of the Source Catchments model. To assist the Lake Tai project - "Policy Application of Catchment Modelling and Non Point Source Pollution Management", Melbourne Water has evaluated the success and challenges of using such models in planning for water quality improvement across a large region.

The Better Bays and Waterways Plan was able to incorporate several key findings from the model. In particular the model was successful at demonstrating the importance of diffuse pollutant loads and which land-uses contributed the most loads. The model was able to quantify the significant threat posed by increasing urban development as well as simulate various regulatory scenarios to help offset this impact. Finally but importantly, implementation targets were incorporated into the final plan based on scenario modelling from PortsE2.

Models like PortsE2 are critical for developing water quality plans however like all models they need to be developed thoughtfully. This paper should help the Lake Tai Water Pollution Treatment Project in developing a sound and useful Source Catchments model. Below is a summary of some of the key aspects of model development and application that Melbourne Water believes to be critical for a successful model:

- Ensure all stakeholders who have an interest / stake in the model inputs or outputs are consulted and involved in the model development and analysis.
- Ensure clear documentation of decisions during model development and analysis phase to ensure transfer of knowledge.
- Be clear on the objectives of the model - a single model cannot provide all managers and decision makers with the tools necessary to make informed decisions.
- Ensure adequate time is allowed for assessing results and refining (or if needed, rebuilding) the model, before management decisions are made.
- Ensure catchment delineation and land-use types, including their spatial representation, reflect objectives of the model and will deliver the desired outputs.
- Allow for future needs of the model and the ability to incorporate new data and scenarios.
- Pay particular attention to calibration of the model – and ensure good communication between the modeller/s and those using the outputs of the model.
- Understand the types of results required at the beginning of the process and set up a methodology / process for extracting results in the desired format.
- If developing targets for pollutant load reduction is an objective of the model then be very clear on the form of these targets and the methodology before the model is developed.
- Land-use change scenarios can be a very powerful use of the model but ensure the methodology is established before the model is developed.
- Modelling management interventions such as Best Management Practices (BMPs) - e.g. Water Sensitive Urban Design (WSUD) or rural land Best

Management Practices - can be very useful however careful consideration of the modelling approach and uncertainties is required.

- Incorporate costs, and cost effectiveness to modelled management actions, along with other factors that will influence decisions.

Title: **Locality Map**

Figure: ??-??

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

LEGEND

Study Area

BMT WBM

www.wbmpl.com.au

Filepath : I:\M7520_I_GML MH\DRG\WQU_001_080825 Locality.wor

Table of contents

1 Background

This section provides an overview of water quality issues in waterways and receiving embayments in the Melbourne region. It includes background to a recent Water Quality Improvement Plan undertaken in partnership by the Victorian Environment Protection Authority and Melbourne Water, along with the rationale for utilising the E2 modelling framework. An overview of the objectives of the model is provided along with some key outcomes and uses of the model.

1.1 Background

Over the past few decades, waters of the Port Phillip and Western Port region have greatly benefited from protective legislation such as the Environment Protection Act 1970, along with ensuing statutory policies and a suite of Environmental Management Plans, as well as significant investment in on-ground works. However the catchments' waterways and bays are still threatened by diffuse pollution, urban expansion, and climate change, each of which presents significant management challenges.

In 2004, Melbourne Water and EPA Victoria were provided with funding from the Australian government to develop a Water Quality Improvement Plan for waterways and bays of the Port Phillip and Western Port region. What followed was development of Better Bays and Waterways, a five–year plan that contains 93 actions within a series of management programs (MW and EPA, 2009).

Water quality in the waterways, Port Phillip Bay and Western Port is threatened by several key pollutants (Table 1).

Table 1 Pollutants investigated in the Better Bays and Waterways Plan

Bay or waterway	Key pollutant	Other pollutants
Waterways	Phosphorus	Nitrogen, suspended solids, toxicants, pathogens
Port Phillip Bay	Nitrogen	Phosphorus, suspended solids, toxicants
Western Port	Total Suspended Solids)	Nitrogen, phosphorus
Waterways and beaches (recreational use)	E. coli (waterways), Enterococci (marine and beaches)	Litter

Catchment modelling is an important tool when planning for water quality investment. While there are several modelling frameworks to choose from, the E2 modelling framework within the eWater modelling toolkit included the appropriate functionality and industry acceptance that was needed.

The E2 modelling framework has been superseded by Source Catchments.

This discussion paper provides a reflection on the experiences gained by Melbourne Water staff in developing and applying the E2 modelling framework. There have been many lessons learnt through the process that will hopefully assist others in embarking on a similar project. Finally, recommendations for future model developments and use are also discussed.

1.1.1 Objectives of the model

The catchment modelling framework was primarily used at Melbourne Water in development of the PortsE2 model. PortsE2 was developed as a decision support system (DSS) for the development of the Better Bays and Waterways Plan (BB&W) – Water Quality Improvement Plan (WQIP) for Port Phillip and Western Port catchments and bays. The intent of the DSS as described in the WQIP contract was to:

- Provide data and information on current water quality and pollutant loads
- Determine water quality hot spots
- Identify pollutant sources and priority areas for management

- Enable ‘scenario-testing’ of different land management practices and management interventions
- Assess priority water quality management programs (which would be most effective and where)
- Assist in target-setting
- Provide the degree of confidence to which the modelling outputs are reliable
- Will identify where data is missing or patchy, and where we need to gather more data or research to improve the reliability of the model outputs.

Secondary objectives of the model were to:

- Provide a tool for tracking implementation of the WQIP and attainment of WQ objectives, regional targets
- Provide a tool to guide the water quality monitoring program (current data collection programs will be reviewed and re-focussed to meet the needs of the model)
- Be a model that can be used by all natural resource management agencies in the Port Phillip and Westernport region.

The Port Phillip and Westernport region covers 12,800 square kilometres with 8,000 kilometres of rivers and creeks and over 4 million people living within its boundaries. Model development went through two incarnations. The first-generation product by Argent (2006) generated loads (TSS, TN, TP, Salt, Pathogens, Toxicants) to satisfy BB&W requirements. The model included 12 land-use categories and over 189 sub-catchments in the region (Figure 1). The second version of the model was recalibrated utilising data from Melbourne Water’s load monitoring program, to give greater certainty in the loads estimates entering the bays (BMT WBM, 2009).

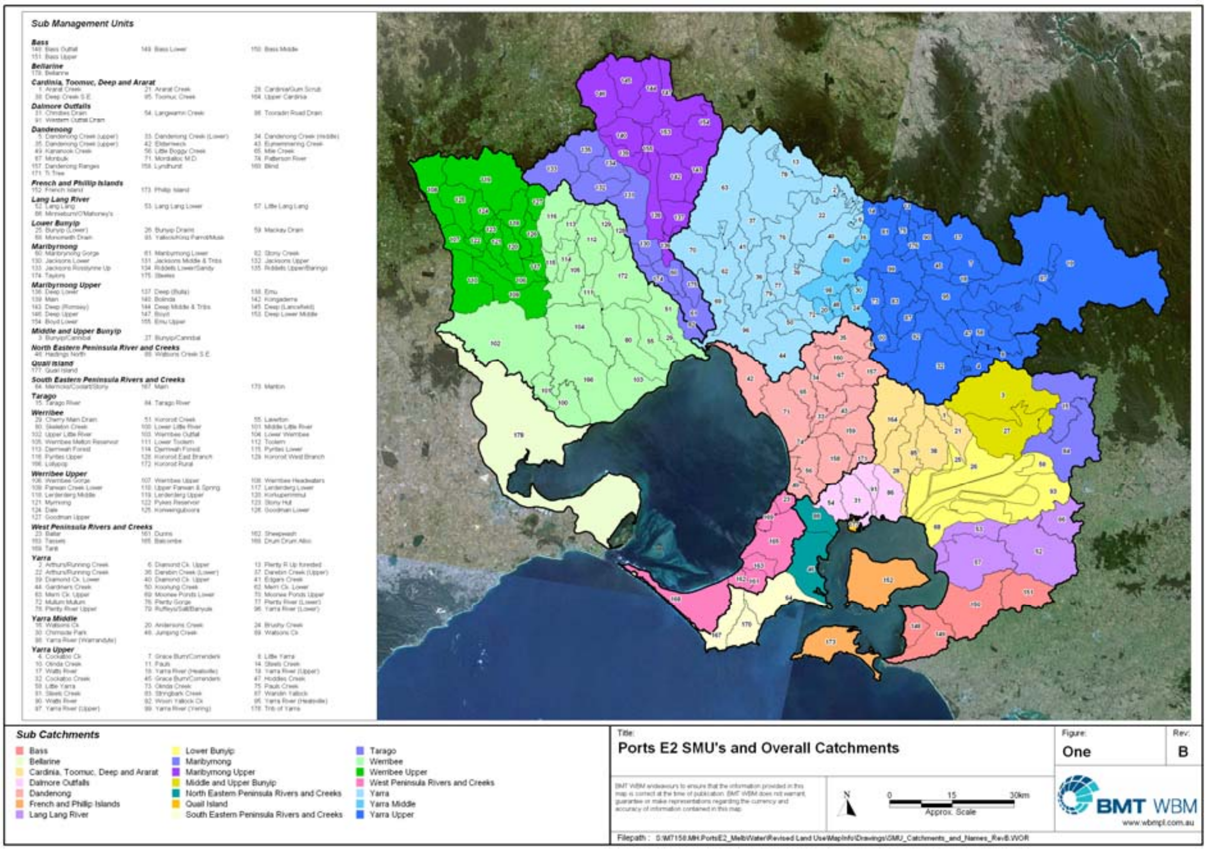


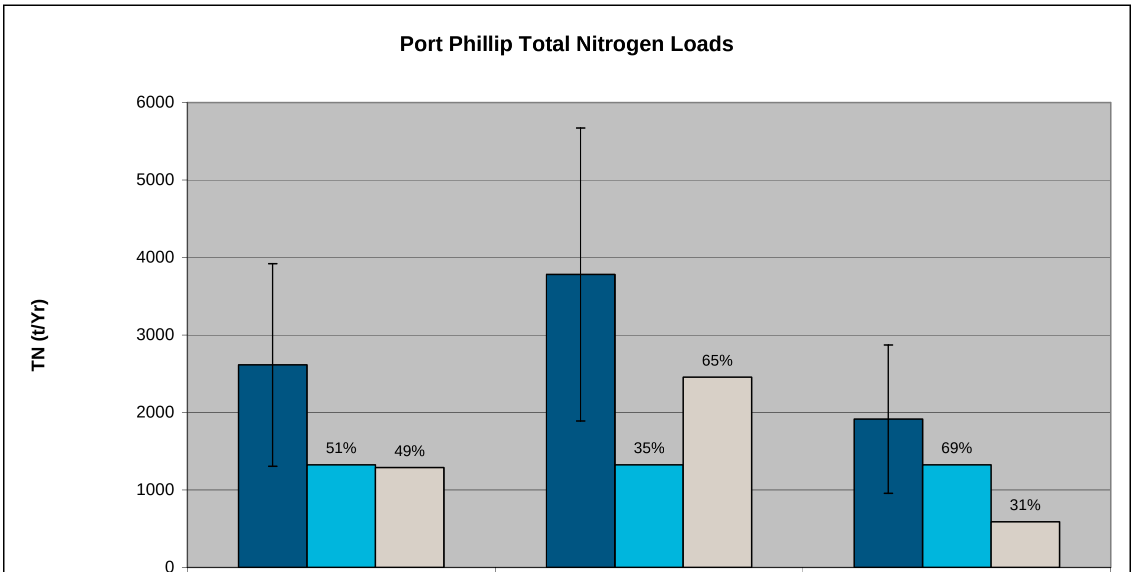
Figure 1 Catchment breakdown used in the PortsE2 model.

1.1.2 Outcomes from PortsE2

The model provided critical load-based data for the Better Bays and Waterways Plan that also lead to priority actions and investment within the plan. Some of the most useful outputs from the model included:

- Quantifying the relative contribution of point source versus diffuse loads.
- Quantifying the source of diffuse loads e.g. contributions from various rural and urban land-use classes.
- Scenarios modelling assisted in setting five-year implementation load-based targets used in the Better Bays and Waterway Plan.
- Modelling and estimating the increase in pollutant loads from projected urban development.
- Estimating and comparing mitigation measures (best management practices) for a range of land uses and land management activities.

The model compared diffuse against point-source loads for both Port Phillip Bay (Figure 2) and Western Port (Figure 3). Results indicate that diffuse and point-source loads are fairly evenly split in the Port Phillip Bay catchment, while diffuse loads dominate in the Western Port catchment. The analysis also showed that diffuse loads dominate in wetter years.



	Ave. Year	Wet Year	Dry Year
Total	2613.2	3781.1	1913.4
Point Sources	1324.0	1324.3	1323.5
Diffuse	1289.2	2456.8	589.9

Figure 2 A comparison between diffuse and point-source Total Nitrogen loads entering Port Phillip Bay for three climate scenarios.

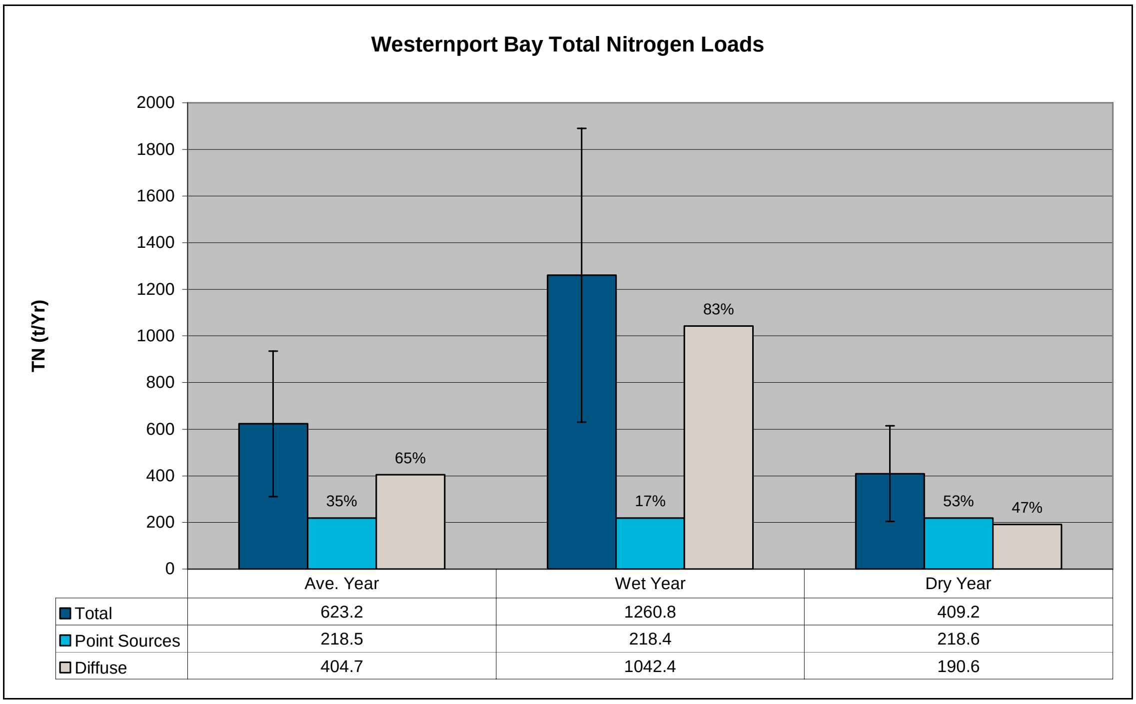


Figure 3 A comparison between diffuse and point-source Total Nitrogen loads entering Western Port for three climate scenarios.

The model was able to quantify which land uses contribute most pollutants to receiving waters (Figure 4). While urban land uses (residential, commercial and industrial) make up a relatively small proportion of total catchment area (19% of the Port Phillip region and 2% of the Western Port region), they contribute a disproportionately large amount of total contaminant load generated across the regions. This was most pronounced in the Port Phillip catchment, where stormwater runoff from urban land uses was the greatest source of pollutant load (49-60% of modelled loads).

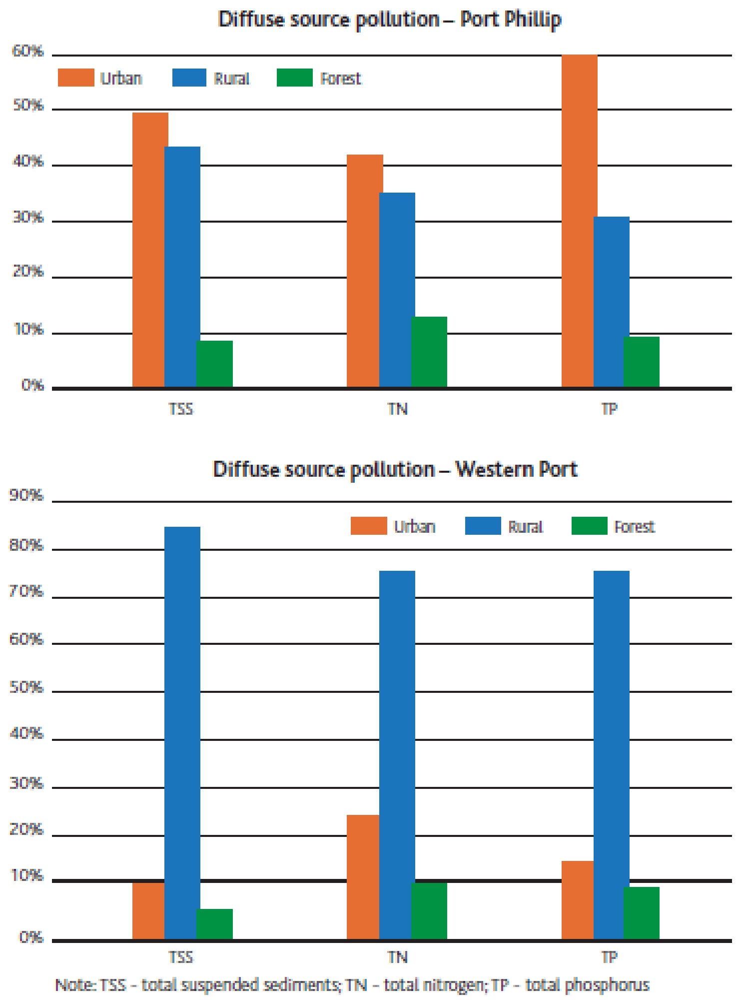


Figure 4 A broad land-use breakdown of diffuse loads for TSS, TN and TP across the Port Phillip and Westernport catchments.

Predicted increases in pollution entering the two bays due to future urban development were made using the PortsE2 model. Estimates were based on average year climate data, and drew upon Melbourne 2030 future land zoning data. Results showed significantly greater increases in loads from the Port Phillip catchment compared to Westernport catchment. For example, nitrogen loads to Port Phillip Bay are predicted to increase 23% by 2030 (**Figure 5**). Results also highlight the importance of incorporating Water Sensitive Urban Design (WSUD) into new developments to prevent or at least minimise load increases.

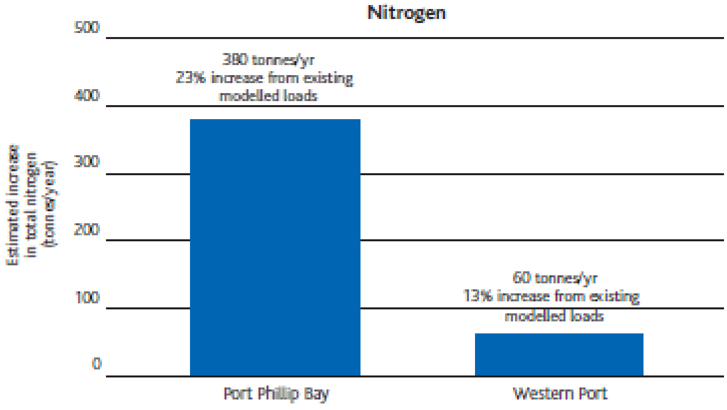


Figure 5 Estimated increase in total nitrogen loads from expected green-field and in-fill development by 2030 from 1996 – based on Melbourne 2030 (after Melbourne Water, 2009)

2 Model Set-up

This section provides some of the key areas of model development that worked well for the Ports E2 project along with some areas that could have been improved.

2.1 Model Set-up

It is important to spend a significant amount of time on setting up the model. While not available at the time, eWater's Best Practice Modelling document (Black *et. al.,* 2011) is now a good reference on how to adequately set-up and make the most out of such models.

Overall, the PortsE2 model has a good base for such a large catchment, guided by a multi-agency, multidisciplinary working group. Significant effort went into defining sub-catchments, reporting location, land-use classes and in the data inputs required for the model to run; e.g. rainfall – all of which provided substance for that good base.

Since building PortsE2 for a specific purpose Melbourne Water has realised the need to ensure such models are set-up to be used in the medium to long-term future. Such effort upfront can alleviate problems in the future when trying to re-calibrate the model and update it when better quality data is available. As future needs change it is also important to be able to alter the model to answer different questions with minimal fuss.

Keeping each process well documented in the model set-up is very important so data can be updated and easily understood.

2.1.1 Model objectives

Clear objectives are needed before a catchment model can be built. These objectives will drive the way the model should be built and calibrated and for what it can be used. It is also important to remember that a single model cannot provide all managers and decision makers with the tools necessary to make informed decisions. A model calibrated to answer a certain question is not always useful to answer another question. It is important to be clear about what you want the model to be able to analyse and the outputs it will produce before it is built. To help derive these objectives and help model development, a multi-agency working group was set up during the PortsE2 process. Importantly, this working group involved both modelling experts and policy development people. This ensured there was a good understanding of implications of different decisions that may be taken along the process. This process worked well for initial set-up of the model and there was a good degree of model ownership by the group. A couple of negatives however were that the group did not have enough technical representation (modelling expertise was contracted to competent suppliers) and the group did not continue to meet consistently throughout life of the project.

Some of the objectives that were most successfully met included:

- the objective “Enable ‘scenario-testing’ of different land management practices and management interventions” was particularly success in assessing future urban development impacts,
- the “Assist in target-setting” objective was met as region-wide implementation targets included in the plan were based on load estimates around off-setting urban development over a five-year period, and
- the objective “Will identify where data is missing or patchy, and where we need to gather more data or research to improve the reliability of the model outputs” has lead to several projects to refine and improve data behind the model.

2.1.2 Model inputs

Reliable and accurate model inputs in catchment modelling are crucial. With regards to the PortsE2 model, the DSS was constructed using historical data on flow and water quality, including the effects of storages, extractions and point sources. This data was of reasonable accuracy, with significant errors identified through quality checking processes carried out by the relevant expert agency. Any errors in these data sets that were not identified during the data collation process will affect model accuracy. Time should be spent on verifying quality of rainfall and PET (potential evapotranspiration) input data. It should also be noted that if rainfall and PET data need to be created for the model, they are able to be revisited and reproduced easily.

Sub-catchment delineation is a very important step in building a catchment model, especially as it requires an entire model re-build if changes are needed. In order to calibrate the model, catchment outlets should generally coincide with gauges and storages. It is also a good idea to delineate catchments to gauges not currently used in the calibration, as they may become useful at a later date.

Selection of functional units (i.e. land-use types) is also important; especially if land-use based results are needed. A knowledge gap noticed in PortsE2 was that the majority of functional units selected did not have enough data to support individual constituent generation values (i.e. water quality concentrations). Therefore it is important to select land uses that you will be able to parameterise properly in the model. At the beginning it is also important to be clear about specific land uses that are needed for reporting purposes and to consider ways in which they can be lumped into broader classes. Land uses may be updated after the model is built however this may affect calibration of the model.

Generally, the catchments and land uses in the model were well suited to objectives of the model. Further improvements, particularly relating to land use, are provided in section 3.1.1.

2.1.3 Calibration

Calibration of a catchment model is a complex process. To have any certainty in results of the model it must be calibrated to an adequate level. Also depending on needs of the model, it may be calibrated in different ways. Various temporal scales may be used to look at annual, monthly, daily results or sub-daily results, as well as looking at event based results. It is easy for experts to fail to communicate the full ramification of certain approaches, therefore discussions about the tool should be exercised alongside the calibration exercise.

During the PortsE2 model build, it was noted the time spent on the initial calibration was insufficient. The Commonwealth Government (funders) were keen to see the model as accurate as possible and hence wanted it to match actual (monitored) loads as closely as possible. A second phase was undertaken to recalibrate the model to more closely match actual (monitored) loads. The problem however was the model was only calibrated at outlets to the bays, and not to upstream catchments. This highlighted a lack of understanding of the purpose and implications of calibrating the model in this way. Further calibration of gauges higher up the network is now needed to make simulations more useful for both bay and catchment results. There was little internal checking or ability to inform this part of the process – subsequent peer review of the model identified calibration as an issue. The use of PEST (BMT WBM, 2009) to calibrate the model has meant we also cannot vary certain parameters (e.g. impervious fraction) to model land-use change because it does not reflect a real physical parameter anymore. This shows the importance of choosing a calibration process that is applicable to the objectives of the project.

Key steps to consider in making improvements to the PortsE2 model in order to reduce uncertainty include:

- Verify/improve flow calibration and validation on a regional specific basis, with appropriate allowance for flow routing through the local stream network
- Calibrate to more gauges and more gauges higher up in the catchment
- Include as appropriate, initial estimates/rates of in-stream sediment, nutrient and other pollutant decay and transformation processes
- Verify/improve pollutant export/water quality calibration and validation to locally available loads monitoring data
- Given the above, ensure the model can still produce results on a land-use basis.

2.1.4 Extraction of data from the model

It is critical to develop a user-friendly front-end to enable model results to be extracted when needed during run-times - or have an in-house modeller on hand to produce results when needed. This was not present with the PortsE2 model. Results were often needed in different formats and it was difficult to predict from the beginning what outputs were needed. Lengthy tables and multiple maps and graphs were produced – many of which were not actually used to any great extent. Other than the consultants who developed the model, Melbourne Water staff could not easily access results directly from the model – making it very difficult to extract results in a form that was different to the generated reports.

2.1.5 Summary and key lessons

Generally the PortsE2 model was set-up well for the desired objectives. It was a large complex model that came with high expectations. Some of the issues resulting from the model arose because the E2 modelling framework was in its infancy. Many of these issues have now been resolved in the new and improved Source Catchment modelling framework. Other issues related to process among agency representatives, and their differing expectations. Some key points to keep in mind when developing similar tools include:

- Ensure all stakeholders who have an interest or stake in the model inputs or outputs are consulted or involved in the model development.

- Ensure clear documentation of decisions made during model development and actions taken to ensure transfer of knowledge.
- Ensure adequate time is allowed for assessing results and refining the model before thinking about management implications.

3 Model application

This section discusses how the PortsE2 model was applied, how well it met the objectives and what improvements can be made. It focuses on specific types of results and scenarios that were utilised most heavily during the project and needed for the Better Bays and Waterways Plan.

3.1 Model application

The model has been used in a variety of ways. While not reported in this paper, an important application of the model has been to use it as a plug-in to an embayment hydrodynamic model. This model required daily pollutant load data from PortsE2 in order to show patterns of nutrient and sediment movement around Port Phillip Bay.

The PortsE2 model has ability to be used in a variety of ways. Outputs considered most useful were the region-wide results; where loads originated; which catchments were high generators, and what best management practices had greatest benefit in reducing loads. Targets are a complex field ranging in definition from Resource Condition Targets (RCTs) that are measurable within the receiving water, to implementation targets, which can be less scientifically based. A discussion on some of the successes and challenges from application of the model are outlined below.

3.1.1 Land-use based loads

Land-use based load results can be very useful in catchment modelling – e.g. how much do urban catchments contribute versus rural catchments. These types of results were identified as an objective at beginning of the project and were ultimately incorporated into the final Better Bays and Waterways Plan. One of the striking statistics is that while the urban area makes up a relatively small proportion of total Port Phillip catchment area (19%) it contributes between 49-60% of the diffuse contaminant loads (i.e. TSS, TN and TP). This is a result of the large increases in stormwater runoff coming from impervious surfaces, such as roads and roofs.

The accuracy of these results however has been questioned. Uncertainties are related to the broad-scale and mixed land-use calibration. As discussed in the section above, it is important to understand the likely uncertainty of results and attempt to set up the model to best accommodate reporting needs to achieve these results.

Calibrating to more gauges, improvement of water quality parameters for each land-use type, and a total model re-build may help us estimate land-use based results much better. Given these results were utilised heavily, it is important that to begin with, land-use types are well defined.

Land use was mapped using several of sources of data, including State government land-use planning zone data, a State roads database and a State government rural catchment land-use spatial dataset. The initial model showed unusually high loads from roads. Subsequent investigation revealed that the land-use breakdown for roads was inaccurate. Significant effort was put into re-analysing the land-use dataset and refining the classes. Roads were subsequently lumped into other urban land-uses i.e. residential (including roads), industrial (including roads), as at the time, roads data was not accurate enough to be separated, or were the parameter sets applicable.

A recent Melbourne Water project has developed a method using high-resolution aerial photos with infra-red (IR) band to automate mapping of impervious areas (e.g. roofs and roads) (Kunapo 2010). This dataset now covers the region and has potential to be utilised within future model revisions.

3.1.2 Reporting catchment based loads

The model was set up to report loads over a 10-year period, enough for initial objectives of the model. Typical wet, dry and average years were also selected from an analysis of rainfall data. This provided a simple way to report representative results for a range of climate conditions. That said, average-year results were found to be the most useful.

Time-series loads were not utilised heavily. This was partly because of large uncertainties in the results. There were also some concerns that results would be compared to previously modelled loads undertaken as part of an earlier significant Port Phillip Bay study. It established a statutory nitrogen load reduction target (see section 3.1.4 for further information around this target).

3.1.3 Hot spots

'Hot spots' are generally thought of as areas that generate high pollutant loads per unit area. They are often considered priorities for management. However, results from the PortsE2 model showed catchment factors, such as rainfall distribution across the region, generated the most obvious hot spots. The urban area also stood out as a large hot spot. Figure 6 reveals this trend where high loads per unit area occur for much of the urban and much of the agricultural catchments to the east of Melbourne – that have relatively higher rainfall than the western region.

As the Better Bays and Waterways Plan was reasonably high level, further analysis of these hot spot areas was not undertaken. High-level actions resulting from these observations were around targeting urban area for implementation of various Water Sensitive Urban Design type actions - from capacity building local government to on-going construction of regional stormwater quality wetlands.

Rural land management across the region was also given priority in the final plan because it is considered cost-effective in reducing loads in these catchments through better farm practices. A Rural Land Program has been developed however it is still in its infancy. As it is a pilot, two catchments were selected for on-ground actions. In addition to other criteria, selection of pilot catchments was based on modelled high generators of loads. Hence these catchments were in the east where rainfall tends to lead to higher loads.

Further analysis of per unit area loads could have been undertaken however it was not possible given the high level of the plan and its timeframe. Local Sewage Treatment Plants are often highlighted as hot spots, along with intensive agricultural practices. These may have been specifically identified had further analysis been undertaken. Given this is such a valuable part of the application of the model it is an area that certainly could have been given additional attention.

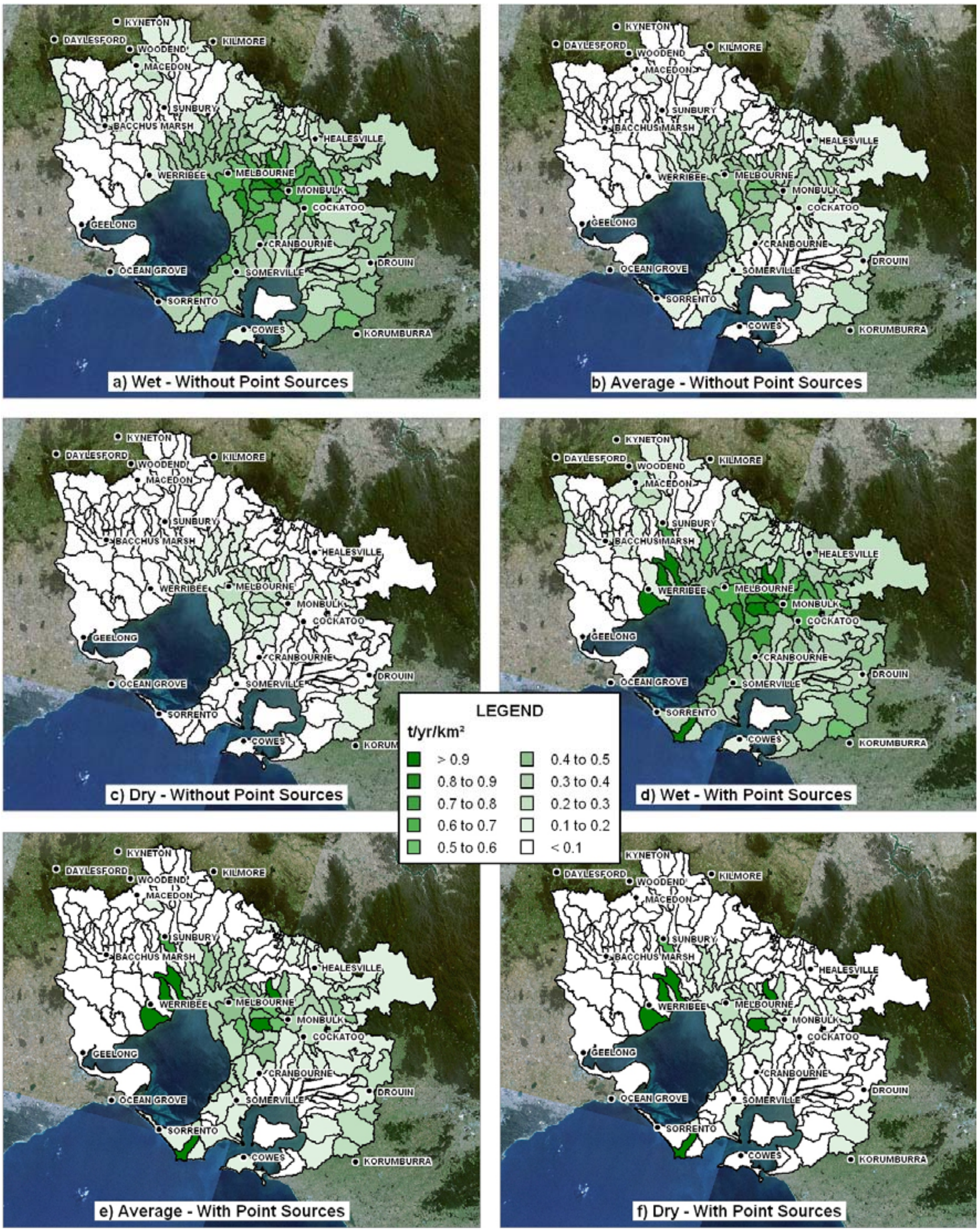


Figure 6 Total Nitrogen Load Generation Rate Comparison for Wet, Dry and Average Years

3.1.4 Targets

Based on a large study of Port Phillip Bay in the 1990s (Port Phillip Bay Environmental Study 1996 - Final Report: CSIRO), the Victorian government introduced a nitrogen reduction target. This target was based on an assessment of the ability of the bay to process nitrogen and hence what was considered to be a sustainable input. A 1,000-tonne reduction from a 1996 baseline, by 2006, was set and included in the Port Phillip Bay Environmental Management Plan. There was an expectation that the PortsE2 model would be able to assess where and if the target had been met. It was also expected that PortsE2 would help set new targets and be used to track management actions and target attainment. It became apparent through the process that the model would not be able to deliver on these objectives.

Target setting is a complex area requiring more information than just modelled loads. It is important to establish early in the process whether a tool is able to assist in setting targets and understand the processes involved. Model outputs and their uncertainties must be properly understood. Policy makers and decision makers need to clearly understand model uncertainties and the range of these uncertainties in order to set targets appropriately. In this case there may have been different expectation between different levels of government and a lack of scientific understanding of water quality processes.

It was eventually recognised that it was not appropriate to utilise results from PortsE2 in assessing compliance with the statutory 1,000-tonne nitrogen reduction target. This assessment is more appropriately undertaken utilising Melbourne Water’s actual loads monitoring program along with an appropriate and agreed statistical analysis. Despite several years of monitoring at a number of waterways as they enter the bay, a 10-year drought in Melbourne resulted in too few storm events to enable a comparison of current loads against the 1996 baseline, and whether the target had been met.

Despite uncertainty around whether a 1,000-tonne reduction has been achieved or not, PortsE2 has been very useful in exploring future land-use and management scenarios (see case study below).

CASE STUDY

Simple illustrations make for powerful messages

Melbourne Water's business case for future investment in water quality improvement programs such as capacity building programs with local government and advocacy for regulation on urban development drew upon the simple graph below. The graph was clearly able to show that without any intervention urban development will continue to increase loads. Hence In order to meet the 500 tonne catchment target a range of management options are needed.

It is important to keep this sort of information simple so that Chief Executive Officers, Managing Directors and politicians can easily understand the message. Costs and cost effectiveness are also invaluable to determining the right mix of programs. And supporting graphs showing the different levels of uptake of different management options would also be useful.

(See sections below on how these various scenarios were modelled).

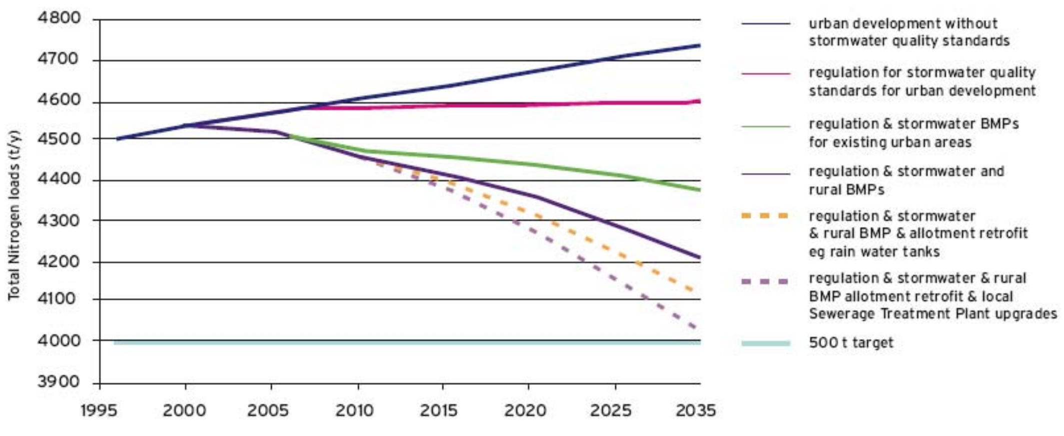


Figure 2: Strategies to achieve the 500 t/y target for Port Phillip Bay from the 1996 baseline. Predicted increases in loads due to urban development have been estimated using the Ports E2 model. Reductions due to regulation include the impact of the existing stormwater standards in statutory planning controls and future 5 star requirements included in building regulations. Reductions from stormwater Best Management Practices (BMPs) include a mix of Melbourne Water wetlands and local government works with uptake in local government WSUD increasing over time. Reductions from rural land management BMPs also increased over time with increasing uptake rates. The scenarios are cumulative.

3.1.5 Point sources

Point sources (i.e. loads from Sewage Treatment Plants) were considered a low threat to the bays; largely because they are already regulated and controlled. Many treatment plants discharging to waterways were decommissioned in the 1970s as the two larger treatment plants (discharging to Port Phillip Bay or Bass Strait) came on-line. The largest treatment plant (Western Treatment Plant) has been upgraded and has reduced loads to below its required level (and has accounted for future growth). However, further analysis could have been undertaken on a catchment specific basis to assess the remaining smaller, local treatment plants. While a majority of point sources in the model were from Sewage Treatment Plants, it is possible to improve point-source inputs by considering certain drains as potential point sources. Currently, highly polluted drains would not be highlighted - as functional units within catchments are based on the broad-scale water quality parameterisation within the model.

3.1.6 Land-use change scenarios

The PortsE2 model has been very effective at revealing significance of load increases resulting from urban development. However it became apparent that setting up the model to run such scenarios is critical. Initially only green-field development (conversion of farming land to urban land) was captured - leaving out potentially significant loads from consolidation and renewal of existing urban areas (in-fill development). A separate assessment of in-fill development was undertaken using MUSIC, a different eWater CRC modelling tool, as PortsE2 was unable to incorporate the required inputs.

Better data and a greater understanding on modelling approaches are leading to better predictions of future development impacts. It is now possible to model development patterns along with changes over time; e.g. 2030 and 2060. The data comes from State government spatial planning datasets. An Urban Growth Boundary (UGB) defines the area within which urban development may occur. Various spatial datasets also outline zoning of particular parcels of land; e.g. whether land can be developed as industrial, commercial or residential. It is critical to consult with planning and other State government departments (e.g. DPI and DPC) to inform land-use change scenarios.

The PortsE2 model essentially converts functional units (land-use classes) from rural to urban, and applies the relevant parameter set. Changes in impervious fraction is typically what drives change in runoff from rural to urban, along with a different suite of water quality parameters. It is important to ensure this parameter reflects the actual physical impervious fraction (and not just treated as a calibration variable) so that scenarios such as those described above can be adequately modelled. This has been a key lesson learned throughout the PortsE2 project.

3.1.7 Treatment measure scenarios

Management scenarios that were undertaken in PortsE2 were for:

- Regional wetland construction
- Distributed water sensitive urban design (WSUD) e.g. streetscape scale
- Allotment (household) scale rainwater tanks and raingardens
- Rural Best Management Practices (BMPs).

A number of factors lead to a fairly simplistic approach to management scenarios within the model. These included:

- PortsE2 runs at a daily time-step – many water quality treatment measures such as wetlands, rainwater tanks, and filter strips, require sub-daily time steps.
- The lumped style model makes it difficult to assess physico-chemical processes and hence many rural BMPs, such as fertiliser application or track management, cannot be discretely modelled.
- Scenarios were applied to all relevant catchments and land uses and not selected catchments, hence results were mainly a comparison of benefits of each treatment system on a region-wide basis.

Several different but fairly simplistic approaches were ultimately used for each of the scenarios, all of which require refinement in the future (see WBM, 2007 for detailed assumptions for each scenario).

It was felt that the most appropriate way to model the variety of rural BMPs; e.g. fencing waterways, and fertiliser management, was to apply a percentage reduction filter in the model. These percentage reductions were based on research findings on how well these various measures reduced pollutant loads. The final reduction also had to incorporate an assumed uptake rate; i.e. how many land owners would be willing to implement actions.

While the Source Catchments modelling framework has the ability to 'plug in' MUSIC modelling algorithms, there are several limitations to its use at present. Urban WSUD scenarios were firstly modelled in MUSIC and resulting output water quality concentrations were used in the PortsE2 scenario. There are many assumptions in building up the scenario and careful consideration is needed at this stage. The results provide an indicative idea on how effective such management interventions can be, but uncertainties are very large.

Analyses of results were fairly limited and hence were not heavily utilised or relied upon in the final plan. Regional figures were typically used to show potential of various actions and to compare against each other. An analysis of cost effectiveness is vital when comparing treatment options. An economic study was carried out as part of the WQIP (MW and EPA, 2009), yet the treatment modelling was fraught with numerous assumptions and resulting uncertainties. Overall, the trend shows that rural BMPs remain cheaper than urban WSUD.

An oversight in the modelling process was to omit Melbourne Water's Stream Frontage Management Program, which includes revegetation of riparian zones and stock exclusion from waterways. Quantifying the water quality benefit of this extensive program is a recommendation for the future.

While there are many challenges in modelling various management scenarios, the latter are useful and necessary for planning investment in water quality. This is an evolving field and assumptions and modelling ability are improving.

4 Melbourne Water and Future Modelling

This section provides an overview of the next steps for Melbourne Water in terms of Source Catchments modelling.

4.1 Future modelling

Since the completion of the Better Bays and Waterways Plan Melbourne Water has initiated several Source Catchments models and also made a business case to employ an in-house modeller. This position is being part funded by eWater CRC and two teams within Melbourne Water.

The Source Catchments modelling framework is being used to develop a Stormwater Quantification Tool to assist Melbourne Water in harvesting projects. The model utilises much of the underlying data from Ports E2 yet is customised for its specific needs.

Source catchments was also used in an eWater application project during it's development. The application project focussed on the re-calibration of the Yarra Catchment by utilising some of what was learnt from the Ports E2 model. It was used to model and assess various streamflow scenarios, with the Source Catchments outputs being used as inputs into a Dissolved Oxygen model.

It is proposed over the next 12 months to rebuild Ports E2 into the Source Catchments framework. It is envisaged that new simulations and scenarios will be needed for strategic planning purposes over the next couple of years. In addition the EPA is currently seeking updates to the model to link with their hydrodynamic model of Port Phillip Bay.

It is envisaged that the model upgrade will build on the lessons learned from the E2 model and incorporate the following:

- Recalibration of the model using best available data and ensure it's undertaken at the most appropriate scale
- A review of functional units, in particular include the ability to model different densities of urban land uses
- A review of water quality parameters

There is a need to revisit the future land-use and best management practice scenarios. This requires a review of the various methods and underlying data to improve upon the accuracy of the previous model.

5 References

Argent R. M. (2006). PortsE2: A Decision Support System for Water Quality Improvement in Port Phillip and Western Port. CEAH Report 01/06.

Black, D., Wallbrink, P., Jordan, P., Waters, D., Carroll, C., Blackmore, J. (2011) Guidelines for water management modelling: Towards best practice model application. © eWater Cooperative Research Centre 2011. ISBN: 978-1-921543-46-3

BMT WBM (2009). PortsE2 Model Calibration and Extension Project: Draft Report. BMT WBM. Brisbane.

Kunapor (2011). Directly Connected Impervious Data Compilation for Melbourne Water Selected Catchments.

MW and EPA (2009), Better Bays and Waterways: A Water Quality Improvement Plan for Port Phillip Bay and Western Port. ISBN Print 978-1-921603-41-9, ISBN Web 978-1-921603-42-6, Melbourne Water Corporation and Environment Protection Authority Victoria, August 2009, Melbourne, Australia.

WBM (2007). Port Philip Bay and Westernport 'PortsE2' Model Application and Assessment Project - Scenario Assessments, WBM, Brisbane