Background report for the Adelaide Coastal Water Quality Improvement Plan

Report 4 Modelling the catchments of Adelaide coastal waters

Modelling the Catchments of Adelaide Coastal Waters

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Title :	Modelling the Catchments of Adelaide Coastal Waters
Author :	Tony Weber
Synopsis :	

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0			A B McAlister		T R Weber

DISTRIBUTION

DESTINATION	REVISION			
	0	1	2	3
SA EPA	pdf			
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1 INTRODUCTION

The Coastal Waters off Adelaide have been the focus of science and research over the last several years through a dedicated program of projects under the banner of the Adelaide Coastal Waters Study. Through the various projects in this study program, efforts have focussed on quantifying the ecosystem health and causal factors of deterioration of that health. It has been identified that diffuse pollutant loads are a significant contributor to ecosystem health decline in the region, especially those pollutants which may cause light attenuation and therefore seagrass loss. This project has therefore focussed on developing a catchment model which allows the quantification of the diffuse pollutant loads being delivered to the coastal waters and predicting the impacts of land use change from both the pre-European condition through existing land use to that which may result from future urban development.

The use of predictive tools to estimate the effects of land use change and management has increased over the last several years with the development of catchment modelling tools through the former CRC for Catchment Hydrology and its successor, the eWater CRC. These tools, once they are developed and calibrated, allow for reliable assessments of the impacts of land use change, best management practices (e.g. Water Sensitive Urban Design, riparian buffers etc), climate variability and climate change on catchment response in terms of constituent loads and runoff.

Within the catchments draining to the Adelaide Coastal Waters, the E2 modelling framework has been applied to simulate a range of catchment land uses, including rural lands, urban residential areas, commercial, industrial and significant parklands and areas of native vegetation. The generation of constituents in these areas was then quantified and routed through a stream network model and 'delivered' to the ultimate receiving waters of the region. This catchment model is the third application of the E2 modelling framework in the region, and compliments previous projects in the Mt Lofty Ranges Storage Catchments and the catchments of the River Murray and Lower Lakes.

2 CATCHMENT CHARACTERISTICS

2.1 The Catchment

The Adelaide Coastal Waters Catchment is formed by a number of larger creek and river basins, plus a multitude of smaller coastal stream and stormwater drainage subcatchments. The major river and creek basins include the Gawler, Torrens, Port, Onkaparinga and Sturt Rivers, and a number of larger creeks (e.g. Brownhill, Cobbler, Smiths, Adams, Dry, Salt and Templar Creeks). A number of catchments have significant storages as part of the water supply catchments for Adelaide and interbasin transfers are a particular feature of the storage network. Little, if any water flows beyond the storages for the majority of the climate record, though occasional spills have been documented during extreme rainfall events. In modelling the Adelaide Coastal Waters catchments, it was considered that these storage catchments contributed little, if any, loads under most climatic conditions and dam operating protocols.

Modelling of the storage catchments in a separate project showed that the complexity of dam operating rules, interbasin transfers, and supplemental water from the Murray River offtakes prevented the use of a catchment model to accurately predict the magnitude of releases and spillages if any were to occur. Anecdotal evidence also suggested that no planned releases were made downstream of storages as any minor spills were usually diverted via interbasin transfers (Y. He pers comm.) and only one or two unplanned releases have occurred in the last 20 years. As such, the most downstream storage was treated as the catchment boundary for any of the storage catchments which had the potential to flow into the Adelaide Coastal Waters. This is consistent with previous assessments of the stormwater catchments as documented in Wilkinson et al, 2005 where only those areas downstream of the water supply systems were considered as stormwater contributing areas.

A locality map is shown in

Figure 2-1 outlining the catchment boundary used for this study.

2.2 Drainage Network

The drainage network of the subcatchments within the Adelaide Coastal Waters Study (AWCS) region has areas of considerable complexity as shown by a small section of

stormwater drainage network in

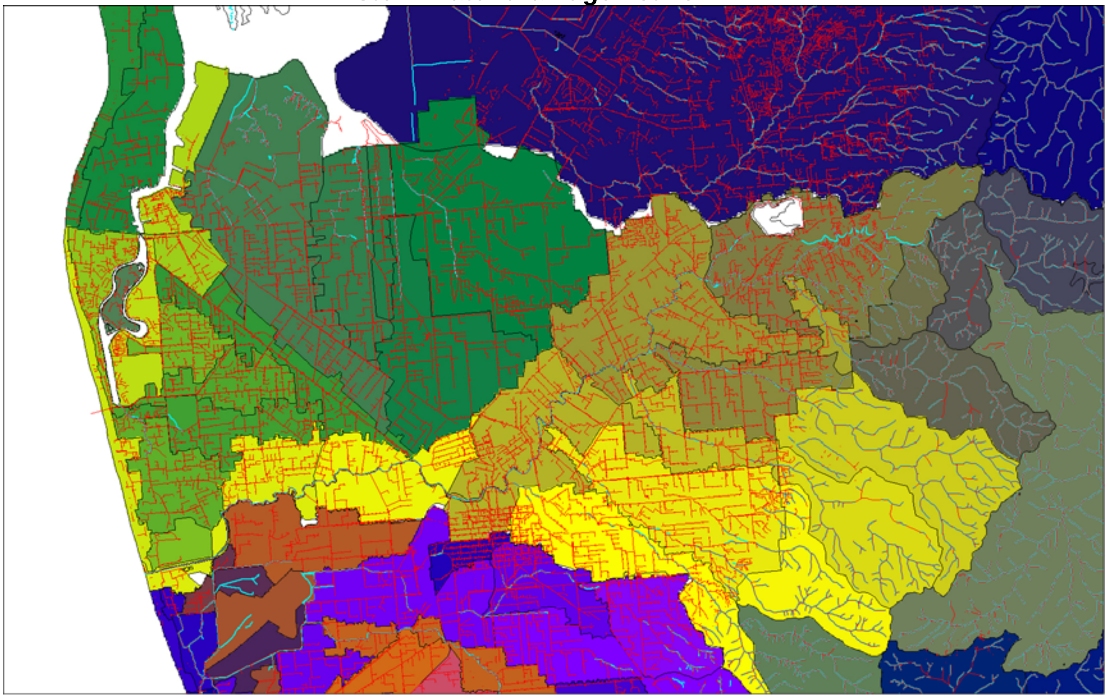


Figure 2-2. This complexity is a result of various stormwater reticulation schemes to alleviate flooding in the relatively flat areas of the region around the central business district and towards the north and it was obvious that numerous subcatchment cross-connections occur. Obviously, this is mostly typical of the urbanised parts of the catchment, especially in the Torrens and Port River subcatchments, and those discharging directly to the coastal waters. Catchments to the north east (e.g. Gawler River), and those south of the Sturt River had drainage networks which were focussed around existing waterways with smaller stormwater reticulation networks in some locations.

Considerable change from the pre-European drainage network has occurred in the region, with the Torrens and Patawalonga (Sturt River, Brownhill Ck and Keswick Ck) systems being the most heavily modified with dedicated drainage channels being constructed, some of which completely altered the discharge regime. In the Patawalonga system, construction of a large, concrete lined channel has directed flows which previously discharged into a large area of swamps and wetlands into an efficient drainage system which delivers stormwater flows and loads directly into the ocean. As such, diffuse pollutants which may have settled or been biologically assimilated by the wetland system are now transferred rapidly to the coastal waters. While the catchment model contained a scenario describing pre-European land use, the drainage network was not modified to replicate the pre-European condition as the full extent of drainage network change from that period was not known. It should therefore be considered that the catchment loads predicted from that scenario may over represent the loads actually discharged to coastal waters at that time.

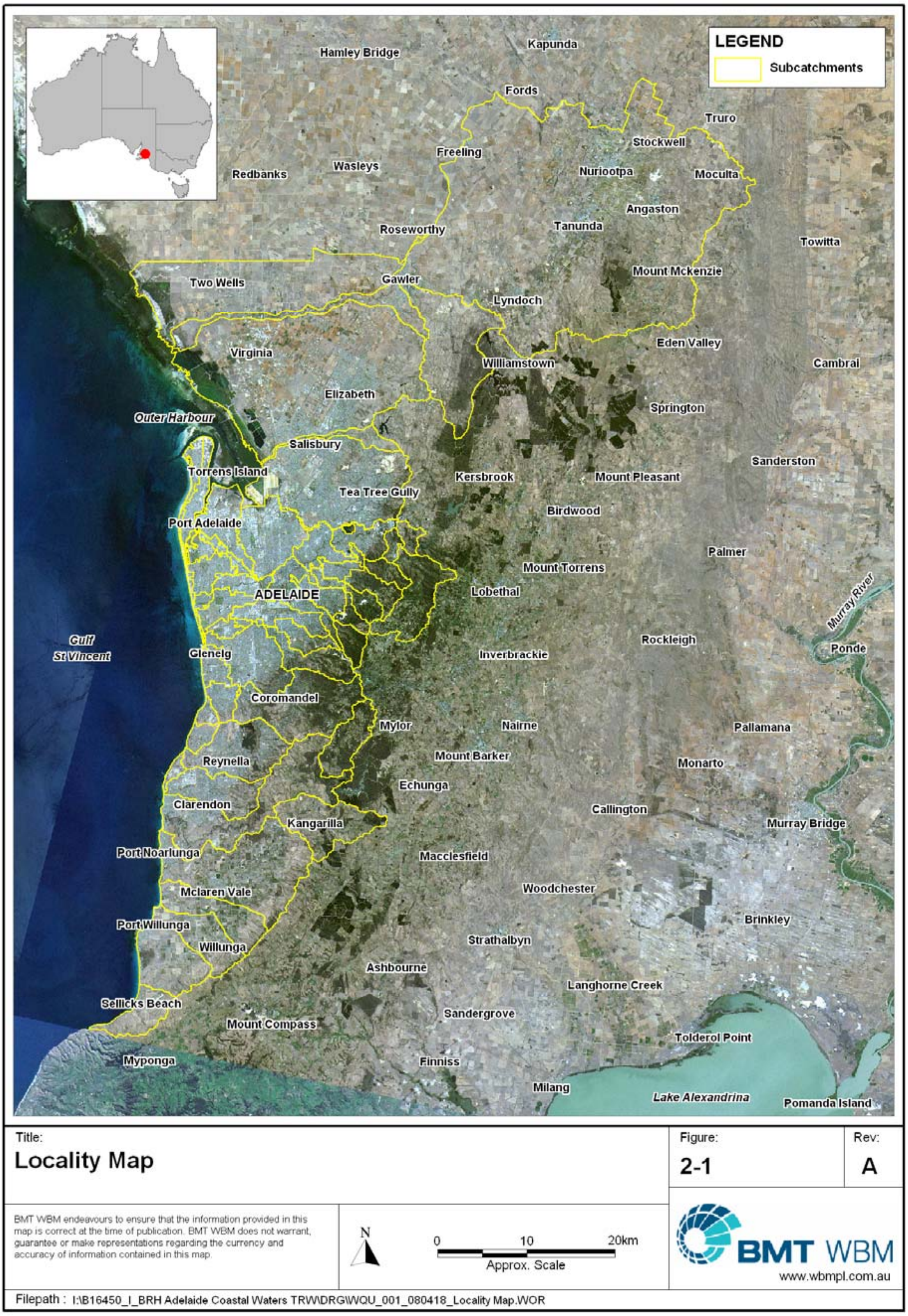


Figure 2-1 Locality Map

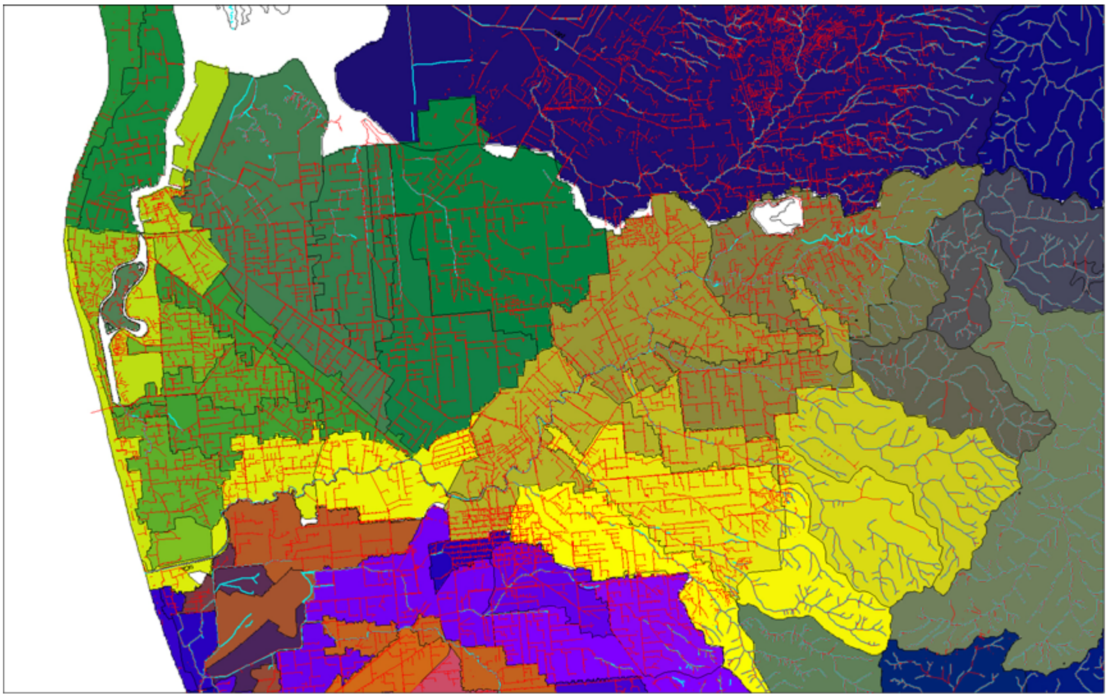


Figure 2-2 Example of Stormwater Drainage Network – Port River

2.3 Land Use

Land uses within the catchments of the Adelaide coastal waters are a mixture of urban, agricultural, rural living and open space categories, with these being further subdivided into numerous classes, as shown in Figure 2-3.

In terms of area, agricultural and urban land uses dominate the region (72% in total), with only 11% present as greenspace (forest, parkland etc). Large lot residential land (sometimes called rural living) occupies 17% of the catchment area. The areas of each land use class are represented in

In addition, a future land use map was created, based on GIS layers received from Planning SA outlining future greenfield and redevelopment areas within the region. Two additional land use classes representing Future Urban and Future Dense Urban areas were added to the existing land use map.

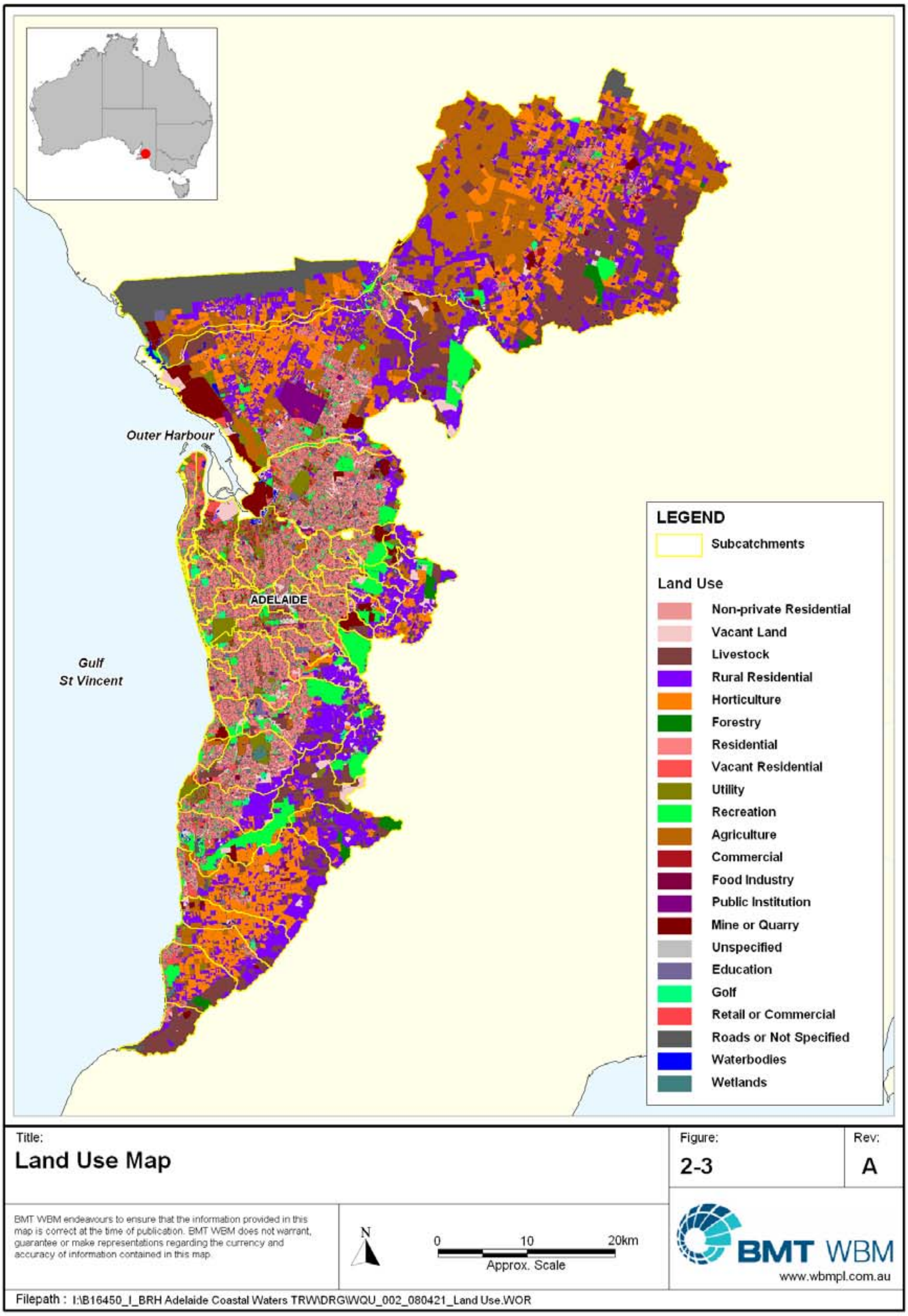


Figure 2-3 Adelaide Coastal Waters – Land Use

Table 2-1Land Use Classes

Class Name	Percent	Area (ha)
Non-private Residential	0.3%	79
Vacant Land	3.2%	848
Livestock	12.2%	3276
Rural Residential	16.4%	4392
Horticulture	13.2%	3524
Forestry	0.7%	187
Residential	11.3%	3036
Vacant Residential	1.8%	474
Utility Industry	2.8%	752
Recreation	5.6%	1508
Agriculture	13.5%	3627
Commercial	0.8%	221
Food Industry	0.4%	116
Public Institution	1.2%	316
Mine/Quarry	2.4%	656
Unspecified	0.0%	0
Education	0.9%	234
Golf	0.4%	112
Retail/Commercial	0.5%	136
Roads or not specified	11.6%	3097
Waterbodies	0.6%	155
Wetlands	0.2%	46

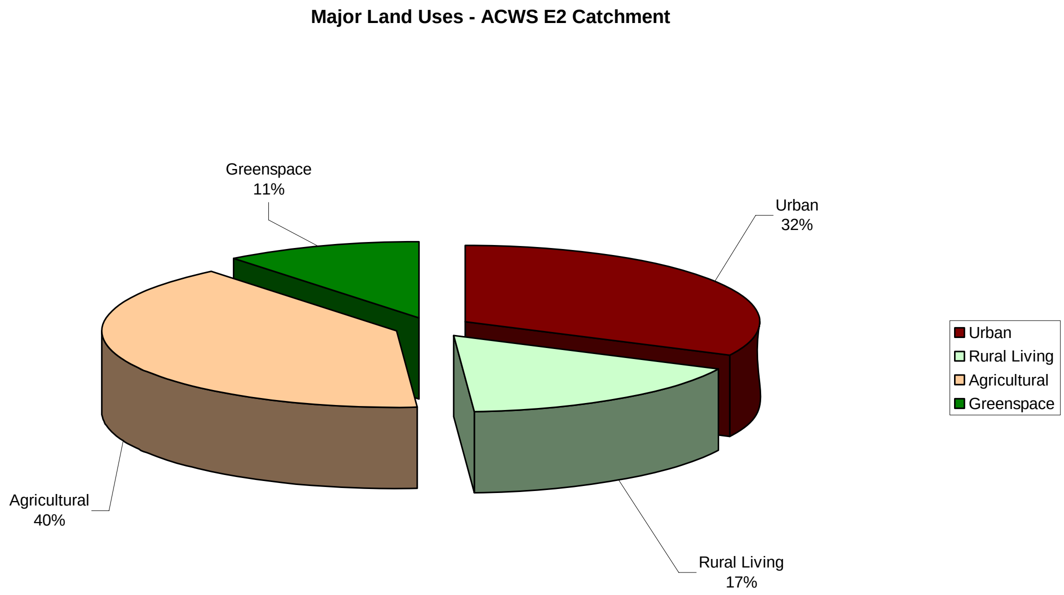


Figure 2-4 ACWS Catchments Land Use Breakdown

3 METHODOLOGY

3.1 Data Collection

Spatial information was collated from several sources and provided to BMT WBM by the SA EPA. The majority of this data was extracted from layers used by DLWBC and SA EPA. Climatic information for the catchment was obtained from the SILO national database and the PET Atlas of Australia and further information on the layers used is provided below.

3.2 Catchment Model Background

The use of catchment decision support tools has been facilitated greatly through the availability of modelling tools provided by the former CRC for Catchment Hydrology and the current eWater CRC through the Catchment Modelling Toolkit (see www.toolkit.net.au). The tools available on the toolkit website allow a catchment modeller to define catchments, calibrate hydrology and develop simulations of catchment responses. .

In order to provide the ability to simulate current catchment characteristics and responses, in addition to evaluating impacts of land use change and the implementation of best management practices, the E2 modelling framework was chosen as the most appropriate tool for application within the Adelaide Coastal Waters catchments given previous successful applications of the framework in the region. The E2 framework is not one model, but a framework in which groups of different models can be selected and linked such that the most suitable model to describe a particular aspect of the catchment can be used.

To construct a catchment model within E2 therefore requires the user to define which model components are required and how they should be linked together. The underlying data within the model is some spatial description of the catchment, whether simply a subcatchment map, or a digital elevation model. These are then joined together via a node-link network, which is then parameterised and calibrated to complete the catchment model. These steps are described below:

Step 1 – The catchment and streams are described spatially using either a digital elevation model or from topographical data.

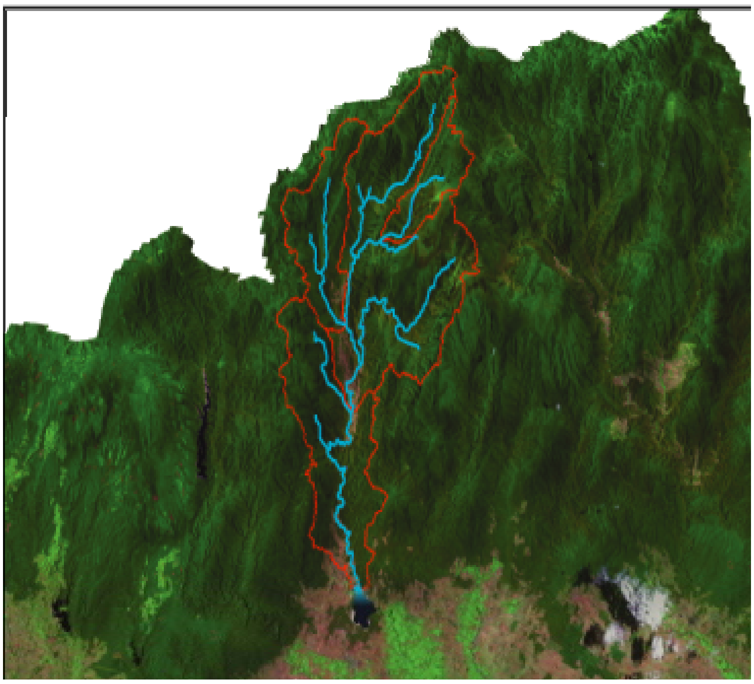


Figure 3-1 Step 1 A Spatial Description of the catchment is developed

Step 2 – A node-link network is built either automatically from the digital elevation model, or manually from the data obtained in Step 1.

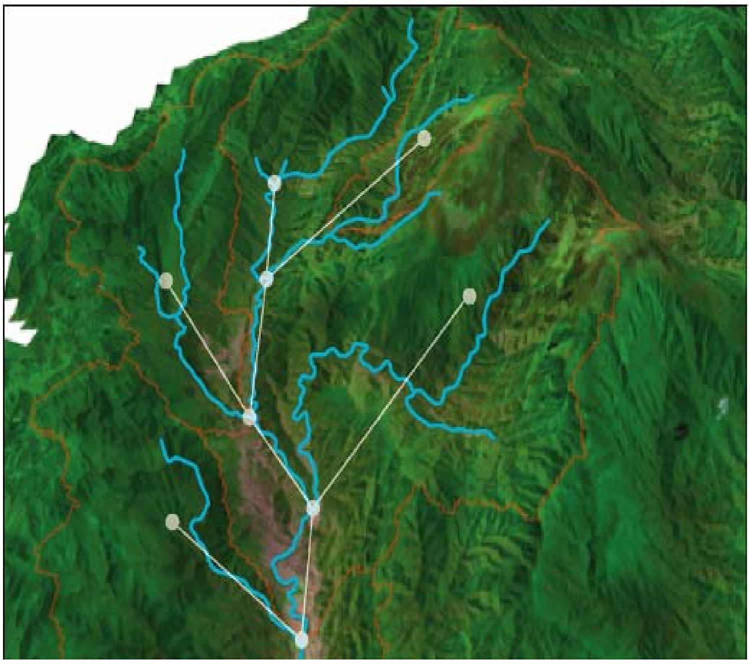


Figure 3-2 Step 2 – A node-link network is constructed

Step 3 – Information about each subcatchment is described and within this step, land use data is used to describe the "Functional Units" within each subcatchment which are considered to have comparable runoff and constituent generation characteristics. These are typically a common set for the entire catchment, though the extent differs within each subcatchment. When the functional units are defined, constituents are then selected that will be common across all subcatchments and functional units.

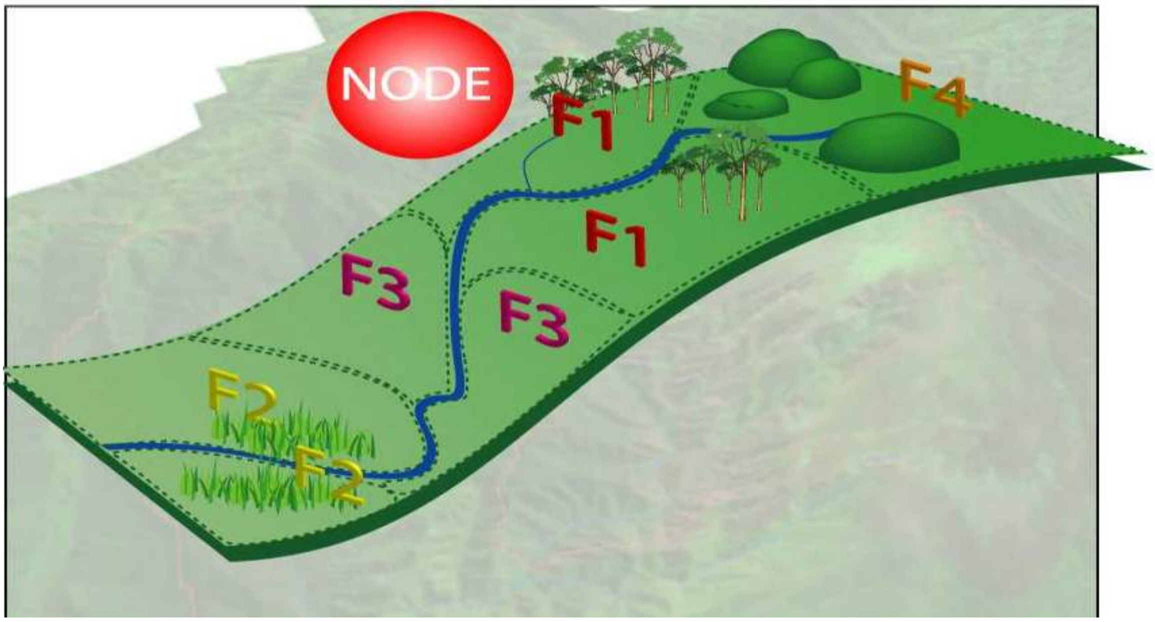


Figure 3-3 Step 3 Functional Units (land uses) are defined for each subcatchment/node

Step 4 – Particular models are selected which are best suited to the subcatchment/node and these then describe (through different parameters) how each functional unit responds to climatic inputs.

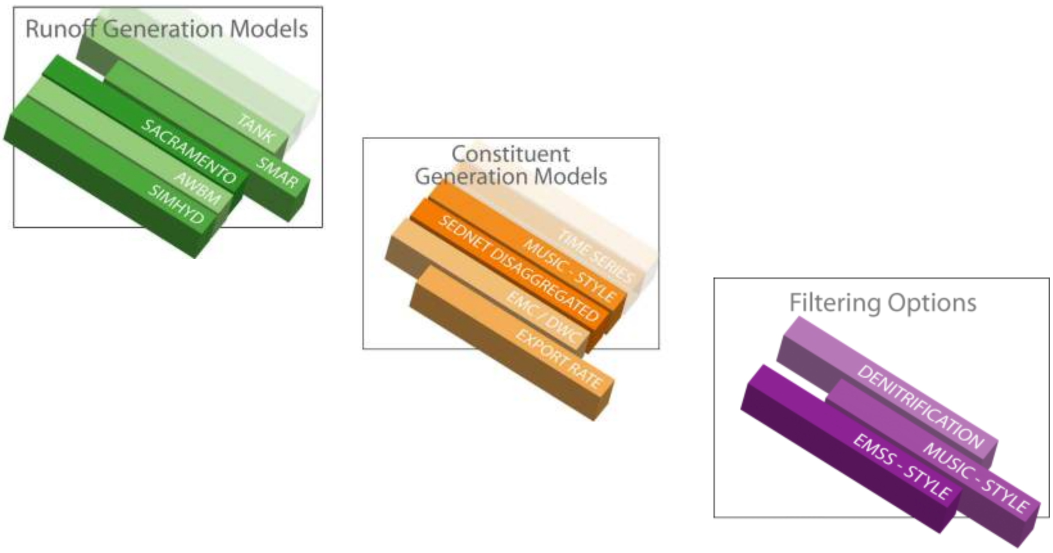


Figure 3-4 Step 4 Node models are selected

Step 5 – Each link in the stream network is defined using an appropriate model in a similar way to the subcatchments in Step 4.

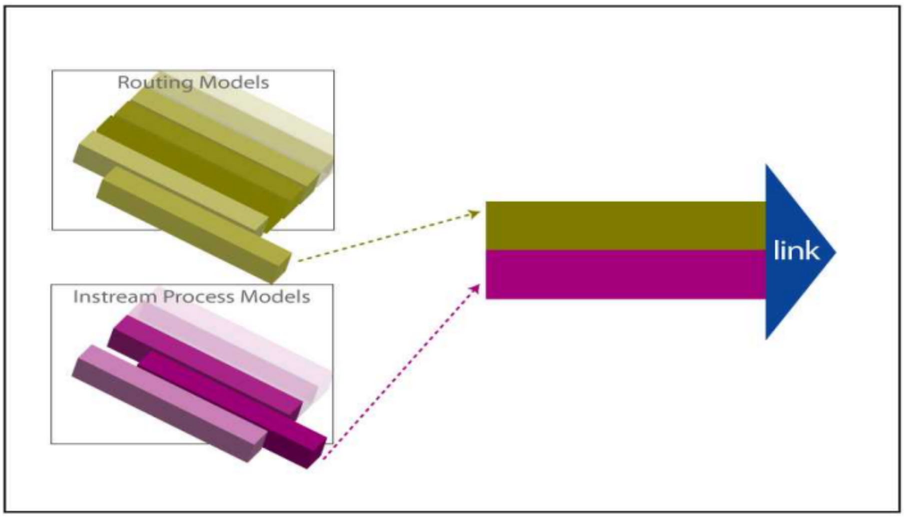


Figure 3-6 Step 5 – Selection of link models

These link models, combine with the models describing the subcatchments/nodes, so that groups of models are linked together to describe the catchment as shown below.

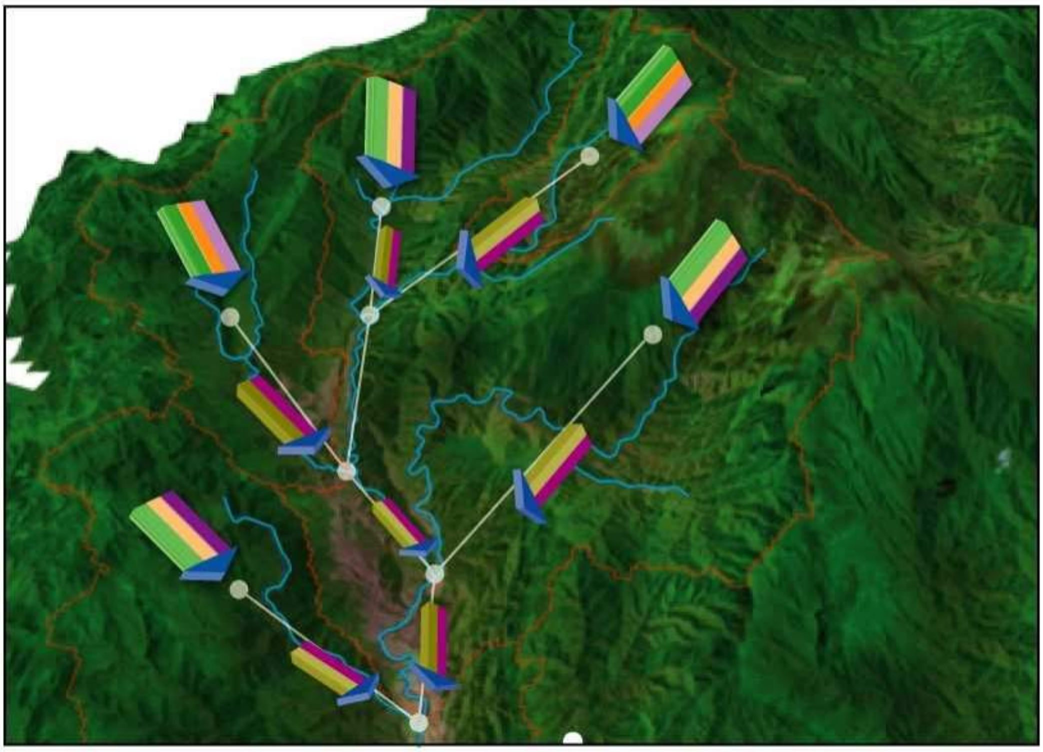


Figure 3-5 Combined node and link models describing the catchment

Step 6 – Climatic Data is selected. This can be either from individual stations, or interpolated gridded data (e.g. SILO, PET Atlas). The E2 framework then interrogates this data for each model run performed.

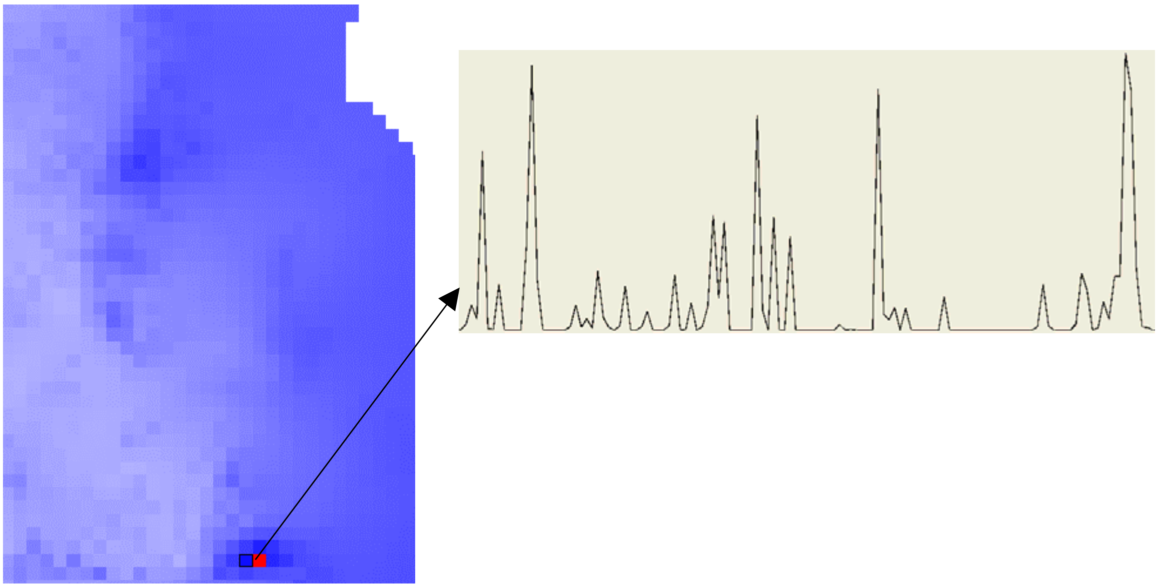


Figure 3-7 Step 6 Climatic data inputs

Step 7 – All models are parameterised and calibrated. This is usually accomplished through comparison with some observed data, such as flow gauging stations and storm event water quality data.

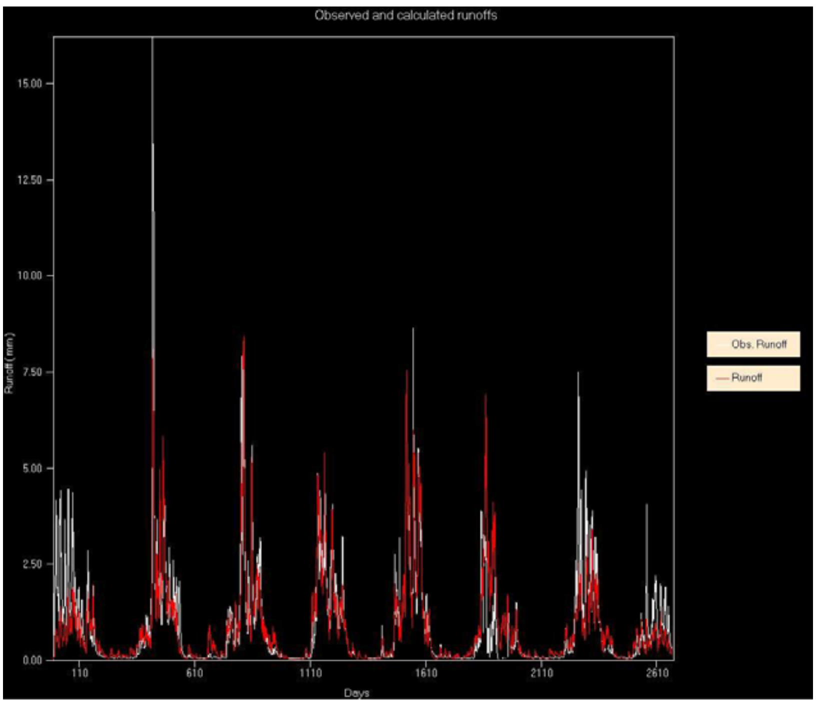


Figure 3-8 Step 7 Parameterisation and calibration

Once the model has been appropriately parameterised, and this has been checked through calibration, it is ready for use. In most cases, the model is set up to represent the existing case. An example of the final model is shown in Figure 3-9.

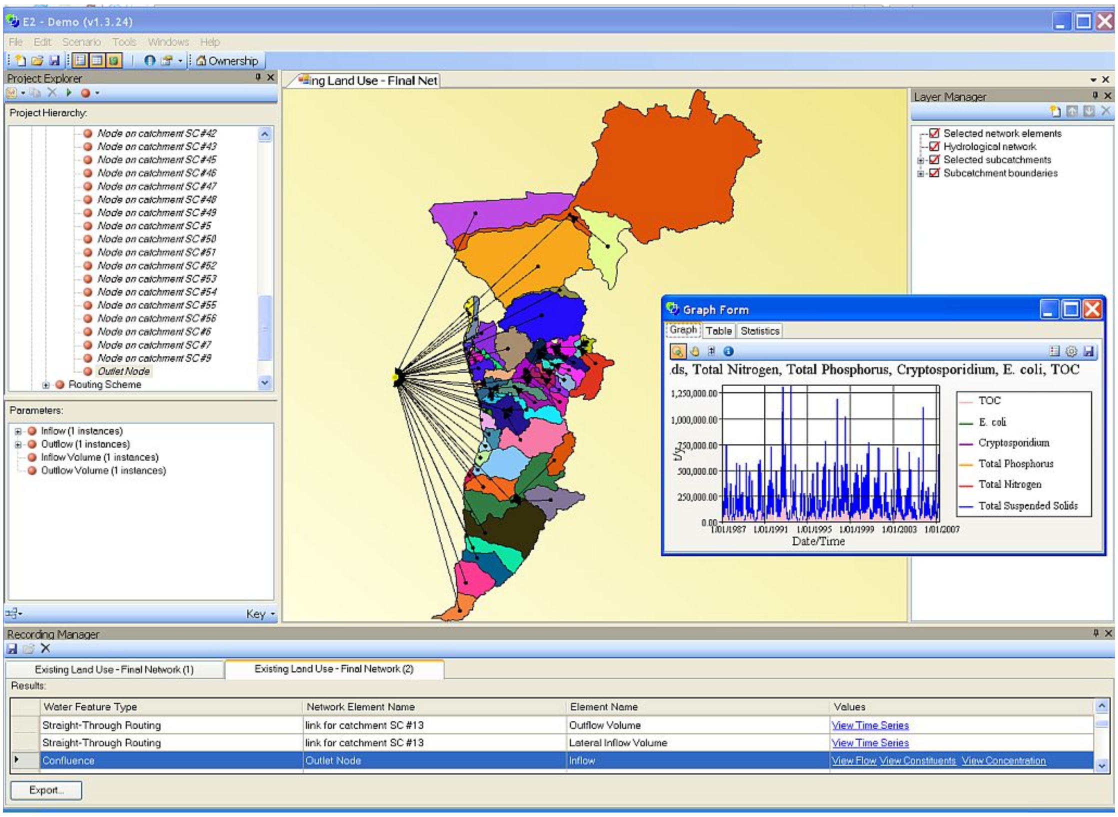


Figure 3-9 Final Model

Results of various scenarios can then be extracted for constituents used in the model and displayed on screen, or exported to other programs such as Excel for compilation or reprocessing.

BMT WBM

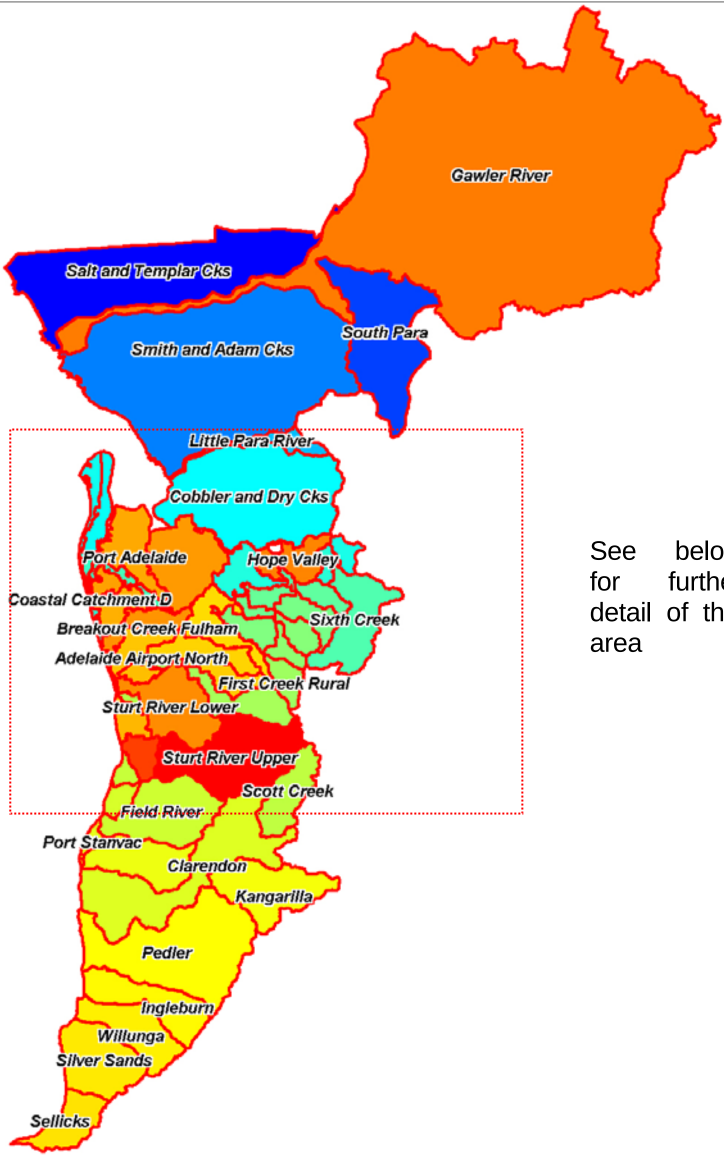
4 DEVELOPMENT OF THE ACWS E2 MODEL

4.1 Overview

The ACWS E2 model was developed according to the steps set out in the previous section; however several iterations in each step were required in order to develop the final model. This is typical of most catchment model developments in that the optimal model is developed through several iterations where the most appropriate combinations of node and link models are selected which best describe the catchment processes and responses. The development of the model was accomplished through several versions, each one representing changes in hydrological or constituent generation models or parameters to achieve better calibration results or to improve the representation of the catchment response.

4.2 Step 1 - Spatial Representation of the Catchment

In building an E2 model, the user has the option of manually drawing a node-link network based on an existing subcatchments layer, or selecting to use a digital elevation model (DEM), where this GIS layer is used to derive subcatchments at a particular level of stream defining threshold. In the numerous applications of E2 completed by BMT-WBM, we have found that the DEM method tends to generate "artefacts" flatter areas of catchments which do not adequately represent the subcatchment boundaries and defined flow paths. As such, given the extensive areas of flat terrain in the catchment, the manual drawing method was used to draw the node-link network. The subcatchments layer was derived from several predefined subcatchment boundary layers for all major catchments in the region which were combined and converted to an ascii raster for use within E2. The final adopted subcatchments are shown for the whole region, plus in greater detail around the central part of the catchment.



See below for further detail of this area

Figure 4-1 ACWS E2 Model Final Subcatchment Layout (Version 3.1)

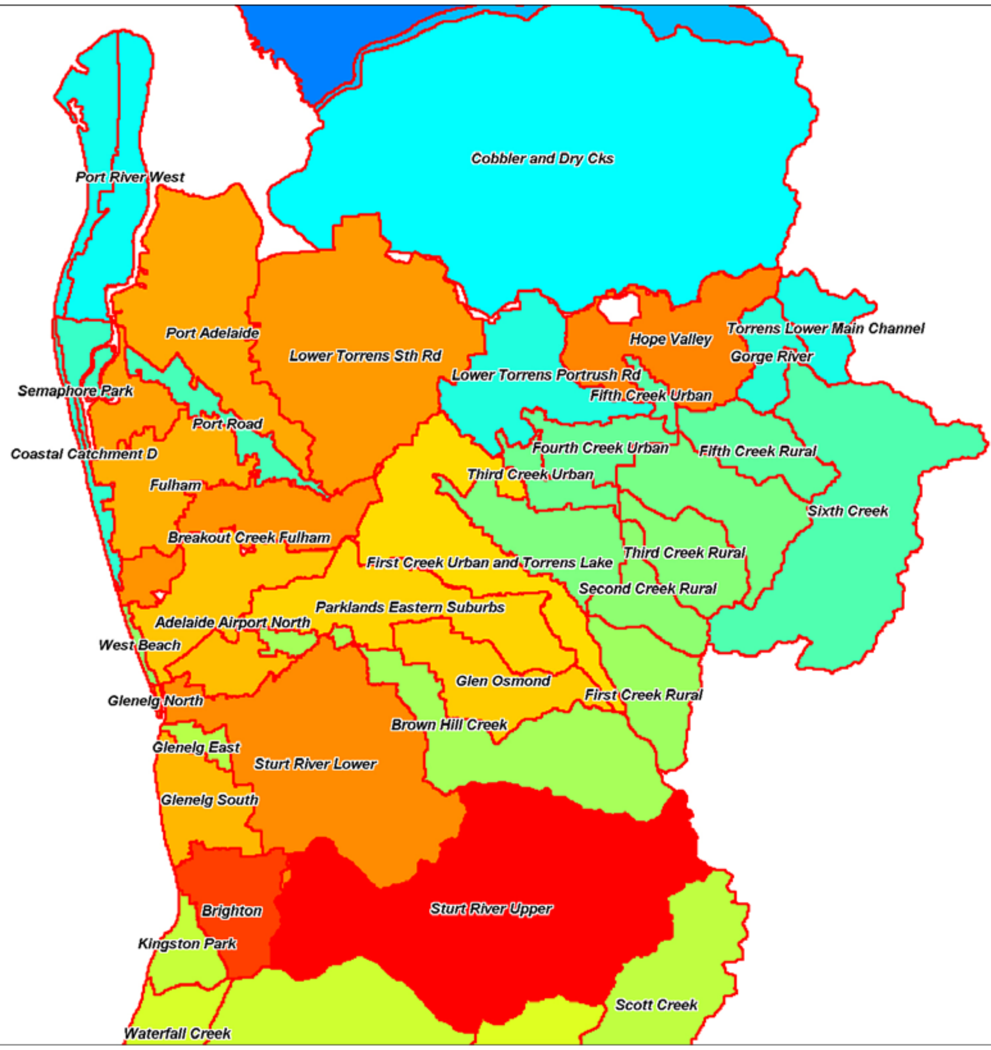


Figure 4-2 Central Subcatchments

4.3 Step 2 - Creation of the Node-Link Network

Once the subcatchment boundaries had been defined, the subcatchment map was imported into E2 as an ascii layer. Given the issues previously noted regarding flat terrain in the region, the manual drawing method was used to generate the node-link network. Considerable difficulty was found in identifying the flow paths of some subcatchments due to the complexity of the stormwater drainage network layer provided. Several iterations of the node-link network definition were required to ensure that they were consistent with the major subcatchment boundaries, however it is thought that this may not be entirely accurate given that the stormwater network appears to indicate cross-connections between several subcatchments in different major river basins, especially in the subcatchments around the Torrens and Port Rivers. The resultant node-link model is shown below.

Figure 4-3 ACWS E2 Version 3.1 Node-Link Network

4.4 Step 3 – Functional Unit Definition

4.4.1 Land Uses

Initial land use discretisation was obtained from a land use layer provided by SA EPA and assumed to represent existing land use (approximately 2002-2004). The land use classes were simplified slightly to improve model performance. Land use classes that were expected to have similar constituent generation rates and hydrology, or for which no specific data on hydrology or constituent generation was available, were combined where this was expected not to compromise the ability to create subsequent land use change scenarios. The final functional units used for the E2 model are outlined in Table 4-1 below. In addition, for the future land use scenario, two additional land use classes were added, Future High Density Urban and Future Residential Urban. This information was based on GIS layers received from Planning SA outlining future greenfield and redevelopment areas within the region.

Table 4-1 Functional Unit Classification

Landuse Class	*Raster Value*	*Functional Unit*	*Area (ha)*
Commercial	12	Commercial/High Density	221
Public Institution	14	Commercial/High Density	316
Education	17	Commercial/High Density	234
Retail/Commercial	19	Commercial/High Density	136
Forestry	6	Forestry	187
Horticulture	5	Horticulture/Ag	3524
Agriculture	11	Horticulture/Ag	3627
Utility Industry	9	Industrial	752
Food Industry	13	Industrial	116
Livestock	3	Livestock	3276
Mine/Quarry	15	Mining	656
Roads or not specified	20	Roads	3097
Rural Residential	4	Rural Res	4392
Vacant Land	2	Unspecified_OpenSpace	848
Recreation	10	Unspecified_OpenSpace	1508
Unspecified	16	Unspecified_OpenSpace	0
Golf	18	Unspecified_OpenSpace	112
Non-private Residential	1	Urban	79
Residential	7	Urban	3036
Vacant Residential	8	Urban	474
Waterbodies	21	Water	155
Wetlands	22	Wetlands	46

For the future land use map, the following table outlines how the Planning SA future land use classes were "lumped" into similar functional units to those described above, as described in Table 4-2 below.

Table 4-2 Assumed Future Land Use Functional Units

Planning SA Land Use Code	Description	E2 Functional Unit
AA	Aged Accommodation	Future High Density Urban
AP	Apartments	Future High Density Urban
BA	Broadacre rezoning	Future Residential Urban
LB	Land Bank	Future Residential Urban
LD	Land Division	Future Residential Urban
RD	Redevelopment	Future Residential Urban

4.4.2 Constituents and Generation

While the E2 models currently available do not allow specific representation of catchment, stream and/or plot scale processes, the "lumped-conceptual" approach used (where the numerous details of subcatchment geospatial and climatic information are lumped together as a single node) contains relevant information that can describe the response of the subcatchment to these processes. An example of this is constituent generation and export from specific land uses in that explicit values, based on event runoff monitoring of individual land uses, represent the results of the processes. The E2 models available to describe this process are limited however, in that they only allow for constant values to be set for base flow and event flow conditions (the 'Event Mean' Concentration and 'Dry Weather' Concentration approach). Constant areal loading rates can also be used. This is a reasonable compromise where longer-term averages are required (e.g. mean annual loads), however it does not accurately represent either seasonal variations expected within some catchments or variations due to flow rate or incident losses.

For the ACWS catchments, the constituents selected represent those identified within previous programs within the Study as being of concern, or those which are of interest to identify impacts of land use change. They have been derived from catchment monitoring activities (such as those event monitoring activities undertaken by SA EPA's Watershed Protection Office) and data obtained through analysis of existing literature (e.g. Fletcher et al 2004) and consistent with those used in the other E2 applications in the region. For one particular constituent of concern, Colour Derived Organic Matter (CDOM), no event based concentration data was able to be obtained, as such, total organic carbon (TOC) was used as a surrogate for CDOM as data was available in the literature. It should also be noted that there was only information for the event mean concentrations of TOC from urban and dense urban land use classes, so these were scaled according to the ratio of total nitrogen EMCs and DWCs for remaining land use classes.

The final constituent list selected for the E2 model and the EMCs and DWCs used are shown in Table 4-3 below.

Table 4-3 Constituents and Concentration Parameters

Constituent	Land Use				
	Forest/ Open Space	Grazing	Agriculture/ Horticulture	Urban	Dense Urban
Event Mean Concentrations (mg/L)					
Total Organic* Carbon	9.5	19	25	19	30
Total Phosphorus	0.2	0.28	0.36	0.28	0.28
Total Nitrogen	0.8	1.6	2.1	1.6	1.6
Total Suspended Solids	20	140	140	140	140
Dry Weather Concentrations (mg/L)					
Total Organic* Carbon	4.8	8.3	8.3	8.3	13.1
Total Phosphorus	0.03	0.07	0.07	0.07	0.07
Total Nitrogen	0.4	0.7	0.7	0.7	0.7
Total Suspended Solids	7	10	10	10	10

* EMCs and DWCs were scaled for TOC according ratios of total nitrogen

4.5 Step 4 – Node Model Selection

For each node within the ACWS network, models needed to be defined and parameterised in order to best describe the hydrology within the catchment. Consideration of the catchment response led to the selection of the SimHyd rainfall runoff model for this purpose. This model has been applied to catchments across Australia at a range of scales by BMT WBM, CSIRO and others. It has been shown to be ideally suited to catchments with a mix of urban and rural lands through calibration exercises undertaken by the former CRC for Catchment Hydrology (Chiew and Scanlon 2004).

4.6 Step 5 – Link Model Selection

Nodes within the ACWS E2 model were joined through links to the catchment outlet. These links route both flow and constituents to downstream nodes and as such can be configured in several different ways to represent in stream processes. Initially the links were configured with a Muskingham-Cunge flow routing model in order to represent the lag in flows from the top of the catchment to the downstream outlet. Through the calibration process, it was found that this caused changes in both flow and constituents that were considerably greater than that observed from the gauged data. It is likely that this is due to a limitation in the routing models that allows a minimum lag of 12 hours for each link. Given that the length of some links is relatively short, the lag time would be of the order of minutes to a maximum of 1-2 hours during most events. It was therefore concluded that the routing models were not appropriate to the ACWS E2 model (as they are currently implemented in E2) and were subsequently disabled.

4.7 Step 6 – Climatic Data Inputs

A SILO rainfall database data drill was used to obtain rainfall at 5km x 5km cells for the entire region. These data were then mapped within the E2 framework and applied to each of the relevant subcatchments.

4.8 Step 7 – Parameterisation and Calibration

Of all the steps in creating the ACWS Catchments E2 model, parameterising and calibrating the model consumed the majority of effort. Hydrological calibration was the major focus as this dictates both runoff and as such constituent loads that will be exported from the catchment. Fortunately, sufficient data were available at several gauging stations throughout the catchment to allow comparative calibration tasks to be completed. The Rainfall Runoff Library (RRL) tool was utilised to undertake the optimisation of parameter values within SimHyd. RRL is another product available through the eWater CRC Catchment Modelling Toolkit and contains several different hydrological models, plus a dedicated calibration window that allows the user to calibrate the hydrology using a variety of objective functions and manual methods in order to obtain suitable parameters for use in the selected model.

Numerous iterations of the RRL calibration tool were undertaken to identify parameters that would yield suitable calibration results based on the observed data at the several flow gauges. In the majority of iterations, the Nash-Sutcliffe criterion (Coefficient of Efficiency) was used as the primary basis for determine calibration performance, with runoff difference being used as secondary criteria. A number of different gauging sites were used to examine hydrological response and this was also combined with the previous calibration efforts undertaken in developing the Mt Lofty Ranges Storage Catchments E2 model. From the latter, two hydrologic regions were derived for the eastern and northern subcatchments, while those around the Adelaide CBD and those with a high degree of urbanisation were grouped as a third hydrologic region. Several references were used to predict suburban, dense urban and rural residential imperviousness and the final values adopted were 25%, 60% and 5% respectively.

The final calibration regions, adopted parameter sets, calibration results and observed vs predicted flow time series are shown below.

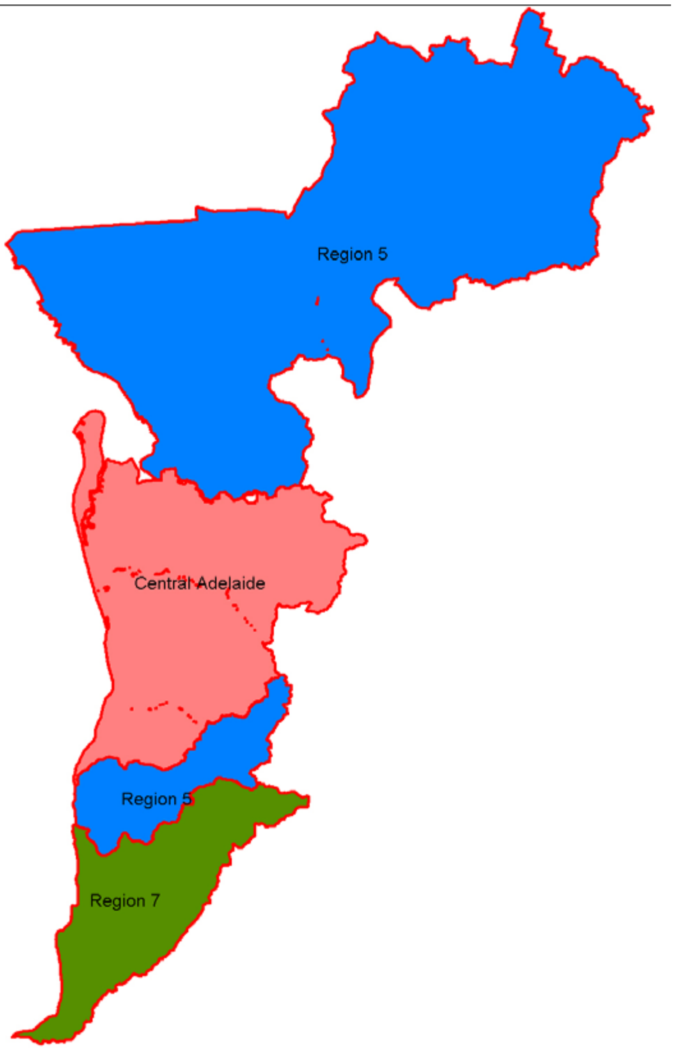


Figure 4-4 Calibration Regions

Table 4-4 SimHyd Parameters

SimHyd Parameter	Region 5	Region 7	Central Adelaide
Baseflow coefficient	0.0056	0.074	0.5
Impervious Threshold (mm)	2	2	5
Infiltration coefficient	203	234	400
Infiltration shape	6	10	3.3
Interflow Coeff.	0.198	0.092	0
Rainfall Interception Store Capacity (mm)	0.5	0	5
Recharge Coefficient	0.265	0.425	0.344
Soil moisture store capacity (mm)	500	500	500

Table 4-5 Calibration Results – Monthly Values Brownhill Ck

Calibration Results	Nash-Sutcliffe Criteria	Correlation Coefficient	Runoff Difference (%)
Calibration Period (13/03/97 - 1/3/07)	0.606	0.781	1.6

These results show that the model is predicting flows reasonably well at the Brownhill Ck gauge, with only a minimal difference between observed and predicted runoff volumes. The correlation coefficient of 0.781 indicates that >78% of the variation in the observed data can be predicted by the model, which is typically considered to be a "strong" correlation (generally in statistical analysis, it is considered that correlation is considered strong if the coefficient of determination is greater than 0.48 and very strong if greater than 0.79).

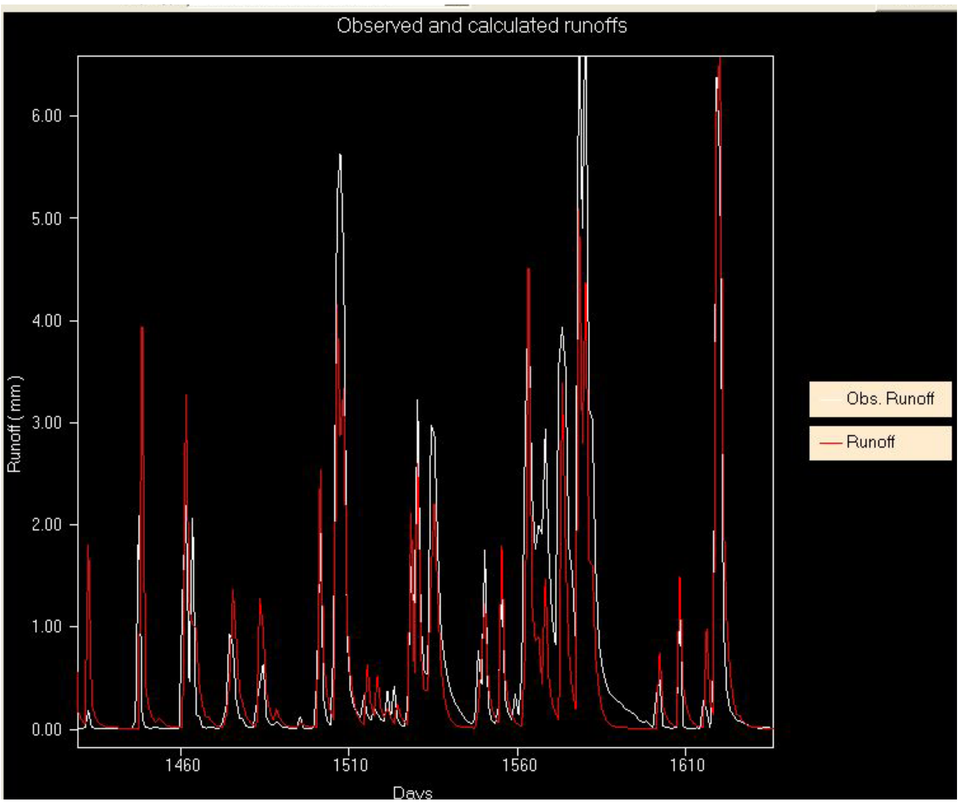


Figure 4-5 Scatter Plot – Observed vs Expected Flows at Fishers Ghost Ck

5 RESULTS AND DISCUSSION

5.1 Application

5.1.1 Background

The application of a catchment model is usually undertaken to answer specific questions on land use change or management or simply to gain a better understanding of the spatial and temporal contributions of areas within the modelling domain. The model provides information which can then be used to assist planning decisions, investment plans for management intervention, or assessments of the relative effectiveness of one management scenario compared to another (e.g. retrofitting Water Sensitive Urban Design in existing urban areas versus replanting riparian buffer strips in rural catchments).

This information can also be passed onto other models, typically receiving water quality models and/or ecosystem health response models.

The results presented below are based on scenarios of the existing catchment, and that likely to have been present prior to European settlement, in addition to future land use changes over the next decade as derived from the Planning SA future land use predictions until.

5.1.2 Spatial Representation

One of the more powerful components of catchment models is the ability to understand the spatial context of flow and constituent fluxes within a catchment. The E2 model allows the user to extract maps showing relative contributions of each subcatchment.

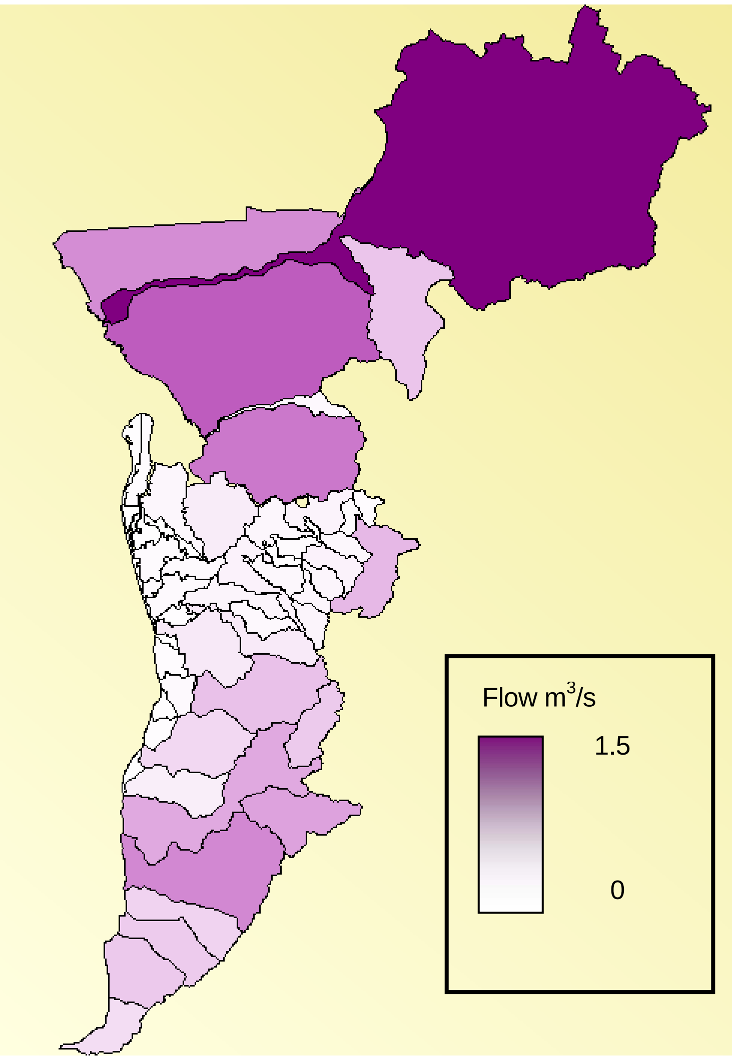


Figure 5-1 Mean Daily Flows

The representation of mean annual flows shows that significant amounts of subcatchment runoff are generated in the north east of the catchment, corresponding to higher rainfall regions, large catchment areas and considerable contributions from unregulated flows. This also is prevalent in mean daily constituent loads, as shown by the Total Organic Carbon loads in Figure 5-2.

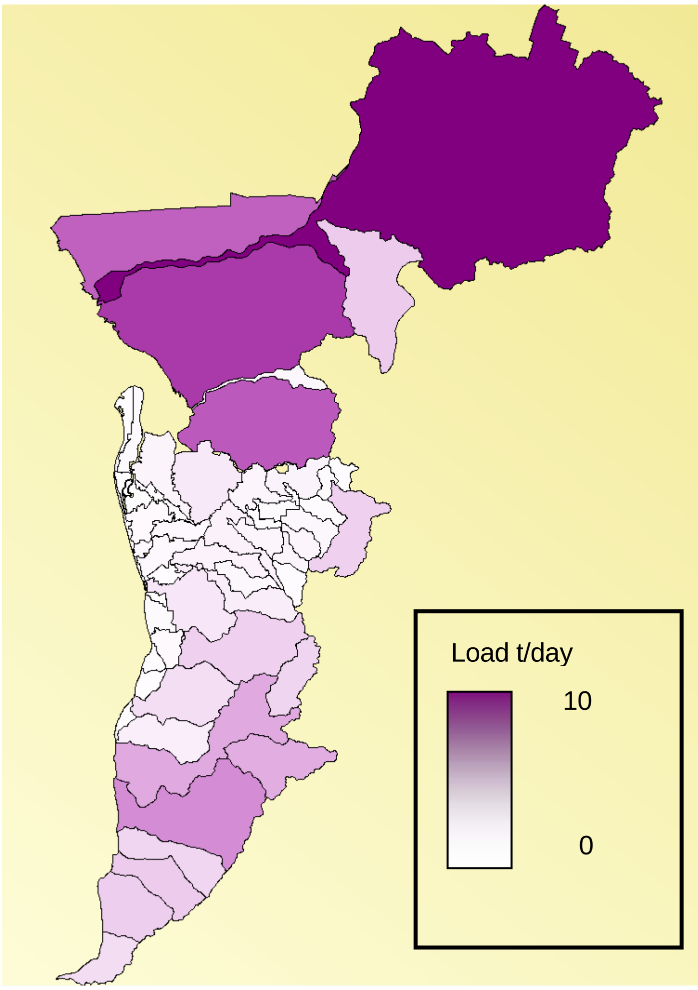


Figure 5-2 Mean Daily Catchment Loads – Total Organic Carbon

While the above is relevant in terms of delivery to the receiving environments of the ACWS region, it should also be studied with reference to areal loads, that is the loads per unit area. This tends shows subcatchments that may deliver "more than their fair share" of loads and together, these can be used to prioritise management actions. Using TOC again as an example,

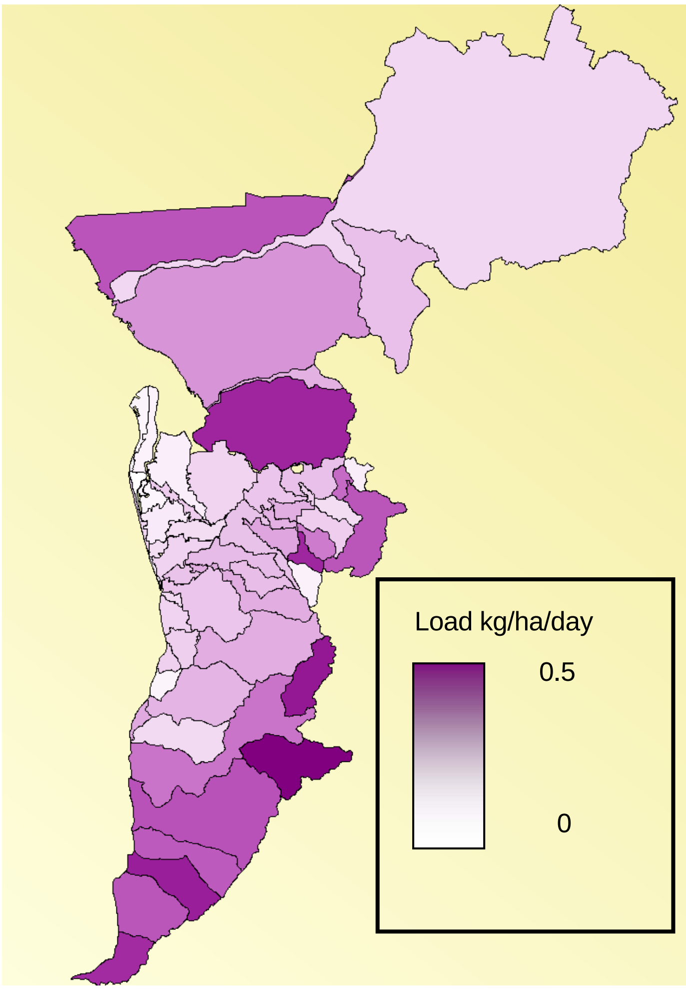


Figure 5-3 Mean Daily Areal Loads - TOC

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5.1.3 Temporal Representation

The E2 model developed for the ACWS region uses daily data as climatic inputs and as a result, this is the highest temporal resolution potentially available from the model. In terms of mean annual loads, the catchment model gives relatively robust predictions, however, caution should be taken in using the same model to understand particular storm events. For this purpose, the model often needs to be recalibrated to give the best representation of those events, rather than for the entire climatic period. In the case of results here, mean annual flows and loads are shown.

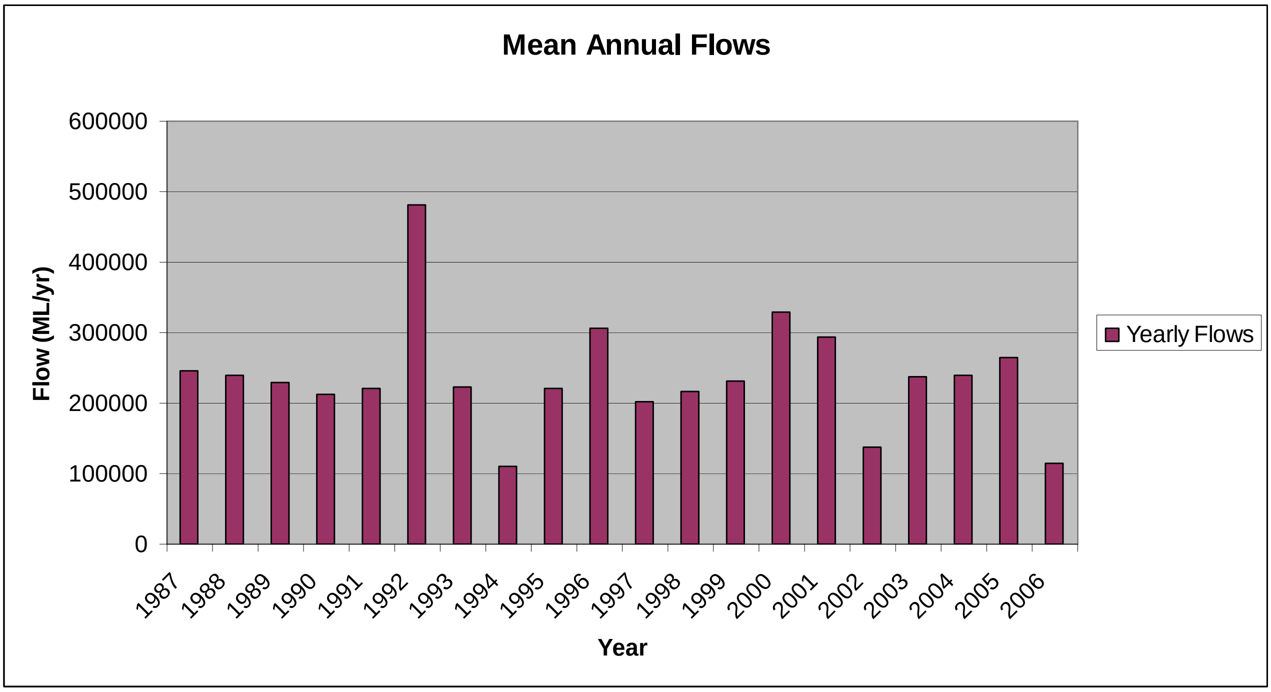

Figure 5-4 Predicted Mean Annual Flows

The mean annual flows above indicate that 1994, 2002 and 2006 were particularly dry in terms of flows discharged, however the remainder of the period was relatively average with the exception of 1992, where nearly double the mean annual flow (averaged over the 20 year period) was released to the ACWS receiving environment. The mean annual flow at the catchment outlet (i.e. a sum of all catchment contributions to the Bay) is approximately 238,000 ML/yr.

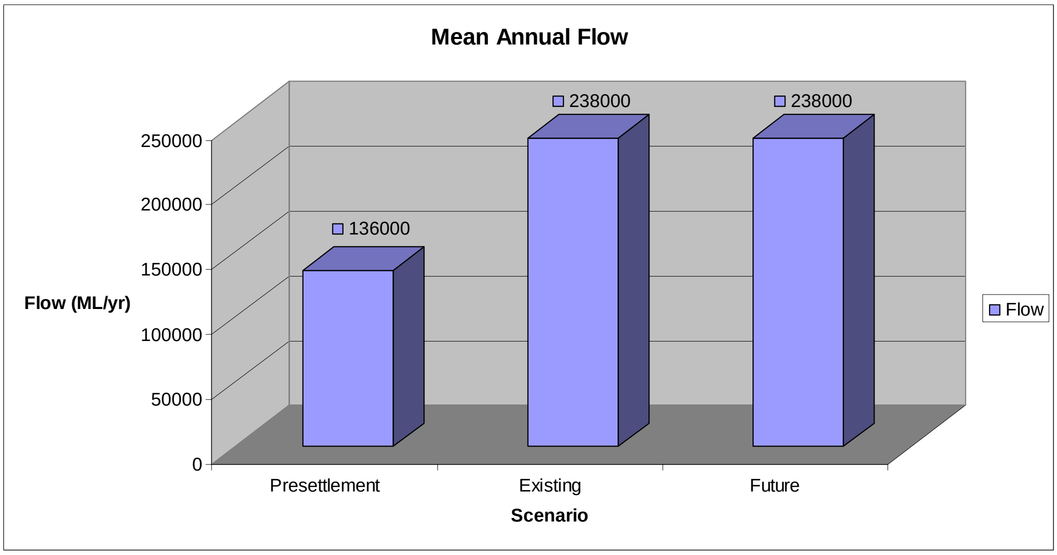

Figure 5-6 Scenario Comparisons - Mean Annual Flows

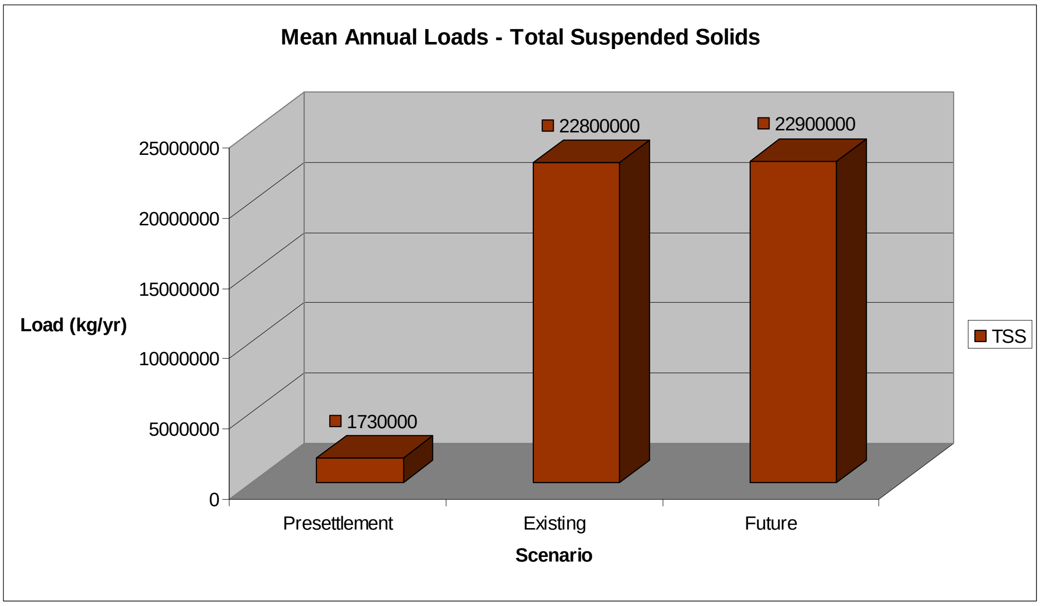

Figure 5-7 Scenario Comparisons – Total Suspended Solids

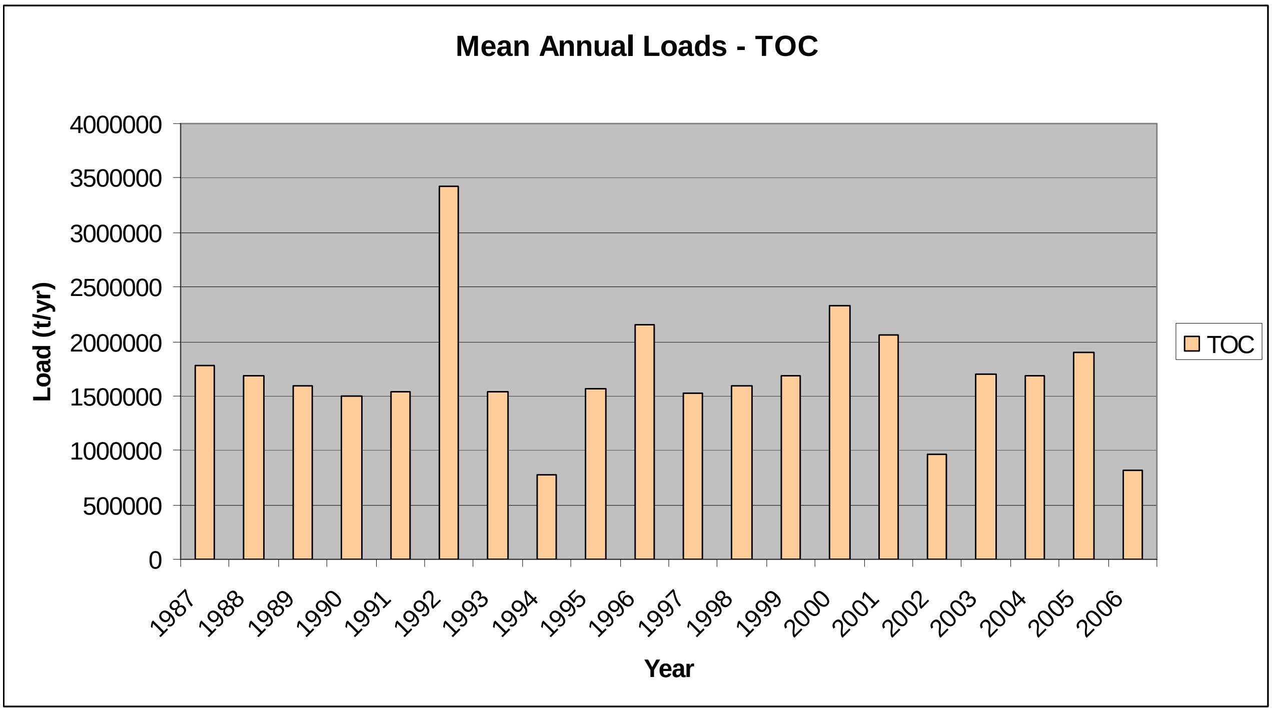

Figure 5-5 Predicted Mean Annual Loads – Total Organic Carbon

As an indicator of typical annual load variability, the above TOC chart shows a similar catchment response to the annual flows, with loads exhibiting similar variation to the flows. This is to be expected as increased flows convey increased pollutant loads to the catchment outlet. The mean annual loads for all constituents are given below for the existing land use scenario.

Table 5-1 Mean Annual Constituent Loads

Constituent	Mean Annual Load (t/yr)
TSS	22,800
TOC	4,630
TN	309
TP	1451

5.2 Scenario Evaluation

5.2.1 Pre-European Settlement

The model was developed with three scenarios included, one representing current land use (approx 2004), a second representing a completely forested catchment as a surrogate for the expected land form prior to European settlement and a third representing future land use. While the assumption of the entire catchment being forested to represent pre-settlement is a conservative one (i.e. it does not consider the influence of indigenous inhabitants land management practices), it provides a useful "baseline" to assess the magnitude of impacts associated with land use changes to the present day. The predicted impacts are shown in the visually in the graphs below.

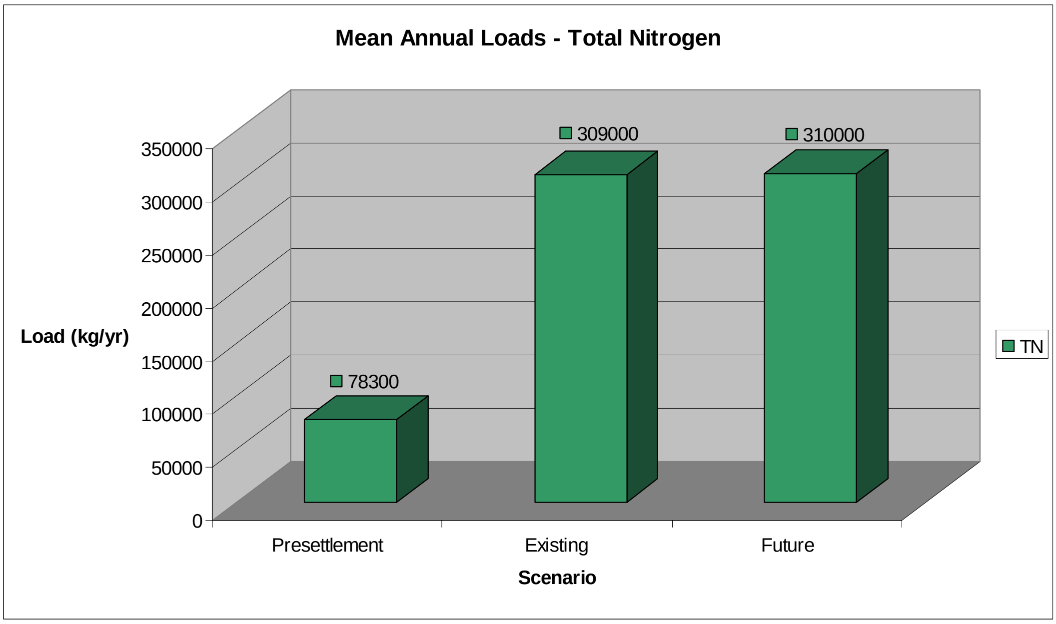

Figure 5-8 Scenario Comparisons – Total Nitrogen

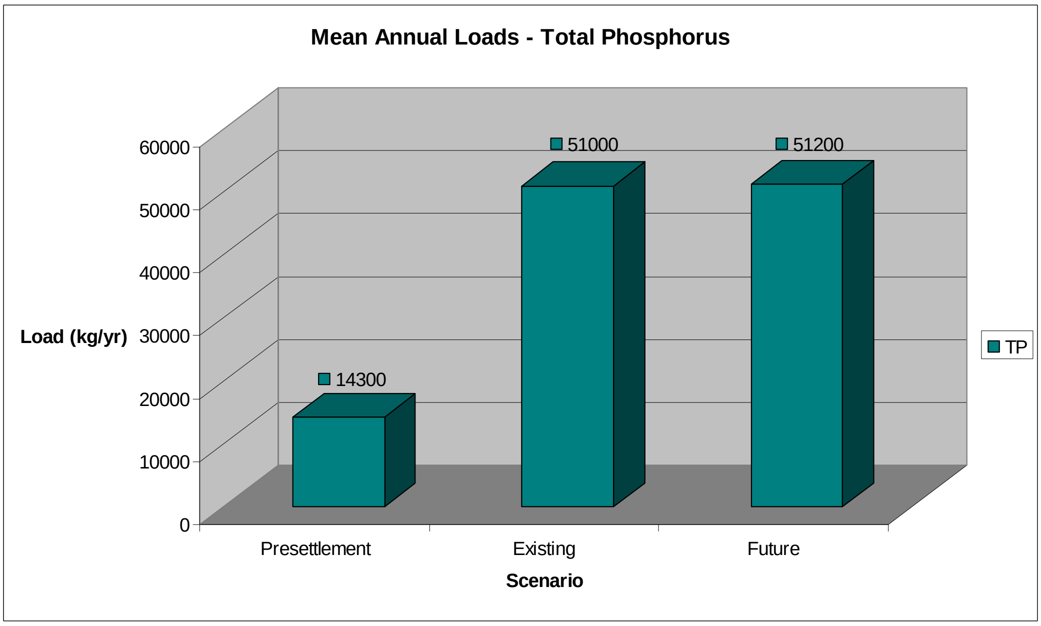

Figure 5-9 Scenario Comparisons – Total Phosphorus

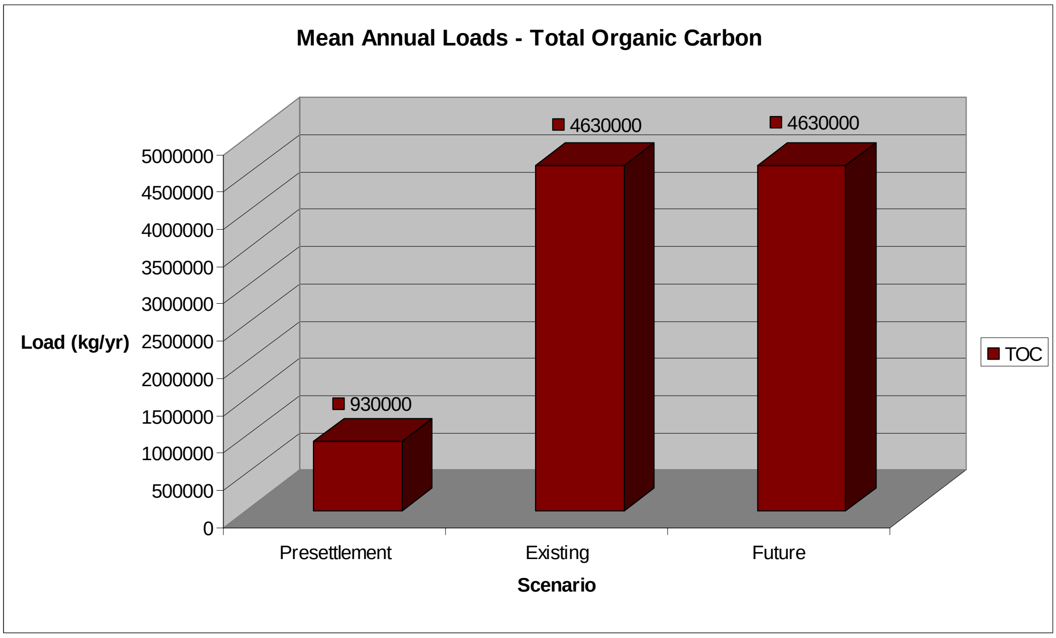

Figure 5-10 Scenario Comparisons – Total Organic Carbon

5.3 Discussion

The above results indicate that significant increases in pollutant loads have resulted as a consequence of European settlement in the Adelaide Coastal Waters catchments, however future land use change is not expected to result in large increases in loads over the next decade (as indicated by the Planning SA future land use estimates). The majority of pollutants currently delivered to the receiving waters appear to be derived from Gawler River catchment, as this represents the largest single subcatchment area contributing to the ACWS region. Further comparisons of areal loads indicate that "hot spot" areas of pollutant generation may be more dispersed and using both actual and areal pollutant loads may be beneficial in prioritising subcatchments for management actions. Subsequent model analyses and scenarios should therefore focus around the types of management actions likely to be suitable for the ACWS region to examine their efficacy in reducing overall pollutant loads to the ACWS region.

5.4 Recommendations

The application of the E2 modelling framework has highlighted several issues that may require further investigation or analysis. Of most difficulty has been the obtaining of specific local event water quality data for the constituents used in the model, especially TOC, which is used as a surrogate for CDOM, considered one of the major constituents of interest in examining the decline of ecosystem health in the receiving waters of the region. It is therefore recommended that monitoring of rainfall events for this particular constituent would be most beneficial in improving the predictive capacity of the catchment model.

It may also be beneficial to couple the outputs of this catchment model to a receiving water quality model of the region. This may be useful to examine the impacts of management actions in the catchment on protecting the ecosystem health of those receiving waters and allow "gaming" of various scenarios to assist in determining those actions which may be most beneficial.

5.5 Summary

This report summarises the overall process of building a catchment model of the Adelaide Coastal Waters catchments and provides some initial results for analysis. Further work is to be undertaken in examining various land use and catchment management actions on loads delivered to the receiving waters of the region, however these predictions may benefit from additional studies as indicated in the recommendations above.

It continues to show that the E2 modelling framework is a suitable tool for application in the region and complements previous catchment models built in adjacent catchments.

APPENDIX A: REFERENCES

Chiew F, Scanlon P, Vertessy R, Watson F, "Catchment Scale Modelling of Runoff, Sediment and Nutrient Loads for the South-East Queensland EMSS", CRC for Catchment Hydrology Technical Report, February 2002.

Fletcher, T, Duncan H, Poelsma P, Lloyd S," Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures : A Review and Gap Analysis", CRC for Catchment Hydrology Technical Report 04/08, December, 2004.

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