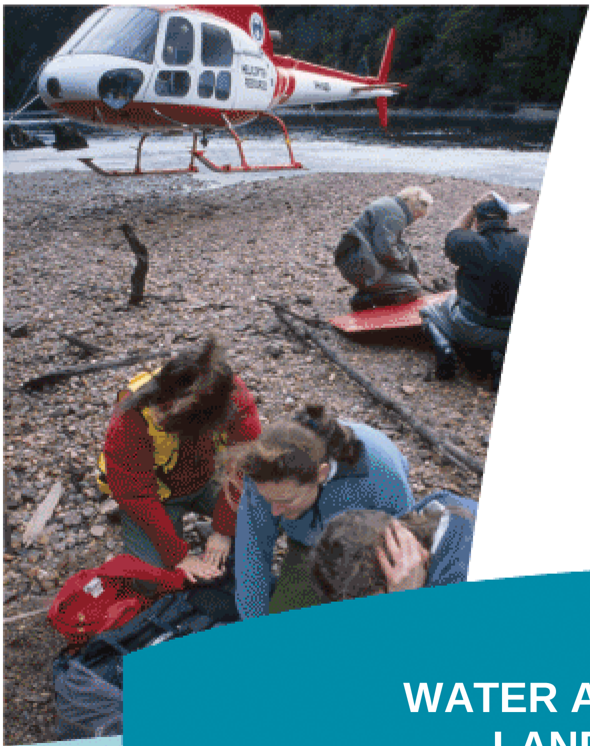

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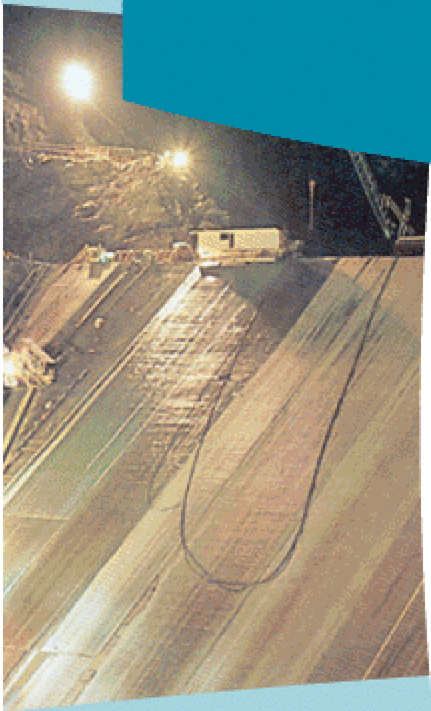
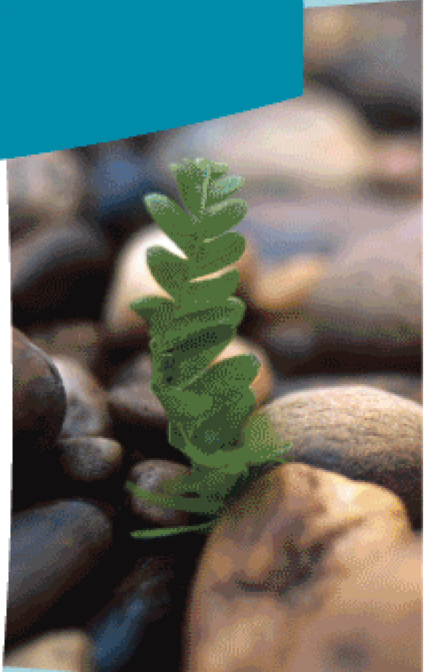
WATER AVAILABILITY AND FOREST LANDUSE PLANNING TOOL

REPORT





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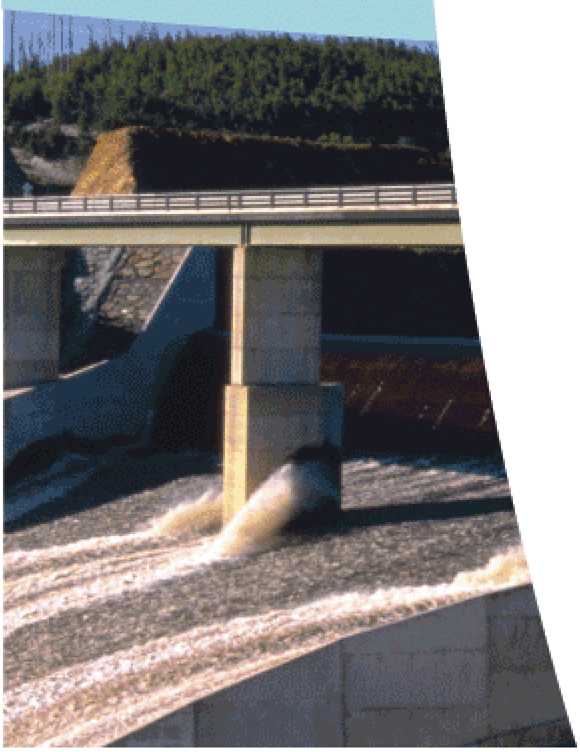

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EXECUTIVE SUMMARY

The Water Availability and Forest Landuse Planning Tool has been developed by Hydro Tasmania Consulting (HTC) for Department of Primary Industries and Water (DPIW). The purpose of the tool is to evaluate the potential risks of impacts on water availability to downstream users and ecosystems resulting from large-scale changes in landuse. The tool incorporates the surface water hydrological models under development for DPIW (Australian Water Balance Model, AWBM), and the Conservation of Freshwater Ecosystem Values (CFEV) database to allow evaluation of the impacts of changes in water availability at the sub-catchment scale on current water allocation and environmental assets.

The tool uses the TasLUCaS equations developed by CSIRO (Brown et al, 2006) as the underlying method for assessing the streamflow from an area associated with a particular landuse. These equations have been developed on a yearly timestep, and for the purposes of this tool, the impacts were disaggregated to a daily timestep in the AWBM. The estimation of daily streamflows is via an AWBM for the catchment. The change in streamflow due to landuse change estimated using the TasLUCaS equations is input to the AWBM for each subcatchment to give daily time series of streamflows under future landuse scenarios.

The impact on water availability to downstream users is investigated using the results of the TasLUCaS equations which are input to the Tasmanian Surface Water AWBM. This displays the impact of change in streamflow due to landuse change on Hydrologic Disturbance Indices, low flow spells, cease to flow days and monthly flow statistics.

The impact on ecosystem values was evaluated by calculating changes to indices in the existing CFEV due to streamflow change resulting from change in landuse. This is presented in a “traffic light” format in the Planning Tool’s GIS interface.

CONTENTS

1. INTRODUCTION

Change in landuse in a catchment has the potential to affect streamflows from that catchment. The Water Availability and Forest Landuse Planning Tool has been developed by HTC for DPIW. The purpose of the tool is to evaluate the potential risks of impacts on water availability to downstream users and ecosystems resulting from large-scale changes in landuse. The tool incorporates the surface water hydrological models under development for DPIW, and the Conservation of Freshwater Ecosystem Values (CFEV) database, to allow evaluation of the impacts of changes in water availability at the sub-catchment scale on current water allocation and environmental assets.

The process flow chart for the tool is outlined in Figure 1.1.

An operating manual is provided with the planning tool.

The tool uses the TasLUCaS equations developed by CSIRO (Brown et al, 2006) as the underlying method for assessing the streamflow from an area associated with a particular landuse. These equations have been developed on a yearly timestep, and for the purposes of this tool, the impacts were disaggregated to a daily timestep in the surface water models.

The impact on water availability to downstream users is investigated using the results of the TasLUCaS equations which are input to the Tasmanian Surface Water AWBM. The impact on ecosystem values is evaluated by calculating changes to indices in the existing CFEV due to streamflow change resulting from change in landuse. The methodologies are presented in Sections 3 and 4 respectively.

1.1 Reference Conditions

The reference conditions for the project were established by considering the inputs to the tool. The Tasmanian Surface Water AWBMs have been calibrated on current landuse, with the inclusion of the appropriate water entitlements for the period of calibration. The “natural” state for these models assumes no extractions, but current landuse. In the planning tool, the hydrologic indices presented for the future case have been calculated using both the current and ‘natural’ conditions as the reference. The indices for the current-future case give an indication of impacts from the current condition, whilst the natural-future indices are directly comparable with those previously presented in the Tasmanian Surface Water Models. This is described in more detail in Section 3.4

It is possible to estimate the change in runoff between current conditions and pre-European settlement conditions using the TasLUCaS equations. If this option is desired, this could be applied to the outputs from the Tasmanian Surface Water models. This would require input data on type, age and area of forest under pre-European settlement conditions.

The expert rule systems used to derive state-wide conservation values and management priorities for Tasmania's freshwater dependent ecosystems use natural flows as the benchmark. The condition scores that have been derived for the future case are based on the natural benchmark. The impact on conservation values may be assessed based on change from the current CFEV values. More detail is provided in Section 4.

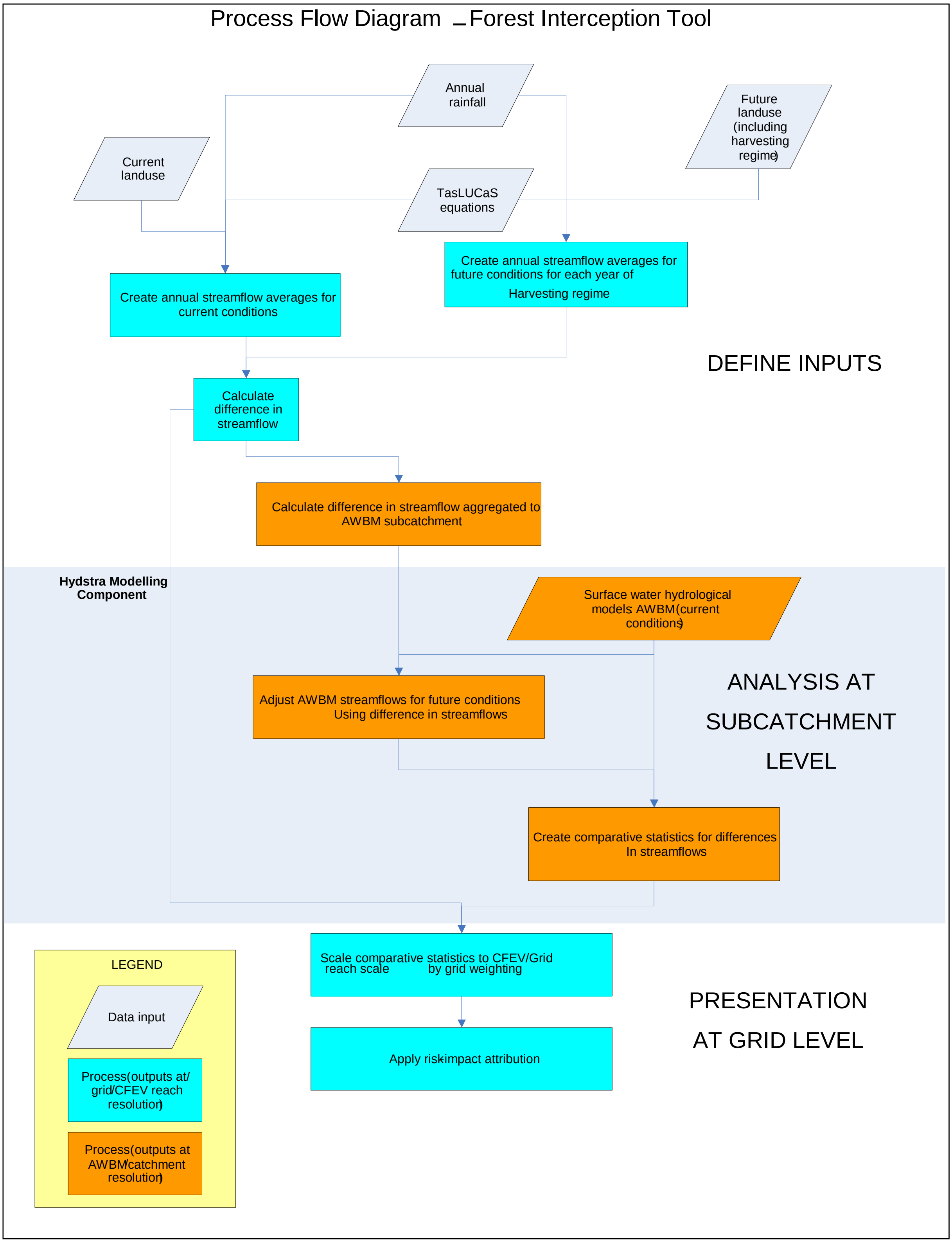

Figure 1.1: Process Flow Diagram, Water Availability and Forest Landuse Planning Tool.

2. ESTIMATION OF CHANGE IN STREAMFLOW DUE TO LANDUSE CHANGE

The estimation of the change in streamflow due to landuse change is via the GIS interface, using the TasLUCaS equations, which are detailed in Section 2.3.

2.1 Current and Future Scenarios

The Planning Tool requires current and future landuse scenarios as inputs. A current landuse scenario is typically provided by Forestry Tasmania and Private Forests Tasmania as an Excel spreadsheet. This data is aggregated by sub-catchment and includes the following items:

- Sub-catchment ID
- Forest Species/Plantation Species
- Year planted (which derives Forest Age) or regenerated (for native forest)
- Current harvest rotation length
- Area

This 'Current Landuse' table is combined with a GIS layer (shapefile) of the sub-catchments and a rainfall data layer to enable mean annual rainfall to be assigned to each forest area, linked by sub-catchment ID. A copy of the Current Landuse table is made to create the 'Future Landuse' table. Within this table, the data is edited to reflect the future landuse scenario.

2.2 Description of layers and tables

All data in the model uses the GDA94 MGA Zone 55 (Geocentric Datum of Australia, Map Grid of Australia) coordinate system.

2.2.1 Model Data

Each time the Planning Tool is run, it requires the following input data:

1. Current landuse table (spreadsheet)
2. Future landuse table (derived from 1)
3. Sub-catchment GIS layer (with sub-catchment ID)

2.2.2 Static Data

The following static data is also required (ie the same data is used for all models that are run)

1. Rainfall (supplied with program). The rainfall data is provided as a raster dataset at 100m resolution.
2. Forest Groups layer
3. CFEV river reaches
4. AWBM model and interface (details of inputs and outputs for this part of the tool are detailed in Section 3).

2.2.3 Configuration Data

The Planning Tool is provided with configuration data that is used by the program. This includes the CFEV Expert Rule tables and lookup tables for the plantation input data.

Plantation lookup tables assign rotation length and TasLUCAS equations to each plantation or forest area listed in the supplied plantation tables. These values are configurable.

These tables are provided in Microsoft Access databases.

2.2.4 Calculation of Change in Annual Streamflow

Change in streamflow is calculated in 2 separate ways, depending upon whether the Forest Groups layer is used to refine the calculation.

2.2.4.1 Calculate Annual Streamflow with Tabular Data

When tables rather than spatial data is used to describe the plantations and forests in subcatchments, the streamflow is calculated for each forest area in the tables. Streamflow is calculated for the current scenario (for this year), and for each of the next 100 years based on future management scenarios. These results are aggregated by subcatchment, weighted by area.

2.2.4.2 Calculate Annual Streamflow with Forest Groups

When using the Forest Groups layer, the streamflow is calculated for each polygon in the Forest Groups layer for the current year and each of the next 100 years based on the supplied future scenarios, and aggregated by subcatchment, weighted on area.

2.2.4.3 Calculate and Export Difference in Annual Streamflow

The difference in streamflow between the current and future scenarios is calculated for each sub-catchment, for each year. The AWBM input spreadsheet is updated with this absolute change, and the subcatchment layer is updated with the relative change (change in streamflow/current streamflow). The GIS display tool displays the relative change in streamflow for each catchment, as either High, Medium and Low.

2.3 TasLUCaS Equations to Calculate Change in Annual Streamflow

The Tasmanian Land Use Change and Streamflow tool was developed by CSIRO (Brown et al, 2006) to enable investigation of the impact of land use change on the annual quantity of streamflow within a catchment. The underlying analysis for this tool is via a set of equations that relate the annual streamflow from an area to the precipitation and landuse. The landuse types include grass, native forest reserve, native forest harvest, and plantation. Forest age and rotation length are required for the streamflow analysis. These equations were derived by regression analysis of data from paired catchment experiments.

The TasLUCaS equations have been used as the basis for estimating change in annual streamflow in Water Availability and Forest Landuse Planning Tool as described in Section 2.2.

The equations are shown below.

For grassland:

$$Streamflow_{grass} = P\left(1-\left[\frac{1+0.5\times\frac{1100}{P}}{1+0.5\times\frac{1100}{P}+\frac{P}{1100}}\right]\right)$$

For unclassified areas:

$$Streamflow_{other} = P\left(1-\left[0.5\times\frac{1+2\times\frac{1410}{P}}{1+2\times\frac{1410}{P}+\frac{P}{1410}}+(1-0.5)\times\frac{1+0.5\times\frac{1100}{P}}{1+0.5\times\frac{1100}{P}+\frac{P}{1100}}\right]\right)$$

For native forest reserve:

$$Streamflow_{NFR} = \sum_{A=1}^{A=200} P\frac{\left(1-\left[\frac{1+2\times\frac{1410}{P}}{1+2\times\frac{1410}{P}+\frac{P}{1410}}\right]+\left[aA\exp(bA)+c\left(\frac{2}{1+\exp(dA)}+\exp(eA)-2\right)\right]\right)}{200}$$

For native forest harvest areas or plantations:

$$Streamflow_{NFH\,/\,Plantation} = \sum_{A=1}^{A=R.L} P\frac{\left(1-\left[\dfrac{1+2\times\dfrac{1410}{P}}{1+2\times\dfrac{1410}{P}+\dfrac{P}{1410}}\right]+\left[aA\exp(bA)+c\left(\dfrac{2}{1+\exp(dA)}+\exp(eA)-2\right)\right]\right)}{R.L.}$$

Where:

Streamflow = annual streamflow

P = annual precipitation

A = forest age

a, b, c, d, e = fitted parameters

a = 0.3163, *b* = -0.5170, *c* = 0.7641, *d* = -0.024, *e* = -0.0196

RL = rotation length (years)

From Brown et al (2006).

3. DAILY STREAMFLOW MODELLING

3.1 Background

The Australian Water Balance Model (AWBM) component of the Water Availability and Forest Landuse Planning Tool has been adapted from the surface water models developed for DPIW under a previous project (eg. Hydro Tasmania Consulting, 2004). The AWBM is used in this tool to give a daily timeseries of streamflow on a subcatchment basis. The subcatchments were defined in the previous surface water modelling project.

The AWBM model is a relatively simple water balance model with the following characteristics:

- it has few parameters to fit,
- the model representation is easily understood in terms of the actual outflow hydrograph,
- the parameters of the model can largely be determined by analysis of the outflow hydrograph,
- the model accounts for partial area rainfall-run-off effects,
- run-off volume is insensitive to the model parameters.

For these reasons parameters can more easily be transferred to ungauged catchments.

The AWBM routine used in this study is the Boughton Revised AWBM model (Boughton, 2003) that reduces the three partial areas and three surface storage capacities to relationships based on an average (Table 3.1).

Table 3.1: surface stores and capacities.

Partial area of smallest store	A1=0.134
Partial area of smallest store	A2=0.433
Partial area of smallest store	A3=0.433

Capacity of smallest store	C1=0.01*Ave/ A1=0.075*Ave
Capacity of smallest store	C2=0.33*Ave/ A2=0.762*Ave
Capacity of smallest store	C3=0.66*Ave/ A3=1.524*Ave

The AWBM routine produces two outputs; direct run-off and base-flow. Direct run-off is produced after the content of any of the soil stores is exceeded; it can be applied to the stream network directly or by catchment routing across each subcatchment. Base-flow is usually supplied unrouted directly to the stream network, at a rate proportional to the water depth in the ground water store. The ground water store is recharged from a proportion of excess rainfall from the three surface soil storages.

The soil stores are depleted by evapotranspiration.

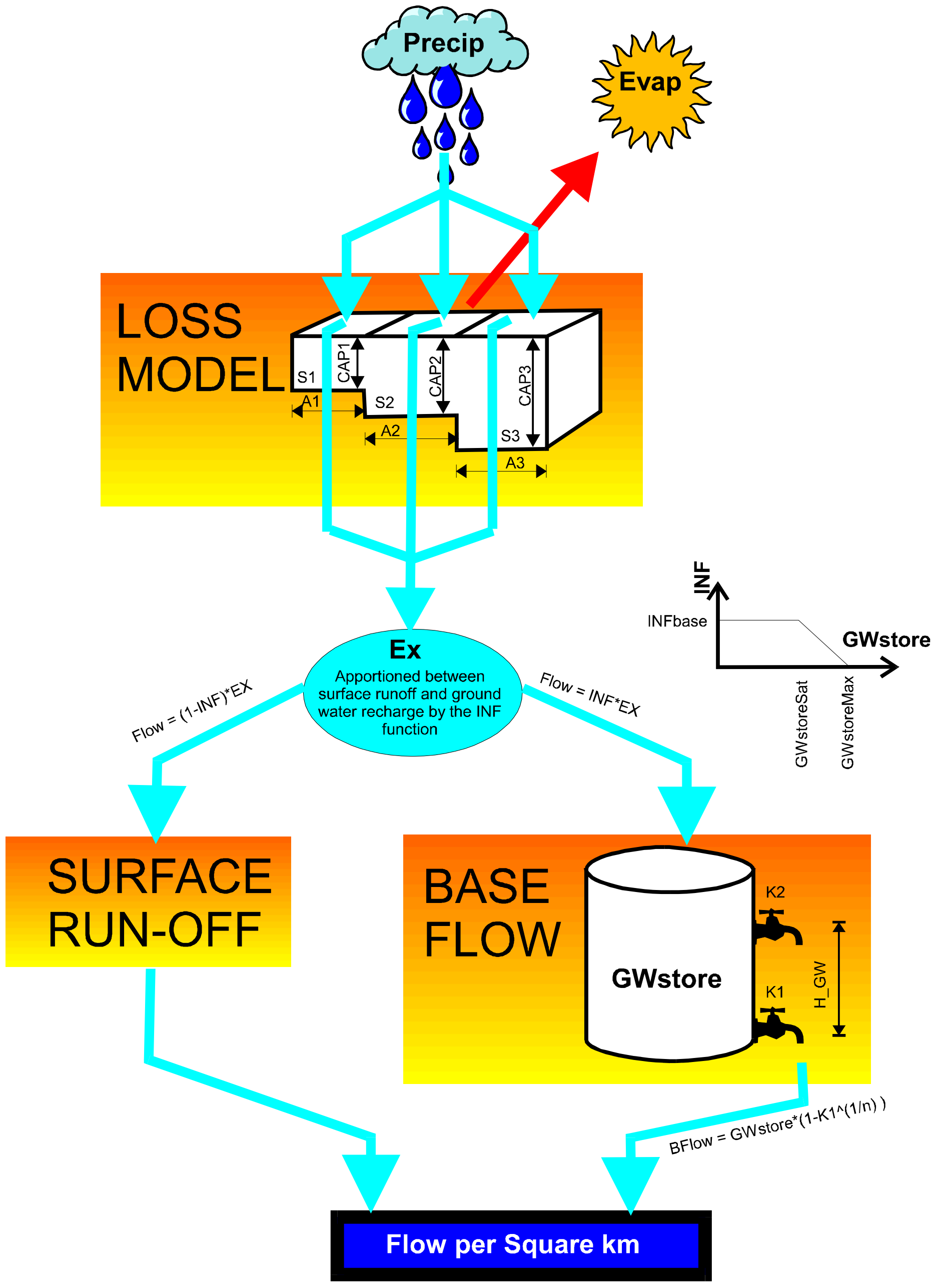

Figure 3.1: AWBM Conceptual diagram

3.1.1 Channel Routing

A common method employed in nonlinear routing models is a power function storage relation.

$S = K.Q^n$

K is a dimensional empirical coefficient, the reach lag (time). In the case of Hydstra/TSM Modelling:

$$K = \alpha . L_i$$

and

L_i = Channel length (km)

α = Channel Lag Parameter

n = Non-linearity Parameter

Q = Outflow from Channel Reach (m3/s)

A reach length factor may be used in the declaration of α to account for varying reach lag for individual channel reaches. eg. α.fl where fl is a length factor.

Parameters required by Hydstra/TSM Modelling and their legal bounds are defined in Table 3.2.

Table 3.2: Routing parameters.

α	Channel Lag Parameter	Between 0.0 and 5.0
Li	Channel Length (km)	Greater than 0.0 (km)
n	Non-linearity Parameter	Between 0.0 and 1.0

3.2 Modifications to Tasmanian Surface Water Models AWBM

3.2.1 Temporal Scale

The AWBM Hydstra model was modified for this project to include the changes in annual streamflow due to landuse change calculated with the TasLUCaS equations. The GIS interface generates a time series of the predicted change in annual streamflow for each year of the model run period, based on the current or reference condition and proposed land use changes. This time series of annual streamflow change populates a spreadsheet in the Excel interface, which is then automatically input to the AWBM.

For the purposes of this project, a daily estimate of change in streamflow was required to calculate the desired flow statistics. The annual change in streamflow was disaggregated to a daily value by determining the percentage of the annual flow that occurred on a given day (before extractions occur) and multiplying this by the total annual change in streamflow for the appropriate year. This was then added to the current daily outflow to give daily outflow for the future landuse conditions.

$$\Delta Streamflow_d = \frac{Streamflow_{nat,d}}{Streamflow_{nat,y}} \times \Delta Streamflow \times CA$$

Where:

$\Delta \ Streamflow_d$ = Change in streamflow on day d in year y (ML/d)

$Streamflow_{nat,d}$ = Streamflow on day d, in Year y, with no extractions (ML/d)

$Streamflow_{nat,y}$ = Streamflow in Year y, with no extractions (ML/d)

$\Delta Streamflow$ = change in streamflow between future and current landuse cases (mm), from TasLUCaS equations (future annual streamflow – current annual streamflow for year y).

CA = Catchment area (km^2)

In order to correctly calculate the proportion of yearly flow, the model is run in natural mode (without extractions or change in landuse conditions) before running in current and then future landuse modes.

3.2.2 Cease to Flow and Low Flow Statistics

The Tasmanian Surface Water AWBM was also modified to output cease to flow days and low-flow spells. Low-flow spells have been defined as flows under the 90th percentile natural (i.e. no extraction) flow. The 90th percentile natural flow is automatically input to the model for each subcatchment, and the number of days below this flow are counted. The output from the model is average low-flow spells per year.

Cease to flow days are counted cumulatively over the period of the model run and averaged over the number of years of the run.

3.3 AWBM inputs

Most inputs for the model will have previously been entered for catchments completed under the DPIW Surface water modelling project. These inputs are described in detail in the Surface Water Modelling report for the relevant catchment (e.g. Hydro Tasmania Consulting, 2004) and include:

- Information on the current water entitlement allocations in each subcatchment obtained from DPIW and input to the “In-Entitle” worksheet in the interface.
- Environmental flow requirements for each subcatchment, input in the “In-EnvF” worksheet
- Daily climate data sourced from the SILO data drill, Queensland Department of Natural Resources & Mining. The Department has made available 0.05o x 0.05o (about 5 km x 5 km) interpolated gridded rainfall data based on over 6000 rainfall stations in Australia.

Model inputs specifically for the planning tool are:

- Annual change in streamflow for each subcatchment. This is automatically populated from the GIS interface using the TasLUCaS equations.
- A “Rainfall factor” which is used to multiply all rainfall inputs to the model to investigate the effects of changes in rainfall on streamflow. This is automatically populated from the GIS interface.

3.4 Model Outputs

Outputs from the AWBM are displayed by subcatchment in the model interface. The outputs include:

- Annual and monthly flow statistics.
- Hydrologic disturbance indices (detailed in Appendix A). These are given for three cases:
    i. natural compared with current,
    ii. future landuse change scenario compared with current, and
    iii. future landuse change scenario compared with natural.

Both the natural and current reference conditions are used with the future landuse case. The future–natural indices are comparable with the current-natural indices, so give an indication of impact of any landuse change to the indices originally presented in the Tasmanian Surface Water Models. The future – current indices give a direct calculation of the impact of changes in streamflow on the indices.

- Number of cease-to-flow days per year under the current and landuse change scenarios.
- Flow duration curves for current, natural and landuse change conditions.
- Average annual streamflow and change in annual streamflow under landuse change scenario over the period of the model run.
- Low-flow spell analysis (average number of occurrences per year of flow spells less than the 90th percentile, for given spell lengths) over the period of the model run for current and landuse change scenarios.

4. IMPACTS ON ENVIRONMENTAL ASSETS

One of the purposes of the Planning Tool is to allow evaluation of the impacts of changes in streamflow on environmental assets. The Planning Tool by assesses the change in condition for various indices in the Conservation of Freshwater Ecosystem Values (CFEV) database for this evaluation.

4.1 Condition Mapping

For the purpose of this report, a river Condition is defined as:
"The degree of change from the 'natural' or pre-European settlement state for a high level, definable system category" An example of a system category is Sediment Input.

An Index is defined as:
"A predictor variable for a system Condition"
For example, e.g. RS_URBAN (degree of and impacts from urbanisation) is a predictor variable for the Sediment Input Condition.

A score is defined as:
"The numerical value for a river Condition or Index."

A value is defined as:
"The ordinal value, High, Medium or Low, associated with a particular score for a river Condition or Index."

This section of the report deals with the methods for assessing and mapping the impacts to river section conditions as a result of changes in the Flow Abstraction Index, RS_ABSTI. The term "mapping" describes the transformation of Index and Condition scores to ordinal values, which are defined by the Index lookup tables for the CFEV database, (V1.0 (2005)*)* and the Expert Rule tables as defined in Appendix 3 of the draft CFEV report (DPIW. In prep.)

The algorithm for determining the impacts to a given river section is as follows:

Part 1: Determine the current river Condition values.

1) Query the CFEV database for the current scores of all pertinent river section Indices.
2) Map the Index score to their corresponding values (via CFEV lookup tables).
3) Given 2) above, determine the resulting score for each Condition in the river section (via Expert Rule tables).
4) Map the scores in 3) to their corresponding ordinal values (via CFEV lookup tables).

The result is the Condition values, High, Low or Medium, for all river conditions (RS_SEDIN, RS_FLOW, RS_GEOM, RS_BUGSCO, RS_BIOL and RS_NSCORE).

Part 2: Determine the river Condition values for a change in the RS_ABSTI value.

This may be done by performing all of the steps in Part 1, but using the change in the MAF value from the AWBM model for RS_ABSTI, rather than the value contained in the CFEV database (Refer Section 4.3).

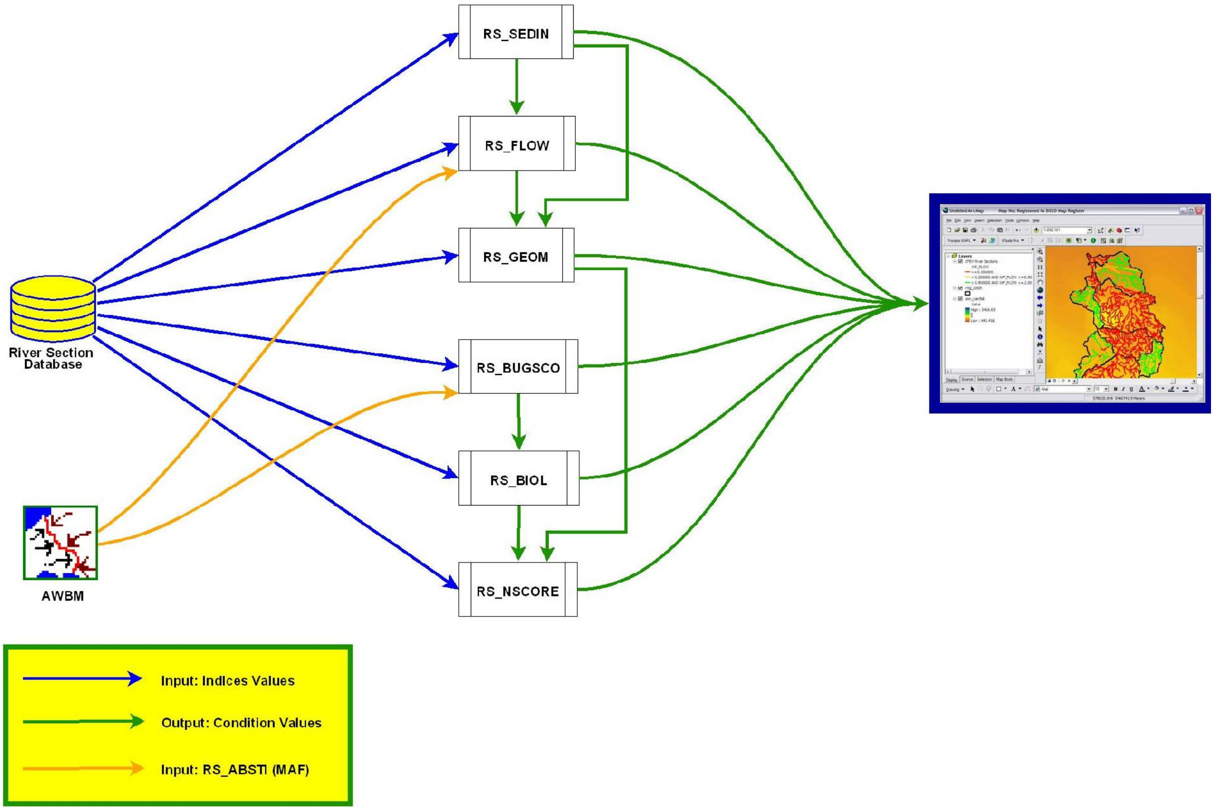

Figure 4.1: Data flow for assessing Rivers Section Conditions

Figure 4.1 graphically illustrates the relationships between the various river system Conditions. From this it can be seen that, whilst the output from the AWBM model feeds only into the ***RS_FLOW*** and ***RS_BUGSCO*** Conditions, the inter dependence of the expert rules is such that any change to the Index *RS_ABSTI* (or MAF, the surrogate used in this project) potentially results in changes to all but the ***RS_SEDIN*** Condition. Therefore, consistent with the aims of this project, all of the river system Conditions need to be re-evaluated whenever the Index, RS_ABSTI (MAF), changes.

The mappings between the numeric Index scores and their corresponding ordinal values (Low, Medium or High) are defined in the project database, described in Expert Rule Definitions, Section 4.3. This database provides a single repository and mechanism for determining ordinal values from numerical scores for both river Conditions and their associated Indices.

Whilst the lookup database will map Index scores to Medium values, the current Expert Rule Definition tables (as defined in DPIW. (in prep.)) do not define outcomes for any Medium Indices. In the event of an Index having a Medium value, the GIS interface will currently substitute this for a High value; this may be simply amended as required.

4.2 Estimating Change in Condition Index Score due to Landuse Change

The change in Mean Annual Flow Index due to change in landuse, calculated from the daily streamflow outputs from the AWBM, was used as a surrogate for a change in the condition score of the flow abstraction index, RS_ABSTI.

RS_ABSTI rates all river sections according to the amount of change in volume of long term mean annual flow ('yield') due to the net effects of all abstractions (removal) and diversions (into and out of the catchment) of water. RS_ABSTI takes into account hydro and WIMS abstractions and is obtained for each river section by dividing the Sum of Upstream Net Abstractions by the Natural mean annual runoff for the river section. Note that this Abstraction Index may be negative (<0) if the result is a net increase in flow from inter-catchment transfers, however the absolute value is used in condition determination.

In the Tasmanian Surface Water models, the Mean Annual Flow Index (MAF) provides a measure of the difference in total flow volume between current and natural conditions. It is calculated as the ratio of the current and natural mean annual flow volumes and assumes that increases and reductions in mean annual flow have equivalent impacts on habitat condition. A value of 1 represents no hydrological disturbance, while a value approaching 0 represents extreme hydrological disturbance. As the difference between 'current' and 'natural' conditions in the Tasmanian Surface Water Models are purely due to the differences in abstractions, this is considered a good indicator for RS_ABSTI.

To determine the impact on CFEV, the change in Mean Annual Flow Index due to landuse change ("Future Landuse to Natural" – "Current to Natural") was added to the RS_ABSTI value.

$$RS\_ABSTI_{new} = RS\_ABSTI_{old} + \Delta MAF$$

$$\Delta MAF = \frac{FutureLanduseFlow - CurrentFlow}{NaturalFlow}$$

The change in Mean Annual Flow is obtained on a subcatchment basis. This change is applied to the RS_ABSTI condition score for all reaches within the subcatchment. Where a reach crosses subcatchment boundaries, the appropriate value is applied to each section of the reach.

4.3 Expert Rule Definitions

The tables below were extracted from the lookup database described in Section 4.1, Condition Mapping. They detail the relationship between Index and Condition scores and their ordinal values, Low, Medium and High.

Routines within the GIS interface define score ranges as follows:

LB>= score >UB

where LB = score Lower Bound, UB = score Upper Bound

This is done in the same manner for both Conditions and their Indices.

There is no separate mapping given in this work for artificial pipes; such scores are represented simply as low impact outcomes (this corresponds to High values for Indices and Conditions).

These tables were extracted directly from the "*lookup tables for the CFEV database, V1.0 (2005)".*

To illustrate by example, a score of 0.5 for the Index RS_CATDI, in the Condition RS_SEDIN (Sediment Input – RS_SEDIN) will be mapped to a Medium value.

The actual Expert Rules Definition tables, used for the lookup and evaluation of Condition scores from Index values, are those given in Appendix 3 of the draft CFEV report (DPIW. In prep.).

4.3.1 Sediment Input – RS_SEDIN

Table 4.1: RS_SEDIN Index score-to-ordinal mapping

RS_SEDIN – Index lookup				
ConditionName	INDEX	LB	UB	Value
RS_SEDIN	RS_CATDI	0	0.05	L
RS_SEDIN	RS_CATDI	0.05	0.95	M
RS_SEDIN	RS_CATDI	0.95	999999	H
RS_SEDIN	RS_URBAN	0	0.0001	L

RS_SEDIN – Index lookup				
ConditionName	**INDEX**	**LB**	**UB**	**Value**
RS_SEDIN	RS_URBAN	1	999999	H

Note: for the above table, the score for the Index, RS_URBAN, is either 0 (significant impacts) or 1 (minor impacts), corresponding to Low and High values respectively. The value, 999999, is included for programmatic reasons only.

Table 4.2: RS_SEDIN Condition score-to-ordinal mapping

RS_SEDIN – Condition lookup			
ConditionName	**LB**	**UB**	**Condition**
RS_SEDIN	0	0.4	L
RS_SEDIN	0.4	0.8	M
RS_SEDIN	0.8	999999	H

4.3.2 Flow Change Condition – RS_FLOW

Table 4.3: RS_FLOW Index score-to-ordinal mapping

RS_FLOW – Index lookup				
ConditionName	**INDEX**	**LB**	**UB**	**Value**
RS_FLOW	RS_ABSTI	0.4	999999	L
RS_FLOW	RS_ABSTI	0.1	0.4	M
RS_FLOW	RS_ABSTI	0	0.1	H
RS_FLOW	RS_FLOVI	0	0.1	L
RS_FLOW	RS_FLOVI	0.1	0.5	M
RS_FLOW	RS_FLOVI	0.5	999999	H
RS_FLOW	RS_REGI	0.15	999999	L
RS_FLOW	RS_REGI	0.05	0.15	M
RS_FLOW	RS_REGI	0	0.05	H

Table 4.4: RS_FLOW Condition score-to-ordinal mapping

RS_FLOW – Condition lookup			
ConditionName	**LB**	**UB**	**Condition**
RS_FLOW	0	0.4	L
RS_FLOW	0.4	0.8	M
RS_FLOW	0.8	999999	H

4.3.3 Geomorphic Condition – RS_GEOM

Table 4.5: RS_GEOM Index score-to-ordinal mapping

RS_GEOM – Index lookup				
ConditionName	**INDEX**	**LB**	**UB**	**Value**
RS_GEOM	RS_FLOW	0	0.4	L
RS_GEOM	RS_FLOW	0.4	0.8	M
RS_GEOM	RS_FLOW	0.8	999999	H
RS_GEOM	RS_GEORESP	0	0.0001	L
RS_GEOM	RS_GEORESP	0.5	0.5001	M
RS_GEOM	RS_GEORESP	1	999999	H
RS_GEOM	RS_SEDCA	0.8	999999	L
RS_GEOM	RS_SEDCA	0.1	0.8	M
RS_GEOM	RS_SEDCA	0	0.1	H
RS_GEOM	RS_SEDIN	0	0.4	L
RS_GEOM	RS_SEDIN	0.4	0.8	M
RS_GEOM	RS_SEDIN	0.8	999999	H

Table 4.6: RS_GEOM Condition score-to-ordinal mapping

RS_GEOM – Condition lookup			
ConditionName	**LB**	**UB**	**Condition**
RS_GEOM	0	0.2	L
RS_GEOM	0.2	0.8	M
RS_GEOM	0.8	999999	H

4.3.4 Macroinvertebrate Condition – RS_BUGSCO

Table 4.7: RS_BUGSCO Index score-to-ordinal mapping

RS_BUGSCO– Index lookup				
ConditionName	**INDEX**	**LB**	**UB**	**Value**
RS_BUGSCO	RS_ABSTI	0.15	999999	L
RS_BUGSCO	RS_ABSTI	0.05	0.15	M
RS_BUGSCO	RS_ABSTI	0	0.05	H
RS_BUGSCO	RS_BUGSOE	0	0.4	L
RS_BUGSCO	RS_BUGSOE	0.4	0.8	M
RS_BUGSCO	RS_BUGSOE	0.8	1.0001	H
RS_BUGSCO	RS_FLOVI	0	0.5	L
RS_BUGSCO	RS_FLOVI	0.5	0.9	M
RS_BUGSCO	RS_FLOVI	0.9	1.0001	H

Table 4.8: RS_GEOM Condition score-to-ordinal mapping

RS_BUGSCO – Condition lookup			
ConditionName	**LB**	**UB**	**Condition**
RS_BUGSCO	0	0.5	L
RS_BUGSCO	0.5	0.8	M
RS_BUGSCO	0.8	999999	H

4.3.5 Biological Condition – RS_BIOL

Table 4.9: RS_BIOL Index score-to-ordinal mapping

RS_BIOL – Index lookup				
ConditionName	**INDEX**	**LB**	**UB**	**Value**
RS_BIOL	RS_BUGSCO	0	0.5	L
RS_BIOL	RS_BUGSCO	0.5	0.8	M
RS_BIOL	RS_BUGSCO	0.8	1.0001	H
RS_BIOL	RS_EXOTICF	0	0.0001	L
RS_BIOL	RS_EXOTICF	0.04	0.0401	L
RS_BIOL	RS_EXOTICF	0.32	0.3201	M
RS_BIOL	RS_EXOTICF	0.65	0.6501	M
RS_BIOL	RS_EXOTICF	0.8	0.8001	H
RS_BIOL	RS_EXOTICF	1	1.0001	H
RS_BIOL	RS_FISHCON	0	0.0001	L
RS_BIOL	RS_FISHCON	0.5	0.5001	M
RS_BIOL	RS_FISHCON	1	999999	H
RS_BIOL	RS_NRIPV	0	0.2	L
RS_BIOL	RS_NRIPV	0.2	0.8	M
RS_BIOL	RS_NRIPV	0.8	999999	H

Note: for the above table, the score for the Index, RS_EXOTICF, will be one of several different states; 0 and 0.04 for low impacts, 0.32 and 0.65 for medium impacts, 0.8 and 1.0 for high impacts; these correspond to Low, Medium and High values respectively.

Table 4.10: RS_BIOL Condition score-to-ordinal mapping

RS_BIOL – Condition lookup			
ConditionName	**LB**	**UB**	**Condition**
RS_BIOL	0	0.4	L
RS_BIOL	0.4	0.8	M
RS_BIOL	0.8	999999	H

4.3.6 Naturalness Condition – RS_NSCORE

Table 4.11: RS_NSCORE Index score-to-ordinal mapping

RS_NSCORE – Index lookup				
ConditionName	**INDEX**	**LB**	**UB**	**Value**
RS_NSCORE	RS_GEOM	0	0.6	L
RS_NSCORE	RS_GEOM	0.6	0.85	M
RS_NSCORE	RS_GEOM	0.85	999999	H
RS_NSCORE	RS_BIOL	0	0.4	L
RS_NSCORE	RS_BIOL	0.4	0.8	M
RS_NSCORE	RS_BIOL	0.8	999999	H

Table 4.12: RS_NSCORE Condition score-to-ordinal mapping

RS_NSCORE – Condition lookup			
ConditionName	**LB**	**UB**	**Condition**
RS_NSCORE	0	0.6	L
RS_NSCORE	0.6	0.85	M
RS_NSCORE	0.85	999999	H

4.4 Modifications to Condition Index Score

The mappings between Index values and Condition scores are based on the Expert Rule definition tables as at the date of this report. It is important to note that modifications/reruns of the CFEV program may result in different Condition scores for the various permutations of Low, Medium and High values of the respective Indices.

In such an event, the Expert Rule lookup tables in the database supplied with this project will need to be amended (these are simply transcribed directly from Appendix 3 of the draft CFEV report (DPIW. In prep.)). The tables in question are:

- ER_RS_SEDIN
- ER_RS_FLOW
- ER_RS_GEOM
- ER_RS_BUGSCO
- ER_RS_BIOL
- ER_RS_NSCORE

4.5 Display of Condition Index Score

A GIS display tool is provided to enable impacts of landuse change on CFEV condition scores to be investigated. This classifies various conditions into High (red), Medium (orange) and Low (green). The default threshold values are supplied by the CFEV expert rule database tables, but these values can be changed by the user if desired. The display tool gives the option of classifying data by current scenario or by future scenario (averaged over the model run).

5. REFERENCES

Brown, A.E., P.B.Hairsine, A. Freebairn (2006): *The development of the Tasmanian Land Use Change and Stream Flow (TasLUCaS) tool*. CSIRO Land and Water Science Report 54/06

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Hydro Tasmania Consulting (2004): *NAP Region Hydrological Models, Ringarooma Catchment*, Department of Primary Industries Water and Environment.

Sinclair Knight Merz (2005): *Natural Resource Management (NRM) Monitoring and Evaluation Framework*, Murray Darling Basin Commission, MDBC 08/04.

6. GLOSSARY

AWBM	Australian Water Balance Model
CFEV	Conservation of Freshwater Ecosystem Values
DPIW	Department of Primary Industries and Water
HTC	Hydro Tasmania Consulting
TasLUCaS	Tasmanian Land Use Change and Streamflow tool
MAF	Mean Annual Flow Index

incompleteness or similar defect in the information or any default, negligence or lack of care in relation to the preparation or provision of the information.

7. APPENDIX A – HYDROLOGIC DISTURBANCE INDICES

There are three hydrologic indices calculated. These used:

- Natural flows and current flows (farm dams and irrigation);
- Natural flows and future landuse flows;
- Current flows and future landuse flows.

The indices include:

- Hydrological Disturbance Index
- Index of Mean Annual Flow
- Index of Flow Duration Curve Difference
- Index of Seasonal Periodicity
- Index of Seasonal Amplitude

The indices were calculated using the formulas stated in the Natural Resource Management (NRM) Monitoring and Evaluation Framework developed by SKM for the Murray-Darling Basin (MDBC 08/04).

Hydrological Disturbance Index: This provides an indication of the hydrological disturbance to the river's natural flow regime. A value of 1 represents no hydrological disturbance, while a value approaching 0 represents extreme hydrological disturbance.

Index of Mean Annual Flow: This provides a measure of the difference in total flow volume between current and natural conditions. It is calculated as the ratio of the current and natural mean annual flow volumes and assumes that increases and reductions in mean annual flow have equivalent impacts on habitat condition.

Index of Flow Duration Curve Difference: The difference from 1 of the proportional flow deviation. Annual flow duration curves are derived from monthly data, with the index being calculated over 100 percentile points. A measure of the overall difference between current and natural monthly flow duration curves. All flow diverted would give a score of 0.

Index of Seasonal Amplitude: This index compares the difference in magnitude between the yearly high and low flow events under current and natural conditions. It is defined as the average of two current to natural ratios. Firstly, that of the highest monthly flows, and secondly, that of the lowest monthly flows based on calendar month means.

Index of Seasonal Periodicity: This is a measure of the shift in the maximum flow month and the minimum flow month between natural and current conditions. The numerical value of the month with the highest mean monthly flow and the numerical value of the month with the lowest mean monthly flow are calculated for both current and natural conditions. Then the absolute difference between the maximum flow months and the minimum flow months are calculated. The sum of these two values is then divided by the number of months in a year to get a percentage of a year. This percentage is then subtracted from 1 to give a value range between 0 and 1. For example a shift of 12 months would have an index of zero, a shift of 6 months would have an index of 0.5 and no shift would have an index of 1.