THIS IS AN EXTRACT FROM A INTERNAL REPORT PRODUCED FOR THE DEPARTMENT OF WATER AND SANITATION (DWS)

CURSORY DESCRIPTION OF THE INFORMATION FLOW (LINKAGES) AMONG SOFTWARE SYSTEMS APPLIED BY DWS

(Original Document: February 2018)

1 BRIEF DESCRIPTION OF THE WATER RESOURCE MODELS & WRMF

1.1 Pitman model (rainfall-runoff simulations)

The purpose of the Pitman model (WRSM2012) is to prepare natural time series and other module parameters that are needed for the simulation models; WRYM, WQT and WRPM.

The primary functions of the Pitman model entail the following:

- Configure and define a network layout of modules representing all the elements in a catchments and river system in accordance with a study specific resolution definition. The network resolution is define by the catchment area size coupled with the river reaches requiring explicit simulations within the river system or water resource system being studied.
- Calibrate the Runoff Units (which simulates runoff from rainfall) by iteratively adjusting relevant parameters in order to obtain the best comparison between simulated and observed stream flow time series. This is achieved by simulating the changes in all catchment activities as they occurred during the historical period for which the calibration simulation is performed. (The calibration period is defined by the availability of reliable rainfall and gauged flow time series data.)
- Perform simulations to derive the natural and present day (constant development) flow time series. The monthly natural flow time series is used for historical analyses in WQT, WRYM and WRPM as well as the stochastic stream flow modelling process.

1.2 Water Quality (Salinity) Calibration Model (WQT)

The WQT model simulates Dissolved Major Solids (DMS) and Sulphate with the purpose of calibrating the various water quality modules. A network structure is defined to represent the river and catchment configuration of a particular water resource system. There are seven module or simulation elements, each can be linked to the system network in according to the layout of the river system

1.3 Water Resource Yield Model (WRYM)

The purpose of the Water Resource Yield Model (WRYM) is to determine the yield capability of water resource systems through monthly simulations using historical and stochastic hydrology (runoff) for constant catchment development scenarios.

The model functions include the following:

- Long-term yield determination, historical and stochastic – risk analyses.

- Determine subsystem operating rules.
- Derive short-term yield vs. reliability curves.
- Hydropower production estimation.
- Assess water availability for water use allocation planning.

The main characteristics of WRYM are:

- Network defines river layout (configuration).
- Modularly configure elements, including: Irrigation, Wetland. Mine, Stream flow Reduction activities.
- Flexible method to model water resource system operating rules
- Apply network linear solver to enable transfer and supply operating rules.

1.4 Water Resource Planning Model (WRPM)

The Water Resource Planning Model (WRPM) is designed to undertake projection risk analysis for a 10 to 50 year planning horizon providing analytical support for development and operations planning of water resource systems. The primary result of the model is a projection of the annual risk of drought restrictions based on planned infrastructure changing and scenarios (estimates) of future water requirement and return flows.

The model functions include the following:

- Multi user sector hierarchal or priority based drought restriction (allocation) - using risk classes with criteria and the short-term balance between water yield and water requirements.
- Water quality blending and dilution rules.
- Simulate changing infrastructure, operating rules as well as water requirements and return flows in the projection risk analysis.
- Hydropower production estimation.

The main characteristics of the model are:

- Network defines river layout (configuration).
- Modularly configure elements (see WRYM above).
- Flexible method to model water resource system operating rules, these can be changes over the simulation period.
- Apply network linear solver to enable complex transfer and supply operating rules.
- Water quality modelling (Major Dissolves Salts and Sulphate.

1.5 Water Resource Management Framework (WRMF)

DWS has developed the Water Resource Management Framework (WRMF) to provide information management of data applied in water resource analysis processes. It serves as a Graphical User Interface with data entry Dialogs (windows) and result display methods from some of the simulation models. The WRMF provides information management for the following:

- WRYM and WRPM.
- Rainfall (Rainfall data Information Management System).
- Stomsa (Stochastic streamflow model of South Africa).
- Daily Diversion (Determine monthly flow diversion efficiency characteristics using daily data analysis).

- IFR Pre-processing (Prepare IFR – parameters for the ecological water requirements simulation element – also known as the Instream Flow Requirements (IFR).
- Rain Water Harvesting (RWH): Calculate how many days a family can be supplied with rainwater.

2 INFORMATION FLOW (LINKAGES) AMONG SOFTWARE SYSTEMS

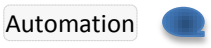
The flow of information (data) between the software systems and analyses processes is displayed in the schematic diagram presented in **Figure 2-1** and discussed in this document.

2.1 Orientation of Figure 2-1

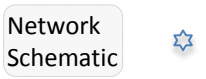
The blue blocks in the diagram represent the four simulation models as well as the WRMF, the arrows represent the direction in which electronic information (data) is passed (flows) among the elements. Bi-directional arrows indicate that information is interchanged between the software systems.

The Legend items in **Figure 2-1** have the following meaning:

- Represents processes carried out by analysts to convert electronic data from one format to another.
- This may include calculations but mostly is to change the format of the data from one model to the next.
- This involves manual steps using file editors and/or Excel spreadsheets.



- Indicates where there are current software algorithms that perform iterative analysis automatically.
- Each of the automaton processes (A, B, C and D) are describe in subsequent paragraphs.



- Indicates that all the models make use of network schematics, which is the visual representation of the electronic network – an essential tool used by analysts to “interact” with the software systems.
- The electronic network and the schematic represent the layout and interconnectivity of the water resource system of rivers, catchments, transfer conduits and reservoirs.

- This symbol indicates data (set of electronic files) either results from the associated model or input data for the model.
- The format of all the datasets are text of ASCII files.

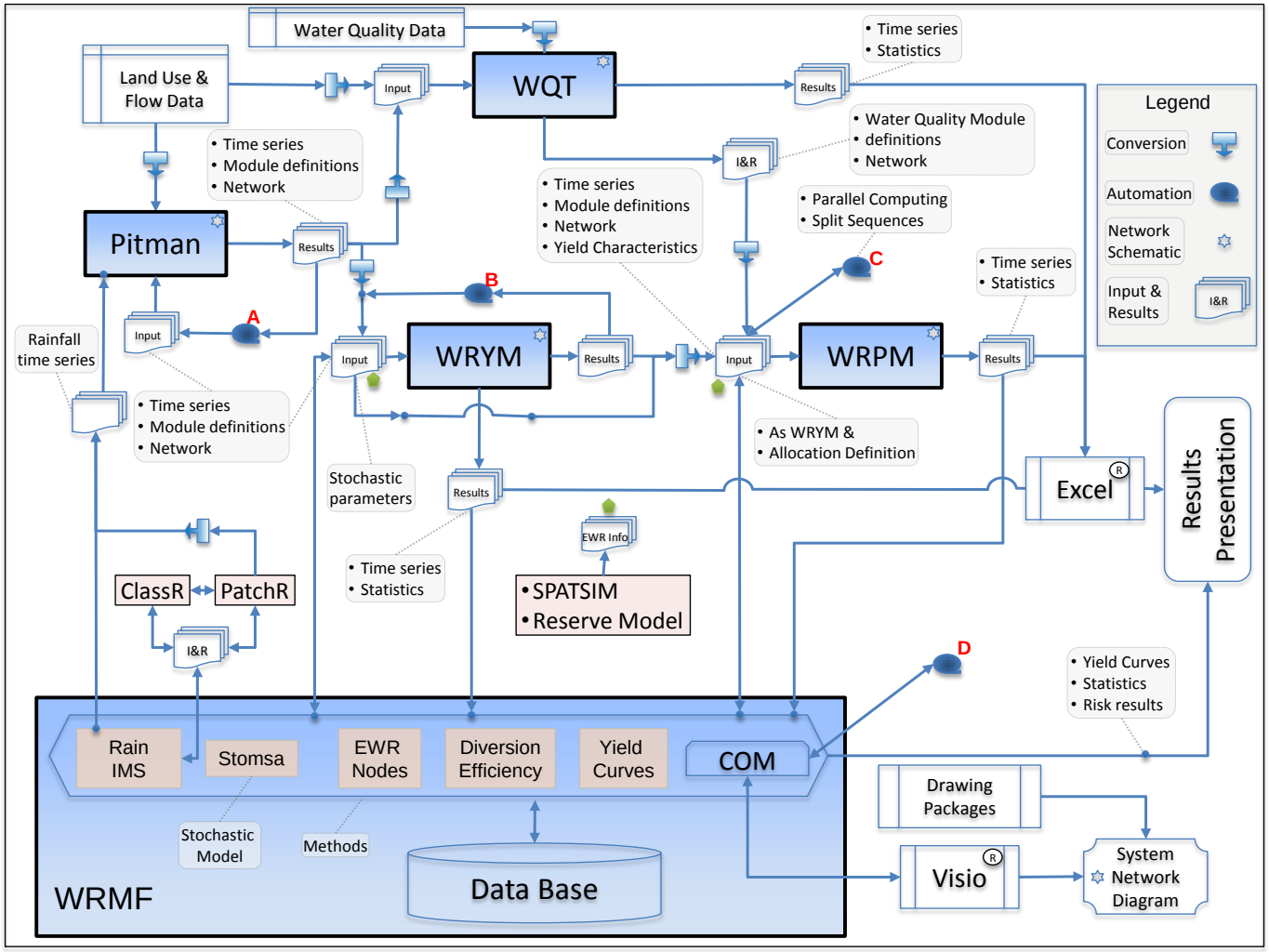
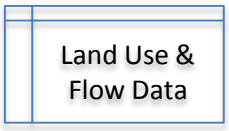


Figure 2-1: Schematic of the Water Resource Analysis Processes (linkages between software systems)

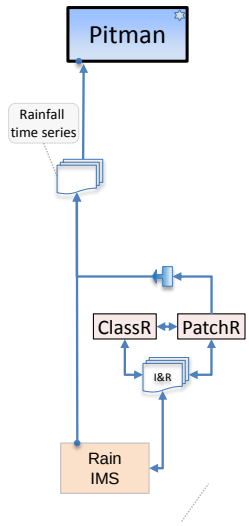
2.2 Description of processes and information flow (linkages)

Hydrology related processes:

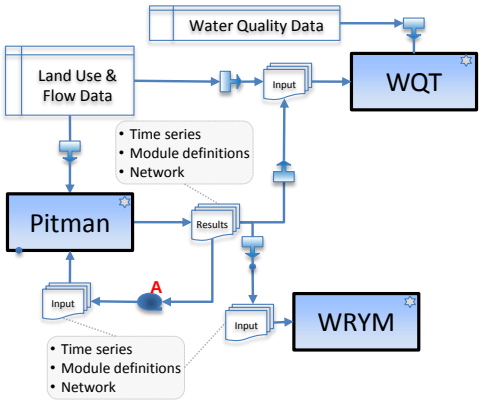
The processes shown on **Figure 2-1,** likened to the Pitman model, is commonly referred to as hydrological analysis and has the purpose to develop hydrological data (time series and module parameters) required by the other simulation models. See descriptions below:



- This "Land Us" component represents all data required to model the implications of various land use activities have on the water balance is a river system of catchment.
- The "Flow data" is the available measured river, transfer and abstractions flow data. Much human resource time is spent to analyse these for consistency and eliminate all unreliable data.

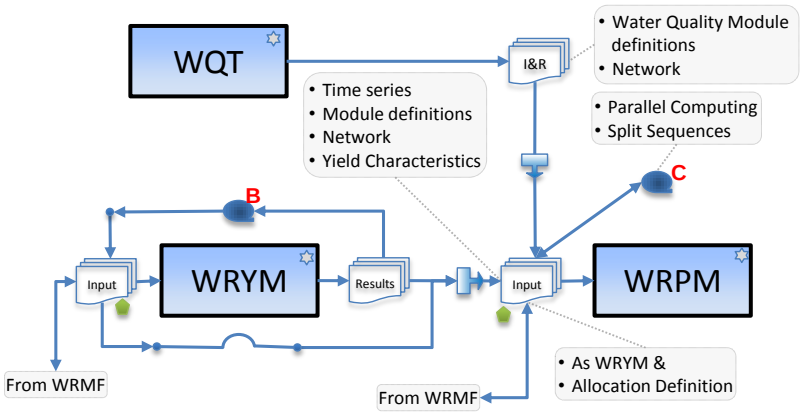


- This leg of the diagram indicates the processes relating to rainfall data analysis.
- The Rain IMS module in WRMF consists of a rainfall time series database and various methods to select, display, compare and analyse the available data.
- ClassR and PatchR are standalone Fortran software systems dealing with the classification of rainfall stations and infilling (patching) on missing or unreliable monthly data.
- The rain station data from PatchR and ClassR are converted to catchment rainfall for use in the Pitman rainfall runoff model.



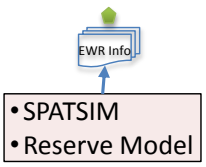
- A : Automation of analysis to produce storage vs. yield results for selected failure recurrence intervals using an Excel utility and iteratively running the Pitman Model.
- Due to the differences in file formats or structure of Pitman, WQT and WRYM, various conversion steps are required to prepare the input text files as indicated [ ].
- The preparation of water quality data for WQT requires various pre-processing steps to convent, infill and validate recorded data.
- There are typically changes required to the network schematic [ ] using drawing software (CAD, Visio, Corel Draw ect.) in order to:
  - Represent different functionalities of the models.
  - Different focus of the analysis carried out with each model.

Yield and planning analysis processes:



- [B] Automation using Excel utility to analyse multiple sets of inter reservoir operating rules for optimisation.
- [C] Undertake split sequences analysis to utilise multiple computer processes. Manualy configured using Power Shell.

- The input data for WRYM and WRPM are in text file format and once configured manually in WRMF (through dialogs) can directly be exported (and imported) for analysis from the WRMF, **except for the water quality data**. *The required data management methods and data base tables for WQT has not been incorporated in the WRMF*. The WRMF management of WRPM is therefor only limited to systems where water quality is not modelled.
- **WRMF does not have functionality to manage Pitman or WQT data**. There are two processes to populate WRYM and WRPM:
  a) Through Dialogs in WRMF (see above).
  b) In most cases data is manually converted (from Pitman and WQT) using text editers and Excel. Thereafter the WRYM input text file can be imported into WRMF.
- Note that although many input parameters are identical, **the structure and format of the input data for WQT, Pitman, WRYM and WRPM are different** requering mannual conversions.
- There are duplicat network definitions defined in the WRPM when water quality is simulated in for a water serource system. Due to this there are many manual steps to undertake modification. **It is recommended that this data structure of WRPM be consolidated to eliminate the need for duplicate input data.**



- [ ] The data input of WRYM and WRPM to simulate the Ecological Water Requirments (EWR) is produced by SPATSIM or Reserve Determination software system.
- Adjustments of the EWR structures are caried out from time to time using Excel utilities. Typically these adjustments are to up or down scale the EWR flows to other river locations or to scale the EWRs in cases where the natural hydrology has changed.

Water Resource Management Framework (WRMF) components:

Stomsa

- STOMSA: Performs the parameter estimation and verification test of the Stochastic Streamflow Model - Delphi version.

EWR Nodes

- Defining the reference inflow nodes for the EWR method.

Diversion Efficiency

- Calculate the monthly diversion efficiency relationship used in WRYM and WRPM.
- Use daily flow data and allow for EWR releases.

Yield Curves

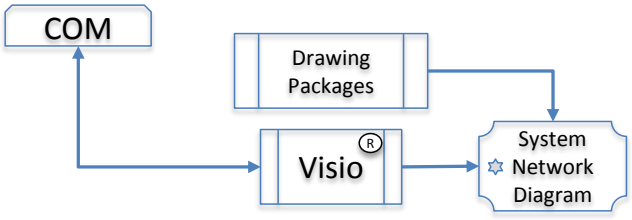
- Develop the yield vs. reliability curves from WRYM simulation results.
- Prepare graphs and equation parameters – used in WRPM for the allocation procedure to calculate the level of drought restrictions.

COM

- The COM server provides programmatic access to data management methods in WRMF from Excel, Visio and other software system able to utilise COM libraries.

System network schematics:

The schematic diagrams of water resource systems are an essential visual aid, extensively used by the system analysts across all the analysis processes.



- Schematic network diagrams are generated and maintained by drawing packages or Microsoft Visio.
- The drawing software packages are typically CAD, Power Point and Corel Draw.
- There are various methods in the COM server that provide programmatic access to Dialogs and data using VB scrip functionality in Visio.
- In both the above cases it remains the analysts' responsibility to ensure the network schematics are up to date. **It is proposed that alternative methods of generating schematics be investigated.**

Result processing and presentation processes:

Result processing procedures have the purpose to convert the simulation results into information for:

a) Interpretation and evaluation by the analyst and

b) Information to communicate to decision makers and stakeholders.

WRMF

- Methods for producing graphs, tables and statistics are built into the WRMF.
- The process requires importing of the appropriate result text files from WRYM and WRPM.
- The selection of elements to display graphically is through a tree view dialog.

Excel

- Several Excel utilities have been developed to read the result files from WRPM and WRPM and bulk or batch process the generation of graphs from predefined list of elements.
- Excel is also used to auto generate monthly monitoring reports for to track simulation results against recorded data. These are converted to pdf and emailed to stakeholders.

Results Presentation

- Result presentation of the analysis are required to:
  a) Document the analysis in study reports.
  b) Present the results to managers, stakeholders and decision makers.
- Power Point is the primary software package applied to import the require graphs or tables (mainly from Excel) and provide explanatory annotations to highlight pertinent observations.
- Note that due the presence of VB script capability in PowerPoint and MS Word, auto generation of documents using the results from the software systems can be developed.