4. ANALYSIS PROCEDURE

4.1. OVERVIEW OF THE MODEL

The Water Resources Yield Model (WRYM) of the South African Department of Water Affairs (1999) is a network model which uses a sophisticated network solver in order to analyse complex water resource systems under various operating scenarios. The strength of the WRYM lies in the ability to change the operating rules via the external system data files and no changes to the actual program source code are required.

The WRYM is based on the assumption that a water resource system can be represented by a flow network. A water resource system can be configured using nodes and links to represent the various elements of the system being modelled. By careful selection of penalty structures, the network can be analysed for each time period and solved using an efficient network solver which has evolved from network programming techniques. The WRYM can represent any water resource system which incorporates the following physical processes:

- Naturalised inflows;
- Precipitation and evaporation associated with reservoirs;
- Diffuse irrigation and afforestation demands from the various catchments:
- Storage and releases of water from reservoirs;
- Physical discharge controls at the outlets from reservoirs;
- Specified inflows from adjacent subsystems on a monthly basis;
- Specified demands (e.g. agricultural, industrial and municipal),
- Water flow in channels (e.g. natural streams, diversion channels, minimum flow channels, multi-purpose min-max channels, pumping channels etc.); and
- Losses in conveyance channels.

The WRYM is capable of simulating a wide range of operating policies governing the allocation of water in a multi-purpose multi-reservoir system. Water resource problems involving energy production, flood control, water supply, irrigation, low flow augmentation, diversion and navigation requirements can be modelled using WRYM. A major advantage of the WRYM is its flexibility in allowing the user to define operating policies governing the allocation of water by altering penalty structures in the data set rather than modifying the source code of the program. Full details of the background and application of the WRYM are provided in the User Guide (South African Department of Water Affairs, 1999).

The WRYM was designed to assess the long-term yield capabilities of a system for a given operating policy. It is used to analyse systems at constant development levels (i.e. the system and the system demands remain constant throughout the full simulation period). The WRYM can be used to analyse a historical flow sequence - usually in the order of 20 to 80 years in length. Unfortunately results obtained from historical analyses alone can be very misleading and depend to a great extent on the period of record used in the analysis.

To this end, stochastic flow sequences are also included in the analysis process. Clearly it is extremely important to specify not only the yield values but also the corresponding level of assurance or alternatively risk of failure. The reliability associated with a given yield is of the utmost importance and provides an indication of the level of assurance or risk of failure associated with the yield value.

4.2. DESCRIPTION OF PENALTY TYPES

A typical WRYM system schematic is presented in **Figure L.1** in **Annexure L**. Both penalty structures for the dam storage zones and penalty structures for the channel reaches are depicted in this schematic. **Figure 4.1** indicates a typical penalty structure for the storage component of a dam. There are three "columns" in the figure, namely the zone boundary name, the zone penalty and the zone boundary elevation.

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FSL	10000	630.5 masl
RCL	5	628.0 masl
DSL	15	625.0 masl
Bottom	10000	622.0 masl

Figure 4.1 : Typical penalty structure for a dam indicating different storage zones.

The elevation defines the levels relative to mean sea level of the boundaries of the various zones used in the penalty structure. In this case there are four such zones, which are described below :

- The uppermost zone represents the flood zone and comprises anything above the full supply level (FSL) of 630.5 m.a.s.l. If water enters this zone it does so at a penalty of 10 000 units and is therefore a very "costly" zone in which to store water.

- The second zone is between the FSL (630.5 m.a.s.l.) and a selected Rule Curve Level (RCL) of 628.0 m.a.s.l. This is one of the working storage zones of the reservoir which has a penalty of 5 units. All zones below the FSL can be thought of as having a value rather than a penalty associated with them. For example, any water in the second zone has a value of 5 units, and it will therefore incur a penalty of 5 units to take water from this zone to meet a demand elsewhere.

- The third zone is between the RCL and the dead storage level (DSL) of 625.0 m.a.s.l. Water in this zone has a value of 15 units and represents the other working storage zone of the reservoir.

- The water between the DSL and the bottom of the dam (622.0 m.a.s.l.) has a value of 10 000 units and the penalty is such that it will be very "costly" to draw water from this zone, so it will not contribute to meeting the yield.

The four penalties used in this scenario have the effect of restricting the working storage of the dam to the second and third zones. Should a second dam be utilised in the system then the penalties of the working storage behind that dam would have to be of appropriate values so as to create an operating rule which prioritises the sequence of abstractions from the various working storage zones. It should be noted that a dam should have at least one working storage zone but it can have a maximum of seven if required by an operating rule.

In most cases, the channel penalties take the forms shown in **Figure 4.2**. The two examples in this figure would be used to represent the following :

- Channel 35 , is a general flow channel that has a single penalty structure for an unlimited flow. The range in flows is between zero and infinity and the associated penalty for this range is 0 units.

- Channel 5 is a demand channel that has a double penalty structure for a specified demand (Dem). Any shortfall in this demand results in a penalty of 250 units. There is a zero penalty if the demand is supplied in full.

These are examples of two of many penalty structures which may be used in an analysis.

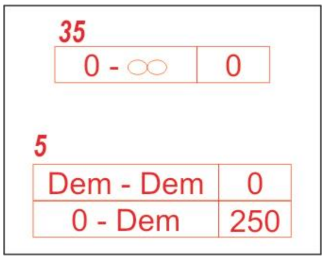

Figure 4.2 : Typical penalty structures for system channels.