XP rafts

URBAN & RURAL RUNOFF ROUTING APPLICATION

xpsoftware

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TECHNICAL DESCRIPTION

Graphical Expert Environment (XP)

The graphical EXPERT environment, (XP), is a friendly, graphics based environment utilized by a range of software developed by XP Software. It encompasses data entry, run-time graphics and post-processing of results in graphical form.

With xprafts the EXPERT shell acts as an interpreter between the user and the model in the classical style of an embedded expert system. The environment incorporates both pre-and post-processors which use the expert knowledge of experienced users to filter the input data and to create and interpret a valid and reasonable model of the system being simulated.

The EXPERT environment of xprafts allows the engineer to devote more time to gaining an understanding of the problem rather than devoting significant effort to the mechanical tasks of entering and checking data, getting a program to run and interpreting reams of output. xprafts will revolutionize your Urban and Rural Stormwater Drainage practice. The program allows you to quickly and confidently create and solve your drainage network. You will have answers in hours instead of days.

xprafts allows you to work with your CAD and GIS drawings to create a scaled view of the drainage basin being considered. A detailed base map may be used and the drainage network created as a layer on top of this map. Base maps may be used from every major CAD and GIS package.

Overview

xprafts is a non-linear runoff routing model used extensively throughout Australasia and South East Asia. xprafts is has been shown to work well on catchments ranging in size from a few square meters to 1000's of square kilometers of both urban and rural nature. xprafts can model up to 2000 different nodes and each node can have any size subcatchment attached as well as a storage basin. xprafts uses the Laurenson non-linear runoff routing procedure to develop a stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or a design storm utilizing Intensity-Frequency Duration data together with dimensionless storm temporal patterns as well as standard AR&R 1987 data. In the xprafts 2009 (aka v8.0), a PMP (Probable Maximum Precipitation) generation module has been incorporated, which simulates PMP for Australia for short or long durations.

Three loss models may be employed to generate excess rainfall. They are (1) Initial/Continuing, (2) Initial/Proportional and (3) the ARBM water balance model. A reservoir (pond) routing model allows routing of inflow hydrographs through a user-defined storage using the level pool routing procedure and allows modeling of hydraulically interconnected basins and on-site detention facilities.

Three levels of hydraulic routing are possible including simple Manning's based lagging in pipes and channels, the Muskingum-Cunge procedure to route hydrographs through channel or river reaches or the hydrographs may be transferred to the xpswmm/xpstorm hydrodynamic simulation model.

Hydrology

Hydrograph Generation

The Laurenson runoff routing procedure is used in xprafts for the following reasons:

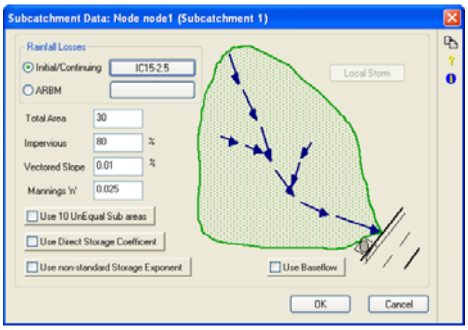
- it offers the most flexible model to simulate both rural and urban catchments
- it allows for non-linear response from catchments over a large range of event magnitudes
- it considers time-area and subcatchment shape
- it offers an efficient mathematical procedure for developing rural, urban, and mixed runoff hydrographs at any subcatchment outlet.

Data requirements for the xprafts consist of:

- catchment area
- slope
- degree of urbanization
- loss rates
- observed or design rainfall

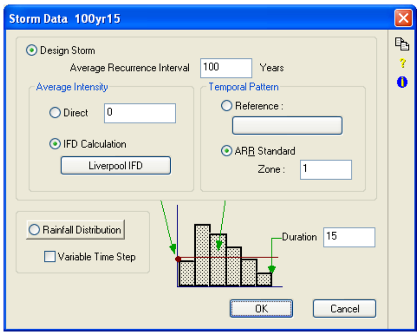
These data are used to compute the storage delay coefficient for each of the subcatchments and hence to develop the non-linear runoff hydrograph. A default exponent is adopted although the user may override this value with either a different non-linear exponent or a rating table of flow vs. exponent to define different degrees of catchment non-linear response.

Each subcatchment is divided into 10 sub-areas. Each of the sub-areas is treated as a cascading non-linear storages obeying the relationship $S=bQ^n$, where n by default is set to -0.285 and b is computed from observed catchment event data or specified in terms of the catchment parameters. The rainfall is applied to each sub-area, an excess computed and the excess converted into an instantaneous inflow. This instantaneous flow is then routed through the subarea storages to develop individual subcatchment outlet hydrograph.



Any local Intensity-Frequency-Duration information may be used to generate the hydrographs. Rainfall input can be of two types, either Design Rainfall or Historic Events. Design rainfall may be entered as a dimensionless temporal pattern with average rainfall intensity or in Australia may be extracted directly from AR&R 1987. Within Australia, the intensity information may be entered from Volume 2 of AR&R 1987 and the appropriate intensity for the given ARI and duration will be computed automatically. The Zone may be entered and the appropriate temporal pattern will be automatically selected from the inbuilt standard temporal patterns from AR&R 1987.

Historical events may be entered by the user in either fixed time steps or variable time steps allowing long lengths of record to be defined relatively easily. Alternatively the rainfall data may be read from an external rainfall file in either of two ASCII text formats. They are the HYDSYS file format or the XPX file format.

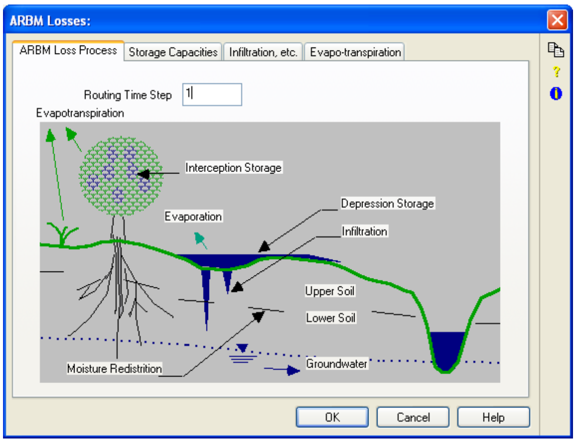


Loss Models

The rainfall excess may be computed using either of the following methods:

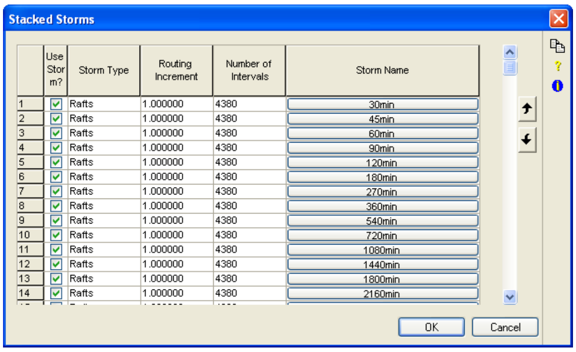
- Initial/Continuing: The initial depth of rainfall which is lost is specified along with a continuing rate of loss. For example 15mm initial loss plus 2.5 mm/hr of any further rainfall.
- Initial/Proportional: The initial depth of rainfall which is lost is specified along with a proportion of any further rain which will be lost. For example 15mm initial and 0.6 times any further rainfall.
- ARBM Loss method: Infiltration parameters to suit Philip's infiltration equation using comprehensive ARBM algorithms are used to simulate catchment infiltration and subsequent rainfall excess for a particular rainfall sequence and catchment antecedent conditions. Data describing such things as the sorptivity, hydraulic conductivity, upper and lower soil storage capacities, soil moisture redistribution, groundwater runoff and catchment drying are required. Many of these data may be found from field measurements and this model allows for more realistic modeling of catchment response to storms especially with multiple

bursts. A proportion of the outflow from the ARBM loss method may be redirected as base flow in a given reach.

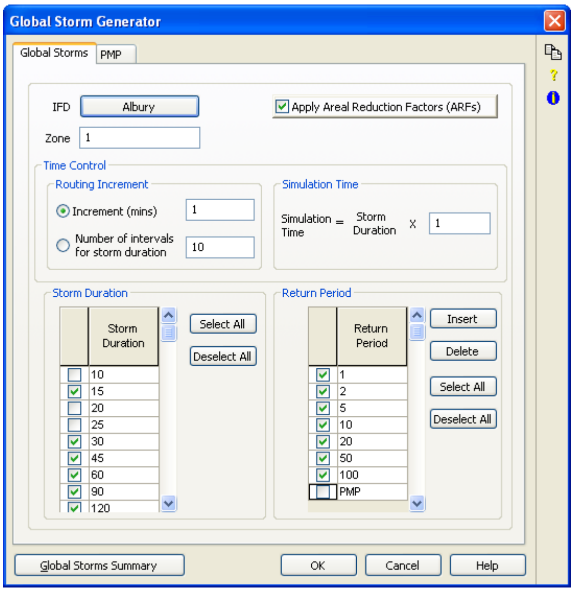


Storms

Any number of storm events may be analyzed in the same run and the results displayed on screen to determine quickly the critical duration for each location in the drainage system. Simulation runs of any length, from minutes to years, may be accommodated.

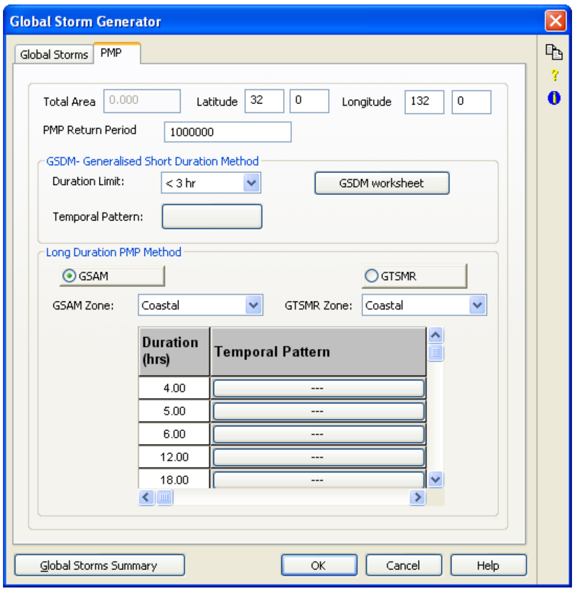


A new Automatic Storm Generator is included in version 8.0, which allows the user to generate storms with any durations and return periods including PMP for the study area.



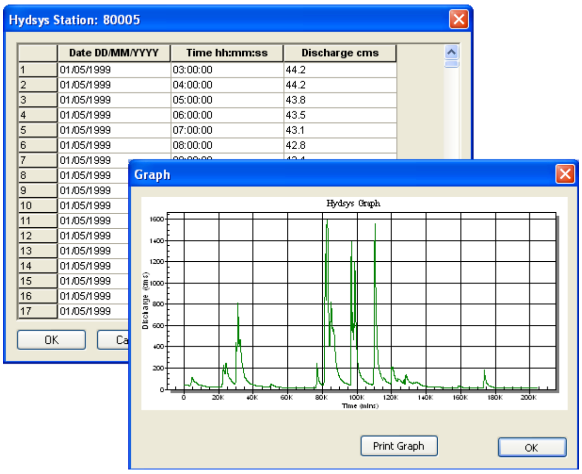
PMP Estimation

In version 8, PMP estimation tool has been incorporated to estimate the PMP for Australia for short and long durations. This tool adopts the methodology described in the GSDM (Generalized Short Duration Method), GSAM (Generalized Southeast Australia Method), and GTSMR (Generalized Tropical Storm Method) Guidebooks by Australian Bureau of Meteorology. PMP storms can be generated and simulated for any short or long durations depend upon the location of the project area.



Gauged Data

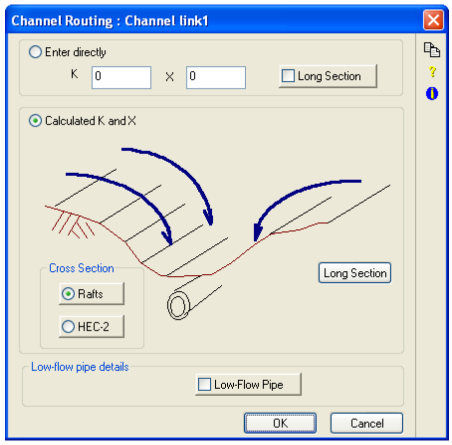
Gauged data may be entered by the user or read directly from an external file and compared to the computed hydrograph to assist in the calibration and verification of the drainage network simulation.



Hydraulics

The hydrographs which have been developed at the individual nodes may be transported through the drainage system in three ways.

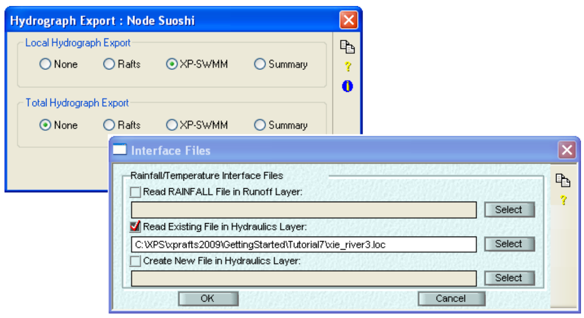
- Translation (Lagging). The user specifies the length of travel time from one node to the next and the hydrograph is translated on the time base by this length of time with no attenuation of peak flow. Appropriate values may be arrived at by estimating the velocity of flow and consequently the wave celerity, and knowing the length of travel.
- Pipe Flow. A pipe may be specified (or sized) to carry some or part of the flow with any flow in excess of pipe capacity travelling via the surface to either of two destination nodes. The travel time in this pipe may be computed or set to a fixed number of minutes.
- Channel Routing. A Channel/Stream may be defined using either compound trapezoidal channel or HEC-2 style arbitrary sections. The cross-section shape may imported directly from an existing HEC-2 file. The Muskingum-Cunge method is used to route the flow through the channel with the consequent attenuation of the peak flow and delay of the hydrograph peak.



- Diversion Link. Any node may have a diversion link defined in addition to the normal link which will divert some or all of the flow to an alternate destination node elsewhere in the drainage system.
- Pipe Design. Manning's equation is used to size the pipes to carry the peak discharge in the reach

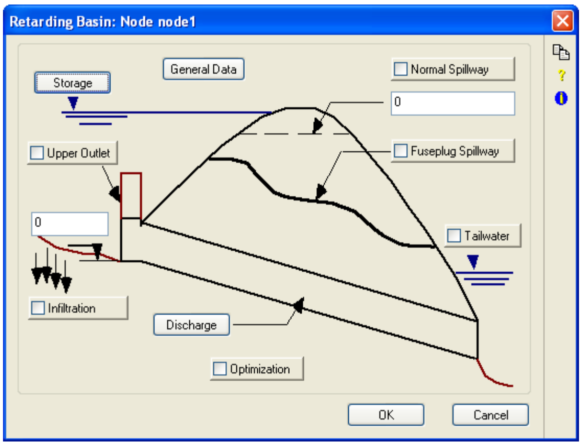
Hydrodynamic Link Routing

The hydrographs generated in xprafts may be directly transferred to the xpswmm/xpstorm hydrodynamic link routing. Hydrographs may also be read back into another xprafts model.



Storage Basins

(On-Site Detention, Ponds, Dams, etc.)

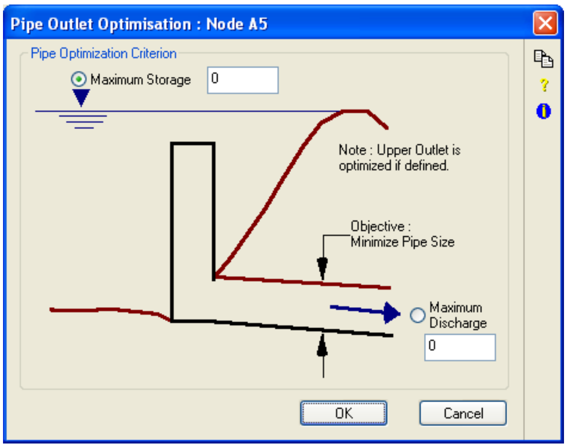


Any node in xprafts may be defined as a storage node. This storage may be quite small (a few cubic meters) or quite large (a few gigalitres), or any size in-between. On-line and off-line storages may be simulated and the storages may be hydraulically interconnected.

Puls' level pool routing technique is used to route the inflow hydrograph through the nominated storages. A stage storage relationship is defined for each of the storages. The outlet structures that may be handled include:

- circular pipe culverts
- rectangular box culverts
- broad crested weirs
- sharp crested weirs
- ogee weirs
- erodible weirs
- multi-level weirs
- high level outlets
- rating curve outlets
- evaporation
- infiltration

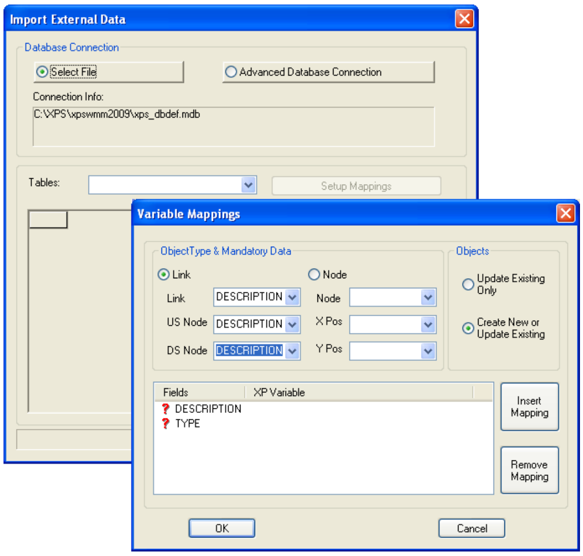
Optimization methods are available to help design the basin. You may optimize the basin for a maximum discharge or for a maximum allowable storage.



Importing Data

Data may be imported from an ASCII text file in the XPX file format. This format allows the user to create new data and objects as well as update and add to existing xprafts networks. This facility may be used to import information from GIS, FIS, CAD packages and other databases.

An Import External Database feature is available to enhance the integration of the program with commercially used ODBC compliant databases such as MS Access, MS Excel, Arc View, MapInfo etc.



Plan drawings may be imported from virtually any CAD package or GIS to be used as a scaled base map.

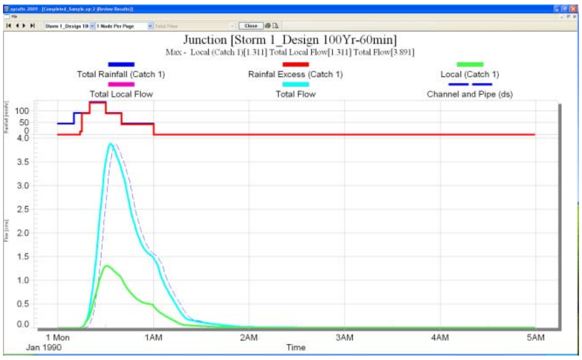
Alternatively, xp tables can be used to import data from any spreadsheet. The data can be copied and pasted to the pre-defined table.

Output

xprafts provides results and data in various forms. All graphical displays may be output to printers, plotters or to DXF files.

Graphical Output

xprafts provides graphs of rainfall, rainfall excess, hydrographs including total and local components of the hydrographs. Stage history and storage history are also available for any pond or basin in the drainage system. The graphs for up to 16 locations may be displayed and printed or results exported to a comma delimited ASCII text file for use in spreadsheets or databases.



Tabular Reports

Comprehensive tabular reports may be generated for both the hydrology and the hydraulic results and data.

In addition to the formatted tabular reports, an ASCII text output file is available with detailed information on both the hydrology and the hydraulic calculations.