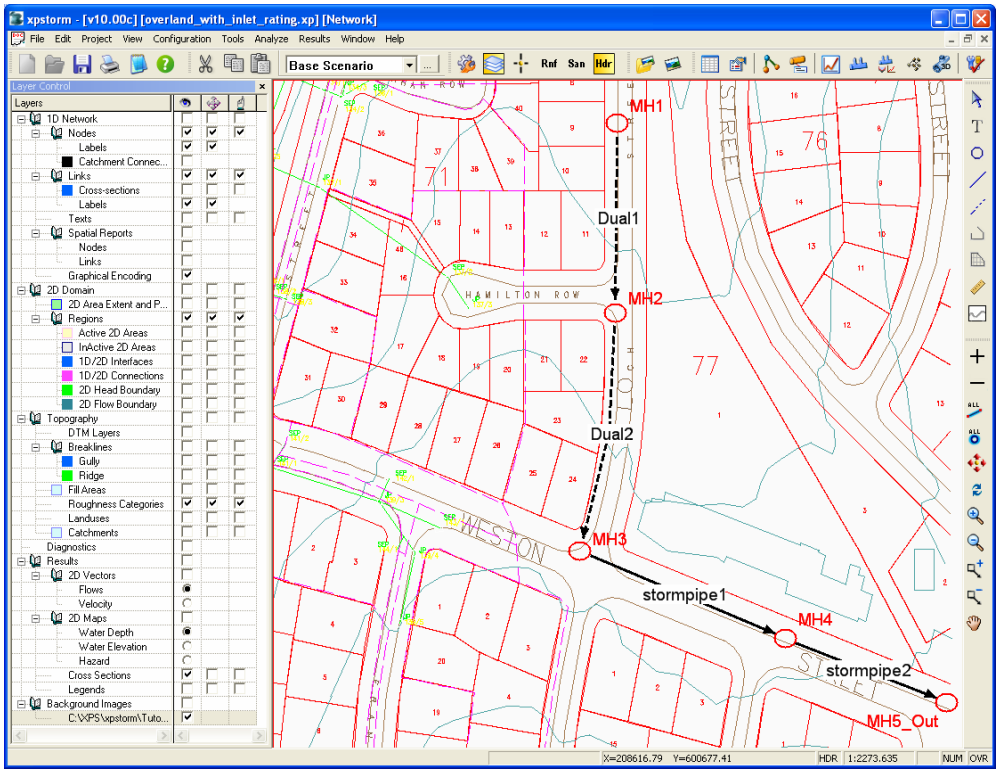
Technical Description

xpstorm is a complete software package for modeling Stormwater flows and pollutants. It is used by scientists, engineers and resource and asset managers to simulate natural rainfall-runoff processes and the performance of engineered systems that manage our water resources.

xpstorm is used to develop link-node and spatially distributed models that are used for the analysis, design and simulation of stormwater collection and conveyance systems. xpstorm also models flow in natural systems including rivers, lakes, floodplains with groundwater interaction and with the optional Water Quality add-on module also routes pollutants and removal through these systems.



xpstorm is used for:

Stormwater Management
- Collection system design & analysis
- Detention facility optimization
- Stormwater treatment analysis
- Comprehensive Stormwater Master Plans
- Best Management Practices analysis
- LID and WSUD

Floodplain Management
- Identifying flood hazards
- Develop mitigation strategies
- Generating flood maps
- Formulate disaster recovery plans

Analysis performed by xpstorm

Hydrology
- Actual and design precipitation events
- Single event and continuous simulation
- Deterministic runoff
- Groundwater infiltration and discharge
- Temporary surface storage

Hydraulics
- Dynamic wave
- Pressure flow
- Pumping **(Optional)**
- Dual drainage and looped networks
- Reverse flow and adverse grades
- 2D Flow routing **(Optional)**

Water Quality (Optional)
- Pollutant buildup and washoff
- Street sweeping
- Pollutant transport
- Treatment analysis and optimization
- Sediment transport
- BMP analysis and design

Contents

Key Features

Included in Base Package

GIS Integration - connect to OBDC compliant databases, import and display ESRI shape files and MapInfo files.

Scenario Manager - compare graphically and in tables model results for various scenarios. All model data is available in the Scenario Manager

Global Storms - compare graphically and in tables model results for various rainfall events. Efficiently compare multiple return period design storms and develop level of service assessments of the drainage network.

Dual Drainage - xpstorm dual drainage capabilities can simulate flow in conduits and in streets when flow is limited by inlet capacity or undersized closed conduits.

Animations - review and present customizable animations including dynamic long section, color coded dynamic plan view and the fully 3D perspective view.

EPA SWMM 5.0 Compatibility - xpstorm can import EPA-SWMM version 5.0 model and the earlier version 4 files.

Optional Add-ons

Real Time Control - expands the control capabilities for gates valves, flow regulators, moveable weirs and, and telemetry-controlled pumps. It's sensors can be any combination of velocity, flow and water level at nodes, conduits, pumps, weirs or orifices in the network

2 Dimensional Hydrodynamic Modeling - model overland flows, street flooding and floodplains using either a 1D-2D integrated model or a complete 2D model.

XP Viewer - distribute your model to stakeholders in a read only format. Model simulations, including all scenarios may be reviewed with the downloadable free XP Viewer software.

EPA SWMM 5 Exporter - convert any xpstorm model to an EPA SWMM Version 5 .inp file.

DTM Module - incorporates Digital Terrain Models (DTMs) as Triangular Irregular Networks (TINs) into any 1D or 2D model.

Pumps & Orifices - used to model pumping stations and orifices. Pumps may operate base on dynamic head, static head well volume or well depth. Orifices may be circular or rectangular and have time varying properties.

Water Quality - simulates the buildup and washoff of contaminants (non-point sources) in catchments, the direct entry of pollutants into sewers (point sources), transport through collection and conveyance systems and, treatment of stormwater and wastewater by natural and engineered processes .

Special Applications

BMP Evaluation - xpstorm can be used to analyze and design a wide variety of Best Management Practices for reducing stormwater flows, improving stormwater quality, and reducing the magnitude and frequency of CSOs.

Overland Flow - xpstorm can simulate overland flows in dual drainage systems such as parallel street and pipe systems as well as, integrated pipe and 2D overland flow routing.

LID - Low Impact Development, also known as Water Sensitive Urban Design (WSUD) or Ecologically Sustainable Development (ESD) is a philosophy that focuses on specific sustainable water conservation goals. Its aim is to minimize adverse impacts to the hydrologic cycle and water quality principles of low impact development require that projects not increase peak flows.

FEMA Flood Studies - xpstorm is approved by US Federal Emergency Management Authority (FEMA) as meeting the minimum requirements for models used to delineate flood plains and to support applications for revisions to established maps.

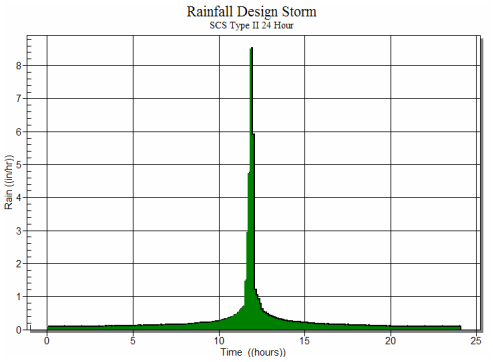
xpstorm simulates the complete hydrologic cycle in rural and urban watersheds. Beginning with single or multiple rainfall events and base flows, it models flows through collection, conveyance and treatment systems to the final outfalls. All hydrologic processes including snowmelt, evaporation, infiltration, surface ponding, and ground-surface water exchanges are included in the model.

Rainfall

Users may select either design or actual storm events. Rainfall hyetographs may be linked to a model using off line files or assigned from a global list to catchments. Continuous simulation is used to model catchment response to long term rainfall records and can include multiple rainfall stations.

Design storms for any duration and return period may be created from a library of rainfall patterns that includes:

- SCS Types: I, IA, II, II Florida Modified, III, B
- Huff Distributions
- Chicago Storm
- AR&R temporal patterns
- User defined distributions



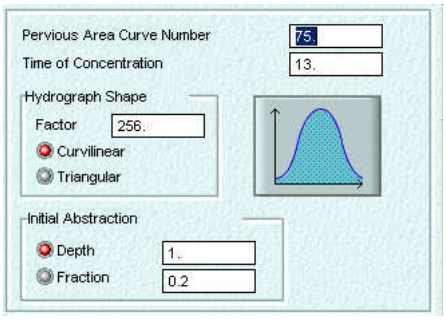
Each subcatchment can reference a separate hyetograph enabling the modeling of radar rainfall data, localized storm events or the timing of the hyetographs can be adjusted to simulate movement of a storm across a watershed.

xpstorm also models snowmelt using the Degree-Day method developed by the US National Weather Service. Continuous and event simulations of snowmelt can be performed.

Runoff

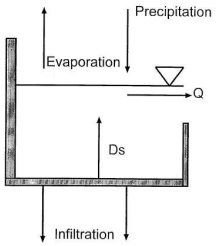
There are numerous methods available for computing storm runoff hydrographs for events or continuous simulations. These are:

- Non-linear Runoff Routing (US EPA Runoff Method)
- SCS Unit Hydrographs using a Curve Number with curvilinear or triangular unit hydrographs.
- Kinematic Wave
- Snyder Unit Hydrograph
- Snyder (Alameda County) Unit Hydrograph
- Nash Unit Hydrograph
- Santa Barbara Urban Hydrograph
- Laurenson's Non-linear Runoff Routing (RAFTS)
- Rational Method
- Colorado Urban Hydrograph Procedure (CUHP)
- LA County F0601
- Modified Rational Method
- Sacramento Nolte Flows
- Sacramento Method



Non-Linear Runoff Routing

The primary hydrograph generation method in the EPA SWMM model is the non-linear runoff method. Overland flow hydrographs are generated by a routing procedure using Manning's equation and a lumped continuity equation. Surface roughness and depression storage for pervious and impervious area parameters further describe the catchment. The subcatchment width parameter is related to the collection length of overland flow and is easily calculated based on the watershed area. Urban, suburban, and rural areas of any size may be simulated using Non-linear reservoir routing.



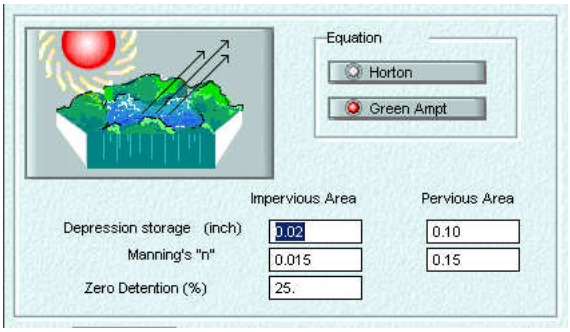
$$Q=\frac{1.486}{n}\bullet W\bullet(d-d_s)^{5/3}\bullet S^{1/2}$$

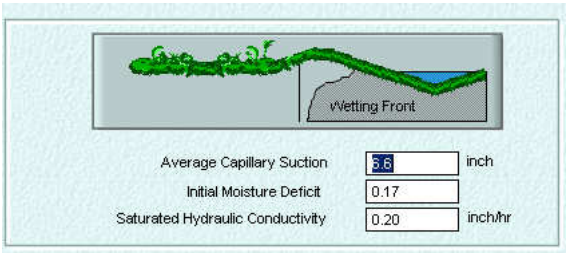
The other hydrograph methods such as SCS, SBUH, Rational, etc. are primarily used for single event simulations. The SWMM runoff method is a deterministic hydrologic method suitable for comprehensive analysis and design.

Groundwater Interactions

Subcatchment infiltration can be coupled to groundwater and is computed using the methods:

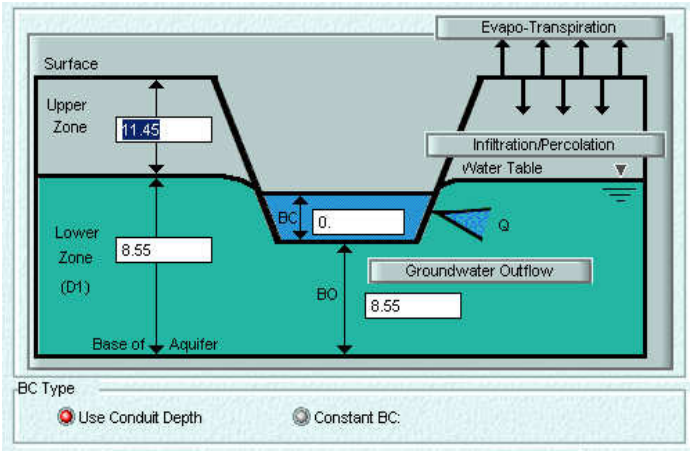
- Horton
- Green-Ampt
- SCS Method
- Initial and Continuing Loss
- Proportional Loss
- Initial and Proportion Loss





If groundwater is simulated then the unsaturated zone interacts with the infiltration from the watershed surface. Decreased infiltration increases surface runoff. For example, the water table can rise to the ground level from excessive infiltration and the infiltration rate will be reduced.

The recovery of depression storage between storms is achieved by means of evaporation as well as exponential recovery of infiltration capacity. Sub-surface flow is routed through saturated and unsaturated zones using the method of lumped storages. Sub-surface outflow is computed using a power equation. Seasonal variation in groundwater levels drives base flows in streams and inflow in sewers.



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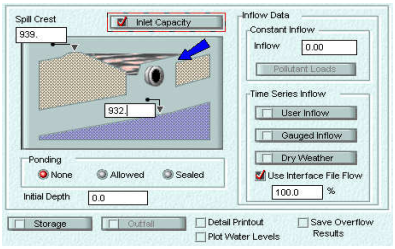
The xpstorm Hydraulics engine solves the complete St. Venant (Dynamic Flow) equations for gradually varied, one dimensional, unsteady flow throughout the drainage network. The calculation accurately models backwater effects, flow reversal, surcharging, pressure flow and tidal outfalls and interconnected ponds. The model allows for looped networks, multiple outfalls and accounts for storage in conduits. Flow can also be routed using the US EPA EXTRAN solutions and with kinematic or diffusive wave methods.

Node Data Dialogs

Data are easily entered and reviewed in graphically enhanced dialogs. Check boxes indicate which options are invoked. Radio buttons are used for selecting a single option. Copy and paste tools are used to replicate data between objects.



Inlet Capacity and Dual Drainage

xpstorm determines the captured flow for a range of inlet types including slot, grate and curb opening inlets. Options for calculating the inlet capacity are:

- Maximum capacity
- Rated by approach flow
- Rated by approach depth
- HEC-22 hydraulics

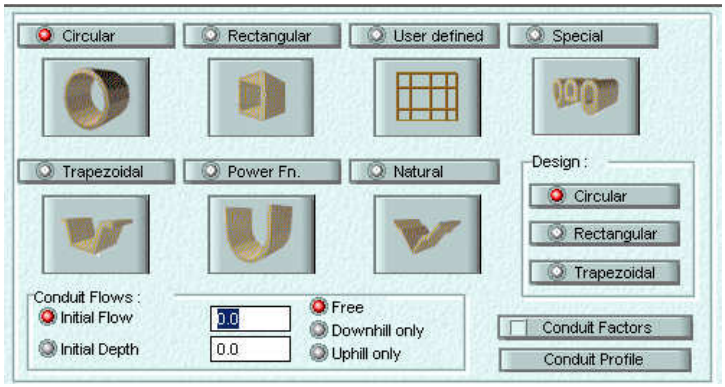
Flow not captured by the inlet can be stored on the surface and lost from the system or diverted automatically to overland flow conduits. Additionally with the optional xpstorm 2D module, surface flows are routed on a 2D grid.

Conduit Shapes

There are more than 30 different pre-defined hydraulic elements available for hydraulic routing plus user-defined open and closed conduits making the number of available shapes virtually limitless:

- Circular
- Rectangular
- Horseshoe
- Trapezoidal Channel
- Rectangular Triangular Bottom
- Baskethandle
- Modified Baskethandle
- Egg-shaped
- Power Function Channel
- Catenary
- Gothic
- Semi-Circular
- Rectangular Round Bottom
- Arch
- Vertical Ellipse
- Horizontal Ellipse
- Rating Curve
- Regulator
- Reaction Link
- User-Defined Closed Section

xpstorm can also accommodate channels and conduits having roughness changes as a function of depth and can simulate sediment deposition and transport in all conduit shapes.



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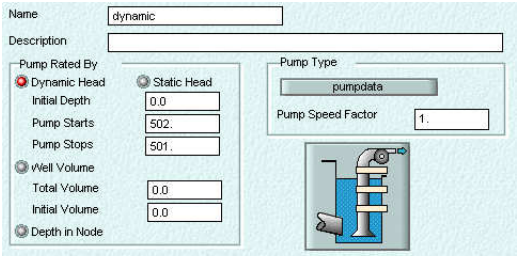
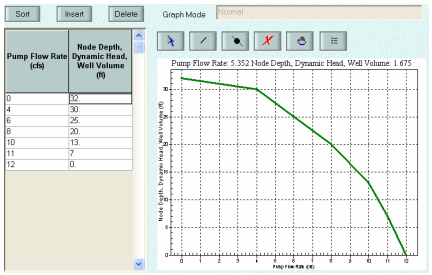
Pumps

Pumping of storm or wastewater is easily modeled in xpstorm. A pump station may be represented as either an in-line lift station, or an off-line node representing a wet-well, from which the contents are pumped to another node or outfall. Up to seven pumps may be assigned to a pump station. The pumps may be selected in any order.

Pumps may be one of six types:

- **Rated by Well Volume** An in-line or off-line pump station with a wet well; the rate of pumping depends upon the volume (level) of water in the wet well.
- **Rated by Depth in Node** An in-line or off-line lift station that pumps according to the level of the water surface at the junction being pumped.
- **Rated By Dynamic Head** An in-line or off-line pump that pumps according to the depth (head) difference over the pump using a multi point pump curve and starting and stopping control elevations.
- **Rated By Static Head** An in-line or off-line pump that pumps according to the head at the upstream node using a multi point pump curve and starting and stopping control elevations.
- **Special Dynamic Head** These pumps use a rule curve to modify the behavior of the dynamic head pump based on the depth at either an adjacent or non-adjacent node.
- **Variable Speed** These pumps are defined by pump curves that are based on wet well depth or other user defined parameters.





Control Structures and Diversions

In gravity conveyance systems, a variety of structures are used to measure, control and divert flows. In xpstorm all diversions occur at nodes and the complex hydraulics of flow regulation devices are easily modeled. User defined diversion rules that direct flow to the appropriate node Control devices in xpstorm include:

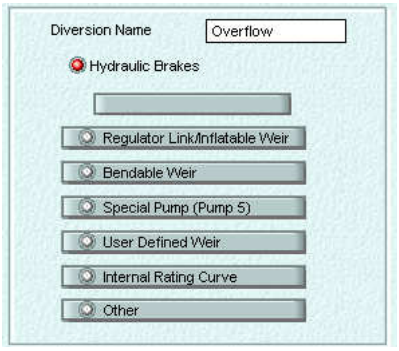
Weirs:

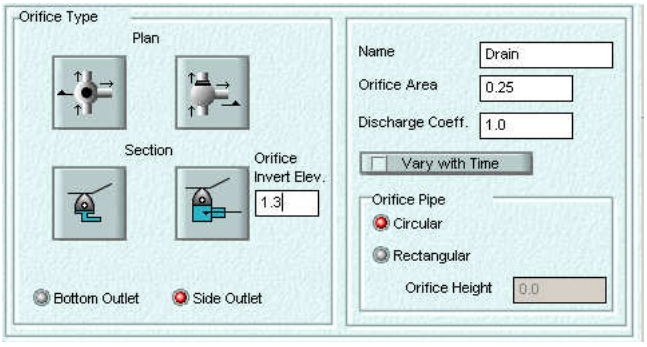
- Transverse
- Side flow
- Inflatable
- Bendable
- User defined geometry

Orifices:

- Circular bottom
- Circular side
- Rectangular bottom
- Rectangular side

Orifices may have time dependant area and discharge coefficients.





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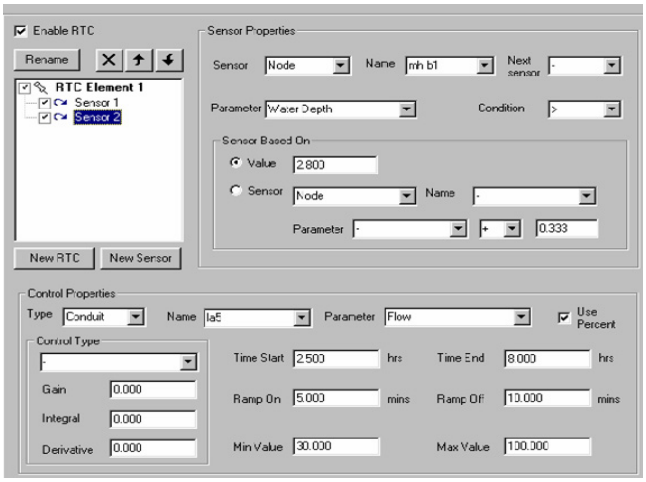
Real Time Control

xpstorm's Real Time Control (RTC) optional module expands the control capabilities for gates valves, flow regulators, moveable weirs and telemetry-controlled pumps. It extends RTC to a comprehensive management and design tool. It's sensors can be any combination of velocity, flow and water level at nodes, conduits, pumps, weirs or orifices in the network. The generic real time control option provides the ability to control any conduit, pump, weir, orifice or rating curve from an unlimited number of sensors.

The types of elements subject to RTC and the Parameters capable of being controlled are:

Element	Parameter
Conduit	Flow, Roughness, Diameter (or Depth)
Node	Depth, Elevation
Pump	On Elevation, Off Elevation, Speed Factor, Pump Flow Rate, Well Volume
Weir	Flow, Crest Elevation, Surface Elevation, Length, Discharge Coefficient
Orifice	Area, Discharge Coefficient
Rating Curve	Flow

Other control parameters include Start and Stop time of the control, ramp times, and a second set point. Operators can be concatenated with Boolean operators, and parameters can be compared with other sensors or with absolute values. Real time control can be activated only during certain hours of the day, and control can turn on and/or off over a user-defined time period.



Detention Storage

In addition to conduits, channels and other flow elements, flow may also be routed through a variety of different storage shapes. The shape of the storage may be defined as:

- Constant surface area (tank)
- A power function

Also, a stepwise linear relationship may be defined as:

- Stage vs surface area
- Elevation vs surface area
- Stage vs volume
- Elevation vs volume

The routing of flows through the detention storage units is performed by:

- Modified Puls method in the kinematic wave of the Sanitary layer
- Dynamic flow equations (St Venant) in the Hydraulics layer

Interconnected ponds and detention basins can be modeled in either parallel or series. Storage can be assigned from the invert of a node to represent typical detention ponds or for the ground surface to represent surface storage such as trap lows, sag inlets or flooded inlets and intersections.

2D Hydrodynamic Model

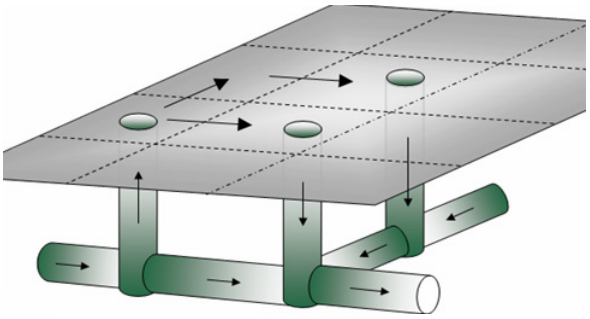
Fully two-dimensional (2D) models have been widely used for modeling river and coastal hydraulics and recently have become a viable practical option for modeling urban floods. As a stormwater management tool, 2D models are more accurate and produce results that are far more readily accepted and understood by managers, decision makers and other stakeholders.

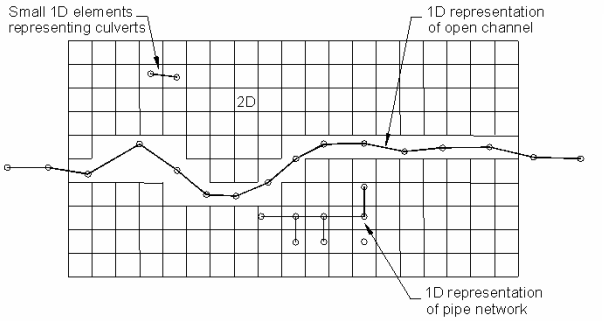
The 2D modeling add-on utilizes the TUFLOW program developed by WBM Oceanics Australia and The University of Queensland. xpstorm has incorporated the TUFLOW engine into a user-friendly graphical interface which walks the user through preprocessing of input data and the calculation of the model. All of xpstorm's familiar tools for generating tables, graphs, and animations are available for reviewing, analyzing and presenting model results. New 2D and 3D animation tools make it easy to present results to managers and decision makers.

1D - 2D Integrated Model

A powerful feature of xpswmm 2D is its ability to dynamically link to any 1D (quasi-2D) model in an integrated fashion. The user sets up the model as a combination of 1D network domains linked to 2D domains as single model.

Stormwater flows overland until it enters the underground network. Surcharges may exit the network and resume overland flow.

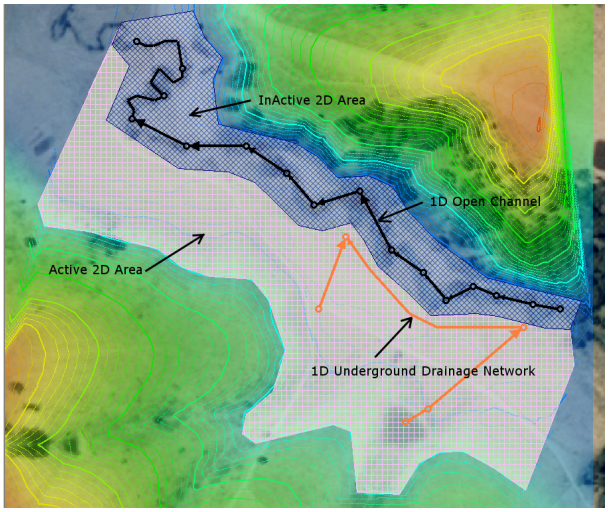




1D elements may be integrated into an 2D flow area to accurately model 1D flow.

Graphic Tools for 1D-2D Model Building

1D-2D models are constructed with objects. These objects are represented as points, polylines and polygons. xpstorm2D has a set of tools that allow the user to quickly lay out the model and manage the properties of the objects.



The flood plain is represented as a Active 2D Area polygon. It borders the 1D Open channel which is represented as an 1D InActive Area. The 1D Underground Drainage Network is added to the model.

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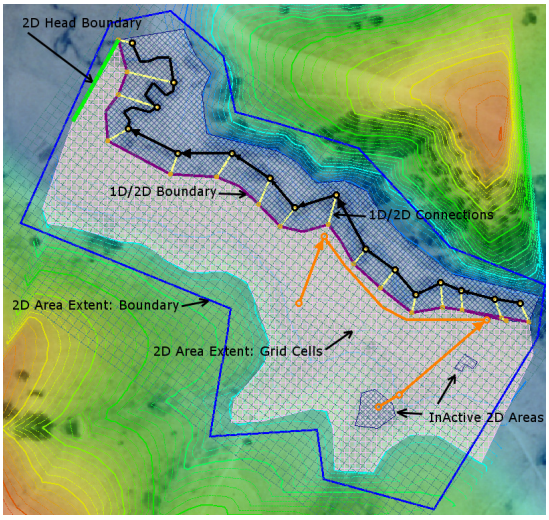
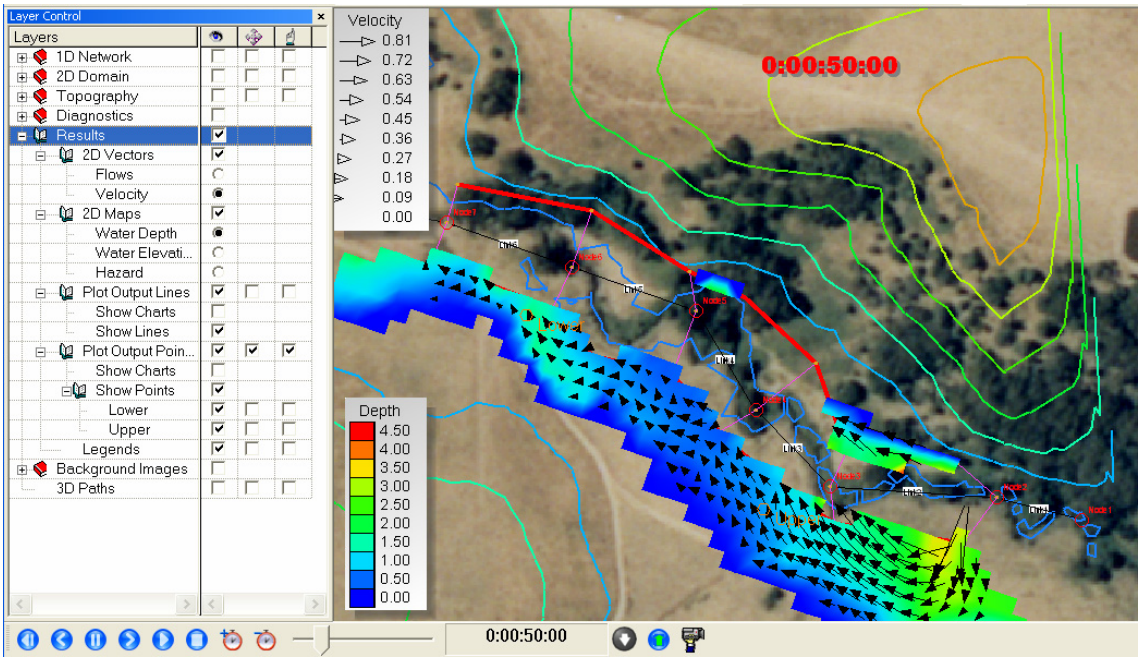
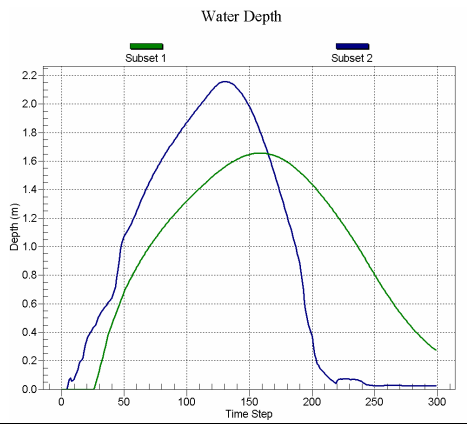
Polylines represent 2D Head Boundary and the 1D/2D Boundary. Raised areas in the flood plain are represented as InActive 2D Area polygons. The 2D Area Extent is defined by a rectangular grid.



Viewing Model Results

Animations are used to view and present model results. Color coded maps display time series of water depth, surface elevation or hazard. Scaled vectors display time series of flow or velocity. Scaling and color coding are user defined. VCR-like buttons are used to run the animations which may be recorded as AVI files.





Time series plots of water depths at user defined points or water profiles are easily generated. These plots may be displayed, printed or exported as graphics files.

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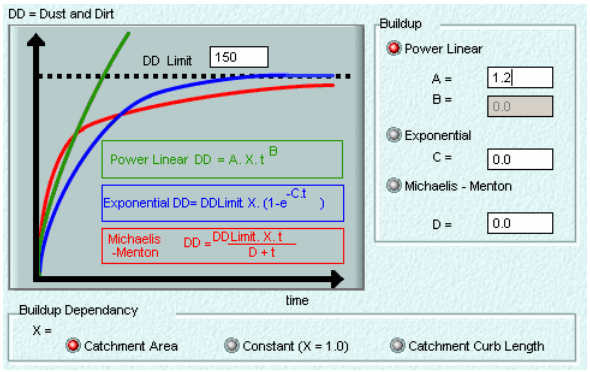
xpstorm provides a full suite of tools for modeling of processes impacting water quality in watersheds. The software simulates the buildup and washoff of contaminants (non-point sources) in catchments, the direct entry of pollutants into sewers (point sources), transport through collection and conveyance systems and, treatment of stormwater and wastewater by natural processes and engineered devices.

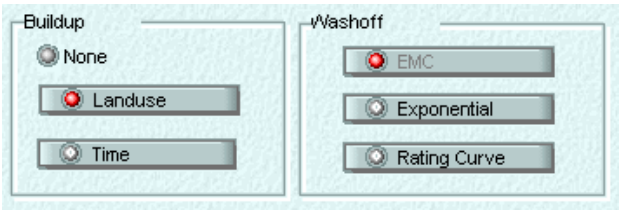
Buildup and Washoff

xpstorm provides a variety of tools for modeling the build up of any pollutant in a subcatchment. The buildup may be modeled using the US EPA time dependent Dust and Dirt model. Buildup parameters may be assigned for each pollutant and landuse combination in the watershed.

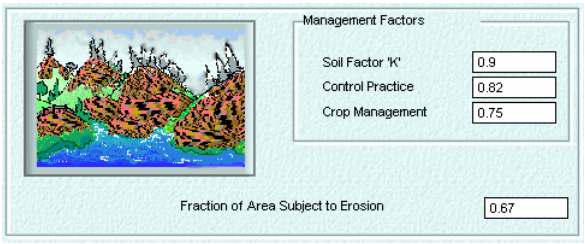


Washoff during rainfall events may be modeled using:

- Event Mean Concentration (EMC)
- Exponential: dependant on flow and availability
- Rating curve: relates concentration to flow



Erosion

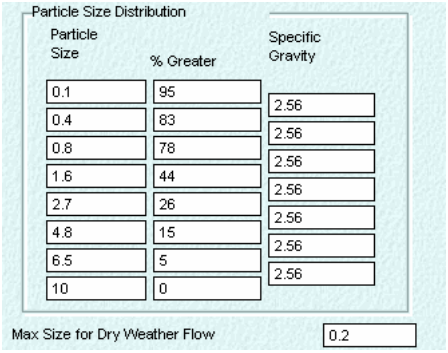


Soil erosion is modeled using the Modified Universal Soil Loss Equation (MUSLE) and the erosion pollutant can be optionally added to the TSS loads.

Sediment in Pipes

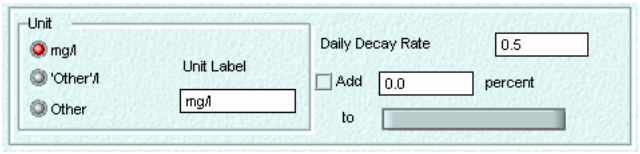
Residual bottom sediment in the pipes may be resuspended and deposited again due to the flushing action of the conduit velocity. Scour and deposition is simulated in all conduits in the system.

The methodology uses a particle size distribution, and specific gravity, for each desired pollutant, and maintains a time history for each conduit of the maximum particle diameter in suspension and the minimum particle size in the bed. Particles in motion are routed downstream in each conduit by complete mixing, the same as other water quality parameters. Mass-weighted values of the maximum particle diameter in suspension are routed downstream for entry to subsequent conduits.



Water Quality Routing in Conduits

Quality routing is performed by advection and complete mixing in conduits. Each constituent may be subjected to first order decay during the routing process. The decay of one constituent has no effect on other constituents present.



Routing of quality parameters is performed by using the integrated form of the complete mixed conduit volume. The routing becomes closer to pure advection (plug flow) as the number of conduits is increased.

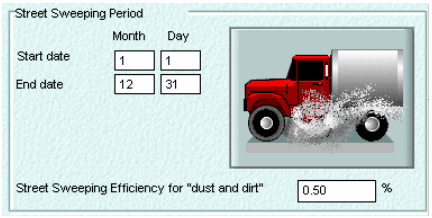
Water Quality Modeling in Storage Units

Quality routing is performed as plug flow or complete mixing in storage units. Storage and treatment devices are simulated as a series and/or parallel network of units each with optional flow-storage routing using the modified Puls method.

The treatment simulation uses either user-defined removal equations (for example, removal as exponential function of hydraulic residence time) or sedimentation theory coupled with particle size-specific gravity distribution for constituents. The user may enter any valid equation to describe the treatment of the various constituents and xpstorm will parse this equation and apply it to the simulation.

BMP Analysis

Best Management Practices (BMP's) and Low Impact Development (LID) strategies may be simulated using the above procedures in xpstorm. The model will quantify the effect of the a BMP or LID technology in terms of reduced flow (peak or total volume) and contaminant load.



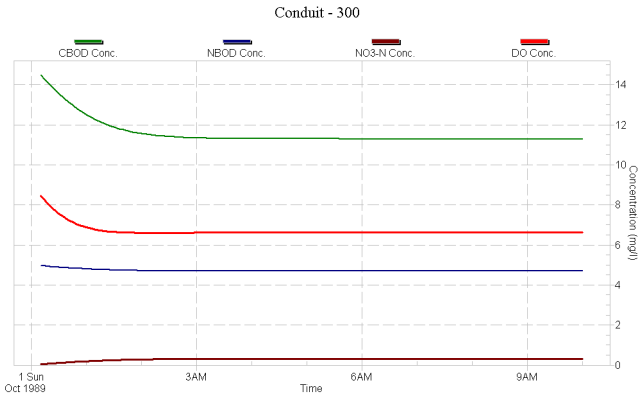
Typical BMP and LID strategies simulated by xpstorm are:

Rain gardens	dry detention basins
Green roofs	wet ponds
Rain barrels	swales

In addressing overflow problems, the software can identify the volume of spillage, flooding and the concentration of any pollutants or sediment build-up. The modeler may evaluate solutions such as storage, treatment and real-time control adjustments to prevent system failure.

Dissolved Oxygen Cycle

The behavior of dissolved oxygen (DO) and the constituents that drive the DO cycle including carbonaceous BOD, nitrogenous BOD as well as nitrate can be simulated in xpswmm. User defined inputs allow for temperature and salinity correction, sediment oxygen demand and parameters used in the O'Conner or Covar reaeration equations.



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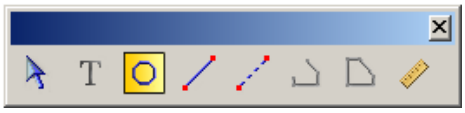
xpstorm's graphical environment allows the modeler to create and modify the network interactively on the screen using a mouse and graphic tools. Convenient graphical wizards guide the user through a range of required and optional data. The internal knowledge-base "intelligently" reviews the input to prevent incorrect or inconsistent network structures or data from being created.

xpstorm also contains a variety of tools to jump-start model building by using data from other previous projects, other models and external sources.

Digitizing Networks

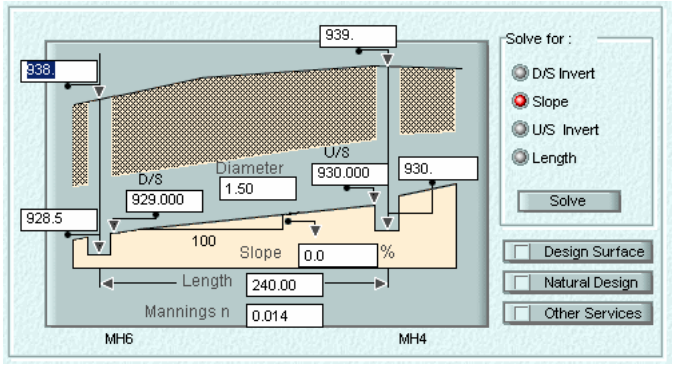
xpstorm has tools for quickly laying out, navigating and, annotating networks. Layouts can be constructed on a scaled background or on a blank screen. The color and size of text labels can be adjusted for optimum readability. Single elements or groups of nodes or links can be selected for editing.



Dialog boxes

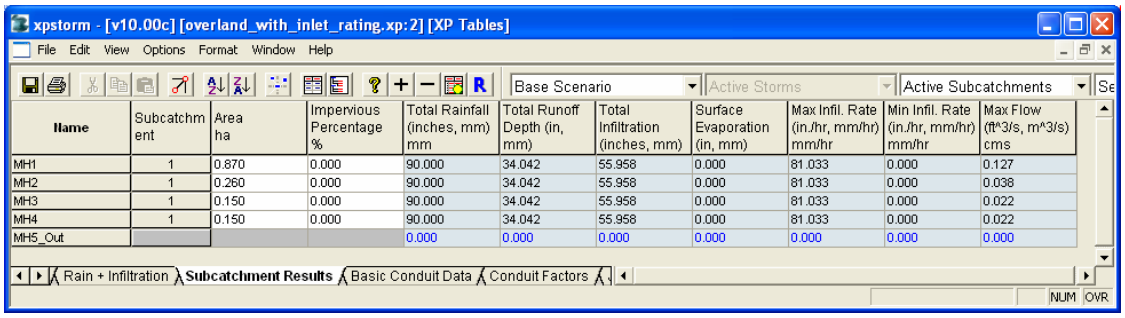
xpstorm has numerous dialog boxes that assist data entry. Schematic diagrams indicate the definition of various parameters. Pop-up screen tool tips provide additional information such as units and field definitions to assist the users.

This dialog box displays the Solve feature which calculates and enters the selected dependant variable. For example, knowing the upstream and downstream inverts and the conduit length, the slope is calculated.

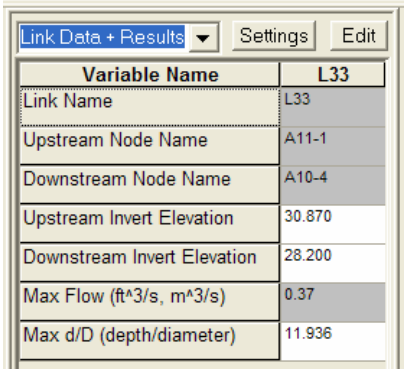


XP Tables

XP Tables offers an excellent complement to the dialog-based interface. XP Tables provides views of data and results that can be quickly sorted, edited and copied to or from other applications such as Excel spreadsheets. Filters can also, be applied to the table so that only the objects meeting specified criteria are displayed.



Quick Data View

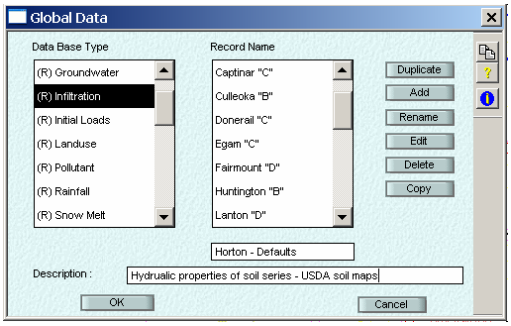


The Quick Data View tool displays a user-defined set of input data and results for any link or node in the model. It is effectively a custom dialog that dynamically displays current values of the defined set of parameters. The view may be docked or moved anywhere on the viewing pane and resized. The display is updated when a new link or node is selected. It is an excellent tool for reviewing the model data combined with the results.

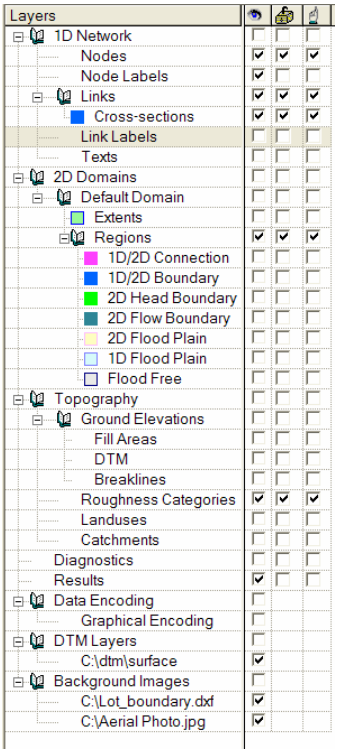
Global Data

The global data tool allows for the management of data that may be referenced from multiple nodes and links. This reduces data redundancy dramatically and the associated problems of updating many locations when changes are made. Examples of global data include rainfall, infiltration, pollutant description, cross sections, dry weather flows and pump curves. A series of dialog boxes are used to assist editing and assigning global data to the model.

The global database can be efficiently loaded by import, merging models together and by using one or more of the XP Software supplied template files.



Layer Control



The movable and dockable Layer Control Panel allows the user to manage the graphical display of the model. The display of layers (model links and nodes, text, topography, DTMs, and background images) may be switched off/on with check boxes. Model layers may also be locked (from editing) or have their selectable attribute switched off/on.

The layers are organized into an expandable/collapsible tree structure .

Background Layers

xpstorm allows the user to layout the network over a CAD (.DXF or .DWG) drawing or a GIS layer (.SHP or .MIF). The ability to include a background image also includes georeferenced digital pictures such as .BMP, .JPG, .TIF files.

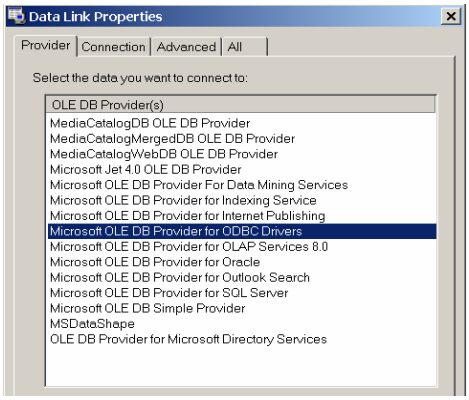
Alternatively, schematic network layouts can be created without the objects being georeferenced.

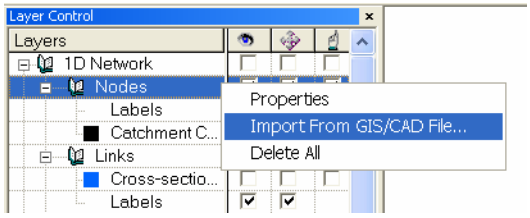
GIS Integration

xpstorm is streamlined to utilize GIS and CAD data for modeling. It has the ability to display raster and vector files as background images from commercial drawing and GIS applications without the purchase of additional software.

With its integrated GIS link xpstorm enables you to exchange data with other external databases such as ArcGIS, MapInfo, Asset Management Software, Access and Excel or any other ODBC compliant database.

xpstorm's layer control panel allows the management of geospatial data sets including visualization and direct import of geometric objects such as polygons, polylines and points to the appropriate xpstorm layer.





A right click launches a pop-up dialog for directly importing nodes or links from a GIS or CAD file.

Exchanging data with EPA SWMM

Existing information may be imported into xpstorm from Version 4 through 5 EPA SWMM data files. Any xpstorm model may exported to an EPA SWMM Version 5 .inp file.

Text Files

Data may also be imported from an ASCII text file in out proprietary XPX file format. XPX files are free format and use a simple script to allow import of all required data. Comma Separated Values (CSV) files can be included in XPX files to allow import of multiple input variables to a range of objects and links. This allows the user to create new data and objects as well as update and add to existing xpstorm networks. Large data sets exceeding 10,000 conduits can be managed easily using XPX files.

Network Navigation

Numerous zoom and pan tools allow the user to quickly navigate across the model. Other icons in the tool strip aid in creating a network layout and there are icons to the Show/Hide All Node and Link Names and select All Links and Nodes. Simply depressing the icon will toggle on/off the labels for node and links.

Whether you are modeling in 1 or 2 dimensions, integrating elevation data is an essential step in constructing your model. xpstorm incorporates Digital Terrain Models (DTMs) as Triangular Irregular Networks (TINs) into any 1D or 2D model. Our software offers a comprehensive set of tools that are used to create, import, display elevation data layers, and to derive properties of network elements from the DTM.

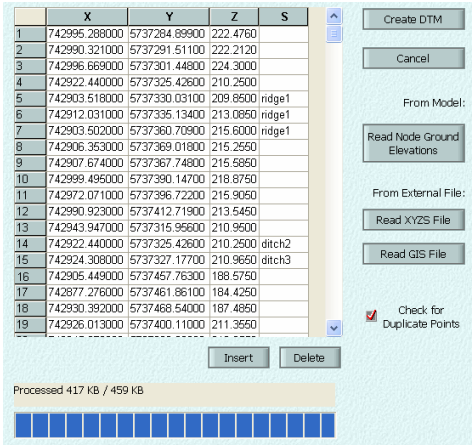
DTM Builder

The DTM builder constructs a TIN from a x, y, z text file. The "S" column is used to designate break lines. Multiple DTMs can be tiled together.

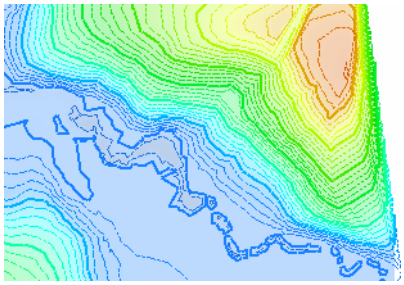
Additional options include creating a DTM from:

- Existing node ground elevations
- MapInfo MIF files
- ESRI shape files and ESRI Grid files

The dialog allows for direct editing of points and block copy and paste operations.



Manage DTM Display



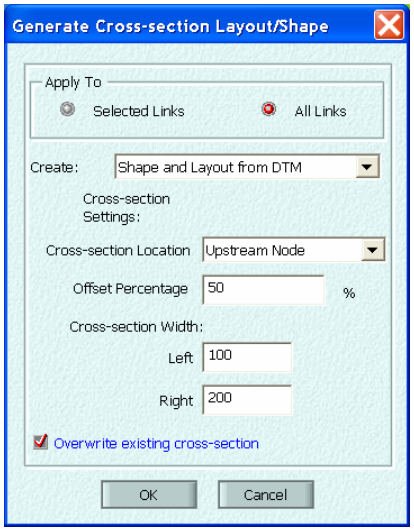
The color scale, transparency and contour line format of the TIN can be adjusted or toggled on/off with the display properties dialog in the Layer Control Panel.

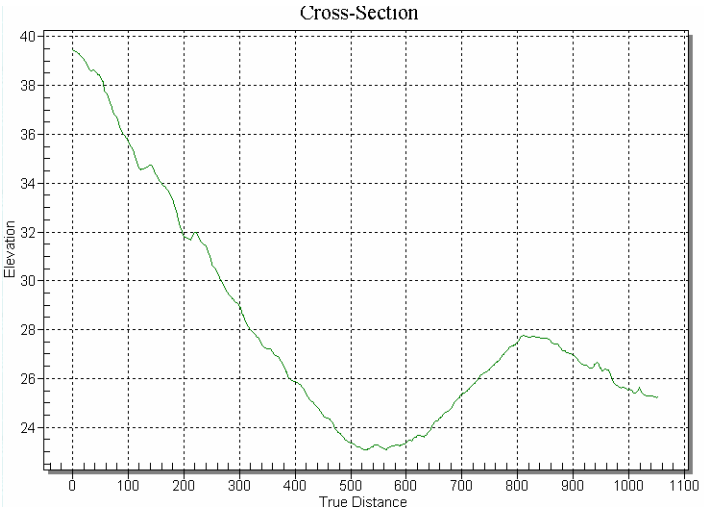
The elevation of the mouse location is displayed in the status bar.

Using DTM Data

After the DTM has been incorporated into the model a variety of tools are available to perform such tasks as:

- Generating node ground elevations from the DTM
- Creating cross section shape files along open channels
- Creating cross section profiles along any user defined polyline.

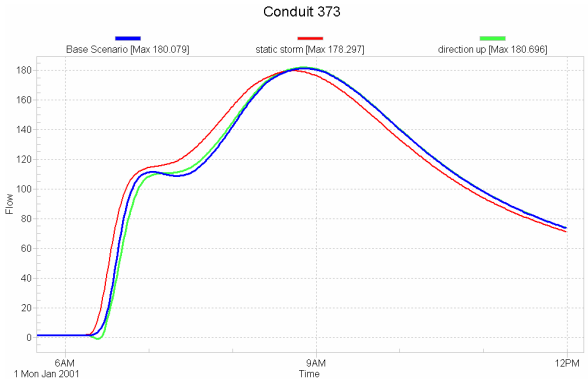




Running xpstorm is more than clicking on the calculate button. When using xpstorm, the modeler can monitor the calculating engine and the hydraulics at selected locations, make adjustments and rerun the calculations. After the simulation xpstorm offers a variety of tools that assist in calibrating, adjusting designs and producing final output.

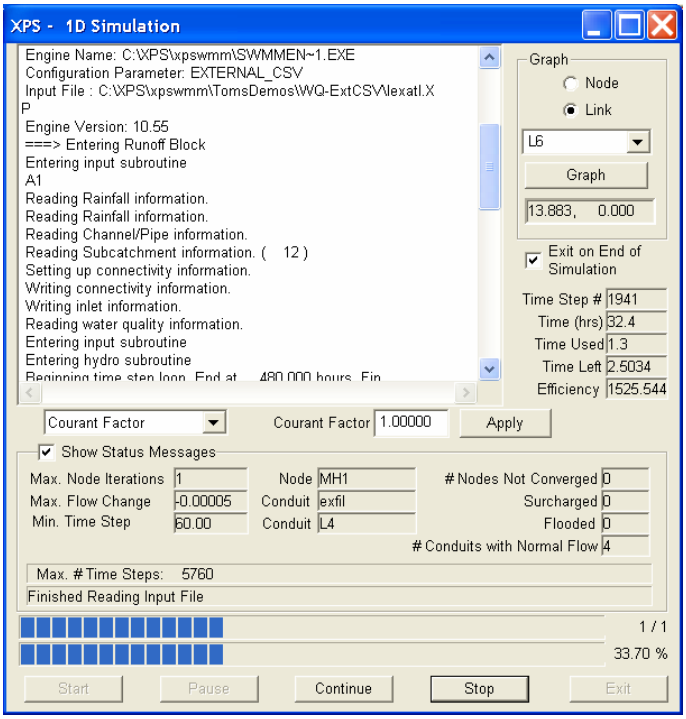
Scenarios

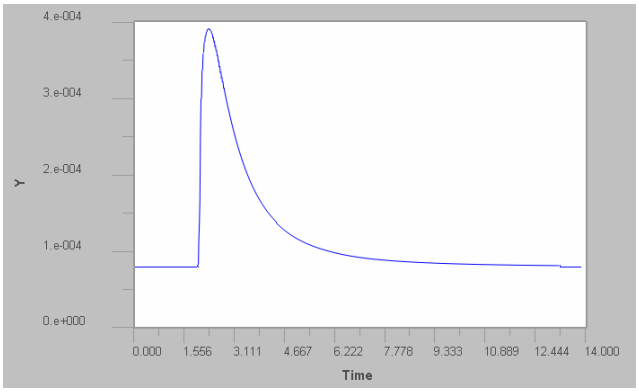
The Scenario Manager allows you to create multiple scenarios. A scenario can have different configurations, storms, control strategies or boundary conditions. The modeler can easily analyze the networks performance under different storm events and future development conditions.



Run Time Graphing

A run time graphing tool aids in monitoring the progress of the analysis engine. During a run the user can select a link or node and then the Graph button. Then while the simulation is being executed the selected object's flow or water level will be displayed and continuously updated in a graphing window. A sample of this graph is shown below for link L6





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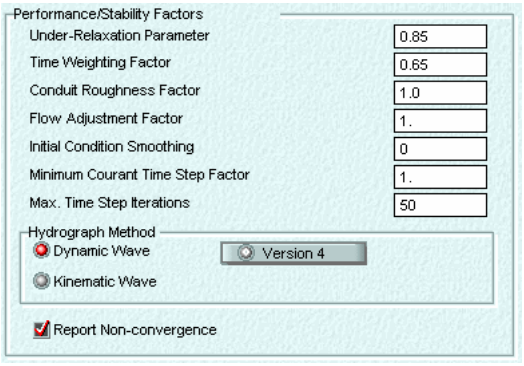
Proprietary Dynamic Wave Routing

xpstorm uses a proprietary dynamic wave routing procedure. The solution method is inherently stable and has a fast run time by using a self modifying time step. Throughout the simulation, the time step is adjusted to insure stability and flow balance. There are several techniques available to improve the performance of the calculating engine. Additional simulation parameters allow optimization of the solution. They include:



- Global settings for minor losses, flow multipliers, roughness factors
- Courant time step factors
- User defined fixed and relative tolerances
- Minimum time step
- Automatic modification of short conduits

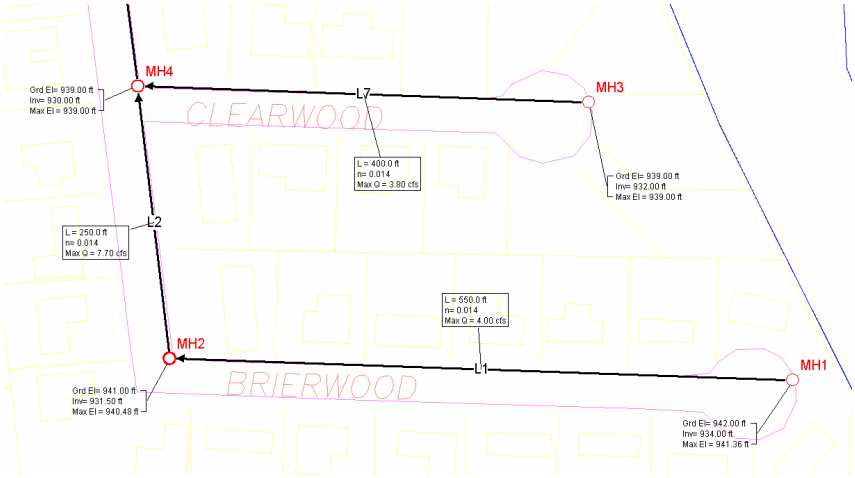
For compatibility with older EPA SWMM models the three Version 4 solutions are also available in xpstorm. Routing of the flows may also be accomplished using the kinematic and diffusive wave solutions.

Model Calibration

xpstorm offers a variety of tools to assist in model calibration. Calculated values of flow, velocity or HGL may be plotted over measured values. XP Tables may be used to make global adjustments to model parameters. Scenarios can be used to show both graphically and in tables the differences resulting from calibrating factors.

Spatial Reports

Spatial reports of model data and simulation results can be shown onscreen. A box attached to the link or node will show items such as the peak flow and conduit diameter (select from several hundred available fields). Model results may also be shown using thematic plotting or graphical encoding in which the color and size of the links and nodes is dependent on the model data or results.



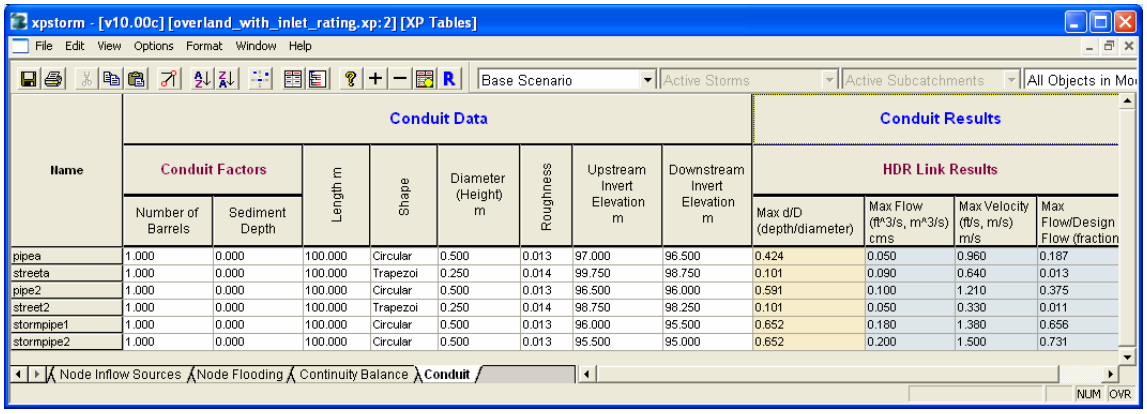
Model Summary

A comprehensive output file is also created similar to the output in EPA SWMM. This output file is the *.OUT text file and contains extensive input and output information. During scenario runs or when simulating multiple rainfall events with global storms, multiple output files are generated.

When a model is calculated, tens of thousands (sometimes millions) of data points are created in the resulting time series. xpstorm has tools to organize and present in a manner that allows the modeler to understand the processes that have been simulated. Utilities can be assessed from the menus to break up rainfall and pollutant time series to events and ranks those events. In addition, xpstorm has numerous tools for producing professional quality graphics and exporting text and graphics to other software packages.

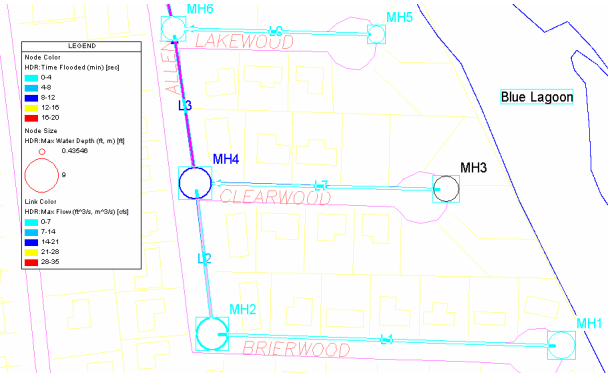
XP Tables

The XP Tables tool will generate customized tables of both input data and results. Tables may be easily formatted by font, alignment and numeric format. Tables may be easily exported as text files or to publishing software.



Name	Conduit Data								Conduit Results			
	Conduit Factors		Length m	Shape	Diameter (Height) m	Roughness	Upstream Invert Elevation m	Downstream Invert Elevation m	HDR Link Results			
	Number of Barrels	Sediment Depth							Max d/D (depth/diameter)	Max Flow (ft^3/s, m^3/s) cms	Max Velocity (ft/s, m/s) m/s	Max Flow/Design Flow (fraction
pipea	1.000	0.000	100.000	Circular	0.500	0.013	97.000	96.500	0.424	0.050	0.960	0.187
streeta	1.000	0.000	100.000	Trapezoi	0.250	0.014	99.750	98.750	0.101	0.090	0.640	0.013
pipe2	1.000	0.000	100.000	Circular	0.500	0.013	96.500	96.000	0.591	0.100	1.210	0.375
street2	1.000	0.000	100.000	Trapezoi	0.250	0.014	98.750	98.250	0.101	0.050	0.330	0.011
stormpipe1	1.000	0.000	100.000	Circular	0.500	0.013	96.000	95.500	0.652	0.180	1.380	0.656
stormpipe2	1.000	0.000	100.000	Circular	0.500	0.013	95.500	95.000	0.652	0.200	1.500	0.731

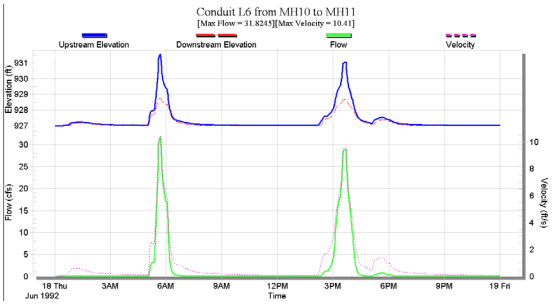
Graphical Encoding



Often also called thematic viewing or plotting, this tool allows variables (or themes) to be displayed using graphical entities of objects. Currently six entities are supported, 3 for both links and nodes. These are; Color, Size or Width, and Text Label Size. The variables (or themes) include input data plus calculated results.

Hydrographs

Graphing of results for flow, velocity, concentration and load may be displayed for any point in the system with anywhere from 1 to 16 graphs displayed on a single page. The scales, series symbols, grids and fonts of these graphs can be easily adjusted to meet publication requirements. Parameters that may be graphed include:



- Flow
- Velocity
- Infiltration
- Snowmelt
- Groundwater stage
- Groundwater flow
- Hydraulic grade line
- Rainfall excess
- Soil moisture
- Pollutant load
- Pollutant concentration
- Storage node inflow and outflow

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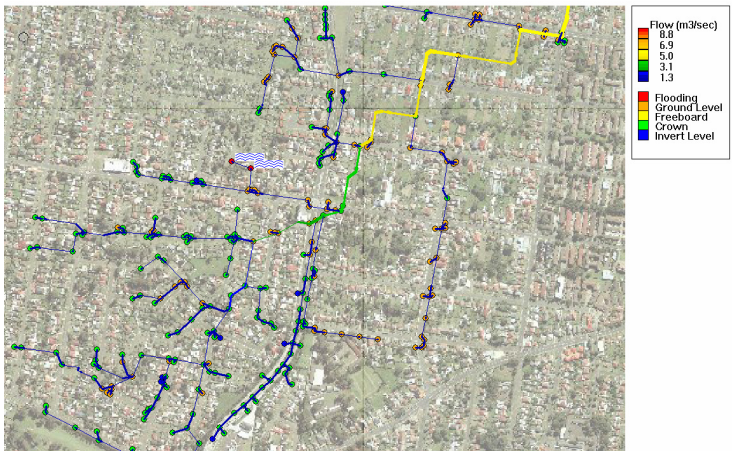
Animations

Model results for the entire simulation period may be viewed in any profile, plan or section view. The display of the animation is controlled by a set of VCR like buttons. At any time step the animation may be printed or exported as a graphic file.

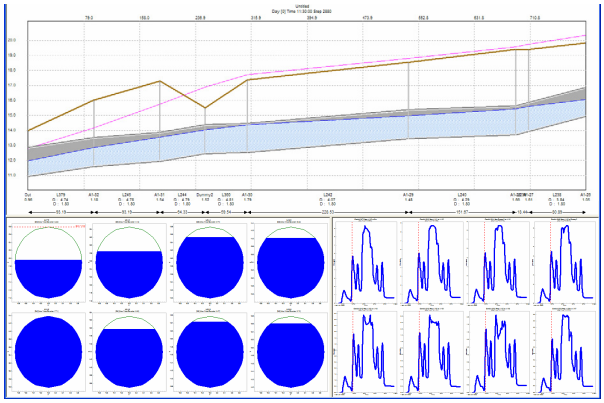
Dynamic Plan Plotting

The results may also be replayed on the plan view with the size and color of the nodes and links changing to reflect changes in the Flow, Velocity and Depth during the simulation period. Instantaneous direction of flow is also indicated.

Scaled plan drawings, including the base map of information, may be generated and output to DXF files, printers and plotters.



Dynamic Section View

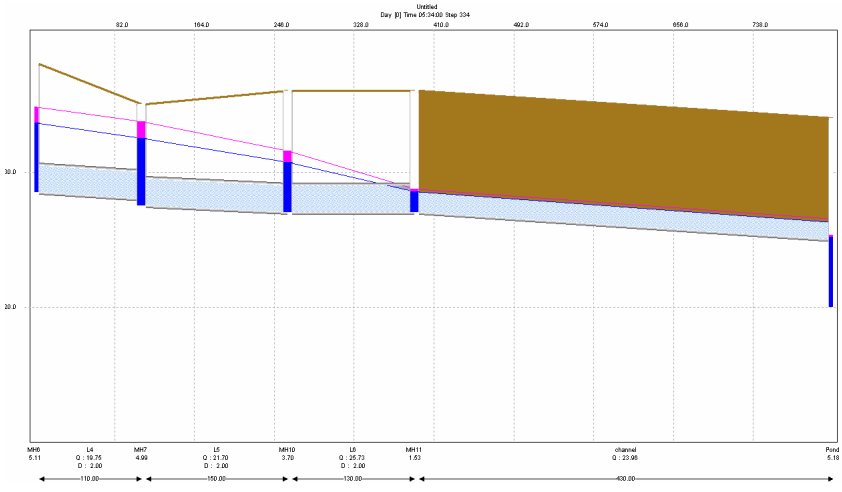


The results may also be replayed on a multi-panel view presenting a profile, cross sections and hydrographs. Dynamic Sections can be construction for a single link or contiguous segment of the network.

Scaled plan drawings, including the base map of information, may be generated and output to DXF files, printers and plotters.

Dynamic Long Profile

A profile for any contiguous segment of the network may be selected for animation of the HGL. The profile displays pipe, manhole and ground geometry and the water levels and HGL over the course of the simulation. The display width of the manhole and other labeling may be adjusted to improve visualization.
Scaled plan drawings, including the base map of information, may be generated and output to DXF files, printers and plotters.



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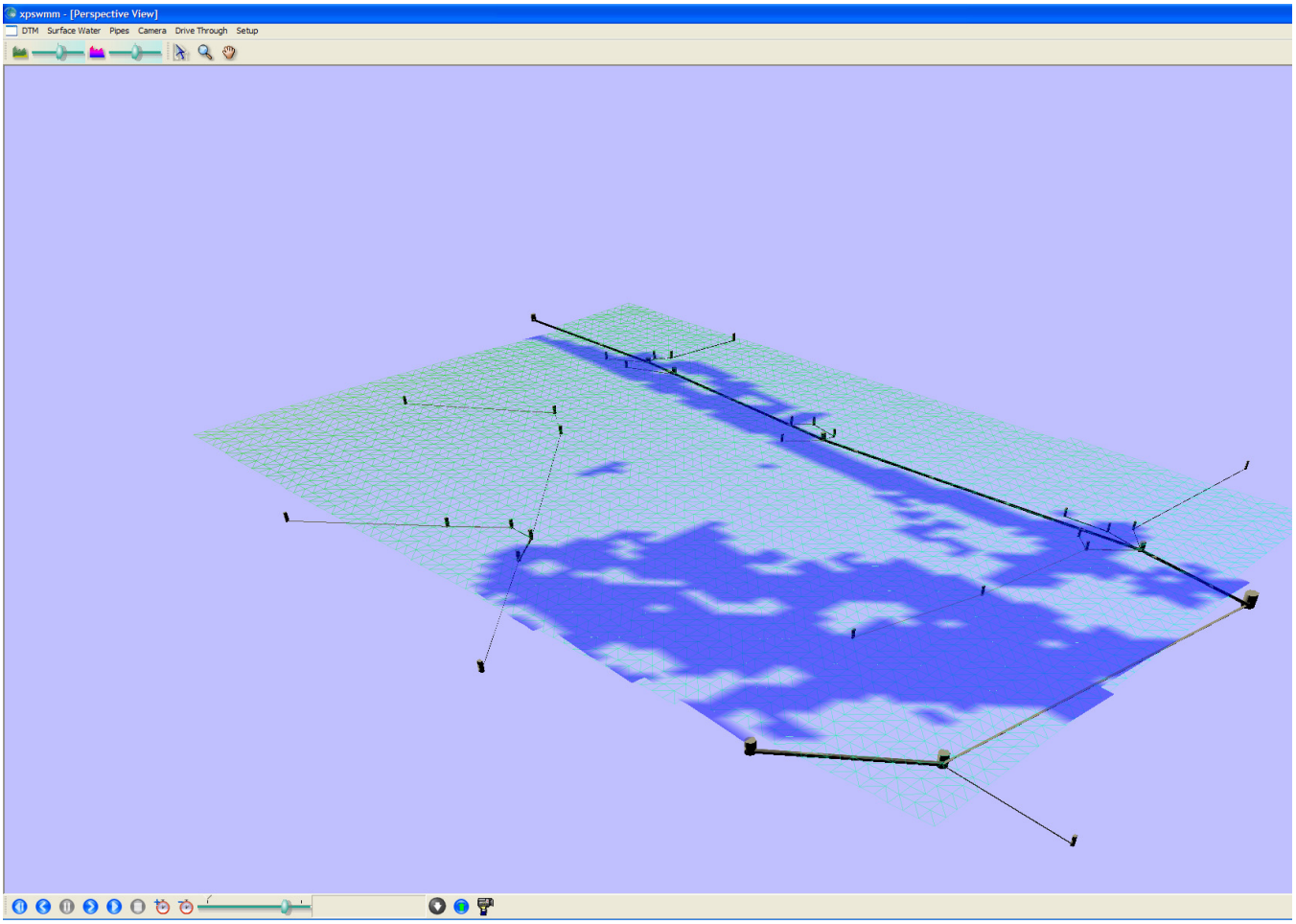
Perspective View

The Perspective View allows model results to be viewed in 3 dimensions. Users may navigate the view by zooming or changing the viewing location. If a DTM is included in the model, it may be viewed in the wire mesh or the shaded mode. Background aerial photos may also be included. The view may be easily manipulated to best view the changing water level during the simulation period.



XP Viewer

The XP Viewer allows data files to be opened and viewed but not modified. The model may be freely distributed to anyone associated with your project. Recipients will have the ability to view and generate all model output including animations of your xpstorm models without the ability to change the model(s) integrity or redoing the simulation.

This is an excellent tool for those customers who need to share their data with others who do not own a license of the software, but wish to view the model(s) data and results.

System Requirements

xpstorm is designed to work on your desktop PC. Requirements for computer power are dependent on the size and complexity of your model, length of simulation, time and other control settings. The following table should be used as a guide.

	Minimum	***Recommended***
Processor	Pentium	Pentium III and higher
RAM	256 MB	1 GB
Operating System	Windows 2000, Windows XP	Windows 2000, Windows XP, Vista
Hard disk	500 MB	2 GB
Display	1024 x 768 256 color	1920 x 1200 32 bit color
Video Card	For 3D viewer 64 MB ram Vertex shader version 1.0 or greater Pixel shader version 1.4 or greater DirectX 9.0	For 3D viewer 256 MB ram Vertex shader version 1.0 or greater Pixel shader version 2.0 or greater DirectX 9.0

Network Capabilities

XP Software offers the ability to run your xpstorm programs over your single location Local Area Network. This enhanced functionality provides you with a network hardware lock which enables any user on your network to run the program from their workstation without the tedium of sharing a hardware key. Alternatively, using the stand-alone hardware lock that is provided with your license the software can be installed on multiple workstations. Your users will be able to access the program according to who has possession of the hardware lock.

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