Boundary Conditions

The following boundary conditions are modeled by the EXTRAN Model:

1. H level functions at internal nodes and outfall nodes:
   a. Free Outfall - The free outfall boundary condition has been modified to allow critical depth, normal depth, or the minimum of critical and normal depth. The previous solution (EXTRAN 4) calculated the minimum of the critical or normal depth in the conduits connecting to an outfall node.
   b. Constant elevation.
   c. Stage history tabulated functions, H(t).
   d. idal (sinusoidal) time series, H(t).

2. Q level functions at internal and outfall nodes, Q(t).
3. Rating curves, $Q = a \cdot y^b$, at internal and outfall nodes.
4. Rating tables of Q versus y at internal and outfall nodes.

EXTRAN computes the current value of hydrograph inflow to each input node in the sewer system at each large time-step. It then reads current values of hydrograph ordinates from an external interface file if the Runoff Block (or any other block) immediately precedes the EXTRAN Block, and/or from line input runoff hydrographs (from the user inflow dialog). EXTRAN then performs a linear interpolation between hydrograph input points and computes the discharge at each input node at the full time step, $t+\Delta t$.

EXTRAN provides for input of up to 100 inflow (standard value, actual value is defined in SWMM, CFG files) hydrographs as input data lines in cases where it is desirable to run EXTRAN alone without prior use of an upstream model or to add additional input hydrographs, either at the same or different nodes, to those computed by the upstream model.

EXTRAN computes seven tide coefficients (if needed), Al through A7, which are in turn used to compute the current tide elevation according to the Fourier series:

HTIDE = A1 + A2 sin wt + A3 sin 2wt + A4 sin 3wt

+ A5 cos wt + A6 cos 2wt + A7 cos 3wt

where

t = current time, hours (units of seconds are used internally),

w = angular frequency 2 pi radians/W (radius/hr), and

W = tidal period in hours

Typical tidal periods are 12.5 or 25 hours. The coefficients A2 through A7 are developed by an iterative technique in which a sinusoidal series is fitted to the set of tidal stage-time points supplied as input data.

EXTRAN evaluates the tidal equations, or interpolates the stage history boundary condition, or uses a lookup table for an outfall defined by a rating curve. It determines the tidal coefficients during the simulation to determine the current tidal elevation for multiple boundary conditions.

Generally, the boundary conditions are calculated using the following procedures:

1. Compute current elevation of receiving water backwater. Depending on the tidal index, the backwater condition will be constant, tidal or below the system outfalls (effectively non-existent). The tidally-varied backwater condition is computed by a Fourier series about a mean time equal to the first coefficient, A1. There are six possible boundary conditions:
   i. Free discharge defined by the normal depth, critical depth, or the minimum of the normal or critical depth.
   ii. Constant elevation. The depth never falls lower than the depth defined by the outfall elevation, but higher depths are possible depending on the flow in the outfall conduit.
   iii. Tidal boundary conditions calculated from coefficients supplied by the user of the model, or generated by the model from tidal data. The tidally-varied backwater condition is computed by a Fourier series about a mean time equal to the first coefficient, A1.
   iv. Stage history, or h(t) calculated by interpolating the time series.
   v. Flow history, or Q(t) calculated by interpolating the time series.
   vi. A rating curve is used to set the node depth, Q(h). The program interpolates the node depth based on a calculated Q.

2. The outfall depth can be assigned in one of three ways: normal depth, critical depth, or the minimum of normal or critical depth for the flow in the outfall conduit. These three options apply to all boundary conditions.
3. A conduit that is surcharged has an upper limit of the conduit depth as the depth boundary condition. This may be a cause of physical oscillations as a reflective wave travels backward through the network system.
4. For outfall conduits with tide gates there is no flow when the computed junction depth is less than the boundary depth.