Section 12 – Hydraulic Design and Analysis

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  - Fixed/Resize
  - Combined Flow
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    - Structures.dat
  - Storm vs. Sanitary
  - Methodology
- HGL/EGL
  - Methodology
  - Generating
  - Displaying
    - Updates

Lab Antecedents:
- .dgn: mesapark.dgn
- data: civil_sns.ini; sns.sdb:

Overview

Given a physical network model and a hydrologic model linked to the physical model, network hydraulic modeling can now take place.

Methodology

A detailed breakdown of the S&S design calculation procedures can be found in the 100+ page *Storm&Sanitary SelectCAD Design Procedures,* published by Bentley and delivered as "stormdp.pdf" with your software. Most of S&S methodology, including Inlet capture methodology and Hydraulic and Energy Grade Line analysis, use as a foundation the Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, available from the National Technical Information Service.

Functionality

The primary hydraulic premises underlying the S&S calculations are
- Steady, uniform flow
- Manning's or Darcy-Colebrook analysis for pipe flow
- Modified Rational Method for runoff computation
- SCS for runoff computation

Given these premises, S&S provides a robust analysis. For example, HGL for adverse-sloped pipes and inverted-siphons work well. HGL Analysis for Pumps, which is very

dynamic in nature, is given a reasonable representation *at equilibrium* given steady uniform flowrates.

The Storm&Sanitary "Design Network" command does an amazing amount of work in a very short amount of time. Analyzing alternative scenarios is almost costless.

Some of the calculations that are performed during a "Design Network" command, include:

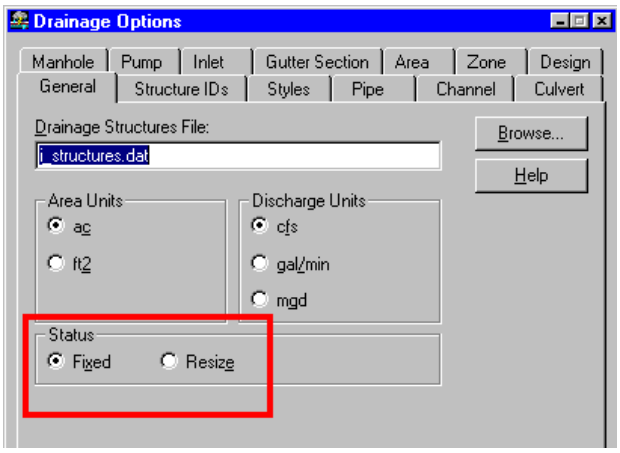
- Sum upstream injected flows
- Sum upstream area flows
- (Storm) Calculate flow travel time in pipes for time of concentration recalculations
- (Storm) Recalculate rainfall intensity based times of concentration plus travel time.
- Gutter flow depth and spread calculations
- Inlet capture percentage from gutter flow characteristics
- Adjust downstream gutter flow to include inlet bypass
- Infiltration
- Headloss at junctions
- Hydraulic and Energy Grade line analysis
- Pipe Sizing based on calculated flow and capacity.
- Inlet Sizing based on sump/gutter capture capacity.
- Junction resizing based on maximum pipe size.

Re-Sizing

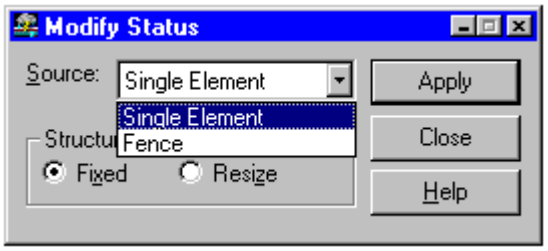
Fixed/Resize

Every Network Structure (as opposed to a Storm Area, Sanitary Zone, or a Utility) in its database record has a field called "Status". The value is either Fixed or Resize. It is this toggle that tells S&S whether to upsize structures to meet design criteria.

Note: on the Drainage Options "General" tab, the lower right frame is for setting the structure status default. It is very important that this default be set to "Fixed" even if you are doing mostly new systems.



It is good practice to explicitly declare a structure to be Resized before AutoDesigning. This can be done either through the Edit/Review command or via the more powerful Modify Status command.



Design Settings

Storm vs. Sanitary

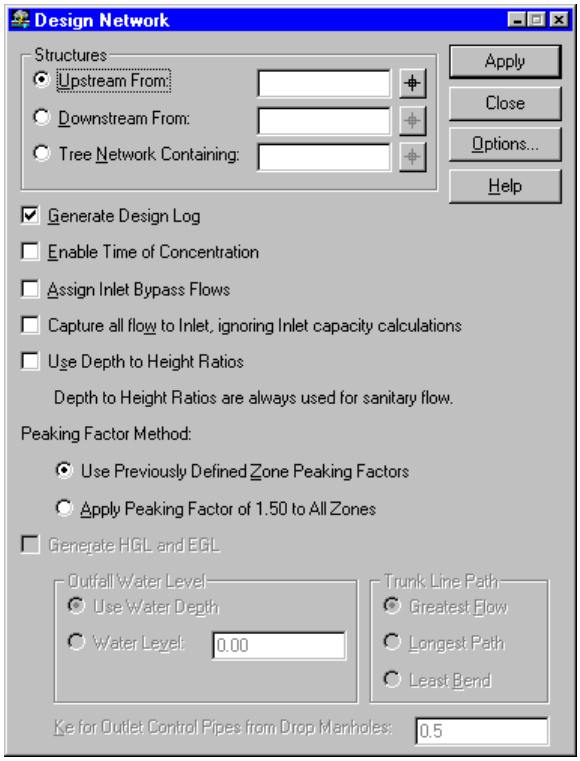
Storm Area Runoff Flow is based on a different methodology than the Sanitary population-based Zone flow. How does S&S manage these different flows in the same structure? The answer is that separate database fields track the required data independently, calculate flows independently, and then sum the answers to provide total flow characteristics. Database Reviews, Annotation and Reports can track the individual and total flow values.

> S&S has an option through which the user can set the product's menus to reflect Sanitary-only, Storm-only and Combined workflows (SC>Tools>Drainage>Menus). Typically, the difference is limited to interface: some tabs or options are not displayed in order to minimize irrelevant presentation.

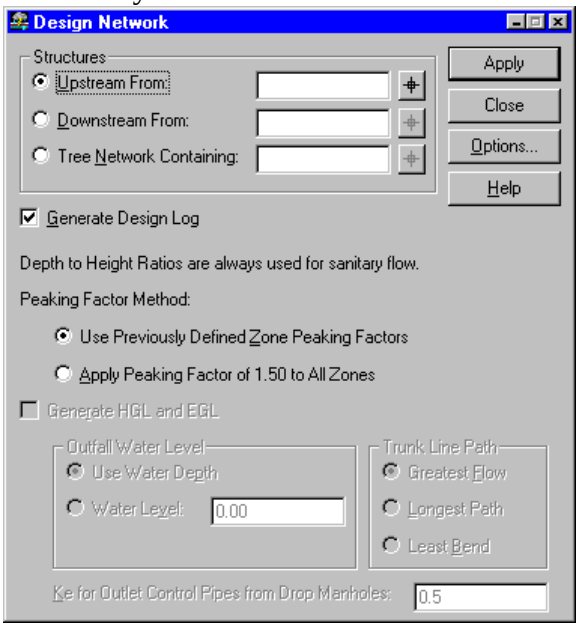
One case where the methodology differs with the interface is Combined flow analysis and Storm-only analysis. Sanitary-only and Combined flow always uses the depth/Height ratios limits defined under Drainage Options, General.

Storm-only has the option of design based on depth/Height criteria or design based on full-flow pipes. Below is the Design Network form for the Combined and Storm-only workflow.

Combined Menus:



Storm-only Menu:

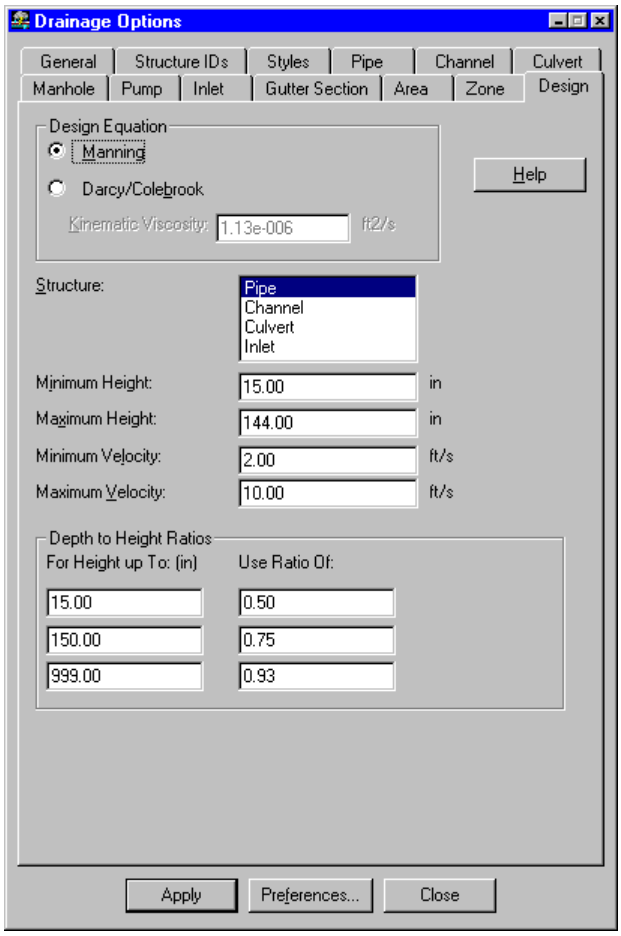


Design Options

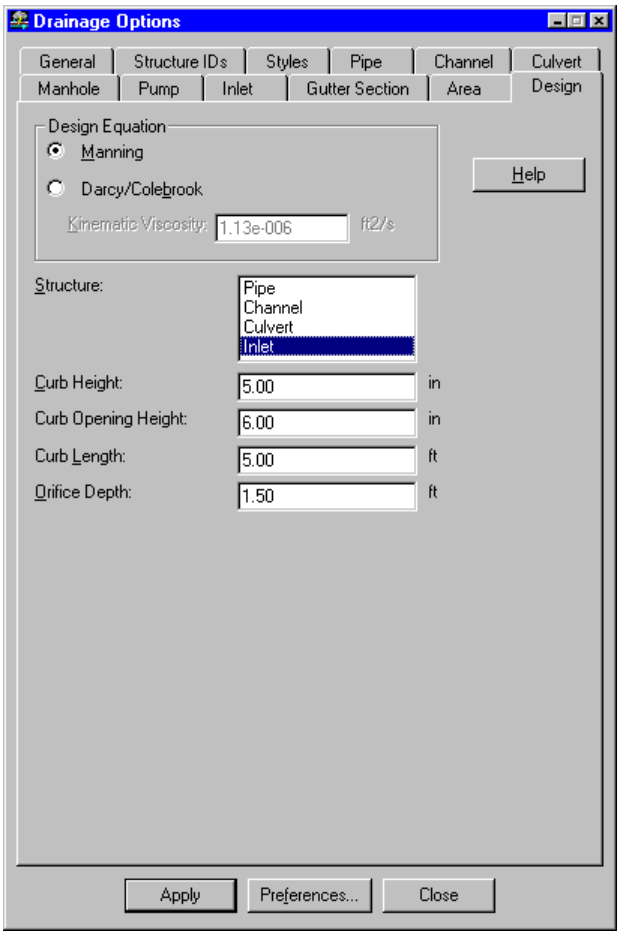
Structures:	Which structures do you want to design? [Almost] Always use "Tree." Tree will find and design all structures in a network regardless of which one you pick. It is the only option that computes HGL and EGL.
Generate Design Log:	Leave ON, extremely useful.
Enable Time of Concentration:	This recalculates area flow intensities based on the area overland travel time PLUS the network travel time.
Assign Bypass flows:	New with v8.2! If no Interceptor has been defined for an Inlet, assumes the next downstream inlet intercepts the flow (not a valid assumption in surface adverse slopes or vertical curves (see Section 12).
Capture all flow to Inlet, ignoring Inlet capacity calculations:	New with v8.2! Forces Area and Injected (into Gutter) Flow into an Inlet even if the inlet is hydraulically incapable of capturing the flow.
Use Depth to Height Ratios:	Resizes Storm/Combined pipes based on Depth to Height ratios defined in Drainage Options>>Design>>Pipe.
Peaking Factor Method:	(Sanitary Flows only). Uses each Zone's previously calculated Peaking Factor –OR- Overwrites Peaking factor with currently active Settings.
Generate HGL and EGL	When ON, performs HGL and EGL analysis
Outfall Water Level:	used for HGL/EGL starting Hydraulic Grade.

Structure Design Settings

The Drainage Options form, Design tab, contains settings that are used during the design process.



Pipe Design Options



Inlet Design Options

By selecting the Structure Type in the Structure list, the respective options are displayed.

Methodology

The following structures are upsized based on the following methodology:

Pipes

Full flow (Storm-only)

1. Determines flow from upstream structures.
2. Calculates a theoretical diameter based on full flow (Manning's backwards).
3. Looks in the structure file (I_structures.dat) for the next pipe size larger than the calculated size (plus a tolerance of 0.2 in/mm)

Depth/Height (d/H) (Sanitary-only and Combined)

1. Same initial steps as above.
2. Normal Depth to Height(Diameter) ratio is computed.
3. Design criteria is checked. If the d/H ratio for the pipe is greater than that allowed in the Design criteria table,
    a. the next pipe size is selected
    b. the normal flow numbers are recalculated
    c. the d/H checked again.
4. The process continues until a pipe size is chosen where the d/H meets design criteria.

Manholes
A field in the structures file for each Manhole size specifies a maximum attached pipe diameter.

Sump Inlets
Upsized based on first size in structures file to accept all injected and area flow at that structure.

On-grade Inlets
Upsized to capture a user-defined percentage of gutter (area) and inject flow.

S&S Modeling Restrictions

S&S has a number of restrictions on flows that may require editing the model before designing the system. In particular, there are some restrictions as to which Flow Sources (Storm or Sanitary) can be attached to a structure.

HGL/EGL

Methodology

Storm&Sanitary makes a solid effort to implement HEC-22's HGL/EGL Analysis procedure. Chapter 7 of HEC-22 is devoted to HGL Analysis, including a 25-page example. The methodology is fairly complex. S&S deviates in some subtle ways from HEC-22, primarily where HEC-22 is poorly suited for graphical display. The solution is robust and hydraulically defensible. Things look right, which is no easy feat.

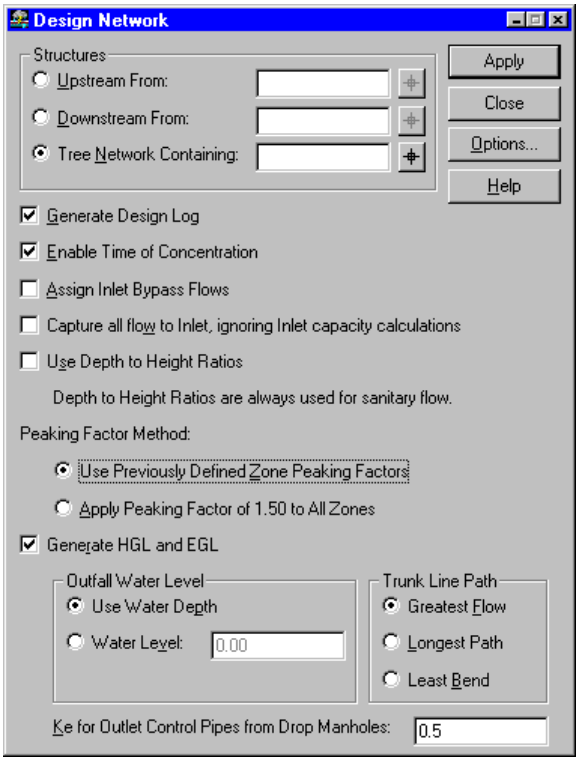
Note: If there is a detail in the implementation that does not work for your organization, please let Intergraph/Bentley know through the normal support channels. Also, the Civil Engineering Users Group, Water Resource subcommittee is interested in your feedback (ask your instructor for information).

The overall HGL methodology is standard hydraulics: start working upstream from the discharge point adding friction losses as one moves upstream. The tailwater elevation can be entered or derived from the normal depth in the discharge structure. Pipe friction slope is based on normal open-channel flow, surcharged flow or full flow due to downstream conditions. Head loss at junctions is computed and added.

For pipes that are of mixed condition (full-flow at the downstream end of the pipe only, due to tailwater effects) the database record is populated with normal flow information. Only in the event of the pipe being completely surcharged will the appropriate records (depth, velocity, headloss) be re-populated with full-flow information.

Generating HGL/EGL

Hydraulic and Energy Grade computations can be performed during the Design Network command only when the entire network is analyzed. When the "Tree Network Containing:" radio button is selected, the "Generate HGL and EGL" option is enabled.



If a design log is generated the latter part includes an HGL/EGL derivation table. Structure records are also updated with the data.

Displaying HGL/EGL

HGL and EGL are objects available for display in the Create Profile command. Checkboxes in front of their object Names in the Create Profile, Network "Symbology" frame are used to dictate whether they will be generated with the profile.

Profile Updates

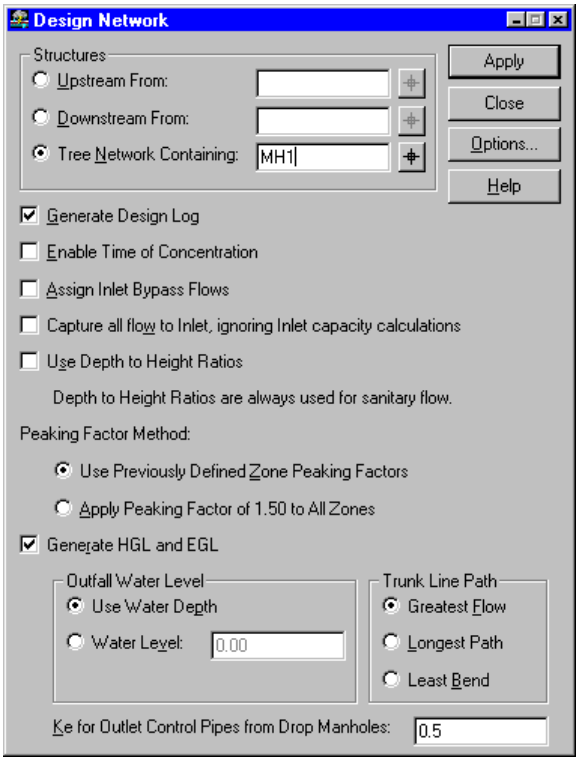
There is a difference between the Profile Generate and Profile Update functions. The Update Profile command updates the HGL and EGL lines where they are already displayed. Updating a Profile that was Created without the HGL or EGL boxes ON will not Create a new HGL or EGL entity.

One of the great things about Storm&Sanitary is the ability to change the network while working in the profile view. Pipes can be resized, raised or lowered and the hydraulic repercussions visualized almost immediately. In most cases, an Update Profile will regenerate the HGL/EGL correctly. In some cases, in particular those case where a pipe changes from partially filled to completely surcharged, the depth, velocity and headloss information is not recalculated until the next Network Design.


It is a very good idea after altering a network to re-Design it. This ensures that all hydraulic information is up to date and subsequent Profile Updates accurately portray the new hydraulic information.

Goal 1 – (Auto) Designing the Network.

1. Select SC>Drainage>Network>Design 



2. In the Structures frame, select the "Tree Network Containing:" radio button.

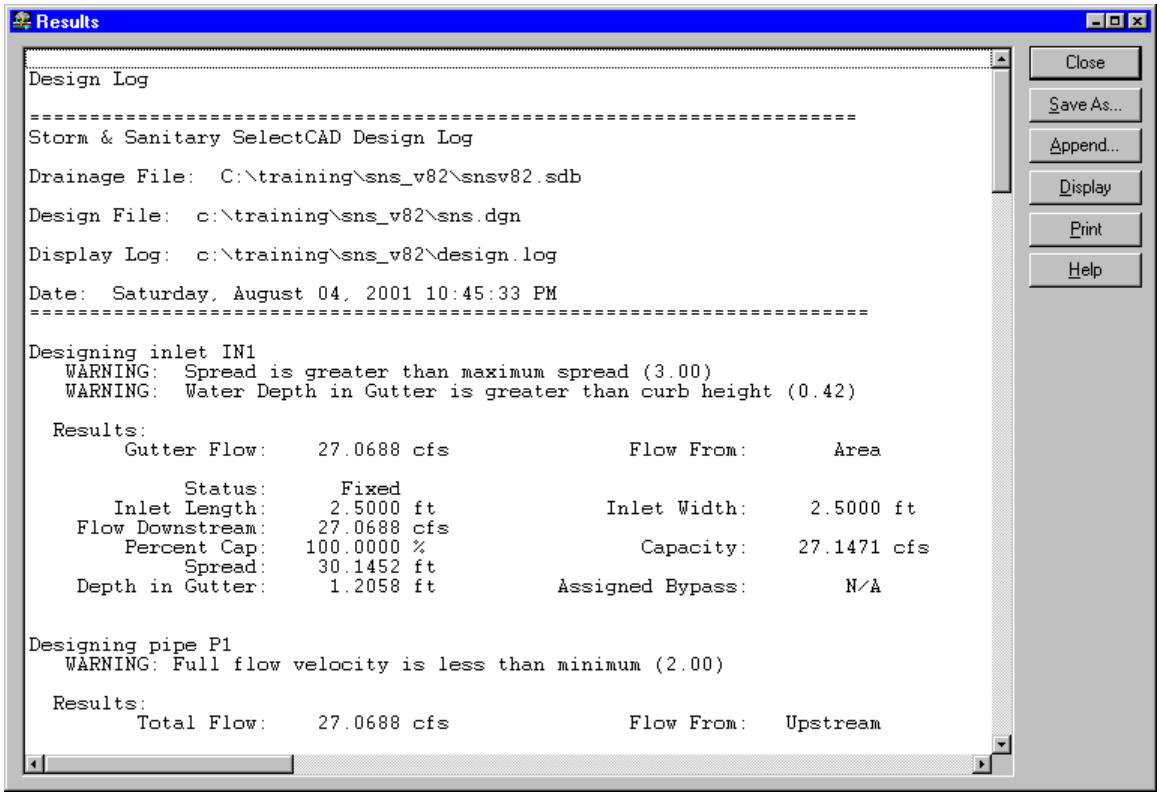
You should always use the Tree option. The other two options are useful only for very large branched networks on very slow machines.

3. Select any structure in the network, either by using the Locator button or by keying in the name.
4. Ensure that "Generate Design Log" is checked (ON).
5. For this lab, ensure that "Enable Time of Concentration" is NOT checked (OFF). This recalculates area intensities based on the area travel time plus the network travel time.
6. Ensure that "Generate HGL and EGL" is checked (ON).
7. Hit Apply.

S&S designs the structures in the network, highlighting each in its sequence. Warnings are sent to the MicroStation command window if Design Parameters are violated

(velocity, spread, etc.). A more severe error stops the processing at the offending structure.

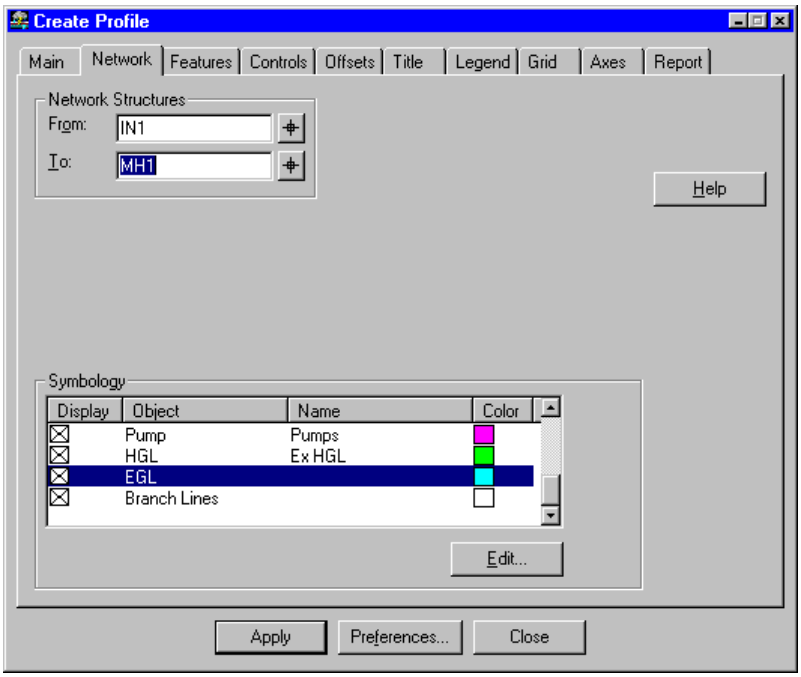
A design log is generated listing a great deal of the information concerning the design. This information is printable, displayable and savable via the controls on the form.



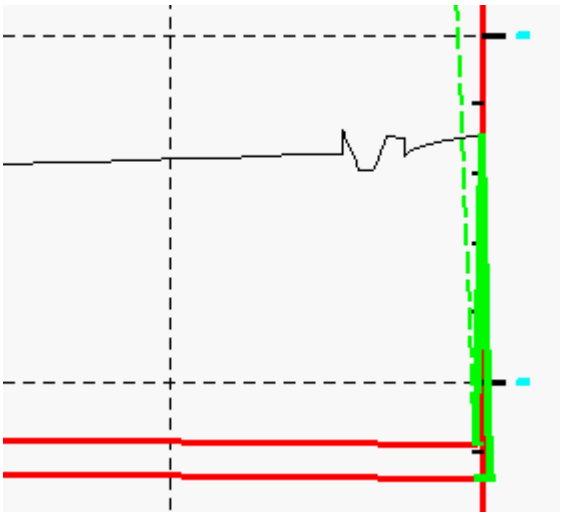
Design Information can be Annotated and Reported.

Goal 2 – Displaying the HGL and EGL

8.	Generate a Profile on the Network (SC>Evaluation>Profile>Create Profile).
9.	Ensure that the HGL and EGL objects are ON.



A trained profession would notice that something is wrong. Do you get a towering profile? Does the HGL shoot straight up?

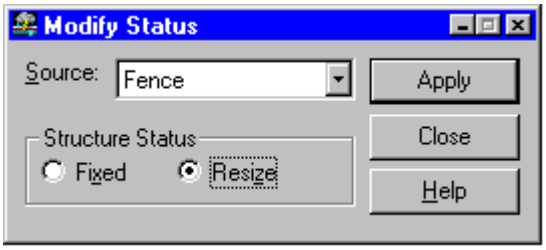


What is happening here is the network is terribly undersized for the flow coursing through it. The Condition field for all the structures is "Fixed." S&S is not allowed to upsize the pipes to meet the design constraints.

Goal 3 - Allowing S&S to Size Structures

Let us allow S&S to design the system.

10. Place a MicroStation fence around the system.
11. Select SC>Drainage>Structure>Modify Status.
12. Select “Fence” for Method.
13. Select “Resize” for Structure Status.



14. Hit Apply.

A message says “Toggle completed”

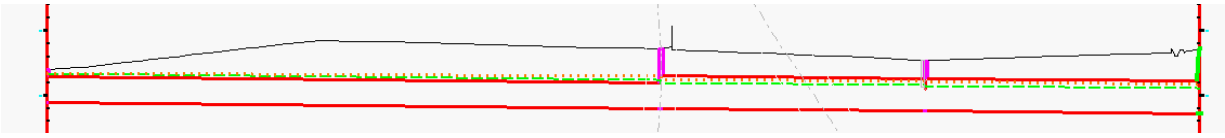
15. Close the form.

Let us re-Design the system.

16. Select SC>Drainage>Network>Design.
17. Hit Apply (all the settings should be the same as the last time).

18. Update the Profile (SC>Evaluation>Profile>Update Profile).

The HGL and EGL should look something like below:



If the HGL is steeper than pipe slope (meaning surcharged) there is a good chance that the maximum size for the pipe type has been reached. For this lab this means that the structure file is incorrect. The structure file in the training directory should be adequate. The file can be checked via Drainage Options>General. Pipe sizes can be checked via Drainage>Structures File.