NETWORK SURVEY MANAGER

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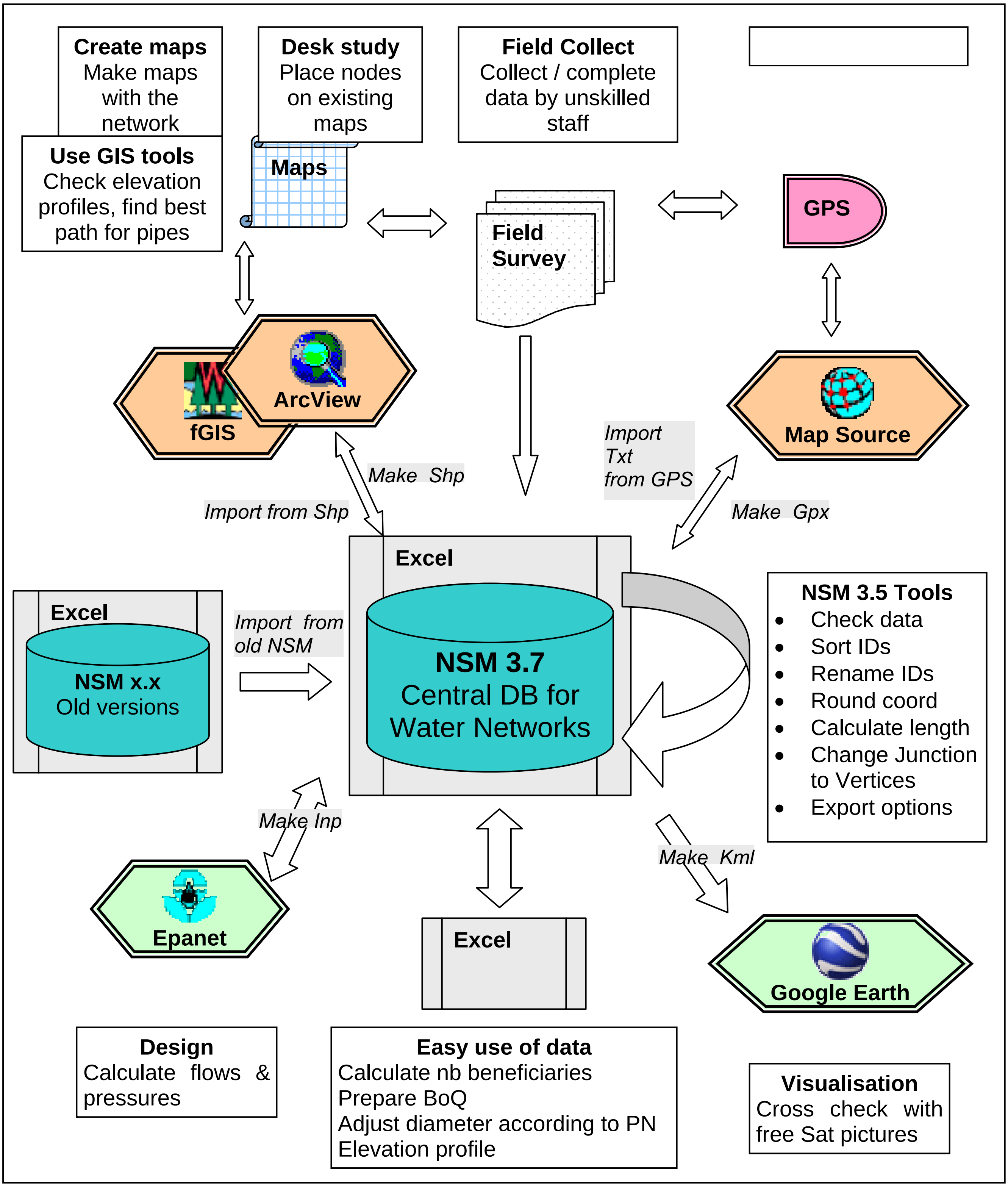
1. Introduction

Network Survey Manager (NSM) is a database built on excel that can monitor, design and plot a water network. The information about this network can come from different sources, such as GPS/field surveying, GIS software or Epanet. Once this information has been managed by NSM, it can be exported to a GIS software, GPS, Epanet or Google Earth. The following figure shows an overall picture of the components that can be involved in NSM and their links.



When NSM is opened, many worksheets already exist and the worksheet "Main" is open.

If trying to do a chronological sequence of the worksheets and tools that will be used, it would be like presented after.
First, a set of parameter must be set in the "main" worksheet.
Second, the data must be entered or imported. Data are entered or imported worksheets that are mentioned right after. If data are imported, it is done with the importation tools.

- The nodes in orange (junction, reservoir, tank), links in green (pipe, pump and valve) and vertices in pink are components of the network. They need to be filled in first.
- The pattern and curve in yellow are information about the water consumption of the community and the pump/tank/reservoir that will be used by the components of the network (for a pump or a junction with beneficiaries). They need to be filled in paralle to the nodes/links worksheet. However, given that some patterns and curves are already implemented, these worksheet might be used without being modified.

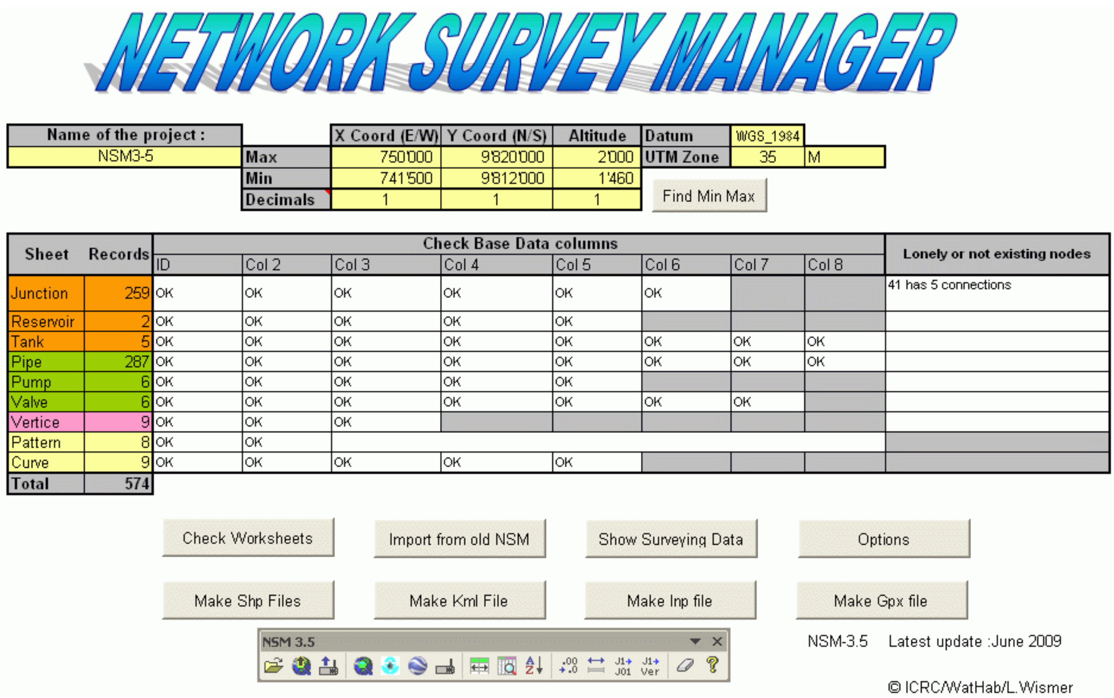
Then data can be organised, modified and checked, using the organisation/modification tools and the "main" worksheet.

The result can be seen in the chart worksheet, which is a chart of the network that is used at the end to visualise the network. Data can be exported with the exportation tools.

To simplify the structure of this document, first the different worksheets will be presented, and then the tools. At the end, a detailed methodology of how to collect data from the field by surveying is given.

2. MAIN

The main sheet is the control center of NSM. It is where the various NSM tools reside and is where the environment settings for the particular project network are set. In this section, only the settings will be discussed. The tool menu will be discussed in the **tool** section.



Name of the project :
Goma New

Name of Project: This is where one enters the name of the network. No two networks should have the same name, else confusion will ensue. In cases where two or more networks are in the same locality, then a serial roman or alphabetical suffix should be used to differentiate them. For example Kandwi I, Kandwi II…. Kandwi N.

Coordinate Bounds: This is a mitigatory measure to ensure that coordinates entered in the various sheets do not go beyond the target area. The bound coordinates should be the limit coordinates of the Minimum Bound Rectangle (MBR) around the network area. The Max(imum) X coordinate (E/W) is the Easting of the farthest edge of the network to the **East**, while the Min(imum) X Coordinate is the Easting of the farthest edge of the network to the **West**. The Max(imum) Y Coordinate is the Northing of the farthest edge of the network to the **North** while the Min(imum) Y is the Northing of the farthest edge of the network to the **south**. The Length refers to the number of digits that coordinate values should have

	X Coord (E/W)	Y Coord (N/S)	Altitude
Max	750'000	9'820'000	2'000
Min	741'500	9'812'000	1'460
Decimals	1	1	1

Elevation Bounds: This is a measure against erroneous elevation entries. It sets the highest and lowest possible values acceptable as valid elevation entries.

Please note that these checks only guard against obvious errors like missing a digit while entering values or adding an erroneous extra digit, or entering a value that would place your network feature outside the target area, BUT does not substitute ones caution and keenness to ensure that the values entered are correct. A wrong value that falls within the network MBR will **not** be detected.

At the right of this table, the command button "Find min max" can find the maximum and minimum values, based on the data you entered in the sheet. This allows the opposite approach. It needs that data are first entered, and then the min and max are found. Based on these values, it can be determined if there is an erroneous data. Again, this will only detect obvious mistakes.

Datum	WGS_1984	
UTM Zone	35	M

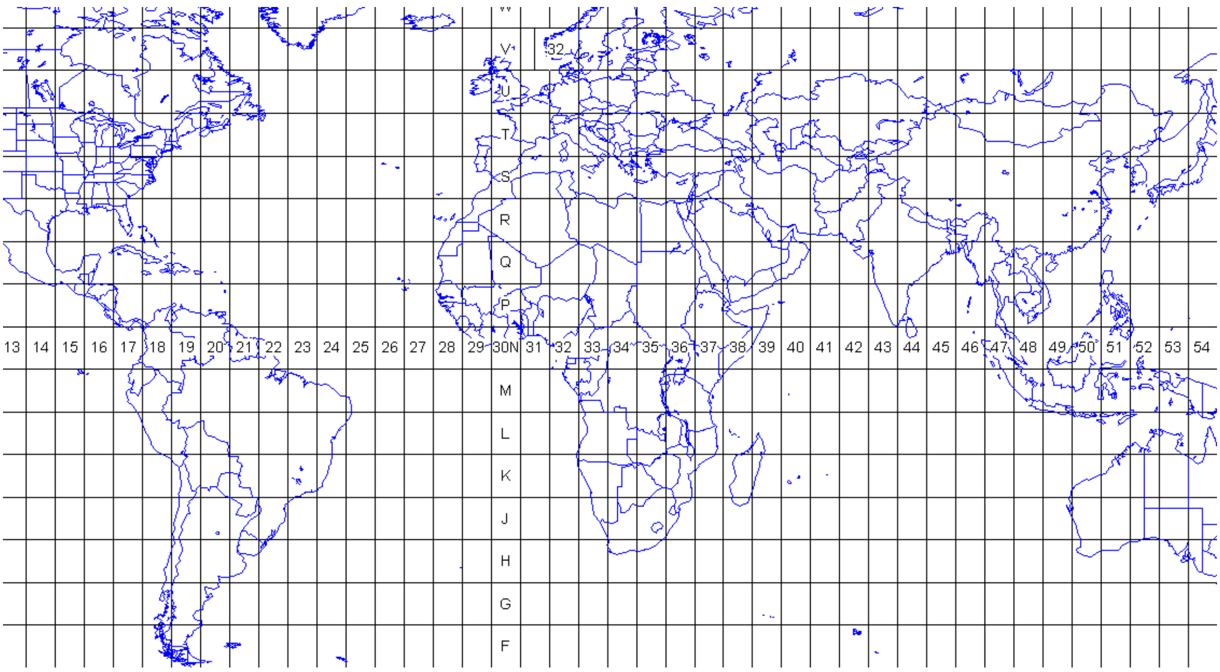
Coordinate System: A datum is a set of orientation, scaling and translation parameters applied to an ellipsoid of known physical parameters (major Axis, Minor Axis and Flattening) to best approximate the geoid. One is expected to understand the datum on which coordinates are declared for ease of data integration. Most of the time, the WGS 1984 is used. Once the datum is determined/selected, the topographical maps and GPS receivers being used in the field must be of or set to the selected datum.

For standardization and ease of tools development, the projection is set to Universal Transverse Mercator (UTM) and all one has to set is the Zone in which the network lies. In case of difficulty, seek expert assistance. The table below can guide in the choice of zone if the longitude of the place is known.

UTM Zone	Zone Range	Central Meridian	UTM Zone	Zone Range	Central Meridian
1	180W - 174W	177W	31	0E - 6E	3E
2	174W - 168W	171W	32	6E - 12E	9E
3	168W - 162W	165W	33	12E - 18E	15E

4	162W - 156W	159W	34	18E - 24E	21E
5	156W - 150W	153W	35	24E - 30E	27E
6	150W - 144W	147W	36	30E - 36E	33E
7	144W - 138W	141W	37	36E - 42E	39E
8	138W - 132W	135W	38	42E - 48E	45E
9	132W - 126W	129W	39	48E - 54E	51E
10	126W - 120W	123W	40	54E - 60E	57E
11	120W - 114W	117W	41	60E - 66E	63E
12	114W - 108W	111W	42	66E - 72E	69E
13	108W - 102W	105W	43	72E - 78E	75E
14	102W - 96W	99W	44	78E - 84E	81E
15	96W - 90W	93W	45	84E - 90E	87E
16	90W - 84W	87W	46	90E - 96E	93E
17	84W - 78W	81W	47	96E - 102E	99E
18	78W - 72W	75W	48	102E - 108E	105E
19	72W - 66W	69W	49	108E - 114E	111E
20	66W - 60W	63W	50	114E - 120E	117E
21	60W - 54W	57W	51	120E - 126E	123E
22	54W - 48W	51W	52	126E - 132E	129E
23	48W - 42W	45W	53	132E - 138E	135E
24	42W - 36W	39W	54	138E - 144E	141E
25	36W - 30W	33W	55	144E - 150E	147E
26	30W - 24W	27E	56	150E - 156E	153E
27	24W - 18W	21W	57	156E - 162E	159E
28	18W - 12W	15W	58	162E - 168E	165E
29	12W - 6W	9W	59	168E - 174E	171E
30	6W - 0E	3W	60	174E - 180W	177^{E}

As can be seen, there are 60 zones of 6^0 longitude belts which run serially from -180^0 Longitude to 180^0 Longitude. Similarly, there are 20 Sectors named serially in alphabetical order from C to X excluding I and O of 8^0 Latitude belts ranging from -80^0 latitude to $+80^0$ latitude. This is such that C-M and N-X represent the southern and northern hemispheres respectively. See the UTM zones and sectors for the whole below. When the square of interest is identified, first read the zone number of the column on the bottom of the map, and then the sector letter on the right. For Switzerland for example, it would give "32T". This map is put in a bigger format in the annexes.



3. NODES

These are the point features on the network. They signify the change in flow and flow characteristics, network outflows and inflows and network storage components. The nodes include Junctions, Reservoirs and Tanks. To fill in these worksheets, data can be imported using the **importation tools** (see the Tool Menu).

3.1. Junctions

Junctions are points in the network where links join together or are changing their characteristics and where water enters or leaves the network. Hence a junction is when you have a T on a pipe, the end of the section, a house connection or change in the pipe's diameter.
For small networks, one can have a junction for every domestic point, while for large networks it might improve efficiency in calculation to model a series of domestic points using one junction with a demand equivalent to the combined demand.
See example modelling below, where the corresponding series of domestic points and connections to the left are modelled into two nodes in the model to the right.

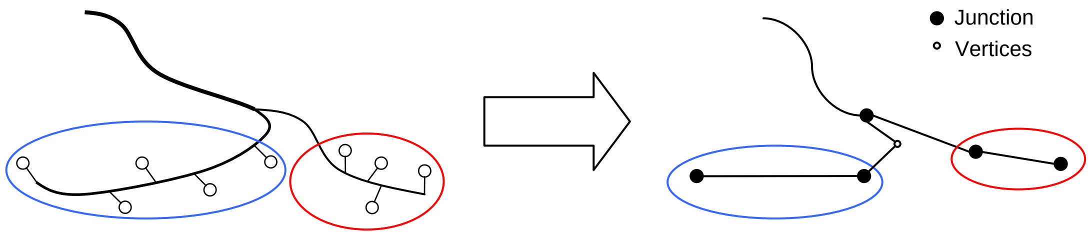
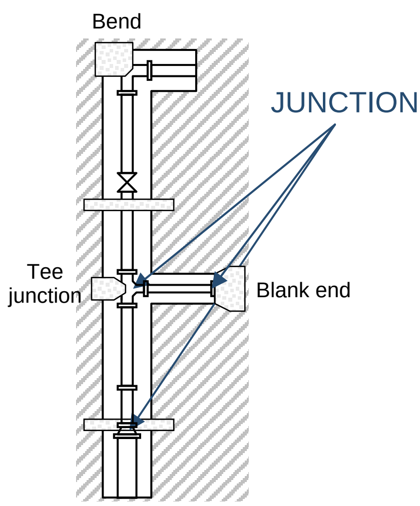


Figure 1 : Modelling domestic connections

Base Data

Base data							
Junction ID	**X-Coord**	**Y-Coord**	**Elev**	**Demand**	**Pattern**	**Emitter**	**Description**
J001	742'933	9'815'965	1'490	5.29	paRural	0.1	T connection
J002	742'746	9'815'745	1'490	3.97	paRural	0.1	Houses XX



Junction ID: This is the unique identifier for the particular junction. Usually a serial sequence preceded by "J" to denote Junction for example J0001, J002, J003……..Jxxxn. Two Junctions should not have a similar ID.

X-Coord: This is the X- coordinate or the Easting of the junction. May be obtained using a GPS Receiver or scaled off a gridded topographic map. Ensure the GPS Receiver is set to the correct coordinate system, correct projection and correct geodetic datum (use UTM zones).

Y-Coord: This is the Y- coordinate or the Northing of the junction. Like with the X-Coord above, may be obtained using a GPS Receiver or scaled off a gridded topographic map.

Please note that projection and datum is important to pay attention to, in this case if a GPS is used, the coordinate settings should be UTM. Check the "main" section.

Elev: This is the elevation of the junction above mean sea level. Please note that this is NOT the elevation of the ground surface above mean sea level but rather that of the actual junction above sea level. Should the junction be buried d-metres below ground surface, then this must be subtracted from the height of the ground surface. Elevation can be approximated using the GPS *(Please remember to indicate under description if this is the case)* or interpolated from the grid contours, but most accurately through trigonometrical heighting or levelling.

Demand: This refers to the outflow from the network at a particular junction. Only domestic points can have demand. The rest of the junctions have zero demand. In most cases, unless metre readings exist, demand is approximated from the beneficiary population. The number of people who are supplied from a particular junction, or the number of jerry cans that are drawn from the junction daily can be used to approximate the demand. It is described in Cubic Metres per Day.

Pattern: This refers to the cycle of demand throughout the day. The regular behaviour pattern of the beneficiary population with reference to demand for water. What times of the day do more people draw the water and what times do one find fewer people. It is the variation of demand with time throughout the day.
Example and useful patterns have been included within the *pattern* sheet of the NSM and one can select the most appropriate one. It can also be adapted by using the excel sheet "demand pattern" available in the annexes of the RefMan, under calculations.
See **pattern** worksheet for more information

Emitter: Emitters are devices associated with junctions that model the flow through a nozzle or orifice. In these situations the demand (i.e. the flow rate through the emitter) varies in proportion to the pressure at the junction raised to some power.

$$Q = s \cdot h^{exponent}$$

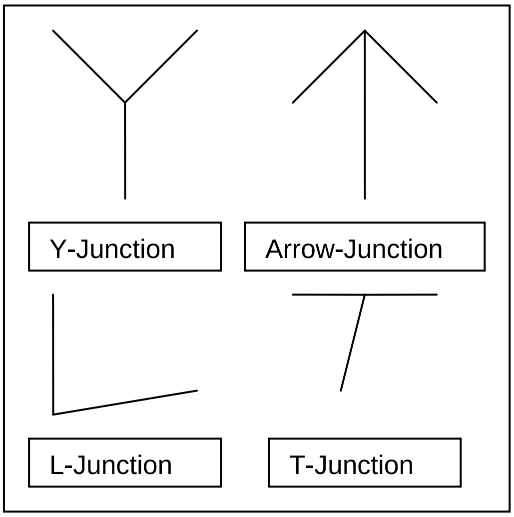
They can be used to simulate leakage in a pipe connected to the junction (if a discharge coefficient and pressure exponent for the leaking crack or joint can be estimated) and compute a fire flow at the junction (the flow available at some minimum residual pressure). In the latter case one would use a very high value of the discharge coefficient (e.g., 100 times the maximum flow expected) and modify the junction's elevation to include the equivalent head of the pressure target.

Description: This is for explanatory notes on any of the various data fields. Any information that is important but not captured by the existing data fields and any relevant remarks.

Additional Data

Additional data refers to all auxiliary data important in understanding the network but also clarifying base data. Some of it is redundant data to enable diagnose network calculation errors and data inconsistencies within the base data. However, if this information is available and relevant, it must be entered. It can simplify things in a couple of years, when the situation has changed and nobody is able to remember how it was before.

Additional info							
Find Type	Beneficiaries	Consumption	Ground Level	Depth	Date Installed	State	Comments



Type: The type of junction it is. Whether T, L Y or Arrow junction.
The find button will determine the type of junction it is, looking at the pipes that comes to that junction and go away from that junction.

Beneficiaries: This is the number of beneficiaries who draw water from the junction. In the absence of water meter data, the demand at a junction, which is base data, is approximated from the number of beneficiaries using some standard indicators. For example 300 people relying on a domestic point could result in a demand of 15m^3 per day assuming a standard water requirement of 50 litres per person per day.

Consumption: This is the approximate daily consumption per person. In cases where an arrangement by the water committee and the community on the daily entitlement per person and/or household, this would be the figure reduced to the units of the number of people. Should you enter households instead of people in "No of People" column, the consumption must also be per household. One is however required to maintain consistency and in this case no of people and consumption per person should be adopted.

Ground Level : (MASL) This is the height of the ground surface above mean sea level at the junction location. It is a working height from which you subtract the depth of the junction below ground to obtain the elevation in base data.

Depth: (M) This the depth in metres of the junction below ground surface. Besides enabling you determine the actual elevation of the junction, is very important information about the junction during maintenance exercise.

Date Installed: This is the date the junction was installed or the date of the last parts service (replacement). Important to determine serviceability and could be obtained from the office or from expert/experienced local knowledge.

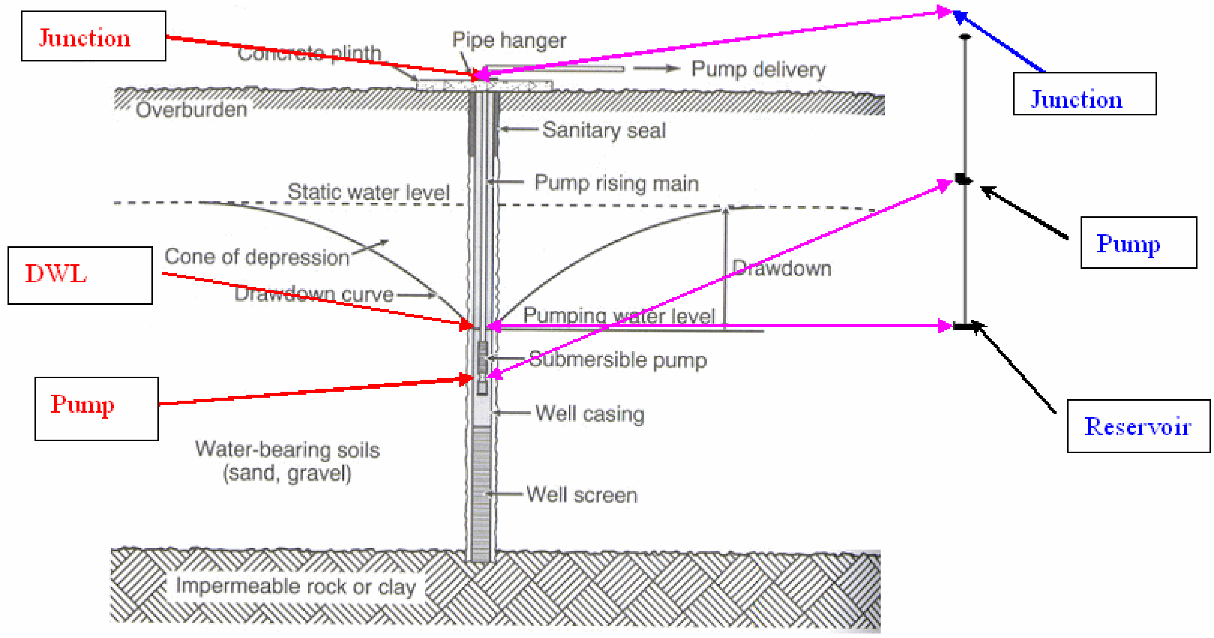
State: This is the state of repair of the junction. Whether it is very good, good, fair, poor or very poor.

Comments: This is for explanatory notes on any of the various data fields. Any assumptions made, any information that is important but not captured by the existing data fields and any relevant remarks.

3.2. Reservoirs

Reservoirs are the sources of water for the network. They are the inlet points through which water enters the network. They may be boreholes, wells, lake, dam, river intake among others.

Please note that the spring is a special case as the discharge of water from the spring is independent of any downstream conditions within the network. As such, a spring is usually modelled as a junction with negative demand. The scalar part of the demand is the total flow discharge from the spring.



Base Data:

Base data					
Reservoir ID	**X-Coord**	**Y-Coord**	**Head**	**Pattern**	**Description**
LacKivu1	747'609	9'813'174	1'460.0		Captage Kivu
LacKivu3	741'761	9'815'633	1'460.0		Captage Keshero

Reservoir ID: This is the unique identifier to identify the particular reservoir in the database. Like all the other components, every reservoir must have a unique identifier which as the name implies must not be similar to any other reservoir. Usually, a serial sequence prefixed with letter "R" as in R001, R002, R003………Rxxxn. However, since for most networks, the reservoirs are boreholes sometimes the prefix may be "BH" instead of "R".

X-Coord: As is the case with the junction, and any other node for that matter, this is the X-Coordinate or the Easting of the reservoir and can be obtained using GPS or by scaling off a topographic map with grid lines.

Y-Coord: This is similarly the Y-Coordinate or the Northing of the reservoir and can be obtained using GPS or by scaling off a topographic map with grid lines.

Head: As can be appreciated from the model above, the head is the height of the Dynamic Water Level (DWL) above mean sea level *(or above adopted Datum)*. This can be obtained by determining the elevation of the ground surface then subtracting the DWL as is conventionally defined i.e. as a depth from ground surface.

Pattern: This is the variation of the Dynamic water level with time. If this is possible to obtain, should be included otherwise, time should not be lost looking for it as it is not too critical.

Description: This is for explanatory notes on any of the various data fields. Any assumptions made, any information that is important but not captured by the existing data fields and any relevant remarks.

Additional Data:

Additional info							
Type	Yield l/d	Protected	Ground Level	Depth	Date Installed	State	Comments

The *Ground Level (m), Depth, Date Installed, State and Comments* are as explained under Junctions.

Type: This is whether the reservoir is a borehole, a River Intake, a Dam, a well, a lake or a connection to another supply network.

Yield l/d: this is the maximum discharge the source can sustain in litres per day

Protected: Whether the water source is protected or not. Please indicate in the description what kind of protection it is.

Quality Data:

This is for information about the quality of water from the source. Whichever method is used to determine the quality parameters must be described under the description column. Please note that water quality is a sensitive issue especially in public water supply and must be handled in a cautious manner.

Quality				
PH	Turbidity	Colour	Conductivity	CommentsQ

pH: The pH of a sample of water is a measure of the concentration of hydrogen ions. It is the negative logarithm of the hydrogen ion (H+) concentration. What this means is that at higher pH, there are fewer free hydrogen ions, and that a change of one pH unit reflects a tenfold change in the concentrations of the hydrogen ion. For example, there are 10 times as many hydrogen ions available at a pH of 7 than at a pH of 8. The pH scale ranges from 0 to 14. A pH of 7 is considered to be neutral. Substances with pH of less that 7 are acidic; substances with pH greater than 7 are basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. This value is obtained either at a water testing laboratory or using a pH meter.

Turbidity (NTU): This is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. Turbidity is measured in NTU (nephelometric turbidity units). May be measured in a laboratory or using a handheld turbidity meter.

Colour (mgPt/l): This is a visual interpretation of the colouration in water. If tested in a laboratory would be measured in mgPt/l, but visually interpreted as greenish, brown or no colour among others.

Conductivity (µS/cm): Electrical **conductivity** (EC) estimates the amount of total dissolved salts (**TDS**), or the total amount of dissolved ions in the water. It is measured in micro Siemens per centimetre (µS/cm).

CommentsQ is like in the other cases used to record any relevant remarks, assumptions or extra information.

3.3. Tanks

These are storage systems used to retain water for distribution in periods when pumping or extraction from the reservoir is not on-going. They are like buffer systems to regulate flow at the distribution end.

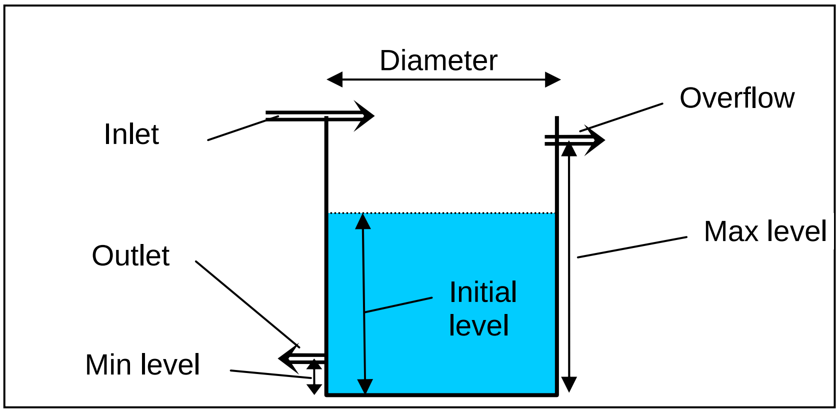


Figure 2 : Tanks modelling

Base Data

Base data										
Tank ID	**X-Coord**	**Y-Coord**	**Elevation**	**Init Level**	**Min Level**	**Max Level**	**Diameter**	**Min Vol**	**Vol Curve**	**Description**
TBusha	749'042	9'819'024	1'619	1.5	0	3	23			Nouveau

Tank ID: This is the unique identifier to identify the particular storage tank in the database. Like all the other components, every tank must have a unique identifier which as the name implies must not be similar to any other tank. Usually, a serial sequence prefixed with letter "T" as in T001, T002, T003………Txxxn.

X-Coord and *Y-Coord* are as explained under Junctions and Reservoirs

Elevation: As shown on the model, elevation is the height of the tank-bottom above mean sea level. Since most of the times they are elevated tanks, this may be obtained by determining the height of the ground surface and adding the height of the tank-base above ground.

Initial Level: This is the height of water surface above tank-bottom in metres at the start of network calculation. In other words, the length of water column within the tank at the start of network calculation/analysis.

Min Level: This is the level of water in tank in metres below which there is no possibility for water to leave the tank. It is the height of the outlet pipe from the base of the tank.

Max Level: This is the maximum height in metres water can attain above the tank base. Usually the height of the overflow pipe from the base of the tank.

Diameter: The diameter of the tank in meters. For cylindrical tanks this is the actual diameter. For square or rectangular tanks it can be an equivalent diameter equal to 1.128 times the square root of the cross-sectional area. For tanks whose geometry will be described by a curve (see VolCurve) it can be set to any value.

Min Vol: The volume of water in the tank when it is at its minimum level, in cubic meters. This is an optional property, useful mainly for describing the bottom geometry of non-cylindrical tanks where a full volume versus depth curve will not be supplied (see next).

Vol Curve: The ID label of a curve used to describe the relation between tank volume and water level (see Volume curve under the **curve** worksheet). This property is useful for characterizing irregular-shaped tanks. If left blank then the tank is assumed to be cylindrical.

Description: any other relevant data

Additional Data

Additional info					
Type	Ground Level	Height	Date Installed	State	Comments

Height: this is the height of the tank

All other additional data are as explained in the junctions and reservoirs.

4. LINKS

These are the edge features on the network. They convey the water between nodes in the network and comprise of Pipes, Pumps and Valves. Again, to import data to fill in these worksheet, see the **importation tools** (in the Tool Menu)

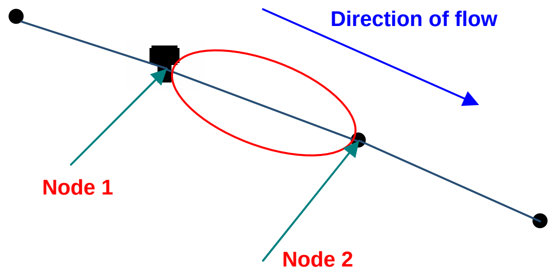
4.1. Pipes

Base Data

Base data								
Pipe ID	Node 1	Node 2	Length	Diameter	Roughness	Find MinorLoss	Status	Description

Pipe ID: A unique identifier for the particular pipe. Usually a serial sequence with prefix letter "P" as in P001, P002, P003………Pxxn

Node 1: The ID of the upstream node, which could be a junction, a reservoir or a tank. The Identifier of the start point of the particular pipe.



Node 2: The ID of the downstream node, which could be a junction, a reservoir or a tank. The Identifier of the end point of the particular pipe.

Length: This is the length dimension of the pipe in "m" and can be calculated if all the necessary vertices are included in the survey and database, else should be measured and manually entered

Diameter: This is the internal diameter of the pipe in "mm"

Roughness: The roughness coefficient of the pipe. It is Darcy-Weisbach roughness and has units of mm.

Material	New Pipe	Old Pipe
Concrete or Concrete Lined	0.300 - 0.700	0.100 - 3.000
Galvanized Iron	0.100 - 0.150	0.200 - 0.500
Plastic	0.001 - 0.002	
Steel	0.020 - 0.060	0.100 - 0.500
Asbestos cement	0.030 - 0.100	

Minor Loss: Losses occur in straight pipes and ducts as major loss and in system components as **minor loss**. Components as valves, bends, tees add head loss commonly termed as **minor loss** to the fluid flow system.

Below is a table of minor loss coefficients for a variety of network components

Type of Component or Fitting	Minor Loss Coefficient - K
Tees:	
Flanged, Line Flow	0.2
Threaded, Line Flow	0.9
Flanged, Branch Flow	1.0
Threaded, Branch Flow	2.0
Threaded Union	0.08
Elbows:	
Flanged Regular 90°	0.3
Threaded Regular 90°	1.5
Threaded Regular 45°	0.4
Flanged Long Radius 90°	0.2
Threaded Long Radius 90°	0.7
Flanged Long Radius 45°	0.2
180° Return Bends:	
Flanged	0.2
Threaded	1.5
Valves:	
Fully Open Globe	10
Fully Open Angle	2
Fully Open Gate	0.15
1/4 Closed Gate	0.26
1/2 Closed Gate	2.1
3/4 Closed Gate	17
Forward Flow Swing Check	2
Fully Open Ball	0.05
1/3 Closed Ball	5.5
2/3 Closed Ball	200
Pipe Entrance (Reservoir to Pipe):	
Square Connection	0.5
Rounded Connection	0.2
Re-entrant (pipe juts into tank)	1.0
Pipe Exit (Pipe to Reservoir):	
Square Connection	1.0
Rounded Connection	1.0
Re-entrant (pipe juts into tank)	1.0

$h_{minor\_loss} = \xi v^2 / 2 g$ (1)

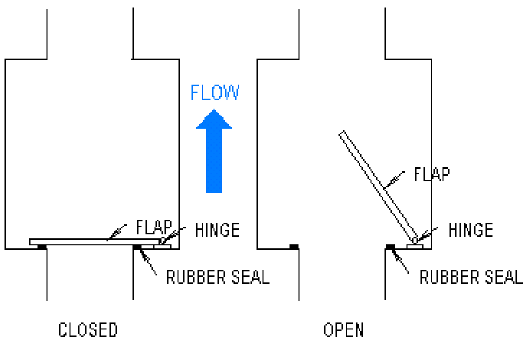
where

h_{minor_loss} = ***minor head loss*** *(m)*

ξ = ***minor loss coefficient***

v = flow velocity (m/s)

g = ***acceleration of gravity*** *(m/s²)*



Status: Whether the pipe is Closed, Open or is fitted with a Check Valve. Check valves are two-port valves, meaning they have two openings in the body, one for fluid to enter and the other for fluid to leave. Could be gate or non-return valves

Additional Data

Additional info						
Material	PN	External Diameter	Find Thickne	Date Installed	State	Comments

Material: This is the material of the pipe such as GI, PVC, Steel etc. It is important to understand the derivation of the absolute roughness values

PN: This is the nominal pressure of the pipe. It indicates the maximum working pressure for a pipe.

External Diameter: This is the diameter of the exterior ring surface of the pipe

Thickness: This is the difference between the internal and external diameters. It is the incident perpendicular distance from the centre of the pipe that is in contact with the pipe material.
The command "find" will return a thickness based on the material and the PN. For this command to work, the material and PN must be put as indicated in the comment relative to their column (for example, for the nominal pressure, it must be written PN10 and not 10). If the material is different than the one proposed in the comment of material, it will return "Mat unknown".

The *date installed* and *State* and *Comments* are as discussed in the earlier instances.

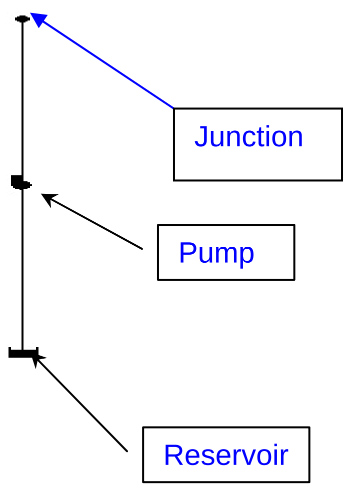
4.2. PUMP

Base Data

Base data					
Pump ID	Node 1	Node 2	PumpCurve	Pattern	Description

Pump ID: A unique identifier for the particular pump. Usually a serial sequence with prefix letters "Pu" as in Pu001, Pu002, Pu003………Puxxn

Node1 & *Node 2* are as explained under pipes except that Node1 is usually a reservoir



PumpCurve: It is the combination of heads and flows that the pump can produce. A Pump Curve represents the relationship between the head and flow rate that a pump can deliver at its nominal speed setting.
Head is the head gain imparted to the water by the pump. A valid pump curve must have decreasing head with increasing flow.

Additional Data

Additional info					
Type	**Power kVA**	**Model No**	**Date Installed**	**State**	**Comments**

Type: What type of pump it is. Usually the manufacturer and the operational mode

Power (kVA): This is the power rating of the pump.

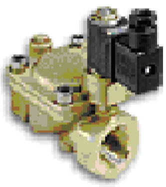
Model No. The model Number as issued by manufacturer or any existing industry standards

The *Date Installed, State & Comments* are as already described in earlier chapters (see Junctions or Reservoirs)

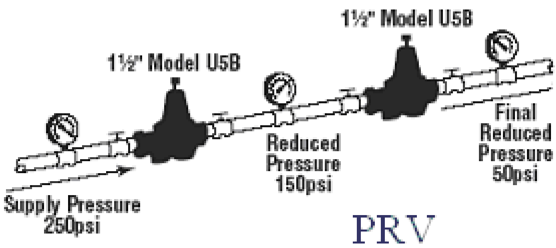
4.3. Valves

Valves are used to control the pressure or flow at a specific point in the network.

FCV

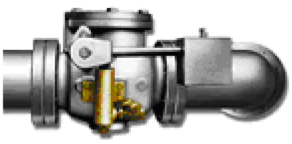


GPV



PRV

Fig. 3 – Two-stage serial reduction configuration



PSV

NOTE: GV & NRV are not considered as valves

Shutoff (gate) valves and check (non-return) valves, which completely open or close pipes, are not considered as separate valve components but are instead included as a property of the pipe in which they are placed

Base data

Valve ID	Node 1	Node 2	Diameter	Type	Setting	MinorLoss	Description

Valve ID: A unique identifier for the particular valve. Usually a serial sequence with prefix letter "V" as in V001, V002, V003………Vxxn

Node 1 and *Node 2* are as described under pipes.

Diameter: The diameter of the valve

Type: This is the type of valve. Only six possible entries can be made and these are PRV(Pressure Reducing Valve), PSV(Pressure sustaining Valve), PBV(Pressure Breaking Valve), FCV(Flow Control Valve), TCV(Throttle Control Valve) or GPV(General Purpose Valve). Please note it is the abbreviations only.

Most common networks do not have these valves and one has to be really sure of the valve before indicating it as a valve. Most valves encountered are NRV (Non Return Valves), air valves and gate valves that are not classified as Valves in this case but included in then properties of the pipes.

Setting: A required parameter that describes the valve's operational setting.

Valve Type	Setting Parameter
PRV	Pressure (m)
PSV	Pressure (m)
PBV	Pressure (m)
FCV	Flow (flow units : m3/h)
TCV	Loss Coeff. (unitless)
GPV	ID of head loss curve

Minor Loss: is a Unit less minor loss coefficient that applies when the valve is completely opened. Assumed 0 if left blank. For further explanation of the minor loss, see under pipes.

Additional Data

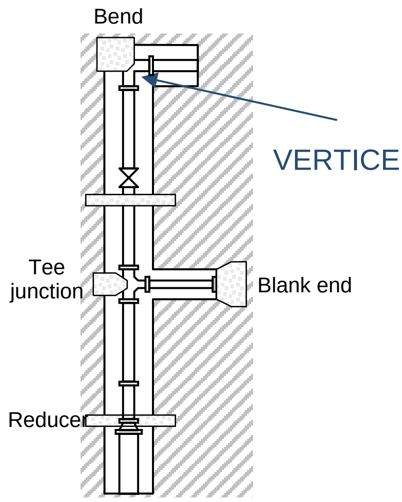
Additional info			
Material	Date Installed	State	Description

The additional information fields are as explained in the previous chapters (see under pipes)

5. VERTICES

These are points along links where there is a change in alignment but which are not junctions or any other node for that matter. Where the link direction changes probably for no flow-relevant reason but to probably keep the network alignment within the acquired easements or to avoid obstacles or for any reason whatsoever not linked to the flow system. The vertex data structure can be used to document such network components like elbows, air valves, gate valves, NRVs among others which would otherwise be missed within the other databases.

There is sometimes the tendency not to use this option and put a junction instead of a vertex. Nevertheless, it simplifies things and is therefore advisable to put a vertex when relevant. It will be seen after that a tool exists to transform a junction into a vertex (see **modification tools** in the tools menu).



Base Data

Base data		
Link ID (pipe)	**X-Coord**	**Y-Coord**

Link ID: This is the link on which the vertex lies. It must be an ID which is already entered either under Pipes(the most usual and expected), valves or Pumps.

X-Coord & *Y-Coord* are as explained under the various node components. See under junctions.

Additional Data

Additional info								
Elev	**Ex ID**	**Description**	**Type**	**GL**	**Depth**	**Date Installed**	**State**	**Comments**

Elev, Depth, Date installed, State and *Comments* are as explained under the junctions section.

Ex ID: This the previous ID. It is used when a junction is transformed into a vertex, with the tools junction to vertex. Otherwise, it is left blank.

Description: one could be able to indicate whether the node is a NRV, Gate Valve, Air Valve or whatever kind of structure.

Type: Here can be put a particularity of the vertex (for example if it is an elbow, a high-point or a low-point)

GL: Ground level, as it was explained in the previous worksheets.

6. PATTERN AND CURVE

6.1. Pattern

This information will be used in a **junction** with a certain number of beneficiaries that will take water or in a **reservoir** or a **pump**. This refers to the cycle of demand throughout the day. The regular behaviour pattern of the beneficiary population with reference to demand for water. What times of the day do more people draw the water and what times do one find fewer people. It is the variation of demand with time throughout the day. It is expressed in percentage or fraction of the average hourly consumption. Thus, an hour that has a fraction greater than one, means that the consumption is greater in that hour than the daily consumption divided by 24 hours, and the other way around. The average of this fraction or percentage should be 1 or 100% respectively.
Here, some examples of pattern have been put.

Varying demand

Demand Pattern	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.1	0.1	0.1	0.1	0.3	1.0	1.9	2	2.0	1.9	1.5	1.1	1.0	0.9	1.1	1.8	2.0	2.0	1.5	1.0	0.3	0.1	0.1	0.1

Constant demand throughout daylight

Demand Pattern	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0

Constant demand throughout the day

Demand Pattern	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Example and useful patterns have been included within the *pattern* sheet of the NSM and one can select the most appropriate one. For example the pattern may be indicated as "paFlat", "paOnOFF" or "paVillage". It can also be adapted by using the excel sheet "demand pattern" available in the annexes of the Reference Manual, under calculations.

6.2. Curve

This worksheet stores information about some data that are used in other worksheets. It is data that have two variables that are linked together (the change of one variable will affect the other). If a graph is done as one variable versus the other, it would form a curve. In this worksheet, the goal is not to put the equation of the curve, but only to put some points (with the value of the two variables it depends from) and the program will extrapolate the value in between these points. The more points are put, the more precise the result will be.

- Pump

This curve will be used in the **pump** worksheet. A Pump Curve represents the relationship between the flow rate in m^3/h (in x) and the head in m (in y) that a pump can deliver at its nominal speed setting, where the head is the head gain imparted to the water by the pump.
On pumps booklets furnished by the supplier, the characteristic curve of the pump is put.
A valid pump curve must have decreasing head with increasing flow.

- Volume

It is used in the **tank** worksheet. This property is useful for characterizing irregular-shaped tanks. For a cylindrical tank, there is no need to create a curve, since when the section VolCurve is left blank it is assumed that the height is directly proportional to the volume. If this is not the case, some height in m (in x) and corresponding volume in m^3 (in y), should be put.

- Efficiency

This refers to the efficiency of a pump, in function of the flow. Indeed, a pump will have varying efficiencies, depending on the flow it pumps. The efficiency will be maximal when the pump works at its nominal point. The efficiency can be used to estimate the power consumption of the pump. Put the flow in m^3/h (in x) and the corresponding efficiency in % (in y).

- Headloss

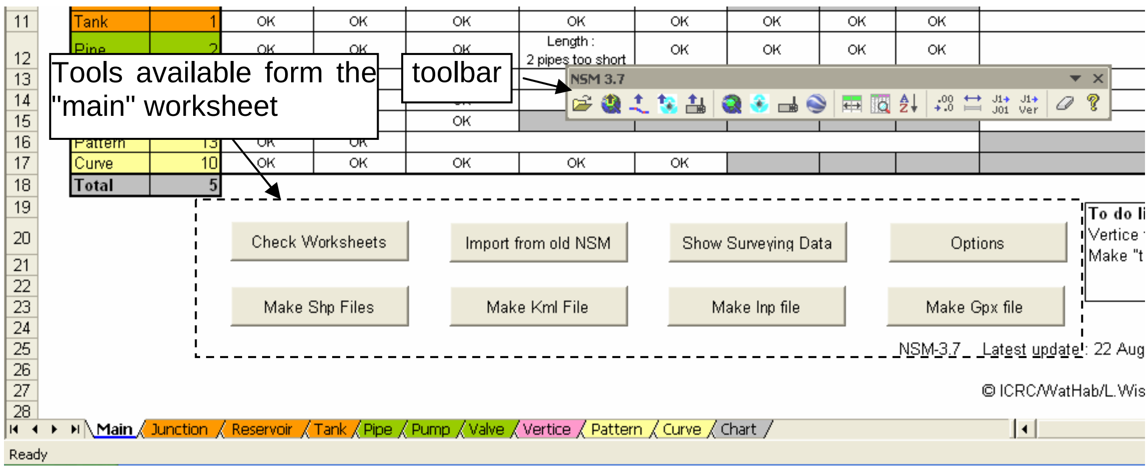
This is used in the **valve** worksheet, when working with a GPV.
The headlosses are function of the flow. Put the flow in m^3/h (in x) and corresponding head loss in m (in y).

7. CHART

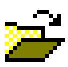
In this worksheet, a 2-D representation of the network is drawn. This might not be sufficient to allow to visualise the network in the space. Therefore, the data can be exported to a GIS software or Google Earth (see **exportation tools**). It could also be exported to a GPS, to check on the field how it would look like. As mentioned before, the data can be exported towards Epanet to make further calculation on the design.

8. THE TOOLS MENU

The tools can either be found on the toolbar (that will be seen from all worksheets), or, for some of them on the "main" worksheet. The tools that have a command on the "main" worksheet can be used from whatever worksheet, because it will affect all sheets; however, it usually makes sense to use this command from the "main" worksheet (especially for "check worksheets" whose result will be shown on the "main" worksheet). For the other tools, they have to be used from another sheet, because they will only modify the sheet that is open, and will not change the other (for example sort worksheet).



8.1. Importation tools


Import from Old NSM: This tool enables backward compatibility. As NSM undergoes evolution, data created in the previous versions would require too much time to convert to the

current version. This tool enables all such data to be automatically imported and converted to the current version.

Import from Shp: Import Nodes data from point shape files (i.e. GIS software), preferably with the same format. Can only be used from a nodes/vertices worksheet.

Import vertices from pipes: this will import the vertices of a pipe that is stored as a polyline in a shapefile. This tool can only be used from the vertex worksheet.

Import Inp from Epanet: this tool will import data from an Epanet project. Be aware that when using this tool, all data in the workbook will be erased.

Import txt from GPS: Import Nodes data from a txt file generated by MapSource. This enable you to get data collected with a GPS, and cleaned with MapSource. It is usually easier to make several files for different kind of nodes (especially when there are a lot of data) and import them one file after another from different worksheets, in order not to have to change manually the worksheet in which the node is put.

8.2. Exportation tools

Make Shapefiles: This tool exports your NSM database into corresponding set of ESRI format shapefiles consisting of all the network components. In the latest version of NSM, a projection file is included for every shapefile to alert the applications interacting with the shapefile on the projection of the shapefile data.

Make inp File: This tool export the network into a ready Epanet (.inp) file which can be calculated and analysed by Epanet.

Make kml File: This tool export the network components into the Keyhole Markup Language (kml) format which can be viewed directly in Google Earth.

Make Gps File: This tool export data into a .txt file that can be loaded on a GPS device.

8.3. Organisation tools

Hide / Show Surveying Data: For all nodes, links and vertices, the first columns are information concerning surveying. This information is not always relevant (for example if the information on the nodes/links does not come from a surveying); therefore, there is the possibility to hide these first columns when they are not needed.

Check Worksheets: This tool is used to verify the validity of data entered in the various sheets, especially the base data.

Sheet	Records	Check Base Data columns								Lonely or not existing nodes
		ID	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	
Junction	10	OK	OK	OK	OK	OK	OK	OK		
Reservoir	1	OK	OK	OK	OK	OK				
Tank	1	OK	OK	OK	OK	OK	OK	OK	OK	
Pipe	11	OK	OK	OK	OK	OK	OK	OK	OK	
Pump	0	OK	OK	OK	OK	OK				
Valve	0	OK	OK	OK	OK	OK	OK	OK		
Vertice	0	OK	OK	OK						
Pattern	13	OK	OK							
Curve	10	OK	OK	OK	OK	OK				
Total	**5**									

It looks out for invalid entries, such as type mismatch, unknown/non-existent component IDs, lonely components and missing data. Straight away the data errors can be singled out and corrected without having to encounter errors in running the other functional tools. The result of this check is given in a table in the "main" worksheet.

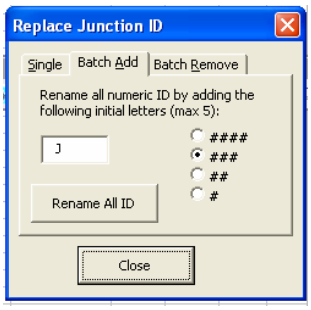
Sort Worksheet: This will sort the worksheet alphabetically based on their ID. Be aware that for example 15 is sorted before 5 (because it looks first at the first number); therefore, in order to be able to use this command in a wise manner the ID should be written with zeros in front (for example 003 instead of 3, the numbers of zeros depends on the number of points that are expected). It will be seen after that there is a tool that allows to rename IDs automatically (see the Rename ID tool).
In order to use this function, you have to be on the worksheet you want to change.

8.4. Modification tools

Round All Coordinates: This is purely for data precision integrity. It rounds off the coordinate values to whole numbers. The technologies currently used to determine the coordinates (GPS & scaling from topo map) cannot yield sub-meter precision.

Calculate Pipe Length: This tool calculates the 3-D length of the pipe where the length does not already exist. Please note that the length will only be correct if the best-fit alignment vertices are observed and included in the database.

Rename ID: this gives the possibility to rename systematically your ID.



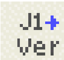
Again this option only works if it is used in the workbook to be modified.
By clicking on it, this kind of window will appear. It has different possibilities (three thumbnail). The first is "single", in which it is possible to change the ID one by one, by choosing the ID to be changed and defining a new ID. The second is "Batch Add". This will automatically change the ID of all nodes that have only a

numerical ID (this means that an ID that has letters in it would not be changed). It is possible to add a letter in front of the ID (for example j for junction), and to define the wanted number of digits, by clicking in front of the number of # that is wanted.

Example
Letter to add: J Number of digits: ### (3 digits)

- If an ID is named 5 before, it would be changed to: J005
- If an ID is called J5, it will not be changed (since it is not only numerical).

The third thumbnail is "Remove Batch", which allows to remove a specific letter/group of letters in front of all ID.



Junction to Vertice: This gives the possibility to change a junction to a vertex. Indeed, it can simplify the network to have vertices instead of junctions when relevant (no pipes attributes changes and no demand). NSM will check if some junctions could be transformed into vertices and ask if it want to be changed.


Erase All Data: This tool enables rapid refresh when a new network database is to be created. All sheets are reset to empty and a new network can then be built from scratch. Be careful to use this tool as it could erase data that you still need.

Options: With this command, some settings can be chosen. First, under the thumbnail "main", the settings that will be used when checking the worksheets can be defined (for example, the maximum number of connections at a node). The thumbnails "KML", "Epanet" and "GPX", some options can be chosen that will be used when exporting the data to these formats. For example, under "Epanet", the unit of the flow can be chosen (whether it is in liters/min of in cubic meters/hours and so on).

9. Surveying

As it was already mentioned in the introduction, there are many ways of collecting your data. One of these ways is the field approach with topological surveying, which is described in more details in this section.

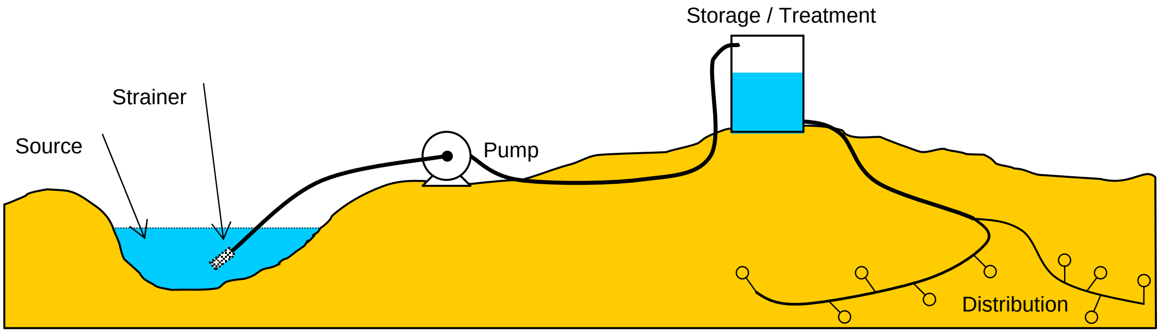


Figure 3 : Actual situation

The survey involves a systematic sketching of a network alignment and its components, positioning the alignment vertices, the network components and naming the various components and vertices.

The sketching may be done on a topographic map of the area if available or on pure plain sheet. The components are symbolized and annotated in the sketch systematically and such annotations used to fill the survey part of the field data collection sheet.

The positioning here refers to determination of coordinates for every important point in the network. It may be done by scaling off the topographic map or by using the GPS receiver. Since different GPS receivers could be used by different teams to carry out survey of the same network, it is important to identify the field officer, the GPS receiver used, the Map Sheet used and the date of survey.

Field Officer		**GPS Receiver ID**	
Date		**Map Sheet ID**	

An example survey process to document the simple network above would proceed as follows:

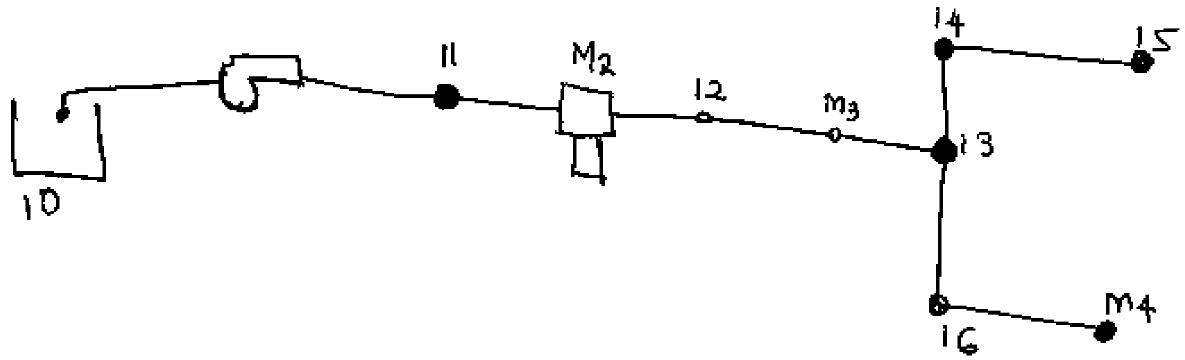


Figure 4 : Sketch the network

As can be seen the network components are symbolized and annotated. The annotations are made simple so as to enable easy field work. The numbers are the serial numbers as obtained from the GPS receiver. The m2,m3,m4 are points which could not be taken by GPS for one reason or the other and are only marked on the topographic map. As can be seen, 10 is a reservoir, 11 is a junction, m2 is a tank, 12 and m3 are vertices and13-16 and m4 are junctions.
The details are then entered into the relevant forms

9.1. Surveying forms

JUNCTION, VALVES & INTERMEDIATE NODES FORM

ID		Depth (m) Confirmed (Y/N)	State (P,F,G,U)	Functioning (Y/N)	Locality	Type (J,V,IN etc)	
Location	GPS Position No.		Pipe_TO	Pipe_From	Type_Size (mm)		
	Map Position No.						
Description							
Elevation		Demand	Curve No.	No. of People	Consumption l/p/d	Total Demand L	

RESERVOIR FORM

ID		Type (Well,BH,,RWC etc)	Yield (Litres/Day) Confirmed(Y/N)	Pump (Y/N)	Pump_Level	Connected(Y/N)	Permanent(Y/N)			
Location	GPS POSITION NO.		PUMP	Power	Type	Model_No	Q_{Low}	Q_{Design}	Q_{Max}	
	MAP POSITION NO:						H_{Low}	H_{Design}	H_{Max}	
Description										

Elevation	Approximate	Confirmed	Water Level	Static	Dyna. T1	Dyna. T2	Description:
Quality	Protected(Y/N)	State (P,F,G,U)	pH (pH Scale)	Turbidity (NTU)		Colour (mgPt/l)	Conductivity (µS/cm)

TANK FORM

ID		Elevation	Volume Curve	Min Volume	Present Level	Minimum Level	Maximum Level
Location	GPS Position No.		Pipe_To	Pipe_From		Date_Installed	Diameter
	Map Position No.						
Description							

LINK (Pipe, Pump, Valve & Intermediate Node) FORM

ID		Type (Pi,Pu,V,IN)	PUMP/ VALVE	Power/ Setting	Pu/V Type	Model No.	Q_{Low}	Q_{Design}	Q_{Max}
							H_{Low}	H_{Des}	H_{Max}
Location	GPS Position No.		Node1 (N1)	Node2 (N2)		Date_Installed	Diameter (mm)		Material
	Map Position No.								
Description									

The data from the forms are entered into the database. They are categorized as Surveying Data, Base Data and Additional Data. For water sources (Reservoirs), the quality data is also a category. The survey data is common for all network components, while the base and additional data very from component to component. See further descriptions below.

9.2. Surveying data

Surveying data											
Form Index	Field O	Date	GPS ID	Map ID	GPS pos No	Map Pos No	Locality	District	Junction ID	Demand	Pattern
F01	Mhd Ali	12.10.08	Z1	P08	136	136	Kandwi	Micheweni			
					137	137					
					-	M01					
					138	138					

This is the information input so as to document knowledge about the survey exercise. It comprises of information about the persons doing the survey work, the instruments used, the date of survey, the area in which the survey takes place and importantly, the field collection sheet used to record field data.

Form Index: This is the index Number of the form used to record field data. Field Data Collection Forms are serialised/Indexed to enable easy identification and to aid trace-back in case of wrong entries or any other sort of human error

Field Officer: This is the name of the field officer who carried out the field survey

Date: The date on which the field data was collected

GPS ID: The Identification Number for the GPS Receiver used to collect the coordinates of the specific network feature. As the project could employ the use of a number of GPS receivers, it would be useful in determining which one was used for ease of traceability and data verification

Map ID: In some instances, the field team does not have a working GPS, in which case a 1:10000 topo sheet section printout will be used to mark the location of the network point feature. This field enables the field team to document which map sheet was used to mark the position

GPS Pos No: Within the GPS Receiver memory, sometimes the point locations are stored using the automatically generated serial numbers. In other cases, though cumbersome, one may be able to fully type out the name of the point feature. This column documents the serial number of the point feature within the GPS Receiver memory
Map Pos No: The identity used to mark the position of a network point feature on the topo sheet printout.

Locality: The village or area in which the survey is carried out. For most networks, this is usually the name of the network, but not always. For some networks, which stride various localities, it is important that the actual locality where the feature lies is indicated.

District: This is the administrative district in which the feature lies.

10. Annexes

10.1. UTM map