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Reduction in Non-Revenue Water in Water Distribution System

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Abstract: Water is the world's most critical natural resource. Rapid population growth and economic development have led to higher demand for water worldwide whereas on the supply side, natural sources of water have become less reliable. This demand-supply imbalance in the water sector calls for more innovative water management practices and suitable technologies. Utilities cannot afford the water loss because of poor operation and maintenance of water distribution infrastructure facilities. The terms theft, smuggling and leakages are most common sources of generation of Non- revenue water (NRW). Newspaper articles around the world, particularly in countries experiencing intense drought and water shortages, are highlighting water theft as a growing problem. Analysis of various city development plans in India shows that water leakages, theft and unauthorized water connections gives rise to a high level of unaccounted water. A recent study on Water Governance (2013) reveals that unaccounted water in Delhi amounts to around 50% of the total water pumped into the system, whereas it is 35-40% in Hyderabad and Bengaluru. The World Bank in its report, 'The Challenge of Reducing Non-Revenue Water in Developing Countries', reveals that 48 million cubic meters of drinkable water escape daily from official supply networks, which is enough to provide water for 200 million people. The same report on India had clearly highlighted that 40-60% of water in Mumbai is lost through illegal diversion. In This paper we have made an attempt to analyze the current methods, their drawbacks and we have provided solution in the form of software-based approach (using Bentley Watergems) which is more relevant as compared to the current field method.
Keywords: Water gems, Smuggling, Leakages, Theft, NRW

I. INTRODUCTION

Non-revenue water (NRW) is the water escaped from the water distribution network in the form of leakages, thefts , unauthorized connections which leads to reduction in revenue generation from the distribution system. The urban water supply in India is characterized by inadequate coverage, intermittent supply, outdated piping, low pressure and poor quality. Chronic shortage of investments and inadequate operation and   maintenance are the major contributing factors. Although the water supply system is inadequate, lack of maintenance and inadequate replacement leads to losses in distribution. Metering errors, water theft and unbilled collection also lead to high levels of Non-Revenue Water (NRW). Moreover, the unwillingness of local/state governments to levy proper user charges to the service provided also lead to poor performance. Water boards in India area able to recover only 30 to 35 per cent of the operation and maintenance (O& amp; M) cost (HPEC, 2011).

In India, where water is treated as a most basic and natural good, the ability to pay for water provision is very limited. Water wasted through losses in the supply and distribution system may provide an opportunity for water boards, and if well managed, the water saved from various leakages and thefts could be redistributed to areas not receiving sufficient water supplies, hence resulting inimproved revenues with comparatively lesser investments.

Non-Revenue Water (NRW) is an issue with almost all water supply utilities in India. It includes physical and commercial losses and free authorized water for which payment is not collected. The major issue affecting the Indian water utilities is the significant difference between the amount of system input volume (SIV) into the distribution system and the amount of actual water billed to consumers, which is the NRW. Average NRW in India is around 38%; just above the global average range of 30% to 35% reported by the World Bank. Though there have been developments in leak detection technologies, their adoption in India has been sluggish, primarily due to the limited revenues that municipalities generate. However, with privatization on the rise, many water utilities are expected to deploy leak detection systems to improve water networks and reduce NRW. The high rate of NRW in India creates a high business potential for deploying Smart Water Meters and Grids.

In existing system, urban water distribution to the users is done with the help of some man power. The person will go to the place and then open the valve to that particular area. Once the time is completed the person will go again to that place and close the valve.

This type of operation needs man power also waste of time to go to that place and come back often. Also, the people may take excess water for their personal use with the help of motor or some other devices. Due to this many users will not receive sufficient water for their use.

Water is the basic needs of the human life. So, it should be given to the people properly and at right time. The theft and leakage can be prevented only when any public inform the officials about the theft. But the probability of public is informing to higher officers are rare. So, the theft prevention or one who does the theft is difficult to identify in the early methods.

II.   METHODOLOGY

There are various methodologies through which we can solve these problems. Some of them are mentioned below.

1) Software Based (Bentley openflow Watergems) approach for leakage and theft localization.
2) MPX Sensor Method
3) Mathematical Model for leakage detection and localization
4) Step Method of Locating Leakages

In this paper we have proceeded with Software based approach using Bentley openflow watergems for analysis of the selected hydraulic model and locating the nodes having higher leakage and theft possibility.

A.   Construction of Hydraulic Model :

A hydraulic model is a network of pipes , junctions of pipes and a reservoir connected to pipe network for the supply of the water. In Bentley watergems we have to generate new hydraulic model. In this software we can lay pipe lines on the road map of any location. For this the road map of the selected location is to be inserted in the software using background layer options. After inserting the map using layout tab, required no. of junctions , pipes and reservoir are located on the map. The design data required for the hydraulic model i.e. input data is shown in the tabular format below

Location : Bhilavadi , Sangali , Mahaashtra (16°59′14″N 74°28′4″E)
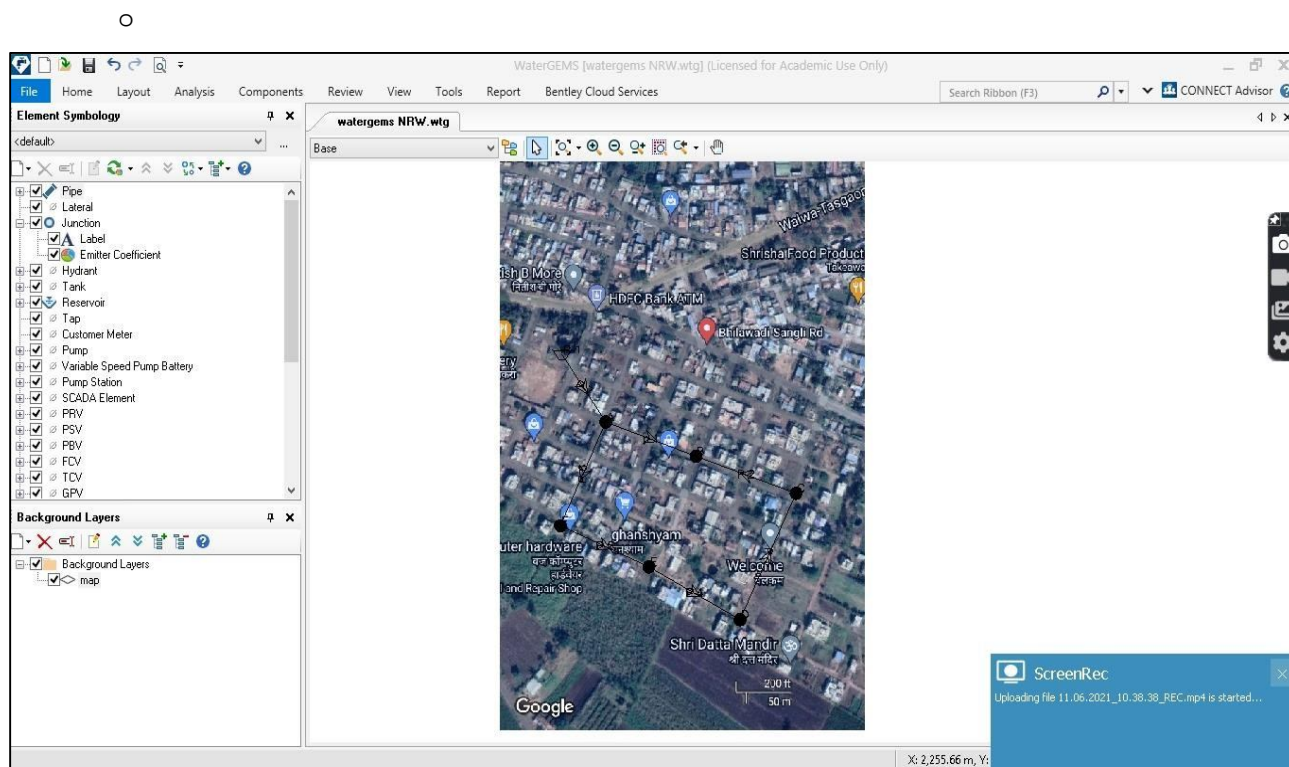
Town Map: Google Earth

o

Fig I : Inserting google map using background layers

Using Following steps to establish a hydraulic network in the software:

1) Put the background later for established the proper water distribution system for which we want.(BhilawadiGaon, Shivajinagar area, Dist-Sangli, Maharashtra). Use the function Background Later >select the file>open in the watergems.
2) Layout the Water Distribution System of Watergems by given the input Data-(Layout function)
   Pipe- Diameter
   Junction (Node) – Elevation of Junction and Demand of the junction.
   Reservoir – Elevation
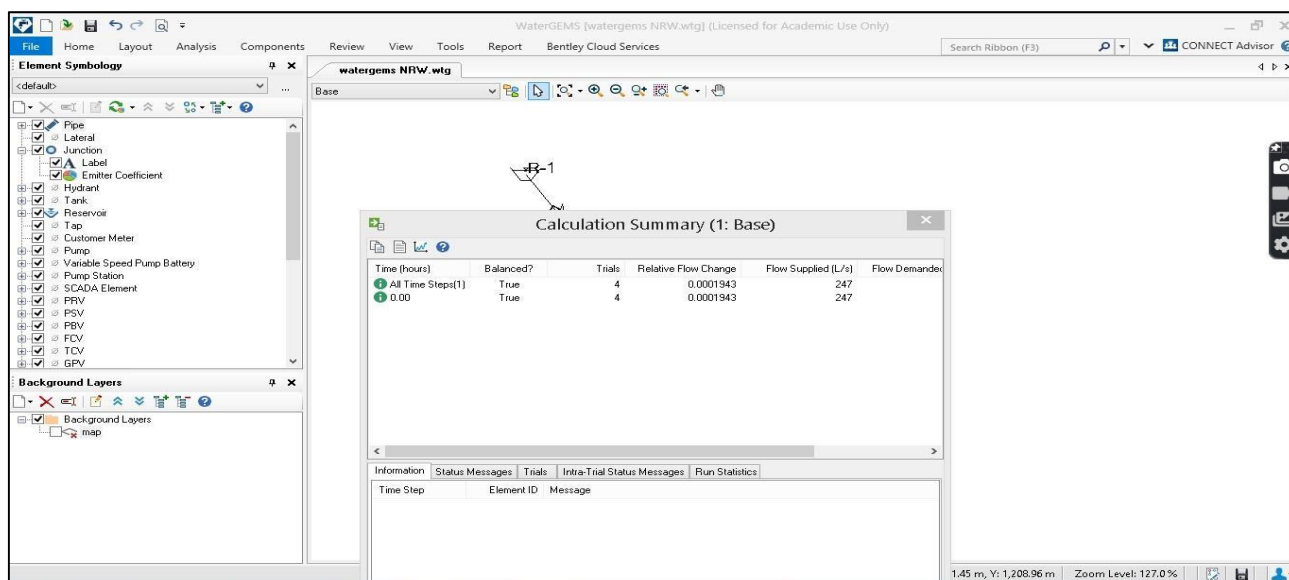3) Compute the system by using compute function.

Fig II : Calculation Summary

Table I - Input Design Data:

Reservoir	Elevation (m)
R1	275
Pipe	Dia. (m)
Reservoir to junction	400
Remaining All	100

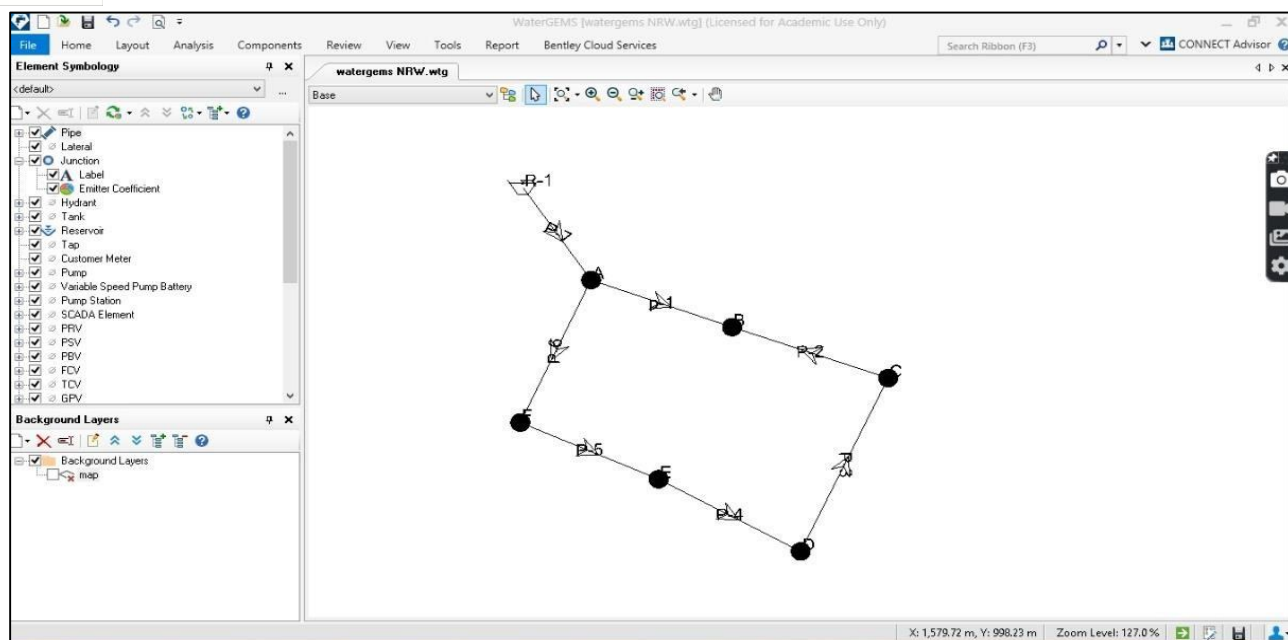| Sr. No.	Junction	Demand (L/S)	Elevation (m)
1	A	86	204
2	B	25	195
3	C	40	187
4	D	42	182
5	E	86	187
6	F	50	195

Fig III: Hydraulic Network (6 junctions , 7 pipes , 1 reservoir)

B. Analysis of the Network

After construction of hydraulic model computing the network to detect errors in the network (loose connection or any misplace). After all errors are corrected open analysis tab and use Darwin calibrator tool and create new calibration study. In this Darwin calibrator tool add Field data manually or import excel sheet or a SCADA file .Feed the Field data at regular intervals of time. Then adjust emitter coefficients (Range 0-1).

By selecting the required hour field data (select data at which there is low demand at consumer end) compute the Darwin calibrator. It gives solutions for the data which is selected. In the solution it shows changes in emitter coefficients for the nodes i.e. possibility of leakage of theft for the node.

Then exporting the results in the form of scenario to visualize in the model .Also give the colour coding for emitter coefficients.

Following Steps can be used for the analysis of leakage and theft in software after construction of hydraulic model:

1) Calibrating the model to observe the leaks in the model
a) Go to Analysis>Darwin Calibrator>Create new Calibration Study>Rename it as Leakage Study.
b) We here given the Field data by manually.

2) Selected the all demand group for solution and selected one field data-
a) (Take the data at odd hour, when there is more flow it's not given efficient data, hence take the hour data when there is low and constant demand and flow)

3) Go to field data tab, here we selected time steps we want to calibrate, weselected12.30 hr for this run. (Also you can run the calibration with different combinations of time steps, or all time steps in one go.) IV. Created new optimized run>Rename it as Leakage Detection.
a) In the Demand tab, selected Detect Leakage Node in the operation column.
b) Entered the following settings
c) Minimum Emitter Coefficient = 0
d) Maximum Emitter Coefficient = 1
e) Increment = 0.01Number of Leakage Nodes = 5Note: You can change the emitter coefficient values as per the amount of leakage.
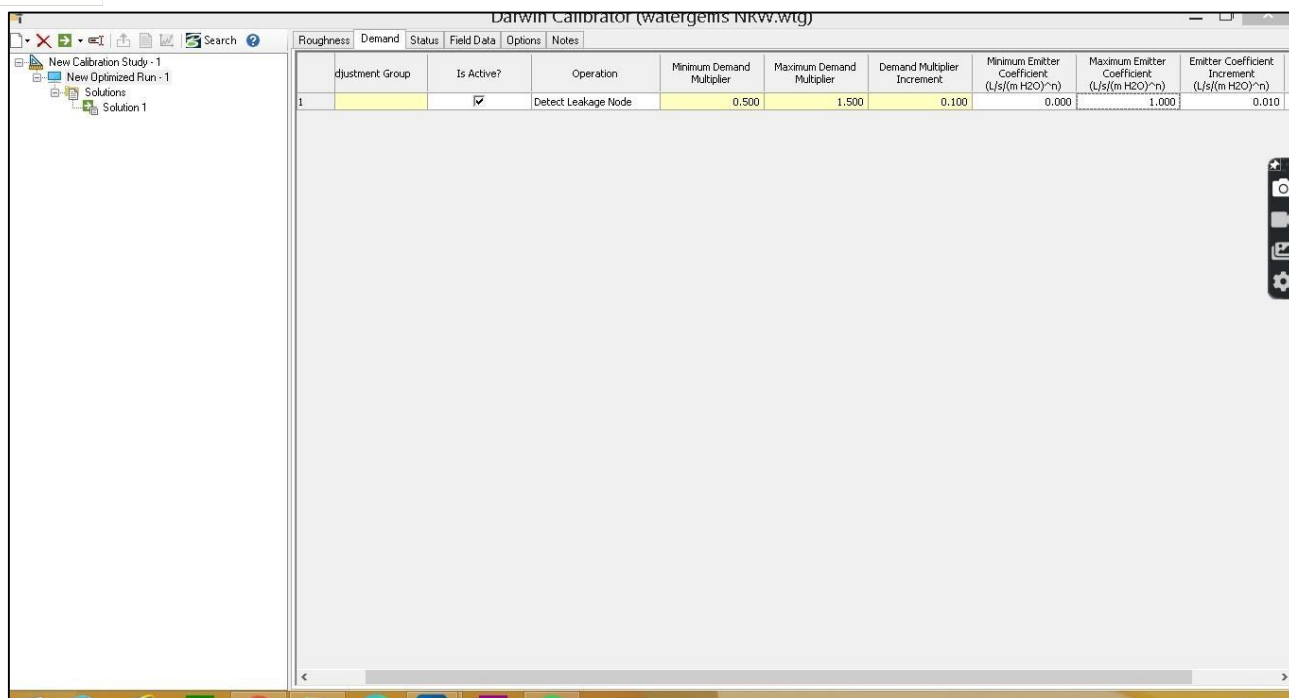
Fig IV : Setting Emitter Coefficients

Computed the Darwin Calibrator once all set.We were not increased the number of solutions by going to options>Optimized run.(Click on the solution 1 in the left side of the window, you can see the number of leakage nodes detected in the right side of the window.) Now exported the results in the form of scenario to visualize in the model. While exporting the results only select Export Emitter coefficients.

Giventhe Colour coding for Emitters Coefficient , To detect where exactly (at junction) leakges happened. 11- At last final result given by watergems software , so we can exactly find the location of the leakges at a real site. (Note, Red- Size of the leakge is more, pink- Size of the leakges less than Red colour codingblue- Size of the leakge less than pink colour coding.. Etc.)
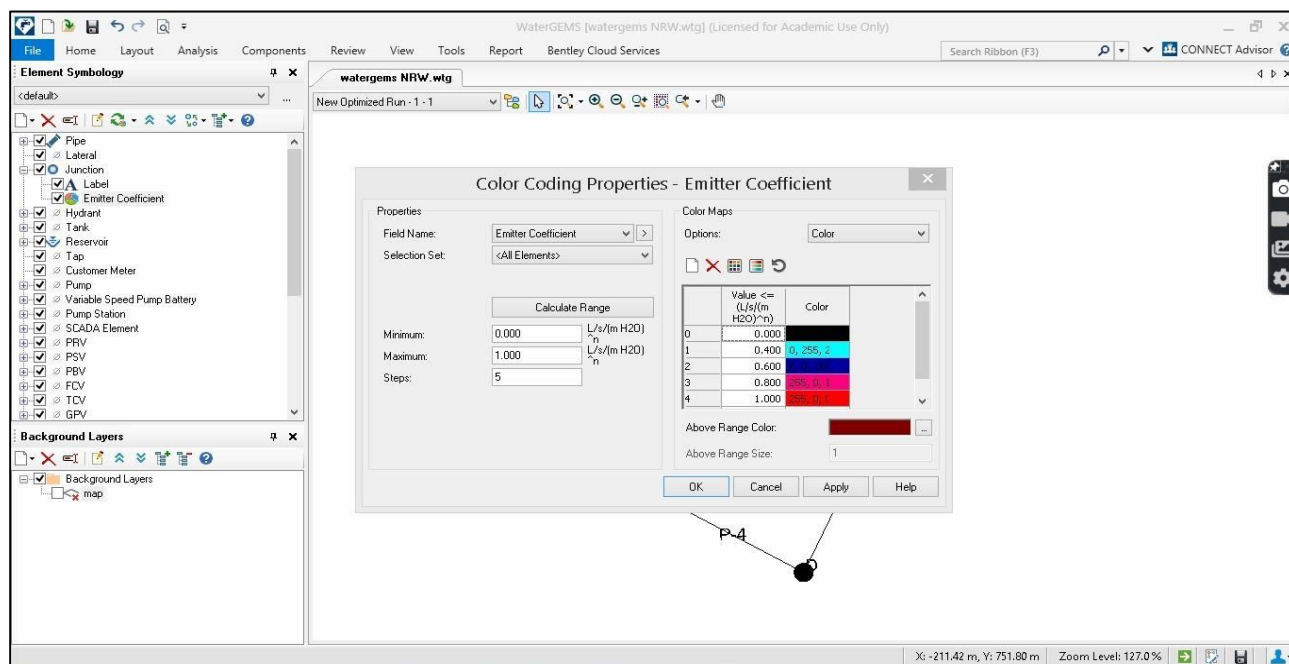

Fig V : Colour coding Properties (Emitter Coefficients)

III. RESULTS

A. *12.30 hr Field Data Snapshot – 4*

TABLE II - Leakage Results

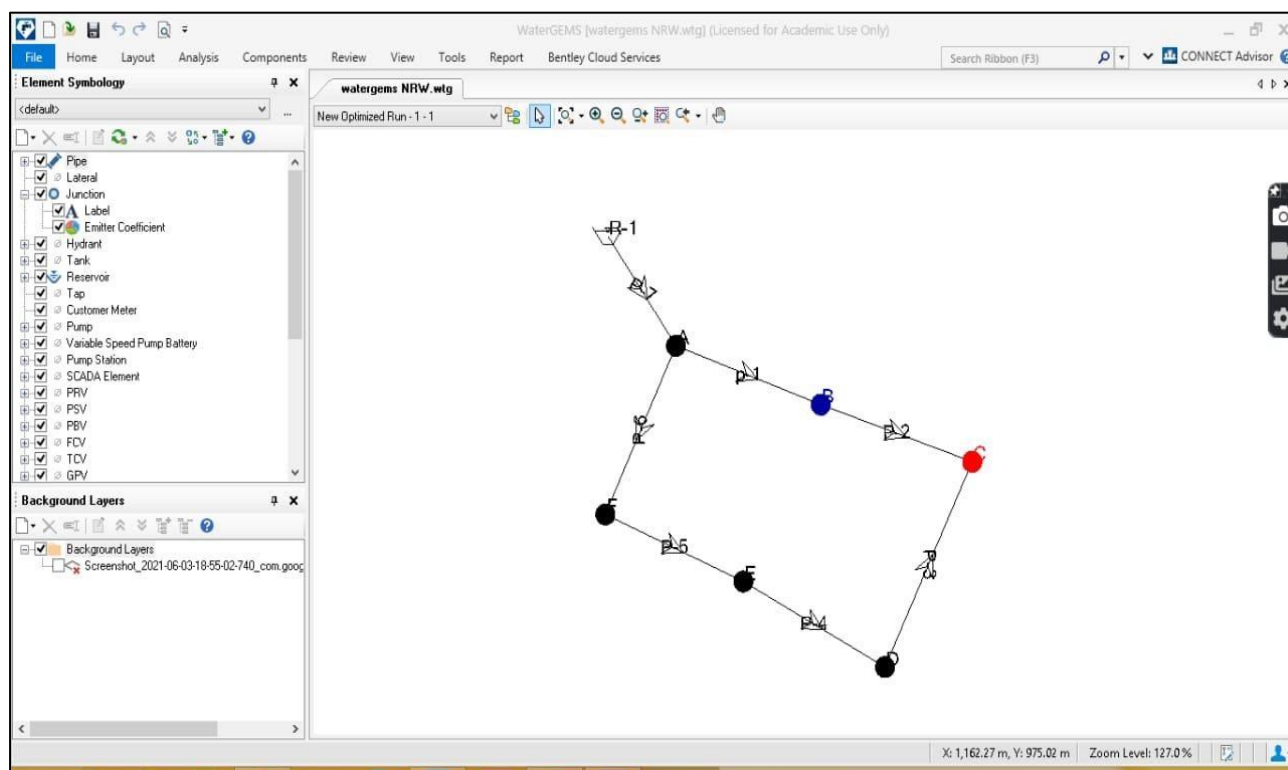| Sr. No.	Node	Original Emitter Coefficient (L/s/(m H2O)^n)	Adjusted Emitter Coefficient (L/s/(m H2O)^n)
1	A	0	0
2	B	0	0.42
3	C	0	1
4	D	0	0
5	E	0	0
6	F	0	0
Sr. No.	Observed Flow (L/s)	Stimulated Flow (L/s)	Difference (L/s)
1	12	11	-1

Fig VI : Leaking Nodes colour coding (red – Highest Leakage , Blue – Lesser than red) • Above results states that junctions B and C are the leaking nodes in the network.

IV. CONCLUSION

Following are the conclusions which we came to know after using the software

A. Bentley Open Flow Water gems can localize exact pipe in the network which have leakage or illegal activity and actual location of the leakage can be located very easily and accurately.

B. Once leakage has been localized to specific pipes within a step area, leak noise correlation can be effectively used to identify precisely where the leak is located along each pipe by Acoustic Devices.

C. Such quick leakage and theft localization system helps in reduction in wastage of water and also increase revenue from system.

D. The process is economical and sustainable to use and adopt and on the other hand it is time saving too.

E. As total work is based on software labour force required is very less.

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