



## Comparative study of HydroCAD(V10) and SewerGEMSVi8 Softwares

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### Abstract

This paper gives a comparative study on the methodology used for the HydroCAD Storm water modeling system (V10) “for the Volume runoff calculations and HydroGraph Analysis” and SewerGEMS (Vi8) Software “for the sanitary sewer design” of the newly developing urban area. The study highlighted the data collection, operating sequence, HydroGraph parameters, pollutant loading steps required for the HydroCAD software users and it gives a user's road map that makes the modeling process simpler overall. The study also emphasises the compatibility of both programmes with AutoCAD and GIS tools, as well as the use of simple calculations to determine runoff peak flows and volumes from a subcatchments. These calculations help users configure, assess, visualize, and compare an infinite number of potential scenarios for the area under study. Both software programmes make it quite easy to build up these computations, which can effectively assist consulting engineers in making decisions.

**Keywords:** HydroCAD, Stormwater Modeling, AutoCAD, GIS

### Introduction

There are two categories for numerous factors that have an impact on the stormwater drainage system in developing nations broadly classified under influence of the human activities and different natural factors. The human activities that have an impact on **natural storm drainage** includes the expansion of metropolitan areas, impermeability, deterioration of plant cover, lack of planning and inadequate management, among other things whereas Natural influences includes patterns of rainfall, characteristics of catchment areas, soil type, the presence of watercourses, and climate change etc. The crucial components of any storm water drainage system include manholes, collection areas, outlets, and conduits with various sizes. The system's primary function is to transport extra rainwater from areas where human populations are located to neighbouring water sources including ponds, rivers, and streams.

Around 80% of the water that is delivered in practice is likely to be turned into waste water, according to CPHEEO. Grey water and black water are the two different categories of sewage. Grey water is wastewater from all home sources other than toilets, while black water is the

waste water from toilets. Sewage system refers to the full network of pipes and manholes used to collect and transport sewage; however it does not include sewage treatment facilities. Centralized sewage systems for large cities use underground pipes, pumping stations, and treatment facilities.

Both the storm water management system and sewage system are the upmost requirements of the urban planning for all the cities. An effort was made to provide affordable storm water and sewage networks designs as per the recommendations mentioned in the CPEEPO manual by utilizing modern methods like HydroCAD and Bentley's SewerGEMS software.

### **Review of literature**

**Baumann H., Ravn H.N. and Schaum A., (2022)** performed studies on Efficient hydrodynamic modeling of Urban Stormwater systems for the real time applications and concluded that 1-D, 1-D urban storm water modeling is an efficient approach for automatic creation of digital models (for exp. required for the SWMM models). Authors compared the efficient 1-D, 1-D model with the real measurements showing satisfactory results which indicated sufficient model accuracy.

**Pawar et.al (2021)** performed studies on Design of the Sewer system for the village Vake using SewerGems and focused on the design of a sewer system using SewerGems software for Vake village situated in Malegaon Taluka, Dist-Nashik, Maharashtra and concluded that with the application of SewerGems software a efficient sewer system for Vake village with detailed design of conduits and manholes could be designed.

**Sopariya H., Patel R.L. and Pathak Y.P. (2018)** performed study for the analysis and design of Sewer Network using SewerGEMs software and concluded that the town road network could be easily drawn in Auto CAD and Ground elevation features could also be generated in GIS platforms and could be easily imported in SewerGEMs. SewerGems is easy to use and proves to capable of designing large to very large sewer networks.

**Patel K. H., and Bhatt B. V. (2017)** performed their studies on the Comprehensive Review on Various Smart Methods for Stormwater Management System and concluded after performing review related to the Stormwater drainage network and management systems that it is to get ideas about smart Stormwater drainage system, as the smart city provided with basic infrastructure to give a better, clean and livable environment and quality of life to live smarter. Smart infrastructure is also the key point of the smart city. For that, the smart management of Stormwater drainage system is also essential. Thus it becomes necessary for the planner to give smart proposals and tools for that.

**Romnée, Ambroise, Arnaud Evrard, and Sophie Trachte (2016)** Developed the design methodology for an urban watershed. They put the five steps into action as follows: Analysis of Indicators 2. Stakes and Approaches Space-based typologies 4. Decentralised management scenarios 5. Decentralised management initiatives. It revealed that a decentralised approach to stormwater management may improve urban planning norms and conventions if the methodology is used to a full watershed.

**Gould, Stephanie et. al. (2016)** In Fairbanks, Alaska, the StormCAD model was developed.

They looked at the relationships between the lead, copper, and zinc—three distinct metals prevalent in stormwater and the ones selected for a thorough investigation.

**Salvan, Leslie et. al. (2016)** Developed a detailed modeling technique at the district size as well as an optimized runoff modelling and management at the Mediterranean city (France) scale. The investigation found that the topography included the surface characteristics, making them completely impermeable—a finding that wasn't totally satisfactory.

**Bhadiyadra, Kishan J et. al. (2015)** Investigated the effectiveness of the current stormwater drainage system as well as the circumstances that contribute to flooding issues in various low-lying, important districts of Surat city. In order to do so, they used a simple quantitative technique and some questionnaire surveys. They then suggested a few solutions that were pertinent to the problem at hand, including a network of subterranean pipes used for temporary storage, a well to recharge groundwater, and a hydraulic ram pump.

**Needhidasan, S., and Manoj Nallanathel (2013)** In Calicut City (Kerala), the new stormwater drains were designed rationally, and some changes were made to the old network's drain sections. They discovered every component of the balanced formula.

**Welker, an L et. al. (2013)** They made an effort to provide a monitoring strategy for the region of Philadelphia's stormwater control methods. They provided three tire monitoring plans into the system and looked at the effectiveness of structural, nonproprietary stormwater control measures.

**Bentley (2011 )** By constructing a Stormwater network model in Dronagiri with the use of Civil Storm and the Dutch technique, researchers were able to better understand the issue of flooding during the heavy rain season and ensure appropriate drainage of the Dronagiri area (Navi Mumbai). (Bentley, 2011: Analysing complex StormWater systems with holding ponds below high tide levels in a Navi Mumbai archipelago.

**Objectives:** This study aims for a comparative study on the methodology used for the HydroCAD Storm water modeling system (V10) “for the Volume runoff calculations and HydroGraph Analysis” and SewerGEMS (Vi 8) Software “for the sanitary sewer design” of the newly developing urban area.

#### **SEWER-GEMS SOFTWARE**

SewerGEMS is a piece of software that streamlines the modelling process by giving users more time to solve wastewater engineering issues, increase capacity, and limit sewer overflows, all of which help utilities adhere to regulatory authorities' requirements for sewer design. The software provides advanced engineering tools for sanitary sewage system design, planning, maintenance, and operation.

SewerGEMS offers users an environment that is simple to use and offers compatibility with four notable and well-known softwares. (Ref. “SewerGEMS V8i Quick Start Lessons”).

#### **These are the platforms:**

For linking the geographic planning and drafting environments, use the microstation mode. The Microstation software supports the use of all SewerGEMS tools.

**ArcGIS mode:** For network and GIS integration, mapping, and ArcMap design. All SewerGEMS tools are compatible with ArcGIS ArcMap.

**AutoCAD mode:** For CAD drafting and layout. In this mode, the tools for SewerGEMS and AutoCAD are both simultaneously accessible.

With advanced tools like LoadBuilder, Modelbuilder, and the Tracking option for changes made throughout the network design process, users are able to keep track of changes and enter primary data more easily, which the software instantly translates to assist in the design and analysis of sewer networks. In order to compare various flow patterns and sanitary load situations, SewerGEMS offers unique comparison and with the help of suitable required input, reliable sewer system for urban/rural area can be designed.

As illustrated in **fig.1** below, different design limitations, including as velocity, top cover, and slope, were taken into consideration when analyzing and developing the network. (Ref. **“Manual on Storm Water Drainage Systems”, Vol. I, CPHEEO, August 2019**).

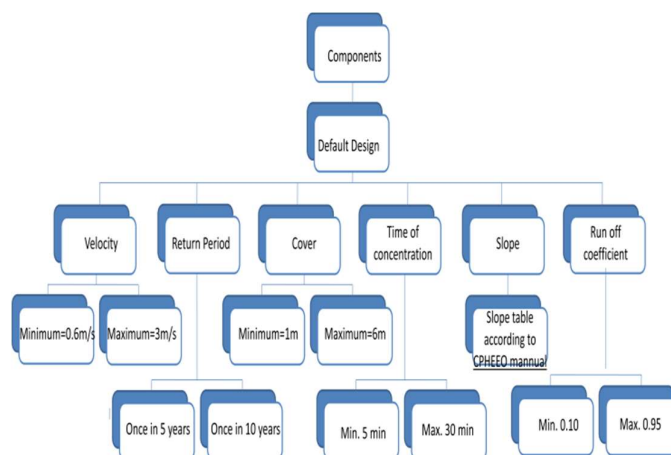


Fig. 1: Design restrictions according to the CPHEEO manual

## METHODOLOGY

### DESIGN OF SEWAGE NETWORKS

**For the design of gravity sewer systems, the steps below have been used:**

1. To locate the desired location(s) for a sewage collection network.
2. To establish system design criteria and become familiar with the most recent regulatory codes and design standards.
3. To gather topographic, geographic, and geologic data.
4. To compile data on the state of the roads, the population, business, other utilities, and community planning.
5. Conduct reconnaissance surveys at locations where there may be a clash with other services.

6. To locate the streets, sewer input sites, and natural drainage systems at the limits of the region to be served.
7. To plan the horizontal layout of the sewage line, manholes, and potential pumping station placements. To create alternative layouts for SewerGEMS-compatible platform feasibility assessments. The SewerGEMS model builder and Trex tool were then used to import AutoCAD file (\*.dxf) and GIS shapefile (\*.shp) files, respectively.
8. To forecast the population and assign it to contributing manholes.
9. To do the hydraulic design of the system and to choose the pipe sizes and slopes. Revise selections until the design criteria are met.
10. To thoroughly examine all designs, assumptions, and possible alternatives.
11. To adjust the design or create substitute designs, or even substitute layouts. The designer will then return to the relevant earlier stage as a result. (The design steps are shown in attached flow chart **fig. 2**)

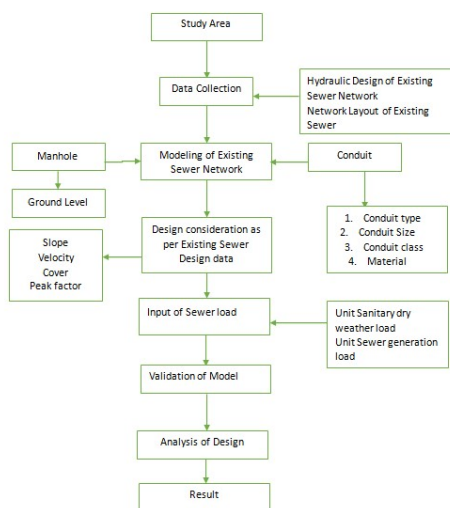


Fig. 2: Flow chart for the design in sewerGEMs

### HydroCAD Software

Powerful hydrology and hydraulics tools are included in HydroCAD, but only a licensed engineer may integrate and use them. Since each user has a particular set of design goals and local needs.

A computer-aided design programme called HydroCAD is used to simulate the hydrology and hydraulics of stormwater runoff. It is frequently used to create runoff hydrographs for a specific watershed and analyse their movement via a drainage system made up of both natural and artificial elements. (Ref. “**HydroCAD Storm Water Modeling System V 10, Owner’s Manual**”).

By maintaining a unique database for the watershed and drainage system, HydroCAD offers a novel approach by enabling users to create an interactive working model for the entire system where modifications can be made and their consequences can be seen.

Numerous methods for the creation and routing of hydrographs are offered by HydroCAD. It also offers a wide range of additional computations that are relevant, including pollutant loading, stage-discharge curves, pond quantities, weighted curve numbers, and time of

concentration. Since HydroCAD has such a wide variety of features, many different studies can be completed wholly within it.

Precipitation Frequency Data from NOAA and compatible websites are directly supported. One can use Pdf files from websites like NOAA, NRCC, and others directly as IDF data. Using any IDF or Pdf data file, generates customized simulated rainfall distributions.

TR-20 and WinTR-20 files can be used to import rainfall distributions and events. New definitions for unit hydrographs, including gamma unit hydrographs:

There are numerous methods for drainage design and storm water modeling, which can be roughly split into two categories:

- 1) Stable-state (constant flow) approaches, like the rational approach, which are frequently applied to storm sewer (pipe) networks.
- 2) Methods for creating and routing hydrographs that simulate the time-varying characteristics of real runoff and model volume-sensitive stormwater components, such as detention ponds.
  - The import and export of tabular data on watersheds.
  - Set up data import or active ground coverings on the new Settings|Watershed screen.
  - Direct AutoCAD import of sub-area data.
  - Automatic Carlson Hydrology watershed import.
  - Automatic classification of precipitation events

## **METHODOLOGY**

### **Operating Sequence**

Although HydroCAD has the flexibility to be utilized in any order, its power is best understood by breaking it down into its five fundamental phases.

### **Step I: Routing Diagram Construction**

The functional parts, or nodes, make up the watersheds **as shown in figure**; the figure illustrates each node's relative position in relation to one another as well as the flow of water between them.

### **Step II: Each node's description**

HydroCAD can compute the outflow from each node once the inflow is known because of the thorough descriptions of each node.

### **Step III: Setting Rainfall Data & Calculation Options**

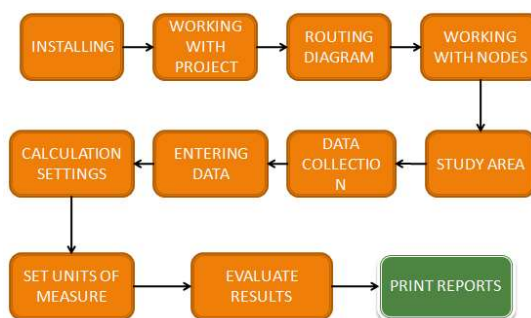
Enter the fundamental data for runoff and routing calculations, such as the parameters of the rainfall.

### **Step IV: Calculating the flow through each node**

Every time a report is chosen, calculations are carried out automatically. HydroCAD determines the outflow and other outcomes for each node by starting at the upstream end of the schematic and working downstream. Multiple inflows are automatically added together. When no changes have been made, a minimum recalculation feature automatically recycles the outcomes of earlier calculations.

### **Step V: Results Presentation and Review**

The user can examine one or more report windows to confirm the watershed's behavior. The calculations and results will immediately update if any modifications are made to the watershed by the user. Flowchart attached as shown in **fig. 3**:



**Fig. 3: Flowchart of working in HydroCAD**

## RESULTS AND DISCUSSIONS

### Hydrograph Parameters

The three highest spots on each hydrograph are used to calculate the **peak flow** for that particular hydrograph. These points are fitted with a parabola, and the parabola's apex identifies the genuine peak. By doing this, changes in the peak that would happen if only one point were taken into account are eliminated. With a narrow peak, when the two closest points fall on either side of the peak and may be several percent below the real peak, this improvement in accuracy is most noticeable.

The **peak attenuation** shows the amount of peak input that is reduced as a result of a routing operation. The peaks of the inflow and outflow hydrographs, as computed above, are compared to find this. The similar parabolic fit to the three highest spots yields the **peak time**. Much more precisely than the time between points, the parabola's apex specifies the time of peak. This value is unaffected by where the points are situated on the "true" curve, unlike the peak flow. The difference between the peak time determined by the inflow and outflow hydrographs and the **time lag** created by a reach or pond. Integrating the flow throughout the hydrograph's time period yields the **hydrograph volume**.

Any flow before or after is excluded from the volume since it can only include flow during the specified time period. Also that the calculated input and outflow volumes may differ because to the lag that is introduced by a pond or reach. This can be fixed if necessary by extending the calculation time period to take into account the complete length of the inflow and outflow hydrographs. Similar to how peak flow is calculated, **peak height, peak depth, and peak storage** are also obtained by interpolation. (This differs from HydroCAD-5, which recorded the peak as the greatest discrete value.)

The biggest value that can be calculated by dividing each discrete flow rate by the associated cross-sectional area is the **maximum velocity**. Comparing this outcome to dividing the peak flow by the comparable area may get slightly different results. The **average flow** rate divided by the appropriate area at each time interval during the routing computation is used to calculate the average velocity. By dividing the reach, channel, or pipe's length by its velocity, the **travel time** is determined. The average and lowest trip times for a reach routing are determined using

the average and maximum velocities, respectively. The trip time is utilized for several reach routing processes to further translate (delay) the outflow (as shown in figs. 4, 5a, 5b & 5c).

30 years rainfall data used for runoff modeling could be obtained using rain gauge records or could also be arranged from IMD sources. The output result of a final runoff volume, hydrographs and tables are shown in figs. 5(a, b, & c). The output mainly comprises of two sub catchments and one catch basin (pond) number in sequence as 1s, 3s and 2p. The sub catchment characteristics comparison of area chosen (in acres), SCS CN numbers (usually adopted from data developed by the SCS (NRCS) and published in ( TR-55), and time of concentration (Tc) (based on new Tc method comprises of different methods). (Direct method entry, log/CN method, sheet flow, shallow concentrated flow, channel flow, pipe channel, parabolic channel, trapezoidal/triangular (V) /rectangular channel flow and lake or reservoir) usually adopted between 5 to 30 minutes for urban typical sub catchment areas. The accumulated flow is directed towards the pond (shown as 2p in fig. 4) through a channel or pipe with different cross sections for storage and potential future outlet flow applications in the form of outlet through accumulation.

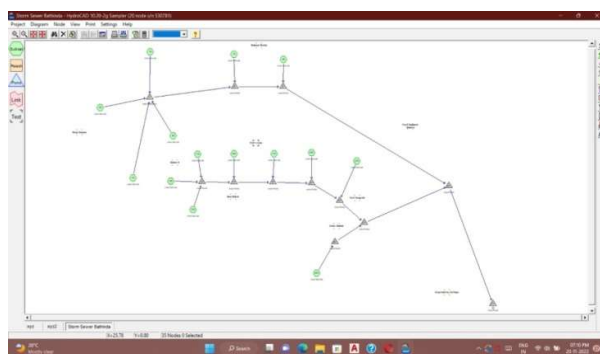


Fig. 4: Layout of the route of stormwater discharge (Routing diagram)

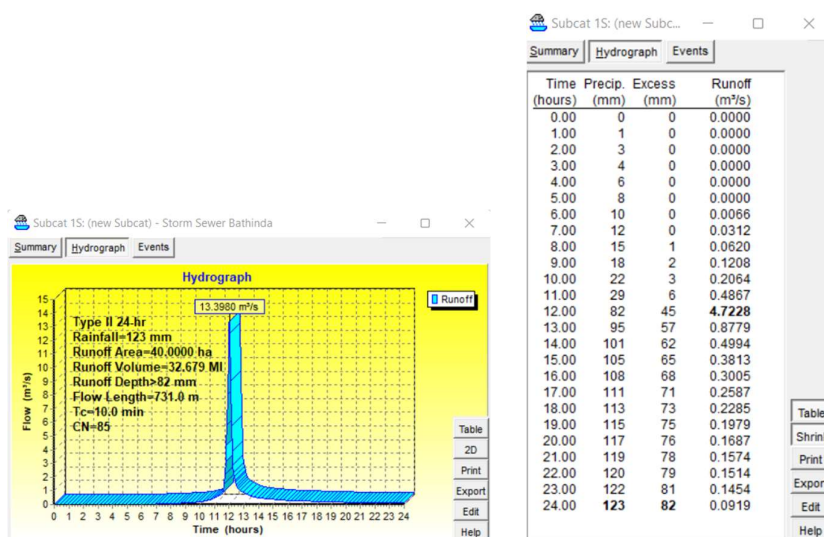


Fig. 5(a): Subcat 1S (Runoff volume n hydrograph table)



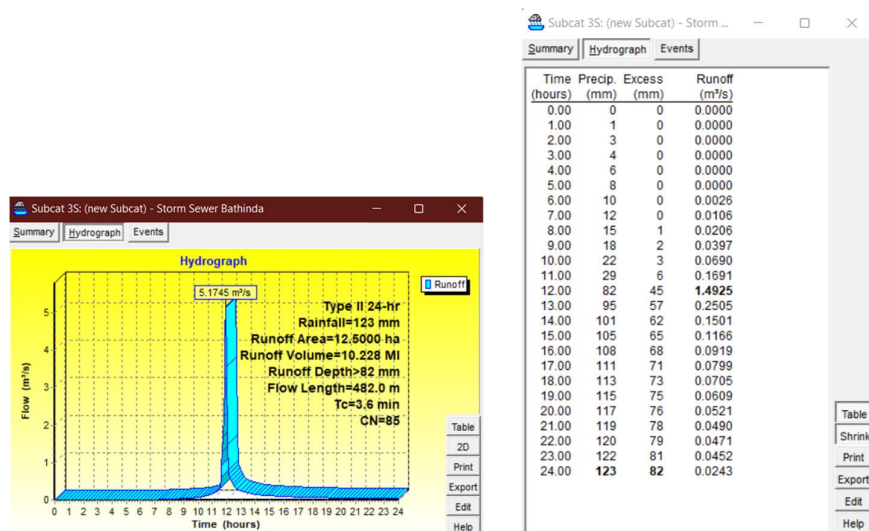


Fig. 5(b): Subcat 3S (Runoff volume n hydrograph table)

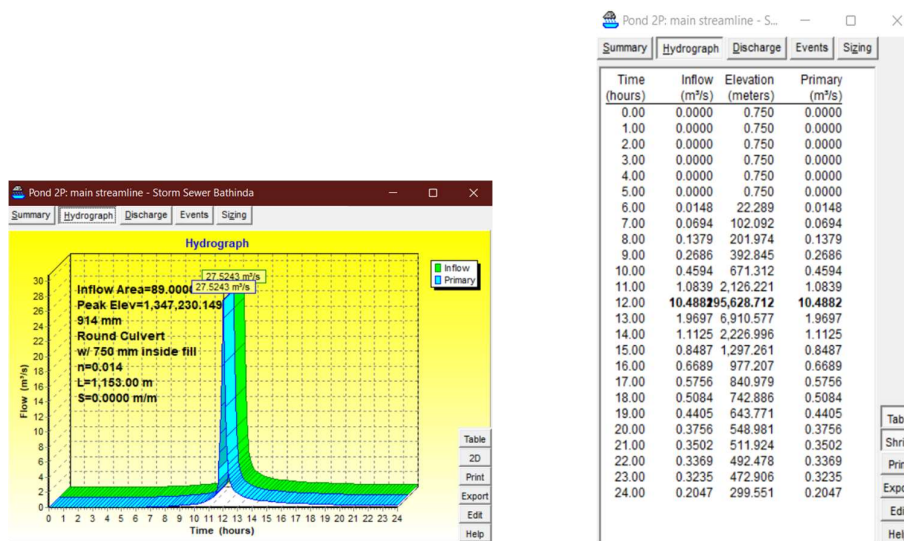


Fig. 5(c): Pond 2P (Runoff volume n hydrograph table)

### Reporting of Land Use

A thorough breakdown of the land use within a project is provided by land-use reporting. This can be applied to residential, commercial, and other applications. Land-use reporting is most frequently employed in conjunction with pollution loading calculations; however it can be used alone as well.

### Pollutant loading

Calculations of pollutant loading are used to determine how many contaminants are present in site runoff. The total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) that will be released from a site over a specific time period are commonly calculated using this method.

Each sub-area is assigned to a particular land-use category, and pollutant concentrations are determined for each category, which makes it easier to calculate the pollutant loading.



The SCS Curve Number (CN) is used to estimate how much of the depth of the precipitation will be runoff. The CN depends on the ground cover and kind of soil. A low CN (such as 30 for some wooded regions) implies a strong retention capability and little runoff, whereas a high CN (such as 98 for pavement) suggests limited retention and heavy runoff (attached fig. 6).

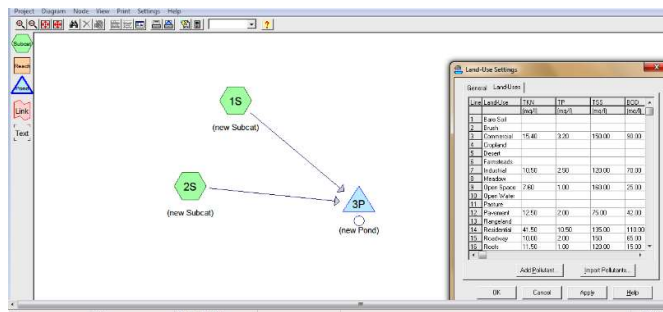


Fig. 6 (Pollutant loading)

The different areas under each form of land use and the concentration of pollutants are taken into consideration. Since the depth of the runoff can fluctuate depending on the catchment, "pollutant loading" is also estimated for each catchment based on the aforementioned criteria.

**SewerGEM:**

“Return period” calculations were made on the basis of ‘rainfall data’ (For ex. 5 years for the studied region). The ‘flow’ from the catchments were calculated for the entire catchment and checked based upon the pipe diameters selected/available (based on available pipe diameter available in market).

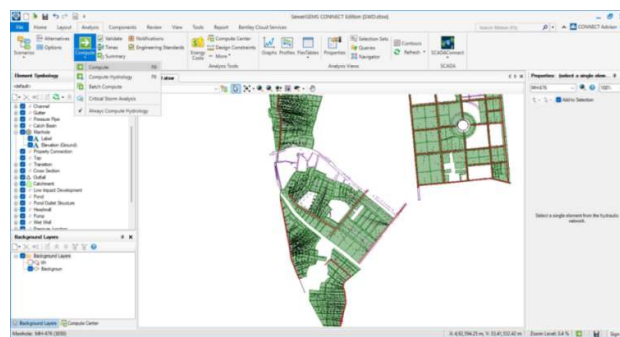


Fig.7 (Output)

Fig.7 shows the output generated by using SewerGEM model. (The output consists of green area (refers to catchment area), brown color lines (refer to pipes/conduits), dotted line representing the catchment areas flow lines of accumulated water and purple lines of background study area).

The utility of the sewerGEMs software is in calculating the more appropriate size of manholes, spacing of manholes and appropriate diameters of sewer pipe, starting from lateral sewer, branch, sub main, main and trunk sewers accumulating total flow gradually and draining out

the total sewer generated from the area using pipe network of different diameters (small diameter to larger diameter pipes in a gradually systematic manner).

This **table no.1** shows an attempt to bridge the knowledge gap required for efficiently using to measure software for design of urban drainage infrastructure as per the regulatory limits.

**Table no.1: Comparison between HydroCAD and SewerGEMS**

HYDROCAD		SEWERGEMS	
Input data	Output data	Input data	Output data
Design Constrain Such as Velocity, Cover and Slope	Runoff volume, Hydrographs and pollutant loading	Design Constrain Such as Velocity, Cover and Slope	Hydraulic Design of Sewer
Sizes of Drain		Type of Drain Network (Circular, Box)	Hydraulic Design Statement of Sewer
Unit sanitary dry weather load (For drainage)		Sizes of Drain	Network Drawing of Design Sewer
Runoff Coefficient		Elevation Data of Area to be design	Hydraulic Design of SWD
Time of Concentration		Unit sanitary dry weather load (For drainage)	Hydraulic Design Statement of SWD
Rainfall events		Sewer Generation load (For drainage)	Network Drawing of Design SWD
IDF Curves		Extreal flow factor also refered as Peak factor (For drainage)	
pollutants		Runoff Coefficient (for SWD)	
		Time of Concentration (for SWD)	

## CONCLUSIONS

The research paper provides comparative assessment on the basis of “methodology/steps needs to be adopted” and “probable outputs obtained” for the efficient design of storm water as well as sewerage system (Urban infrastructure design) for the studied region using HydroCAD and SewerGEMS softwares, consist of mainly the Hydrograph generation and compound flow volume and routing computation for the storm water drainage (HydroCAD) and the conduits and manholes sizing for the efficient sewerage system network designing (SewerGEMS). The storm water management system designed on the basis of the given input parameters/values had advantages as the proposed stormwater network able to collect stormwater runoff from impervious area(s) of the studied regions and also possibility to treat the collected stormwater runoff prior to discharge. HydroCAD combines the most used functions of TR-20 and TR-55, having many other built-in hydraulics, graphics and automatic database and on-screen routing diagram enabling the users to design and sizing of drainage system components in order to control water excess and to develop the most efficient control strategies for minimizing the effects of water excess in the catchment area.

Similarly, effectiveness of the SewerGEMs in s proper sewerage network designing was experienced in the form of most user-friendly and extremely effective for big sewer networks design as for the allotted flow, SewerGEMS offers the smallest diameter which leads to the project's cost-effective solution. Additionally, as an output result, SewerGEMS offers a map with information such as pipe, velocity, altitudes, and flow displayed directly on it with the advantage that for each link, the minimum and maximum velocity conditions easily met. Moreover, by using SewerGEMS software, generation of the layout and longitudinal section drawings with all the required information is very simple and easier to quickly produce the project drawings that are required by designers of the municipal and regional agencies. The designs may also be exported in a variety of well-known file types, such as dwg, dxf, pdf etc., making it very simple to share and modify them as needed during the project. Additionally by using SewerGEMS Network Navigation Tool, necessary network adjustments may also be performed to eliminate defects such loops, dead ends, orphan nodes, etc. Overall, both the softwares are simple to use, and take less time to produce tabular and visual results. The softwares performs a large series of computations, usually used for drainage and sewerage systems design, to serve efficiently consulting engineers in designing appropriate diameters of

the pipes for the efficient and timely draining out of sewerage as well as to ensure proper storm water routing to the pond/outlets designed, thus prove to be very helpful for the large engineering firms and municipal/regional agencies modeling thousands of acres.

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