URBAN WATERSHED RUNOFF MODELING USING GEOSPATIAL TECHNIQUES

DST Sponsored Research Project
(NRDMS Division)

By

Prof. M. GOPAL NAIK
Professor & Chairman, Board of Studies
Email: mgnaikc@gmail.com

Department of Civil Engineering
University College of Engineering (Autonomous),
Osmania University, Hyderabad-500007,
Telangana State, India

OUTLINE OF THE PRESENTATION

- Introduction
- Need of the study
- Objectives of the Study
- Overview
- Methodology
  - Study area Description
  - Data Collection
  - Thematic map Generation
  - InfoSWMM Model Simulation
  - Concluding Remarks
- Future Scope of the Work

INTRODUCTION

- The distribution of rainfall over a year is uneven and therefore during the non monsoon months sufficient water is not available especially for agriculture and drinking.

- It is an essential task to optimize the utilization of water resources within the technical and economic framework.

- In this study spatial and temporal variations of meteorological and watershed characteristics are incorporated.

Cont...

- Storm Water Management Model (SWMM) is used for planning, analysis and design related to storm water runoff, drainage systems, etc in urban areas.
- This software is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality from urban areas.
- The runoff component of SWMM operates on collection of sub catchment areas that receive precipitation and generate runoff.

NEED OF THE STUDY

- Recognition of the specific hydrological problem.
- Measuring the necessary variables by means of remote sensing and conventional methods.
- Design of GIS including data layers and attributes information.
- Building of database for managing required data set.
- The first aspect is to locate, measure, evaluate and distribute the natural resources available in an accurate and detailed manner as possible.
- Spatial data consist of base drainage, transport and land use/landcover.

MOTIVATION OF THE STUDY

- The first aspect is to locate, measure, evaluate and distribute the natural resources available in an accurate and detailed manner as possible.

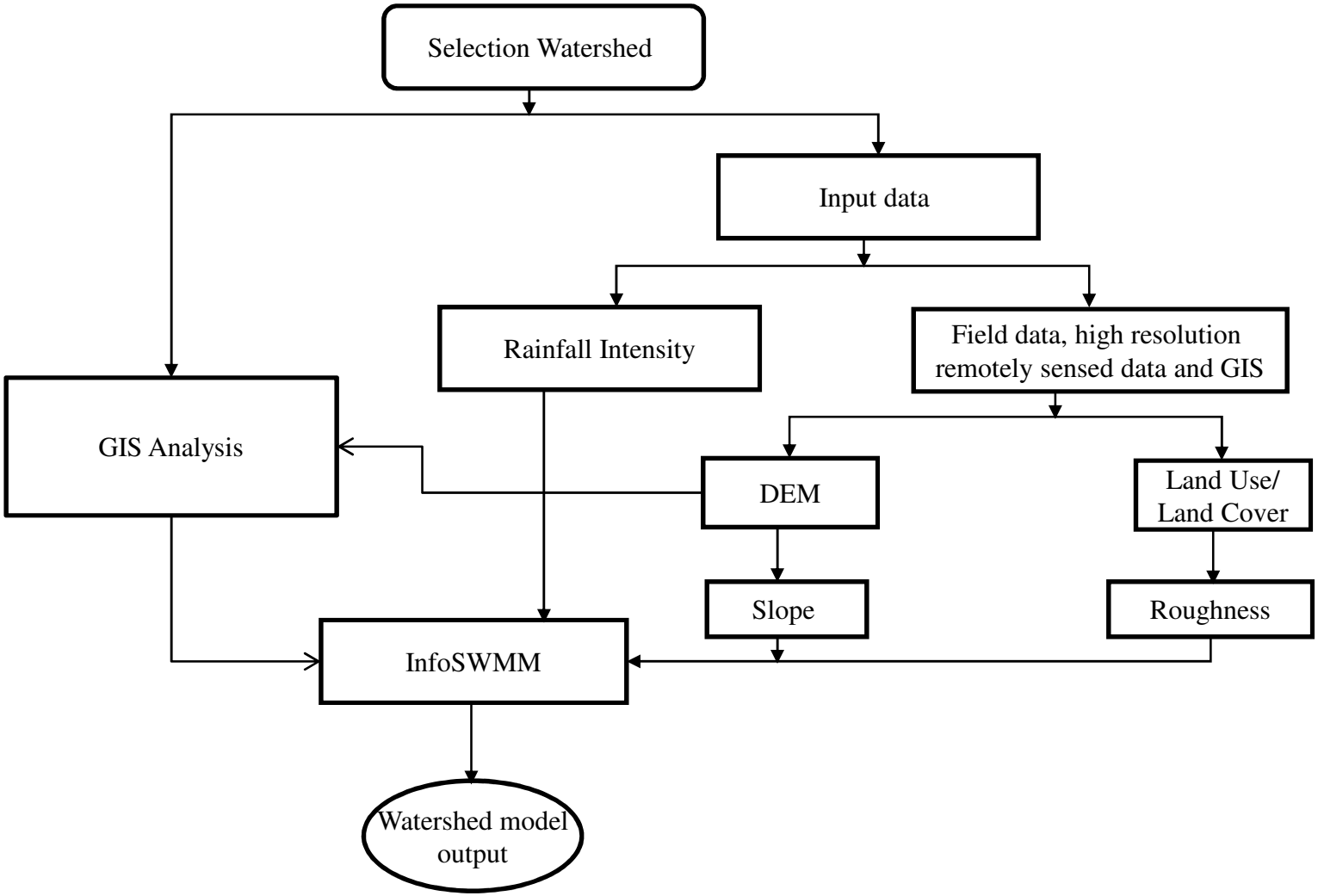
- Spatial data consist of base drainage, transport and land use/landcover.

- Thematic maps are useful for management of natural resources and are prepared using satellite imageries and toposheet data using visual interpretation and digital interpretation techniques.

OBJECTIVES OF THE STUDY

- To investigate the utility of remotely sensed data and geographical information system for urban watershed runoff modelling.
- To develop an integrated approach using remote sensing and GIS to examine the effects of urban growth on surface runoff at the local level by using distributed storm water management model (InfoSWMM).
- To identify the sub-watersheds that is potentially most vulnerable to flood due to urbanization and suggesting the implications of the results for decision making and long-term urban planning.
- To carry out the flow analysis to identify the significant parameters effecting the rainfall-runoff of the watershed.

METHODOLOGY



INFOSWMM MODEL

- InfoSWMM is a dynamic rainfall-runoff model.
- It computes runoff quantity and quality from primarily urban areas.
- The runoff component of InfoSWMM operates on a collection of sub catchment areas that receive precipitation and generates runoff and pollutant loads.
- InfoSWMM tracks the quantity and quality of runoff generated within each sub catchment.
- It also calculates flow rate, flow depth and quality of water in each channel during a simulation period comprised of multiple time steps.

Cont…

- At time (t+Δt) the values for the nodes from the properties at time‘t’ are computed
- Iterate at least 2 times until either all nodes and links are covered or a maximum of iterations are reached.
- Use the values of Q and H at time (t+Δt) for the new times.
- The SWMM solutions for flow and depth at each time step.
- The SWMM solution for flow and depth is solved explicitly at each time step. The new depth and new flow is always based on the old depth and old flow and half and full time step during the time step.

Study Area

- The case study is considered as Osmania University Campus area, which is located in the north eastern flank of Hyderabad.

- The study area lies in between the longitude of 78° 31´ to 78° 32´ 26´´ and latitude of 17°23´45´´N to 17°25´42´´N.

- The Osmania University was established in the year 1918, with the area of 1627.32 acres.

Boundary of Osmania University Campus

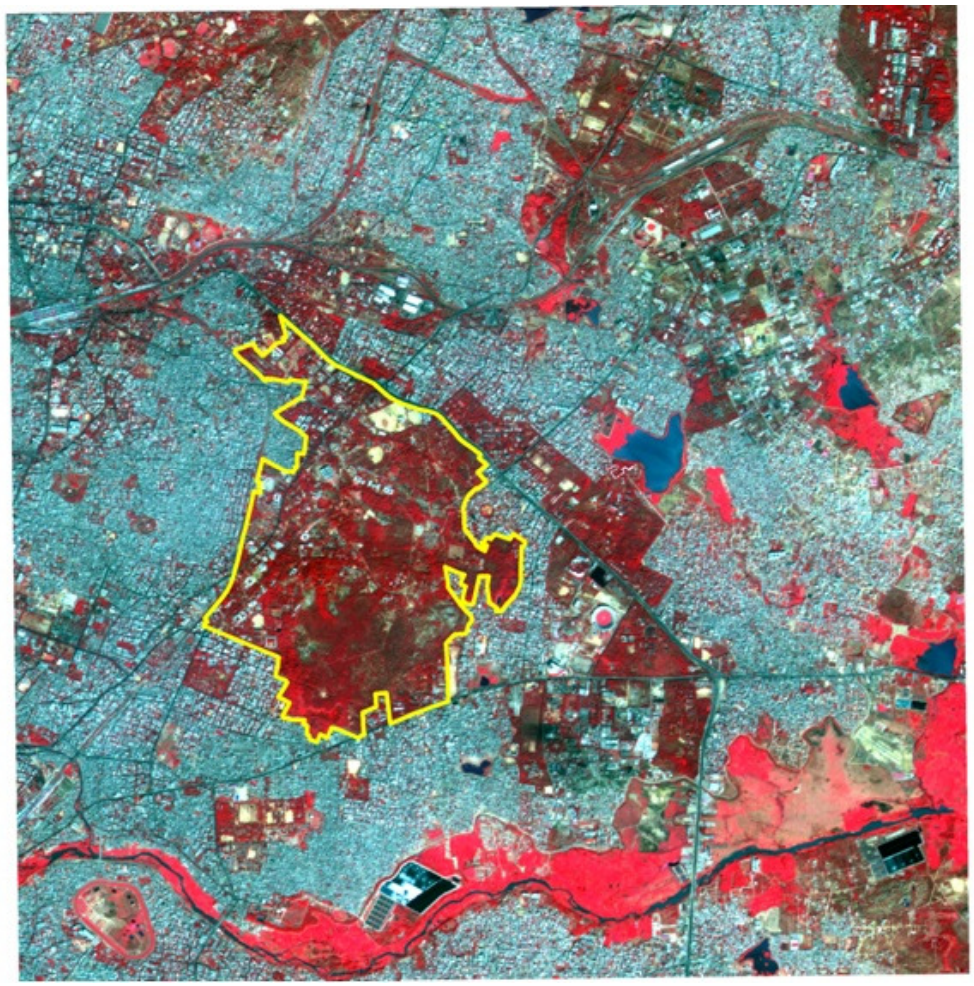


Figure1 The boundary map of the Osmania University campus

Data collection

Data Required:

- Toposheet of the study area
  - scale: 1: 25,000 and 1: 50,000

- Satellite data of the study area.
  - High Resolution satellite data
  - Resource Sat-2, LISS-IV, dt:3rd Dec.2011
  - 5.8 meter Spatial Resolution

- Daily and Monthly rainfall data.

  - Rainfall data collected from NGRI Raingauge Station located eastern part of the study area and IMD Begumpet station.

The Toposheets of scales 1:25000 and 1:50000 were collected from the Survey of India, Hyderabad.

- The Osmania University falls over the toposheet no. 56/k/11NW with a scale of 1:25000.

Remotely Sensed Data

- The geo-referenced image of Resourcesat-2 (IRS-R5) dated 03-DEC-2013 with resolution of 5.8 metre have been purchased from NRSC, Hyderabad.

Meteorological data

- Historical metrological data has been collected from Indian metrological department, Begumpet, Hyderabad. The daily data is for a period of 2 years January 2011 to December 2012.

- The monthly data is collected for a period of 5 years January 2007 to November 2012 from NGRI.

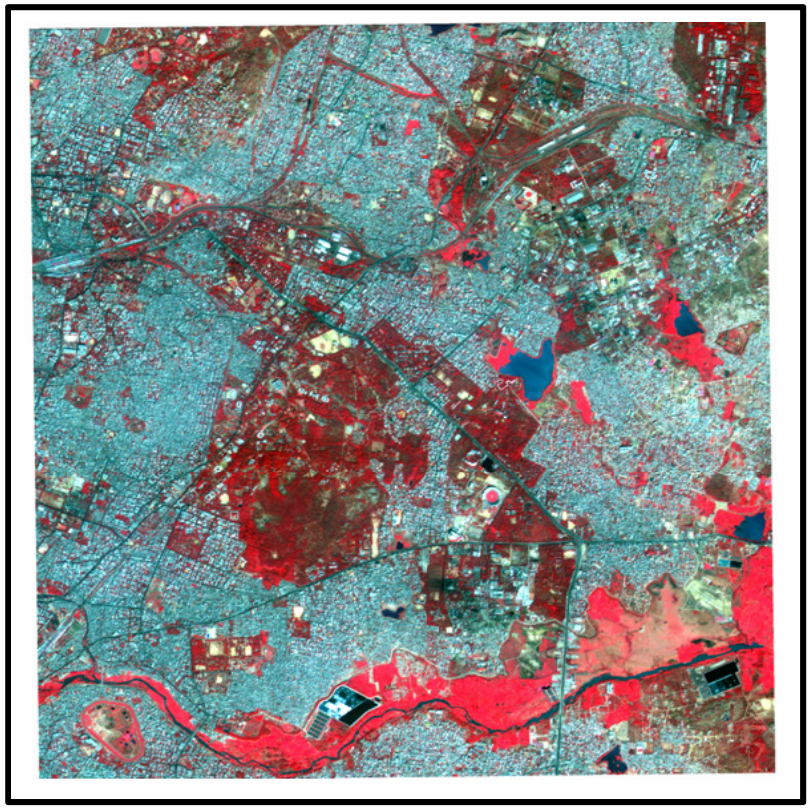


Figure 2 . Standard False Color Composite satellite image of Resourcesat-2 (IRS-R5) dated 03-DEC-2013

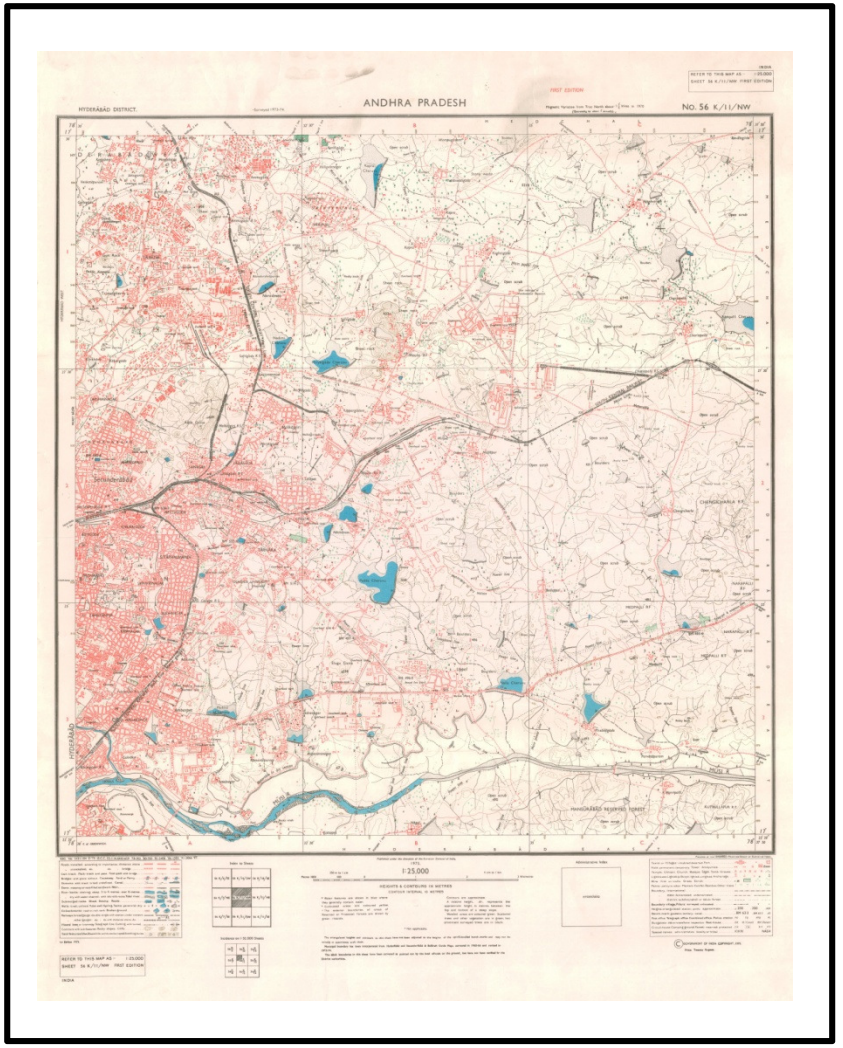


Figure 3. Toposheet 56/K/11 NW from Survey of India

Total Station and DGPS Survey

- Total station survey to extract 1 meter contour throughout the Osmania University campus.
- Total Station Survey to explore the roads and drainage system along the manholes of Osmania University campus.
- DGPS survey was done for checking the accuracy and any corrections if needed.
- The spot heights were used along the contours for creation of DEM

DGPS and Total Station Survey








Figure.4_Identifying the spot heights to create a contour map using the Total Station and DGPS.

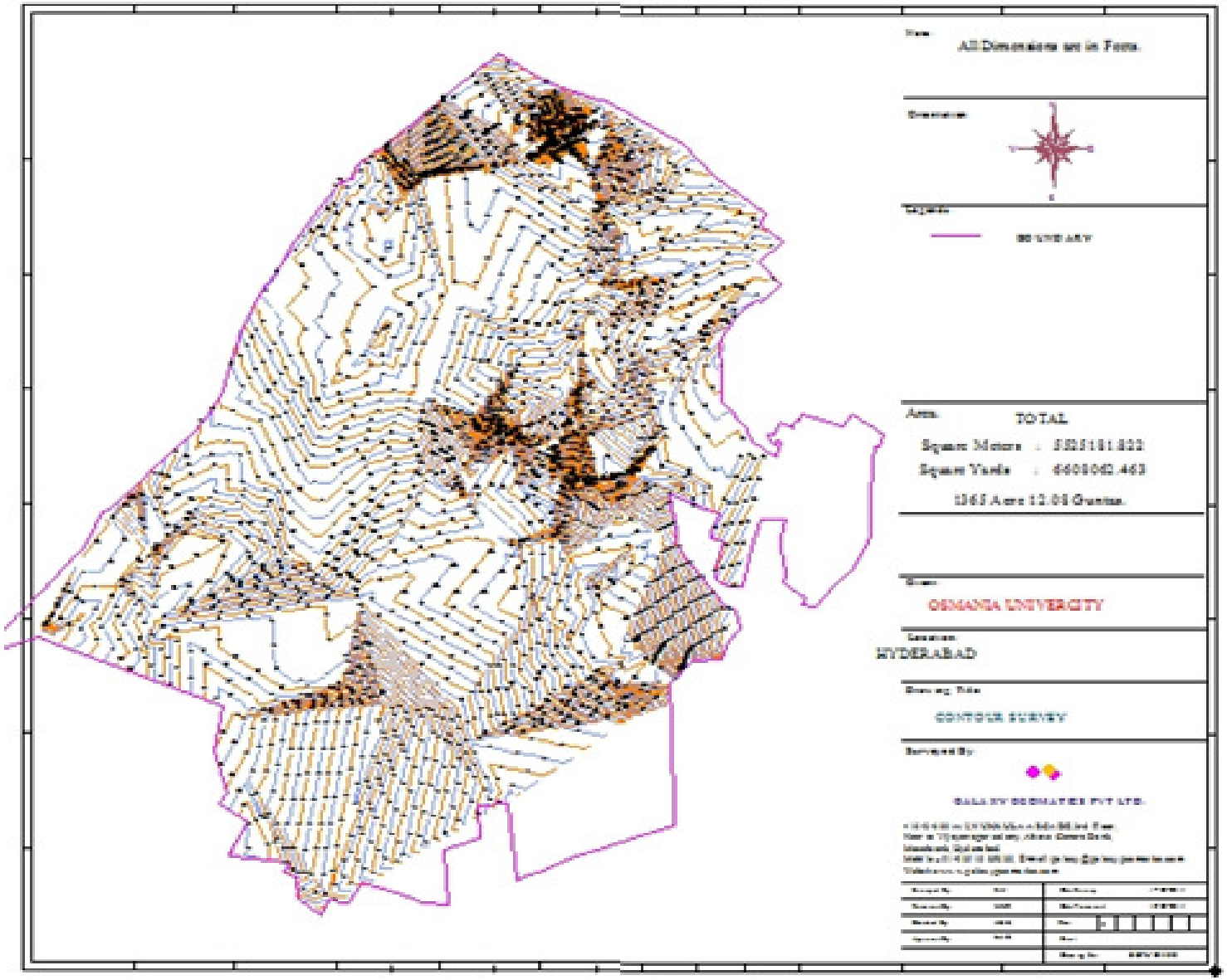


Figure 5. One meter contour map of the watershed along with the spot heights

Thematic map generation

- Base map.
- OU Watershed
- Storm water network map.
- Road network map.
- DEM map of Osmania University campus
- Slope map
- Land Use and Land Cover map

OU Watershed

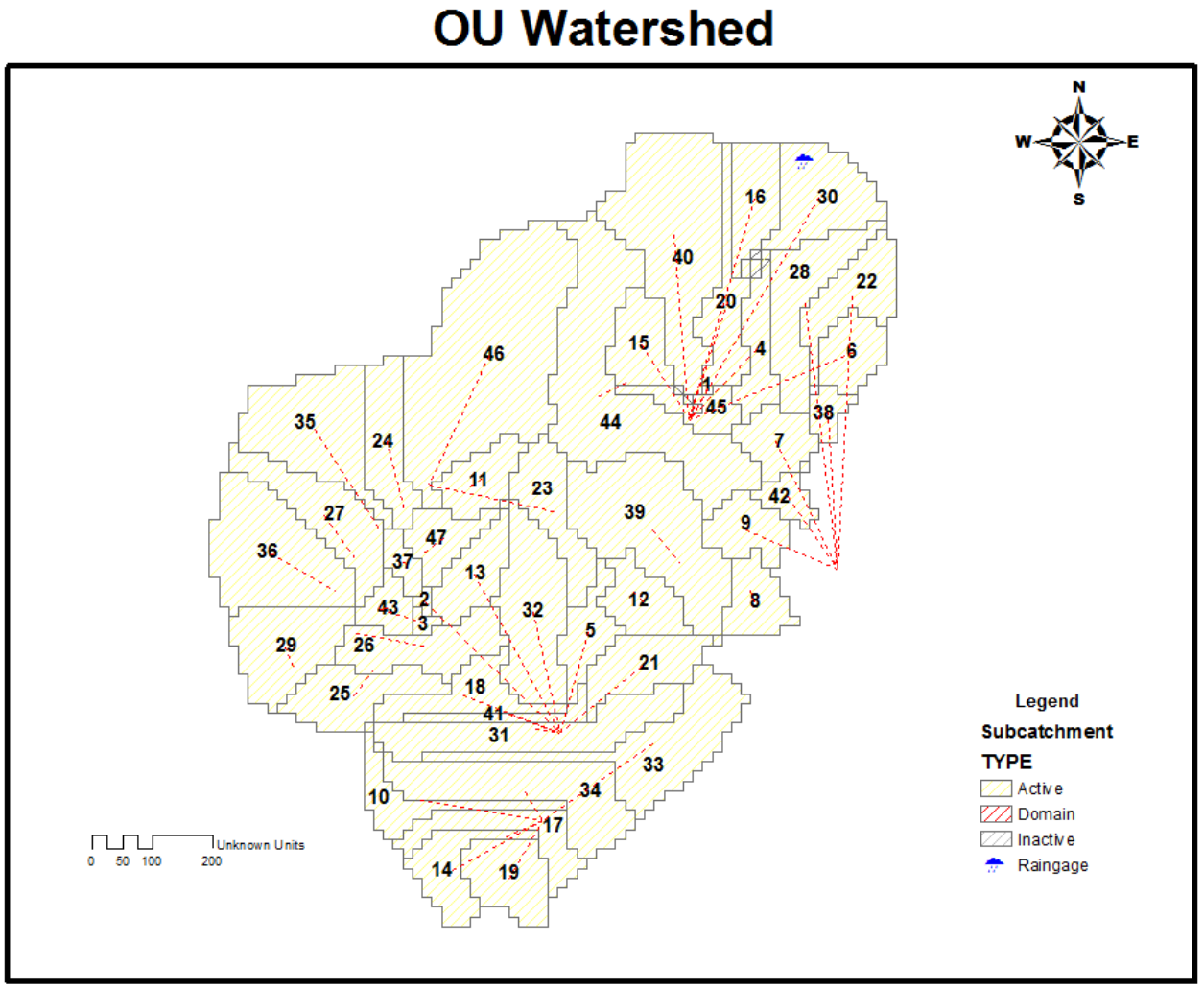


Figure 6. Sub-watershed map of the study area

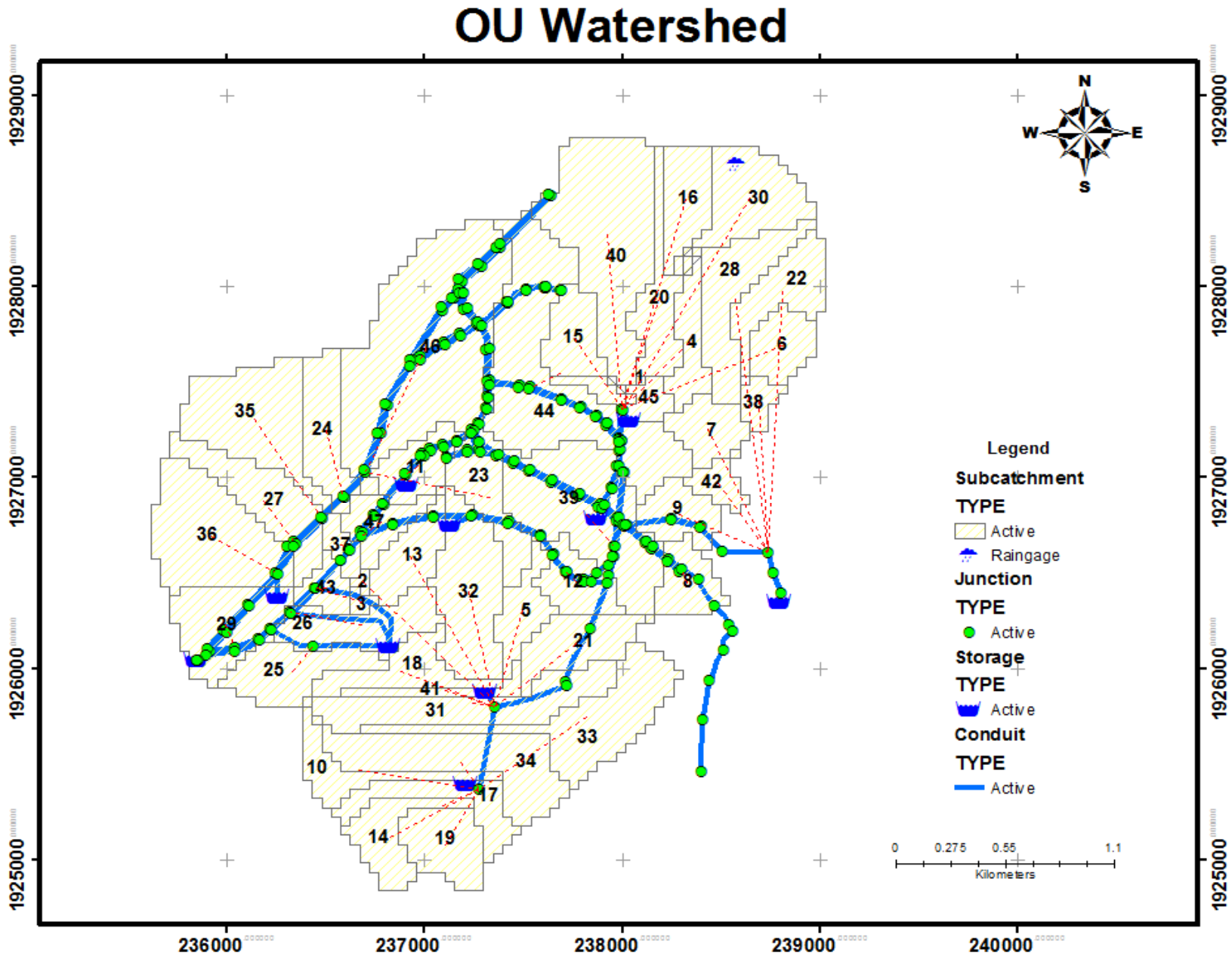


Figure 7. watershed drain networks

Storm water network map

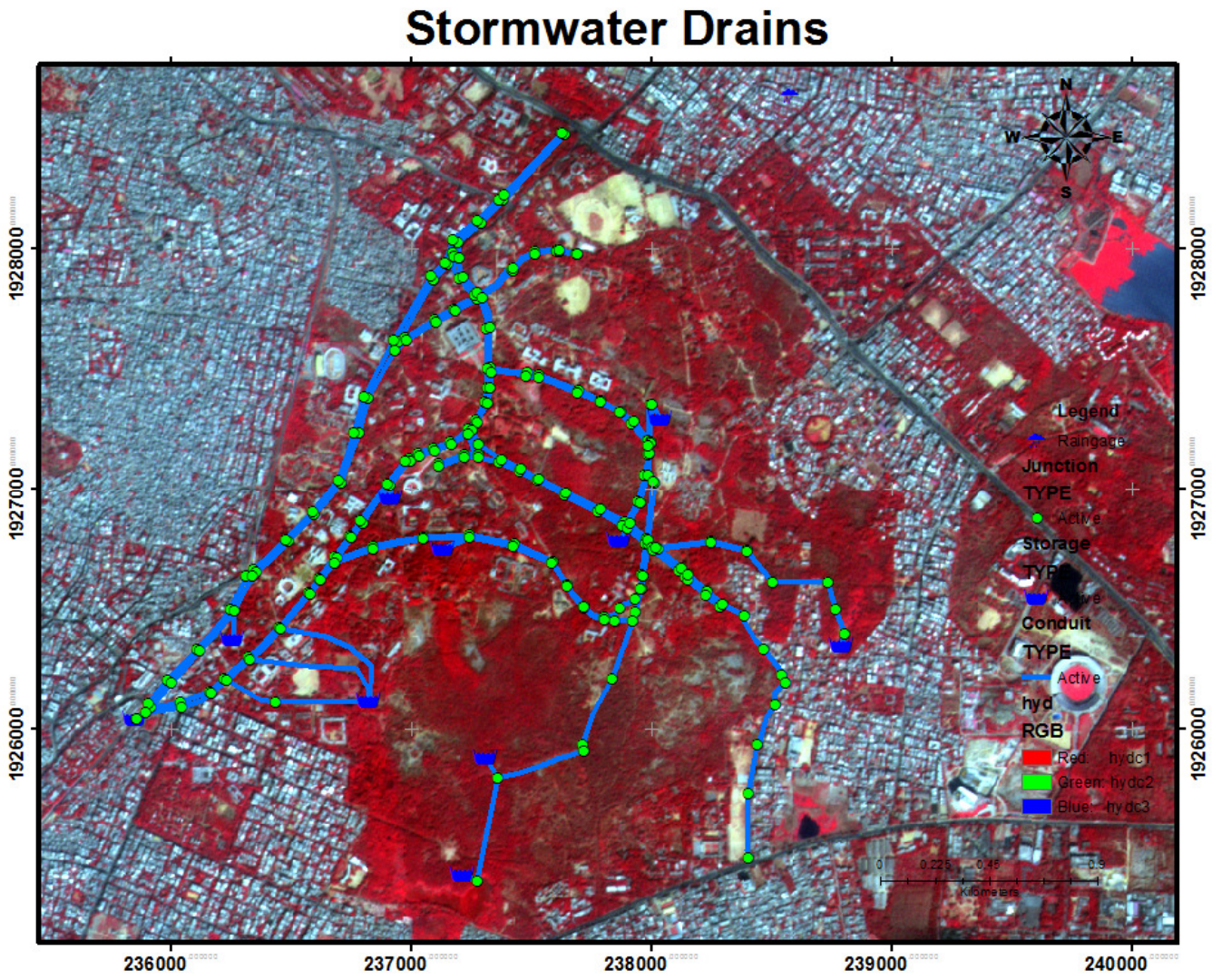


Figure 8. Storm water network map

Road network map.

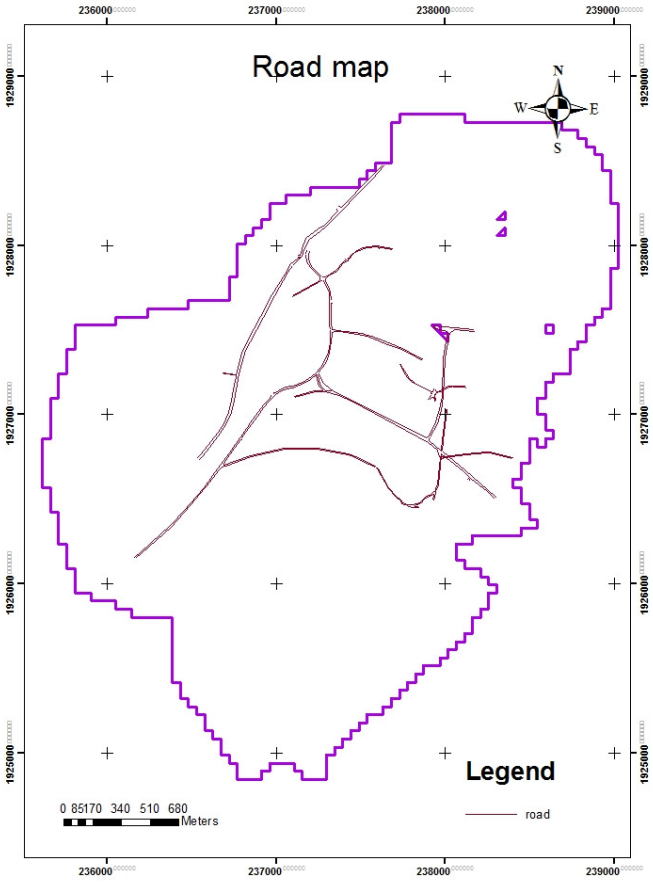


Figure 9. Road network map of Osmania university

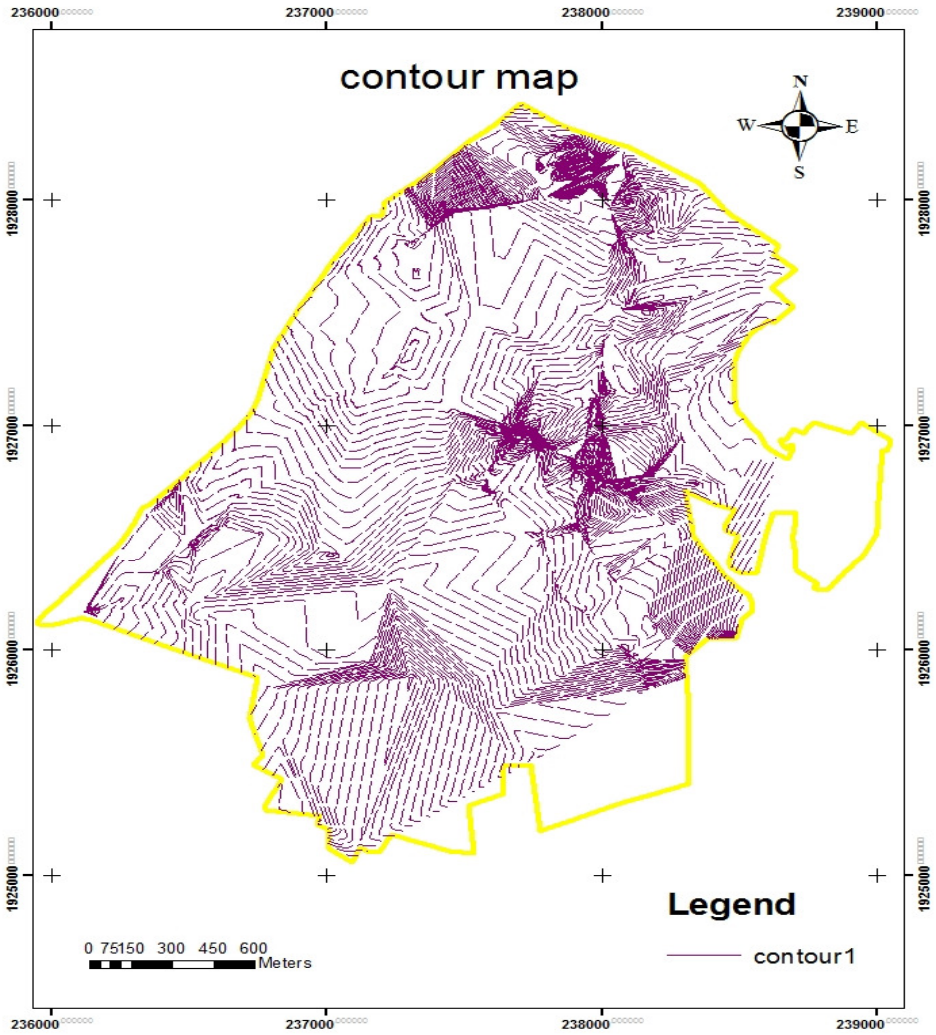


Figure 10. Contour map of the watershed

DEM Map of Osmania University Campus

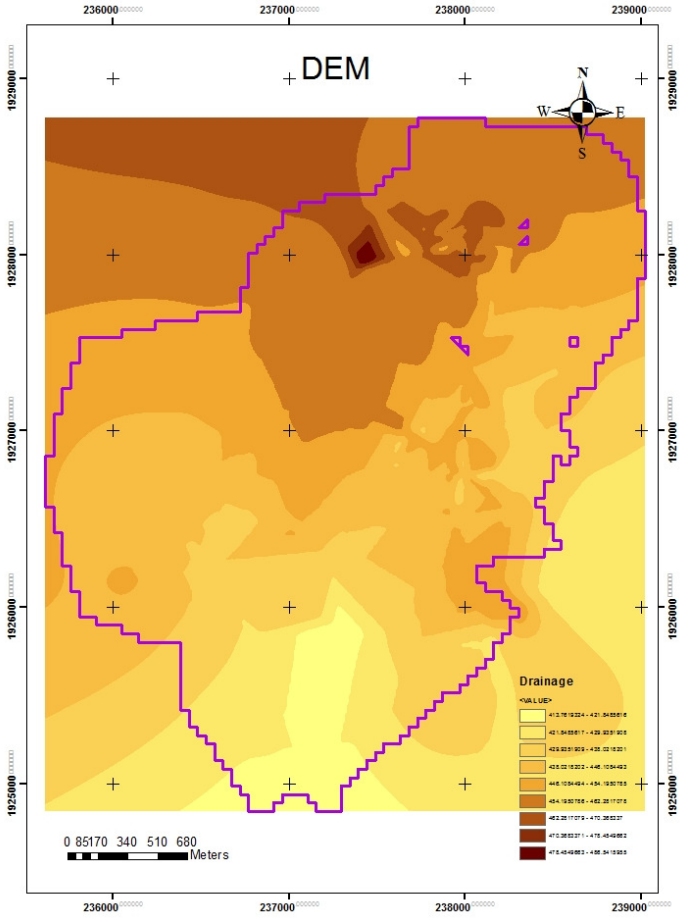


Figure 11. DEM map of Osmania university

Slope Map

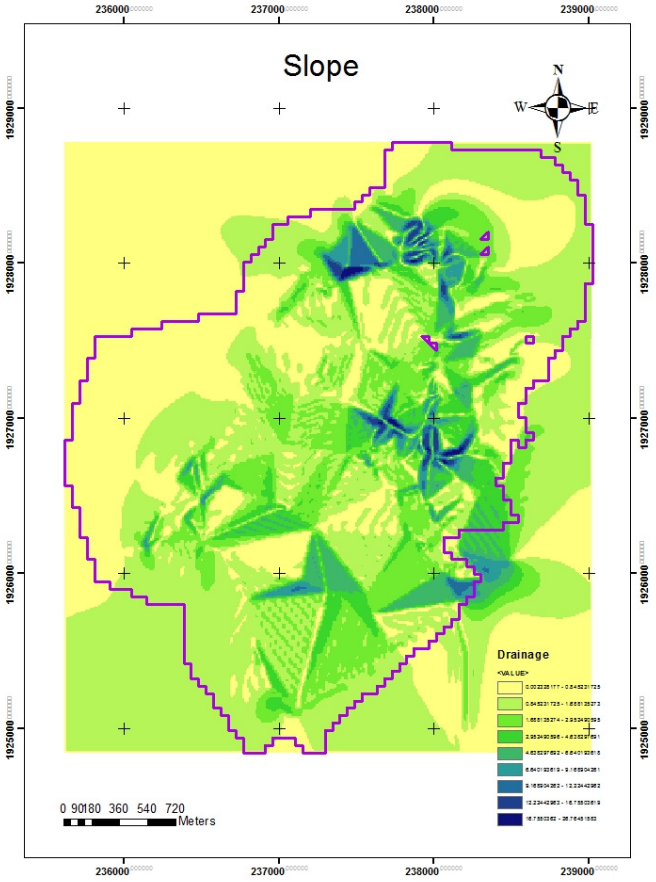


Figure 12. Slope map of the watershed

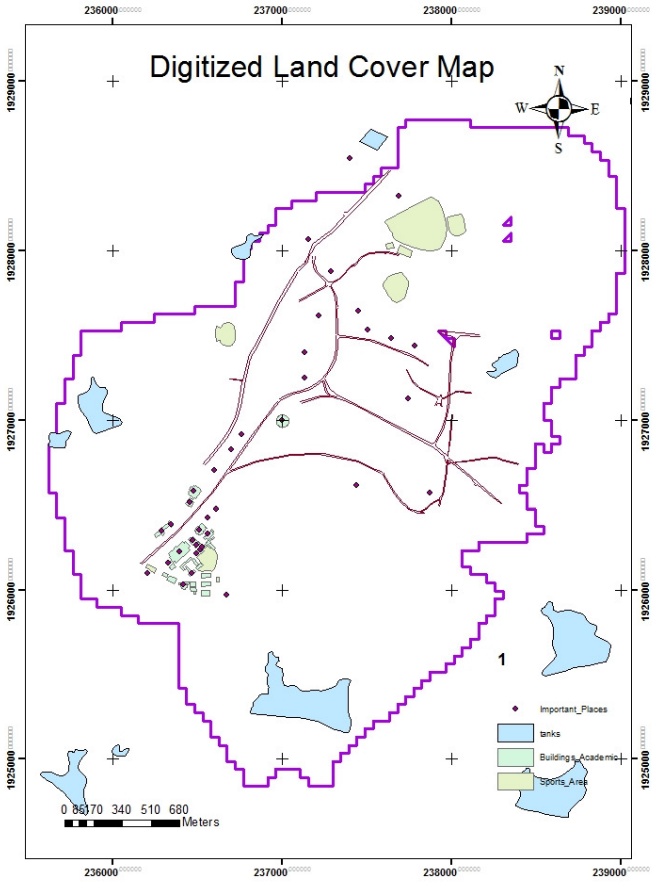


Figure 13. Digitized land water bodies

Metrological Data

InfoSWMM takes met data in .txt format.

All met data has been converted as per the format required by InfoSWMM

Met data includes

- Temperature
- Relative Humidity
- Evapotranspiration
- Wind speed

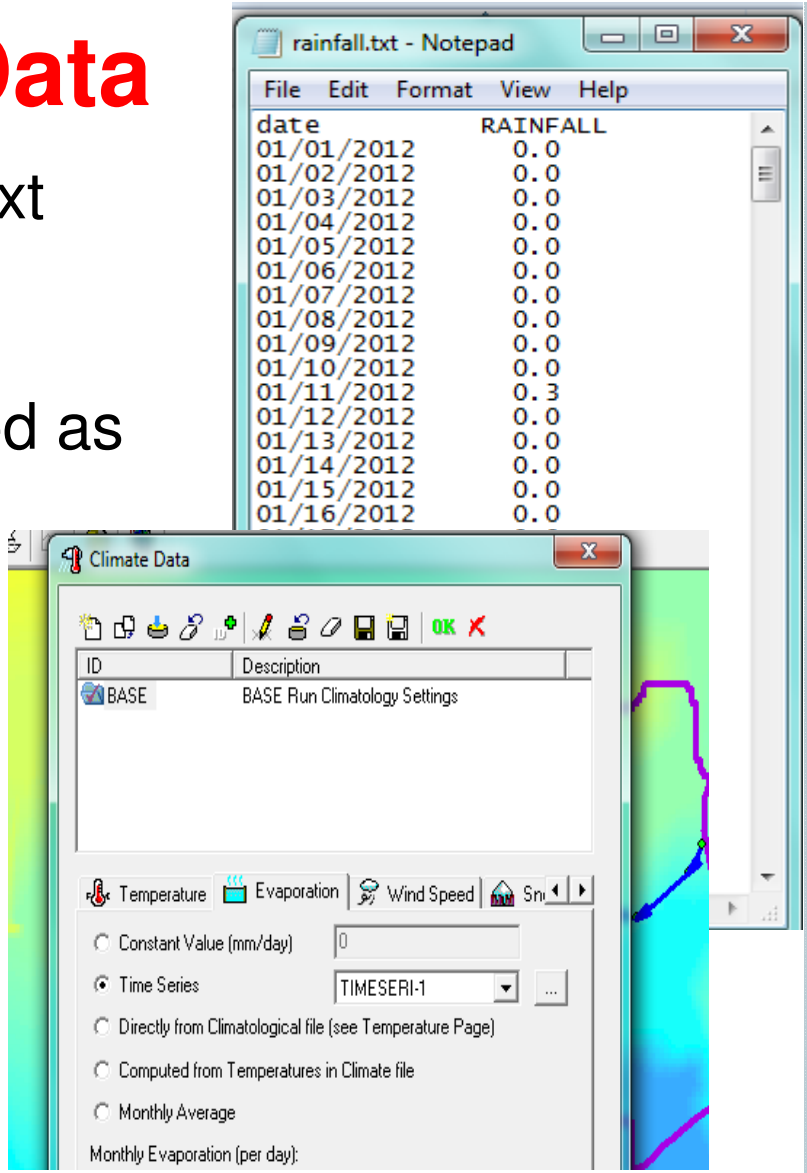


Figure 14. Snapshot of InfoSWMM along with rainfall data

Input data

•In InfoSWMM the junction nodes are created that comprise part of drainage network. The depth and elevation are important components for creating junction nodes.

•For Creating an outfall the elevation is used.

•Conduits are created by joining to junction nodes.

•For creating the rainguage the parameters used are intensity, time interval and time series is used

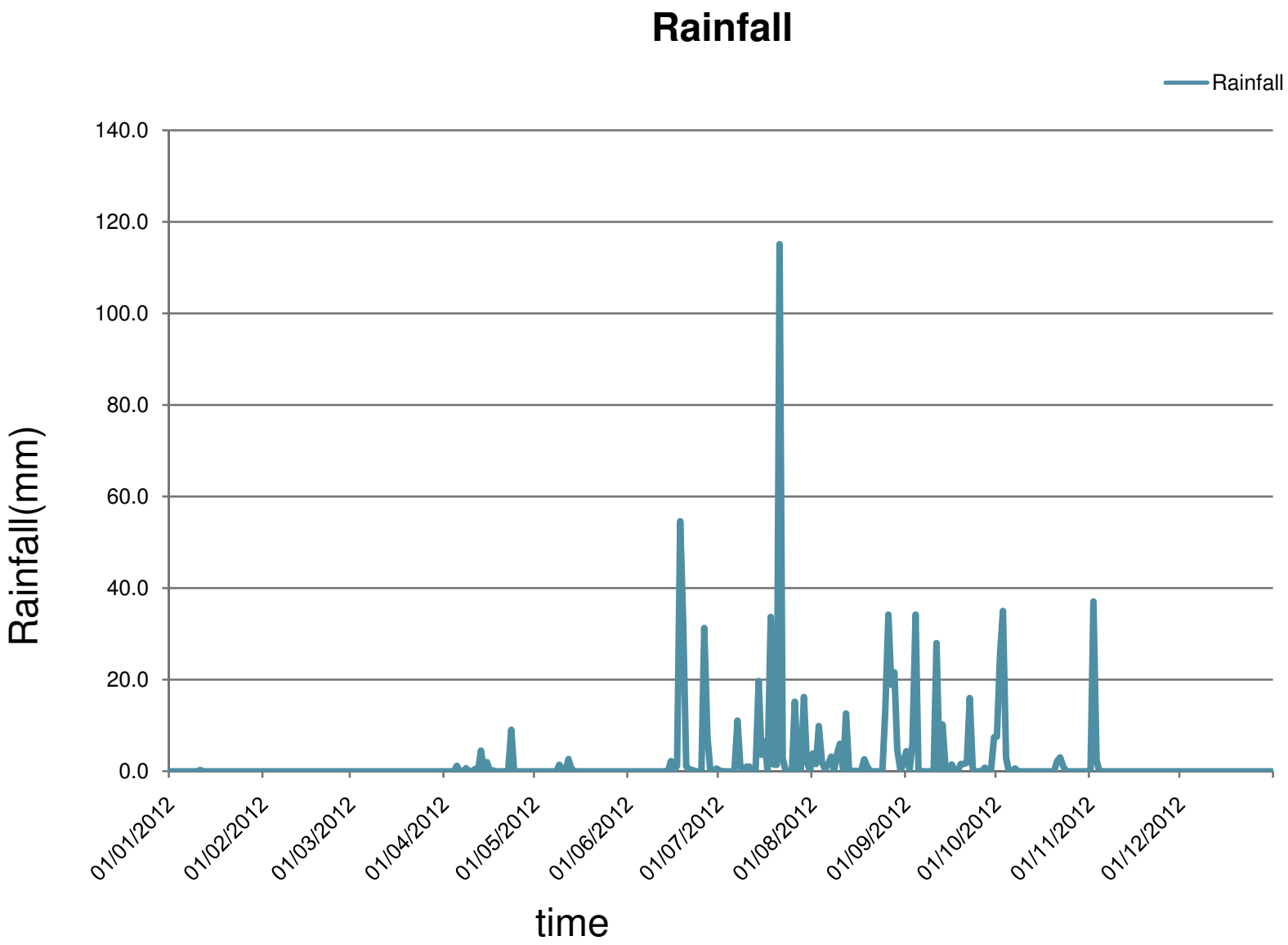


Figure 15.Time vs. intensity graph

Rainfall mm/h

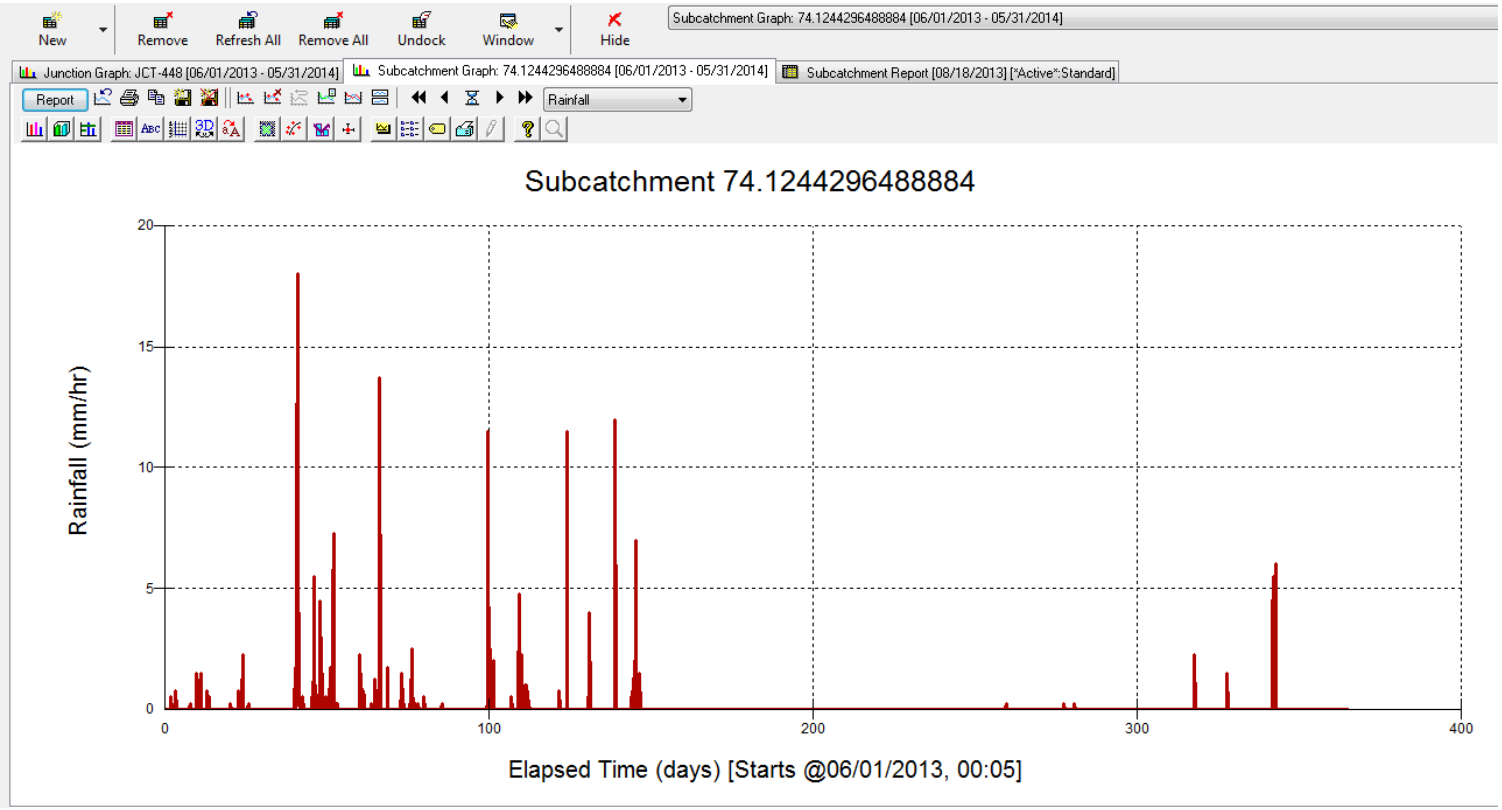


Figure 16.Elapsed time vs. intensity graph

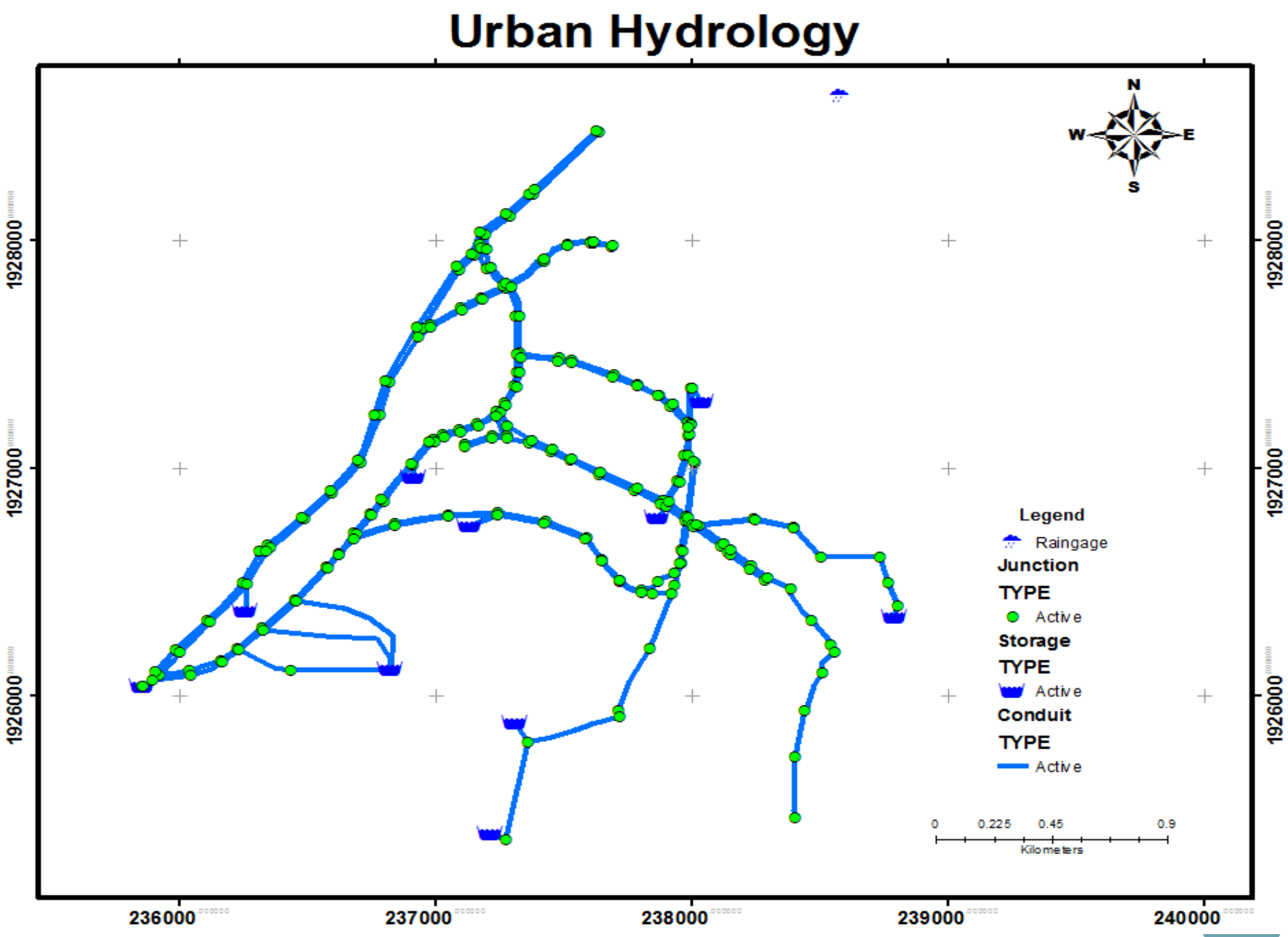


Figure 17. Creation urban drainage system

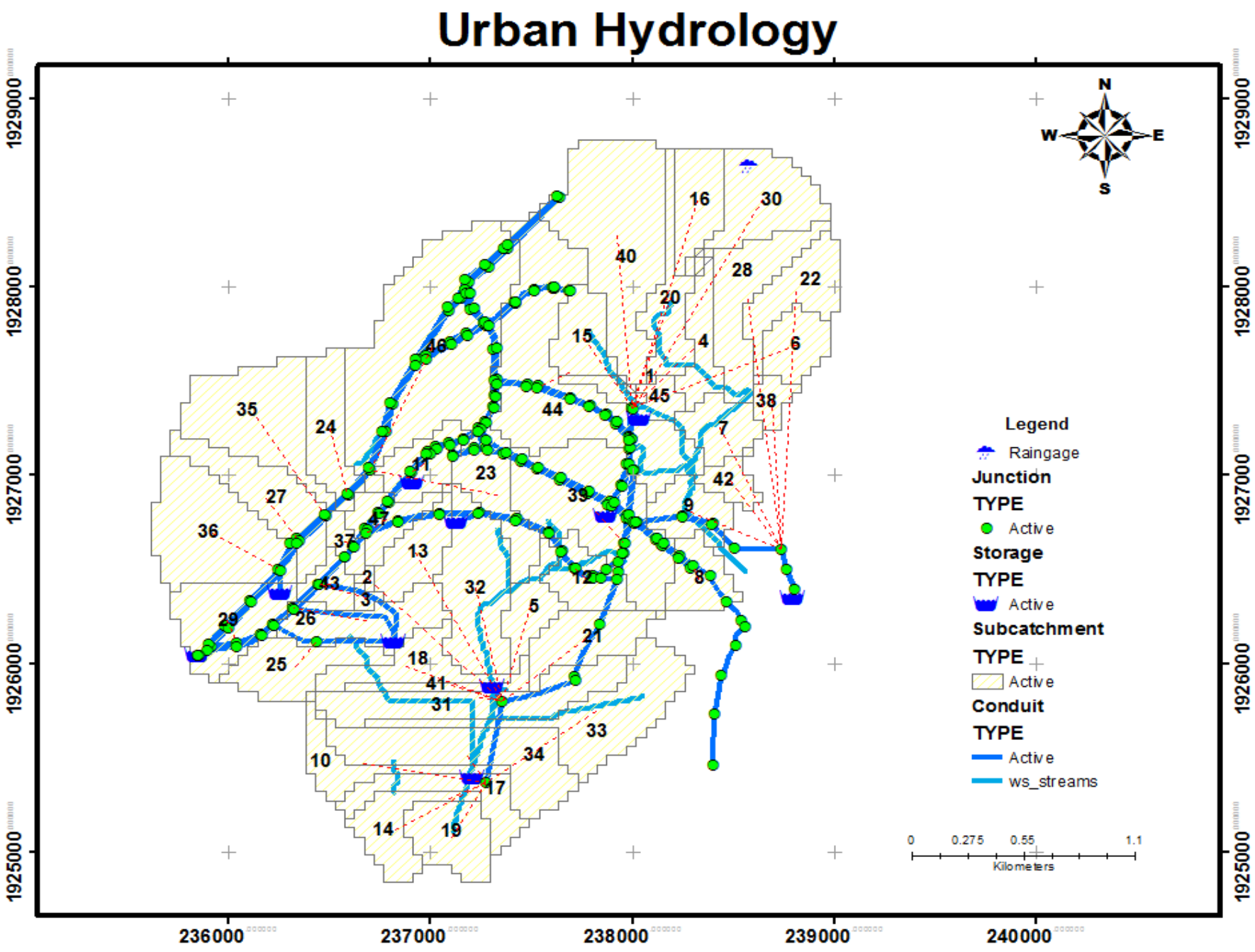


Figure 18. Watershed road network and drainage systems

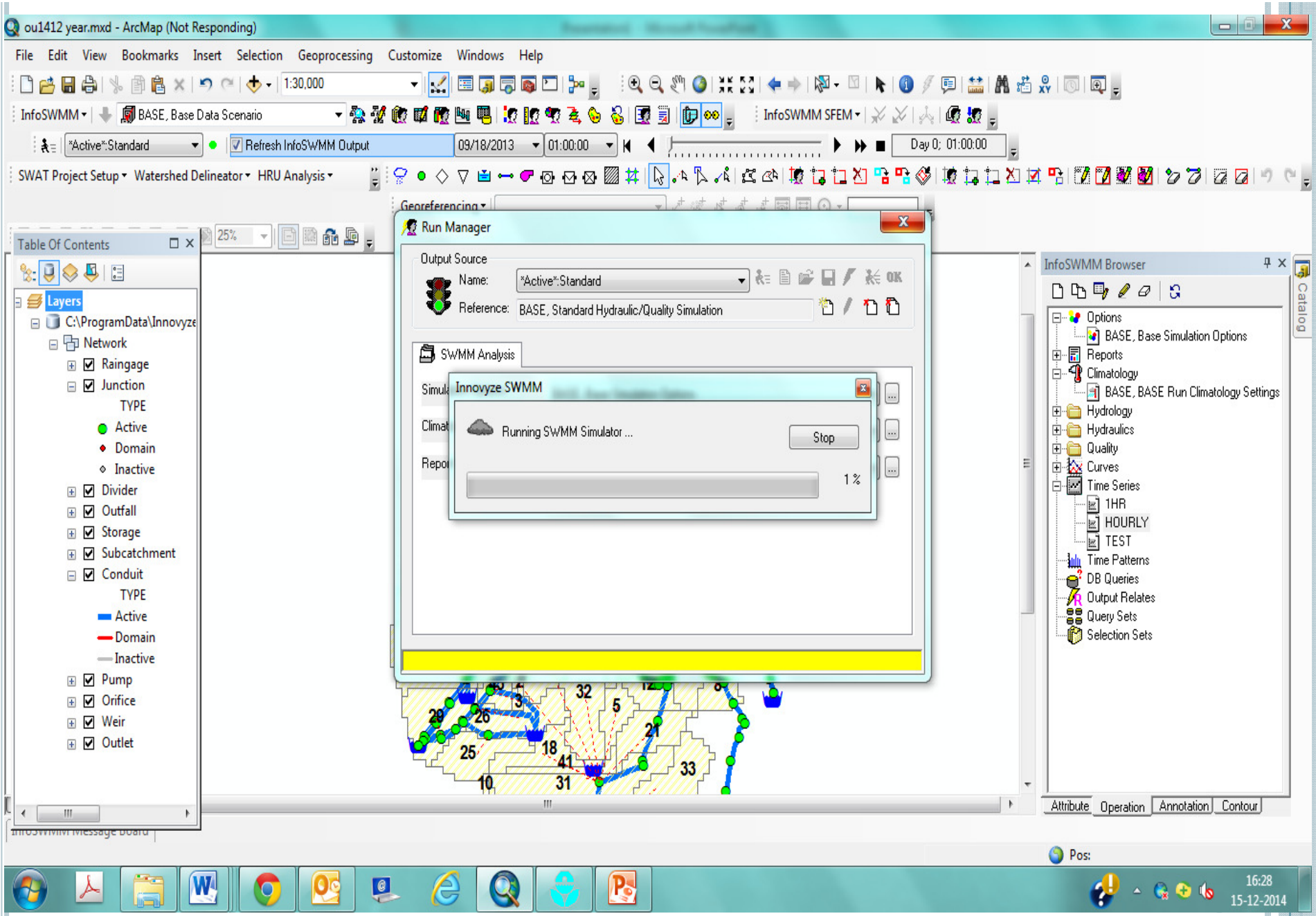


Figure 18. Model screenshot

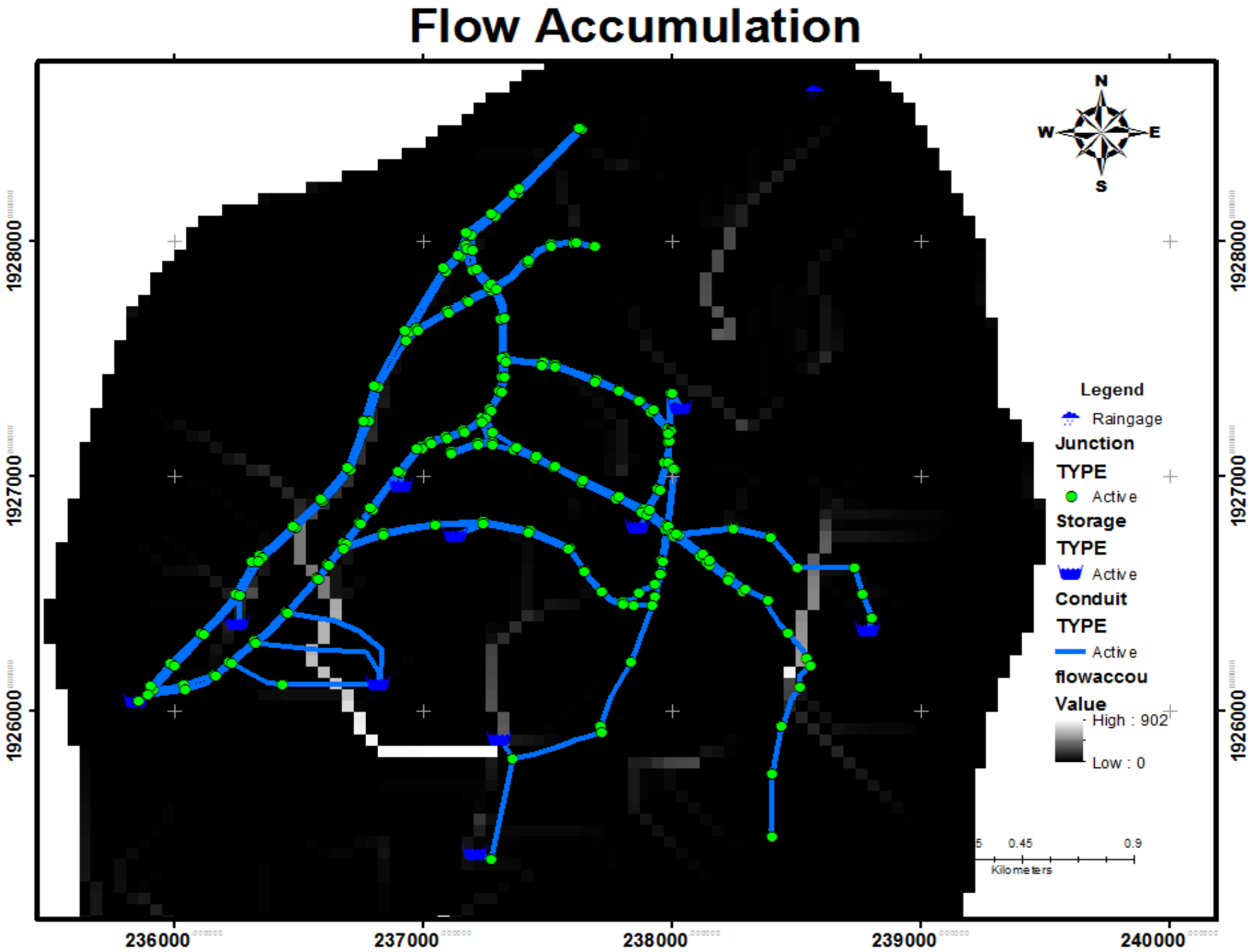


Figure 19. Flow accumulation map

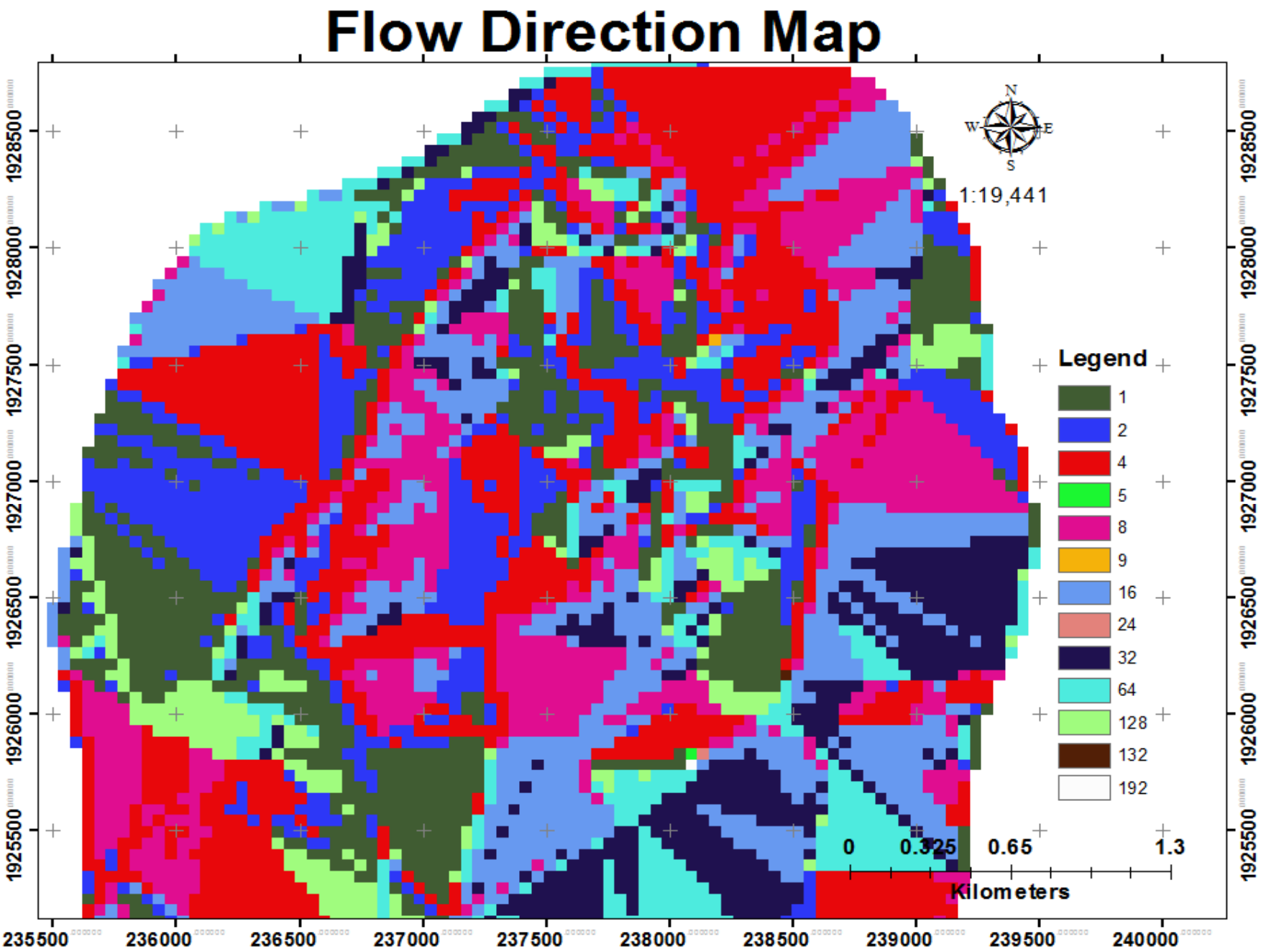


Figure 20. Flow direction map

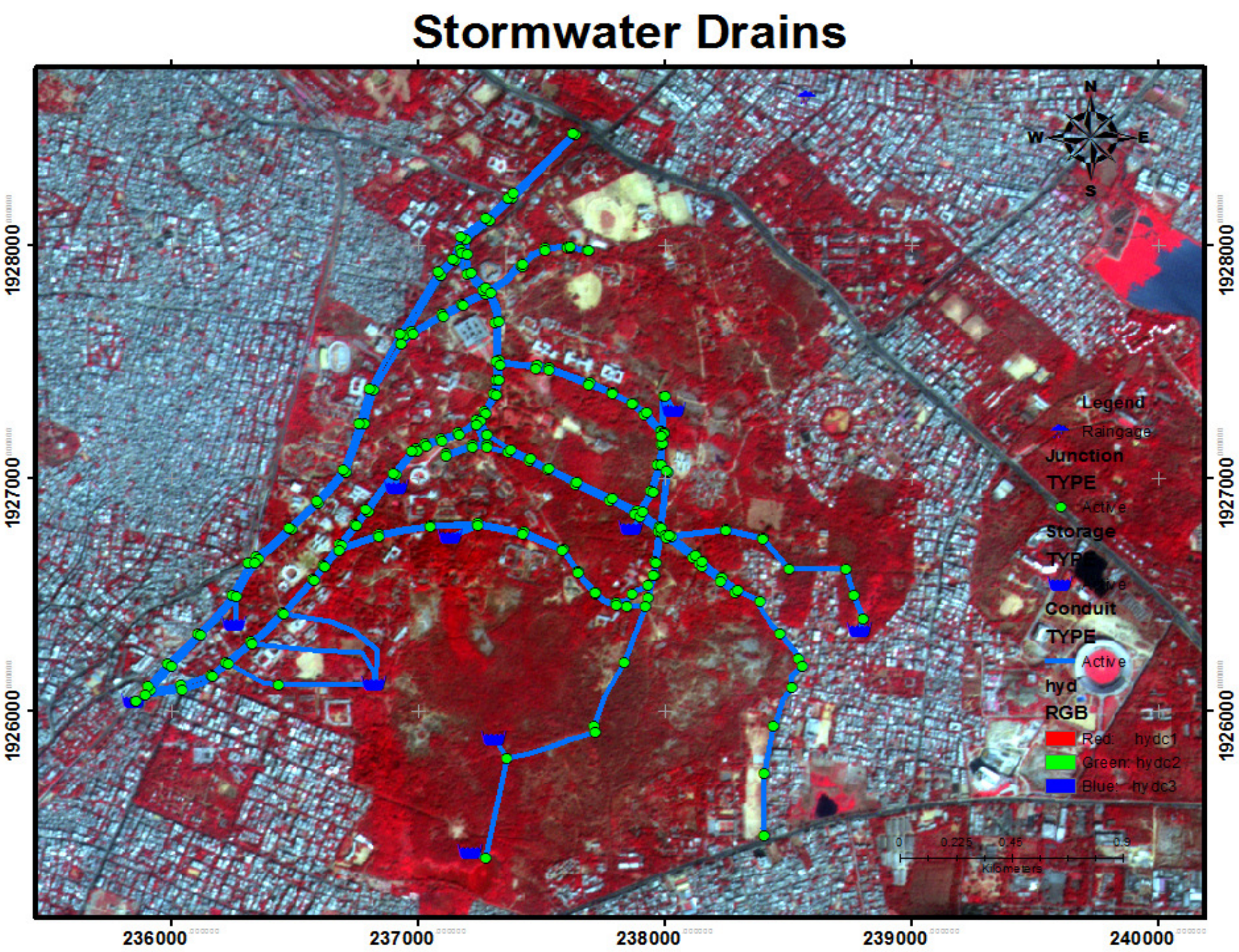


Figure 21. Storm water drains

Junction depth

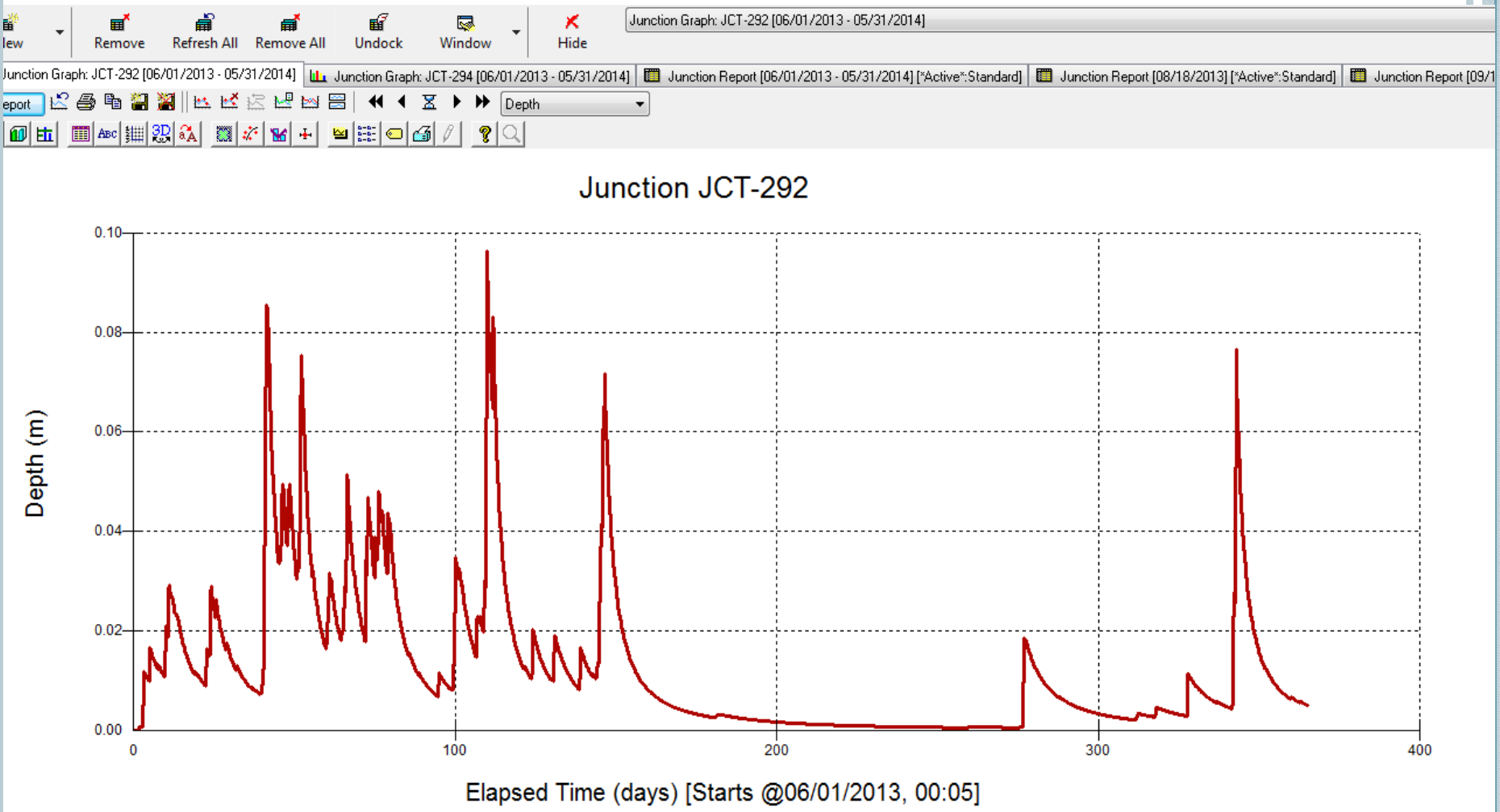


Figure 22. Graph of junction depths versus elapsed time

Junction flow

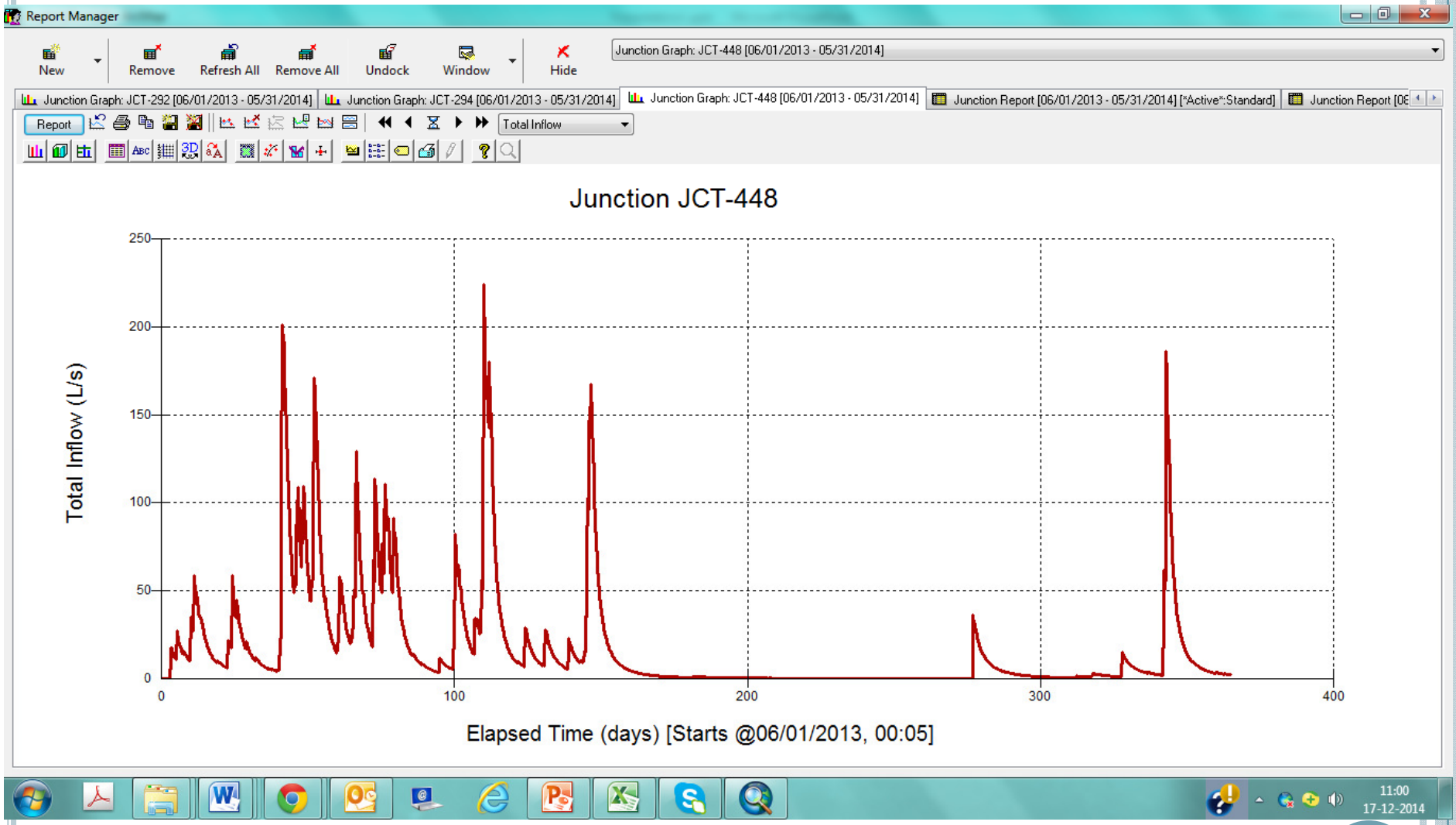


Figure 23. Graph of junction flow versus elapsed time

Rainfall mm/h

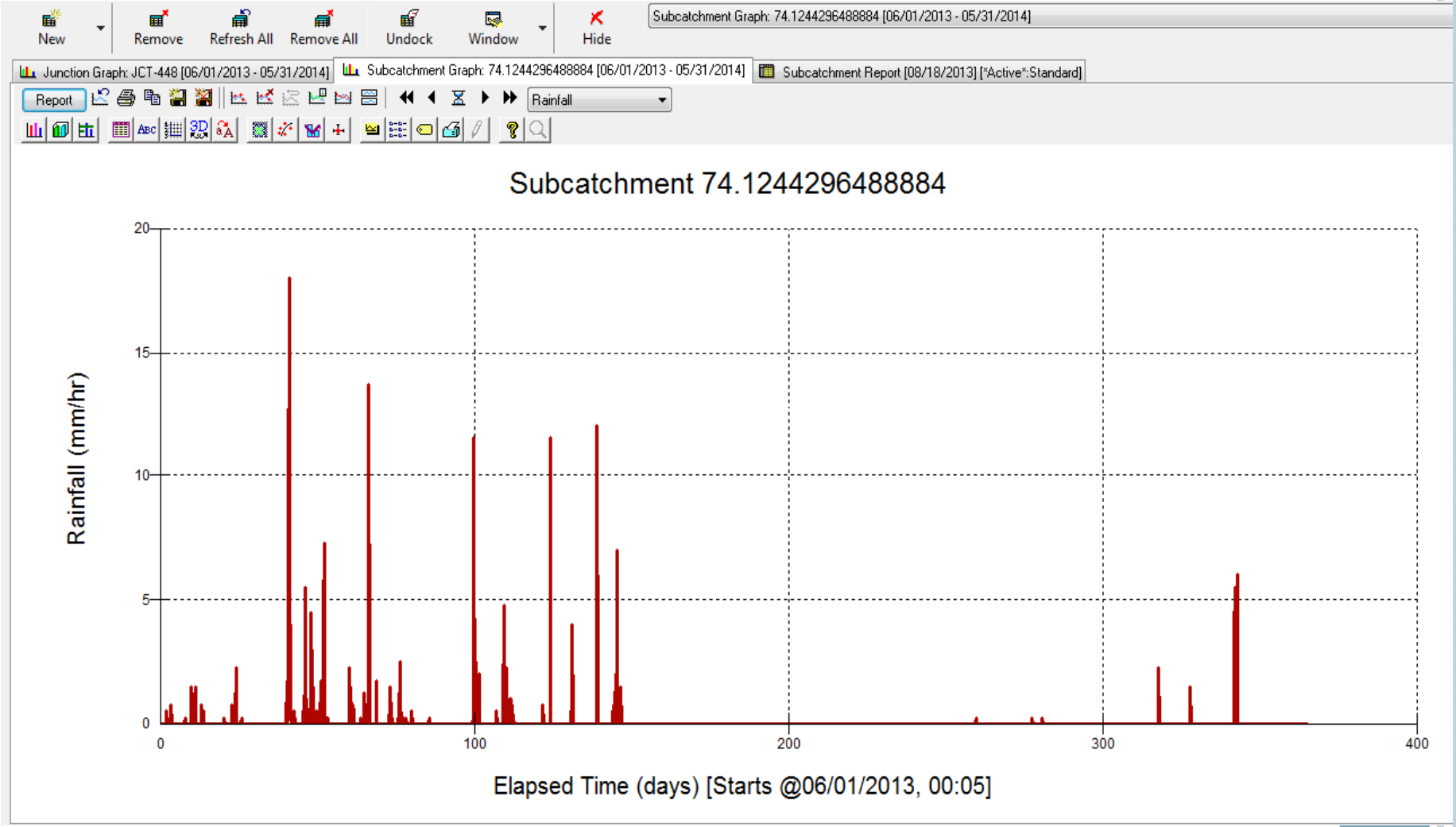


Figure 24. Graph of rainfall versus elapsed time

Sub-catchment Runoff

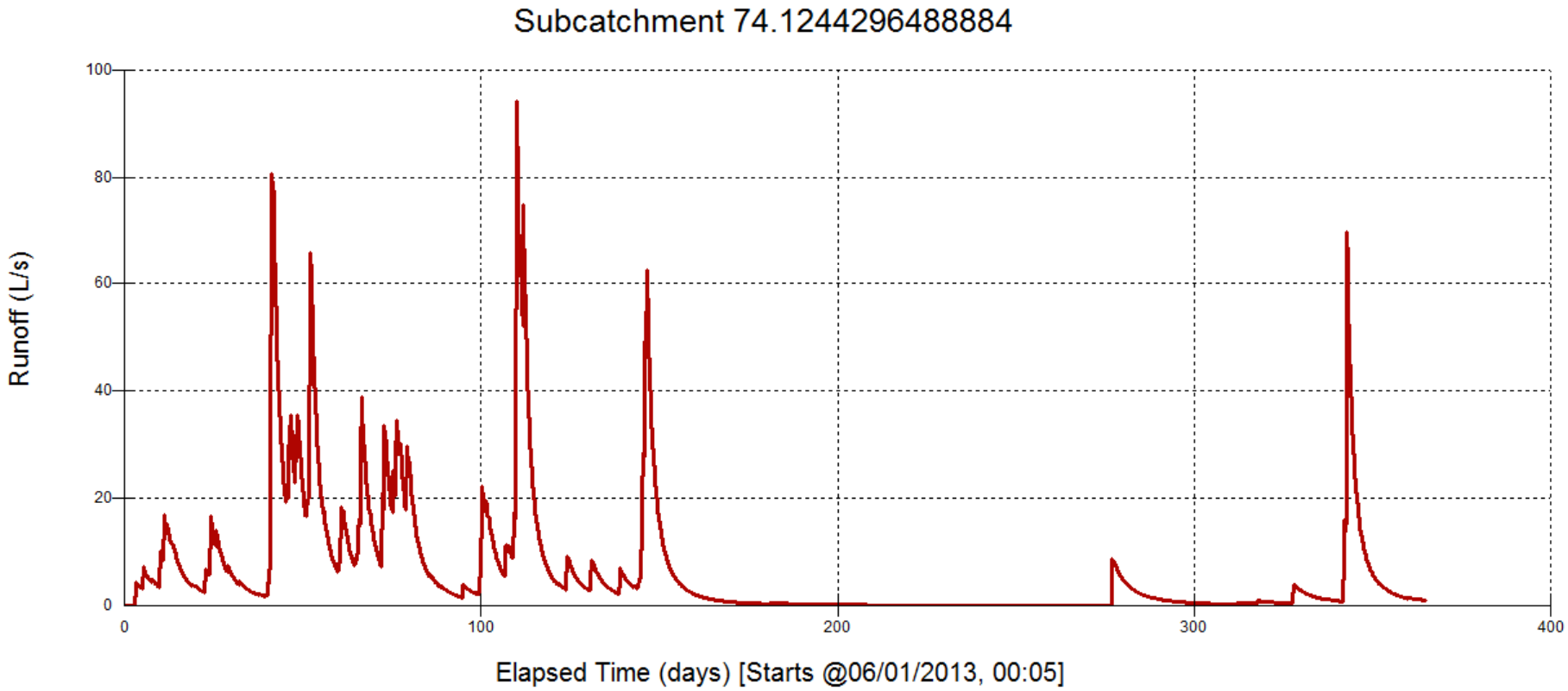


Figure 25. Sub-watershed wise surface flow versus elapsed time

Conduit Flow

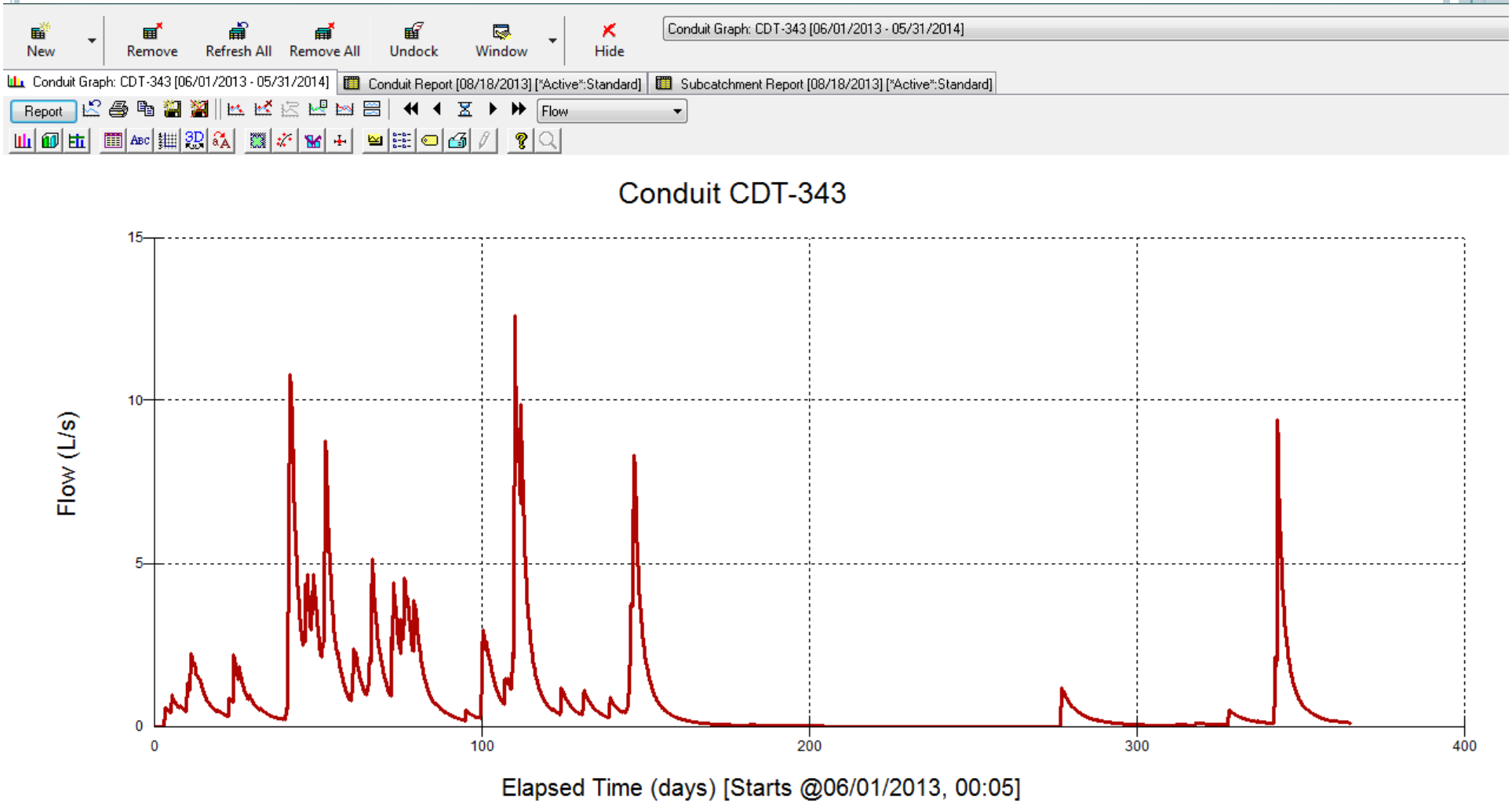


Figure 26. Flow versus elapsed time

Conduit Velocity

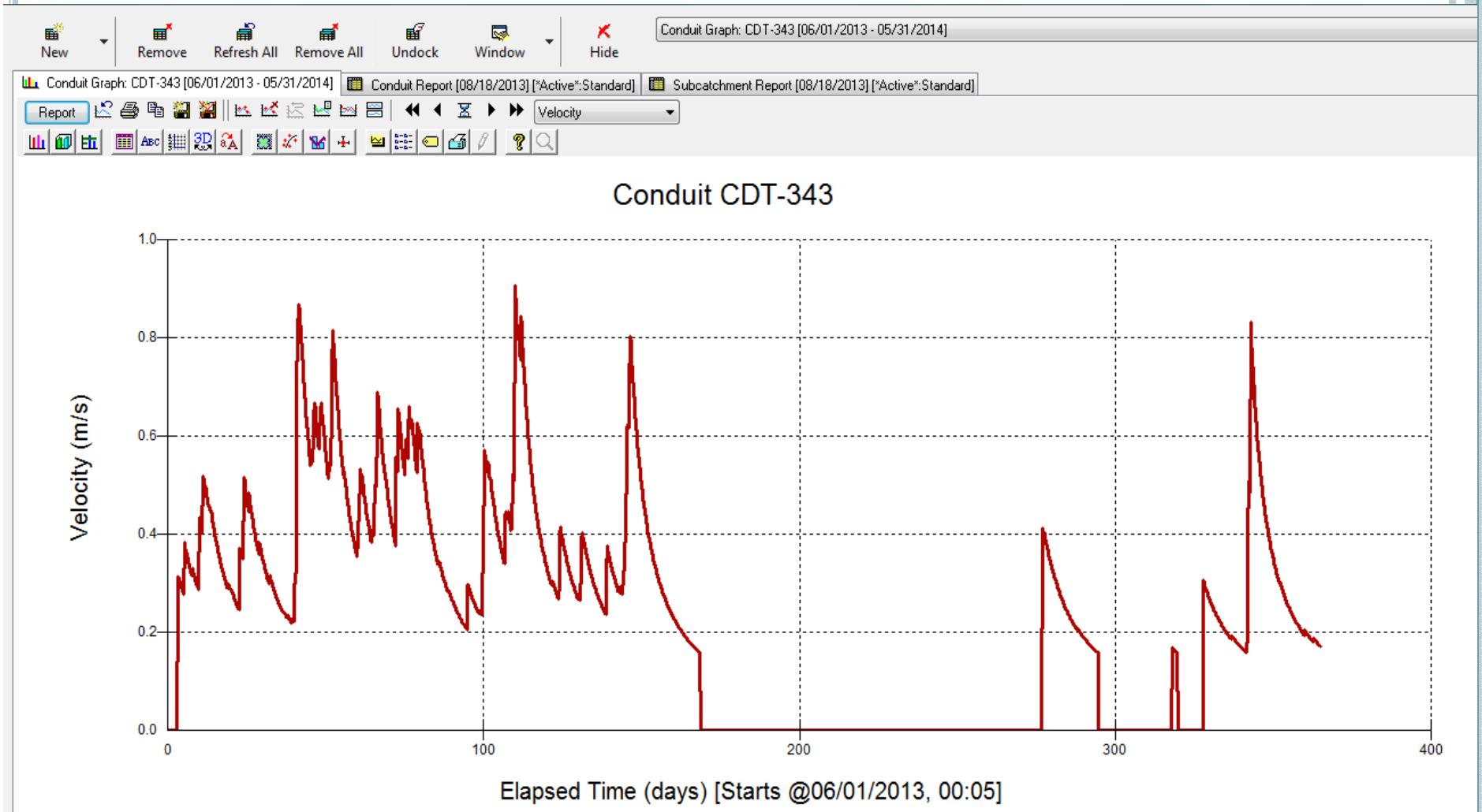


Figure 27. Velocity versus elapsed time

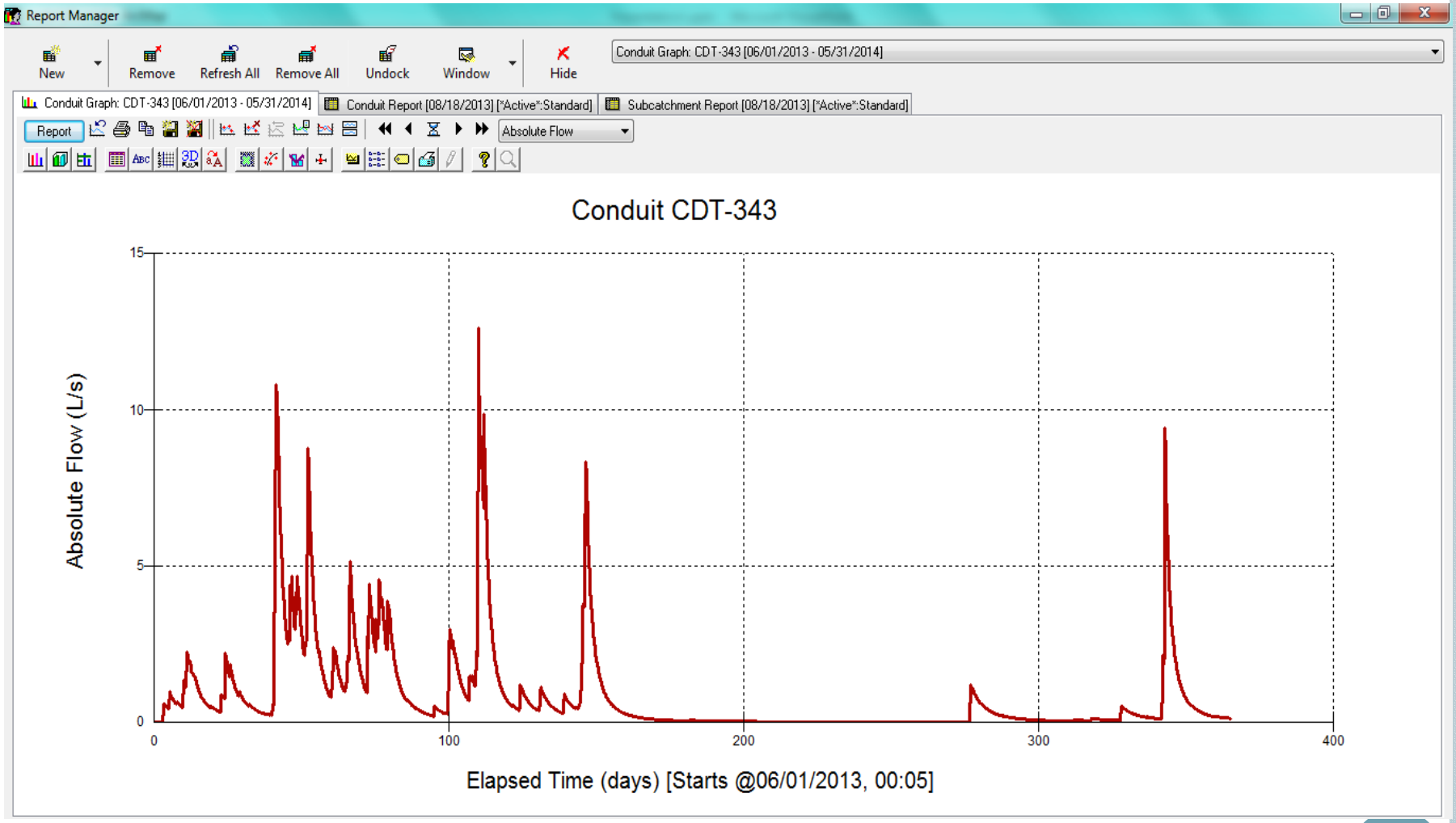


Figure 28. Flow versus elapsed time

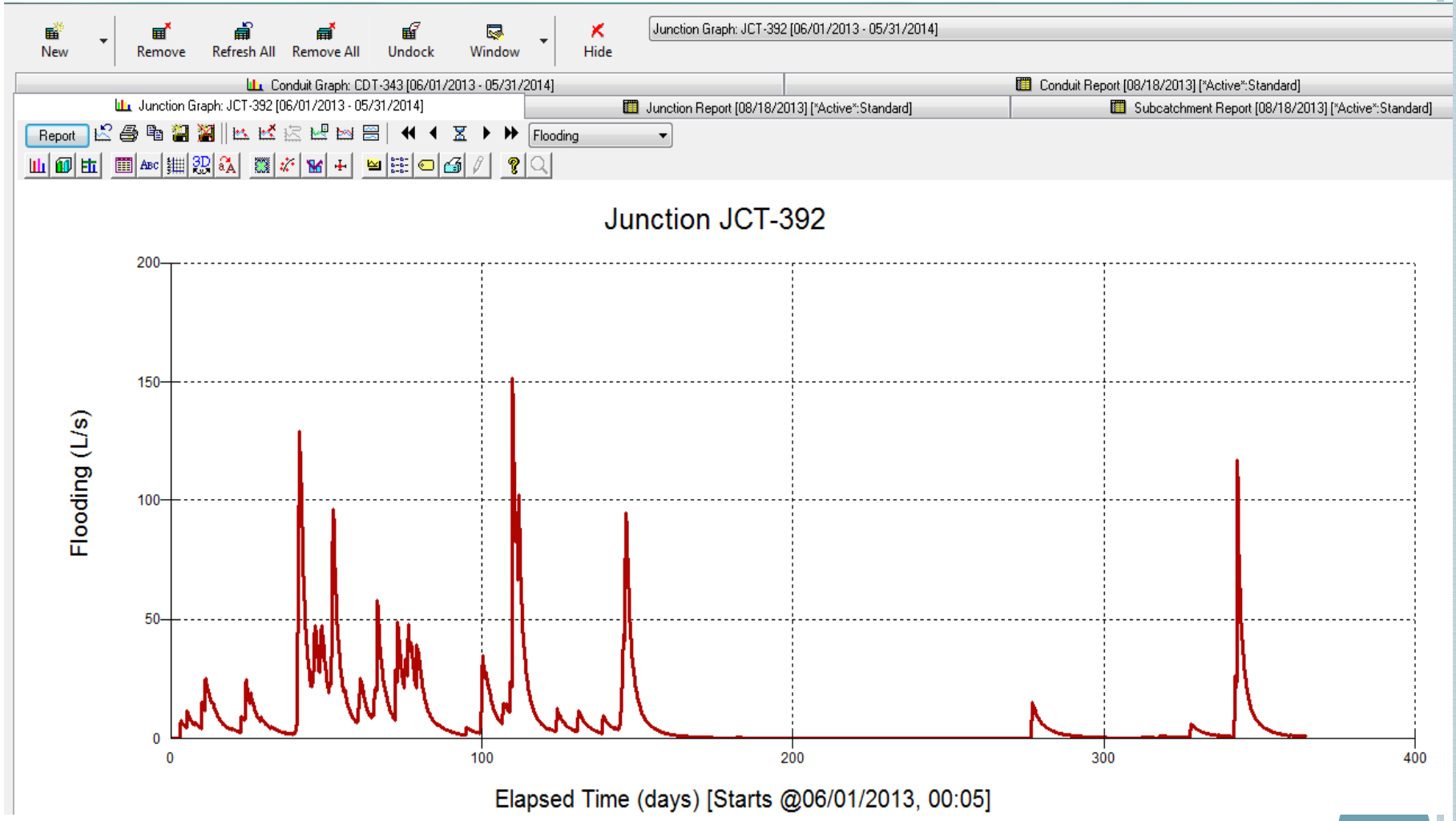
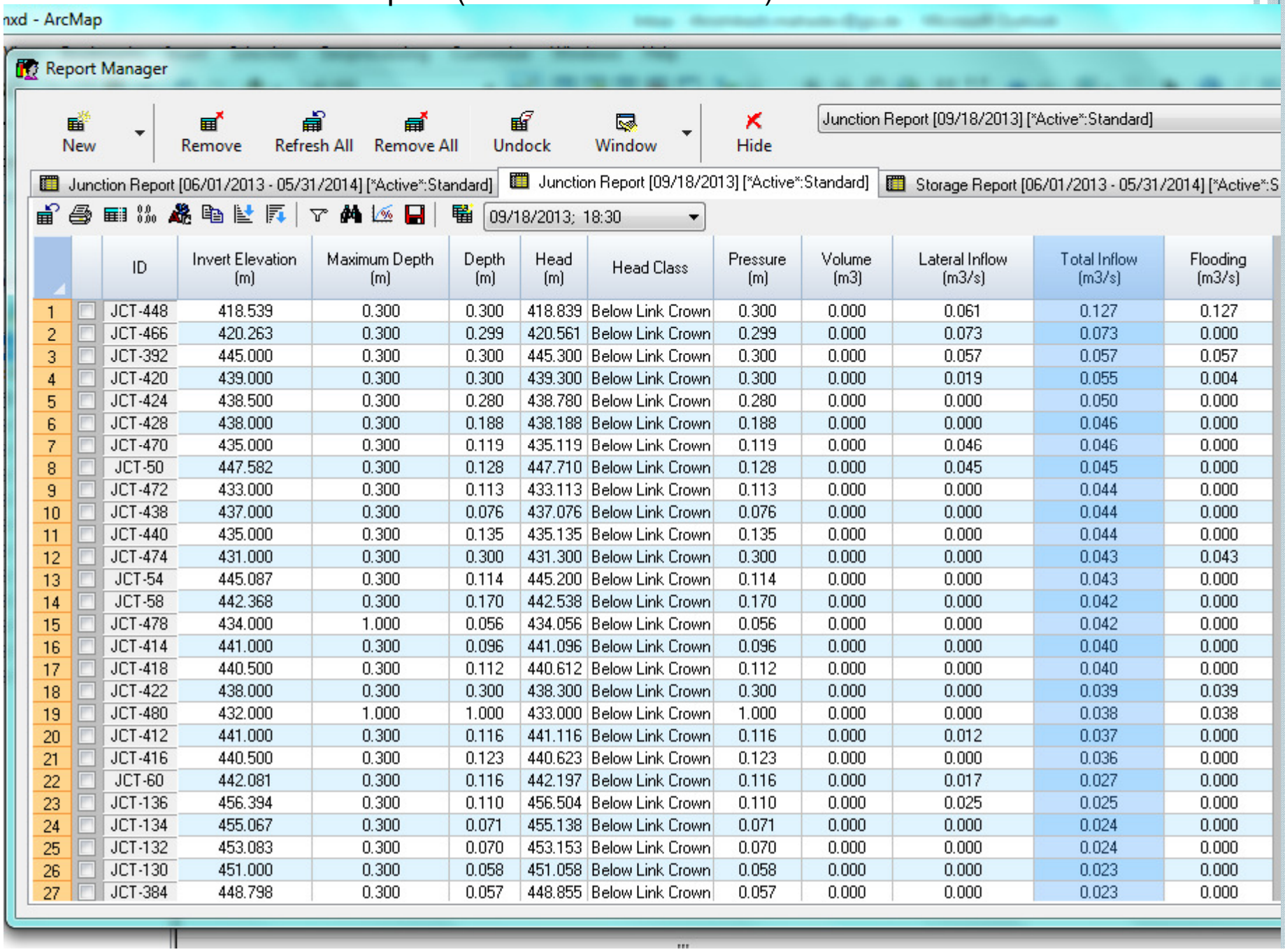


Figure 29. Flooding flow versus elapsed time

Junction Report (18/09/2013 at 1830)



	ID	Invert Elevation (m)	Maximum Depth (m)	Depth (m)	Head (m)	Head Class	Pressure (m)	Volume (m3)	Lateral Inflow (m3/s)	Total Inflow (m3/s)	Flooding (m3/s)
1	JCT-448	418.539	0.300	0.300	418.839	Below Link Crown	0.300	0.000	0.061	0.127	0.127
2	JCT-466	420.263	0.300	0.299	420.561	Below Link Crown	0.299	0.000	0.073	0.073	0.000
3	JCT-392	445.000	0.300	0.300	445.300	Below Link Crown	0.300	0.000	0.057	0.057	0.057
4	JCT-420	439.000	0.300	0.300	439.300	Below Link Crown	0.300	0.000	0.019	0.055	0.004
5	JCT-424	438.500	0.300	0.280	438.780	Below Link Crown	0.280	0.000	0.000	0.050	0.000
6	JCT-428	438.000	0.300	0.188	438.188	Below Link Crown	0.188	0.000	0.000	0.046	0.000
7	JCT-470	435.000	0.300	0.119	435.119	Below Link Crown	0.119	0.000	0.046	0.046	0.000
8	JCT-50	447.582	0.300	0.128	447.710	Below Link Crown	0.128	0.000	0.045	0.045	0.000
9	JCT-472	433.000	0.300	0.113	433.113	Below Link Crown	0.113	0.000	0.000	0.044	0.000
10	JCT-438	437.000	0.300	0.076	437.076	Below Link Crown	0.076	0.000	0.000	0.044	0.000
11	JCT-440	435.000	0.300	0.135	435.135	Below Link Crown	0.135	0.000	0.000	0.044	0.000
12	JCT-474	431.000	0.300	0.300	431.300	Below Link Crown	0.300	0.000	0.000	0.043	0.043
13	JCT-54	445.087	0.300	0.114	445.200	Below Link Crown	0.114	0.000	0.000	0.043	0.000
14	JCT-58	442.368	0.300	0.170	442.538	Below Link Crown	0.170	0.000	0.000	0.042	0.000
15	JCT-478	434.000	1.000	0.056	434.056	Below Link Crown	0.056	0.000	0.000	0.042	0.000
16	JCT-414	441.000	0.300	0.096	441.096	Below Link Crown	0.096	0.000	0.000	0.040	0.000
17	JCT-418	440.500	0.300	0.112	440.612	Below Link Crown	0.112	0.000	0.000	0.040	0.000
18	JCT-422	438.000	0.300	0.300	438.300	Below Link Crown	0.300	0.000	0.000	0.039	0.039
19	JCT-480	432.000	1.000	1.000	433.000	Below Link Crown	1.000	0.000	0.000	0.038	0.038
20	JCT-412	441.000	0.300	0.116	441.116	Below Link Crown	0.116	0.000	0.012	0.037	0.000
21	JCT-416	440.500	0.300	0.123	440.623	Below Link Crown	0.123	0.000	0.000	0.036	0.000
22	JCT-60	442.081	0.300	0.116	442.197	Below Link Crown	0.116	0.000	0.017	0.027	0.000
23	JCT-136	456.394	0.300	0.110	456.504	Below Link Crown	0.110	0.000	0.025	0.025	0.000
24	JCT-134	455.067	0.300	0.071	455.138	Below Link Crown	0.071	0.000	0.000	0.024	0.000
25	JCT-132	453.083	0.300	0.070	453.153	Below Link Crown	0.070	0.000	0.000	0.024	0.000
26	JCT-130	451.000	0.300	0.058	451.058	Below Link Crown	0.058	0.000	0.000	0.023	0.000
27	JCT-384	448.798	0.300	0.057	448.855	Below Link Crown	0.057	0.000	0.000	0.023	0.000

Profile Plot

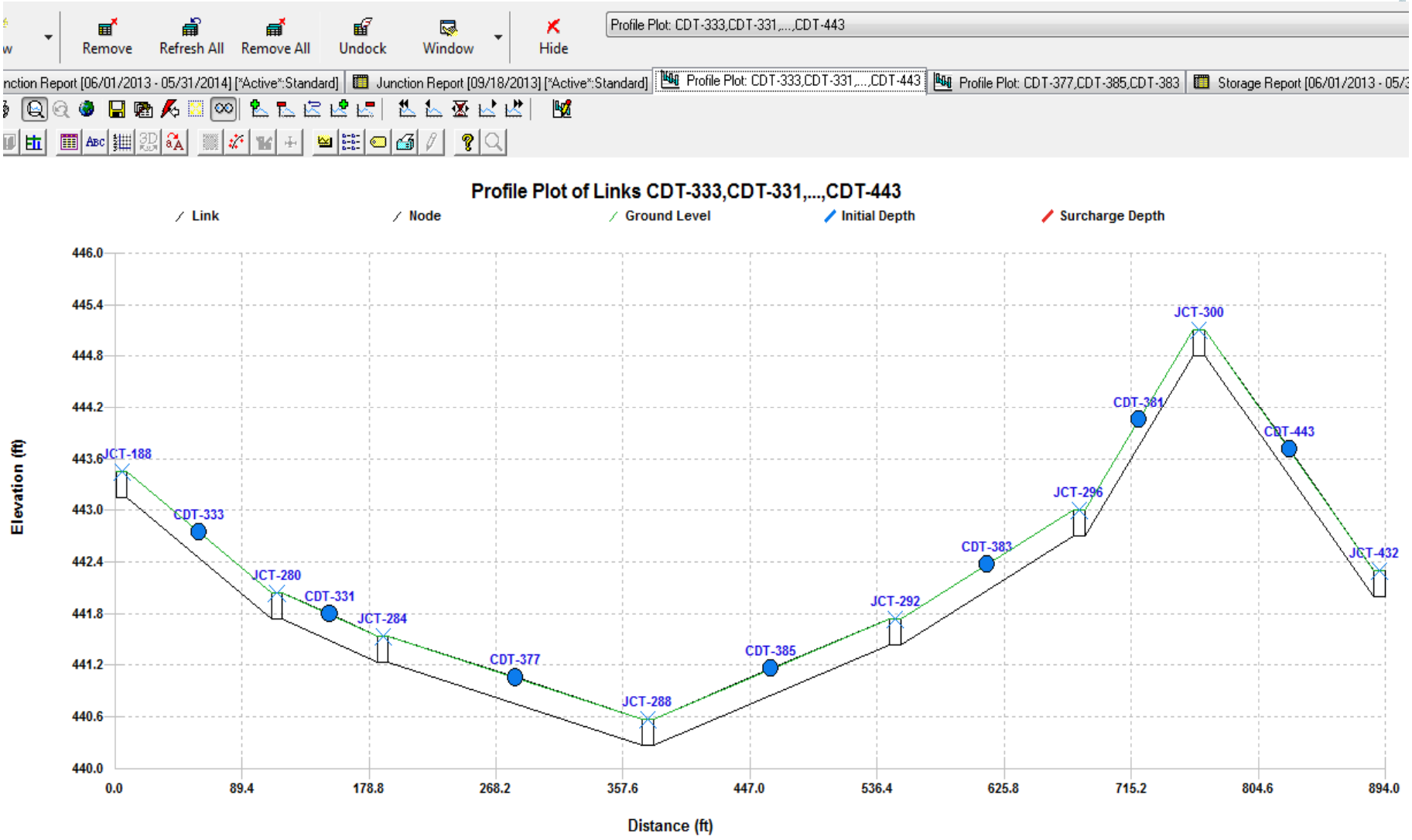


Figure 30. Profile plots of elevation versus distance

Concluding Remarks

- The base map, boundary and the thematic maps have been prepared
- Total Station and DGPS survey have also been done for the study area of Osmania University
- One meter contour map has been created by using total station data and DGPS spot height data.
- Storm water drainage and road network maps created based the one meter contour data.
- Slope map and DEM are created based on one meter contour data.
- Flow Accumulation and Flow Direction maps are also created
- The model is run for flow analysis and profile plots are also generated.

Work to be Done

- Generation of flow hydrograph of the study area.
- Trying to get 1-hour rainfall data for accurate flow analysis.
- Based on the flow analysis data, rainwater harvesting structures and storage ponds have to be created
- Identification and design of storage ponds in the Osmania University study area for recharging the groundwater table.


Thank you