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An Analysis of the Effectiveness of Different Types of Lids in Managing Urban Storm Water

Bhargav P. Majmundar[1] and Girish Parmar[2]
[1]Asso.Prof, Civil Engineering Department, FoE, Gokul Global University, INDIA
[2]AP, Civil Engineering Department, FoE, Gokul Global University, INDIA

[1]Corresponding Author: bhargav.majmundar@gmail.com

ABSTRACT

City increase is one such phenomenon that drives deep changes in land use patterns. From a hydrological perspective, urbanization will increase the impervious surfaces, which end result lower of infiltration and boom of runoff. This consequences is a boom in runoff extent and glide that could reason flooding, watercourse and habitat destruction. In recent state of affairs several Indian cities have witnessed remarkable incidences of flooding due to numerous reasons. Defective urban planning and failure of drainage gadget are taken into consideration as principal motives in the back of flooding and surface inundation in urban regions in growing countries. Most important question stand up that how runoff from new tendencies must be controlled? For that the use of SWMM (Storm Water Management Model) for specific Low Impact Development (LID) as gear for lowering runoff as well as discharge in the storm drainage.

Keywords— Strom Water, LID, Runoff, SWMM, Storm Event

I. INTRODUCTION

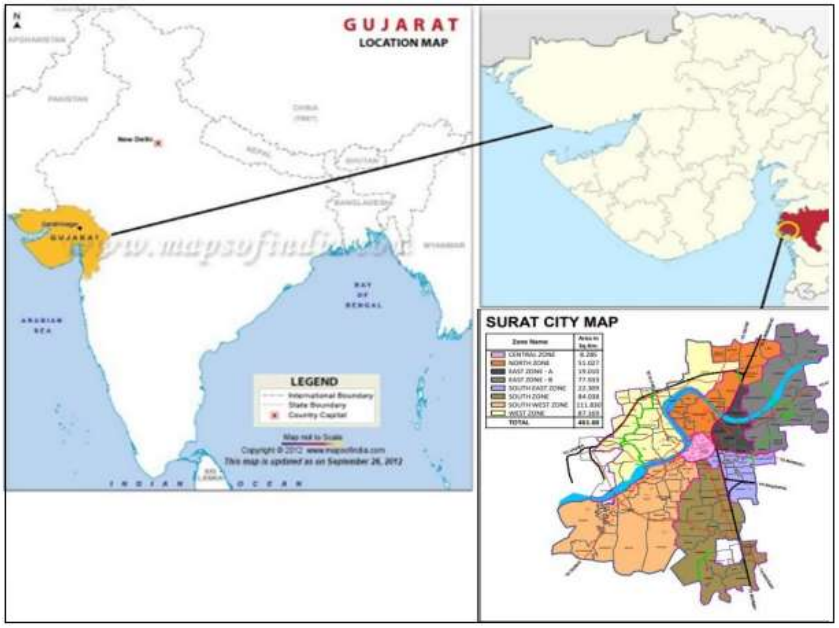
An urban area is definition an area of concentrated human activity, large impervious areas and artificial watercourses. The rainfall on a pervious place may infiltrate into the sub-surface and the rest will become surface runoff. Surface runoff and perhaps infiltration will ultimately circulate a watercourse or a receiving water frame. This isn't the case for an impervious region, wherein almost all the rainfall becomes runoff. The end result is an increase in runoff extent and flow that can bring about flooding, watercourse and habitat destruction. The ability of storm sewers may be overtaxed on occasion and water rises in manholes as well as inundating the city areas. Accordingly, monitoring sewer flow for big cities and prevention or mitigation of damages has constantly been an issue. The costs for drainage works are amongst the biggest items within the budgets of utmost municipalities, and constitute a substantial percent of funding of public works.

Traditional storm water management structures depend upon series and conveyance systems to put off water competently from advanced areas and to defend existence, assets, and health. The systems are engineered and designed consistent with estimates of post-development storm water flows and volumes from pervious and impervious areas.

Low effect improvement storm water control systems can lessen improvement charges thru the discount or elimination of traditional Storm water conveyance and series systems. LID structures can reduce the want for paving, cut down and gutter, piping, inlet systems, and Storm water ponds via treating water at its supply as in its place to at the end of the pipe.

To decrease the city flooding one is the choice to construct distinctive forms of LIDs which is surroundings pleasant type creation and also generate pleasant aesthetic view within the vicinity. For that take Adajan area of Surat metropolis, Gujarat, India for the examine vicinity and output acquire from using SWMM 5.0.

Figure 1: Location Map of Surat city



Source: Website of mapsofindia.com, suratmunicipal.gov.in

Due to its place on banks of the River Tapi near the estuary of the Arabian Sea, the land drainage in Surat metropolis is notably terrible and within the beyond, during the monsoon months, many areas of Surat city suffered brief flooding and blockage of storm water.

Have a look at vicinity incorporates of west region of the metropolis due to the fact it's flood susceptible zone throughout monsoon duration. There are 15 Storm water outlets in this region that discharge the Storm water of total zone in Tapi River. Examine region of west zone shown in fig. 2.

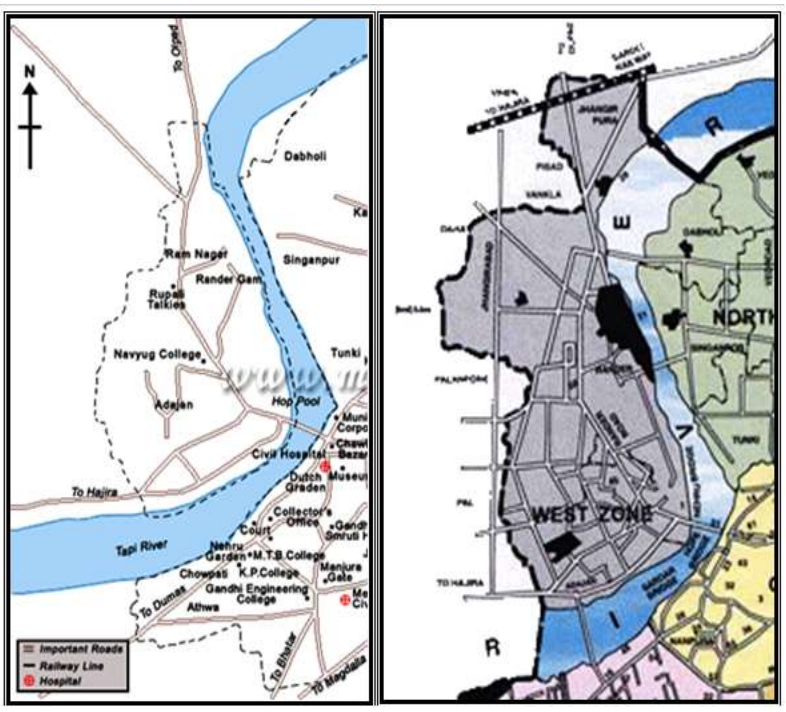


Figure 2: Study area map of West zone of Surat city

Principal consciousness for the look at become on outlet 9 that is located on Adajan region of West region, there's a heavy discharge passes on outlet 9. Essential targets have been to develop the Storm water model and to reduce flooding via the use of special LID method with the help of SWMM software.

III. LOW IMPACT DEVELOPMENT (LID)

Low effect development (LID) is a term which describes a land planning and engineering layout technique to control storm water runoff. LID emphasizes conservation and use of onsite natural features to guard water nice. This method implements engineered small scale hydrologic controls to duplicate the pre-development hydrologic regime of watersheds thru infiltrating, filtering, storing, evaporating, and detaining runoff near its source.

Specific styles of LIDs are used to manage Storm water runoff like: Bio retention cell, Porous pavement, Rain barrels, green roofs, Bio swales, Infiltration trench etc.

LID has multiple advantages, such as defensive animal habitats, enhancing control of runoff and flooding, and lowering impervious surfaces. LID also improves groundwater superiority and increases its amount, which increases aesthetics, consequently elevating community value.

SWMM 5.0:

EPA's Storm Water management model (SWMM) turned into first advanced in 1971, and has considering that gone through several foremost enhancements. It remains widely used all through the arena for planning, analysis and layout related to Storm water runoff, mixed sewers, sanitary sewers, and different drainage systems in urban regions, with many packages in non-urban areas as well.

EPA SWMM five is specific version for the hydrologic performance of particular varieties of LID controls, which include porous pavement, bio-retention areas (e.g., rain gardens, green roofs, and street planters), rain barrels, infiltration trenches, and vegetative swales. The up to date model permits engineers and planners to correctly constitute any mixture of LID controls within a have a look at place to determine their effectiveness in managing Storm water and mixed sewer overflows.

SWMM 5.0 provides an incorporated environment for enhancing examine place enter facts, walking hydrologic, hydraulic and water nice simulations, and viewing the results in a diffusion of codecs. Those consist of colour-coded drainage place and conveyance system maps, time collection graphs and tables, profile plots and statistical frequency analyses.

IV. STATISTICS REQUIREMENT

Many information required for examine like Precipitation, Evaporation, Land use land cover mapping, Plot boundaries, Slope, Soil information, Infiltration data, Aquifers records etc. Records turned into accumulated from one of a diverse agencies for the have a look at purpose.

V. METHODOLOGY

EPA SWMM 5.0 is a dynamic rainfall-runoff simulation version used for unmarried event or long-term (continuous) simulation of runoff amount and first-rate from primarily city areas. The model is split into 4 conceptual compartments atmosphere, land floor, groundwater, and shipping. Precipitation is generated in the ecosystem compartment and acquired with the aid of the land surface compartment. It's far then either infiltrated into the groundwater compartment, or carried into the transport compartment, which incorporates pipes, channels, and other conveyance factors.

For the study undertake method that's proven in fig.3. Generate .imp file of the have a look at place for the software. Input required records within the software program and begin simulation for unique rainfall intensities and view the result at outlet 9.

Figure 3: Methodology of the Study

After reading the simulation for unique Storm event provide suitable LID in sub catchment region of outlet 9. Provide bio retention cell as LID1 inside the sub catchment vicinity having below 80% imperviousness. Provide bio retention in 14% location of whole sub catchment place. For bio retention enter important facts like storage depth, plant volume fraction, surface roughness, surface slope, field capacity, conductivity, suction head and many others feed in SWMM then run simulation and analyze the end result.

On this look at provide Infiltration Trench in region of Recharging properly. So, calculate infiltration fee of recharging well of 30 cm dia. and used of equal to find out the area of infiltration trench.

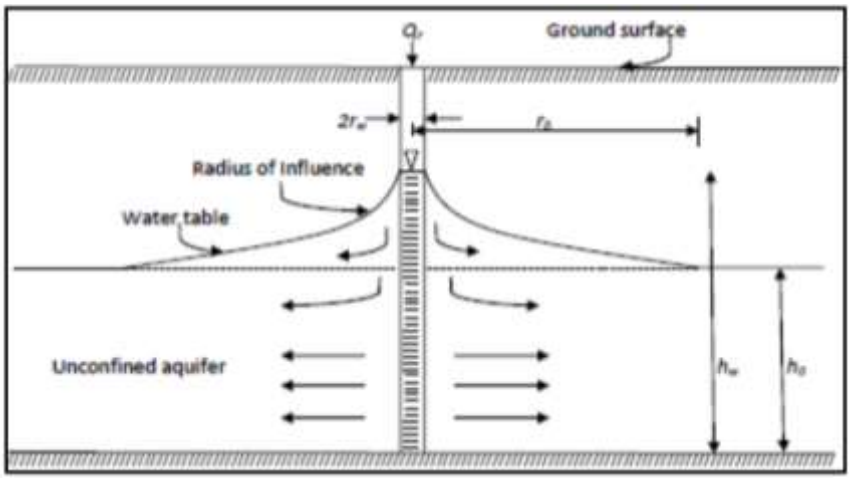


Figure 4: Radial flow from recharge wells penetrating in unconfined aquifers

As per the fig. 4 recharge from Infiltration Well penetrating in unconfined aquifer, the equation may be written as

$$Q = \frac{\pi k(hw^2 - ho^2)}{ln(ro|rw)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(1) Where Q = rate of water entering into recharge well

h_w = depth of water in well above impervious stratum, 28mt.

h_o = depth of water table in unconfined aquifer, 20mt.

r_o= radius of influence,150mt.

r_w = radius of the well, 30cm.

Q = 0.0148 m^3/sec

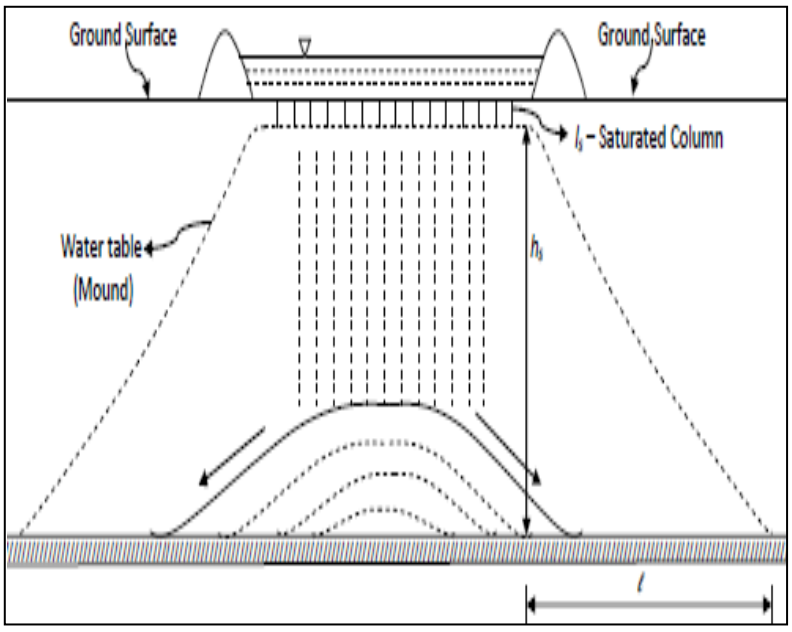


Figure 5: Mechanics of spreading water from infiltration Trench

Rate of Recharge from Infiltration Trench

$$Q = KiA \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where,
K = conductivity mm/hr
i = hydraulic gradient
A = bottom area of infiltration trench
As per fig. 5
$f = ki = k(hs+ls)/ls$
$K = 5.2 \times 10^{-4}$ mm/hr, $i = (20.5+7.5)/ 7.5$

Compare equation (1) and (2)

$KiA = 0.0148$ m^3/sec

A = 7.63 m^2

Rate of discharge for one infiltration trench the region 7.63m2 was equal for 30cm diameter recharging well. Pick out particular sub catchment region and introduced LID2 as a infiltration trench in SWMM added 1 LID2 for each catchment and a couple of LID2 for those catchment areas whose area above 1000m2, brought area of each LID2 as 7.63m2 (calculated), pinnacle width of overland drift taken as 1mt, introduced % initial saturation as zero, and add important records like garage ht., conductivity, clogging component and many others. All information for required for infiltration trench feed in SWMM. Run the simulation with provision of Bio retention cell + Infiltration Trench and also simulation carried with the provision of simplest infiltration trench and examine with without LID for distinct Storm activities. Table 1 indicates the instance for information of LID supplied in SWMM.

Sr. No.	Jn.ID	Sub Catchment ID	Area mt.^{2}	Area of LID (14% of Area) mt.^{2}	Nos. of LID unit	Area of 1 LID (mt^2)	% of impervious	Recharging Well (Nos.)	Type of LID
1	J22	SC02771	1439.62	201.55	4	50.39	14.36	2	Bio ret.Cell
2		SC02767	329.91	46.19	6	7.70	0.00	1	Bio ret.Cell
3		R00596	569.85	79.78			68.92	1	
4		R00594	819.78	114.77			68.92	1	
5		R00510	669.82	93.78			68.92	1	
6		SC02762	1729.54	242.14			99.99	2	
7	J28	SC02778	2139.44	299.52			99.99	2	
8		R00591	1069.72	149.76			68.92	1	
9		SC02773	7228.09	1011.93			97.22	2	
10		R00570	1119.70	156.76			68.92	1	
11		SC02785	659.83	92.38			94.30	1	
12		R00564	719.81	100.77			68.92	1	
13		SC02810	8617.72	1206.48			97.39	2	
14		R00568	1079.71	151.16			68.92	1	
15		SC02788	469.88	65.78			99.88	1	

Table: 1 Type of LID provided in outlet 9

Total 515 sub catchments wherein LIDs are provided. The total catchment area of outlet nine is thirteen, 28,914.Seventy five mt2, in which 1, 86,048.09 mt2 place supplied with the aid of both LIDs bio retention cellular and infiltration trench (i.e.14% of the whole catchment area of outlet 9). The region provided by bio retention cell is 35,557.Sixty one mt2 (i.e.2.67% of the total catchment of outlet 9).

VI. RESULT AND ANALYSIS

An evaluation may be taken for four separate Storm occasion that is 3 day Storm throughout 12th Aug. to 16th Aug. 2011, 2yrs. Storm occasion, 5 yrs. Storm frequency and 50yrs. Storm frequency. Extraordinary storm frequencies are shown in fig. 6.

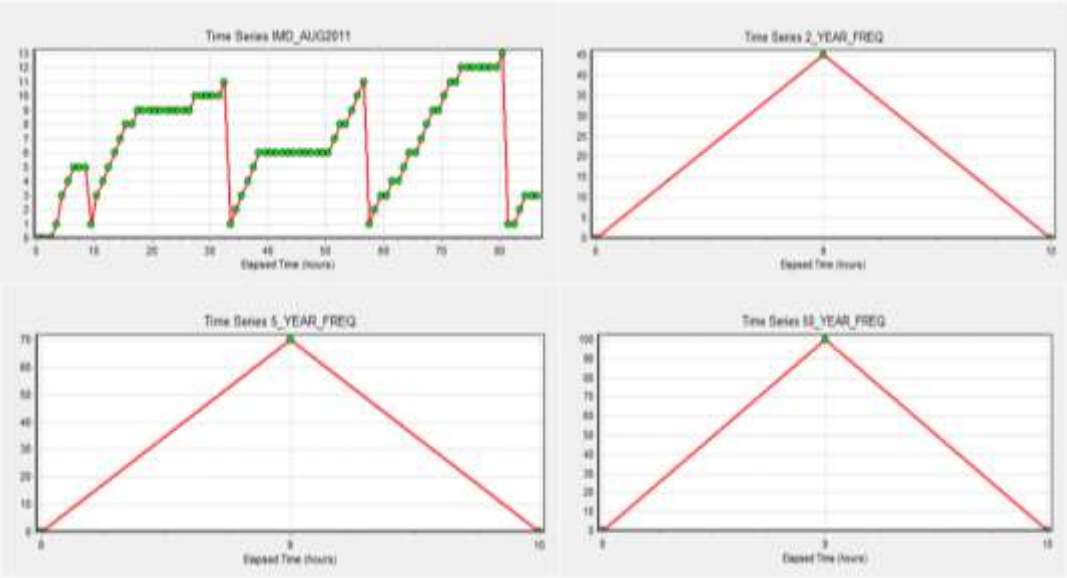


Figure 6: Different strom frequency

Principal focus on result whilst the usage of of bio retention cellular and infiltration trench as an LID. In following methods the result turned into generated for every Storm event.

1. Without LID.
2. With using bio retention cell.
3. With the usage of infiltration trench.
4. With the use of both bio retention cell and infiltration trench.

Main focus on result while using of bio retention cell and infiltration trench as an LID.

Above in step with the above referred to generate the result at outlet nine and have a look at the result for discount in influx at outlet 9 for dissimilar storm event and examine every other. Additionally choose up node J84 to Out 9 of catchment location of outlet 9 which heavily flooded during storm occasion and strive to research the modifications in flooding in Storm drain for without LID and with the usage of LID.

SWMM offers the final file which suggests as a tabular form. Table 2 represents the outfall loading summary for Storm event Aug. 2011.

a) Without using LID

Outfall Node	Flow Freq. Percent	Avg. Flow (CMS)	Max. Flow (CMS)	Total Volume 10^6 lit
OUT 9	99.71	3.036	5.056	780.549

b) with Bio retention

Outfall Node	Flow Freq. Percent	Avg. Flow (CMS)	Max. Flow (CMS)	Total Volume 10^6 lit
OUT 9	99.71	2.986	5.067	764.364

c) With Infiltration trench

Outfall Node	Flow Freq. Percent	Avg. Flow (CMS)	Max. Flow (CMS)	Total Volume 10^6 lit
OUT 9	99.69	2.878	4.870	732.870

d) With Bio ret. & Infil. Trench

Outfall Node	Flow Freq. Percent	Avg. Flow (CMS)	Max. Flow (CMS)	Total Volume 10^6 lit
OUT 9	99.69	2.828	4.882	716.917

Table 2: Outfall Loading Summary for Storm event Aug. 2011 for with & without LID

SWMM also gives node wise result in graphically shows in fig.7 for with and without using LID for storm event Aug. 2011.

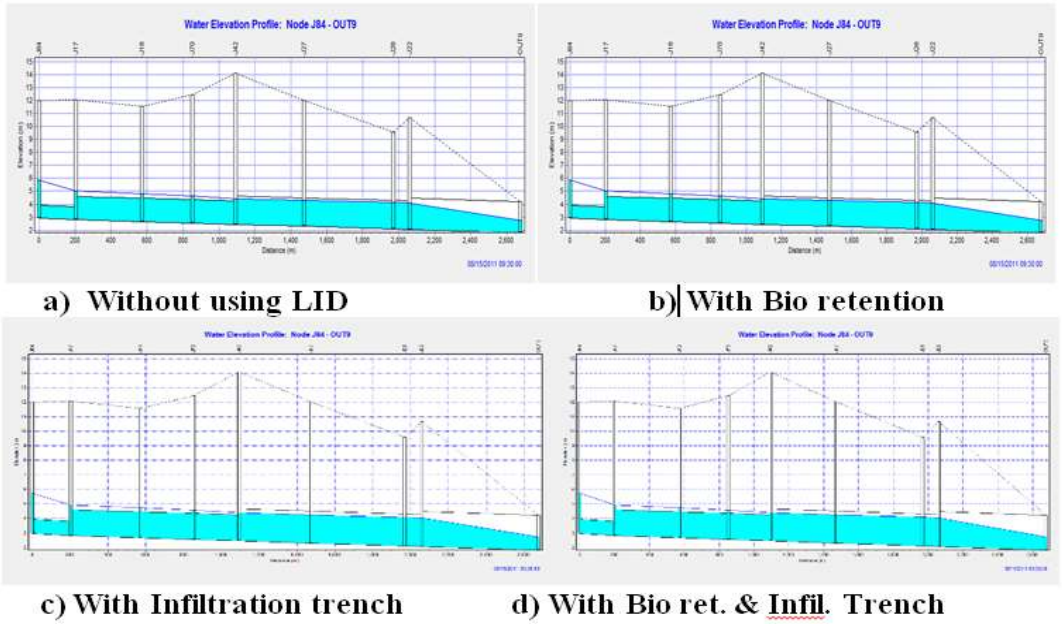


Figure 7: Water Elevation Profile for Outlet 9 for Storm event Aug. 2011 for with & without using LID

Go with the flow intensity in conduit in flooded situation shown in above fig.7 of water elevation profile. In that blue shade suggests water depth in conduit in addition to in nodes and dotted line suggests hydraulic gradient line.

In these way simulation has been carried for different Storm event for the usage of distinctive LIDs and without LIDs and have a look at the report. Fig. 8 suggests the assessment of various Storm occasions with total inflows for Outlet 9 for with and without the usage of different LIDs.

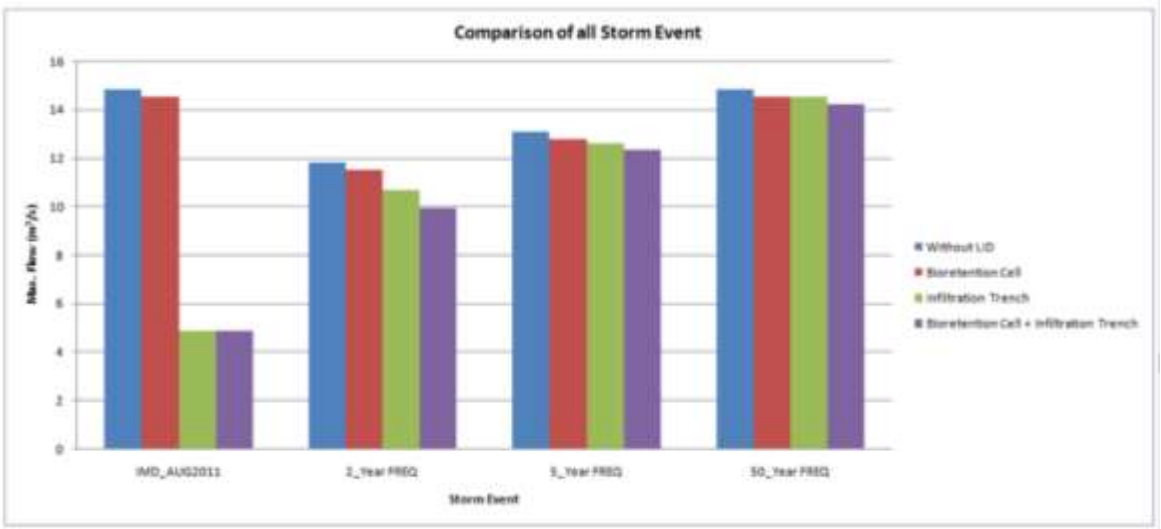


Figure 8: Graph of Rainfall Event Vs Total Inflow for Outlet 9

Evaluation suggests that Infiltration trench isn't always an awful lot a hit LID for reduction of inflow volume in outlet 9 for heavy rainfall inside short period because rainfall produces heavy runoff with high pace reduces the fee of infiltration. In that case bio retention is extra successful due big place available and obstruction of grass for reduction of pace of runoff.

LID Type	Aug-2011	2 yr. frequency	5 yr. frequency	50 yr. frequency
	Outlet 9	Outlet 9	Outlet 9	Outlet 9
Bio retention Cell	2.07	3.6	3.79	3.41
Infiltration Trench	6.11	10.3	4.49	1.2
Bio retention Cell & Infiltration Trench	8.15	14.48	8.46	5.01

Table: 3 Total Inflow Reductions in Percentage by Different Type of LID for Different Storm Event

As in step with above Table 3 comparison shows that after there is an boom in Storm with quick duration the performance of LID for discount of flood also decreases because of heavy depth of rainfall taking place with excessive velocity.

VII. CONCLUSION

In this take a look at exceptional LID strategies and their effect on reduction of Storm water runoff has been studied. Inside the observe area (west region, Surat, India) with the assist of SWMM infiltration trench has been designed for artificial recharge which reduces the lack of water by using evaporation. These help to make the harvested water reach the groundwater desk swiftly. It was also noted that the fluctuation inside the charge of recharge is a characteristic of natural phenomena such as the quantity of rainfall, rate of infiltration, surface drainage, and also artificial factors like the presence of wells prepared for recharge.

The end result virtually indicates that with the single LID like bio retention or infiltration trench there was reduction in the volume of runoff up to 6%, while both LIDs used simultaneously the quantity reduction of runoff boom up to 8% in August-2011 rainfall occasion.

One exciting statement has been obtained that infiltration trench (Recharging well) has extra successful LID for discount of influx for Aug 2011 & 2 years rainfall event compare to the bio retention cell. The result additionally indicates that after there is an unexpected boom in precipitation within brief duration the LIDs cannot work to its complete swing due to the heavy rain fall produce excessive speed of runoff decreases percentage discount of volume of influx in the outlet.

One greater point achieve from result that the proportion fee of quantity discount in runoff with the usage of infiltration trench is higher than the usage of bio retention cell for common rainfall event. So, it's far to be count on that during subject, recharging nicely get identical result with a view to attain for infiltration trench and it's far greater a hit for runoff extent reduction and higher infiltration price.

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