WATER-LOGGING AND GROUND WATER RECHARGE

Ziren Ambaliya[1], Pratik Gajera[2], Shivam Patel[3], Jainam Sanghavi[4], Ruchita Parekh[5]

[1]Ziren Ambaliya, Student, Civil engineering department, Sardar patel College of Engineering, Bakrol, Gujarat, India
[2]Pratik Gajera, Student, Civil engineering department, Sardar patel College of Engineering, Bakrol, Gujarat, India
[3]Shivam Patel, Student, Civil engineering department, Sardar patel College of Engineering, Bakrol, Gujarat, India
[4]Jainam Sanghavi, Student, Civil engineering department, Sardar patel College of Engineering, Bakrol, Gujarat, India
[5]Ruchita Parekh, Assistant Professor, Civil engineering department, Sardar patel College of Engineering, Bakrol, Gujarat, India

---***---

Abstract - *Urban hydrogeology and its complexity are important to understand since half of the world's population is living in urban areas which put pressure on the environment and its water resources. Because groundwater can affect the ground stability, interact with urban constructions and is the primary water resource in many countries. This water logging becomes a burden for the inhabitants of Surat City (East Zone-1) and creating adverse social, physical, economic and environmental impacts. The storm water becomes polluted as it mixes with solid waste, clinical waste, silt, contaminants, domestic water and other human activities that increase the water borne diseases. The stagnant storm water leads to the creation of breeding sites for diseases vectors that becomes a hazard to health as well as being unsightly and foul smelling. As solution of this problem we proposed the location of recharge well and design concept. The study is designed as a feasibility showing foremost the options and potentials to create and apply such analysis and to evaluate the availability usability of existing data available for this. The conceptual model is based on information gathered from Government authorities, literature studies, private agency (Land-mark). The study is based on amount of rainfall, land cover use, Runoff coefficient, Permeability of soil Natural slope of ground (Contour map). This study was used to calculate amount of surface run-off, direction of rain water, recharge well location and design of recharge well.*

Key Words:* *Water logging, Ground water, Water recharge, Urban hydrology, Population

1. INTRODUCTION

The interaction between urban development and groundwater is important to understand since urban environments can change groundwater recharge, groundwater flow dynamics, and local water balance and contribute to contamination by metals and industrial compounds from industries.

Surat City is experiencing environmental degradation due to rapid urbanization, increase in population. The process of urbanization is linked with the economic development, which makes an increasingly higher contribution of the national economy. However, when the growth of urban population takes place at an exceptionally rapid rate, most cities and towns are unable to cope up with changing situations due to their internal resources constraints and management limitations. On one hand, pressures for modernization give rise to continuous development activities, which deplete natural resources. On the other hand, deficiency in the coverage and delivery of urban infrastructures are seriously affecting the general environment and reducing urban efficiency with adverse implication to the national economy.

It has already been mentioned earlier that flooding in Surat (East Zone) area can be classified into two types. One is river flooding that results from high water levels of peripheral river (Tapi River) systems and another is rainfall induced flooding that is caused by high intensity storm rainfall runoff in the city area.

1.1 OBJECTIVE

The main objectives of project are

- The primary focus of the study would be on the factors influencing the waterlogging problem in SURAT during monsoon.
- Develop the understanding for the effects on human life, economy and the environmental quality of the city dur to water logging would be studied.
- At the end of the study, there are some recommendations from the technical view by proposing a design of ground recharge well.
- To provide some recommendation as an input for the concerned authorities for better management of storm water.

1.2 METHODOLOGY

The study would be focus on the rainfall induced flooding treated as water logging due to storm water in this study. The methodological approaches of the study are as follows:

Define problem

↓

Study Area (Est Zone-1)

↓

Data Collection

↓

Analysis Of data

↓

Output Of the data

↓

Proposed Design of Recharge Well

2. DATA COLLECTION

Surat is a city located on the western part of India in the state of Gujarat. It is one of the most dynamic cities of India with one of the fastest growth rates due to immigration from various parts of Gujarat and other states of India. Surat is one of the cleanest cities of India and is also known by several other names like "THE SILK CITY", "THE DIAMOND CITY", "THE GREEN CITY", etc.

Table -1: General information of Surat city

Country	India
State	Gujarat
District	Surat
Latitude	21.112°N
Longitude	72.814°E
Height above sea level	59.22 m
Coordinates	21°10′12.864″N 72°49′51.819″E
Area :- Metropolis Metro	 326.515 km²(126.068 sq. mi) 326.600 km²(126.101 sq. mi)
Population (2011)	44,66,826
Languages	Gujarati, Hindi, Marathi, English

2.1 Population Data

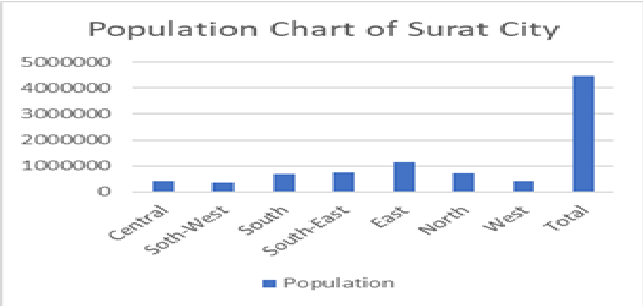

Chart -1: Population of Surat city year

2.2 Rainfall Data

The normal rain fall of the Surat can be considered at 1192 mm with average number of 45 rainy days. The main monsoon period in study area is ranging from June to September. Runoff is calculated from rainfall data.

Table – 2: Rainfall Data of Surat City

MONTH	2013	2014	2015	2016	2017	2018
JANUARY	0.0	0.0	0.0	0.0	0.00	0.00
FEBRUARY	0.00	0.1	0.00	0.00	0.00	0.00
MARCH	0.00	0.00	8.9	1.9	0.00	0.00
APRIL	1.20	0.00	6.20	0.00	0.00	0.00
MAY	0.0	0.4	0.00	0.0	0.1	0.00
JUNE	416.9	36.4	273.6	58.2	240.90	245.00
JULY	642.2	369.40	310.4	376.6	518.7	473.40
AUGUST	328.7	198.1	40.2	308.10	293.10	265.40
SEPTEMBER	516.7	227.7	260.0	234.5	113.10	235.50
OCTOBER	53.0	6.6	0.6	114.30	57.70	79.50
NOVEMBER	0.0	0.5	0.00	0.00	0.00	-
DECEMBER	0.00	0.00	0.00	0.00	20.10	-

Table – 3: Calculation of Annual Runoff

YEAR	SEASONAL RAINFALL(INCH)	SEASONAL TOTAL RAINFALL(MM)	RUNOFF (BY CHATURVEDI'S METHOD) (INCH)
2018	50.92	1298	8.20
2017	53.12	1327	8.44
2016	37.45	947	6.53
2015	43.79	1108	7.36
2014	38.08	966	6.62
2013	84.32	2135	6.22
2012	36.64	927	6.42
2011	40.25	1018	6.91
2010	72.98	1854	10.35
2009	57.77	1470	8.93
Average			6.996

2.3 Bore Log Detail

Well logging also known as borehole logging is the practice of making a detailed record (a well log) of the geologic formations penetrated by a borehole. Bore log detail for location 1 and location 2. Similarly, we have done bore log detail for location 3, location 4 and location 5.

Table – 4: Bore log location detail

NO	LOCATION
1	Blue City, Puna-Simada.
2	Blue Stone Business Hub, Sarthana.
3	Utsav Heights, Nana-Varachha.
4	Dolphin House, Mini-bazar, Varachha Main Road.
5	Saify Soc. Near East Zone Office.

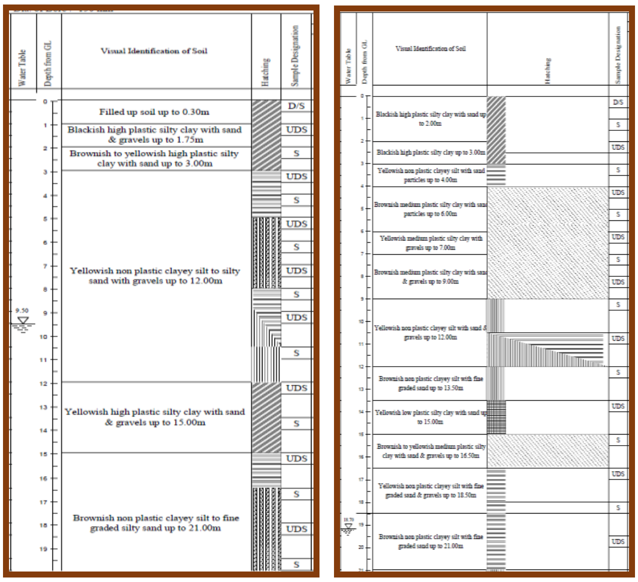

Fig -1: Bore log detail of location 1 and location 2

3. RESULT

The quantity of water to be recharge is calculated as follow. Then number of well which is required to manage surface water are encountered for proposed site. From analysis part, further calculation is carried out to determine the depth of water available on surface.

- **Quantity of Water Available on Surface**
- Hence Average recharge during five year = 6.996 Inch
  = 177.6984 mm
- Maximum Rainfall during ten year = 1470 mm
- Depth of water available on surface = 1470-177.6984
  = 1292.30 mm
- Average quantity of water available on surface =1.292*29.144*10^6 (Impermeable area of Surat)
  = 35.6540 * 10^6 Cubic meter
  = 35.6540 MCM

The maximum quantity of water available on surface from 2009 to 2018 years = 35.6540 *1000 = 3565.40 million liters.

➢ **Recharging of existing well**

- The recharging rate of existing well having the capacity of 25000 litres per hour.
- The recharge capacity per day = 25000*24
  = 600000 litre/day
  = 0.6 MLD
- The rainfall is occurring only 65 days in each monsoon period Surat =0.6*65 (assuming 65 rainy days for one monsoon period) = 39 Million/ litre

- The amount of water still remaining on surface
  = 2190– (39*3) (3 = no. of working well)
  = 2073 Million Liters

From the analysis and estimation, the rain water available on the surface is estimated to 2073 Million Liters for average of ten years data (2009-2018).

So, Number of well still required,
= 2073/39 = 53 wells

In Surat, there are 5 (Five) number recharge well existed but three of them are dead as they are not in working condition due to lack of maintenance and three of them are in working condition.

Hence, from the analysis and results there is a need of additional recharge structure. I.e. there is a need to manage this surface water by any suitable method of ground water recharge. Various method of ground water recharge are explained further.

3.1 Methods of Ground Water Recharging

Method 1: Spreading Basins

This method involves surface flooding of water in basins that are excavated in the existing terrain. For effective recharge highly permeable soils are suitable and maintenance of a layer of water over the highly permeable soil is necessary. When direct discharge is practiced the amount of water entering the aquifer depends on three factors—the infiltration rate, the percolation rate, and the capacity for horizontal water movement. At the surface of aquifer, however, clogging occurs by deposition of particles carried by water in suspension or in solution, by algae growth, colloidal swelling and soil dispersion, microbial activity, etc. Recharge by spreading basins is most effective where there are layer below the land surface and the aquifer and where clear water is available for recharge.

Method 2: Recharge Pits and Shafts

Nine Conditions that permit surface flooding methods for artificial recharge are relatively rare. Often lenses of low permeability lie between the land surface and water table. In such situation artificial recharge systems such as pits and shafts could be effective in order to access the dewatered aquifer. The rate of recharge has been being found to increase as the side slope of the pits increased. Unfiltered runoff water leaves a thin film of sediments on the sides and bottom of the pits, which require maintenance in order to sustain the high recharge rates. Shafts may be circular, rectangular or square cross-section and may be back filled by porous materials. Excavation may be terminating above the water table. Recharge rates in both shafts and pits may decrease with time due to accumulation of fine-grained materials and the plugging effect brought by microbial activity.

Method 3: Ditches

A ditch is described as a long narrow trench, with its bottom width less than its depth. A ditch system is designed to suit topographic and geological condition that exists at the given site. A layout for a ditch and flooding recharge project could include a series of trenches running down the topographic slope. The ditches could terminate in a collection ditch designed to carry away the water that does not infiltrate in order to avoid ponding and to reduce the accumulation of fine materials.

Method 4: Recharge Wells

Recharge or injection wells are used to directly recharge the deep-water bearing strata. Recharge wells could be dug through the material overlaying the aquifer and if the earth materials are unconsolidated, a screen can be placed in the well in zone of injection. Recharge wells are suitable only in areas where thick impervious layer exists between the surface of the soil and the aquifer to be replenished. They are also advantageous in areas where land is scarce. A relatively high rate of recharge can be attained by this method. Clogging of the well screen or aquifer may lead to excessive build-up of water level in the recharge well.

Method 5: Harvesting in Cistern from Hill Sides

In this method construction of small drains along contours of hilly area are done so that the runoff in these drains are collected in a cistern, which is located at the bottom of a hill or a mountain. This water is used for irrigation or for drinking purpose and the water is of good quality.

Method 6: Subsurface Dams

Ground water moves from higher-pressure head to lower one. This will help in semi-arid zone regions especially in upper reaches where the ground water velocity is high. By exploiting more ground water in upper reaches more surface water can be utilized indirectly, thereby reducing inflow into lower reaches of supply. Ground water is stored either in natural aquifer materials in sub-surface dams or in artificial sand storage dam.

Method 7: Farm Ponds

These are traditional structures in rain water harvesting. Farm ponds are small storage structures collecting and storing runoff waste for drinking as well as irrigation purposes. As per the method of construction and their suitability for different topographic conditions farm ponds are classified into three categories such as excavated farm ponds suited for flat topography, embankment ponds suited for hilly and ragged terrains and excavated cum embankment type ponds. Selection of location of farm ponds depend on several factors such as rainfall, land topography, soil type, texture, permeability, water holding capacity, land-use pattern, etc.

Method 8: Historical Large Well across Streamlet

If any historical wells are located near the streamlet, then allow the water into the well from streamlet by connecting drains. In this case the historical wells act as a recharge well so that ground water can be improved.

Method 9: Check Dams

Check dams are small barriers built across the direction of water flow on shallow river and streams for the purpose of rain water harvesting. The small dams retain excess water flow during monsoon rains in a small catchment area behind the structure. Re-assures created in the catchments area send the impounded water into the ground. The major environmental benefit is the replenishment of nearby ground water reserves and wells. The most common case of check dams is to decrease the slope and velocity of a stream to control erosion. The problem of water logging in Vallabh Vidyanagar and remedial measure as ground water recharge using recharge well.

3.2 Recharge well

Surface runoff can also be recharged into dry wells, or simply barren wells that have been modified to functions as cisterns. These hybrid storm water management systems, called recharge wells. It have the advantage of aquifer recharge and instantaneous supply of potable water at the same time. They can utilize existing infrastructure and require very little effort for the modification and operation. Recharge well is a recharging system also consists of primary and secondary filter. Runoff water from the cultivated area is diverted towards recharge well unit through field trenches. It allows to enter in primary filter unit wherein the major sediments were arrested and water flows to the secondary filter unit. Secondary filter unit consist of excavation of soil around the recharge casing pipe by 2.5 m depth and 1.5 dia. From the bottom, up to 50 cm height, small holes are made with pointer at a spacing of 5 cm and this casing pipe is wrapped with nylon mesh. Then the pit is filled with 4 layers of big stone, metal, gravel sand and fine sand one above each. On the top, the unit is covered with cement ring for not allowing the sediment from the flowing water.

- **Component of recharge system**

1. Storm water drain
2. Filtration chamber
3. PVC 160 mm connecting pipe
4. Air vent pipe
5. Perforated V-wire pipe
6. End Cap
7. PVC 160 mm outer well casing

- **Types of recharge well**

There are mainly three types of recharge well according to its location

  - Open recharge well
  - Closed recharge well
  - Modular recharge well

- **Design of Recharge Well**

The overall objective of the design is to create a structurally stable, long-lasting, efficient recharge well that allows surface water to move effortlessly and sediment-free from the surface to confined aquifers. Therefore, wells are of desired volume and quality, and prevents bacterial growth and material decay within the well.

The design of any recharge well should be based on a sound knowledge of hydrology of subsurface material, its geological condition at the proposed site. Information may be obtained by, examining bore logs, lithology information provided by "Bhumi Research Center & material Testing laboratory, Surat". By the study of contour maps, the topography of the region is enforcing the surface water to move Sarthana to Nana Varachha road.

From the analysis part and the study of contour map we have proposed a site for the one recharge well at Blue Point Business Hub, Sarthana, Surat. Thus, based on the various observations used for the design of the modular type recharge well system to be adopted at the proposed site.

Fig - 2: Blue stone business hub

Fig - 3: Recharge well

4. SUMMARY AND CONCLUSION

Development growth of East Zone (Surat City) is upgrading day by day, so that land use of the city is also changing due to that reason obstructions may occur to the natural drains which causes water logging in the city and also the consequence of improper and inadequate operation of drainage. Due to this, there is no proper flow of rain water because of the undulation of ground which may resulting of water logging problem may occurred in many places in city. To mitigate this problem, we had undergone through the hydrological, geological and topographical study of the area and estimate the rain water available on surface and to manage this quantity of water, we proposed a design of one recharge well to encounter the problem. Location of proposed site is inLocation-1, Blue Point Business Hub, Sarthana, (LAT 21.2032° N, LONG 72.8459° E).

The most recent heavy rainfall that brought East Zone (Surat City) to demanded the urgent need for long term planning to overcome water logging problem. We understand the exceptionality of the deluge and that the government and development authorities have no control over the planning, design, operation and maintenance of urban drainage systems. That is a challenge for urban authorities because of unplanned development activities. The effectiveness of storm water management systems can be directly linked to the efficacy of urban management. Therefore, urban drainage systems to be managed effectively and operationally sustainable, greater emphasis needs to be placed upon:

- Co-ordination between urban authorities and agencies those are responsible for different aspects of urban infrastructure provision and management.
- Collaboration between government and non-governmental organizations and promotion of effective partnership with civil society and the private sector.
- Training and human resource development for improved planning, design, and operation of urban drainage systems.
- Understanding of principles and parameters considering while designing a ground recharge well.

REFERENCES

[1] Khondoker Golam Tawhid (2004)," Causes and Effects of Water Logging in Dhaka City, Bangladesh".

[2] A. Longley, J. Margetts, J. M assay, L. M cW illianr and D. Johnson," Groundwater Recharge in Urban Areas " August 2002.

[3] K. M. Atikur Rahman, "Water Logging and Losses in Ecosystem: A Case Analysis on DND Embankment, Bangladesh", Volume-I, Issue-VIII. September 2015.

[4] Hemant Balwant Wakode, Klaus Baier, Ramakar Jha, Rafig Azzam, (2018), "Impact of urbanization on groundwater recharge and urban water balance for the city of Hyderabad, India".

[5] www.suratmunicipalcorporation.gov.in