AQUIFER SYSTEM OF DELHI NCR

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Abstract
The study area lies in parts of Greater Noida where the various land use have been superimposed through the master plan such as residential, commercial, recreational, industrial and forest along with the agriculture land. Ground water availability with the rain water harvesting potential is examined. Various parameters such as specific yield of the soil, water level fluctuation and rain water harvesting potential of the shallow aquifer and deep aquifer are studied. It is observed that the specific yield has got the great variations from forest land use to agriculture, village, residential, commercial and finally institutional. The minimum specific yield is recorded in the agriculture area while the maximum specific yield is recorded in the institutional zone. Similarly, the minimum water level fluctuation occurs in village area where as maximum is recorded in the institutional zone. This study is prepared to superimpose the land use master plan in totality.

Keywords: Aquifer modeling , water level fluctuation, rain water harvesting potential, specific yield of the soil.

1.HISTORY
Water is the most important resource for sustaining life on earth. Human or animal can live without food for few days but cannot live without water. Water is used in different ways such as drinking, bathing, washing, producing energy, irrigating the plants and is also used for recreation and transportation. Polluted water is unsuitable for mankind in terms of health and hygiene. The anthropogenic activities are deteriorating the water quality day by day. This water pollution is due to the rapid growth of population, industrialization and excessive usage of chemicals . It is very important to ensure the quality of groundwater for every human being for the safe health and survival on the earth. Physical, chemical and biological parameters fix the quality of water.Groundwater is one of the most common source of drinking water supply and irrigational use for most of the population of India. Wastewater generated from class-I cities (having more than hundred thousand population) is about 29,000 million L/day and about 45% is generated from class-II towns (having fifty to hundred thousand population) by (Central Pollution Control Board, November 2005), while 35% is generated from metro-cities alone . The influence of different water quality parameters has been elaborated by Brown. Anthropogenic activities are producing fluoride and arsenic pollution in the groundwater of different parts of India (CGWB 2010).

1.1 OVERVIEW
Considering the above-mentioned facts in view, it is important to assess the groundwater quality of the area for domestic and irrigational purposes. The objective of this paper is to avail hydro chemical methods to determine the suitability of groundwater in the area for domestic as well as irrigation purposeswater supply in the area congregates through overhead tanks, tube wells, trunks and other supply lines. At present, nearly 460km length of sewerage network, 500km length of drain-age and nearly 500km length of water supply lines subsist in the area. Under phreatic conditions, groundwater occurred in shallow aquifers declines to the depth of 100mbgl in intermediate and it occurs in deeper aquifers under confined to semi-confined conditions. Groundwater monitoring wells have been

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established in the district to monitor the nature of water level and four times water table are being monitored in a year. Depth to water level of the study area can be divided into various zones on the basis of depth to water ranges. Water level varies from 3.35 to 14.40mbgl in phreatic aquifer whereas it exceeds greater than 9mbgl in most of the non-command areas of the study area.

2. STUDY AREA

Greater Noida is one of the important city located in the Gautam Buddha Nagar district of Uttar Pradesh state (India). It is located at a latitude of 28.47 44°N and longitude of 77.50 40°E. It comprises 124 villages with a population of 107,676 (till March 2014). The area of Greater Noida is about 40,000 hectares broadly bounded by national highway NH-24 in the North West. The city comes under NCR (National capital Territory) region of Delhi. The total land use cover is 13,570.00 hectares with 30.0 hectares of commercial area and 1,970.03 hectares of the total institutional area. The water supply in the area is done through overhead tanks, tube wells, trunks and other supply lines. At present nearly 460□km length of sewerage network, 500□km length of drainage andnearly 500□km length of water supply lines subsists in the area.

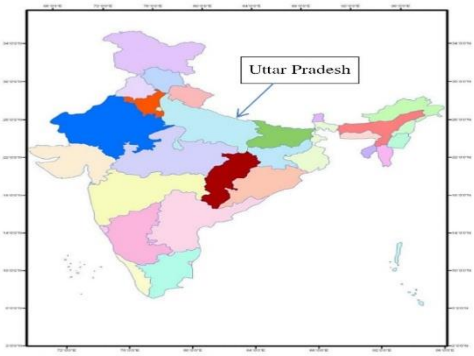
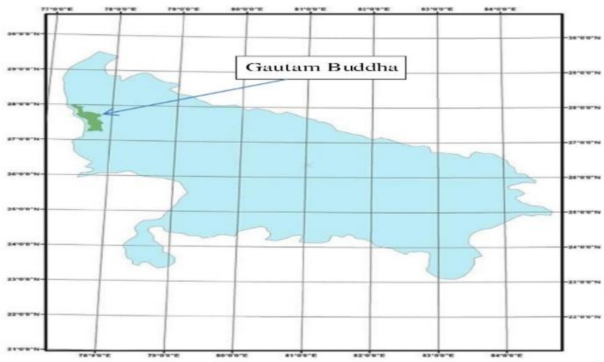
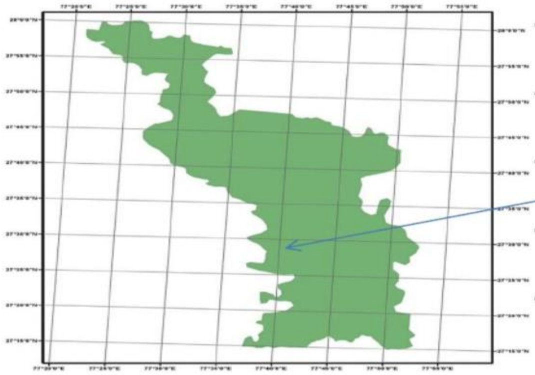


Fig.1. Map of



IndiaFig 2. Map of Uttar Pradesh



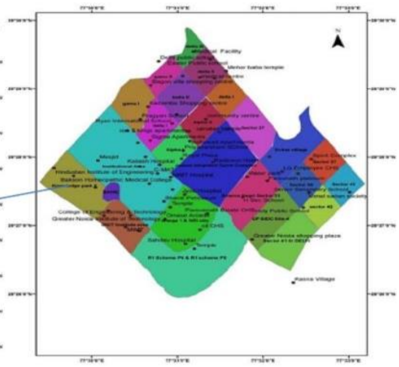


Fig3.(a) Map of district Gautam Buddha Nagar(b) Sampling Point location in Greater noida city

2.1ZONAL WISE DIVISION

1. Residential Area
2. Commercial Area
3. Institutional Area
4. Industrial Area

3. INTRODUCTION

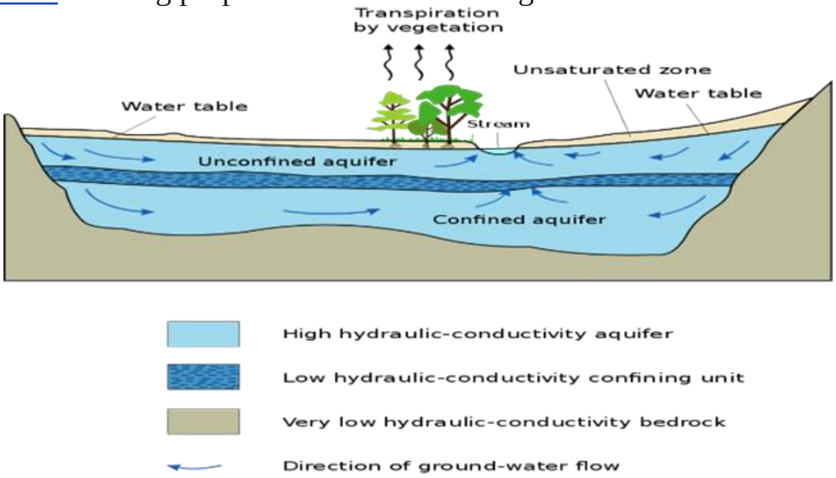
Aquifer:An aquifer is a layer of relatively porous substrate that contains and transmits groundwater. When water can flow directly between the surface and the saturated zone of an aquifer, the aquifer is unconfined. The deeper parts of unconfined aquifers are usually more saturated since gravity causes water to flow downward. The upper level of this saturated layer of an unconfined aquifer is called the water table or phreatic surface. Below the water table, where generally all pore spaces are saturated with water is the phreatic zone. Substrate with relatively low porosity that permits limited transmission of groundwater is known as an aquitard. An aquiclude is a substrate with porosity that is so low it is virtually impermeable to groundwater. A confined aquifer is an aquifer that is overlain by a relatively impermeable layer of rock or substrate such as an aquiclude or aquitard.

If a confined aquifer follows a downward grade from its recharge zone, groundwater can become pressurized as it flows. This can create artesian wells that flow freely without the need of a pump and rise to a higher elevation than the static water table at the above, unconfined, aquifer. The characteristics of aquifers vary with the geology and structure of the substrate and topography in which they occur. Generally, the more productive aquifers occur in sedimentary geologic formations. By comparison, weathered and fractured crystalline rocks yield relatively smaller quantities of groundwater in many environments. Unconsolidated to poorly cemented alluvial materials that have accumulated as valley-filling sediments in major river valleys and geologically subsiding structural basins are included among the most productive sources of groundwater. The high specific heat capacity of water and the insulating effect of soil and rock can mitigate the effects of climate and maintain groundwater at a relatively steady temperature. In some places where groundwater temperatures are maintained by this effect at about 50°F/10°C, groundwater can be used for controlling the temperature inside structures at the surface.

For example, during hot weather relatively cool groundwater can be pumped through radiators in a home and then returned to the ground in another well. During cold seasons, because it is relatively warm, the water can be used in the same way as a source of heat for heat pumps that is much more efficient than using air. The relatively constant temperature of groundwater can also be used for heat pumps.

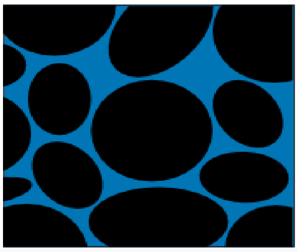
3.1 Hydraulic head

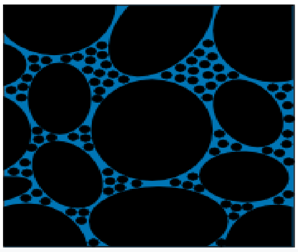
Differences in hydraulic head (*h*) cause water to move from one place to another; water flows from locations of high h to locations of low h. Hydraulic head is composed of pressure head (ψ) and elevation head (z). The head gradient is the change in hydraulic head per length of flow path, and appears in Darcy's law as being proportional to the discharge.



3.2 Porosity

Porosity (n) is a directly measurable aquifer property; it is a fraction between 0 and 1 indicating the amount of pore space between unconsolidated soil particles or within a fractured rock. Typically, the majority of groundwater (and anything dissolved in it) moves through the porosity available to flow (sometimes called effective porosity). Permeability is an expression of the connectedness of the pores. For instance, an unfractured rock unit may have a high porosity (it has many holes between its constituent grains), but a low permeability (none of the pores are connected). An example of this phenomenon is pumice, which, when in its unfractured state, can make a poor aquifer.





High porosity, well sortedLow porosity, poorly sorted

3.3 Water content

Water content (θ) is also a directly measurable property; it is the fraction of the total rock which is filled with liquid water. This is also a fraction between 0 and 1, but it must also be less than or equal to the total porosity.

The water content is very important in vadose zone hydrology, where the hydraulic conductivity is a strongly nonlinear function of water content; this complicates the solution of the unsaturated groundwater flow equation.

3.4 Specific storage and specific yield

Specific storage (S_s) and its depth-integrated equivalent, storativity ($S=S_sb$), are indirect aquifer properties (they cannot be measured directly); they indicate the amount of groundwater released from storage due to a unit depressurization of a confined aquifer. They are fractions between 0 and 1.

Specific yield (S_y) is also a ratio between 0 and 1 ($S_y \leq$ porosity) and indicates the amount of water released due to drainage from lowering the water table in an unconfined aquifer. The value for specific yield is less than the value for porosity because some water will remain in the medium even after drainage due to intermolecular forces. Often the porosity or effective porosity is used as an upper bound to the specific yield. Typically S_y is orders of magnitude larger than S_s.

4.HYDROGEOLOGY

Hydrogeology is the study of groundwater – it is sometimes referred to as geohydrology or groundwater hydrology. Hydrogeology deals with how water gets into the ground (recharge), how it flows in the subsurface (through aquifers) and how groundwater interacts with the surrounding soil and rock (the geology).

Hydrogeologists apply this knowledge to many practical uses. They might:

- Design and construct water wells for drinking water supply, irrigation schemes and other purposes;
- Try to discover how much water is available to sustain water supplies so that these do not adversely affect the environment – for example, by depleting natural baseflows to rivers and important wetland ecosystems;
- Investigate the quality of the water to ensure that it is fit for its intended use;
- Where the groundwater is polluted, they design schemes to try and clean up this pollution;
- Design construction dewatering schemes and deal with groundwater problems associated with mining;
- Help to harness geothermal energy through groundwater-based heat pumps.

4.1 Water Bearing Formation

The thick unconsolidated sediments occur up to the explored depth of 350.0m in the area. The underlying basement comprising Delhi Quartzite has been reported to be encountered at 116.4m depth at Bilaspur Exploratory borehole, 327.0 m depth at Dankaur boreholes in Greater Noida district. Delhi Quartzite deposits take place in Ganga - Yamuna Doab area consist an aquifer system which makes good repository of ground water. It occurs in granular zones made of coarse sand and occasional gravel. Solid clay beds inter lying with sand performed as confining layers and separate the aquifers. The thickness of the unconsolidated sediments gradually increases towards east.

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4.2 .Depth to Water Level

To analyze the nature of water level and its nature, ground water monitoring well is installed in the district and supposed to monitor four times per year. Pre-monsoon and post-monsoon water level data are collected during May and November months respectively. Depth to water level for pre-monsoon and post monsoon periods have identified that the whole area can be separated into various zones on the basis of depth to water ranges. A large area has shallow to moderate depth to water conditions. Water level in phreatic aquifer ranges from 3.35 to 14.40 mbgl during pre-monsoon period whereas it ranges from 2.00m to 13.95 mbgl during post monsoon period. Water levels greater than 9mbgl occur in most of the non-command areas of the district. Few isolated patches deeper water levels arise in east of Jhajhar (Dankaur Block) and Dadri area. Deeper water levels (> 9 mbgl).

4.3. Seasonal Water Level Fluctuation

Water level fluctuation occurs due to the amount of rainfall received by the area. Generally, water level elevates during post monsoon period. Moreover many other factors viz. seepage from canal, base flow of rivers, evaporation losses etc. and also control the outflow and inflow of ground water. It indicates that such areas have moderate to low recharge over the ground water draft during the period. Water level fluctuation is found maximum 3.2 and minimum 2.8m during the period 2017 post monsoon in Greater Noida region

5. ANALYSIS AND DISCUSSION

The aquifer parameters such as specific yield, water level fluctuation, Groundwater potential, Rain water potential are analyzed for Greater Noida region. Table 1 depicts different aquifer parameter values along with their land use. It is observed that there are large variations in all the parameters for the different land use in the study area which are analyzed as follows:

Table 1 Land Use v/s Aquifer Parameters

Land Use	Forest	Institutional	Commercial	Village	Residential	Agriculture
Specific Yield (%)	14	20	14	16	18	12
Water Level Fluctuation (m)	2.8	4.0	2.8	3.2	3.6	2.4
Area (Km^2)(%)	18	14	21	8	26	13
Ground Water Potential*10^6 (m^3)	18.4	28.8	21.2	9.8	42.8	9.3
Rain Water Potential*10^6 (m^3)	9.8	13.2	21.4	4.6	25.6	5.8

5.1.Land use v/s Specific Yield

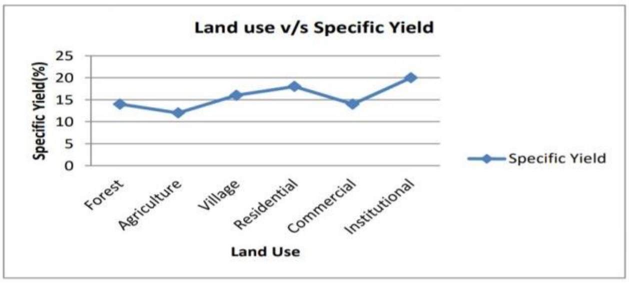
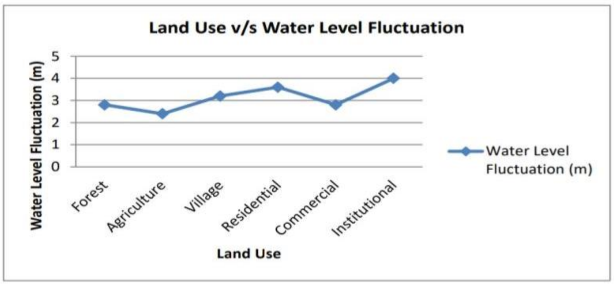


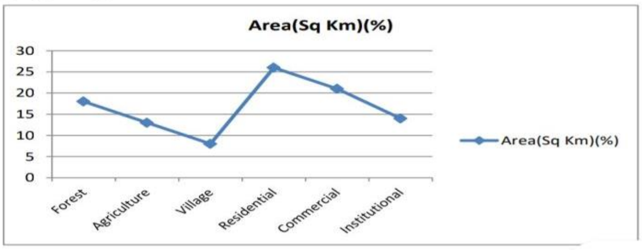
Figure 3 Land use v/s Specific Yield areas.

5.2.Land use v/s Water level fluctuation

Rise in water table elevation is considered in shallow aquifer. It is found due to the accumulation of recharge water across the water table. The Water level fluctuation is recorded in different land use which has been shown in the figure 4. The maximum Water level fluctuation is recorded in institutional areas whereas the minimum water level fluctuation is recorded in agriculture area. However, water level fluctuation in the forest area is recorded as 2.8 m, commercial area is 2.8 m and village area is 3.2 m along with residential areas 3.6 m which clearly show that the heavy withdrawal has occurred in institutional area and less withdrawal has occurred in agriculture areas.



5.3.Land use v/s Area



The area is measured in different land use which has been shown in the figure 5 as well as in the table 1. The maximum area is measured as a residential area whereas the minimum area is measured as a village area. However, forest area is measured as 18%, commercial is 21% and village area is 8% along with residential areas 26%.

5.4.Land use v/s Rain water potential

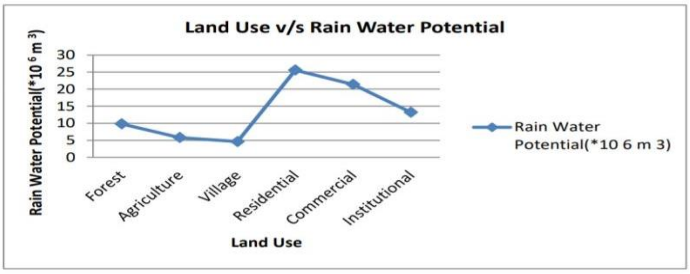
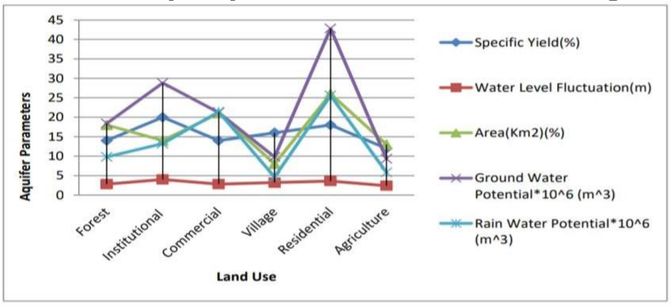


Figure 7 Land use v/s Rain water potential

Dynamics of the Aquifer System in Parts of Greater Noida Using Aquifer Modeling for Different Land Use Pattern The total rain fall collected over an area is called the rainwater endowment of that area. The amount of water which can be effectively harvested is known as the rain water potential. The Rain water potential is recorded in different land use which has been shown in the figure 7 as well as in the table 1. The maximum Rain water potential is recorded in residential areas whereas the minimum in village area. However, the rain water potential in forest area is recorded as $9.8*1^{06m3}$, commercial area $21.4*10^6$ m^3 and village area is $4.6*10^6$ m^3 along with institutional areas $13.2*10^6$ m^3 . It clearly show that high rainwater potential indicates the maximum rain whereas low rain water potential indicates the minimum rain.

5.5.Land Use v/s Aquifer Parameters

It is found that there are large variations in all the parameters for the different land use in the study area which may be analyzed as follows. Different parameters like specific yield, water level fluctuation, area, ground water potential and rain water potential are evaluated for different land use areas. It can be seen evidently that the maximum specific yield is recorded in institutional areas whereas the minimum specific yield is recorded in agriculture area. However, the specific yield is recorded same for forest area and commercial area as 14. In village area, it is recorded as 16 along with residential areas 18. It clearly shows that the coarse sand formation has occurred in institutional area and sandy clay formation has occurred in agriculture areas.



6.SURFACE INVESTIGATIONS

Although groundwater cannot be seen on the earth's surface, a variety of techniques can provide information concerning its occurrence and under certain conditions even its quality. Surface investigations helps us in finding the information about the type, porosity, water content and compactness of subsurface formation. IT is generally done with the aid of electrical and seismic properties of earth and without any drilling on the surface. The information's supplied by these techniques are partially reliable and involve less expenditure. It provided only indirect indications of groundwater so that underground hydrologic data must be inferred from surface investigations. Correct interpretations requires supplementary data from sub surface investigations to substantiate surface findings. It is mainly achieved by the geophysical method viz, electrical resistivity & seismic refraction method.

7. Water Wells:-A water well is a mechanism for bringing groundwater to the surface by drilling or digging and bringing it up to the surface with a pump or by hand using buckets or similar devices. The first historical instance of water wells was in the 52nd century BC in modern-day Austria. Today, wells are used all over the world, from developing nations to suburbs in the United States.

There are three main types of wells, shallow, deep, and artesian. Shallow wells tap into unconfined aquifers, and are, generally, shallow, less than 15 meters deep. Shallow wells have a small diameter, usually less than 15 centimeters. Deep wells access confined aquifers, and are always drilled by machine. All deep wells bring water to the surface using mechanical pumps. In artesian wells, water flows naturally without the use of a pump or some other mechanical device. This is due to the top of the well being located below the water table

7.1 Water Well Design and Construction

One of the most important aspects of groundwater engineering and hydrogeology is water well design and construction. Proper well design and construction are important to maintain the health of the groundwater and the people which will use the well. Factors which must be considered in well design are:

- A reliable aquifer, providing a continuous water supply
- The quality of the accessible groundwater
- How to monitor the well
- Operating costs of the well
- Expected yield of the well
- Any prior drilling into the aquifer

Aquifer suitability starts with determining possible locations for the well using "USGS reports, well logs, and cross sections" of the aquifer. This information should be used to determine aquifer properties such as depth, thickness, transmissivity, and well yield. In this stage, the quality of the water in the aquifer should also be determined, and screening should occur to check for contaminants.

After factors such as depth and well yield are determined, the well design and drilling approach must be established. Drilling method is selected based on "soil conditions, well depth, design, and costs." At this stage, cost estimates are prepared, and plans are adjusted to meet budgetary needs.
Important parts of a well include the well seals, casings or liners, drive shoes, well screen assemblies, and a sand or gravel pack (optional). Each of these components ensures that the well only draws from one aquifer, and no leakage occurs at any stage of the process.
There are several methods of drilling which can be used when constructing a water well. They include: "Cable tool, Air rotary, Mud rotary, and Flooded reverse circulation dual rotary" drilling techniques. Cable tool drilling is inexpensive and can be used for all types of wells, but the alignment must be constantly checked and it has a slow advance rate. It is not an effective drilling technique for consolidated formations, but does provide a small drilling footprint. Air rotary drilling is cost effective and works well for consolidated formations. It has a fast advance rate, but is not adequate for large diameter wells. Mud rotary drilling is especially cost effective for deep wells. It maintains good alignment, but requires a larger footprint. It has a very fast advance rate. Flooded reverse circulation dual rotary drilling is more expensive, but good for large well designs. It is versatile and maintains alignment. It has a fast advance rate.
Well screens ensure that only water makes it to the surface, and sediments remain beneath the Earth's surface. Screens are placed along the shaft of the well to filter out sediment as water is pumped towards the surface. Screen design can be impacted by the nature of the soil, and natural pack designs can be used to maximize efficiency.
After construction of the well, testing must be done to assess productivity, efficiency and yield of the well, as well as determine the impacts of the well on the aquifer. Several different tests should be completed on the well in order to test all relevant qualities of the well.

8. Pumping can affect the level of the water table:

Groundwater occurs in the saturated soil and rock below the water table. If the aquifer is shallow enough and permeable enough to allow water to move through it at a rapid-enough rate, then people can drill wells into it and withdraw water. The level of the water table can naturally change over time due to changes in weather cycles and **precipitation** patterns, streamflow and geologic changes, and even human-induced changes, such as the increase in **impervious surfaces** on the landscape.
The pumping of wells can have a great deal of influence on water level below ground especially in the vicinity of the well, as this diagram shows. If water is withdrawn from the ground at a faster rate that it is replenished, either by **infiltration** from the surface or from **streams**, then the water table can become lower, resulting in a "cone of depression" around the well. Depending on geologic and hydrologic conditions of the aquifer, the impact on the level of the water table can be short-lived or last for decades, and it can fall a small amount or many hundreds of feet. Excessive pumping can lower the water table so much that the wells no longer supply water—they can "go dry."

8.1Water movement in aquifers:

Water movement in aquifers is highly dependent of the permeability of the aquifer material. Permeable material contains interconnected cracks or spaces that are both numerous enough and large enough to allow water to move freely. In some permeable materials groundwater may move several meters in a day; in other places, it moves only a few centimeters in a century. Groundwater moves very slowly through relatively impermeable materials such as clay and shale. (Source: Environment Canada)
After entering an aquifer, water moves slowly toward lower lying places and eventually is discharged from the aquifer from springs, seeps into streams, or is withdrawn from the ground by wells. Groundwater in aquifers between layers of poorly permeable rock, such as clay or shale, may be confined under pressure. If such a confined aquifer is tapped by a well, water will rise above the top of the aquifer and may even flow from the well onto the land surface. Water confined in this way is said to be under artesian pressure, and the aquifer is called an **artesian aquifer.**

8.2Visualizing artesian pressure:

Here's a little experiment to show you how artesian pressure works. Fill a plastic sandwich baggie with water, put a straw in through the opening, tape the opening around the straw closed, point the straw upward *(but* **don't** *point the straw towards your teacher or parents!*) and then squeeze the baggie. Artesian water is pushed out through the straw.

9.CONCLUSION

As demand for water increases, water managers and planners need to look widely for ways to improve water management and augment water supplies. The Committee on Ground Water Recharge concludes that artificial recharge can be one option in an integrated strategy to optimize total water resource management, and it believes that with pretreatment, soil-aquifer treatment, and posttreatment as appropriate for the source and site, impaired-quality water can be used as a source for artificial recharge of ground water aquifers. Artificial recharge using source waters of impaired quality is a sound option where recharge in intended to control saltwater intrusion, reduce land subsidence, maintain stream baseflows, or similar in-ground functions. It is particularly well suited for nonportable purposes, such as landscape irrigation, because health risks are minimal and public acceptance is high. Where the recharged water is to be used for potable purposes, the health risks and uncertainties are greater. In the past, the development of potable supplies has been guided by the principle that water supply should be taken from the most desirable source feasible, and the rationale for this dictate remains valid. Thus, although indirect potable reuse occurs throughout the nation and world wherever treated wastewater is discharged into a water course or underground and withdrawn downstream or downgradient for potable purposes, such sources are in general less desirable than using a higher quality source for potable purposes. However, when higher-quality, economically feasible sources are unavailable or insufficient, artificially recharged ground water may be an alternative for potable use.
The last decade has brought a dramatic shift in awareness of groundwater and our expectations for its management. Groundwater awareness has grown as problems became visible and aquifer functionality decreased. Growing awareness has coincided with technological advancements and understanding of groundwater systems that are shaping the plethora of ongoing groundwater management experiments. The stakes for learning to manage this resource are high. Managed carefully, aquifers are a cheap natural infrastructure that could provide a stable water source for generations. However, without proper management, this natural infrastructure will deteriorate and become unusable, increasing costs of, and reliance on, almost all other aspects of our water systems. Replacing the functions of aquifers through traditional infrastructure projects, whether treatment plants or reservoirs, would come at staggering costs. There is a lack of shared vision as to what constitutes good groundwater management and governance. The consensus at the Aspen Forum was that groundwater needs to be sustainably developed, meaning groundwater use must be balanced among economic development, environmental health, and quality-of-life needs in a way that allows our children and grandchildren to enjoy a use comparable to todays. Technological improvements are creating more opportunities than ever to pursue the sustainable development of groundwater. Across the United States, there are many on-going regulatory experiments focused on groundwater management that are tailored to local conditions and problems. Just as there is not a national water policy, there is no overarching national vision for groundwater to guide its sustainable development. Diverse shareholders might be able to develop a shared vision based on the following ideals:

- Groundwater use must be balanced among economic development, environmental health, and quality-of-life needs for future generations.
- Groundwater and surface water should be integrated, where and when possible, for management decisions, regulations, and policies.
- Groundwater needs to be constantly “visible,” not just when it is at the center of a problem or crisis. 40 a report from the 2017 aspen-nicholas water forum
- Trust, underpinned by transparency, is central to changing

- management approaches.

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