RAINWATER INDUCED URBAN WATERLOGGING AT DHANMONDI OF DHAKA CITY: CAUSES, EXTENT AND SOLUTION

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BACKGROUND AND RATIONALE OF THE STUDY

- There are 22 major locations within Dhaka city that face acute drainage congestion and waterlogging during monsoon on a regular basis and among them one of the most severely affected location is in the vicinity of Dhanmondi 16.
- Waterlogging has been causing adverse physical, social, economic and environmental impacts upon lives and livelihoods of the local people.
- Rainwater induced waterlogging in a planned residential area like Dhanmondi is an emerging one and hence the problem is yet to be explicitly explored.

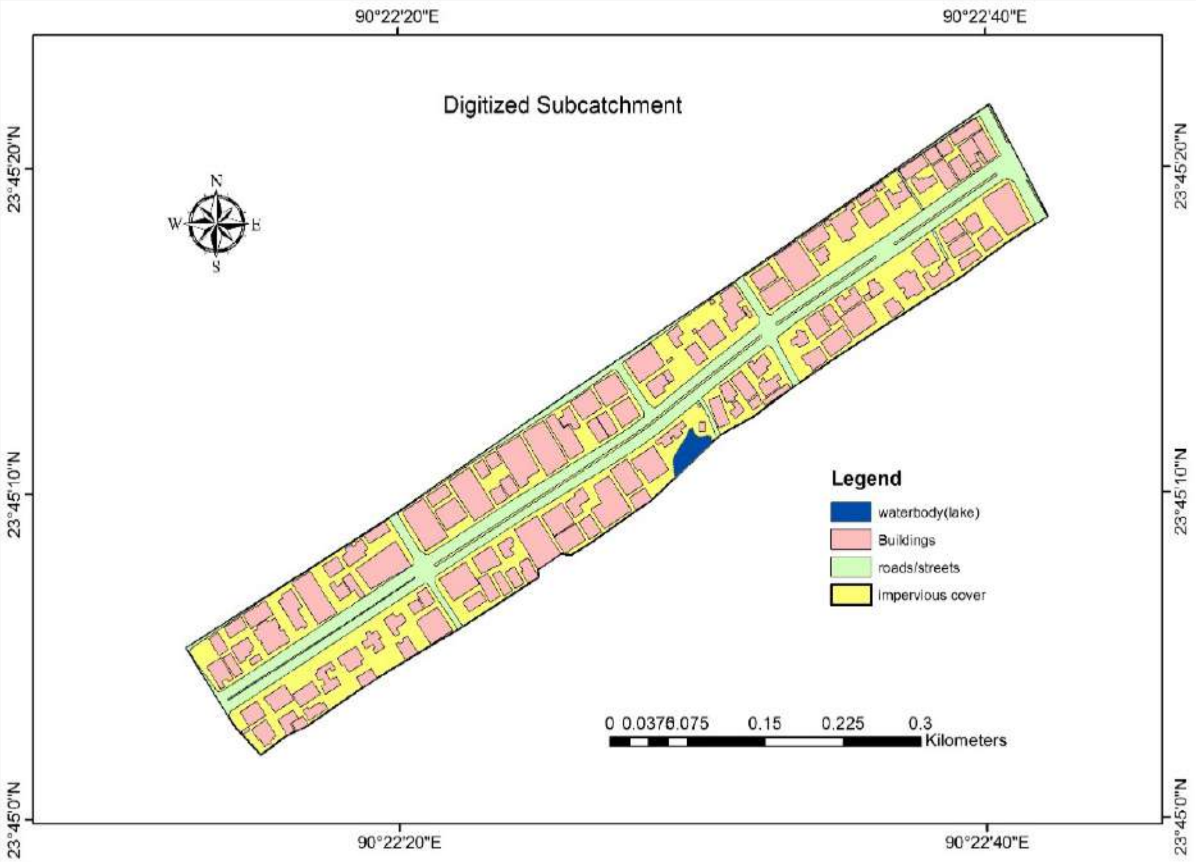
STUDY LOCATION

(Source: Google Earth, 2017)

PROBLEM ANALYSIS

- Evaluation of design adequacy of existing storm water drainage system:

➢ Demarcation of the subcatchment and categorization of features:



Land cover/ land use classes	Area (in Hectares)	% of catchment	Type of material	Coefficient of (Center for Scie Environment 2013)
Buildings/Structures	4.48	40.1%	Concrete (roof)	0.7
Streets/Roads	2.32	20.8%	Asphalt	0.8
Impervious urban coverage (in and around the buildings and roads including pavements, walkways)	4.26	38.1%	Predominantly concrete	0.7
Waterbody (lake)	0.1	0.9%	-	-
	Total= 11.18	100%		

- **Computation of peak surface runoff rate generated by the subcatchment:**

Rational Method formula, Q= CIA/360 = 0 .91 m3/s

- **Maximum discharge capacity of the storm water drainage outlet within the subcatchment:**

As per Manning's formula, discharge rate Q =0 .47 cubic meter/s

Considering 70% drainage efficiency, Q= 0.33 cubic meter/s

- So, the discharge capacity of the prevailing storm water drainage system is nearly one-third to the peak surface runoff rate generated by the subcatchment implying towards design inadequacy of drainage facility.

ANCILLARY CAUSES OF WATERLOGGING (SOCIAL, BEHAVIOURAL AND MANAGEMENT FACTORS)

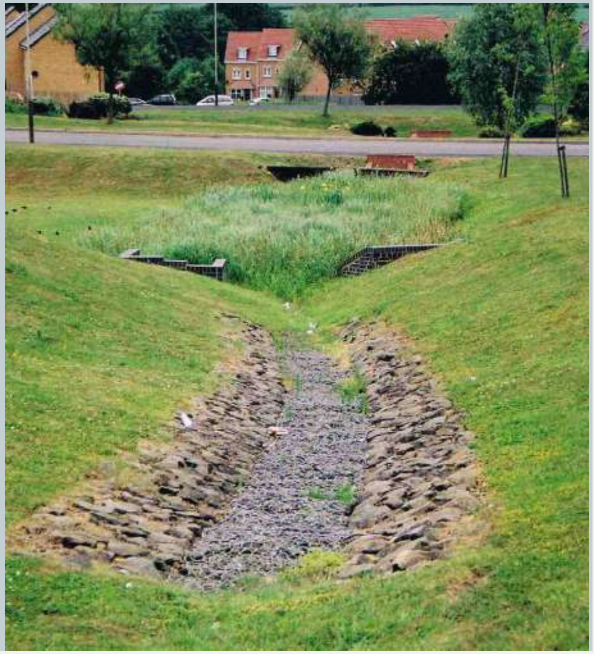
- Changing pattern of intense rainfall events.
- Irregular updating of drainage system.
- Lack of co-ordination and co-operation among the drainage control and maintenance authorities (DWASA and DNCC).
- Lack of appropriate maintenance and regular cleansing of storm water drains.
- Lack of awareness among the local inhabitants.

PROPOSITION OF AN OPTIMUM MITIGATION OPTION:

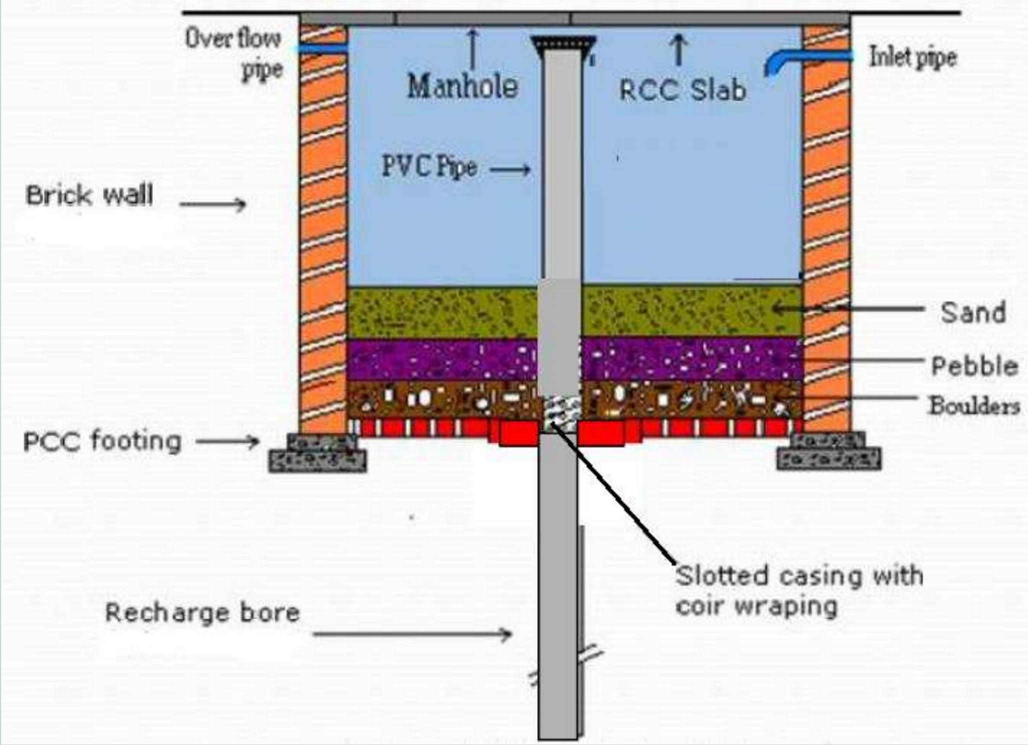
- Existing Practices

Rainwater Harvesting Techniques along Urban Landscape

- Bioswales
- Raingarden



- Typical Recharge Pits/Trenches used for Recharge Well



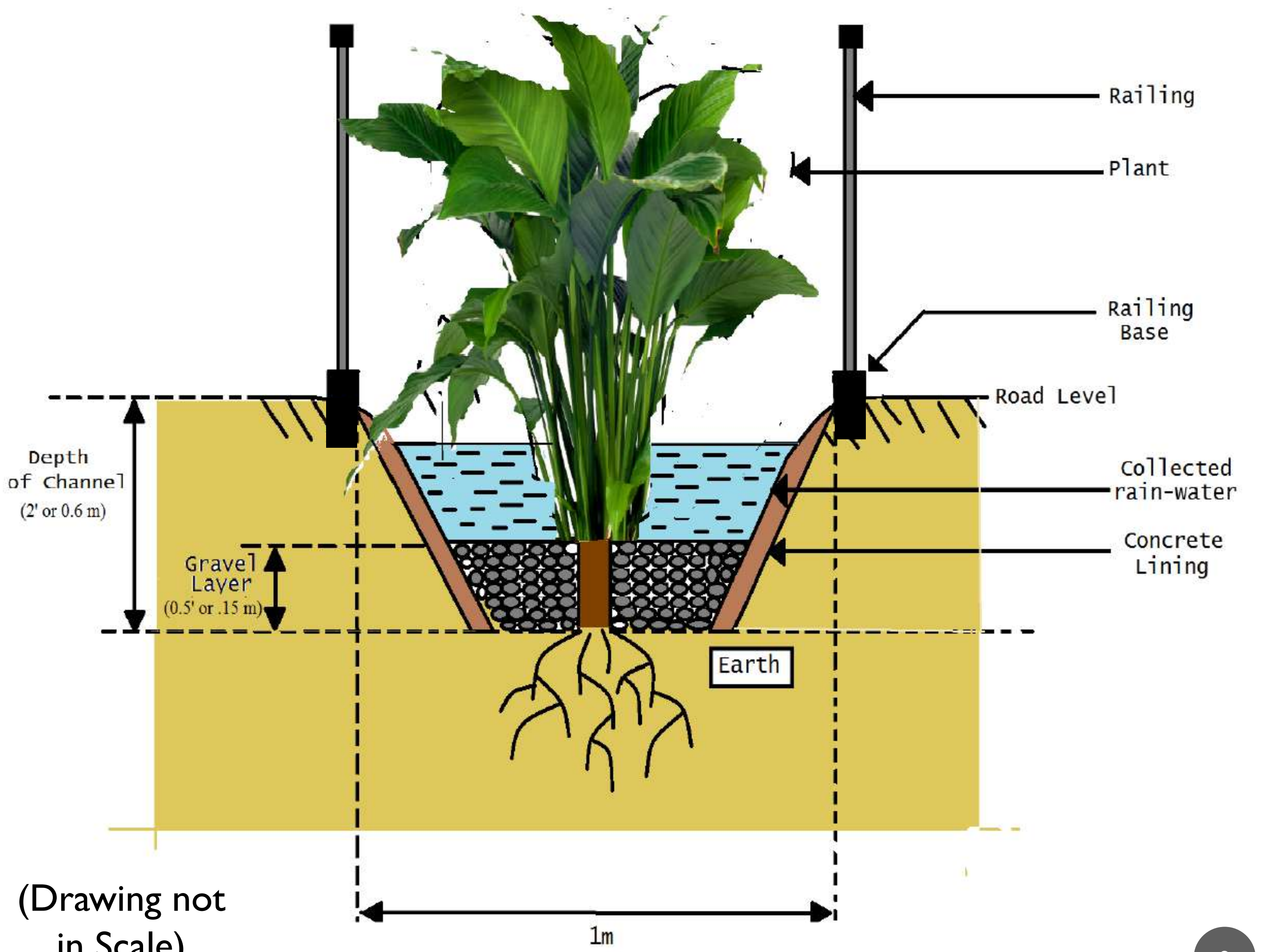
PROPOSED MITIGATION OPTION

- Rain water harvesting through lateral recharge trenches/chambers on roads with recharge shafts or borewells drilled down to the permeable strata has been identified to be the potentially suitable mitigation option. The recharge trenches will be adjoined to constructed channels that will be built following the basic concept of a bioswale.
- The designed structures will be placed along the road divider of Road no.16.
- Main design components:
  - ➢Channel
  - ➢Recharge trenches
    - - Filtering Chamber
    - - Recharge shaft/borewell

PLAN VIEW OF THE PROPOSED SYSTEM

CHANNEL CROSS-SECTION OF THE PROPOSED SYSTEM

- An artificial channel will be built along the entire divider which may serve as bio swale.
- The whole channel section will contain a relatively less dense cover of gravel layer on top of its soil base.
- At the confluence of the channel segments and the recharge trenches, metal wire net will be placed that will prevent the gravels of the channel from entering into the recharge trench.
- Metallic railing can be placed along the channel brims on both side with a reinforced concrete 12” x 6“ (including 6” casting below road surface) lining as a base for the railing. Also, This base will act as guide wall against skidding of the vehicle



(Drawing not in Scale)

RECHARGE TRENCH WITH BOREWELL/RECHARGE SHAFT

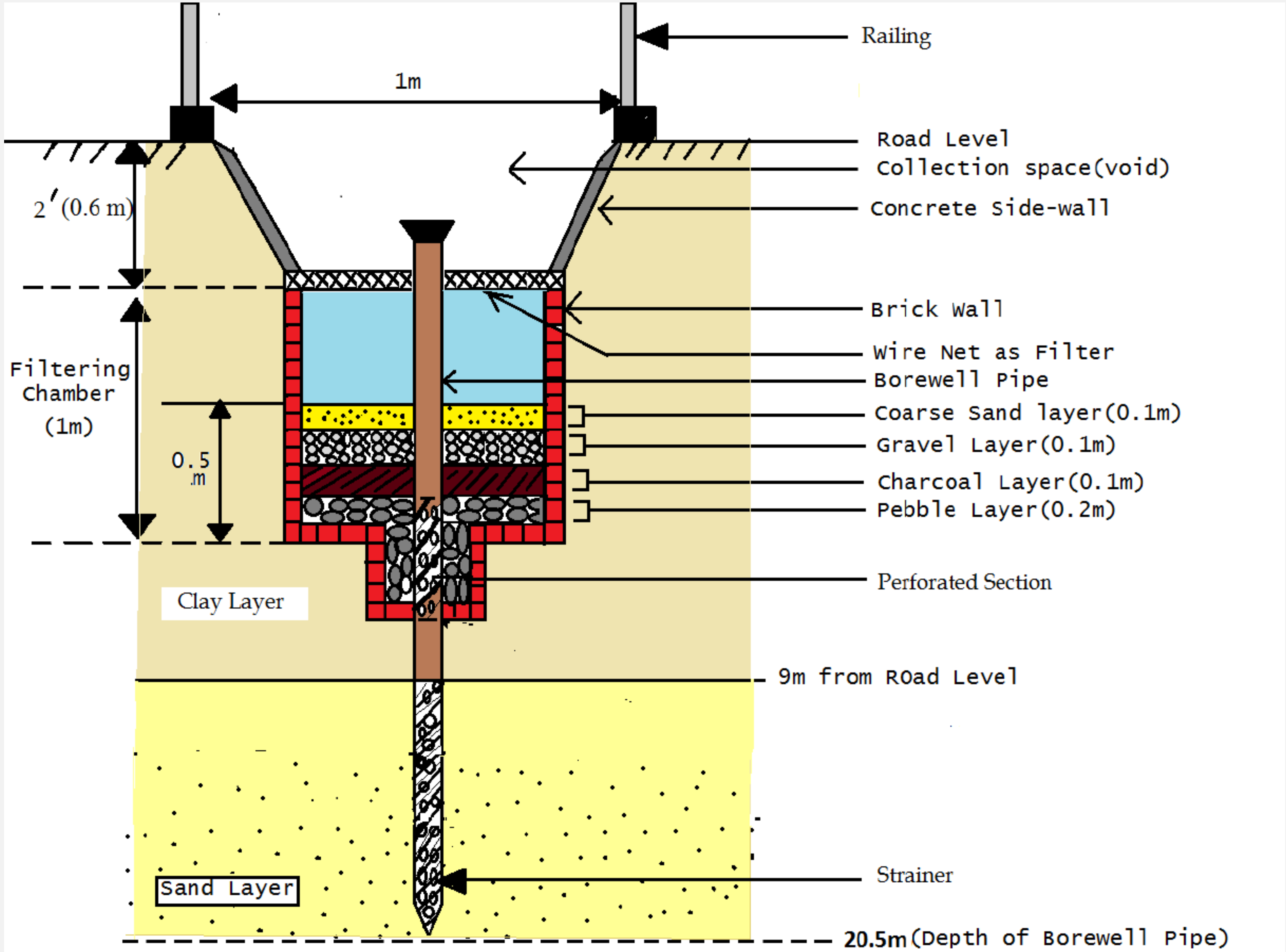
➢ Filtering Chamber

This chamber serves as both the storage space and filtering chamber. The filtering chamber will be excavated down to a depth of 1m below the channel depth.

4 distinct layers:

- Sand layer
- Gravel layer
- Charcoal layer
- Pebble layer

➢ Recharge shaft/borewell



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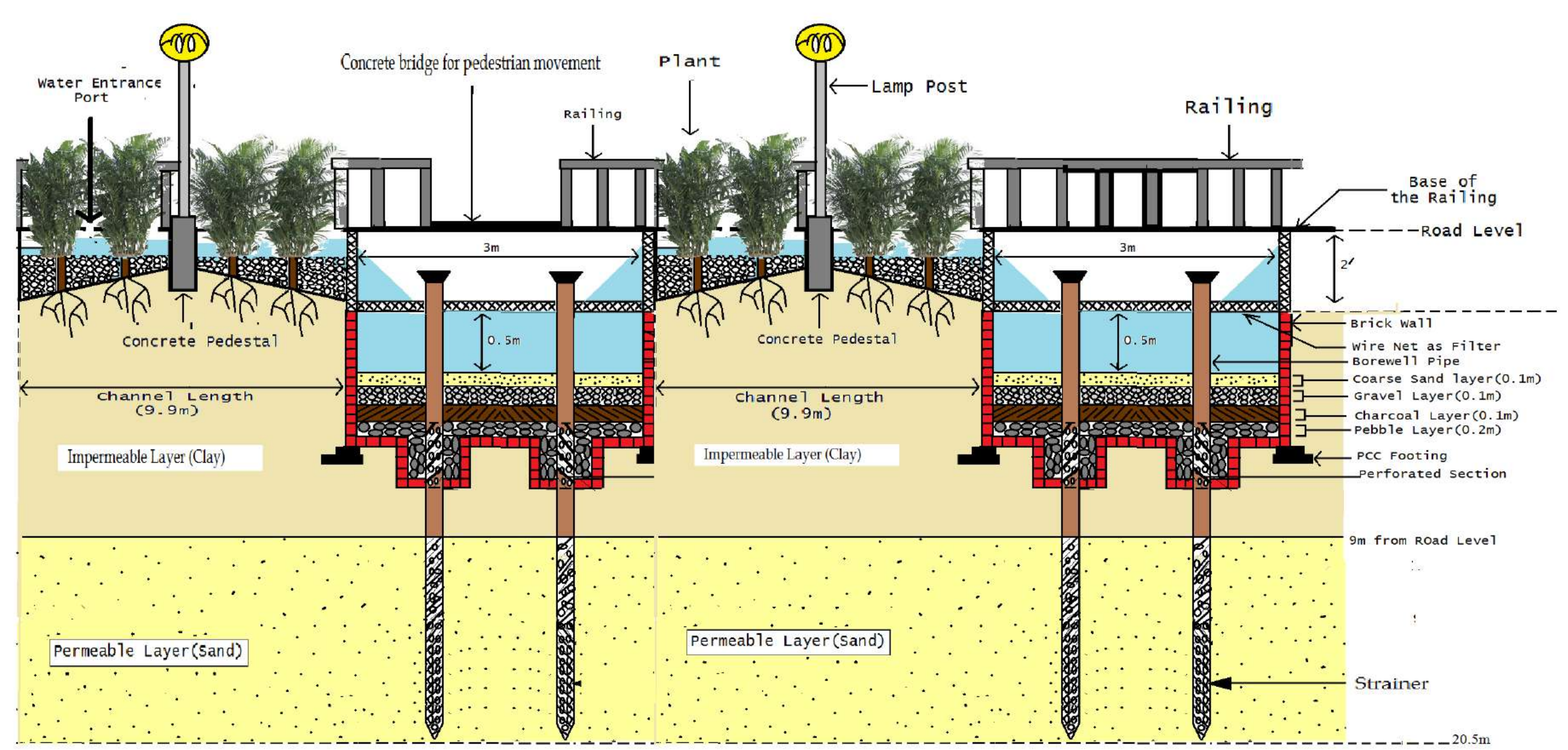
LONGITUDINAL SECTION OF THE PROPOSED SYSTEM



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EVALUATION OF THE EFFECTIVENESS OF THE PROPOSED SOLUTION

- Impact upon waterlogging :

1. ***Total Storage Capacity of the designed system*** = *Storage Capacity of Recharge trenches + Storage Capacity of the Channel + storage capacity of borewell pipes.*

$S = n_R \times V_R + L \times V_c + n_B \times V_B$………………………….... *(1)*

S = Total storage capacity of the designed system

n_R = Number of recharge trenches

V_R = Storage capacity or volume per recharge trench

L = Total length of the channel

V_c = Storage capacity or Volume of channel per unit length

n_B = Number of borewell pipes

V_B = Storage capacity or Volume per borewell pipe

2. ***Volume of water accumulated on road surface after the rainfall has stopped*** *(for a design rainfall intensity and period) = (Total generated runoff rate – Discharge rate of the Storm Water drainage system – Recharge rate of the designed system – Infiltration rate of soil in the channel bottom) x design rainfall period – Storage capacity of the designed system*

$$R = (I - d_d - d_B \times n_B - d_{inf} \times A) \times t_{cer} - S \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Here, R = Volume of water accumulated on road surface after the rainfall has stopped (for a design rainfall intensity and period),

I = Total generated runoff rate for a design rainfall intensity

d_d = Discharge rate of storm water drainage system

d_B = Recharge rate of a borewell

n_B = Number of borewells

d_{inf} = Infiltration rate of soil

A = Total area of the bottom of the channel

t_{cer} = Design rainfall period

S = Total storage capacity of the designed system

3. ***Time required for the discharge of the runoff accumulated on road surface*** *(after the rainfall has stopped) = Volume of water accumulated on road surface after the rainfall has stopped / (Discharge rate of storm water drainage system + recharge rate of the designed system + infiltration rate of the soil in the channel bottom)*

$t_p = R/(d_d + d_B \times n_B + d_{inf} \times A)$ ……………………………………….... *(3)*

4. ***Relative Water Logging Severity Indicator*** *= (Time required for the discharge of total accumulated runoff on road surface after the rainfall has stopped / design rainfall period (Duration of rainfall)) x 100%*

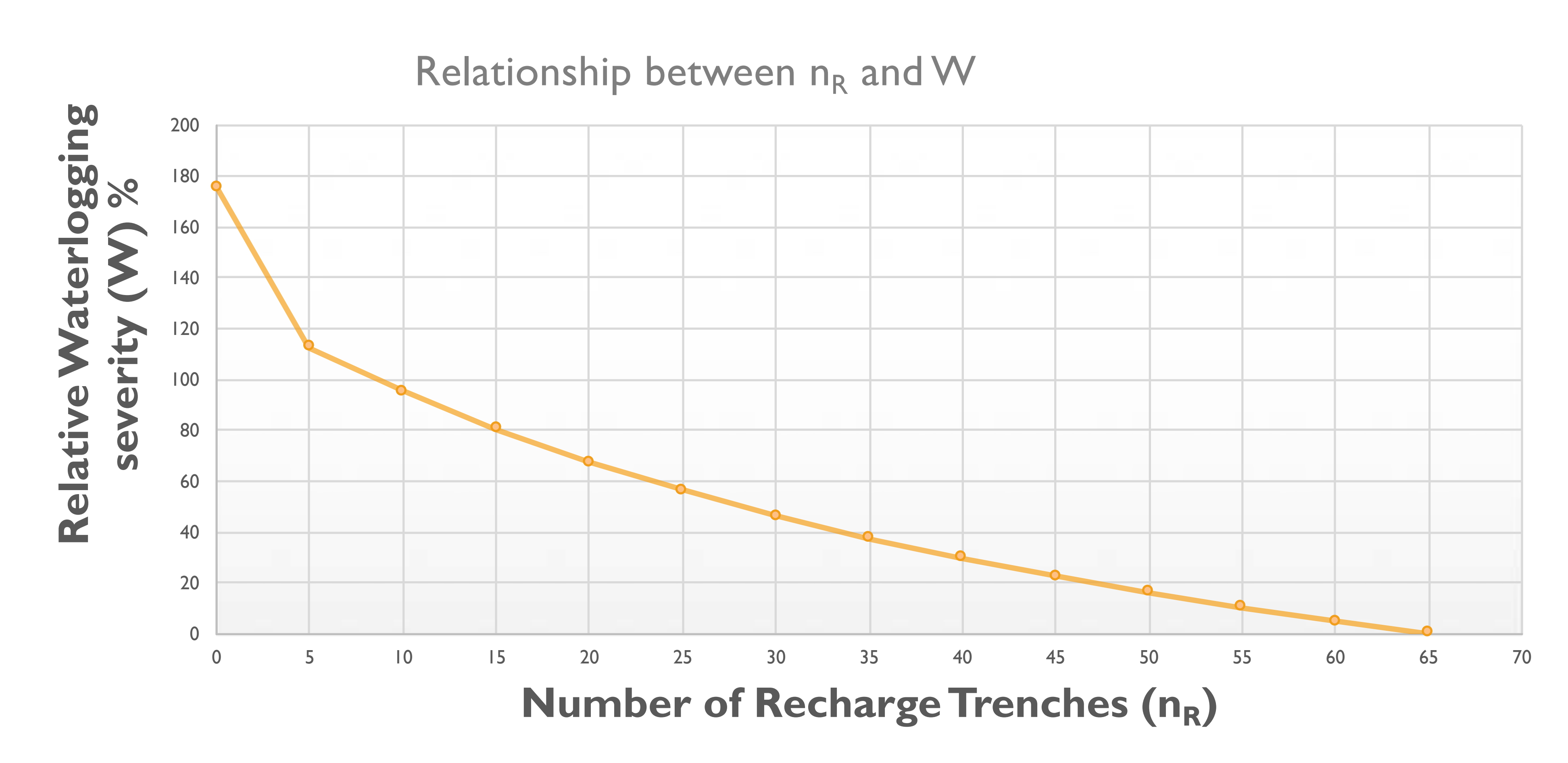
$W = (tp / t_{cer}) \times 100\%$...*(4)*

Here, W = Relative water logging severity indicator

t_p = Time required for the discharge of accumulated runoff (after the rainfall has stopped)

t_{cer} = Time of rainfall (design rainfall period)

GRAPH SHOWING THE RELATIONSHIP BETWEEN NUMBER OF RECHARGE TRENCHES AND RELATIVE WATER LOGGING SEVERITY IN THE STUDY LOCATION (FOR A DESIGN RAINFALL SCENARIO)



IMPACT UPON GROUNDWATER

- ***Potential amount of ground water recharge by the designed system*** *(for a design rainfall intensity and period) = (Recharge rate of borewells + infiltration rate of soil) X Design rainfall period + (Recharge rate of borewells + infiltration rate of soil) X time required for water on road surface to get discharged (After the rainfall has stopped) + Storage capacity of the designed system.*

$GWR= [(n_B \times d_B) + (d_{inf} \times A)] \times t_{cer} + [(n_B \times d_B) + (d_{inf} \times A)] \times t_p + S = 982.6\ m^3$

(Considering design rainfall intensity of 40.2mm/h and rainfall period of 30 minutes)