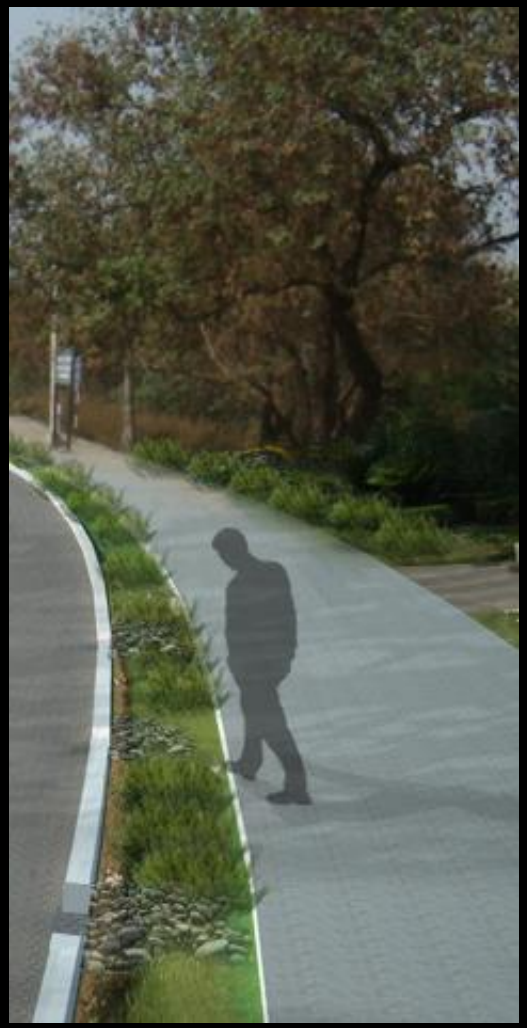
SWM STORM WATER MANAGEMENT

retrofitting our urban streets for sustainable drainage

Draft copy . July 2012



Prepared by:
OASIS DESIGNS INC.

For :
UTTIPEC
DELHI DEVELOPMENT AUTHORITY


Image © 2012 GeoEye

Executive Summary

Storm water management is a process of managing the quantity and quality of storm water by using both structural or engineered control devices and systems (e.g. bio retention ponds) to treat polluted storm water.

Storm water runoff occurs when rain falls over the land surface, such as roads, driveways, parking lots, rooftops and other surfaces that prevent water from soaking into the ground to the landscape. This increases the runoff volume created during monsoon. This runoff, which also contains pollutants is easily carried through the engineered drain channels to the nearby nala and then to the river. causing This also cause flooding and erosion. The pollutant carried in stormwater runoff are sediment, nitrogen, phosphorus, bacteria, oil and grease, trash, pesticides and metals. It comes as no surprise then that stormwater runoff is the number one cause of **"Water pollution in the city".**

To reduce the impacts of storm water runoff, it is required to install sustainable stormwater management practices that reduce the volume and remove pollutants from runoff generated on their development sites.

This guideline book provides the city a practical information on how to create a low-impact development along roadways, parking lots & on the nalas & river banks . Roads and parking lots have many opportunities for managing stormwater. (for ex : Delhi has 25% of it's area under road). These details shall hopefully encourage the use of low-impact development for new and retrofitted road and parking lot projects.

DELHI, CDP
Storm Water Drainage

The DJB, MCD and PWD are jointly responsible for the construction and maintenance of drains in the city. Storm water drainage in Delhi is a complex situation, owing to the combination of a number of natural and man-made drainage systems – five drainage basins; large natural drains; storm water drains along roads; and combined sewer-cum-storm water drains (sometimes as a bypass arrangement for blocked sewer lines). Most of the water collected through different drainage systems finally gets discharged into the river Yamuna. The length of natural drains in the city is 350 km carrying discharge of 1000 m3, whereas the total length of drains is 1700 kms spread over 12 municipal zones.
The BOD levels of waters in 90 % of city drains indicate that the discharge is comparable to a range of weak to strong domestic sewage. The main issues related to the sector are

- Storm water drains carry considerable quantities of raw and untreated effluents
- Lack of maintenance, leading to chocked drains.
- Lack of coordination in planning and construction of roads and drain

Strategies for Civic Infrastructure Development:

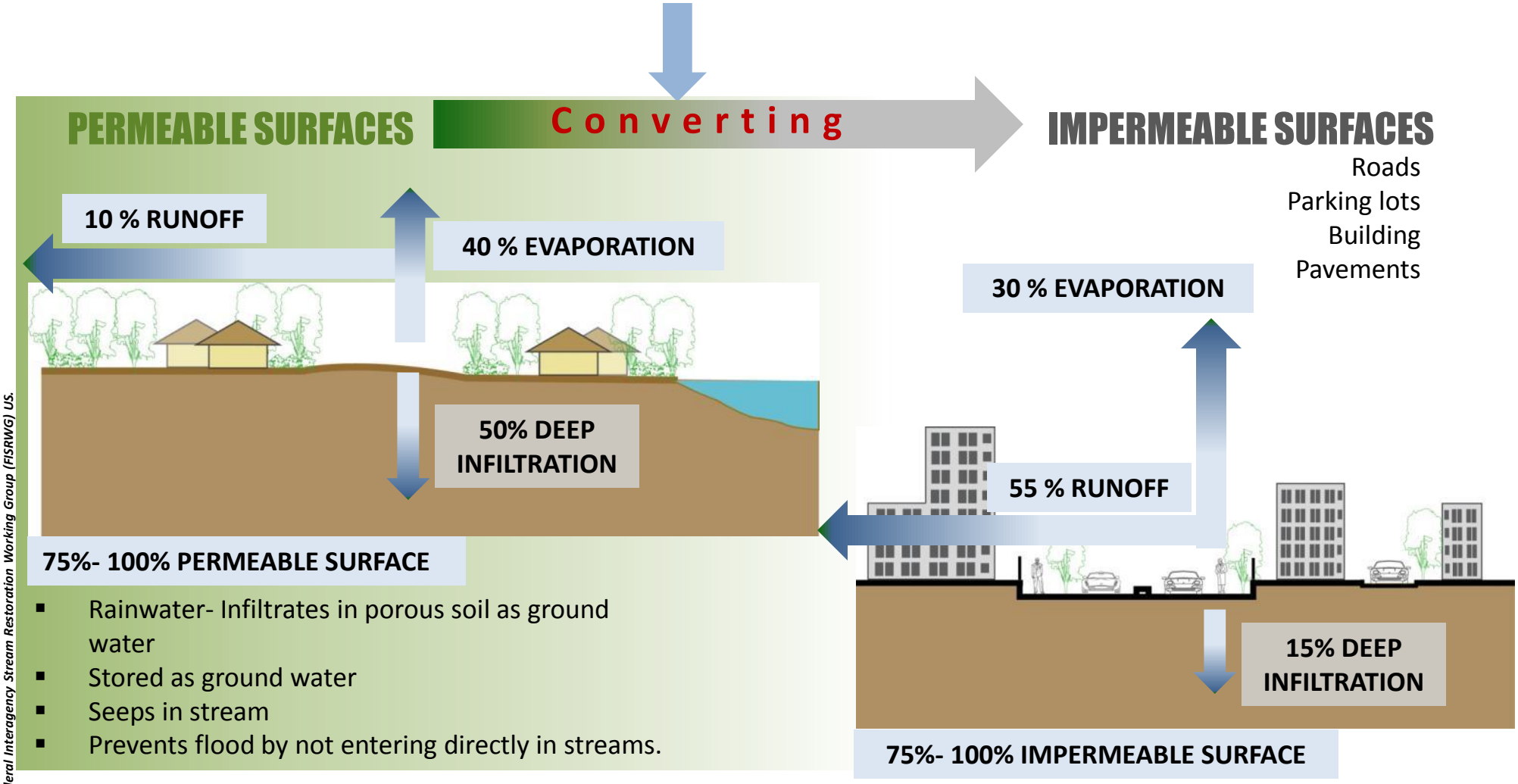
The strategies suggested for improvement of drainage system in the city are *(i) Creation of an appropriate, integrated authority to deal with the sewer drains, the storm water drains and the natural drainage basins of the NCT area; (ii) Short-term repair and de silting of all the drains on emergency basis; (iii) After monitoring the functioning of the South Delhi Greenway Project for Barapulla drain, initiating the same in the medium term for Najafgarh drain, which is by far the largest contributor in terms of discharge into river Yamuna (51.75%).*

The CDP of Delhi only covers storm water drainage & misses out on storm water management. There is a "rain water harvesting guideline" done by CGWB. Which also covers only rain water harvesting on roof tops and some techniques on open lands, but again misses the road & parking lots.

WHY

Why do we need sustainable storm water management in our cities ?

RAPID URBANIZATION



- Rainwater- Infiltrates in porous soil as ground water
- Stored as ground water
- Seeps in stream
- Prevents flood by not entering directly in streams.

Source : Federal Interagency Stream Restoration Working Group (FISRWG) US.

Water crisis looms over India

DIRTY PICTURE Despite rapid urbanisation, cities fail to meet growing water demand, treat sewage, finds CSE study

ht SPECIAL

Chetan Chauhan
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NEW DELHI: Major metros like Delhi and Mumbai face huge water and environmental crises as infrastructure tries to keep pace with the increasing population, says a new study of 71 Indian cities.

The report, Excreta Matter, prepared by the Centre for Science and Environment (CSE), comes at a time when India is urbanising at the highest rate in the world and half of all Indians are expected to be living in cities by 2050. "If we do not get the arithmetic of water waste right, it will drown us in its own excreta," said Sunita Narain, CSE's director general.

The study presents the dirty picture of Indian cities' capacity to treat less than half the sewage they generate. Moreover, the dirty sewage generated flows into rivers like Yamuna in Delhi, Mithi in Mumbai and wetlands in east Kolkata. Even a modern city like Bangalore is able to treat just 30% of its sewage.

What is worse, the treated sewage is not even utilised for non-food or non-bathing purposes. "Most cities don't have water management plans," the report says.

The study also points out another major flaw — water loss during distribution. Over 35% of water in Delhi and about 30% in Mumbai is lost because of leakages, the report says.

Delhi extracts around 12% of its supply of 1,824 million litres per day (MLD) from the ground but fails to replenish the same amount by way of water harvesting. The availability of water in certain regions is around 63 metres below the ground.

Even though the capital's population has increased by 50% since 1994, the increase in water connections is just 3%, the report says, indicating that the Delhi Jal Board has failed to augment water supply in the city.

Mumbai fares no better. Residents of high-rises receive about 220 litres per capita per day whereas those in slums get less than 40 litres. With its population estimated to be 15 million in 2011, it needs about 1,300 MLD to meet the demand.

Kolkata is slightly better than the two in meeting its water requirement but may fall in the same trap if its sewage treatment capacity is not increased. From a water-surplus city, Kolkata is turning into a water-deficient city.

GRAVE SITUATION

File photo of Delhi's Yamuna river. Untreated sewage of the national capital is released into the river

DELHI

- Existing demand (2011): 4,727 MLD
- Existing supply: 1,824 MLD
- Extra supply possible if leakages plugged: 927 MLD
- Required increase in water supply: 24%
- Total sewage generated: 4,456 MLD
- Treatment capacity: 2,330 MLD
- Treated: 1,478 MLD

Disposal: Yamuna river (untreated)

File photo of Mumbai's Mithi river, commonly identified as a drain till the deluge of 2005

MUMBAI

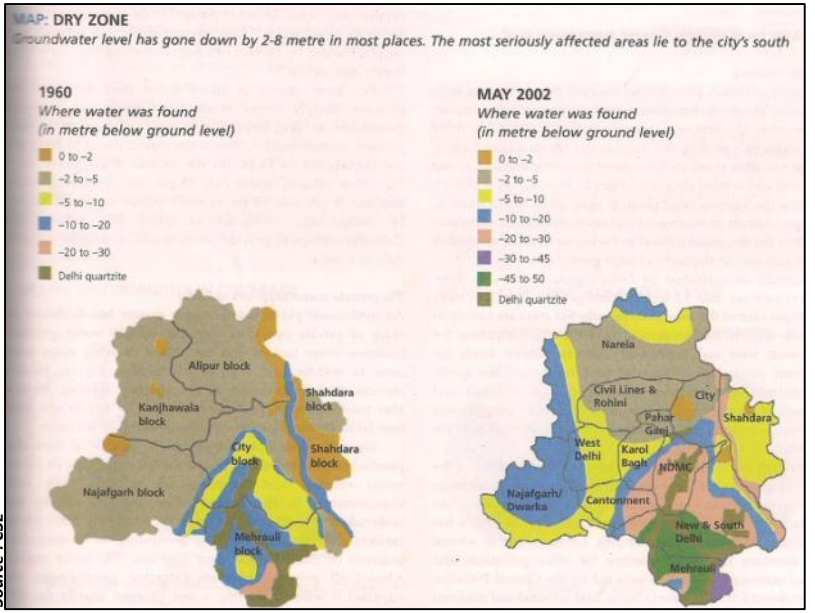
- Existing demand (2011): 4,500 MLD
- Existing supply: 2,135 MLD
- Extra supply possible if leakages plugged: 1,450 MLD
- Required increase in water supply: 48%
- Total sewage generated: 2,800 MLD
- Treatment capacity: 2,284 MLD
- Treated: 1,186 MLD

Disposal: Arabian Sea and Mithi river

KOLKATA

- Existing demand (2011): 1,049 MLD
- Existing supply: 790 MLD
- Extra supply possible if leakages plugged: Nil
- Required increase in water supply: Nil
- Total sewage generated: 1,121 MLD
- Treatment capacity: 173 MLD
- Treated: 173 MLD

Disposal: East Kolkata wetlands and Hoogly river

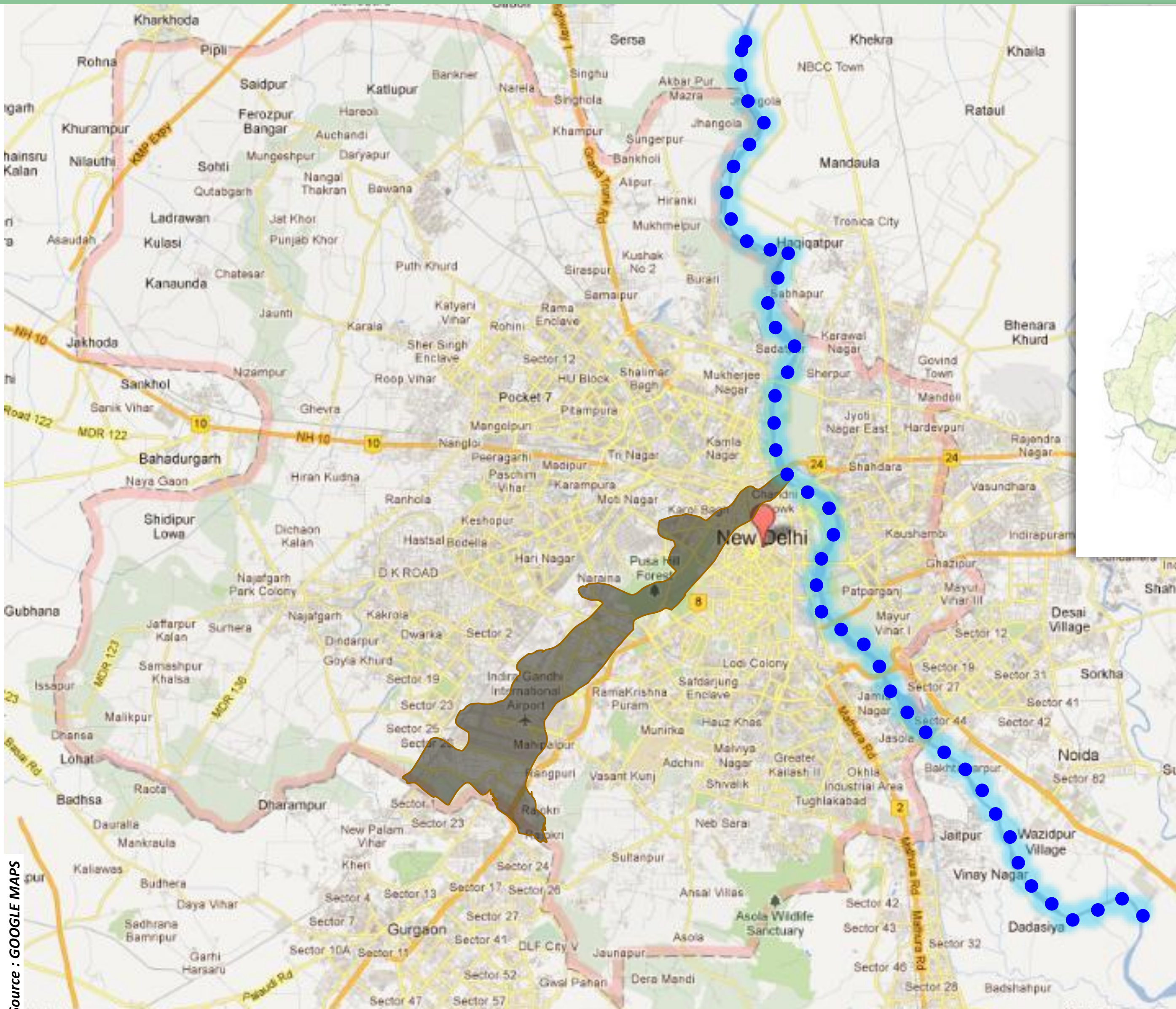


Source : CSE

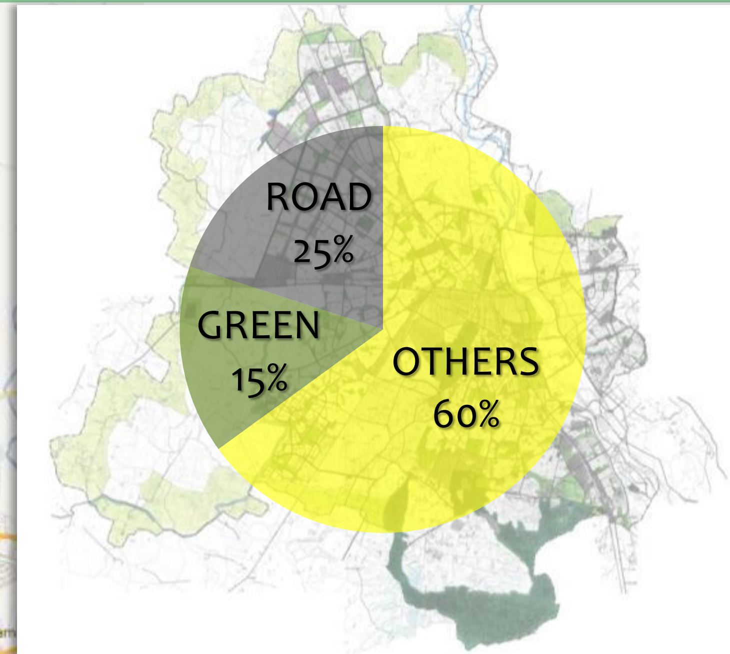
Dry zone map, Delhi

Hindustan Times, 21/02/12

Case of Delhi - Ridge & the River



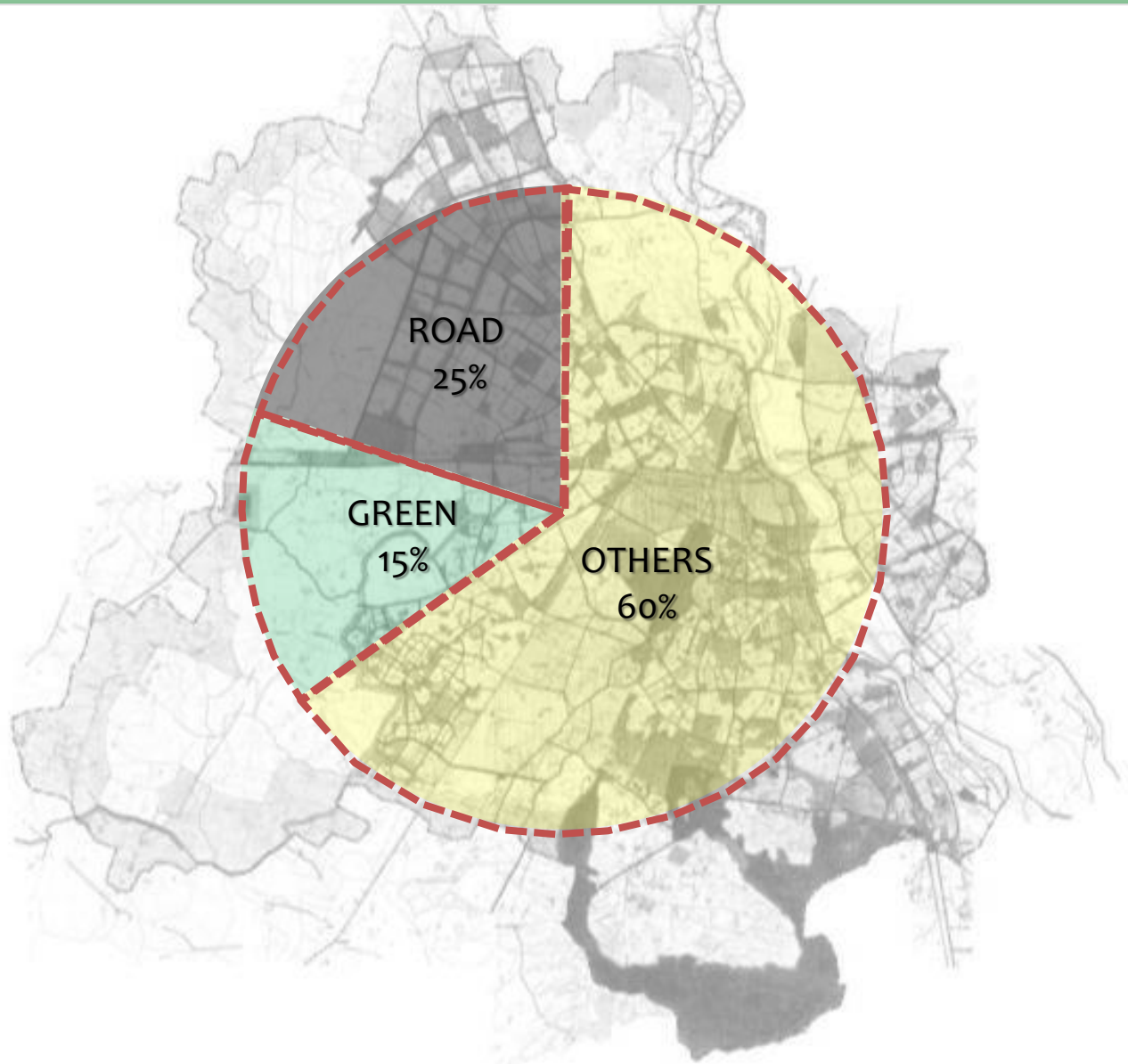
Source : GOOGLE MAPS



LANDUSE PATTERN IN DELHI

Delhi's stormwater drains from the western ridge areas to the river situated in the east. There are 19 major drain outfalls into the River Yamuna.

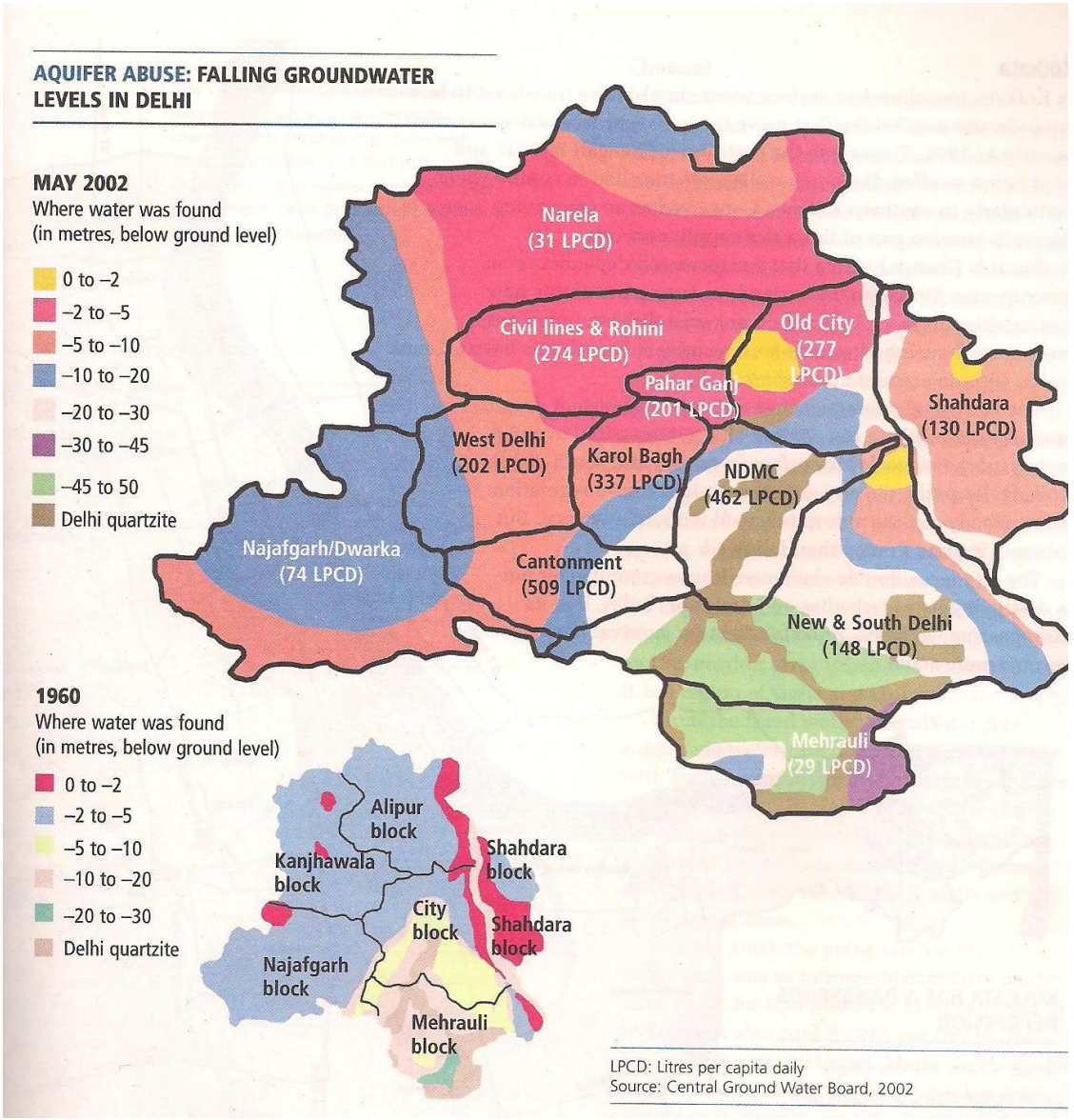
Case of Delhi – storm water management



- Rain water falls on green area
  - some quantity soak in.
  - rest goes to near by drain.
- Other areas
  - Some let the rain water go into the near by drain on road
  - Plots above 100 sq. mt. should do rain water harvesting as per building bye laws.
- Roads
  - All water goes to nalla and then to river.
  - No ground water recharge.

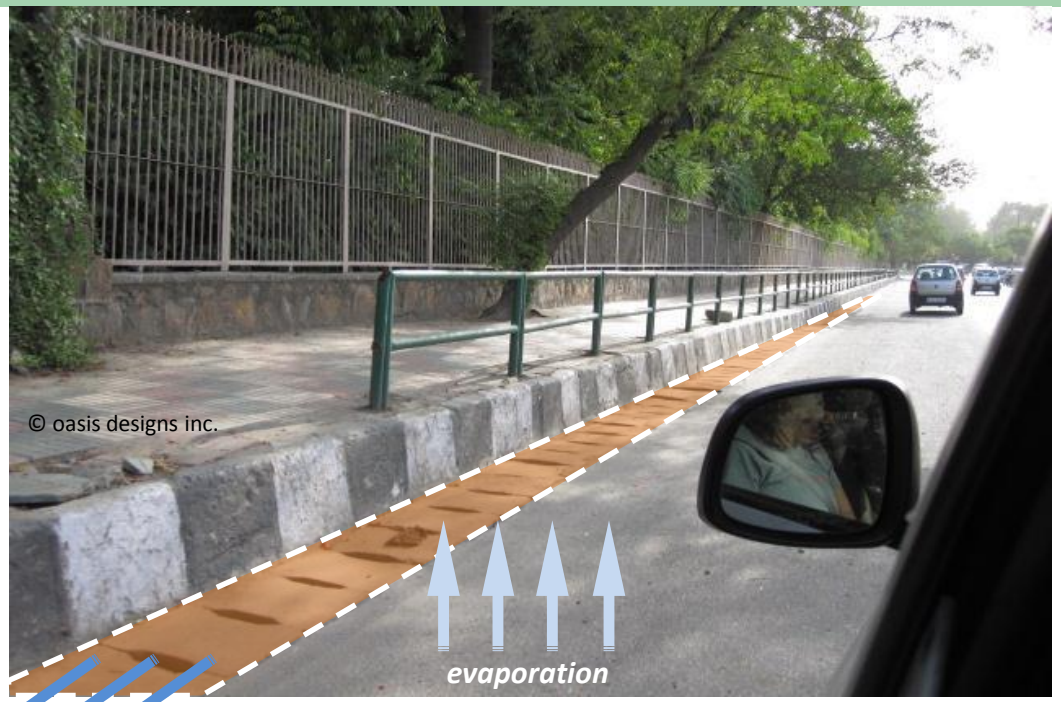
- The average annual rainfall in Delhi is 611 mm.
- However, recharge of ground water gets limited due to decreased availability of permeable surfaces owing to urbanization, and the runoff getting diverted into the sewers or storm water drains that convey the water into the river Yamuna.
- The annual rainwater harvesting potential has been assessed at 900 billion litres or 2500 million liters per day.
- If even 25% of this could be harvested it would imply availability of 625 mld, which would be nearly equivalent to the presently estimated deficiency.
- This is in addition to the potential for roof water harvesting assessed at around 27 mld.

Source : DDA MASTERPLAN OF DELHI 2021



Source : CSE

PRESENT Storm water management facility in the city

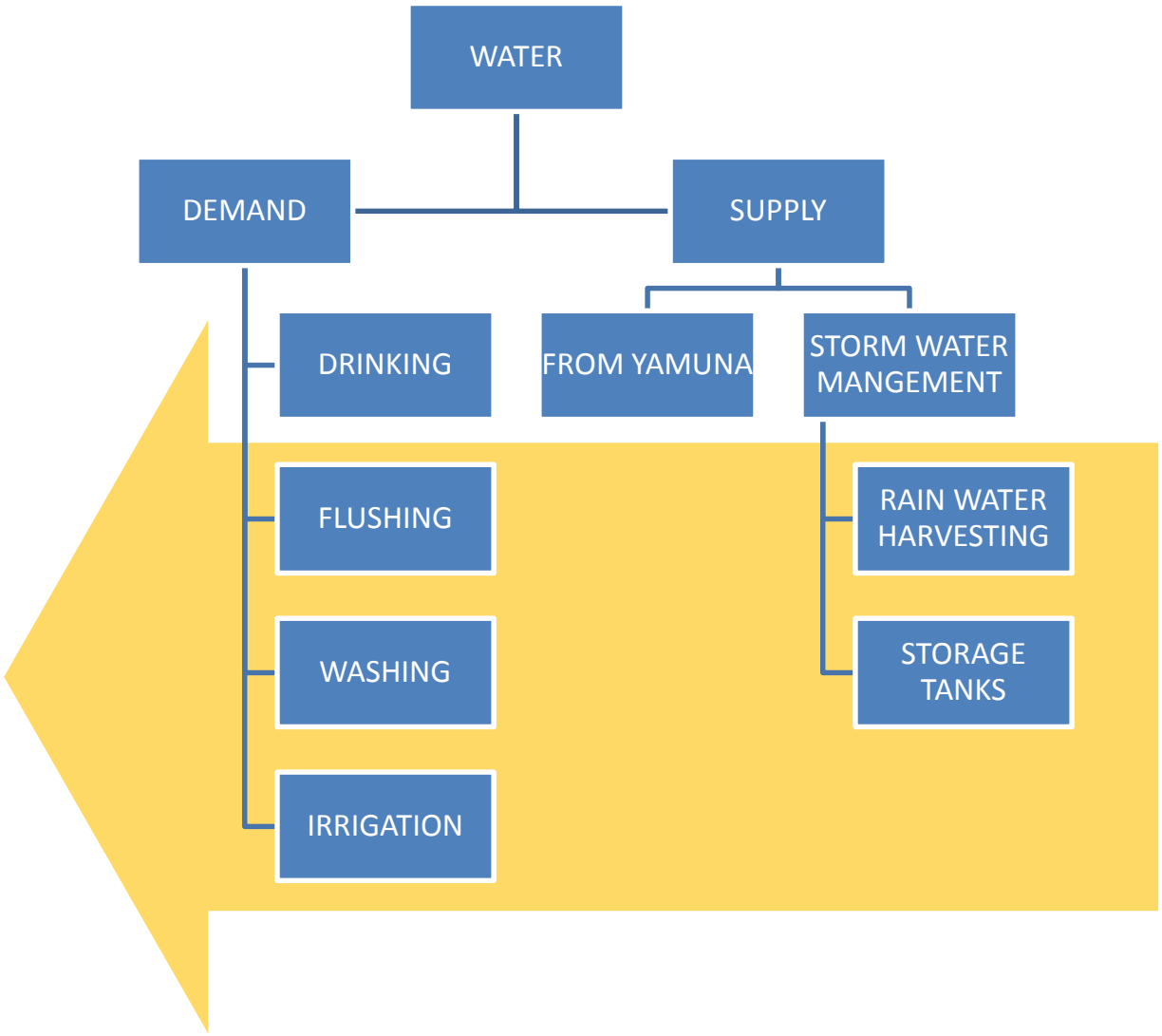


Storm water from road goes to near by drain and then to river.

No ground water recharge

Most of the time, the existing system are clogged up

Sustainable storm water management

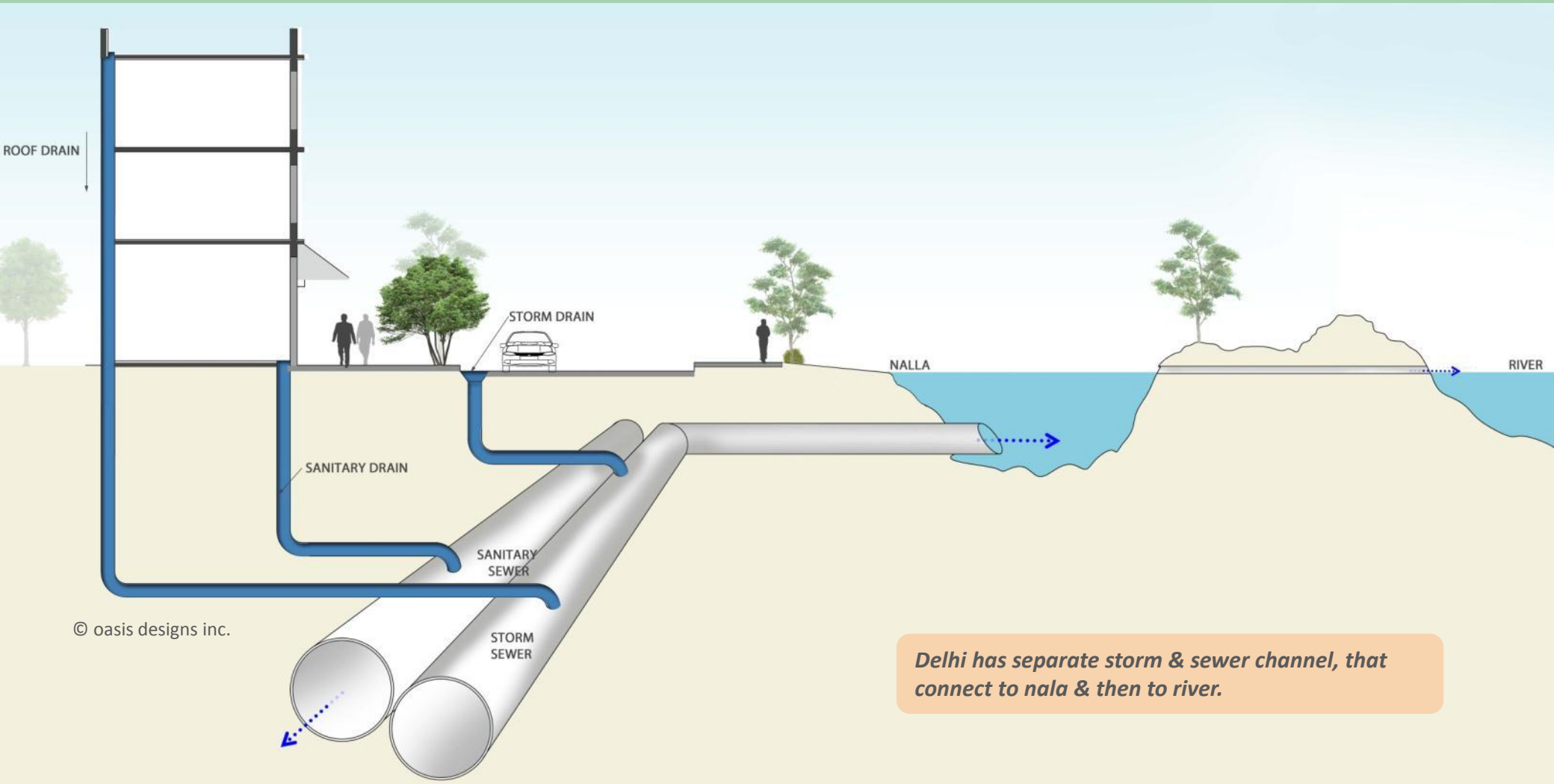


With the help of sustainable storm water management the harvested water can be used for non-potable water uses.

Source : http://ourdelhistruggle.files.wordpress.com/2009/07/flood2.jpg?w=500

In spite Of Water Crisis the city is facing flooding problems.

Existing drainage system in the city



Delhi has separate storm & sewer channel, that connect to nala & then to river.

Present Drainage systems in the city

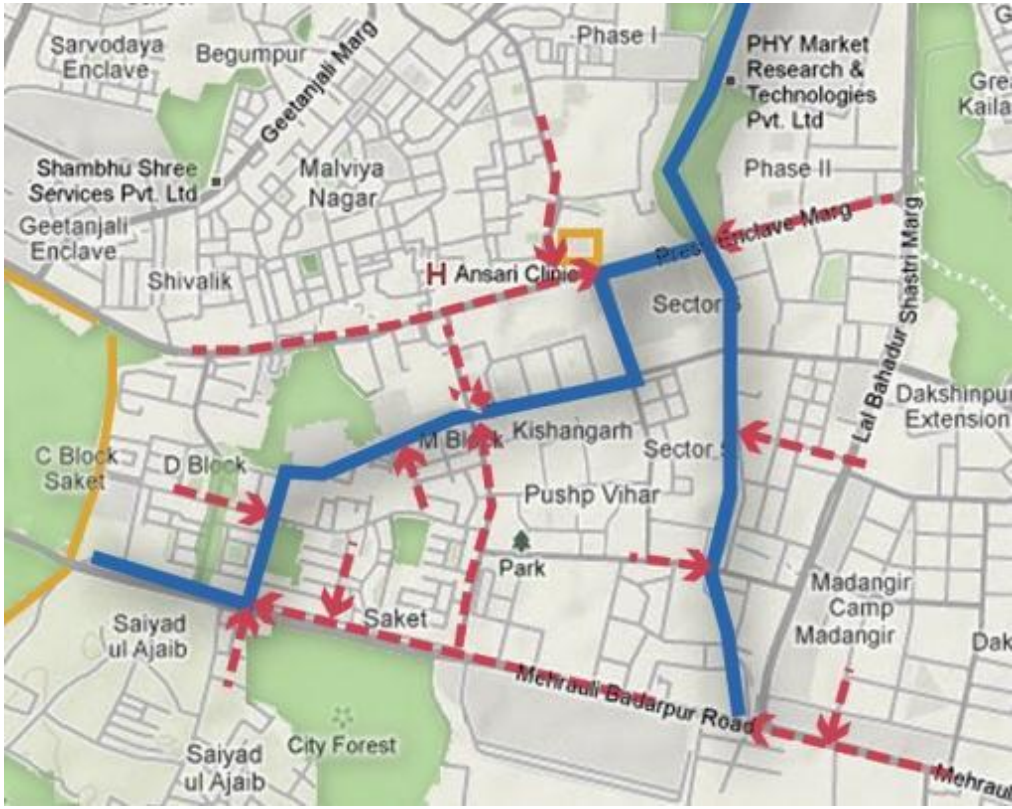
As per Delhi's MPD 2020

"ZERO RUN OFF SHOULD BE ACHIEVED"

The Present drainage system targeting

"100% RUN OFF"

One pipe leading to Another



All the stormwater falls on road and it is diverted towards the closest nala or drain.

Now it's time to STOP & RETHINK.

***Storm Water Retrofit designs** are required to overcome these situations and achieve successful ground water recharge.*

What's a storm water retrofit ?

The installation of a new facility to recharge & treat storm water from existing impervious area.

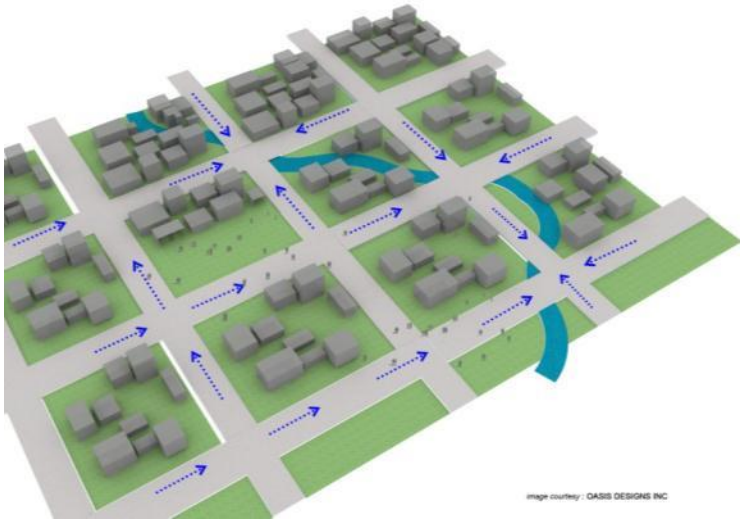
GOALS:

- Retrofit the existing system to achieve sustainable storm water management.
- Use site design techniques that filter, convey, detain, retain , infiltrate and store runoff.

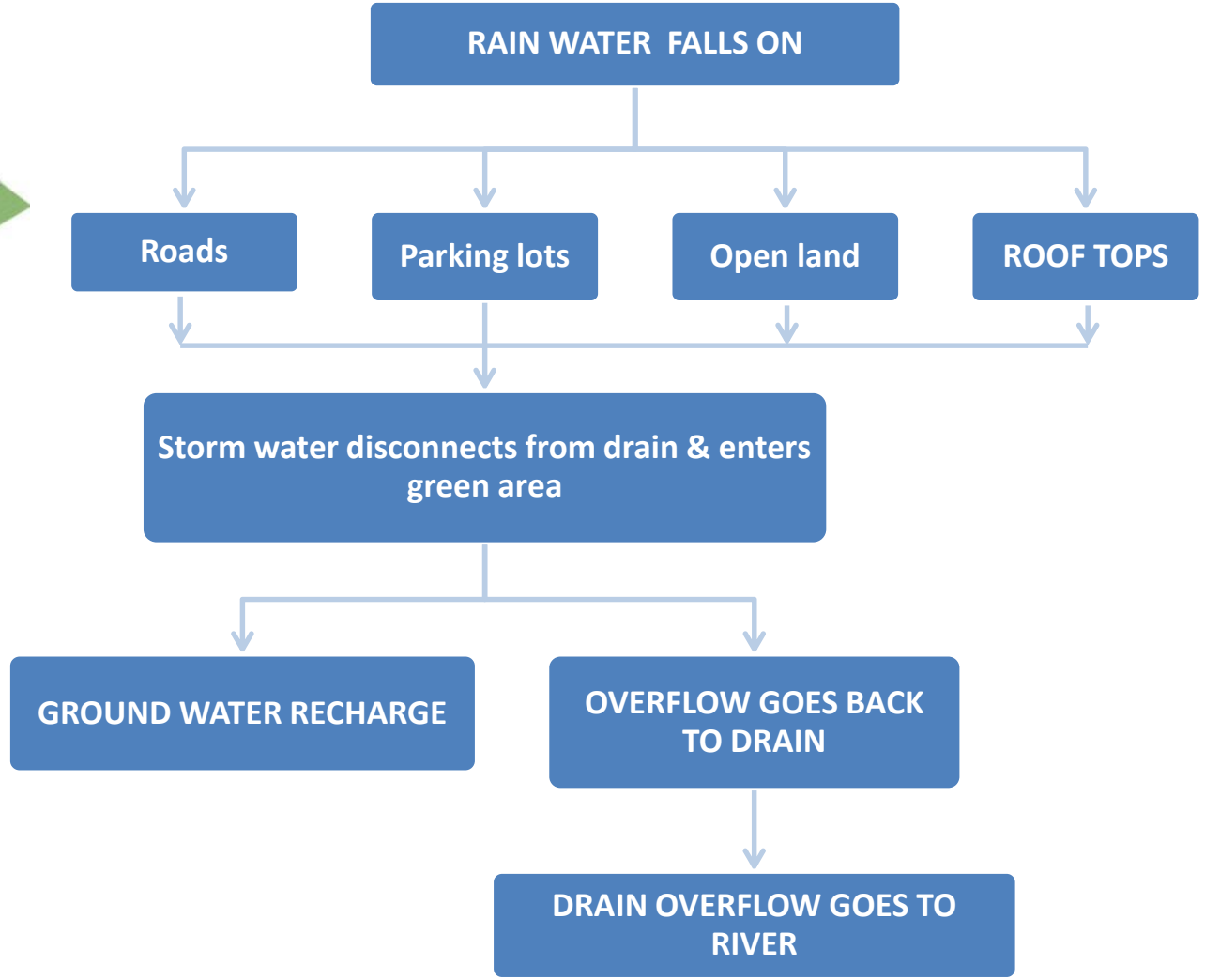
HOW

How do we retrofit our cities to achieve a more sustainable Storm Water drainage system ?

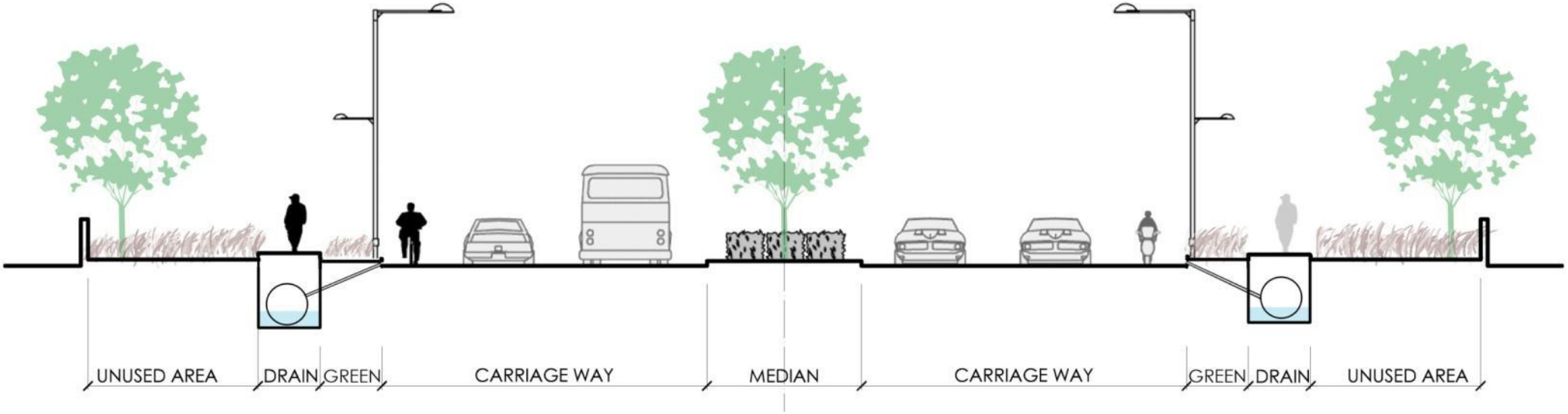
Storm Water Management Strategy – disconnecting the system



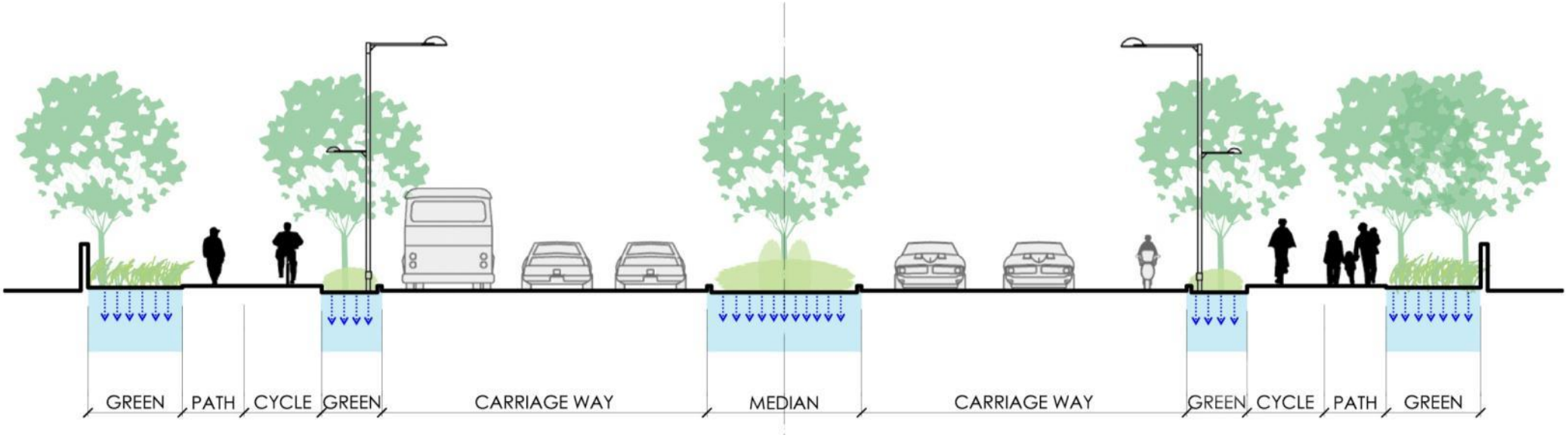
New strategy for disconnecting from the conventional pipe system and using all possible alternate areas for recharge.



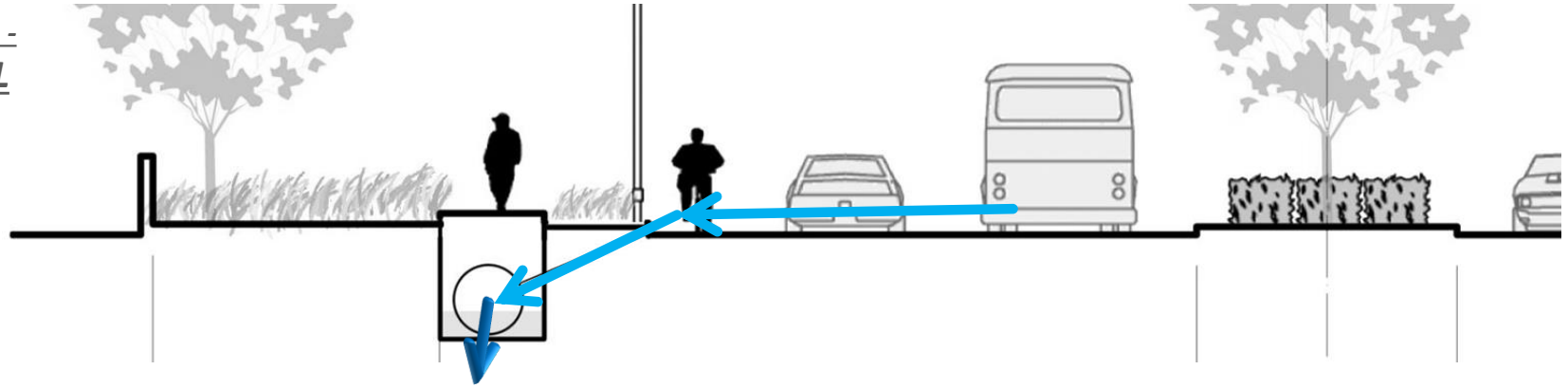
ROAD SECTION - CONVENTIONAL



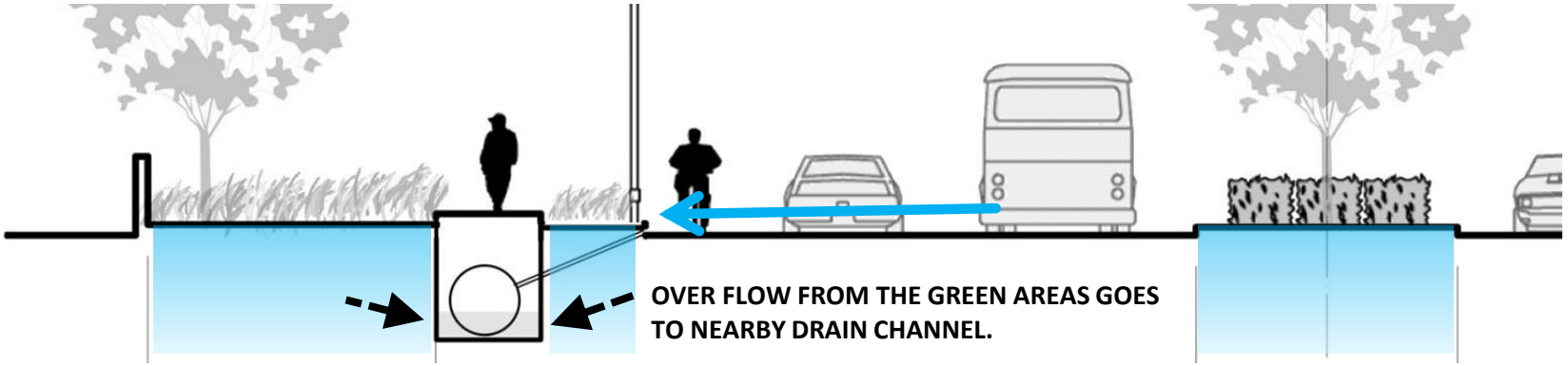
ROAD SECTION - PROPOSED



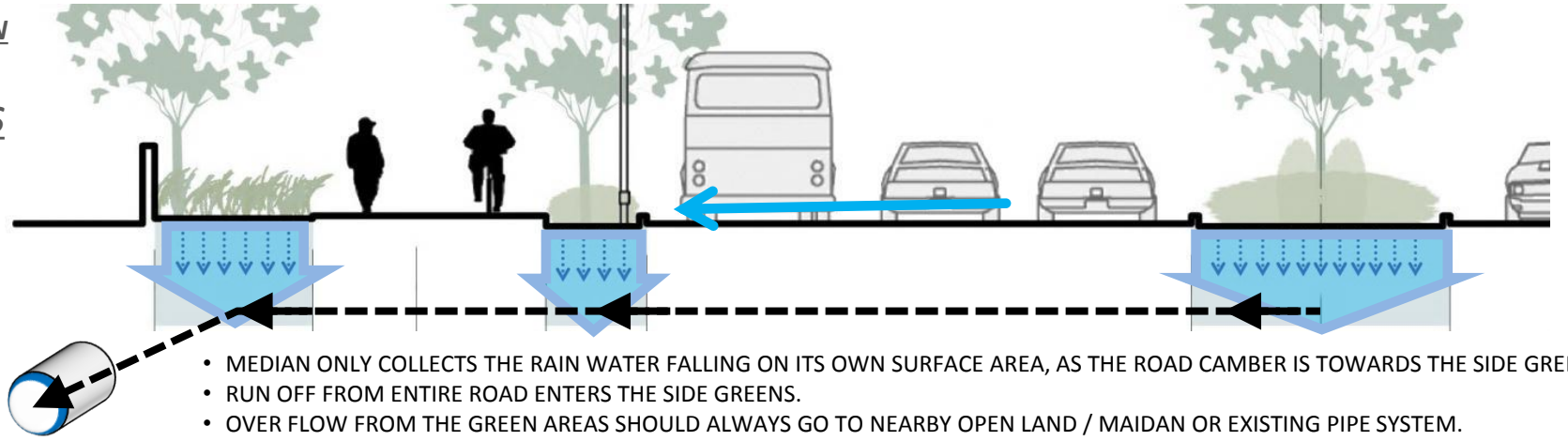
PART ROAD SECTION -
CONVENTIONAL



PART ROAD SECTION
PROPOSED

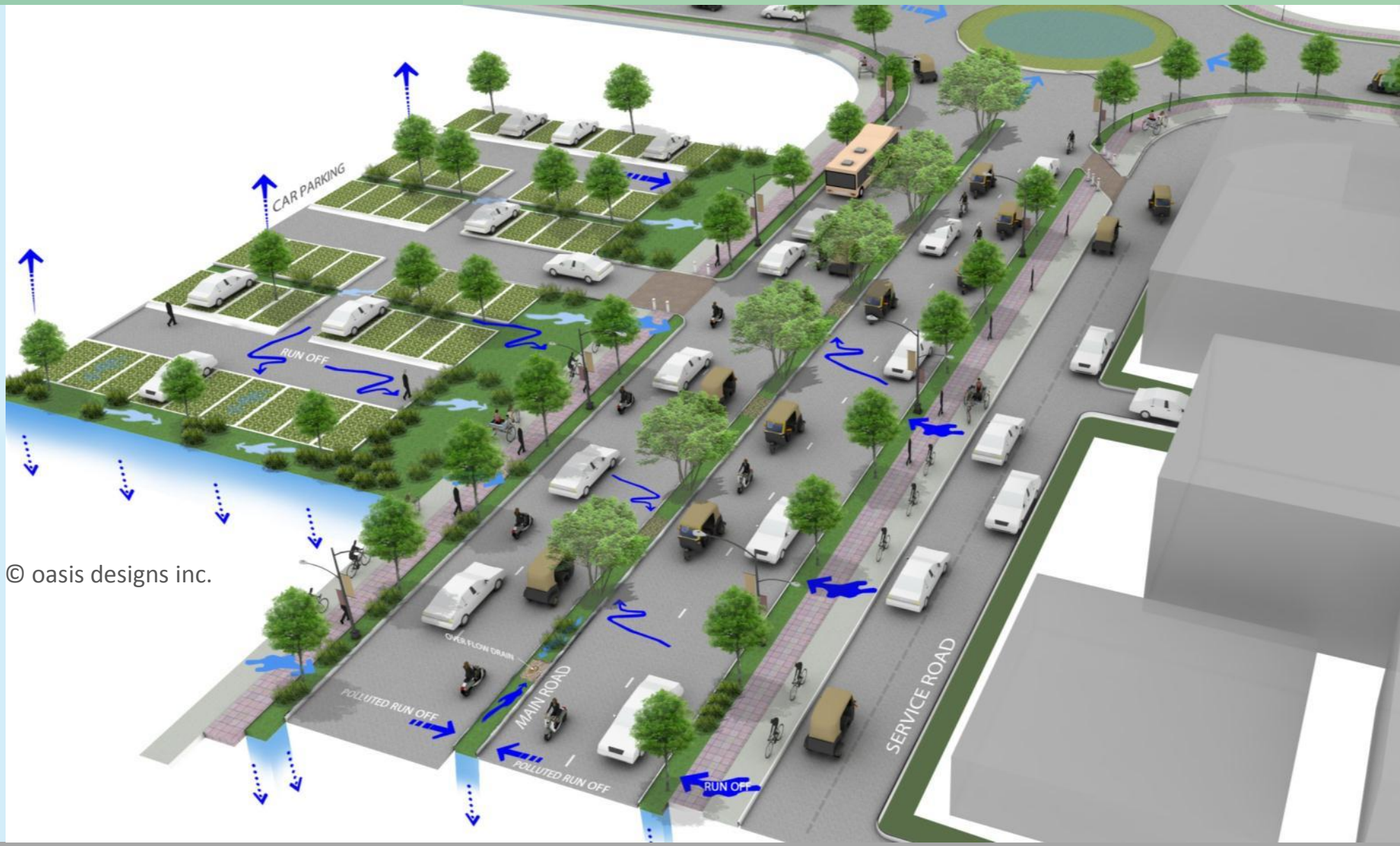


PART ROAD SECTION
– PROPOSED FOR NEW SITES



- MEDIAN ONLY COLLECTS THE RAIN WATER FALLING ON ITS OWN SURFACE AREA, AS THE ROAD CAMBER IS TOWARDS THE SIDE GREENS.
- RUN OFF FROM ENTIRE ROAD ENTERS THE SIDE GREENS.
- OVER FLOW FROM THE GREEN AREAS SHOULD ALWAYS GO TO NEARBY OPEN LAND / MAIDAN OR EXISTING PIPE SYSTEM.

Storm water facilities that can be put on Road



If there is less space on road side,

Water can be taken through drain channel to nearby large green area or other conveyance system / harvesting system.

Design Strategies for sustainable SWM

MANAGE STORM WATER *IN A CITY BY ADOPTING FOLLOWING MEASURES*

- **FILTRATION**
- **CONVEYANCE**
- **DETENTION**
- **RETENTION**
- **INFILTRATION**

Looking beyond conventional details

Conventional Kerb Examples to Avoid

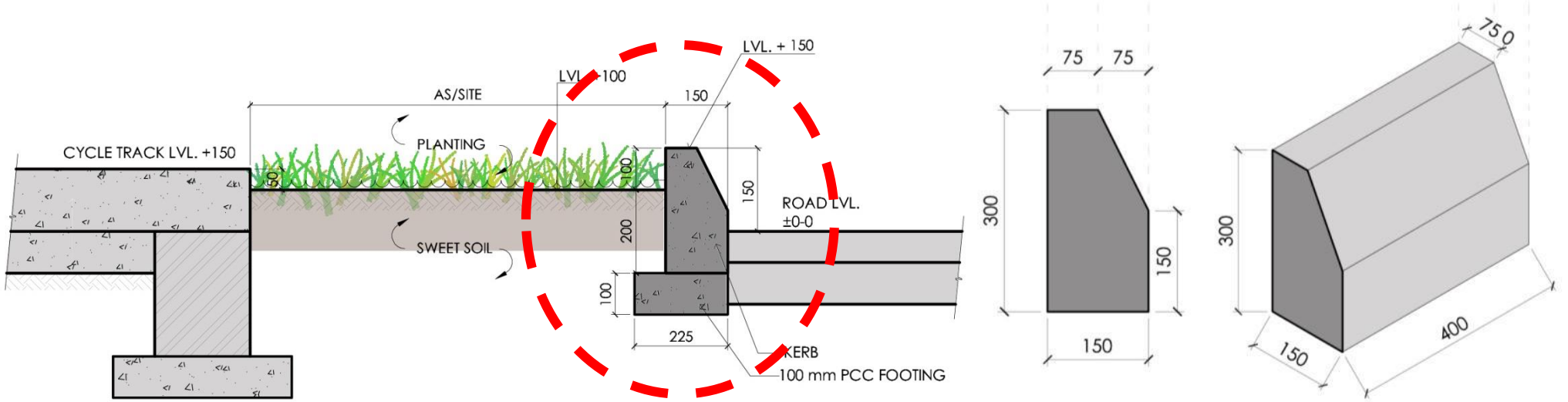
EXISTING

EXISTING STREET IS DESIGNED IN SUCH A WAY , WHERE THE RAIN WATER ENTERS FROM THE BELL MOUTH TO THE DRAINAGE PIPE & THEN TO NEARBY NALLAH.

PROPOSED

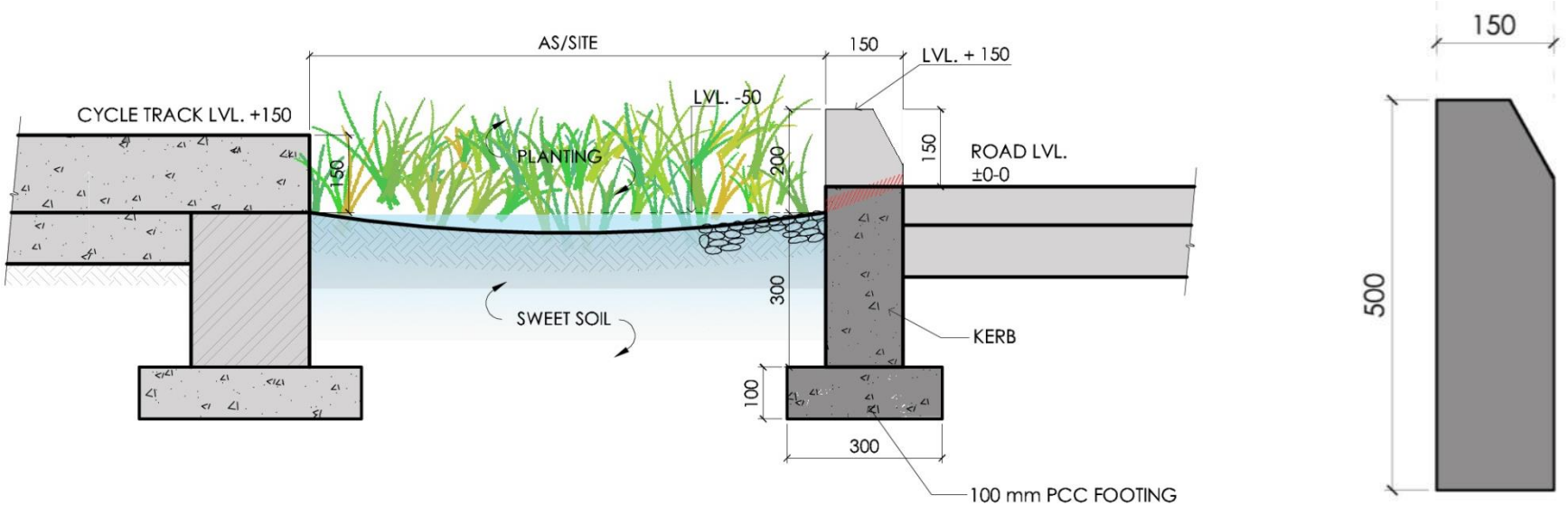
- STORM WATER ENTERS THE ADJACENT GREEN AREA THROUGH **KERB CUTS.**
- THE GREEN AREA **LVL IS ALWAYS LOWER THAN ROAD LVL.**

Conventional kerb stone used on road



GREEN IS HIGHER THAN ROAD LVL

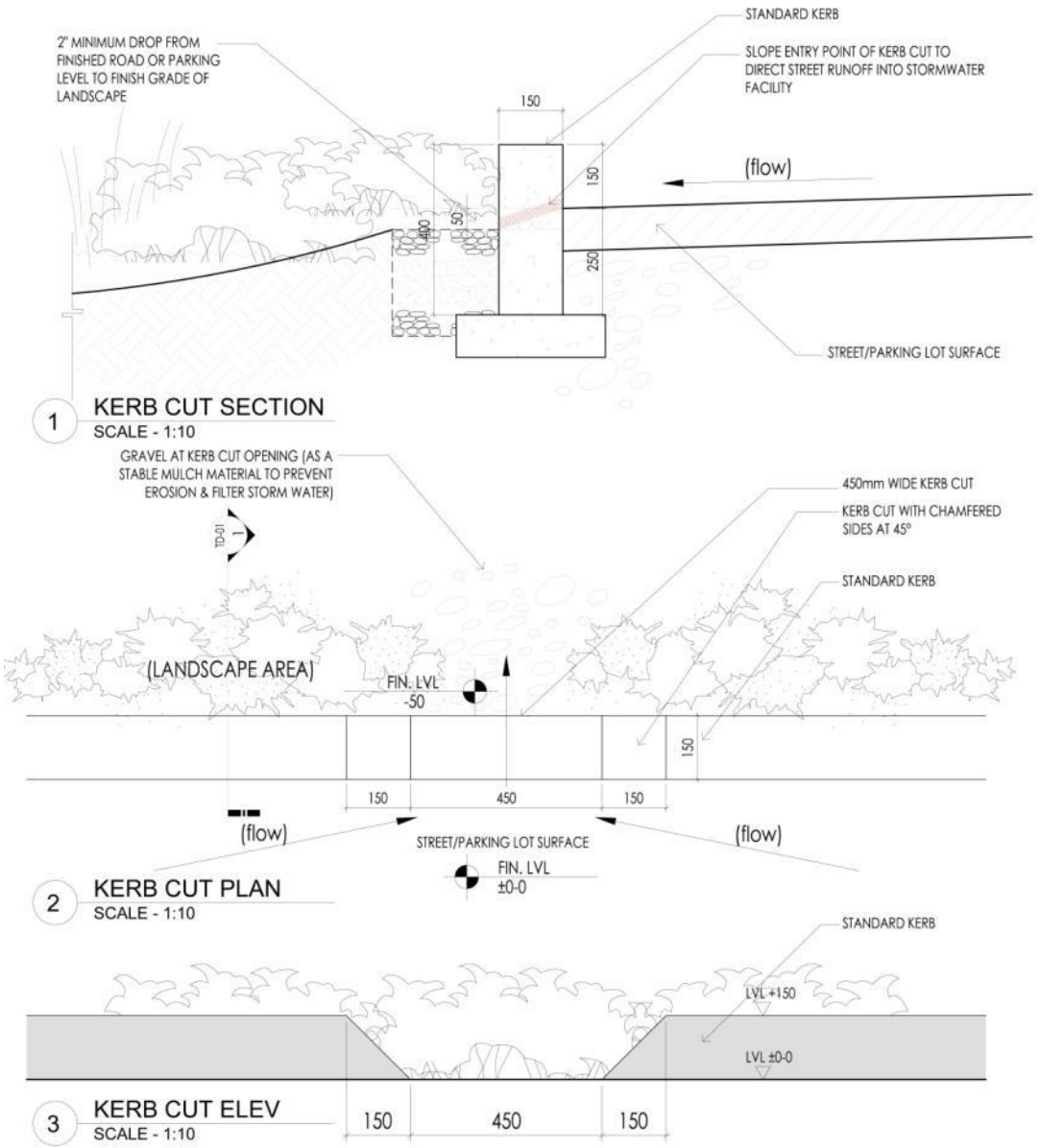
NEW kerb stone for Storm water management

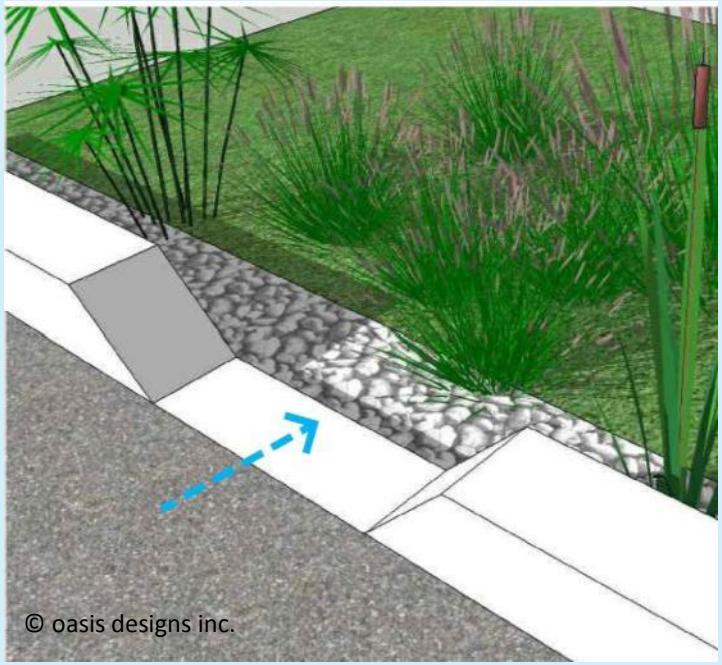


DEEPER KERB STONE SHOULD BE USED TO ACHIVE LOWER GREEN AREAS.

Kerb type to FOLLOW

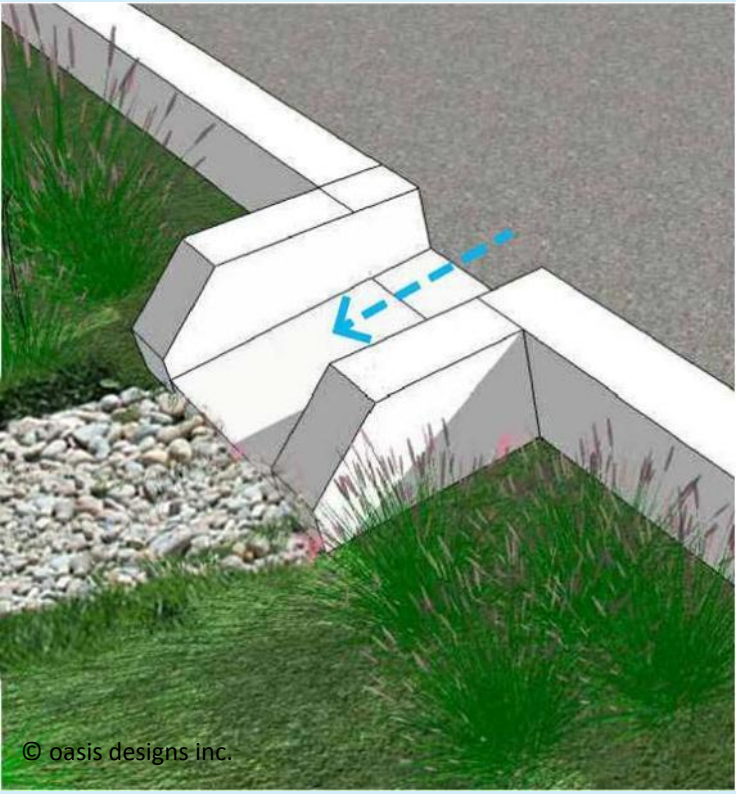
Kerb depth would be more than conventional kerb depth & green area level should be lower than adjacent road level

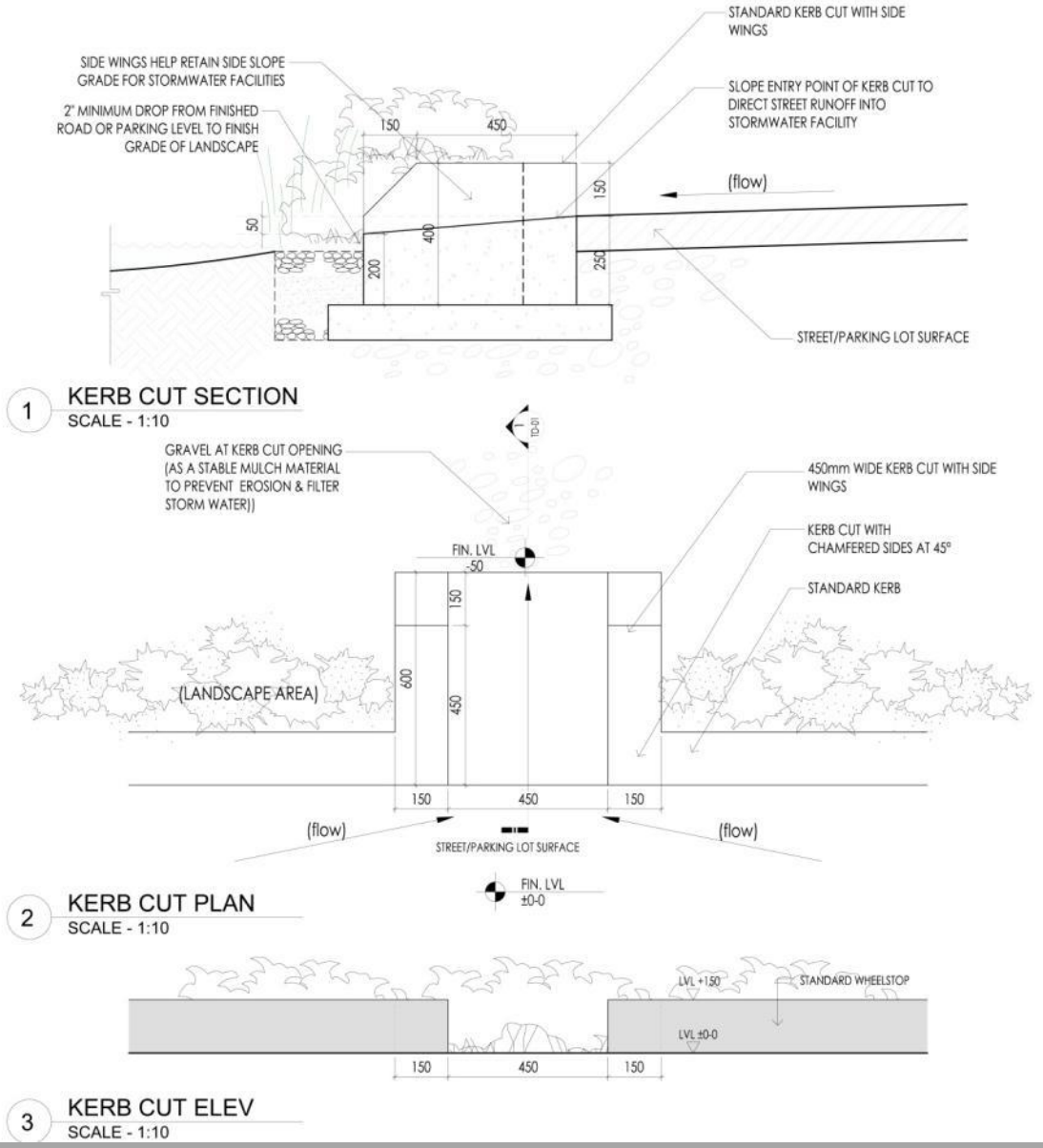




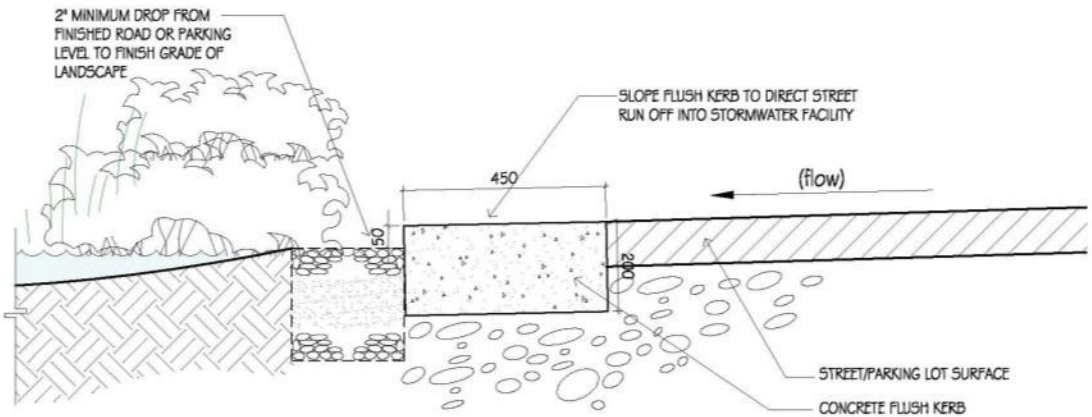
A standard curb cut allows storm water runoff to enter a parking lot rain garden. This curb cut has 45 degree chamfered sides.

Kerb with side wings

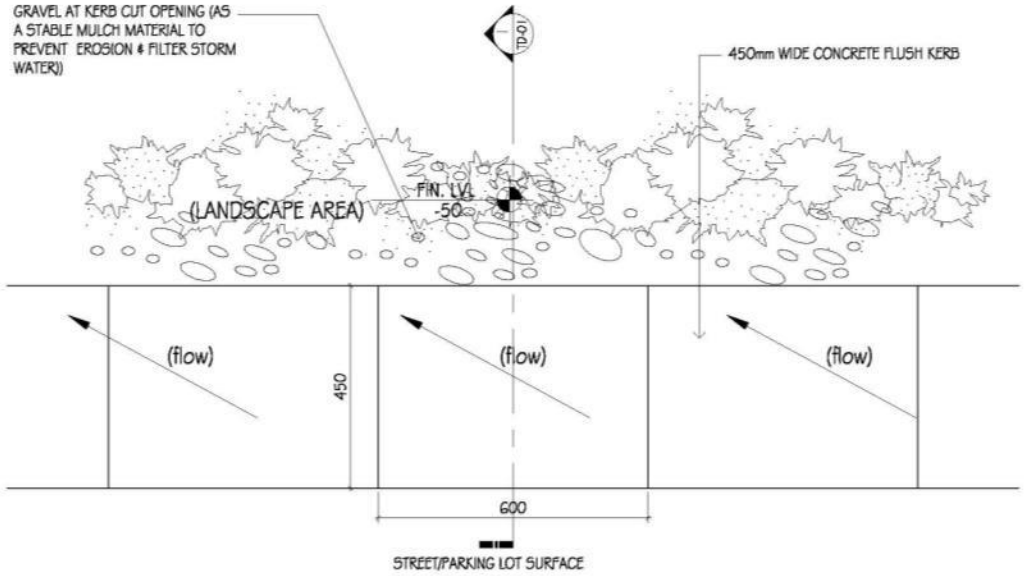




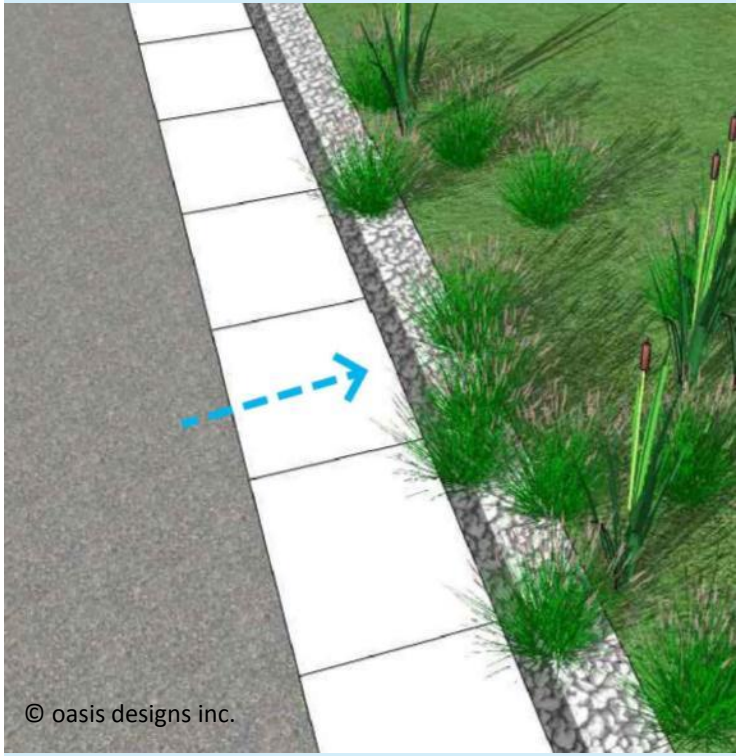
Flush Kerb



1 KERB CUT SECTION
SCALE - 1:10

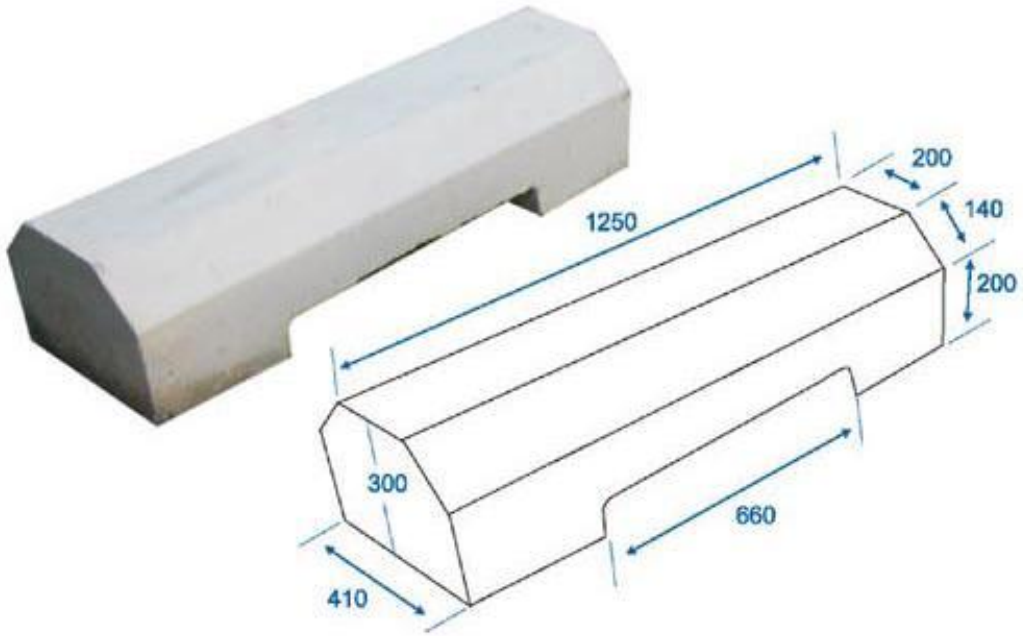


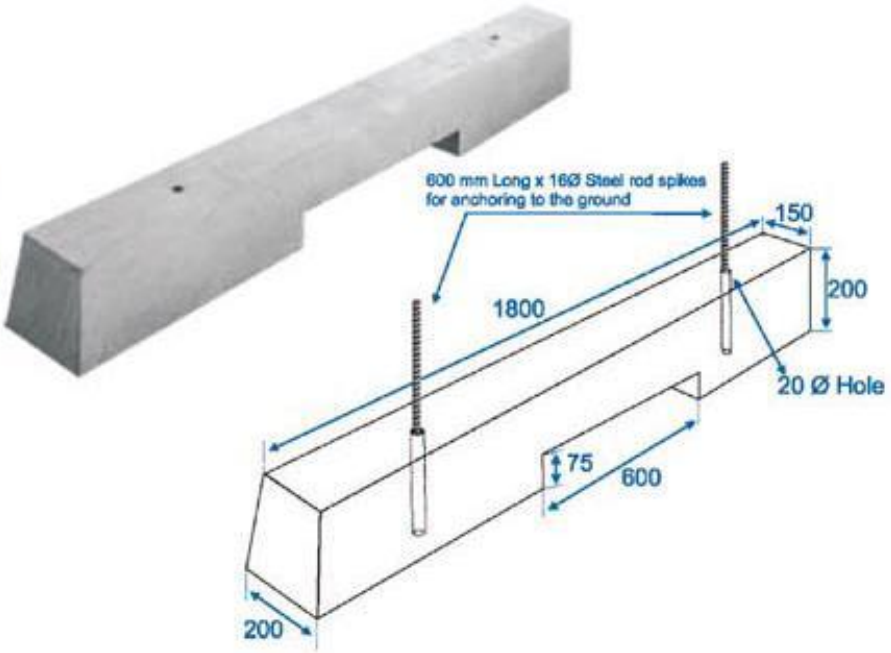
2 KERB CUT PLAN
SCALE - 1:10



KERB STONE available in Existing Catalogues

Image source ***: KK manholes***





Advantages of using above kerb stone

1. Faster runoff of water from road to surrounding areas.
2. No water clogging on the roads & hence longer life of the road.
3. Rain water harvesting by the water is possible.
4. Can be used as a sitting area along the footpath.
5. No separate drainage pipe required.

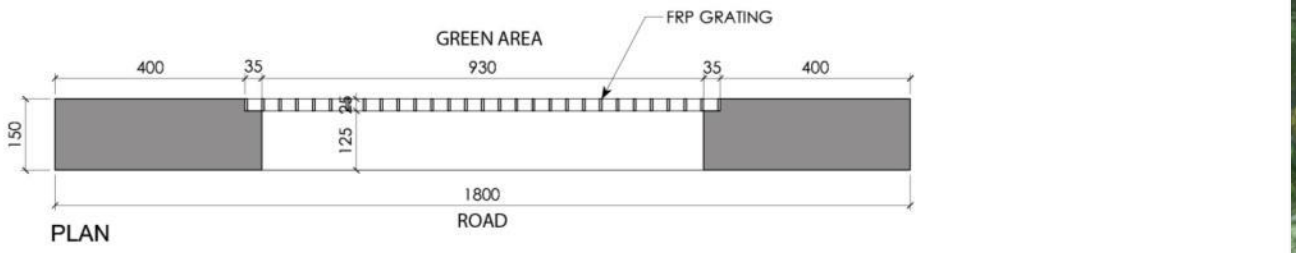
Konkrete Precast Concrete Products are manufactured using the latest vibro-compaction techniques, accurately designed moulds, appropriate reinforcement with circular plastic spacers and a concrete grade of M30 and above. We can also produce customised products for your special needs, subject to large quantities. To order customised products, sizes, strength required and other necessary information needs to be sent.
In our constant endeavour to improve the products, the specifications may change without notice.

All dimensions are in mm

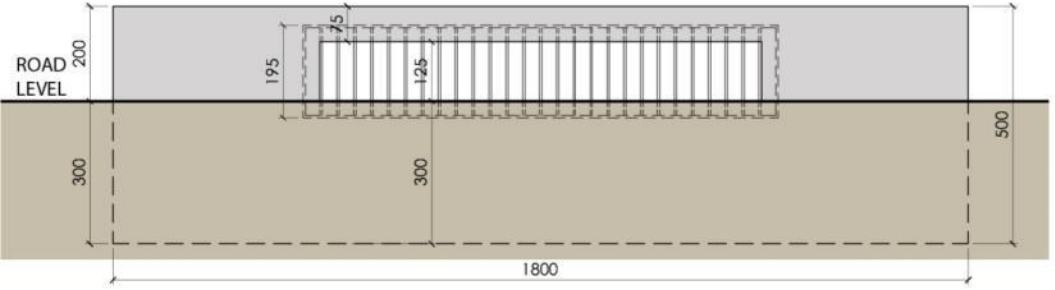
BENEFITS OF PRECAST CONCRETE

STRENGTH – THE STRENGTH OF PRECAST CONCRETE GRADUALLY INCREASE OVER TIME. OTHER MATERIALS CAN DETERIORATE, EXPERIENCE CREEP AND STRESS RELAXATION, LOSE STRENGTH AND/OR DEFLECT OVER TIME. THE LOAD-CARRYING CAPACITY OF PRECAST CONCRETE IS DERIVED FROM ITS OWN STRUCTURAL QUALITIES AND DOES NOT RELY ON THE STRENGTH OR QUALITY OF THE SURROUNDING BACKFILL MATERIALS.

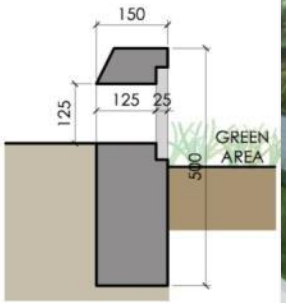
KERB STONE with FRP Grating



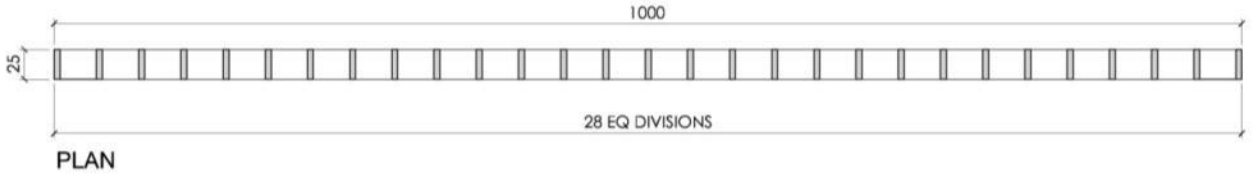
PLAN



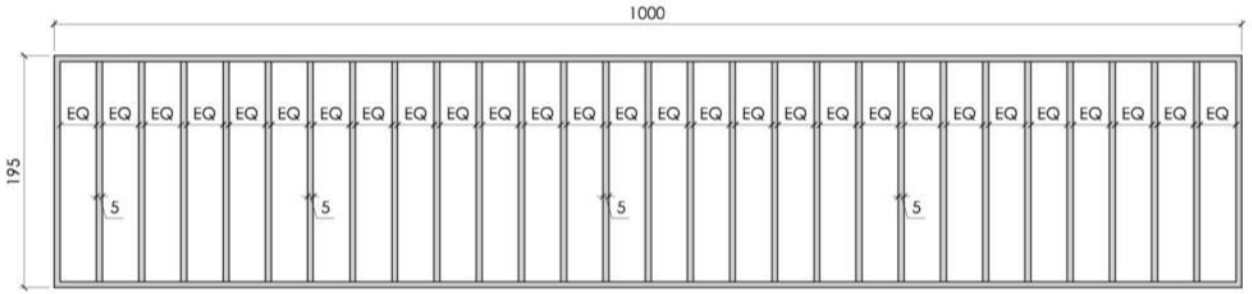
ELEVATION



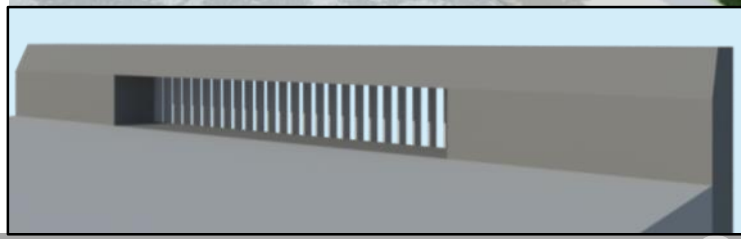
SECTION



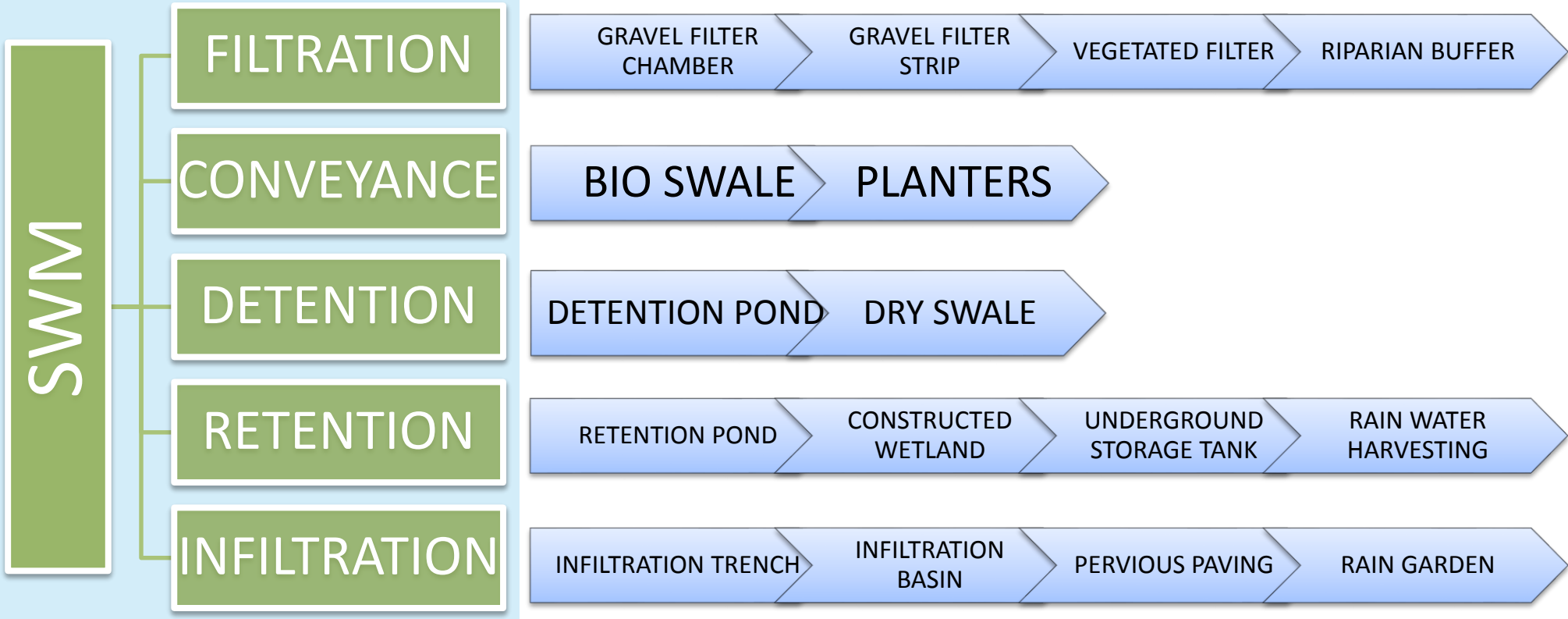
PLAN



ELEVATION



STORM WATER MANAGEMENT CHART



FILTRATION

FILTRATION

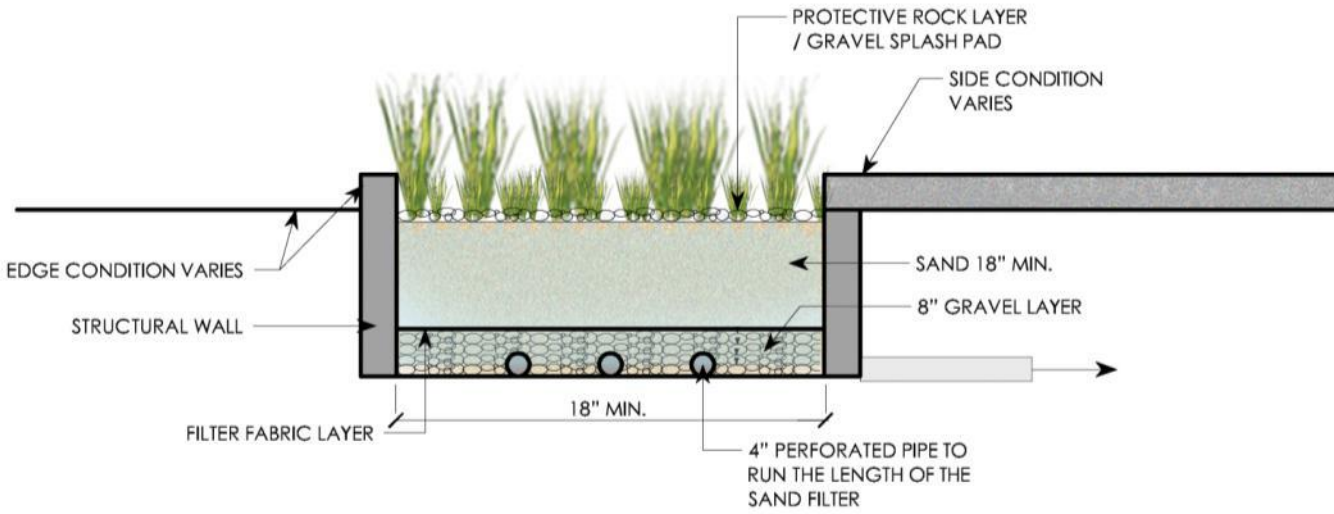
- Filtration can include rock and vegetated swales, filter strips or buffers, sand filters.
- Prevents sediments and other materials from reaching and clogging downstream facilities
- The filtration is effective if flows are slow and depths are shallow.
- The slow movement of runoff through vegetation or gravel provides an opportunity for sediments and particulates to be filtered and degraded through biological activity.
- In draining soils, the filters also provides an opportunity for storm water infiltration, which further removes pollutants and reduces runoff volumes.
- These are especially applicable to parking lots and along highways as they can be sloped into linear grass or rock swales to collect and treat runoff from pavement surfaces. Adjacent pavement level should be slightly higher than the filtration area.

Filtration systems are

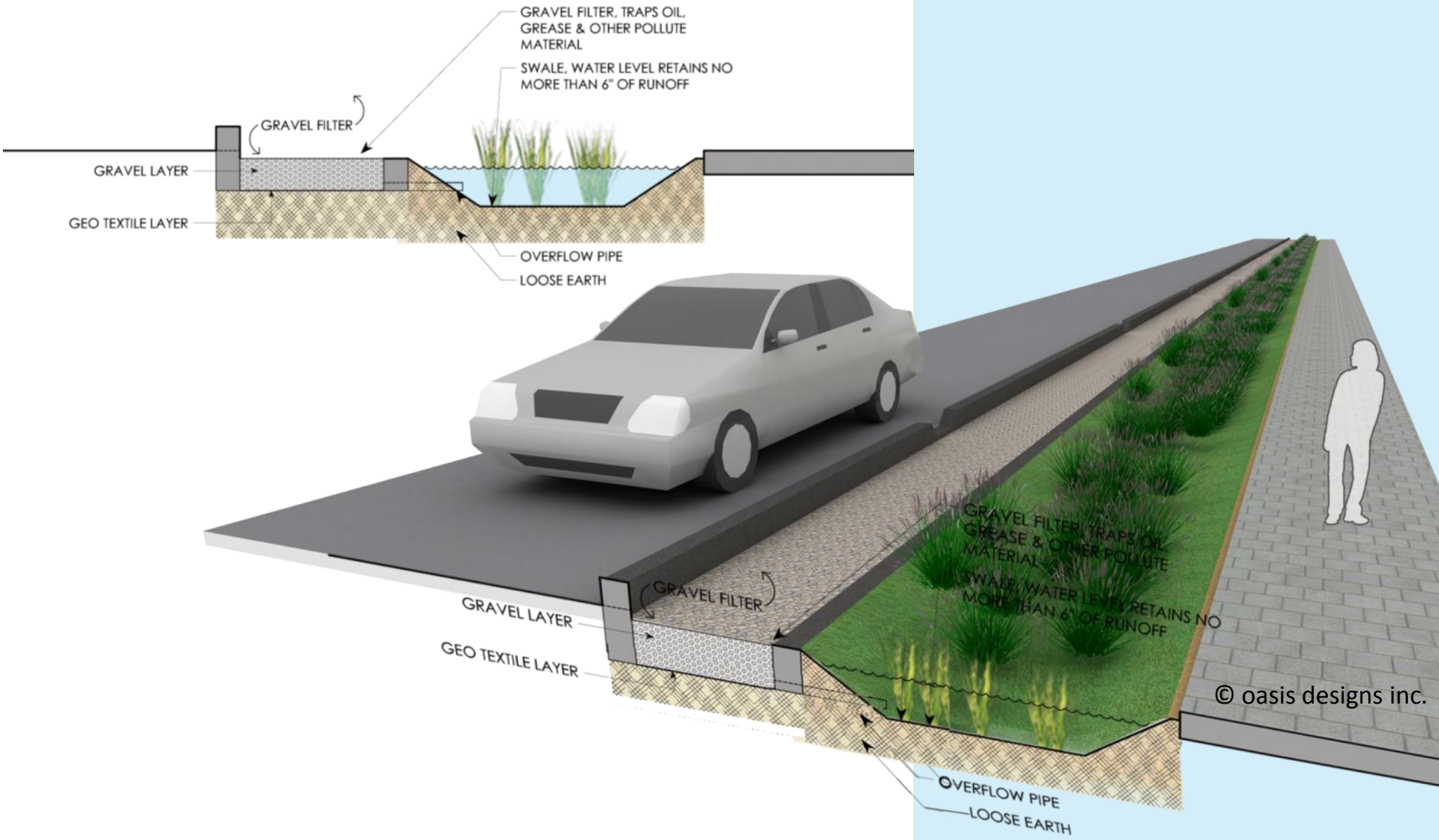
- Gravel filter
- Vegetated filter
- Riparian buffer

GRAVEL FILTER

- Gravel filter can be designed with an impervious bottom or is placed on an impervious surface.
- Pollutant reduction is achieved as the water filters through the gravel & sand.
- Filters may be constructed in-ground or above grade, as they can include a waterproof lining.
- Gravel filters are can be used next to road kerb or foundation walls, adjacent to property lines (if less than 30” in height), or on slopes.
- An overflow to an approved conveyance and disposal method will be required.
- Irrigation facilities to be given for non monsoon season.



Continuous Gravel Filter along road

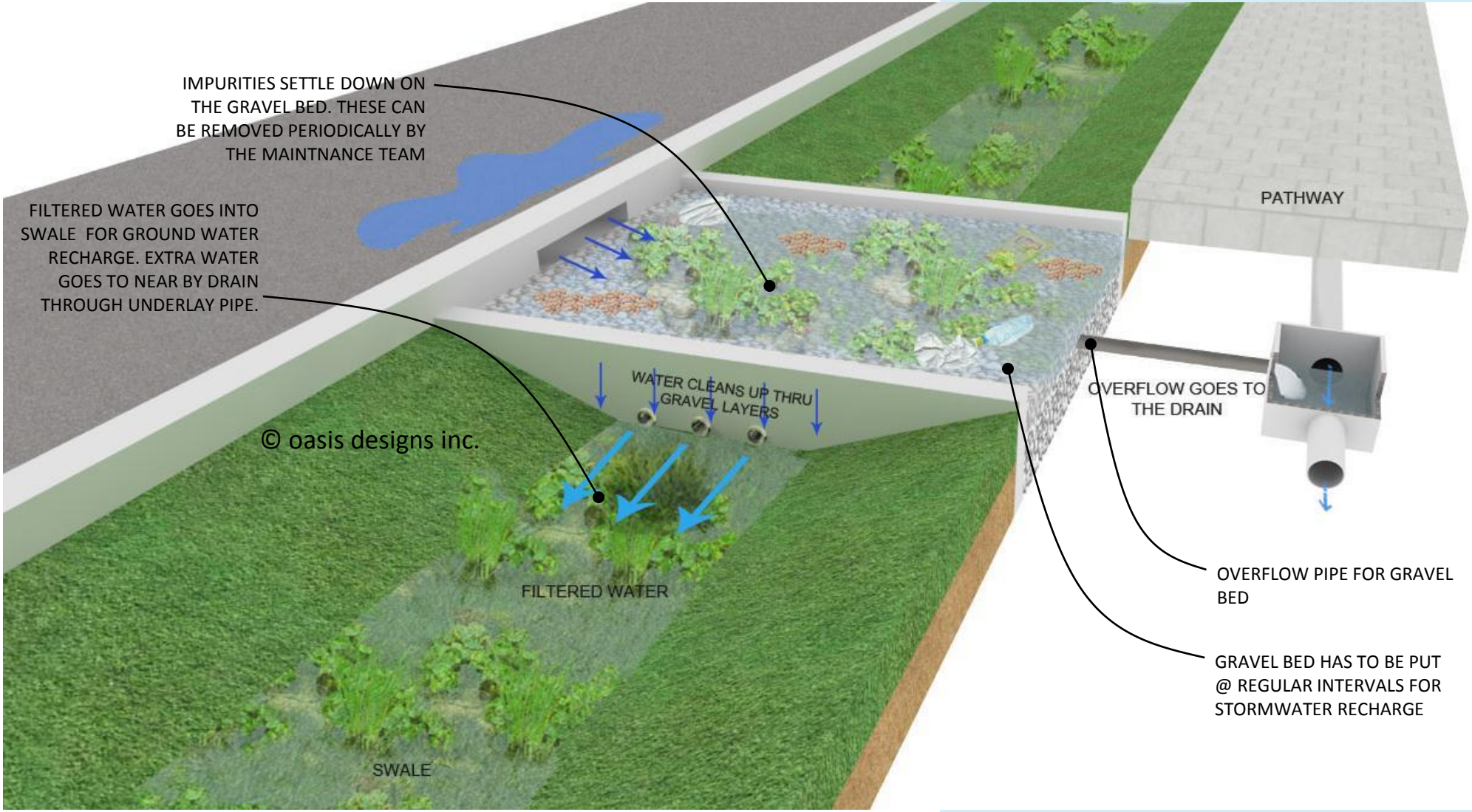


Existing Drain systems on road

FILTRATION NEEDS TO STOP ALL THE DIRT & POLLUTANTS (OIL & GREASE) ENTERING THE STORM WATER CHANNEL & WATER BODIES.

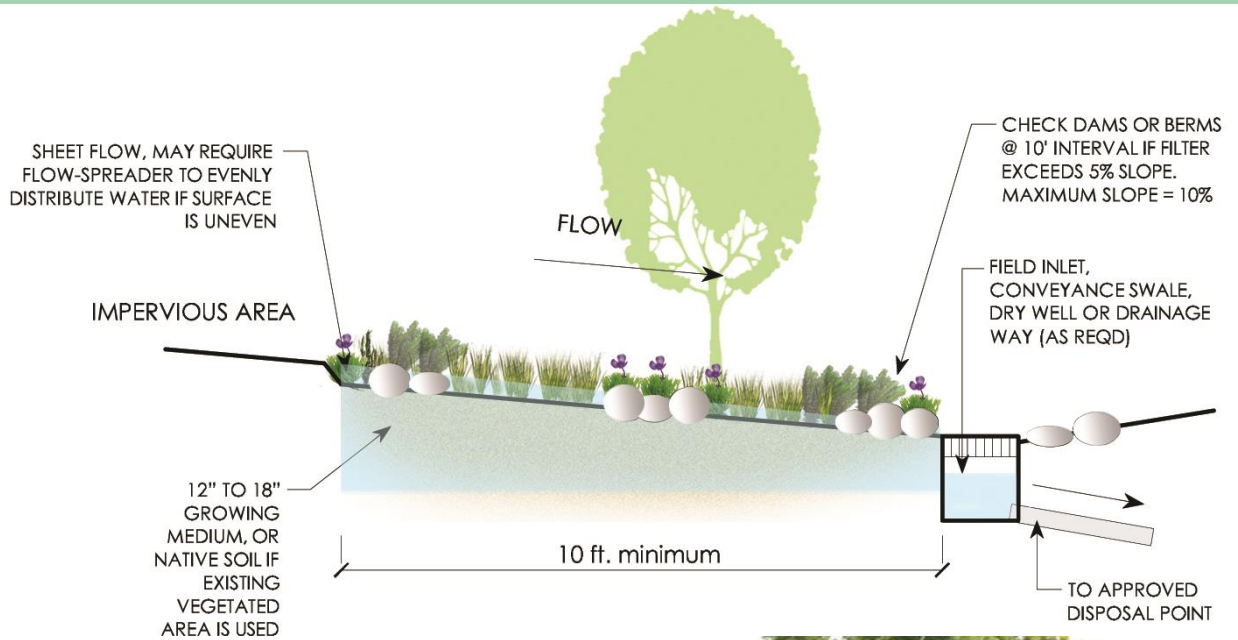
Gravel Filter Chamber @ some intervals –

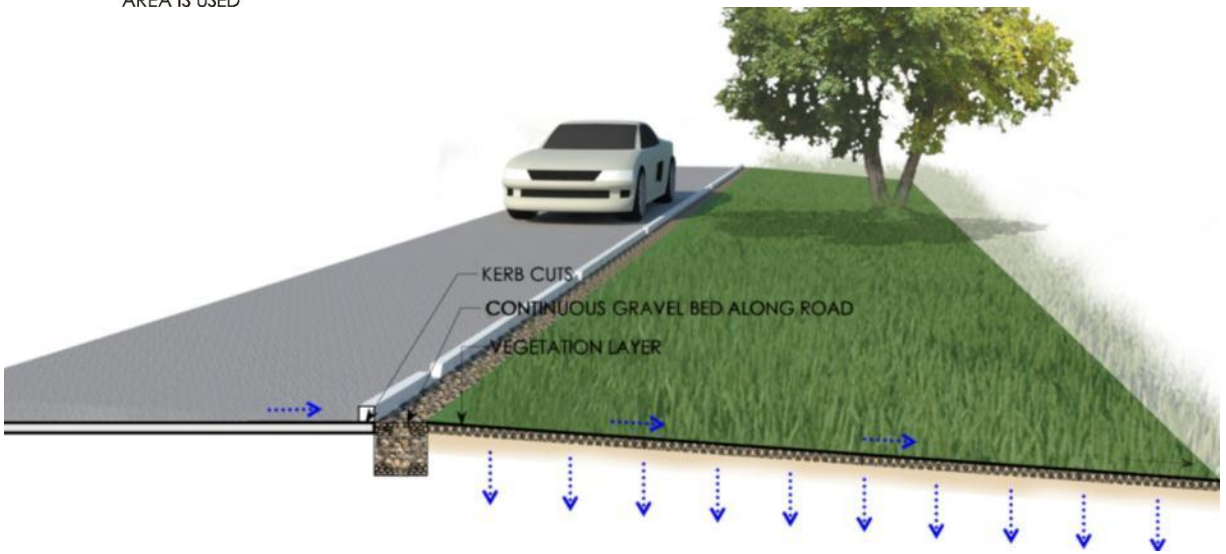
How to control impurities from going in to the green area



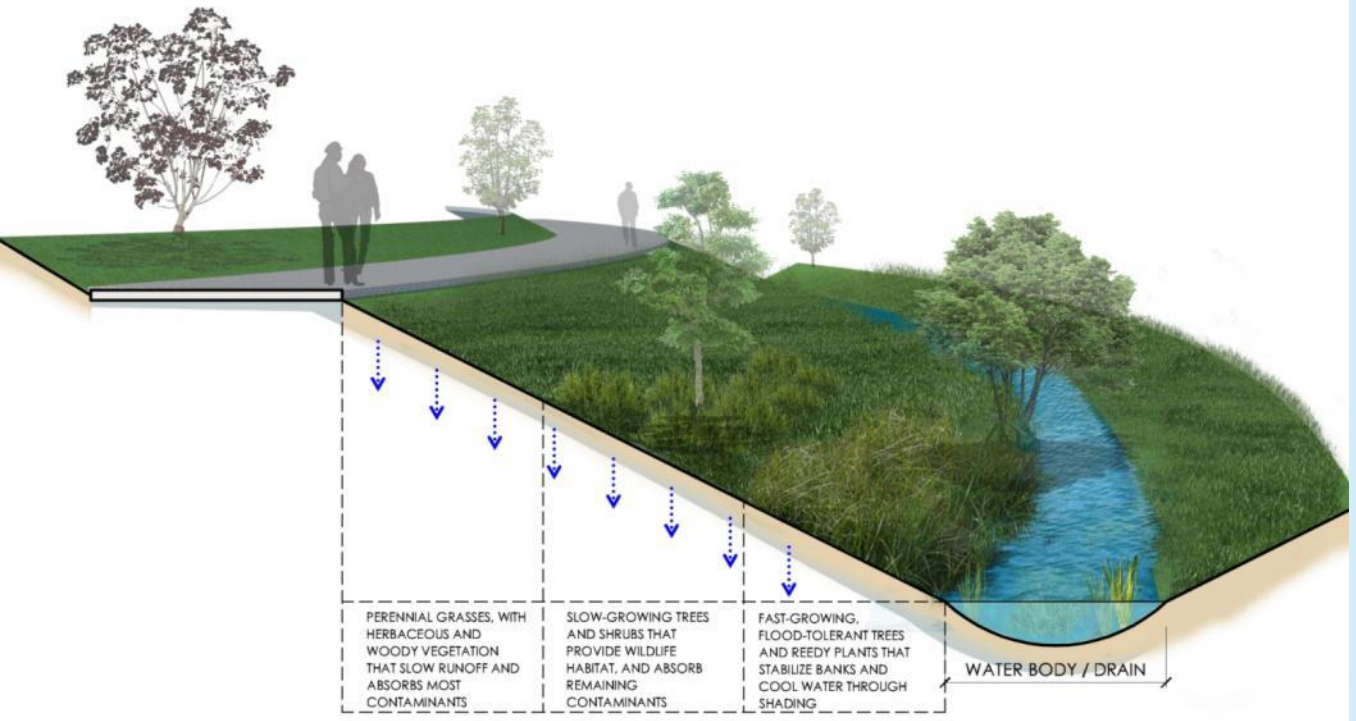
VEGETATED FILTER

- Vegetated filter strips, or vegetated filters, are gently sloping areas used to filter, slow, and infiltrate stormwater flows.
- Stormwater enters the filter as sheet flow from an impervious surface. Flow control is achieved using the relatively large surface area and for slopes greater than 5%, a generous proportion of check dams or berms.
- Pollutants are removed through filtration and sedimentation.





RIPARIAN BUFFER



- A riparian buffer is a vegetated strip along the banks of flowing water body.
- Riparian buffers are a simple, inexpensive way to protect and improve water quality through local plant materials.
- Buffer strips structurally stabilize banks and shorelines to prevent erosion. Trees and shrubs provide shade to maintain consistent water temperature necessary for the survival of some aquatic life.
- Width of the buffer is based on surrounding context, soil type, size and slope of catchment area, and vegetative cover.

CONVEYANCE

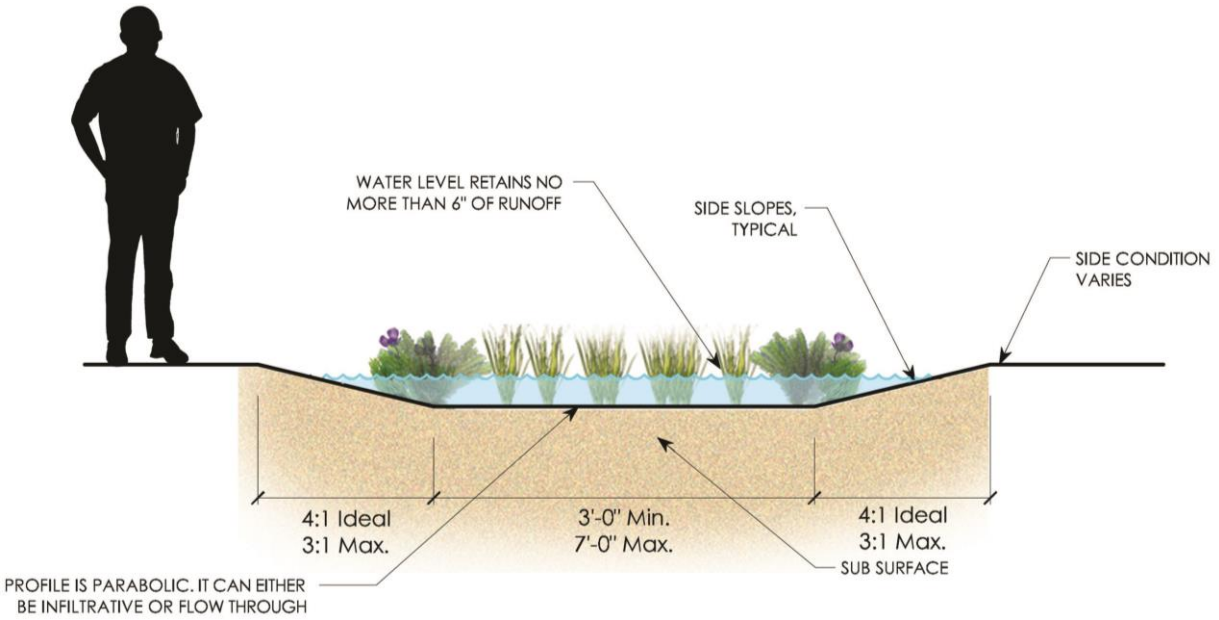
CONVEYANCE

Conveyance systems help storm water run off to capture, convey, and potentially infiltrate before it moves downstream.

Conveyance systems are

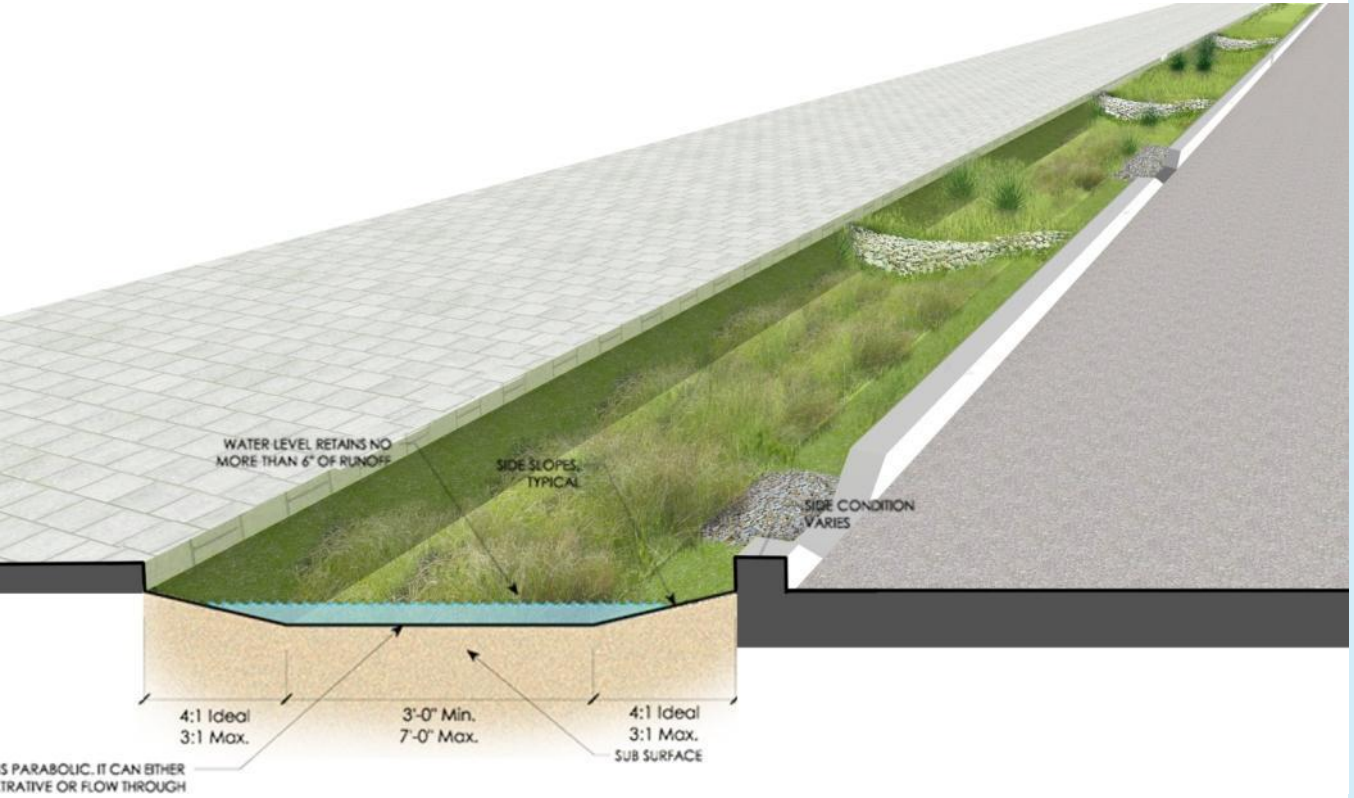
- Bio swale
- Planters
- Green gutter

Bio Swale



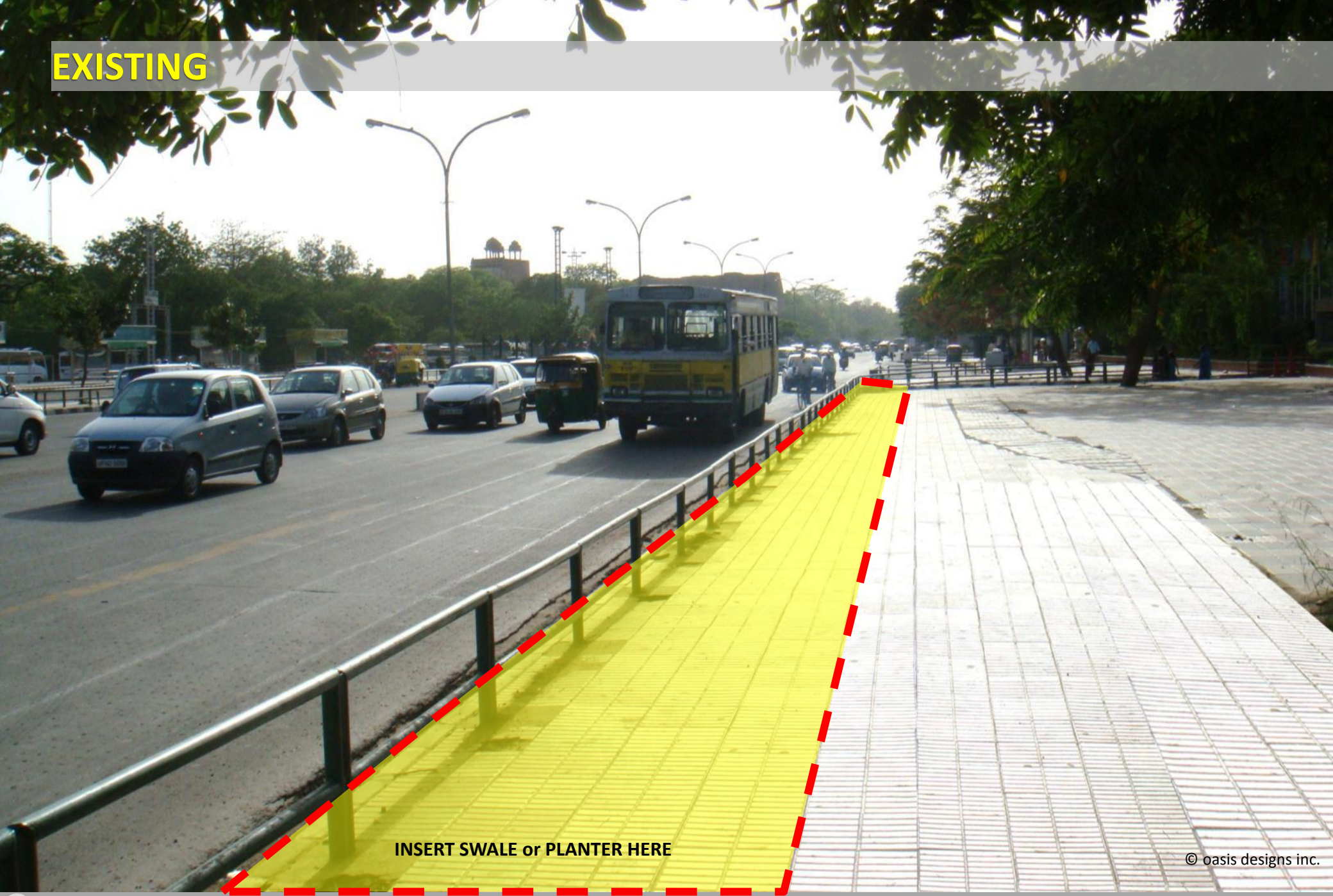
A bioswale is a modified swale that uses bioretention media to improve water quality, reduce the runoff volume, and modulate the peak runoff rate while also providing conveyance of excess runoff.

The bio swale typically has water tolerant vegetation permanently growing in the retained body of water.



- Uses biological process to remove a variety of pollutants
- Able to control flow, reduce volume
- Good retrofit capability
- Provides storm water treatment and conveyance
- Can be part of infrastructure within transportation ROW
- Can be a landscape feature
- Check dams, weirs, or stepped cells need to be used in areas with steep slopes

EXISTING

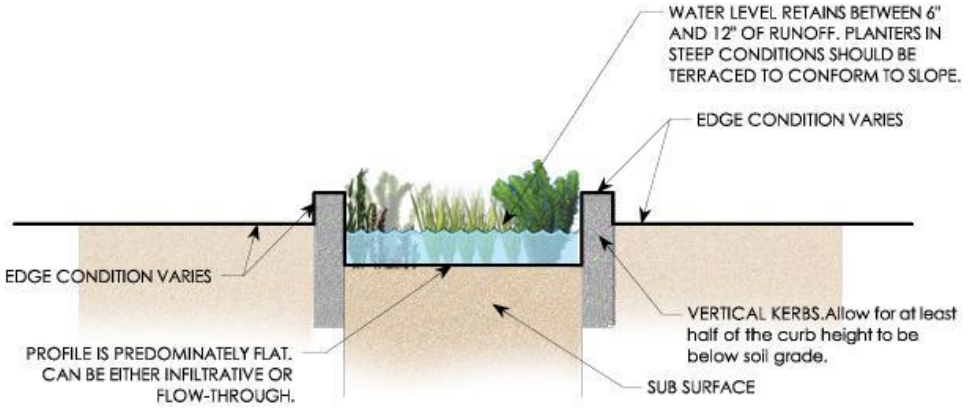


RETROFIT OPTION

Planters

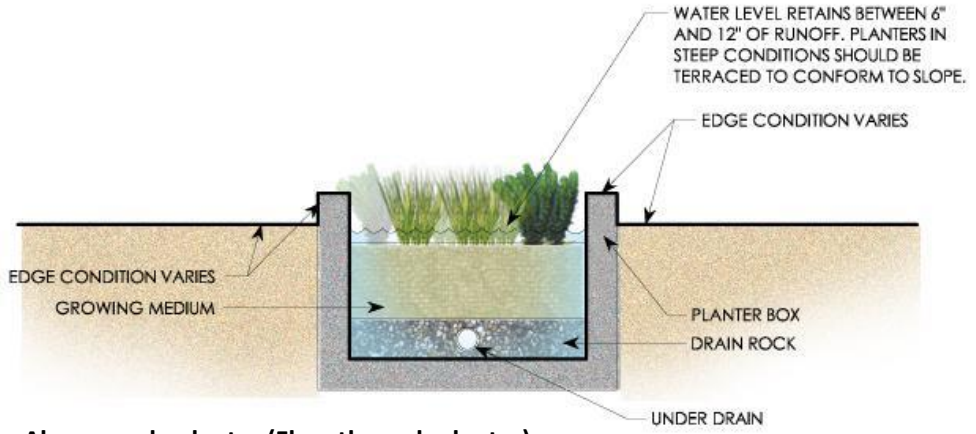
- Infiltration & Flow-through planters are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater runoff.
- They allow pollutants to settle and filter out as the water percolates through the planter soil and infiltrates into the ground.
- Flow rates and volumes can also be managed with infiltration planters.

Planters are contained landscape areas designed to capture and retain storm water runoff.



At grade planter (Infiltration planter)

Filtration is required before the water goes through planter



Above grade planter (Flow through planter)

This type is possible where there is no sub surface, mostly over covered drains and basement slabs.

Planters

source: HARRISON DESIGN

This green street features a continuous flow-through stormwater planter with multiple bridge pedestrian crossings.

source: nEvuE nGAn ASSoCiAtES

This arterial street was retrofitted with a series of stormwater infiltration planters.

source: nEvuE nGAn ASSoCiAtES

A stormwater planter within the interior median of a parking lot.

EXISTING

PROPOSED

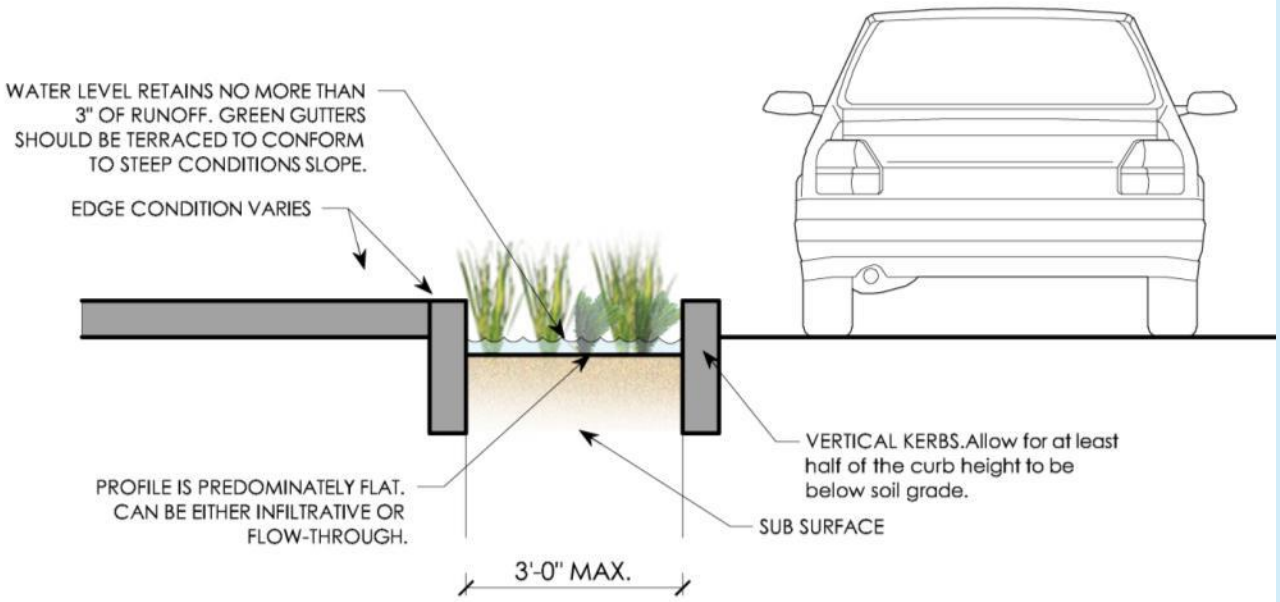
THE PLANTERS ARE CONNECTED THROUGH PIPE BELOW THE RAMP.

Green gutter

EXISTING

PROPOSED

Green gutters are similar to Flow through planter with narrower width of the green area. Here the pollutant removal rate is less .



Green gutters help capture and slow storm water runoff within very narrow and shallow landscaped areas along a street's edge.

- They can often significantly "green" a street with minimal investment.
- Create a more walkable street environment by providing a green buffer between road traffic and the sidewalk.
- Require a long, continuous space to effectively slow and filter pollutants.
- These are very shallow and do not retain large amounts of runoff.

EXISTING

PROPOSED

© oasis designs inc.

DETENTION

DETENTION

Detention systems are designed to store storm water temporarily and then release or reuse it gradually.

The primary purpose of detention basins is to control stormwater runoff .Detention systems store runoff for up to 48 hours after a storm and are dry until the next rain fall. This provides pollutant removal by temporarily capturing runoff.

- Storage capacity dependent on available site area
- Can be used in combination with other stormwater management facilities
- Regular maintenance of vegetation and sediment removal required
- Relatively impermeable soils or impermeable liner
- Forebay (such as filtration techniques)for sediment collection and removal

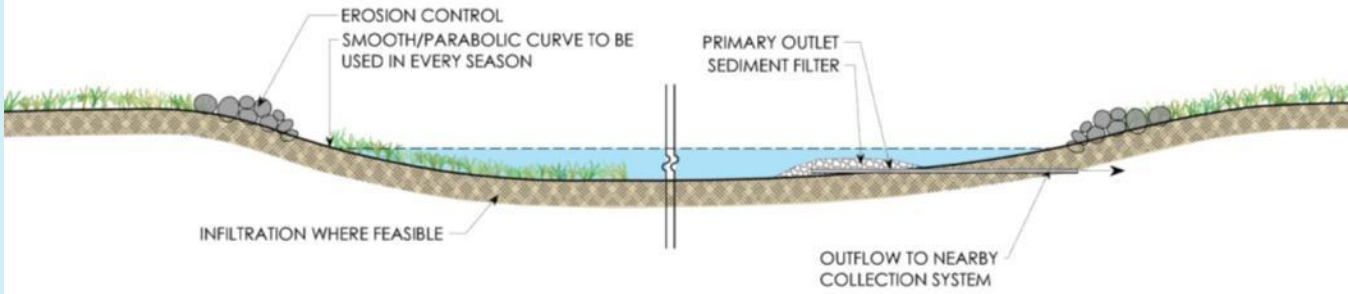
Detention systems are

- Detention pond
- Dry swale

DETENTION POND

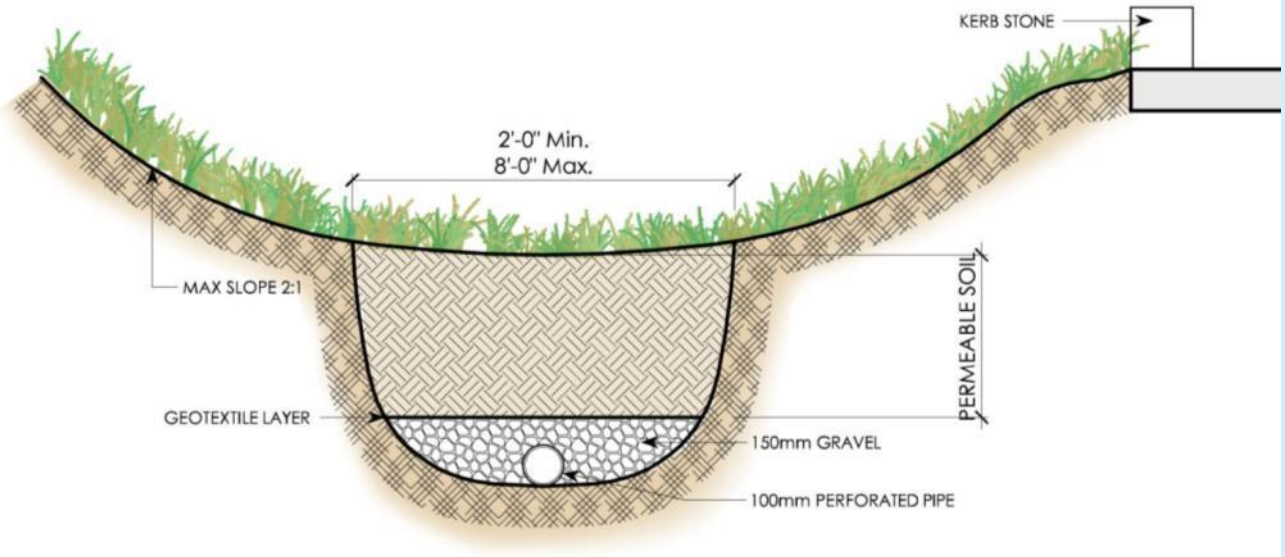
- Detention ponds are temporary holding areas for storm water that store peak flows and slowly release them, lessening the demand on treatment facilities during storm events and preventing flooding.
- Detention ponds are designed to fill and empty within 48 hours of a rain fall and could reduce peak flows and runoff volumes.
- They can be used to provide flood control by including additional flood detention storage.

Areas of possible application:
Play fields, School grounds, Open spaces in the city parks.



source: www.flowstobay.org

DRY SWALE



Dry swales are used at low density residential projects or for very small impervious areas

- Dry swales are simple drainage and grassed channels that primarily served to transport stormwater runoff away from roadways and rights-of-way.
- This provides both quantity (volume) and quality control by facilitating stormwater detention.

RETENTION

RETENTION

Retention areas are surface depressions planted with specially selected native vegetation to capture and treat storm water runoff from rooftops, streets, and parking lots.

- Volume control and groundwater recharge, moderate peak rate control, filtration.
- Higher maintenance until vegetation is established.
- Limited impervious drainage area.
- Flexible in size and infiltration.
- Provide positive overflow for extreme rain fall.
- Natural high groundwater table required for wet ponds and constructed wetlands
- Dewatering mechanism required for wet ponds and constructed wetlands

Retention systems are

- Retention pond
- Constructed wetland
- Underground storage tank
- Rain water Harvesting Structures

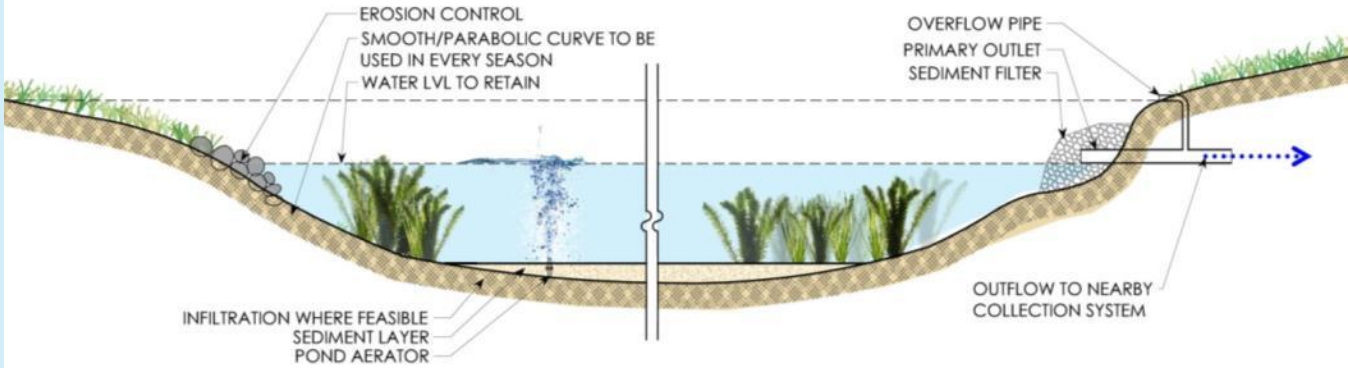
RETENTION POND

- Retention ponds maintain a permanent pool of water in addition to temporarily detaining storm water. These ponds fill with storm water and release most of it over a period of a few days, slowly returning to its normal depth of water.

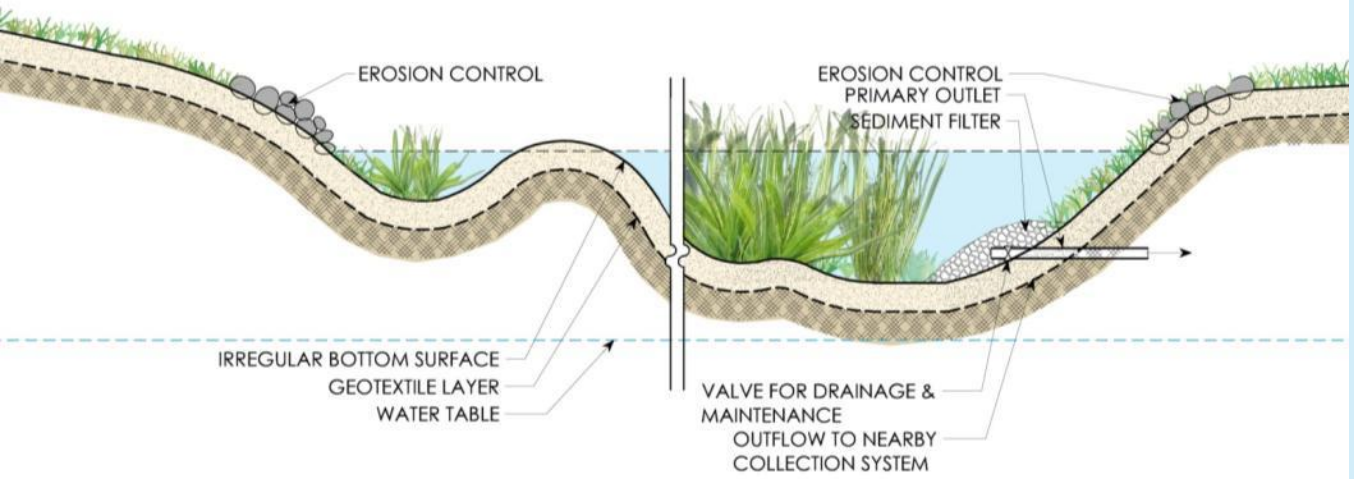
- As these have to maintain a permanent pool, they can't be constructed in areas with insufficient precipitation or highly permeable soils.

- Retention ponds can have aquatic habitat if properly planted and maintained. Regular cleaning and maintenance is needed to ensure proper drainage .

Areas of possible application:
Unused open areas, maidans, Open spaces in the city parks.



CONSTRUCTED WETLAND



- Constructed wetlands are shallow, man-made pool with vegetated systems designed to provide stormwater retention and pollutant removal.
- Can be designed for enhanced nitrogen removal by creating aerobic and anaerobic zones
- Reduces runoff temperature
- Creates habitat . Plants and wetland helps to reduce storm water speed and allows sediment to settle out.
- These can be applied to the areas those were wetland once or low line areas of any site.
- These are different from retention ponds in their shallower depths and large vegetation coverage.

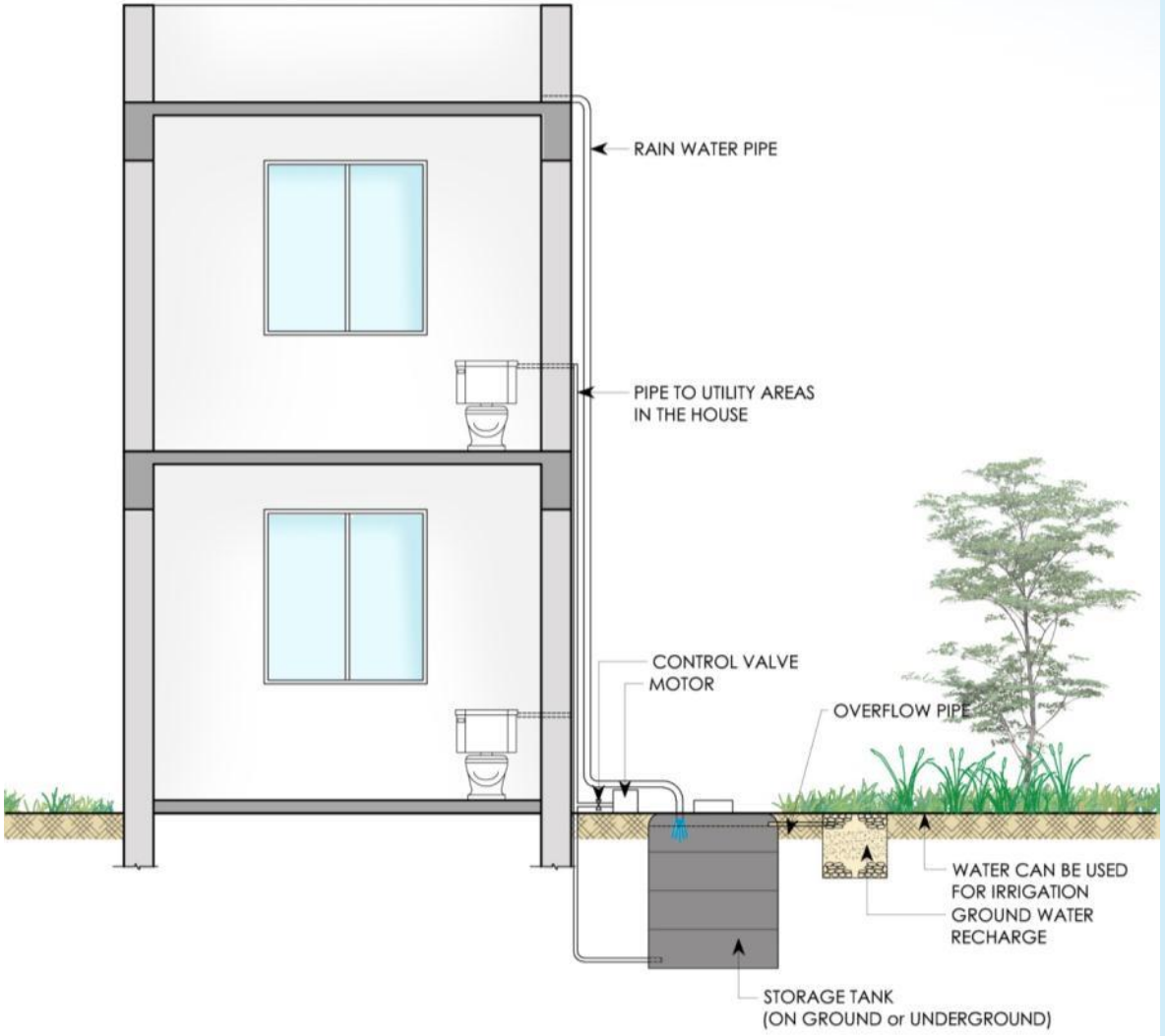
UNDERGROUND STORAGE TANK

All storm water that falls on the road surface and the roadsides can be collected and managed within the ROW.
It need not go out!

Water collected in reservoirs can be used for irrigation

- THE RAINWATER IS PROPOSED TO BE STORED IN A SERIES OF TANKS ALONG THE ROADSIDE TO IRRIGATE THE LANDSCAPE AREAS AND THE MEDIAN
- THESE TANKS CAN ALSO BE PERIODICALLY FILLED UP WITH TREATED S.T.P. WATER

RAIN WATER HARVESTING STRUCTURES



- Stormwater can be collected and reused for non-potable water uses within a house or building, or for landscape irrigation purposes.
- Uses can include reusing water in toilets .
- This will help to reduce the water used from the City water system.
- Rainwater harvesting can be used to manage a portion of the storm water flow and lessen the overall flow control requirement.

INFILTRATION

INFILTRATION

Infiltration system are natural or constructed land areas located in permeable soils that capture, store, and infiltrate the volume of stormwater runoff into surrounding soil.

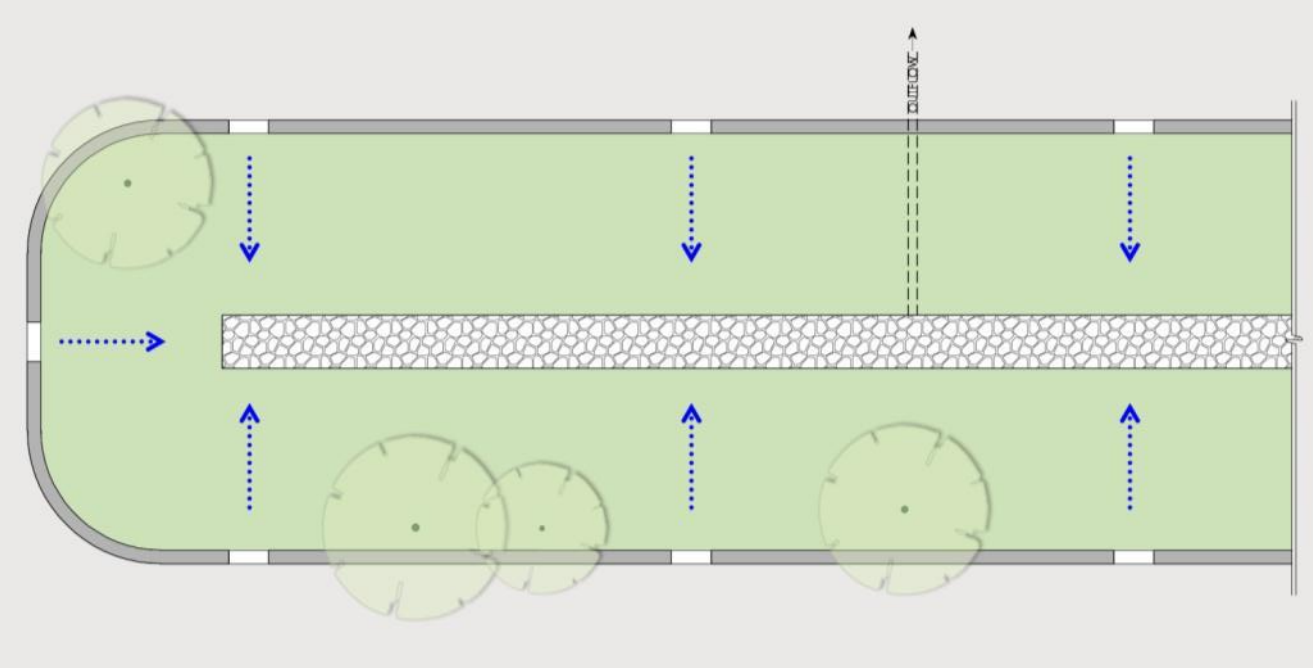
Infiltration systems are

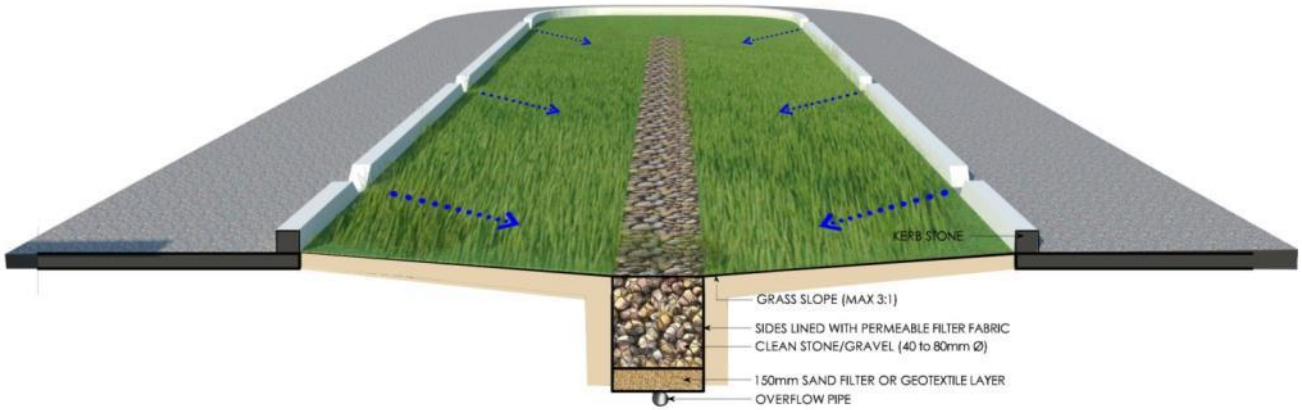
- Infiltration Trench
- Infiltration Basin
- Pervious Paving
- Rain garden

INFILTRATION TRENCH

- Infiltration trenches temporarily hold stormwater runoff within a sub-surface trench prior to infiltration into the surrounding soils.

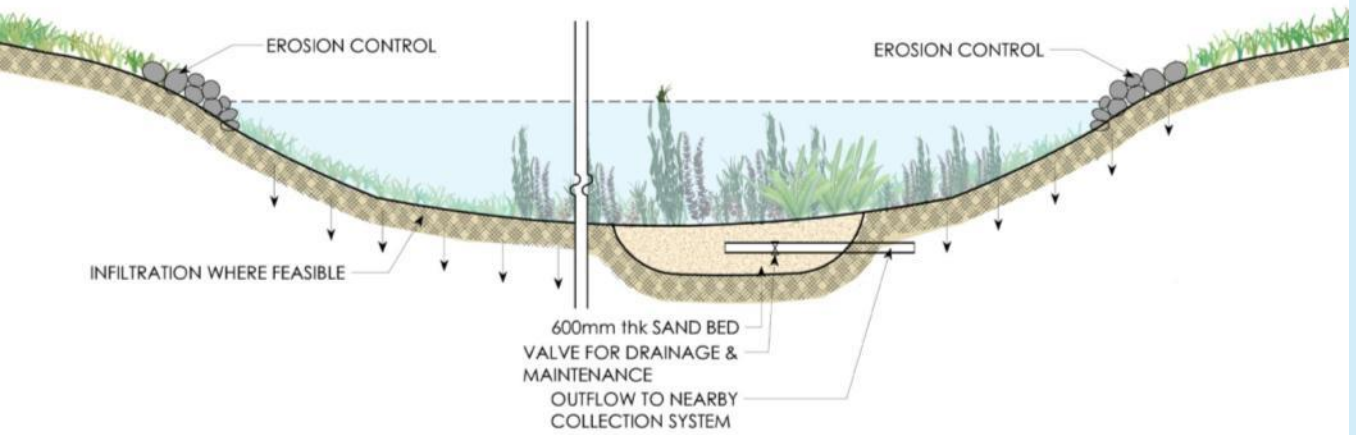
- Stormwater runoff is diverted into the trench and is stored until it can be infiltrated into the soil, usually over a period of several days.





Areas of possible application:
Suitable for drainage areas of approximately 5 acres or less.

INFILTRATION BASIN



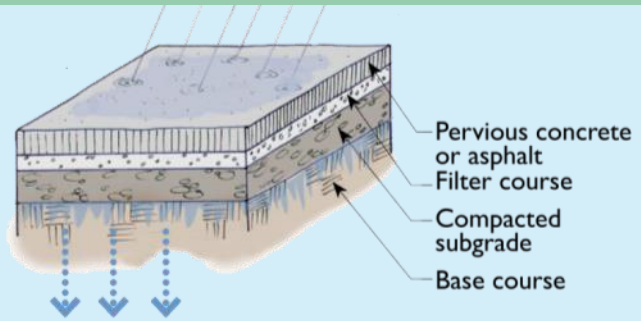
- An infiltration basin is a shallow pond over permeable soil that captures stormwater, stores it, and allows it to infiltrate, using the natural filtering ability of the soil to remove stormwater pollutants.

- They are similar in function to infiltration trenches except that an infiltration basin's stored volume is held above ground, while an infiltration trench's stored volume is held below ground.

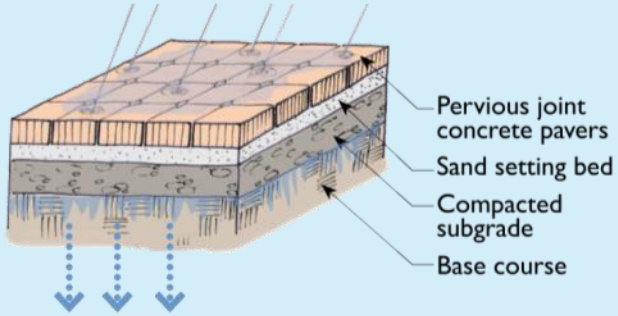
1. A vegetated swales, before infiltration basin can help to stop coarse sediments and oil to enter the basin.
2. A forebay or gravel bed at the entrance to the basin will also extend the basin's longevity and reduce maintenance costs.
3. Deep-rooted plants on the basin bottom reduce the risk of clogging and increase the infiltration capacity by creating small conduits through which water can infiltrate.

Areas of possible application:
Must have minimum soil infiltration rate of 0.5 inches/hour.

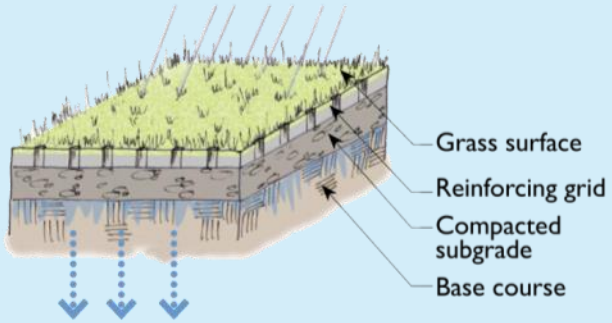
Pervious Paving Options



PERVIOUS CONCRETE or ASPHALT



POROUS JOINT PAVERS



GRASS PAVERS

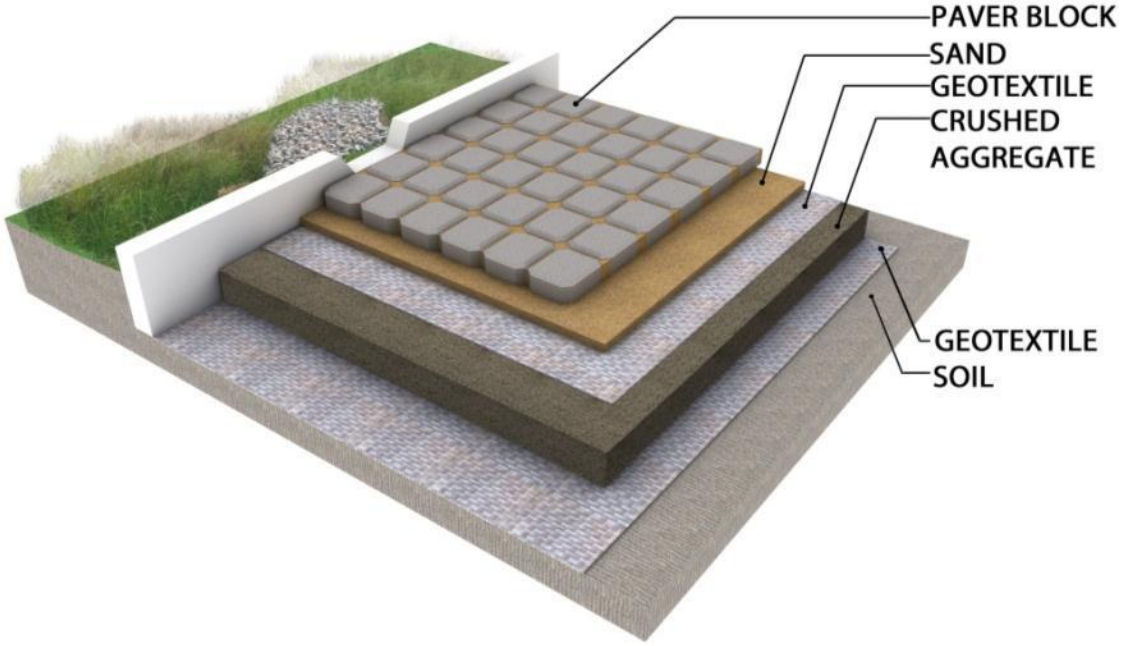
TYPE OF PERVIOUS PAVING

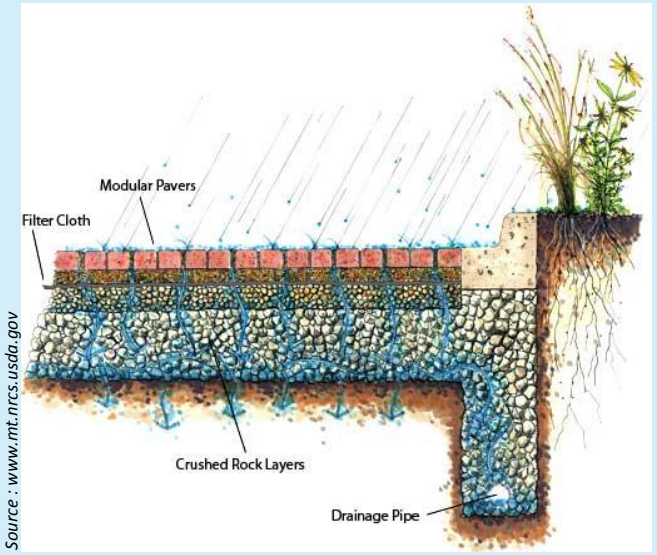
- ***Porous Asphalt***
  (No fine concrete)
- ***Permeable Pavers***
  (Modular Paver Blocks)
- ***Grass Paving***

source: nevue ngan associates

source: www.ritter-technik.co.uk

TYPE OF PERVIOUS PAVING



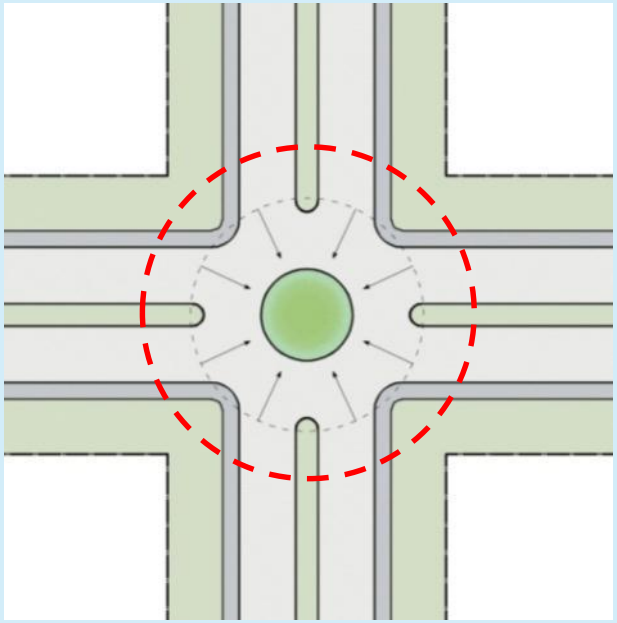


Source : www.mt.nrcs.usda.gov

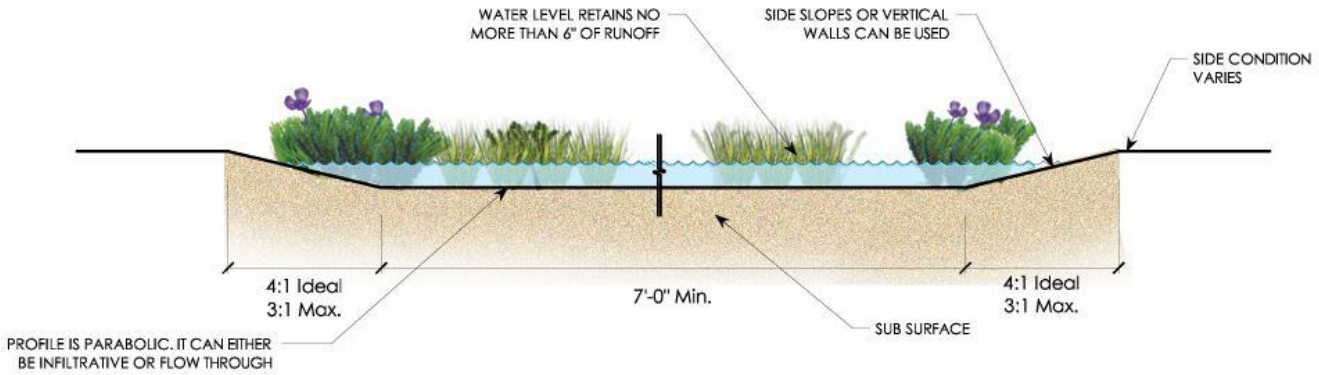
Source : www.hannemanandfineis.com

Pervious paving allows water to infiltrate below the paving and then into soil and groundwater below. By infiltrating most of the storm water on site, the amount of water and pollution flowing into storm water channels and directly to nala and river is greatly reduced. This protects water quality, maintains more stable base flows to nala, reduces flood peaks, and reduces erosion of the nala banks. With infiltration, groundwater is recharged and streams are replenished with cool, clean groundwater in a more natural way.

Rain garden



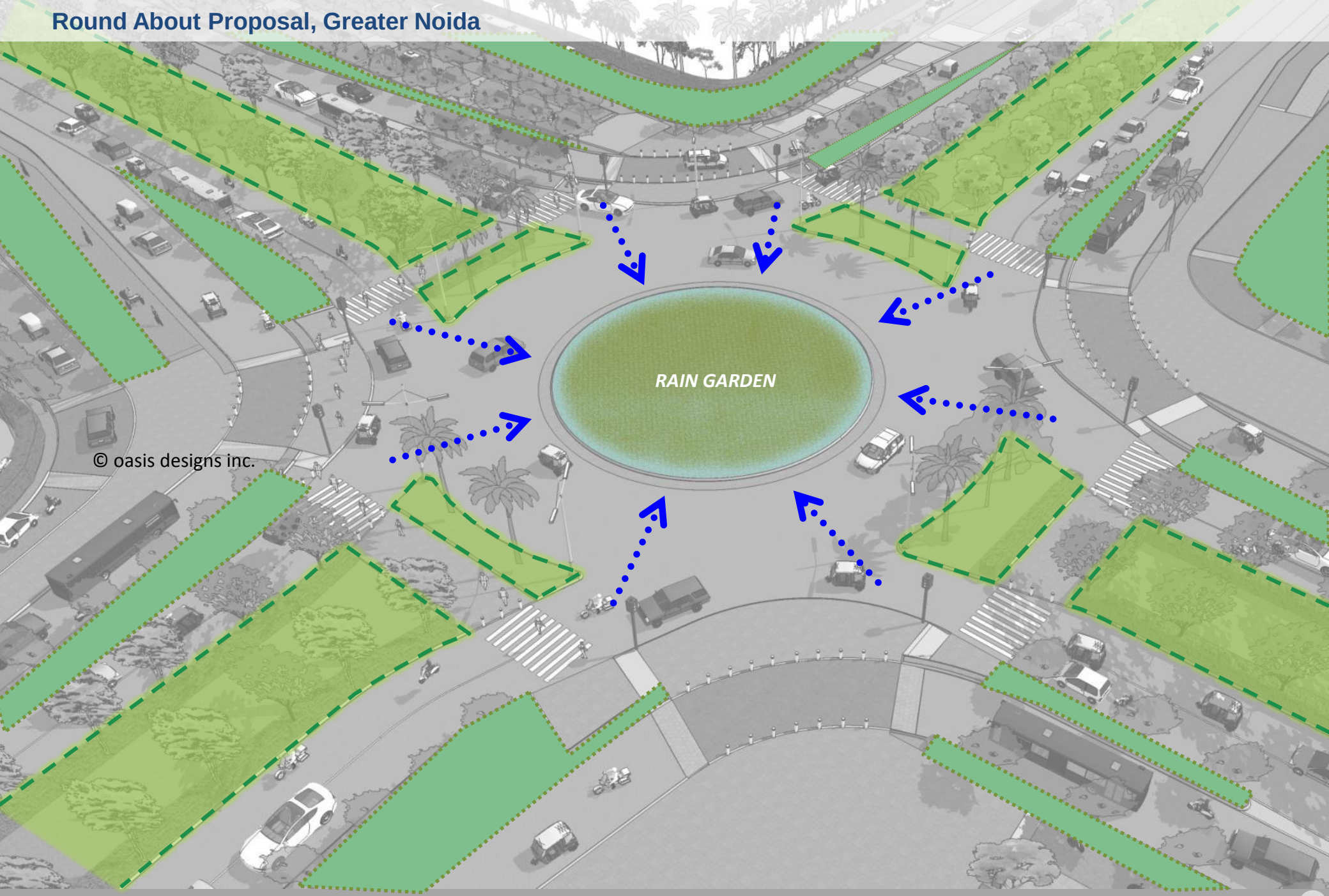
Rain gardens in Round about



- Rain gardens retain storm water, thereby reducing flow rate and overall volume.
- They can also allow for infiltration, depending on the capacity of the native soil.

Rain gardens are shallow landscape areas that can collect, slow, filter and absorb large volumes of water, delaying discharge into the watershed system.

Round About Proposal, Greater Noida

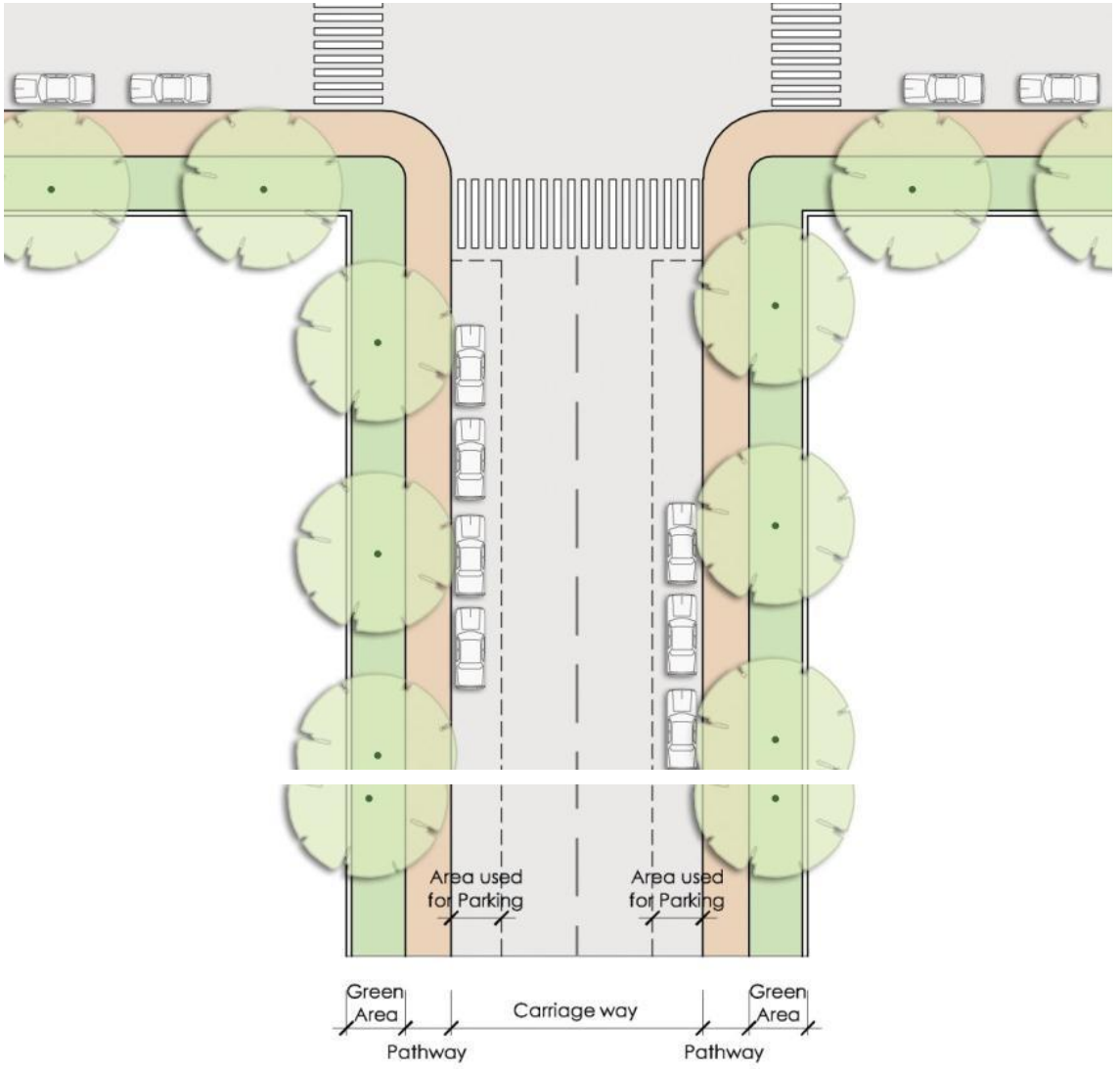


Kerb Extension

CONVENTIONAL WAY

HALF OF THE STREET IS BEING USED FOR PARKING, STORM WATER FROM ROAD GOES TO DRAIN.

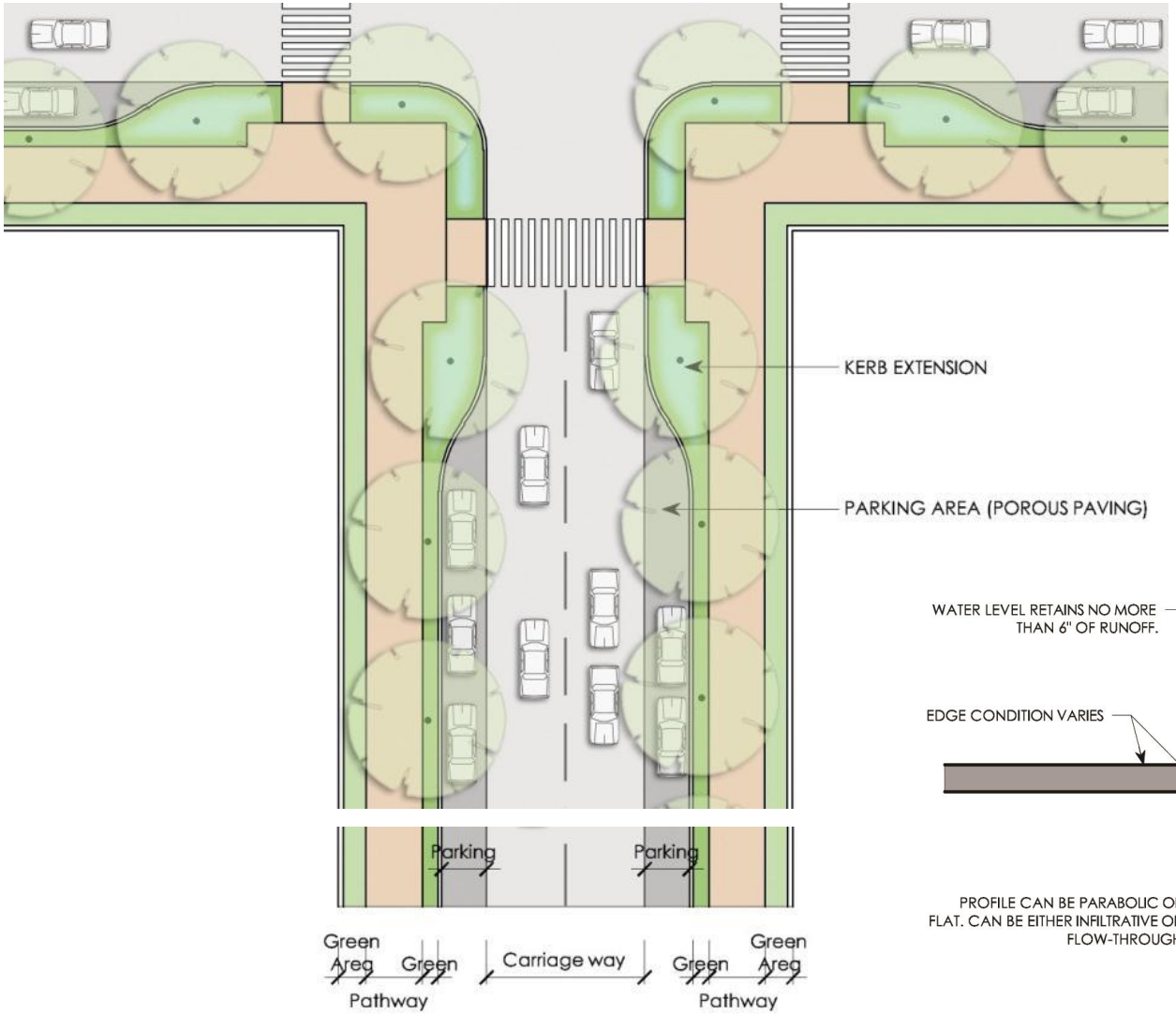
PATHWAY ALONG CARRIAGE WAY

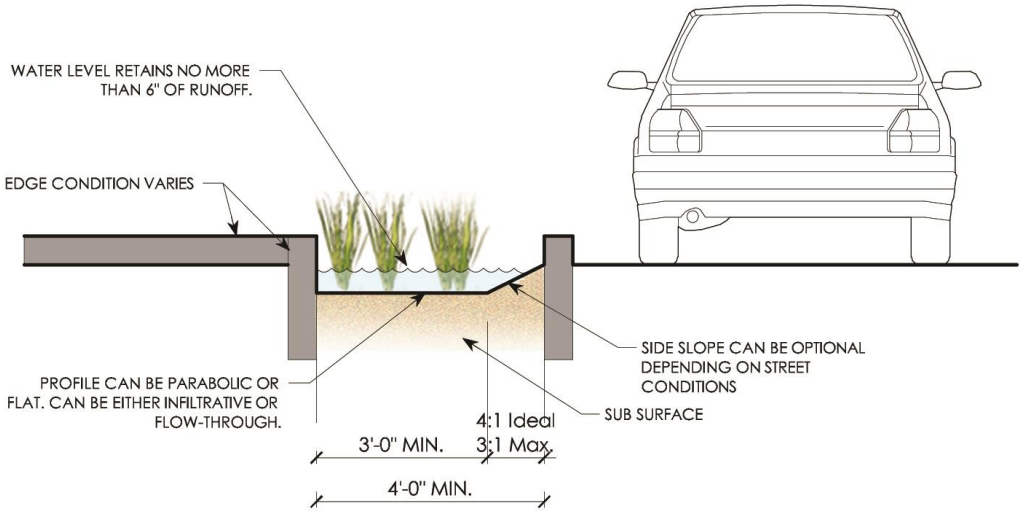


Kerb Extension – for small residential roads only

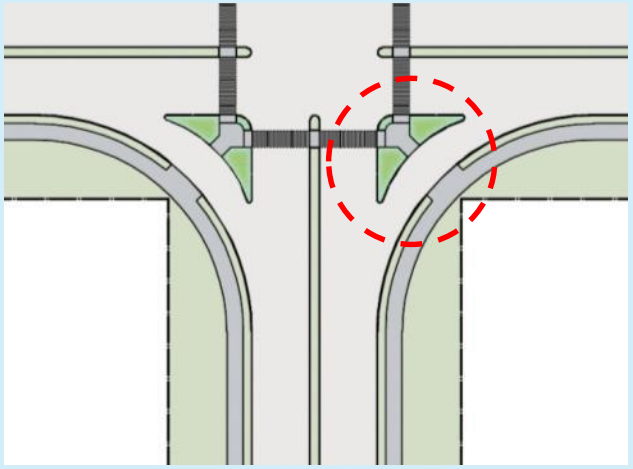
ALTERNATIVE WAY

PARKING AREA HAS BEEN SEPARATED FROM THE CARRIAGE WAY THROUGH DIFFERENT MATERIAL (PERVIOUS PAVING). KERB EXTENSIONS ARE ADDED TO CAPTURE STORMWATER RUNOFF.



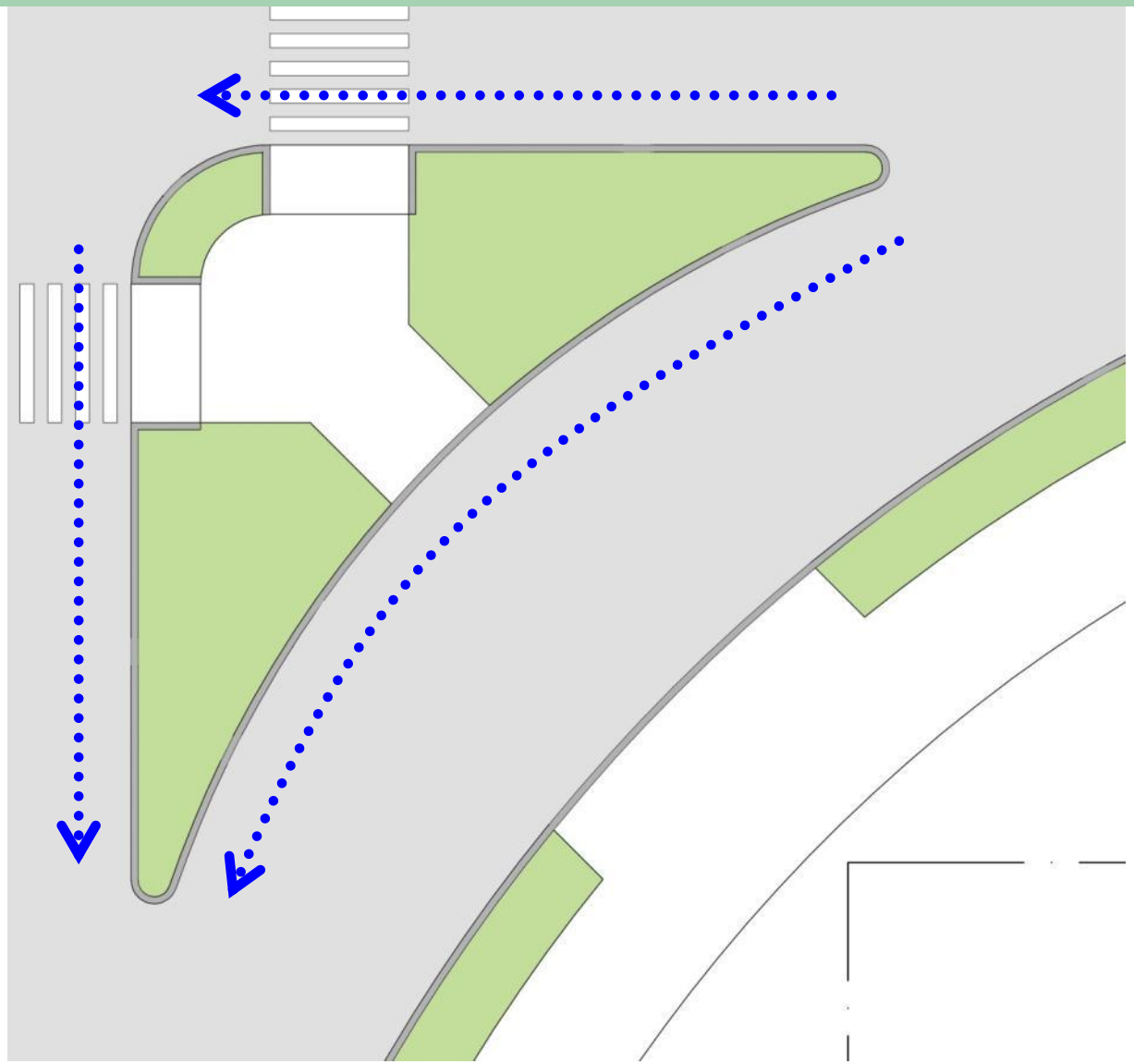


SWM in green islands on street



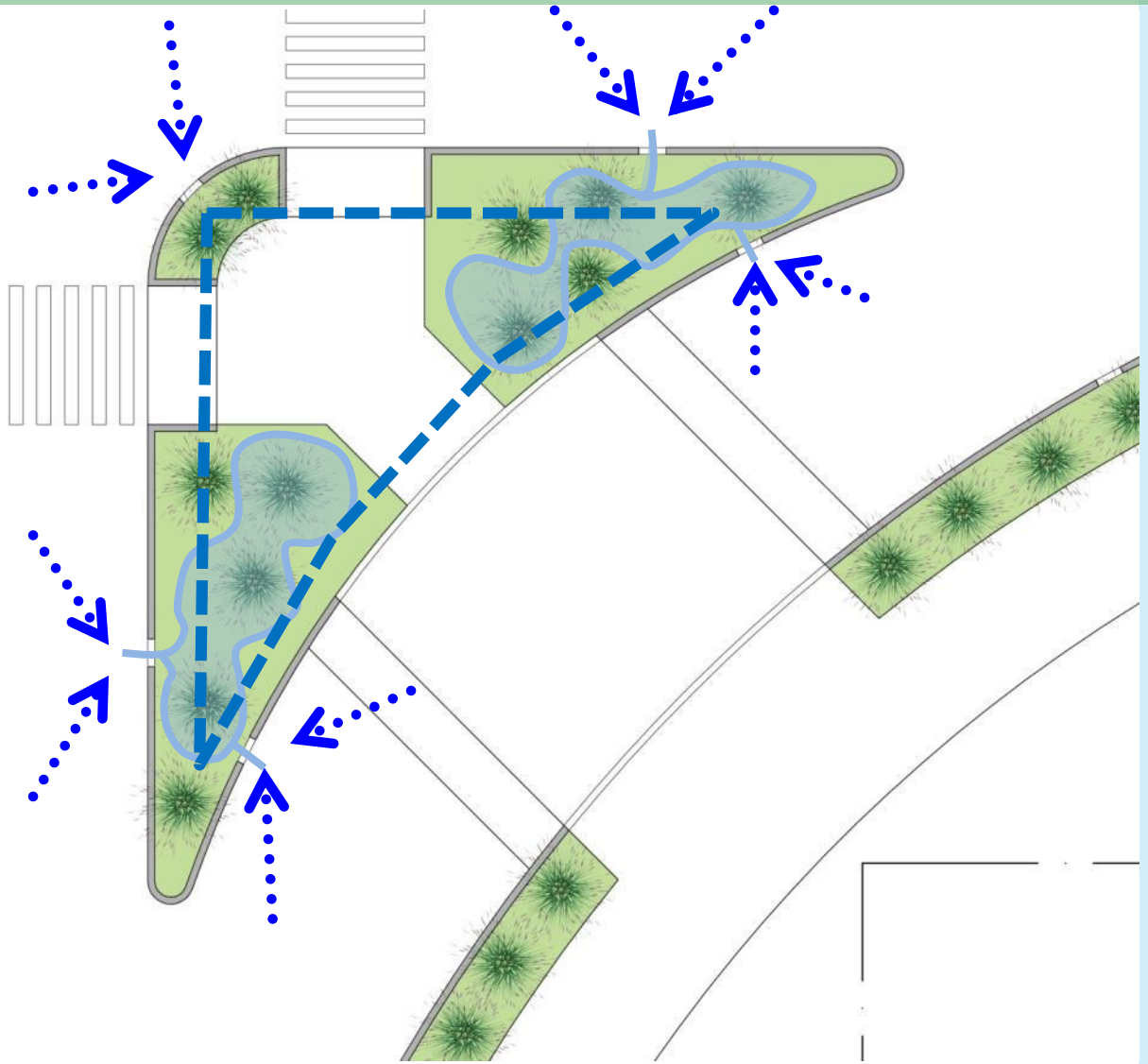
SWM in Triangular Islands

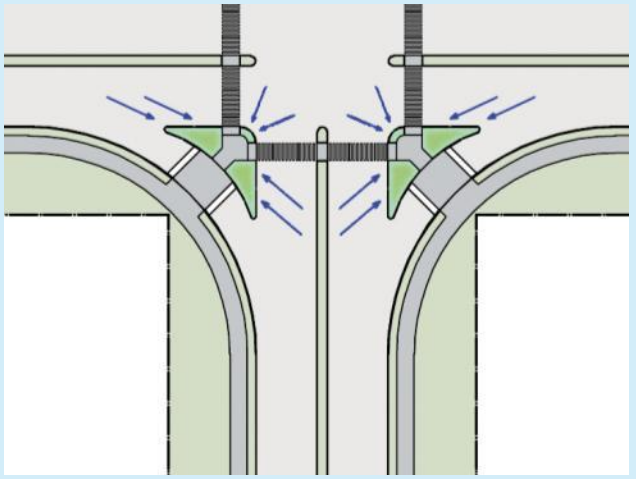
This shows the conventional way of slopes on road and storm water flow direction.



Street Kerbs

By providing kerb cuts in the street kerbs , storm water flow can be managed





- Water enters green area through kerb cuts
- Green areas are connected through sub surface pipe

PARKING LOT TYPES

Parking Lot Types

Parking lots are often designed with oversized parking numbers and travel aisles. It is important to consider that how much average parking is needed in a day. Parking lots often have many empty parking stalls for most of the year. This happens mostly in shopping mall, commercial areas and metro station parking lots. Parking lots are often designed with oversized parking numbers and travel corridors. The overall area can be fully utilized by reducing the oversized dimensions of parking bay and adding sustainable storm water techniques to the rest of the area.

There would be two sizes of parking lots in the city.

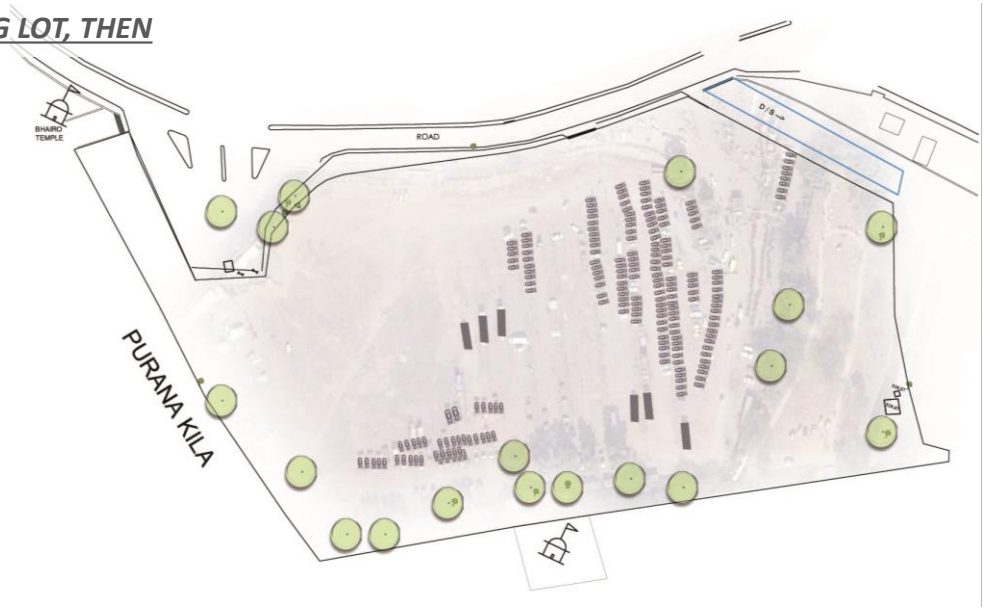
- Smaller parking lots are the difficult to retrofit because there is a high demand for available space. So pervious paving is a good choice for such area.
- In case of larger parking lots, the space is big and are mostly designed for extra cars. So this type can be redesigned with a variety of storm water solutions. The possible storm water techniques that can be used are bio swale, planter, green gutter, rain garden.

Conventional Parking Types

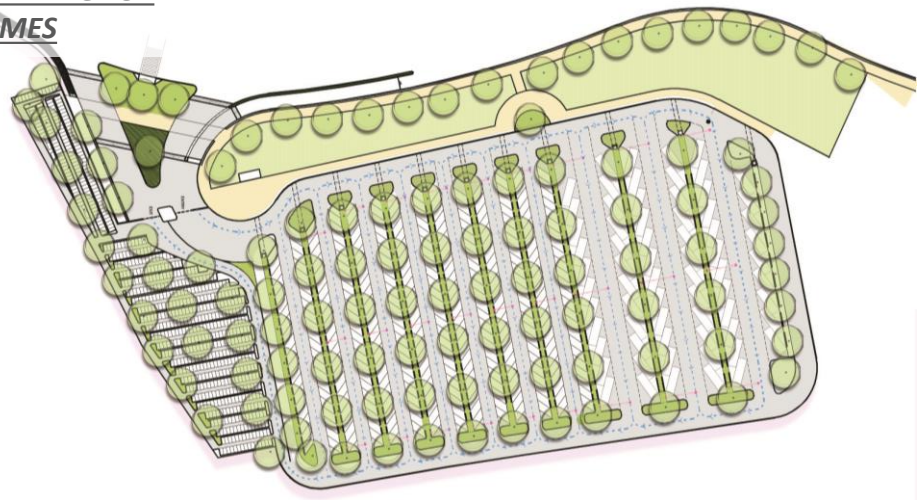
BHAIRON MARG

BHAIRON PARKING , NOW AFTER CWG GAMES

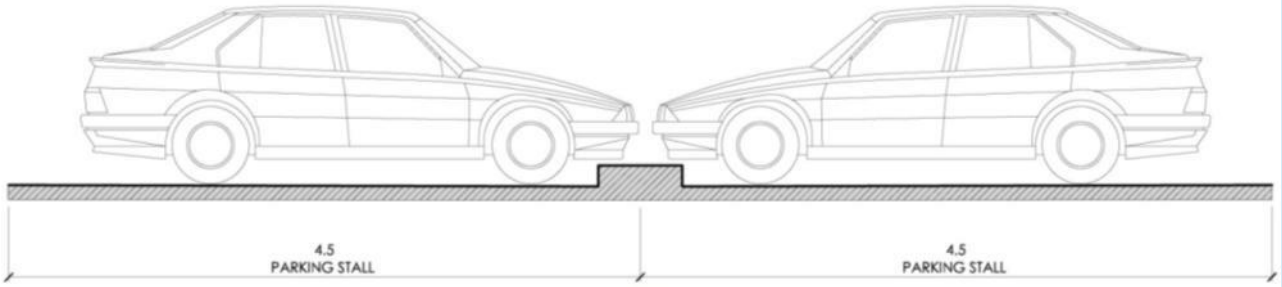
PARKING LOT, THEN



PROPOSED PARKING LOT FOR CWG GAMES

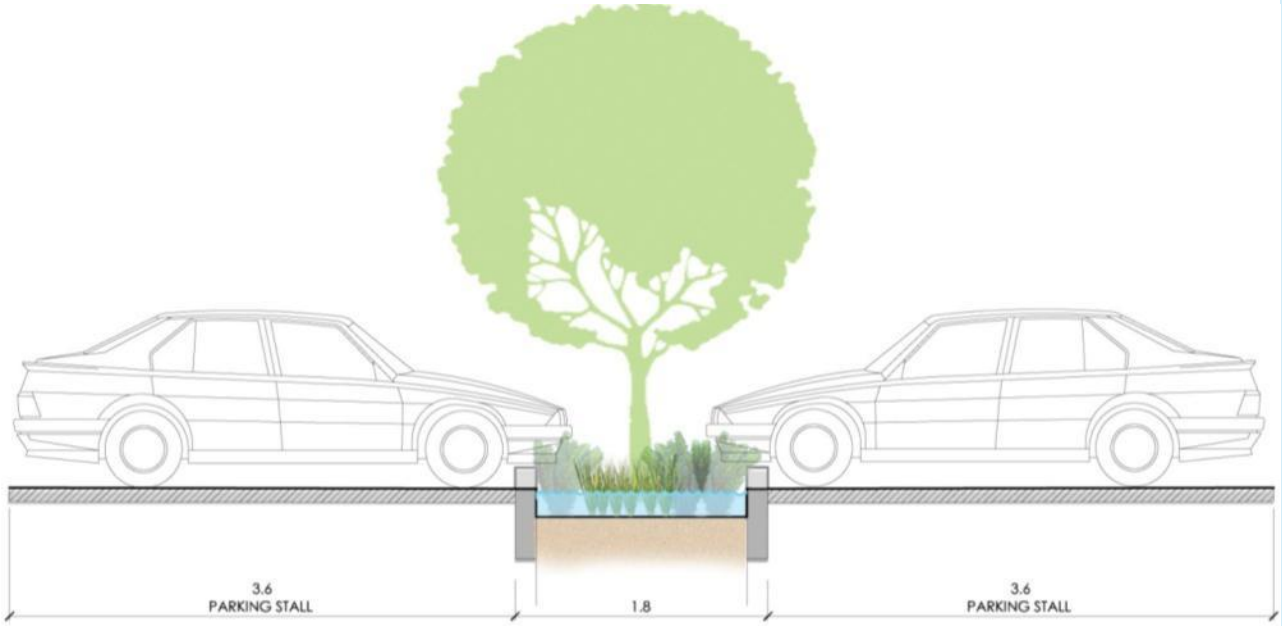


Parking Options



CONVENTIONAL WAY OF PARKING SECTIONS

THIS HAS LOT OF HARD AREA AND ADDS TO HEAT ISLAND EFFECT.



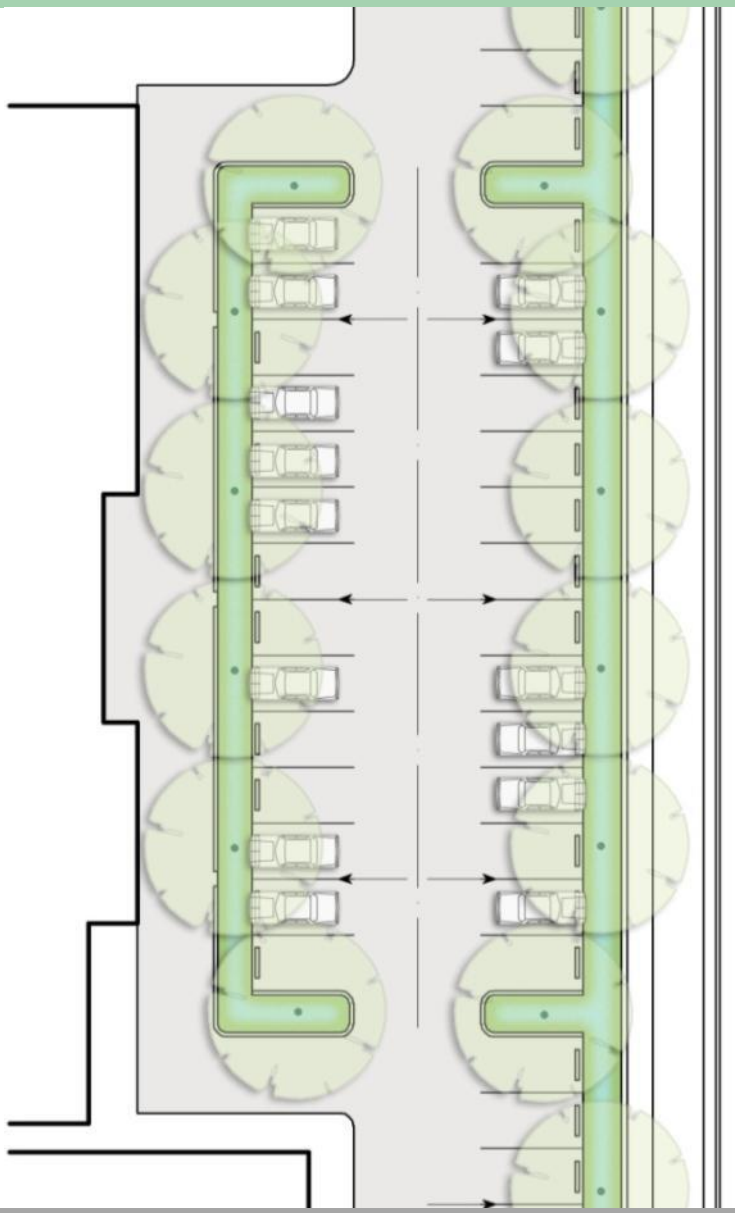
NEW WAY OF PARKING DESIGN

WHERE GREEN AREA INTRODUCTED WITH IN SAME SIZE OF PARKING. THIS SYSTEM REDUCES HEAT ISLAND EFFECT AND HELPS IN STORM WATER MANAGEMENT.

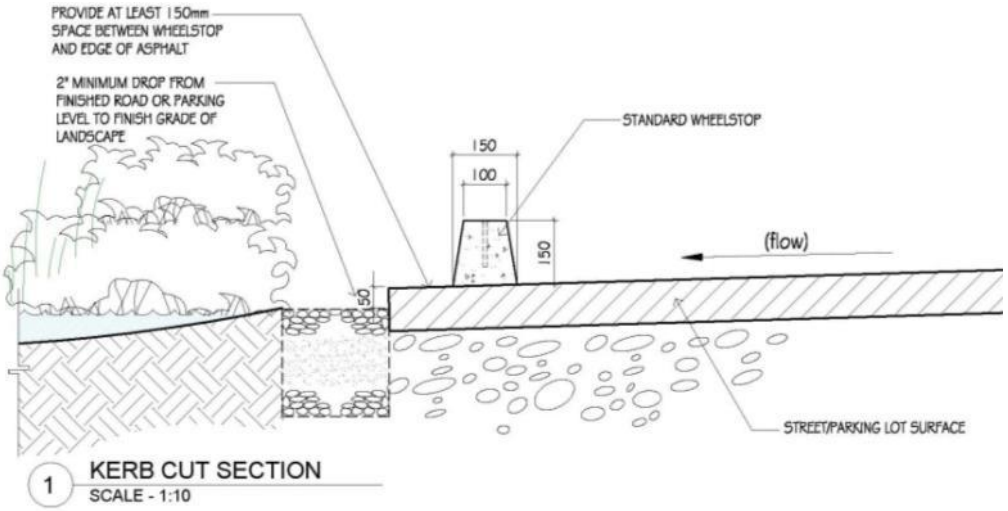
Parking lot with swale / planters

THIS TYPE OF PARKING LOT SHOWS STORMWATER PLANTERS ALONG THE PARKING LOTS.

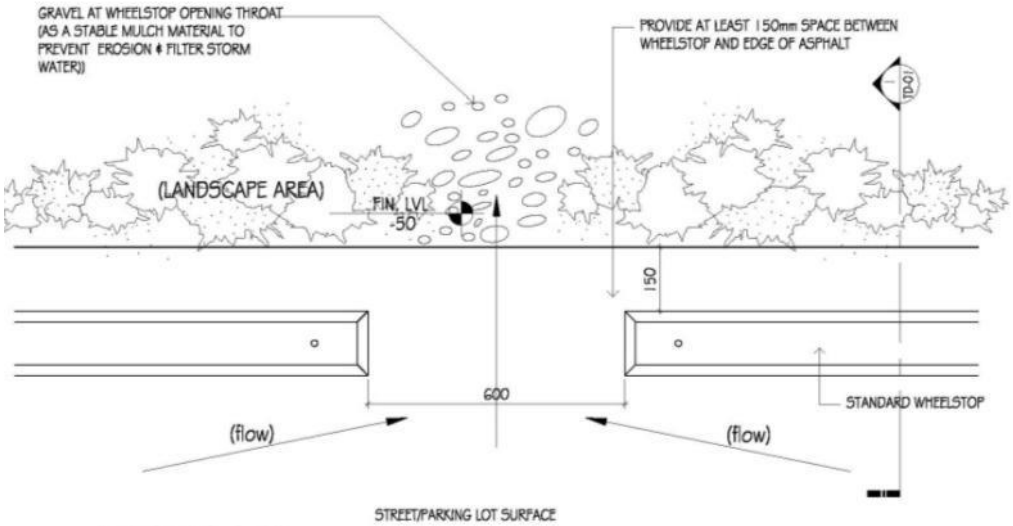
This is one of the simplest parking lot retrofit actions to implement. The best approach is to convert the parking stalls immediately adjacent to a drain inlet. Depending upon the size and parking demand of a particular parking lot, a series of parking stalls may be consolidated into stormwater planters.



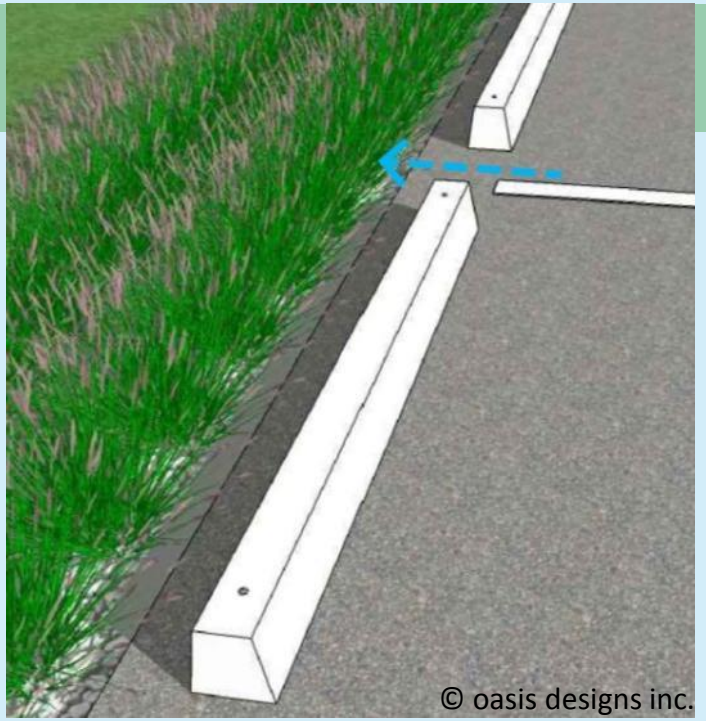
Kerb type to use in parking lot



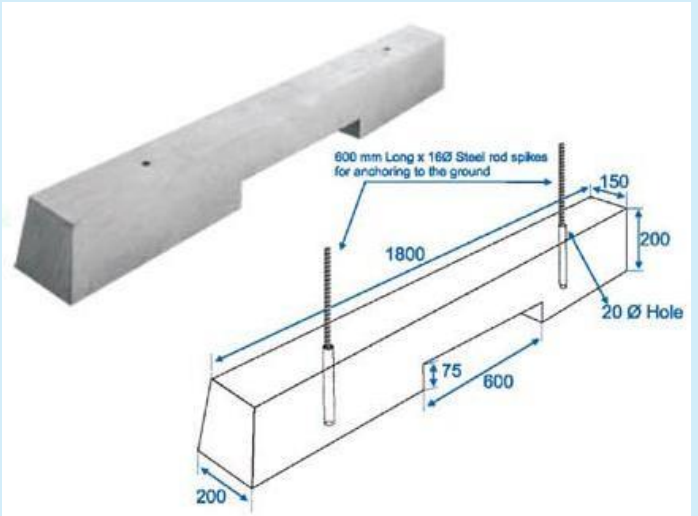
1 KERB CUT SECTION
SCALE - 1:10



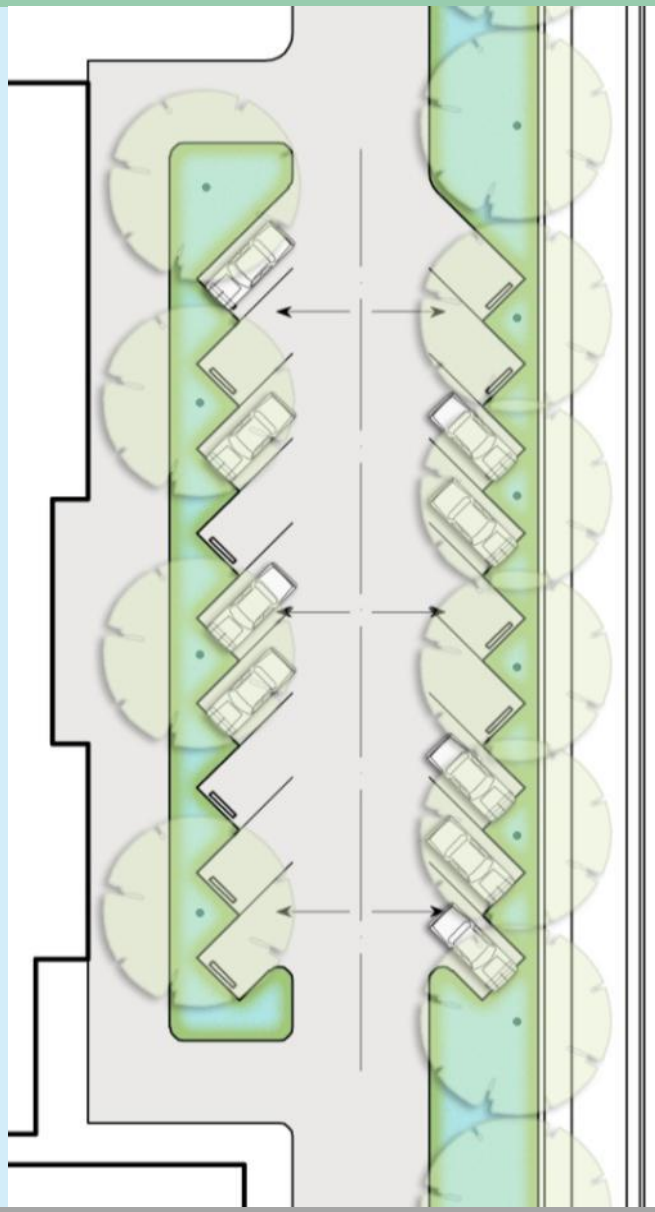
2 KERB CUT PLAN
SCALE - 1:10

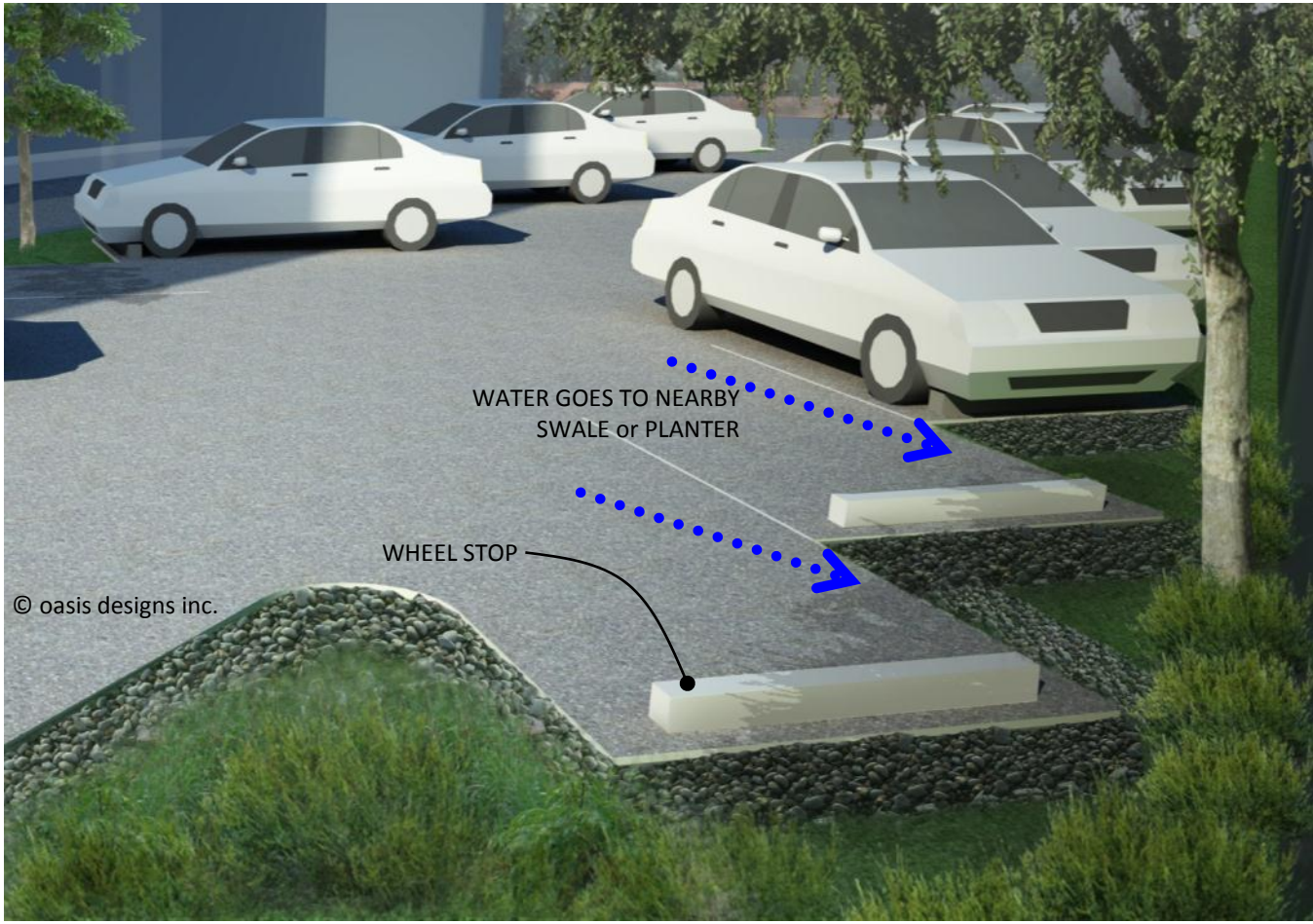


WATER FLOWS TO STORM WATER CHANNELS THROUGH WHEEL STOP

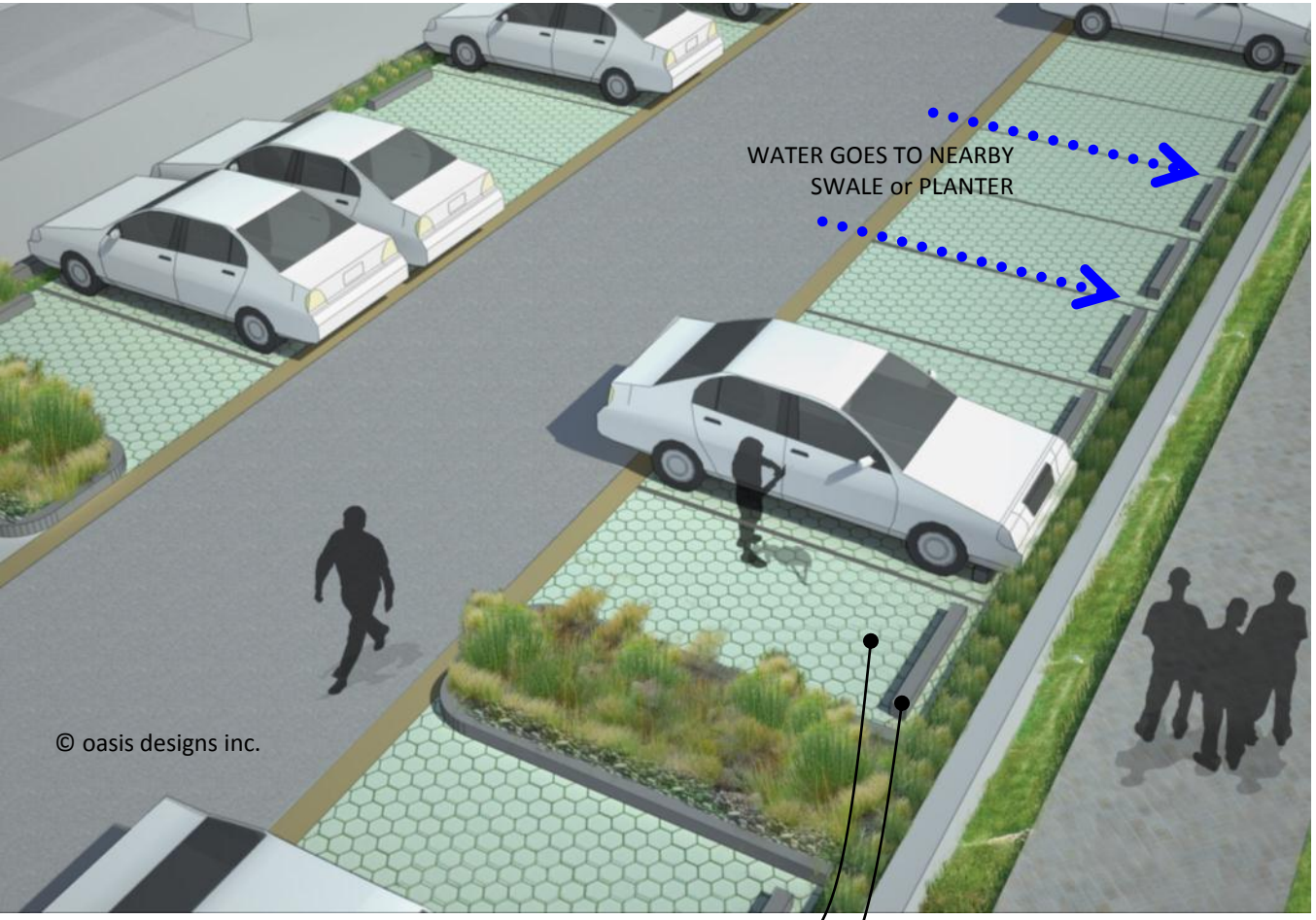


Angled parking lot





Parking lot with pervious paving



OVERFLOW OPTIONS

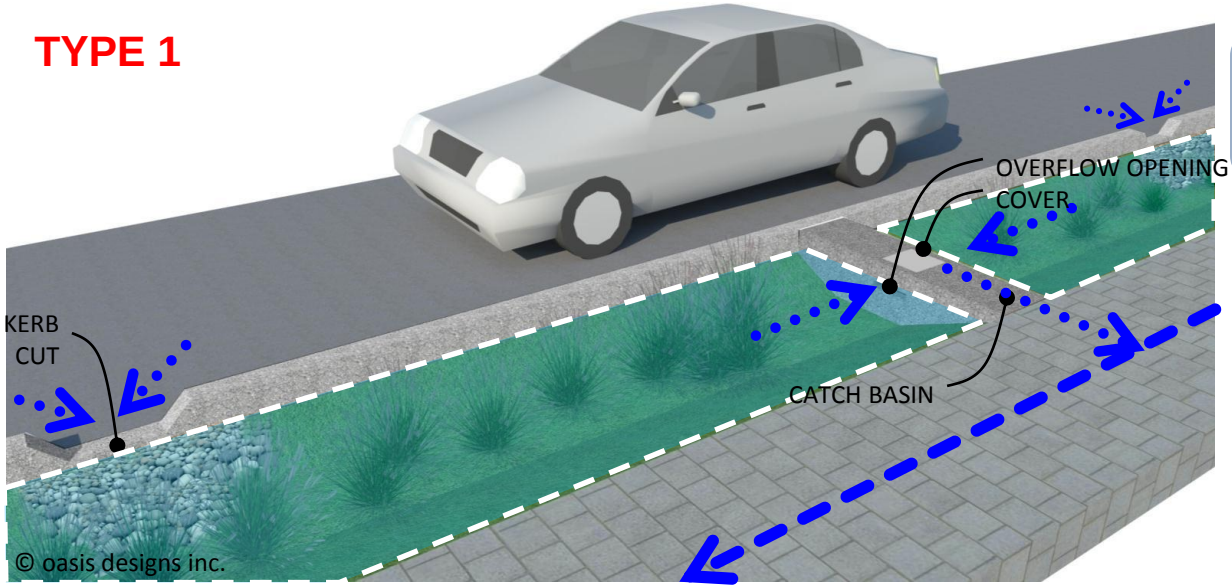
Overflow Options

Overflow options are must for any and every storm water management systems to avoid extreme situations. Overflow within these areas can be managed in many ways depending on what type of stormwater infrastructure is already available.

In retrofit conditions, the overflow can be captured by the existing storm drain inlet and then to nala. This is the most cost-effective and least intensive option. Another option for handling overflow is to construct a new storm drain/overflow channel inlet within the stormwater facility .

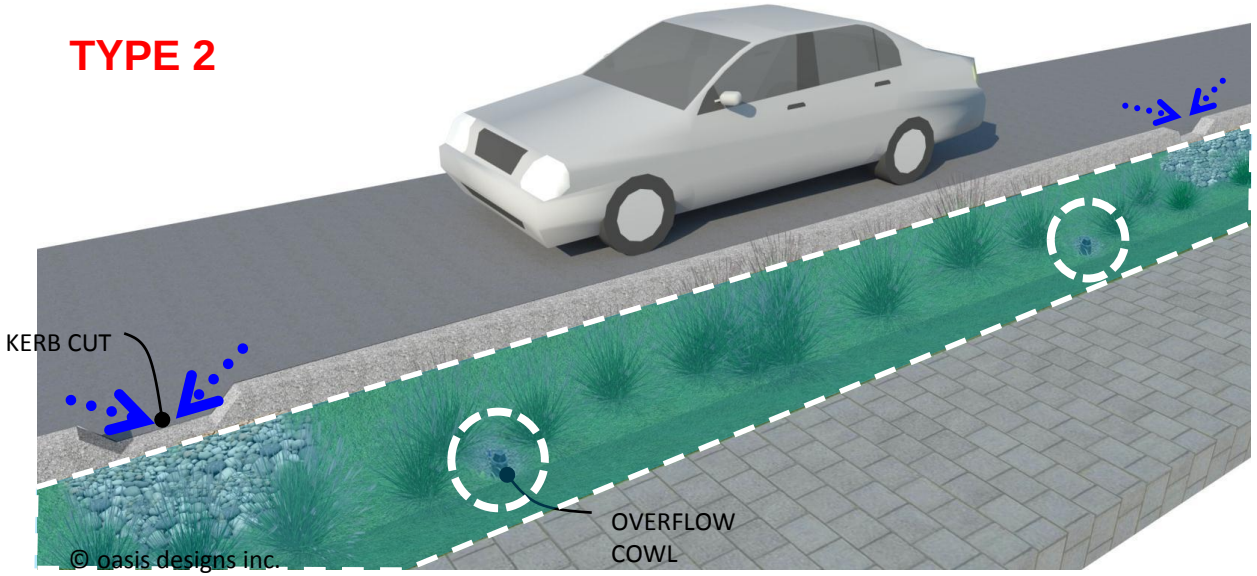
OVER FLOW OPTIONS

TYPE 1



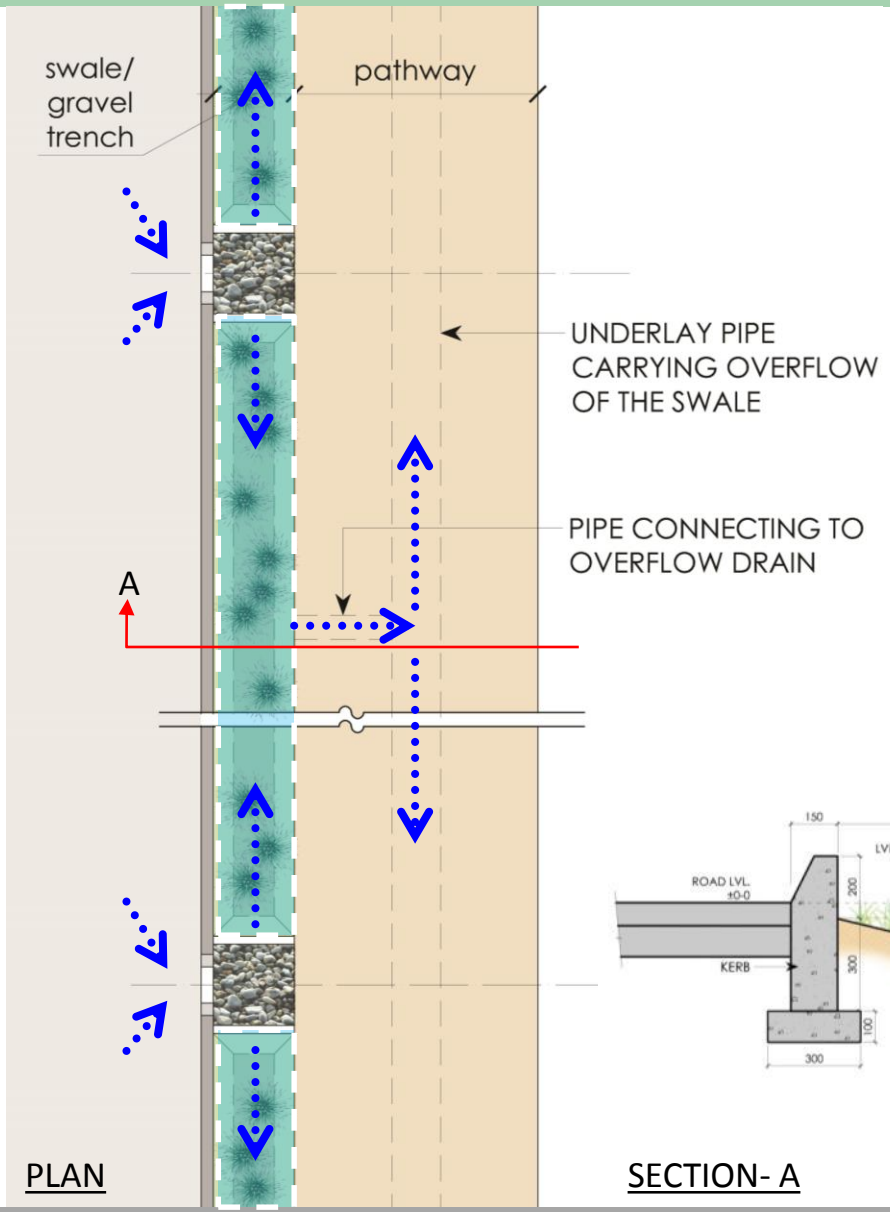
THE EXTRA WATER FROM SWALE GOES INTO THE CATCH BASIN & THEN TO NEAR BY CONVEYANCE SYSTEM

TYPE 2



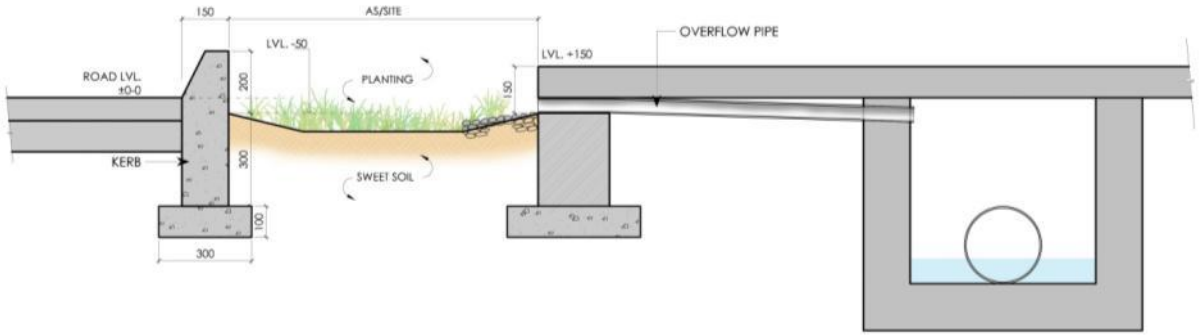
THE EXTRA WATER FROM SWALE GOES INTO THE RAISED COWL & THEN TO NEAR BY CONVEYANCE SYSTEM

OVER FLOW OPTIONS – TYPE 3



PLAN

- Storm water enters the gravel trench
- Filtered water from gravel trench goes to swale
- Overflow from swale enters to the drain below pathway.



SECTION- A

SWM CHECKLIST

SWM CHECKLIST FOR ROADS WITH LONGITUDINAL GREEN AREAS OF FOLLOWING WIDTH EITHER BETWEEN ROAD & PATHWAY OR BETWEEN PATHWAY & BOUNDARY WALL

WIDTH of green areas	FILTRATION	CONVEYANCE	DETENTION	RETENTION	INFILTRATION
< 1.5m	■ GRAVEL FILTER CHAMBER	■ STORM WATER PIPES ■ FLOW THROUGH PLANTERS			
3 – 5m	■ GRAVEL FILTER STRIP	■ SWALE ■ FLOW THROUGH PLANTERS	■ DRY SWALE ■ UNDER GROUND STORAGE TANK		■ INFILTRATION TRENCH
5 – 10m	■ GRAVEL FILTER STRIP ■ VEGETATED FILTER	■ SWALE ■ FLOW THROUGH PLANTERS	■ UNDER GROUND STORAGE TANK ■ DETENTION POND	■ RETENTION POND (PARTIAL)	■ INFILTRATION TRENCH
> 10m	■ VEGETATED FILTER	■ SWALE	■ UNDER GROUND STORAGE TANK ■ DETENTION POND	■ RETENTION POND ■ CONSTRUCTED WETLAND	■ RAIN GARDEN ■ INFILTRATION BASIN

DESIGN & CONSTRUCTION DETAILS

1. *Street profile options*
2. *Managing steep topography*
3. *Designing with different soil conditions*
4. *Choose appropriate plant material*
5. *Soil preparation*
6. *Construction process*

Existing street with less area & barricade along pathway. Pedestrian walking on road

Proposed, pathway with green buffer along trees.

Street profile options

The street profile or width determines how storm water runoff flows off of a street (if the slope is towards median or towards road edge). Street sizes vary as per the use or location. Every street has limitations based on whether a street is newly built, or if it is part of a retrofit project.

new Construction

When building new streets, the storm water facility on a street should be must/mandatory. The type of swm facility to be used depends on the street profile or typology. For new construction, there is far more flexibility for storm water management because the street profile can be designed in a variety of ways.

STORM WATER MANAGEMENT ON STREET TYPES

	Permeable paving	Vegetated and Gravel Filter	Flow through and Infiltration Planter	Swales	Rain Gardens	Green gutters
6mt wide Road	O					O
9mt wide Road	O		O			O
12mt wide Road	O	O	O	O		O
18mt wide Road	O	O	O	O	O	O
24mt wide Road	O	O	O	O	O	O
30mt wide Road	O	O	O	O	O	O
40mt wide Road	O	O	O	O	O	O
45mt wide Road	O	O	O	O	O	O
60mt wide Road	O	O	O	O	O	O

Only if there is a kerb extension

FUNCTIONS OF STORM WATER MANAGEMENT – a broad overview

	FILTRATION	DETENTION	RETENTION	INFILTRATION	CONVEYANCE	WATER QUALITY IMPROVEMENT
Permeable Paving	O	O		O		O
Vegetated and Gravel Filter	O	O		O	O	O
Flow through and Infiltration Planter	O	O	O	O	O	
Swales	O	O		O	O	O
Rain Gardens	O	O	O	O		O
Green gutters	O	O			O	
Wetlands	O	O	O	O		O

This is a commercial street, where there is no green on site. As space is required for movement and parking both, pervious paving is the storm water solution to the situation.

retrofit Conditions

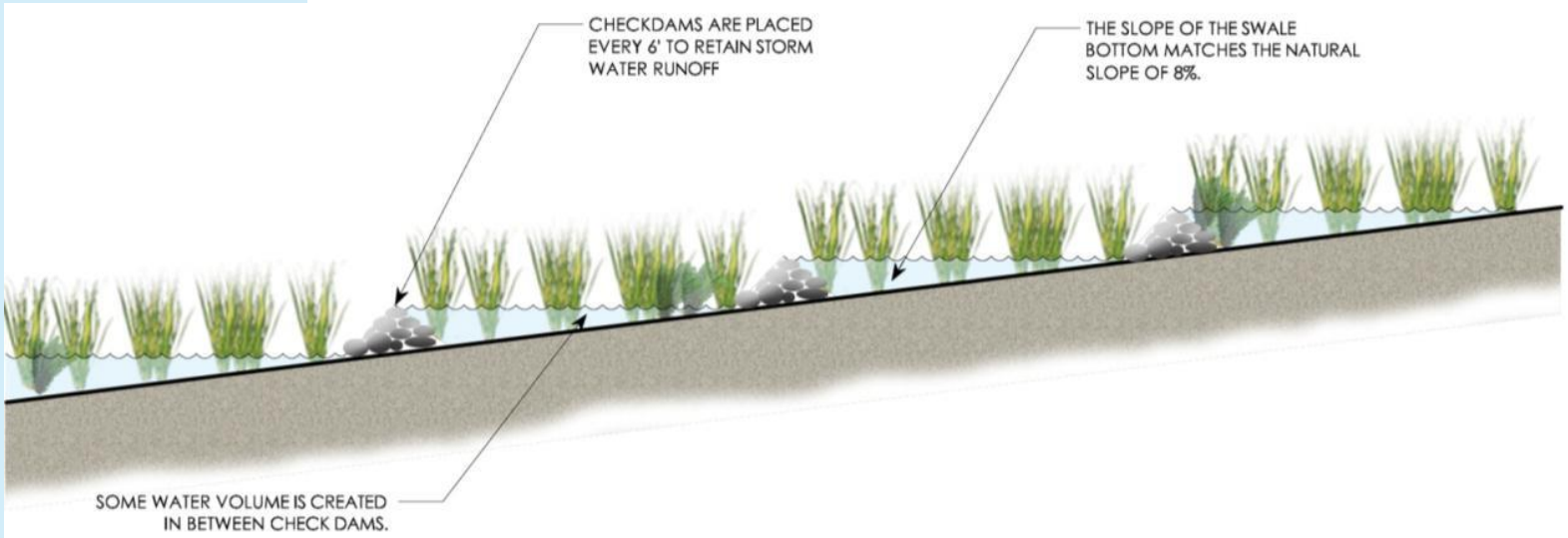
retrofit projects usually offer fewer options for flexibility. The following point should be considered while retrofitting existing streets for storm water management.

- how the storm water drains from the street.

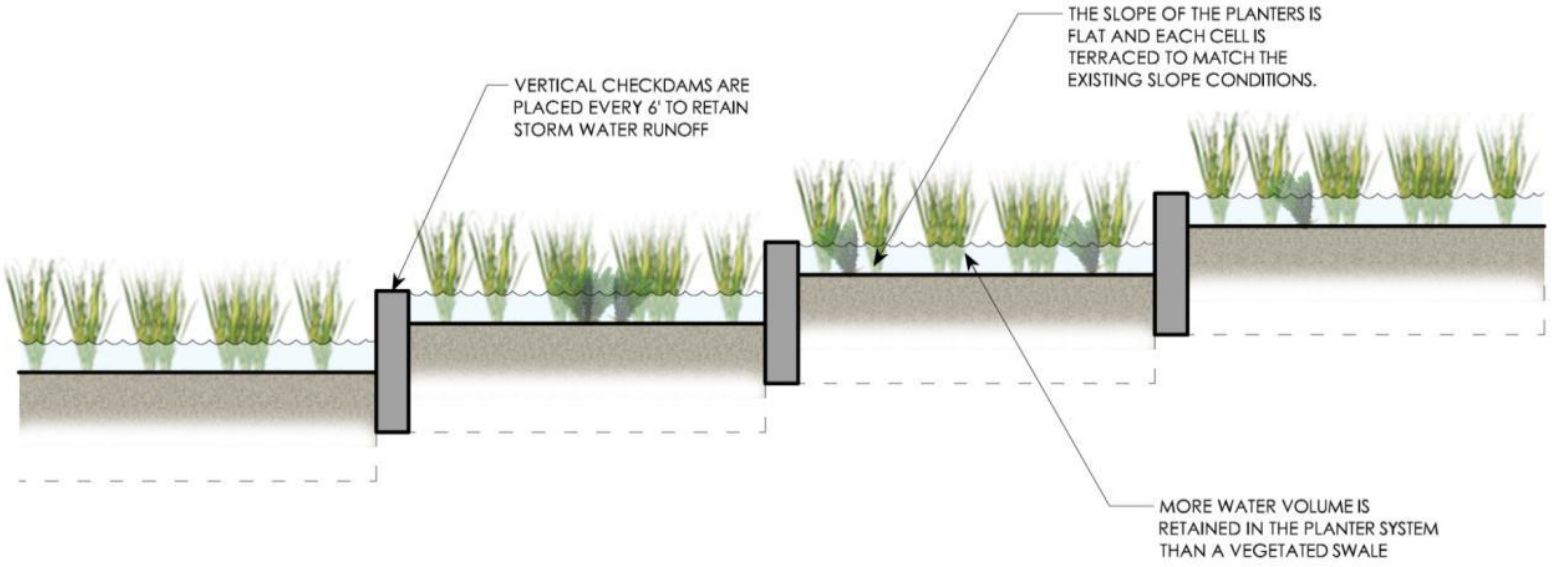
  As it is expensive sometimes, to rebuild the street profile and underground infrastructure. hence, conforming to the existing street profile and identifying storm water solutions that work with this drainage condition, is the simplest and most cost-effective approach to retrofitting a street.

Managing steep topography

Vegetated swale on road edge in slope condition



Storm water planter in slope condition



This is a large triangular island at junction, where the road is on a steep slope. A series of storm water planter provided in the area to collect water at different levels. Excess water goes to the next planter below and then finally to nearby drain.

Design with different soil conditions

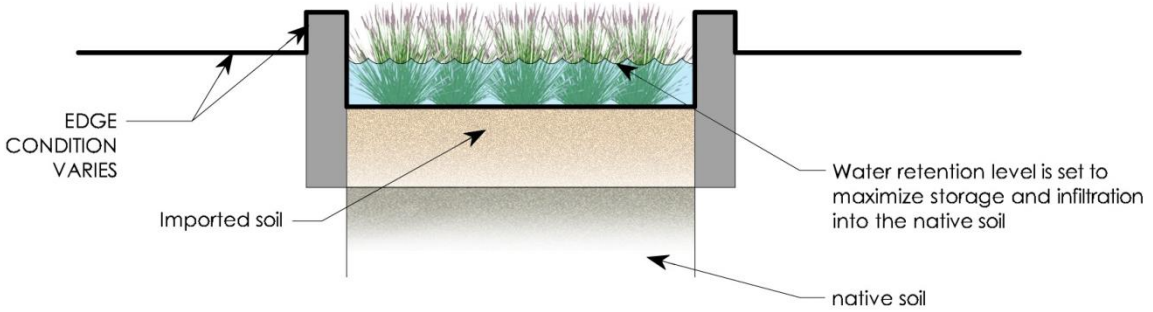
In every city, many sites will not always have both flat terrain and high percolation rates required for infiltration facilities.

- Infiltration facilities should not be designed to retain storm water in areas, that have a high water table, or with some soil contamination.
- Infiltration is also infeasible in areas with steep slopes or high clay content soils.

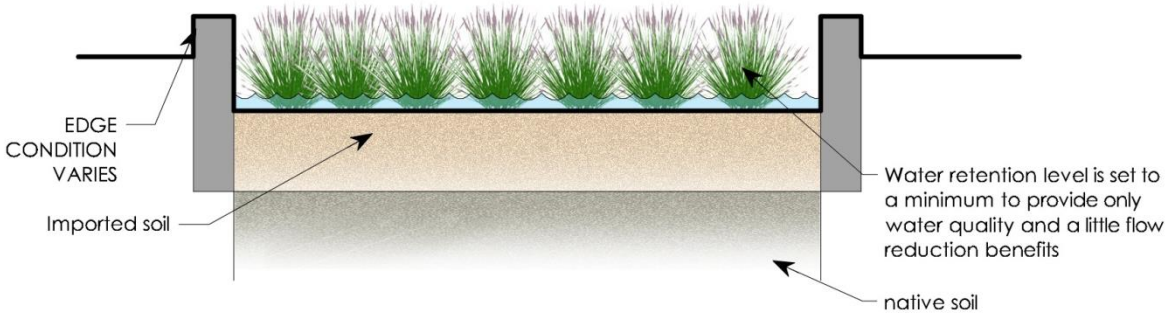
Therefore, we have to follow different techniques other than storm water infiltration.

- Calculate the infiltration rate of particular site.
- Reduce impervious area, that will reduce the amount of runoff needing treatment. (as increasing a site's landscape area by 25% will result in decreasing the site's storm water runoff by almost 25% even without the use of active storm water facilities.)
- Additional under drain (perforated) will be required for soils with low infiltration rates, so that excess water can get its way to storm drain system.

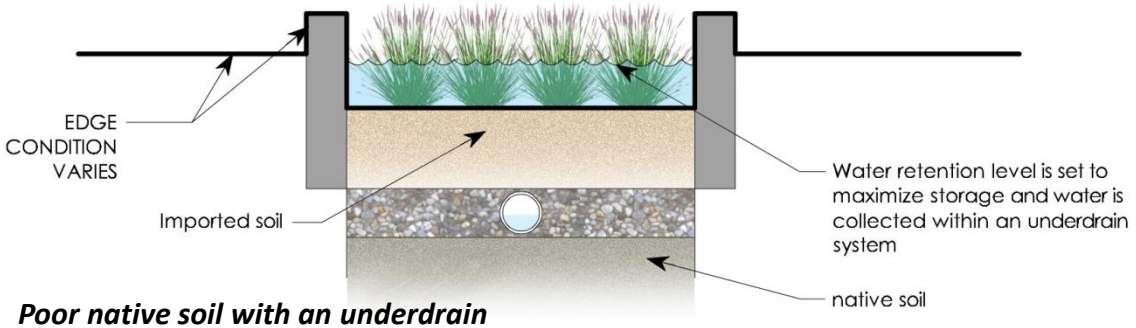
Some sites , where there is poor soil and less space, parking can be provided on the same with pervious paving



Good native soil without an underdrain



Poor native soil without an underdrain



Poor native soil with an underdrain

Planting suggested trees, shrubs, and other plant material with extensive root systems can help loosen tight clayey soils, and allow for more evapotranspiration of water.

The soil bed should be able to infiltrate storm water at a rate of 6 inches/hour.

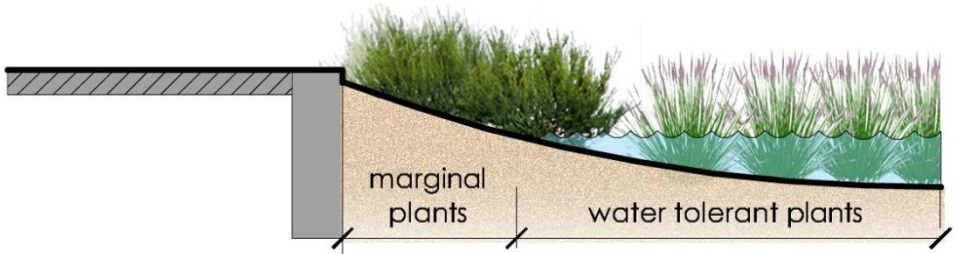
Choose appropriate plant material

Green street and parking lot projects may have different planting zones based on the type of storm water facility used. Storm water facilities that are designed with a side slope condition (e.g., vegetated swales) will have two planting zones: dry and wet.

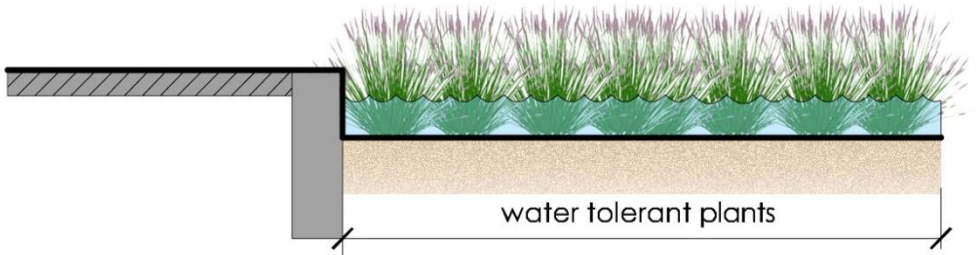
Shrubs, groundcovers, and perennials that grow well in drier conditions should be placed on the upper portions of the side slopes while water tolerant plants, such as sedges and bulrushes, are best suited for the low, flat bottom zone of the storm water facility. Storm water facilities that have only a flat-bottom condition with no side slope (e.g., storm water planters) have only one planting zone that should only be planted with water tolerant plant material. The sections shown explains the typical planting conditions based on storm water facility type.

Planting for Storm water management should be based on following points :

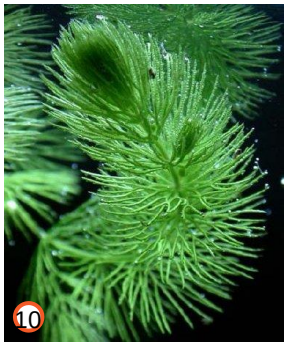
1. Aesthetics
2. Choosing plants that can survive in both “wet” and “dry” conditions.
3. Choose mostly from evergreen plant pallet to get a year-round plant structure.



Planting for swales and rain gardens with sloped bottom



Planting for planters with flat bottom



The following Plants may be suitable for Delhi's soil and climate conditions:

1. Canna
2. Scirpus
3. Phragmites
4. Typha latifolia
5. Cyperus
6. Eichhornia crassipes
7. Salix spp
8. Potamogeton nodosus
9. Sagittaria latifolia
10. Ceratophyllum demersvm

Soil preparation

To add or design SWM facility in a new or retrofit site it is important to check the soil condition of the site and take additional measures if required for better storm water run off.

- A water consultant and soil consultant will be needed to determine the site conditions.
- In general, a mix of weed-free compost, sand, and loamy topsoil will work better in general conditions.
- The soil should not be compacted with heavy equipment during construction as this will result in less water penetration to the site.
- Soil preparation should only be done in dry conditions when there is no standing water on the site surface.
- It is important to keep the soft surface 2-3 inches down from the surrounding hard surface.
- Rocks should be put near kerb cuts to avoid soil erosion.

This is a storm water planter is being prepared for final grading. There will be filling of fine and coarse aggregates of 2' for better water penetration The finish grade will be set 2 inches lower to accommodate a mulch layer.

Construction process

A proper and adequate construction process should be set before starting the project at site.

- For retrofit projects, demolition phase is most important as after extracting the existing concrete or asphalt areas, the native soil conditions have to be inspected to determine the type of soil or if there is any need to add imported soil mix. It is also necessary to know if there is any utility running under the site.
- While concreting the paved areas near SWM site it is important to make sure the accurate grades for storm water runoff.
- Soil Preparation and Grading Phase should be done before monsoon. Finished surface of the green area has to be 2 inches below final grade of the storm water facility to add mulch layer.
- Planting should be done in dry conditions without standing water on the soil surface. If plants are installed in summer season, it is important to provide some irrigation facility in the site.
- After the construction is finished, a regular observation of the site should be done to make sure that the SWM is working properly.

Native soil at the bottom of storm water planter

The storm water planter filled with aggregates, sand and top soil.

MAINTENANCE CHECKLIST

MAINTENANCE CHECKLIST:

Every storm water management system requires regular maintenance. Landscapes designed to perform storm water management functions are not necessarily more maintenance intensive than conventional landscapes. Though regular maintenance is definitely required to avoid clogging of pipes and to remove excess sedimentation or siltation. A concave lawn requires the same mowing, fertilizing and weeding as a convex one and less irrigation after rain is filtered into the underlying soil.

Typical maintenance activities include :

- Periodic inspection of surface drainage systems to ensure clear flow lines. Removing plastic bags and other non biodegradable items.
- Removal of silt.
- Repair of eroded surfaces.
- Adjustment or repair of drainage structures. Regular checking of the overflow pipes / catch pits.
- Soil cultivation .
- Care of plant materials.
- Replacement of dead plants.
- Replenishment of mulch cover.
- Irrigation, fertilizing, pruning and mowing.
- Maintain level of planters & swale, so that there is no back flow.
- Monitoring of the green areas against any external agencies /people dumping any of the waste in these green areas.

Landscape maintenance can have a significant impact on soil permeability and its ability to support plant growth. Proper mulching of the soil surface improves water retention and infiltration. It is important to control the use of medicines & pesticides and prevent over watering. Over watering can lead to run off. Watering should only be done as per requirement to maintain plant health. Organic methods for fertilizers and pest control should be utilized.

IF THERE IS NO AGENCY FOR MAINTAINANCE THEN THAT ROAD SHOULD NOT BE TAKEN UP FOR STORM WATER MANGEMENT

Annexure - I

References:

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Annexure - II

This document is prepared by Oasis designs Inc. to be taken up by various Govt. authorities like UTTIPEC etc. at the city level.

This document is not meant to be comprehensive, the aim is to provide a small reference handbook as a start point towards achieving Sustainable Storm Water Management in the city.

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