LA PARGUERA

GREEN INFRASTRUCTURE MASTER PLAN

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GREEN INFRASTRUCTURE MASTER PLAN

SUMMARY

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CENTER FOR WATERSHED PROTECTION

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PROJECT DESCRIPTION

SITE

La Parguera, a coastal town of 26,000 people, is home to some of the more diverse reefs in Puerto Rico (PR). The La Parguera reef system contains significant stands of both Acropora palmata and A. cervicornus, species listed as threatened under the Endangered Species Act. Acropora palmata is known to be particularly sensitive to sedimentation affecting both reproduction and growth rates. La Parguera entertains a thriving tourism industry associated with snorkeling, driving and a bioluminescent bay, and receives about 100,000 visitors annually. However, stormwater runoff from the hillside town and streets flows directly into the tidal waters and mangroves carrying high levels of pollutants that are damaging the nearshore coral reefs. NOAA NCCOS has monitored PAH (Polycyclic aromatic hydrocarbons- many of which are toxic and carcinogenic compounds associated with combustion of fossil fuels) levels and heavy metals in the near shore sediments and the data shows a clear signal and plume from the town and its impervious surfaces (Figure 1). Further analysis has determined that automobiles, as opposed to boat engineers, are the primary source of these PAHs, implying that stormwater runoff from the heavily developed town is the main contributor of this pollutant (Pait et. al., 2007). This stormwater runoff also carries significant loads of nitrogen, sediment and bacteria as well as other pollutants harmful to coral reefs (La Pointe, 1998). A recent study by Ramos (2006) indicated that unpaved roads and disturbed soils from development or road clearing on the La Parguera hillside are significant sources of sediment in stormwater runoff.

PROJECT

This project proposes to address land based sources of pollution by creating a master green infrastructure plan that consists of conceptual retrofit designs for best management practices (BMPs) at specific discharge points in order to capture and treat stormwater before it enters the tidal waters and nearshore coral environment. This plan will serve as a road map for the future implementation of key projects to decrease nutrient, sediment, and other pollutants stormwater from La Parguera, ultimately improving the quality of the receiving tidal waters and coral reef areas. Center for Watershed Protection, Inc. (the Center) has designed numerous stormwater BMPs located in highly urban environments such as Baltimore, MD, authored or co-authored stormwater manuals for over 10 states and Washington, DC, and customized several BMP specifications for diverse environments including Hawaii and the Pacific islands. Retrofit BMP designs for La Parguera would use native materials and plants and incorporate local community input and engage university landscape architects and the engineering community in a proposed community design charrette.

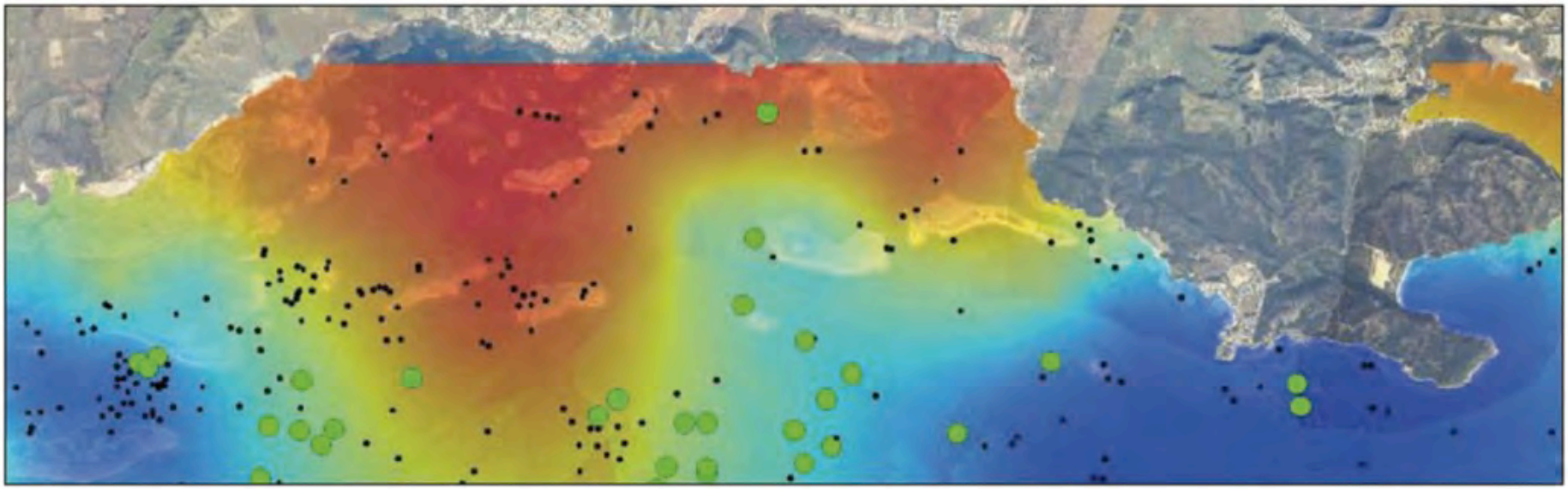


Figure 3. 14. Kriging of total PAHs and coral species richness. Interpolated surface showing l1igh (red) to low (blue) concentrations of PAHs in the nearshore environment (p=0.0425). Black dots indicate survey points for NOAA's CCMA-BB. Green dots indicate locations where coral species ric/mess was in the top 25th percentile. Source: NOAA CCMA.

PROJECT DESCRIPTION

MASTER PLAN

The Master Plan is a framework to guide the implementation of green infrastructure with a coherent language. With this Master Plan we propose a series of physical and landscape strategies to: overcome physical an ecological fragmentation; enhance the existing sense of place were green infrastructure meets public space; enhance the natural resources and to promote the importance of land planning and landscape architecture.

GREEN INFRASTRUCTURE PLAN, LA PARGUERA LAJAS PR

MASTER PLAN FOR WATER MANAGEMENT AND QUALITY IMPROVEMENT

CWPProposedRetrofittingPractices

- outfall+MangroveRestOl<ition
- Rainwater Harvesting+Cistern
- Sand Filters
- FilteringPractice
- New proposed intervention sites
- •Wetpond
- createdWettandPark
- scalerainwater-harvesting
- eioswale
- RoadStabilization
- lawEnforcement

PermeablePavement
Raingarden
GreenStreetBioreten tion

BEST MANAGEMENT PRACTICES

Bioswale/Vegalated Swales

Open, shallow channels whith thick vegetation, on the slopes and bottom, that collect and slowly convey runoff to downstream discharge points.

Green Street Bio-retention

Shallow surface depression planted with native vegetation to treat and capture runoff. Bio-retention techniques mimic natural ecosystems through species diversity, density and distribution of vegetation.

Pennsylvania Stromwater Management Manual

Rain Garden

Shallow surface depression planted with native vegetation to treat and capture runoff. Can be integrated into a site with a high degree of flexibility. Rain gardens can vary in complexity depending on the quantity of runoff volume to be managed.

Pennsylvania Stromwater Management Manual

Permeable Pavement

Is a asphalt or concrete mixed with fewer fine particles to create more air space which allows water to permeate through it. Pollutants are mainly captured within the paver system and the uppermost layers of underlying soil.

www.crwa.org

Rainwater Harvesting

Is the capture, diversion and storage of rainwater for different purposes. It is practical only when the volume and frequency of the rainfall and size of catchment surface can generate sufficiente water for the intended purpose.

Road Stabilization

The use of construction specifications, techniques, and materials to stabilize soils on which a travel way is constructed as part of a construction plan. A travel way may include access roads, subdivisions roads, parking areas, and other on-site vehicle transportation routes not accessible to public traffic.

Wetland/Wetland Restoration

Wetlands can receive discharges from storm water collection systems and other outfalls for the treatment of contaminated or nutrient-enriched water. It also reduces flow velocity,captures suspended sediments and contaminants.

Wet Ponds

Used for the treatment of contaminated or nutrient-enriched water. It also reduces flow velocity,captures suspended sediments and contaminants. It is a combination of a permanent pool and a shallow marsh equivalent to the entire WQ$_v$

Filtering Practices/Sand Filter

Captures and temporarily stores the water quality volume and pass it through a filter bed of sand, organic matter, soil or other media. They are not designed to provide stormwater detention or channel protection.

www.stormwatercenter.net

Mangrove Restoration

Restoration planning should first look at the potential existence of blocked tidal flow or other environmental stresses that may prevent mangrove recruitment (Hamilton and Snedaker 1984, Cintron-Molero 1992). If blocked tidal flows or other stresses are present, they should be removed.

GUIDING PRINCIPLES | BMP

This project proposes to address land based sources of pollution by retrofiting designs for best management practices (BMPs) at specific discharge points and sediment source areas in order to capture and treat stormwater and sediment before it enters the tidal waters and nearshore coral environment.

Wetland Restoration Out Falls: Fore bays

for the treatment of contaminated or nutrient-enriched wastewater; receive discharges from storm water collection systems and other outfalls; make use of natural wetland processes: plants, soil, and associated microorganisms; reduce flow velocity, capture suspended sediments, and adsorb contaminants; the cost is proportional to the number and sizes of treatment cells required ($35,000 to $150,000 per acre for constructed treatment wetlands or about 50% to 90% less than conventional treatment techniques).

Vegetated Swales

are open, shallow channels with thick vegetation covering the side slopes and bottom that collect and slowly convey runoff to downstream discharge points. Best suited for residential, industrial, and commercial areas with low flow and smaller populations feasibility of installing depends on the area, slope, and the contributing watershed. Limitations: impractical in areas with very flat grades, steep topography, or wet or poorly drained soils.

Wet Ponds

combination of a permanent pool, extended detention or shallow marsh equivalent to the entire WQv; A sediment fore-bay is important for maintenance and longevity of a storm-water treatment pond. A pond buffer should be provided that extends 25 feet outward from the maximum water surface elevation of the pond. Woody vegetation may not be planted or allowed to grow within 15 feet of the toe of the embankment

Rain Gardens

is an excavated shallow surface depression planted with specially selected native vegetation to treat and capture runoff and typically underlain by a sand or gravel infiltration bed. Best suited for areas with at least moderate permeability = more than an inch/hour. Cost 5 – 7 dollars per cubic foot. Surface area is dependent upon storage volume requirements but should nor exceed a maximum loading ratio of 5:1. Water accumulation depth should not exceed 6 inches and should empty within 48 hours.

Filtering Practices

Capture and store, temporarily, the water quality volume and pass it through a filter bed of sand, organic matter, soil or other media. Are generally applied to land uses with a high percentage of impervious surfaces. Sediment should be cleaned out when it accumulates to a depth of 6" or more.

Rain Water Harvesting

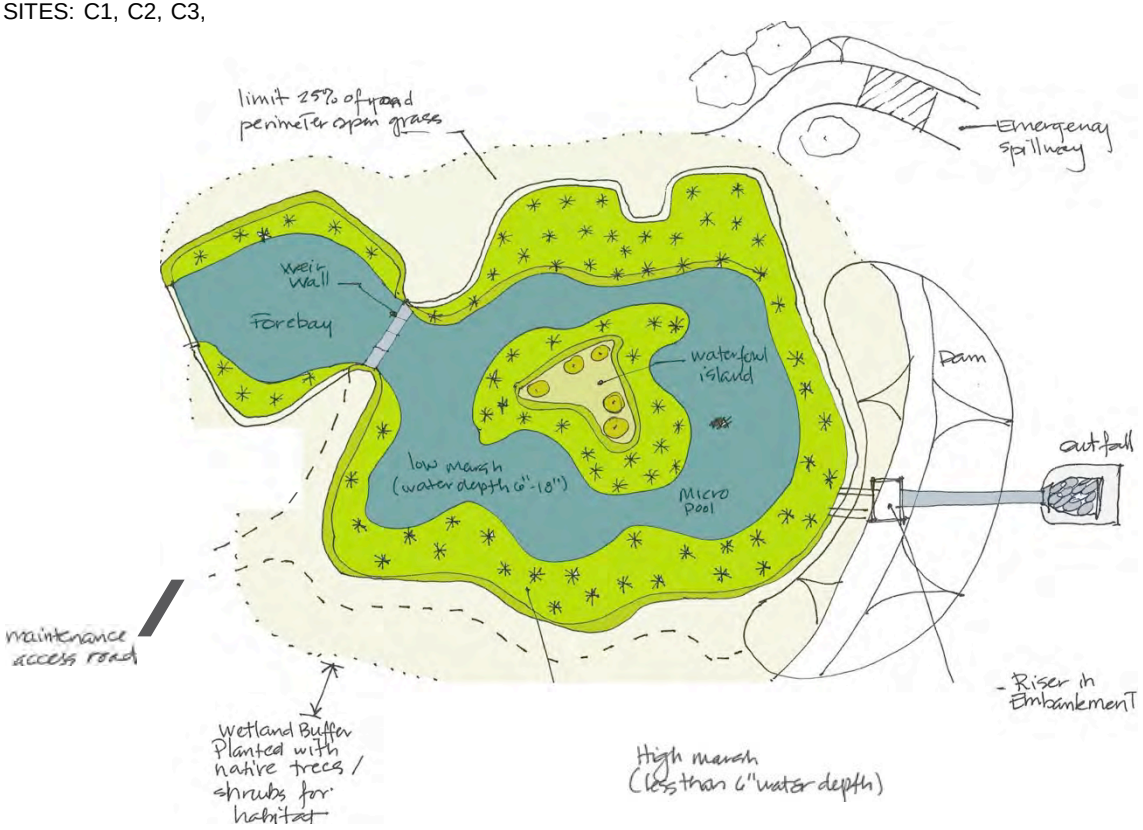
is the capture, diversion, and storage of rainwater for a number of different purposes; is practical only when the volume and frequency of rainfall and size of the catchment surface can generate sufficient water for the intended purpose.

Permeable Pavement

allows rainwater to infiltrate through it, to be filtered and recharged into the ground as groundwater. $7 - $15/square foot, including underground infiltration bed. Can reduce overall project cost by eliminating the need for traditional storm-water infrastructure. Ideally situated on shallow slopes above soils with permeability rates greater than 0.25 inches/hour.

TYPICAL PROVISIONS FOR STORMWATER WETLAND (CONSTRUCTED WETLAND)

SITES: C1, C2, C3,



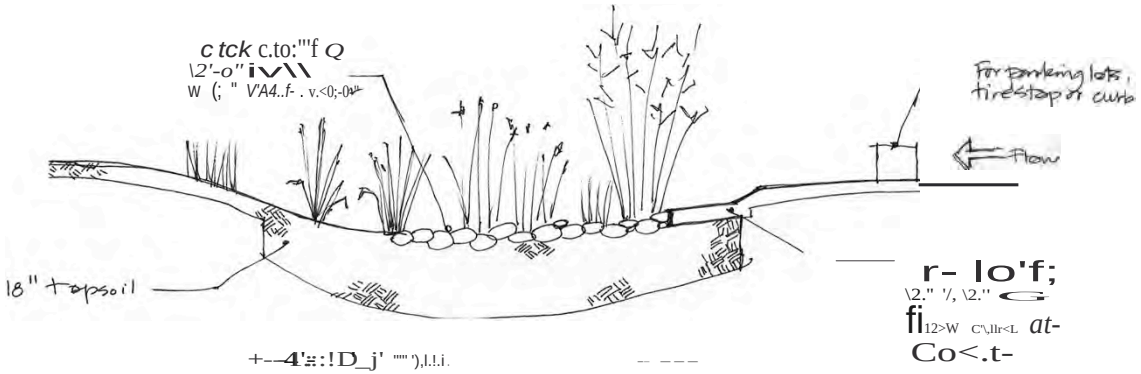
http://www.aila.org.au/lapapers/papers/syrnix-perth/05_Stormwater-wetland-Zone-1--initial-detention.jpg

Photo by Marcus Gary
United States Geological Survey

Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds (see Wet Ponds Fact Sheet) that incorporate wetland plants in a shallow pool. As stormwater runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal, and also offer aesthetic value. While natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands both in terms of plant and animal life. There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.
(http://www.stormwatercenter. neUAssorted %20Fact %20SheetsfTool6_Stormwater_ Practices/Wetland/Wetland. htm)

BIOSWALE (VEGETATED SWALE)

SITES: A1

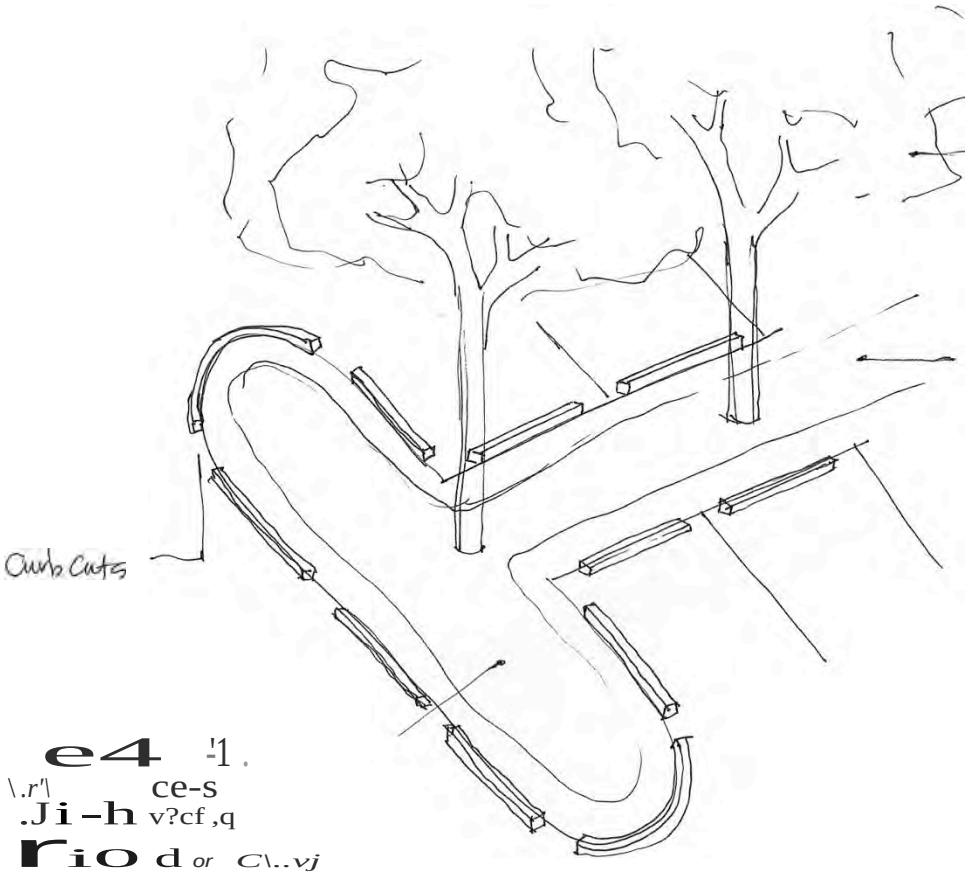


http://knol.google.com/k/-/-/17ruw3d8fyl4e/9auamn/b ioswa le-seattle.jpg

http://farmS.static.flickr.com/4007/4651203085_ab1Oe85599_z.jpg

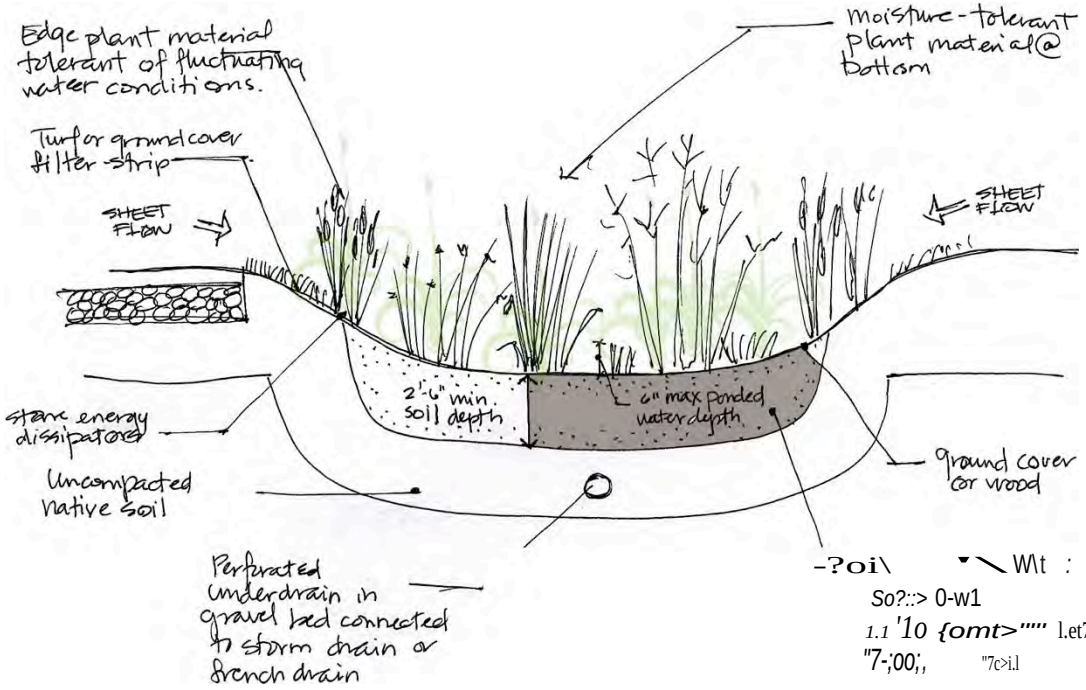
TYPICAL PROVISIONS FOR GREEN STREET BIORETENTION

SITES: 06, 08, F1



RAINGARDENS

SITES: 81, 01_A, 01_8, 03, 04, 05, 07, E1, E200, E201,

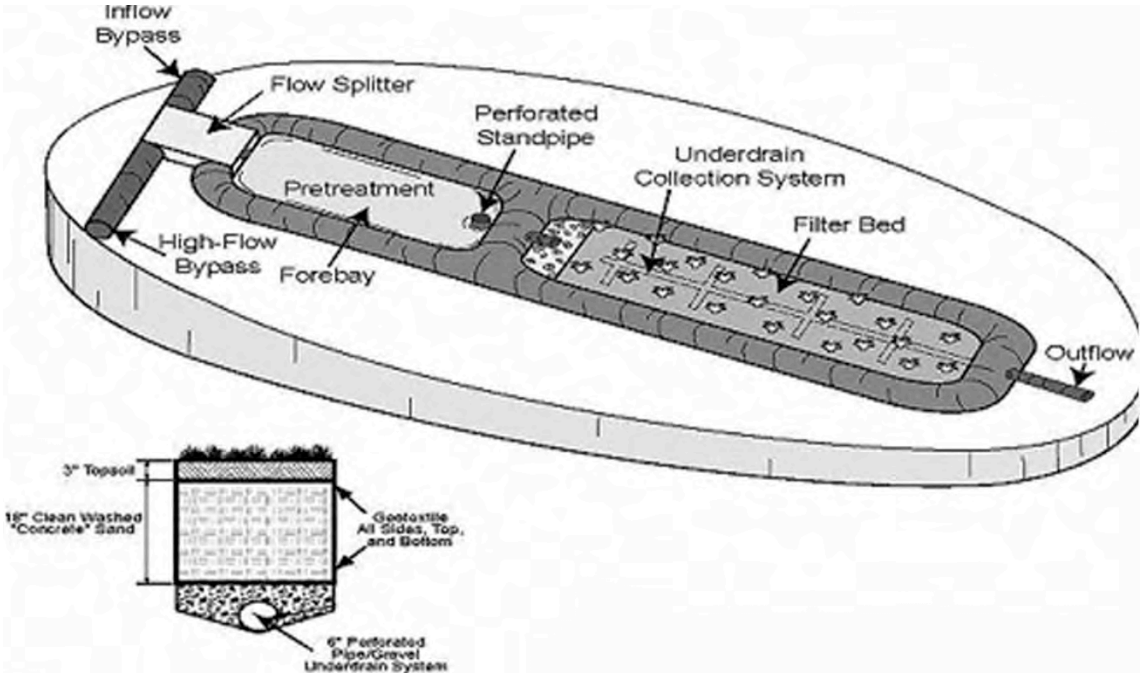


Raingarden in saipan

http://farm4.static.flickr.com/3058/2864438948 _0821d57b 17.j pg

TYPICAL PROVISIONS FOR FILTERING PRACTICES (SAND FILTERS)

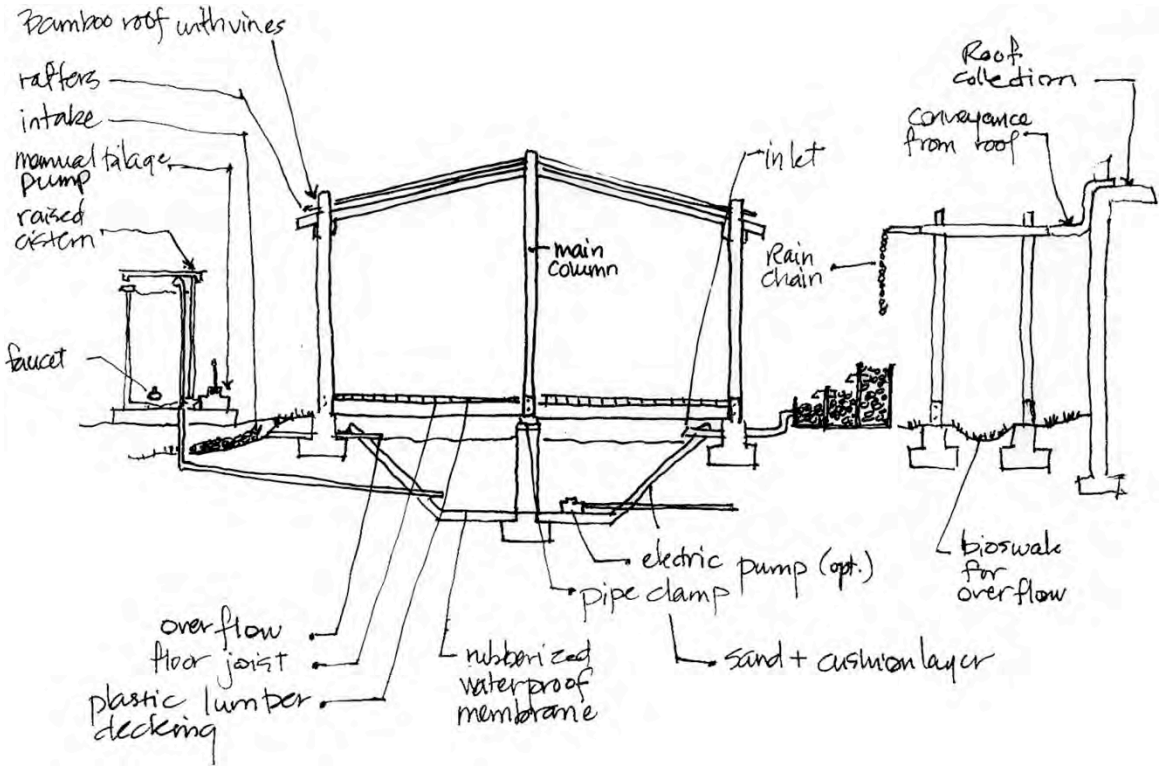
SITES:B3, 01, E200



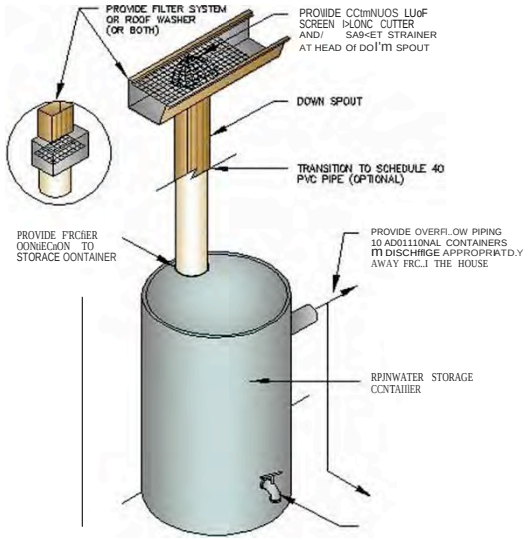
SCHEMATIC OF A SURFACE SAND FILTER

TYPICAL PROVISIONS FOR RAINWATER HARVESTING

SITES: E4



http://bangalore.citizenmatters.in/pics/0001/1645/env-rain--water-harvesting_small.jpg

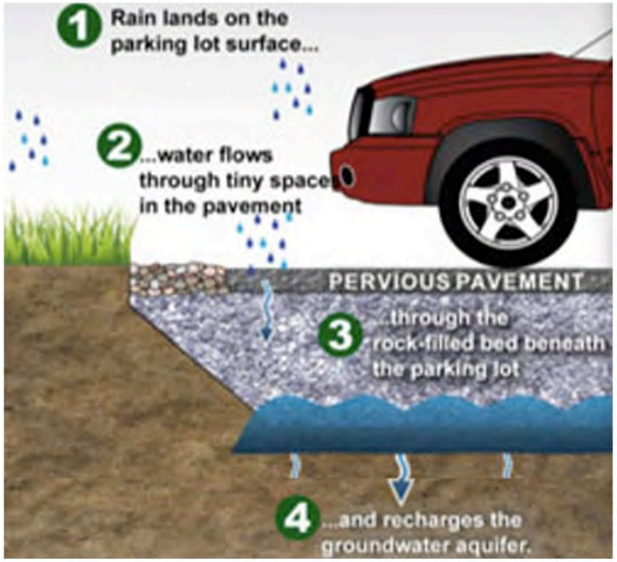


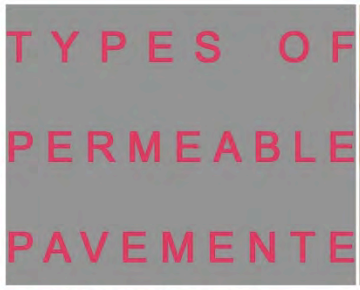
http://groundtec.net/wp-content/uploads/2009/08/rainwater3.jpg

TYPICAL PROVISIONS FOR PERMEABLE PAVEMENT (POROUS PAVEMENT)

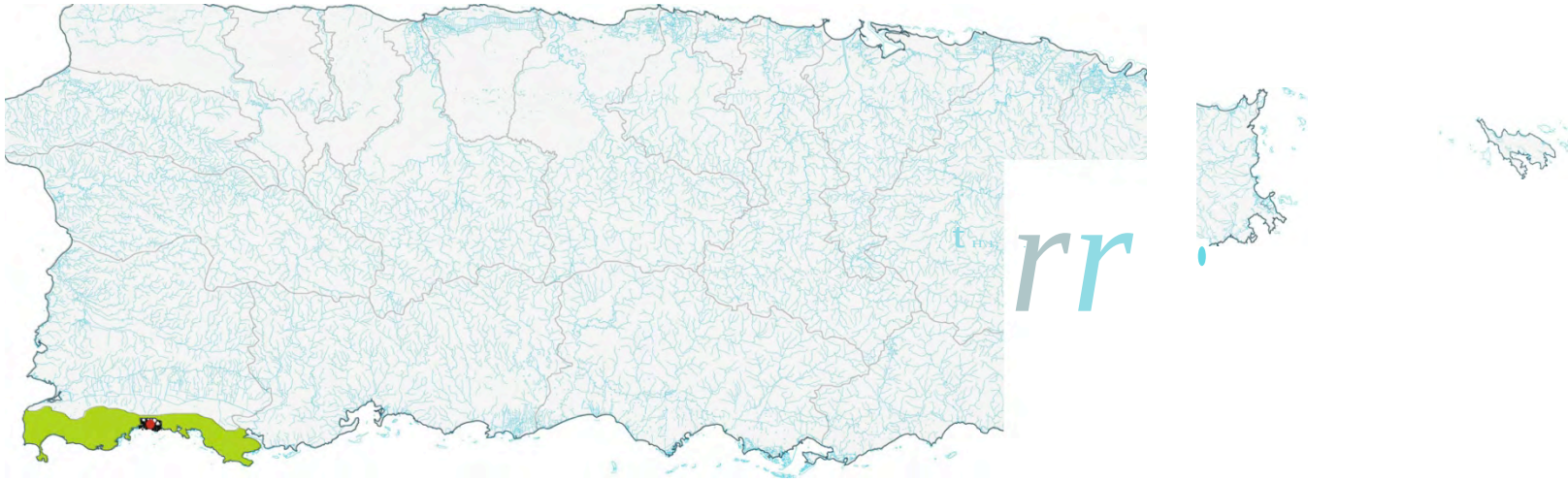
SITES: E1, E201, E6, E7

http:Jlwww.buildinggreen_com/cg bOn/scale_cg?widtt=250&src:fandes/imagesJ1804/pavers .jpg





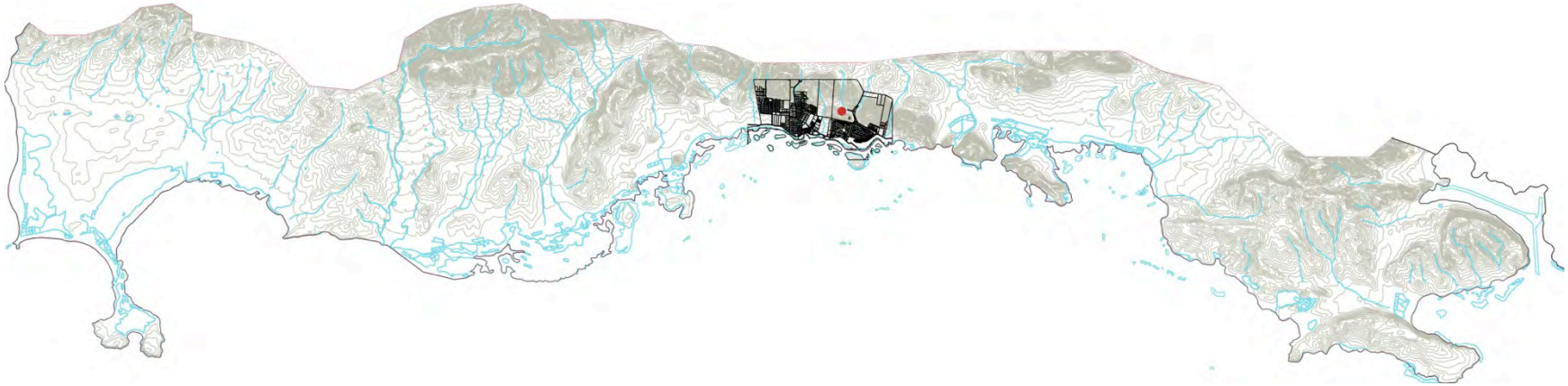
PUERTO RICO WATERSHED AND WATERBODIES



Coast Town La Parguera

Cuenca Rfo Guanajibo

LA PARGUERA CONTEXT FOR SOUTH WEST PUERTO RICO DIRECT DRAINAGE WATERSHEDS



LA PARGUERA SUB-WATERSHED

LA PARGUERA TODAY

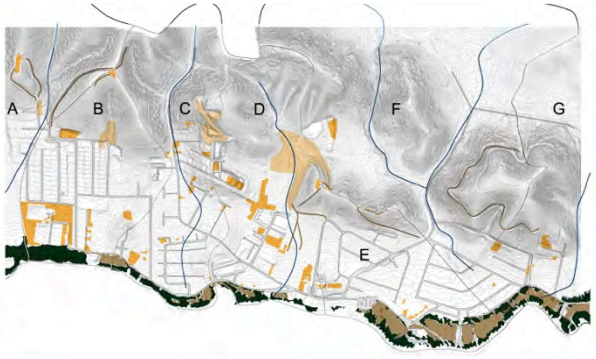
La Parguera is a coastal town of 26,000 people and a hub for tourism all year round increasing the amount of pollutants that reach the coastal water. Even though this project focuses on the reduction of stormwater runoff we identified several deficiencies: lack of coherent connection, fragmented ecosystem and infrastructure and lack of identity, porr quality of public space.

We believe that well designed green infrastructure can contribute to solve this challenges thus turning the infrastructure into space, into public space. Therefore the use of green infrastructure, for enhancing water quality and reducing stromwater runoff among other benefits, can become an agent for addressing social and economic concerns.

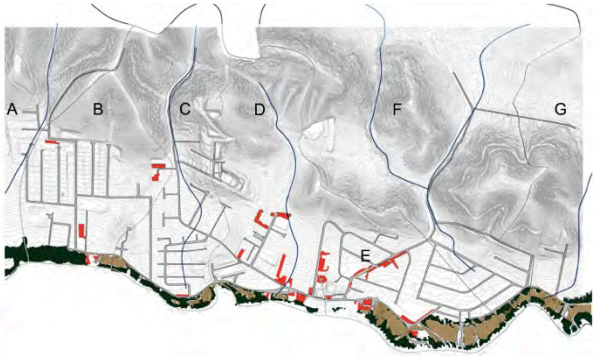
LA PARGUERA TODAY | SITE INVENTORY

LA PARGUERA TODAY | SITE INVENTORY

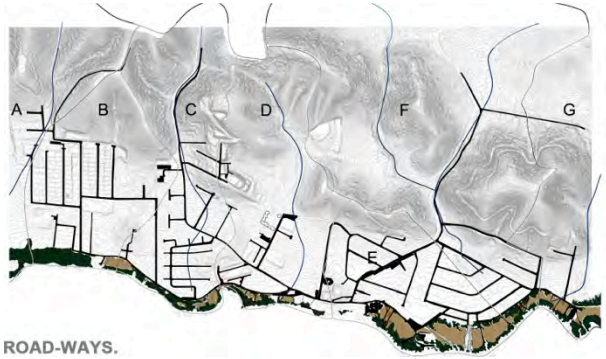
UNDEVELOPED TERRAIN.



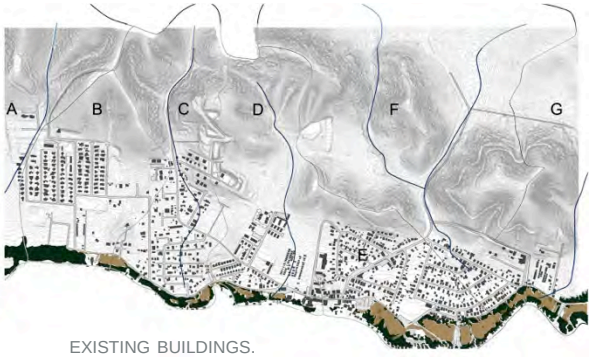
EXPOSED SOILS.



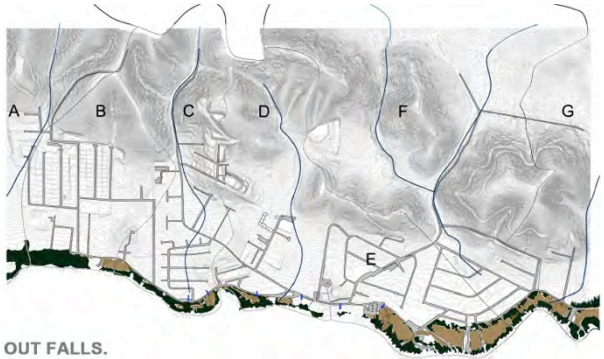
PARKING AREAS.



ROAD-WAYS.



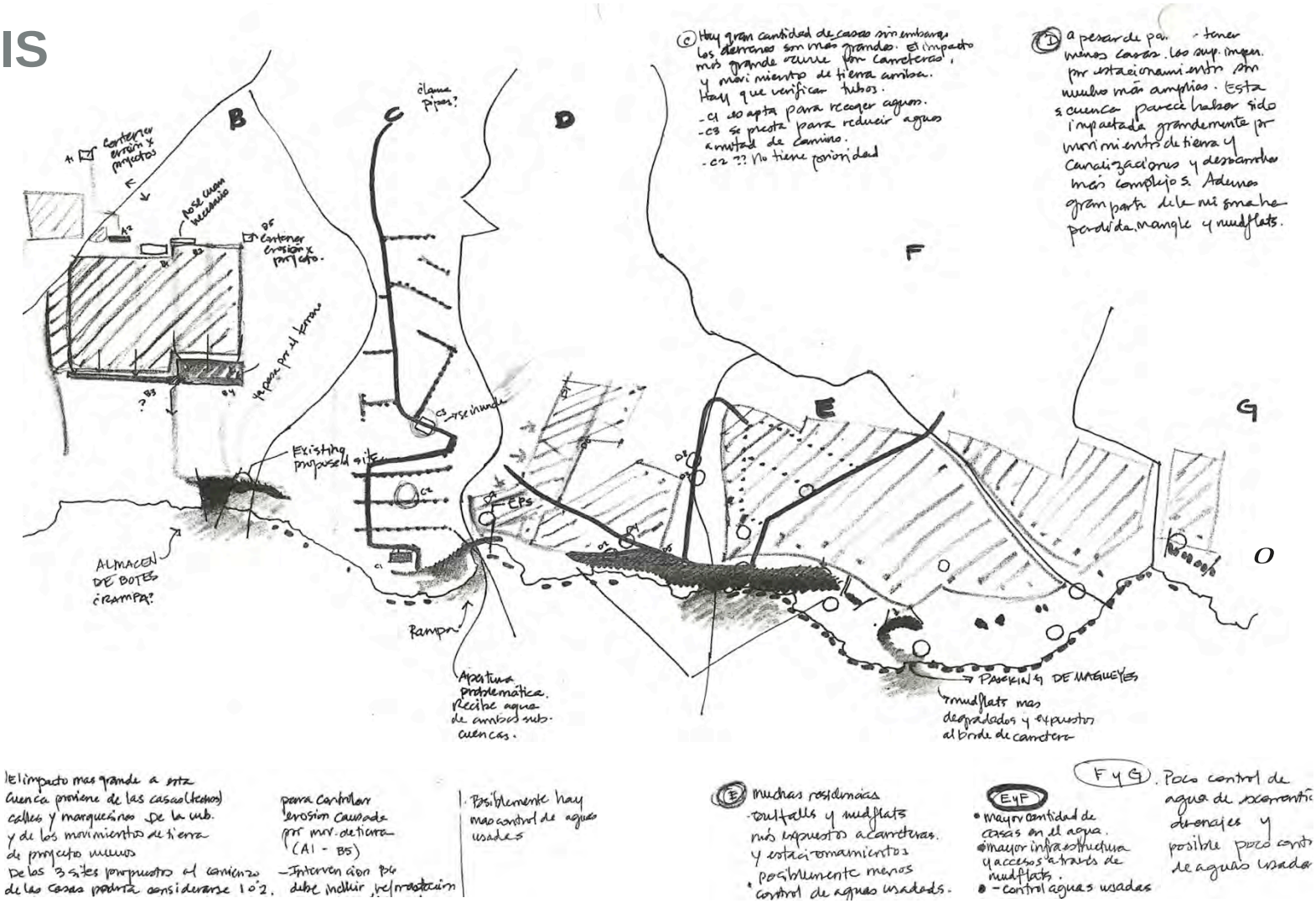
EXISTING BUILDINGS.



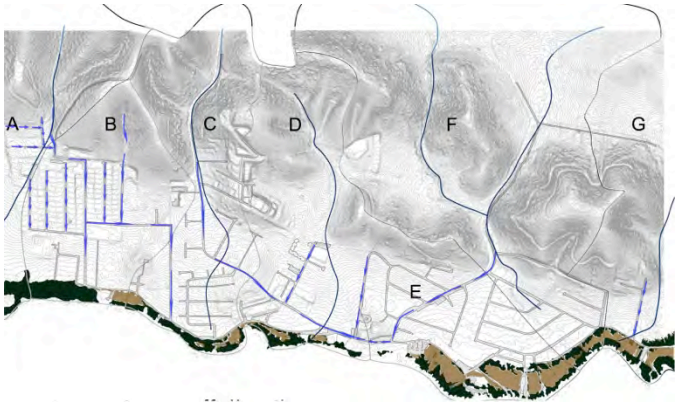
OUT FALLS.

ANALYSIS

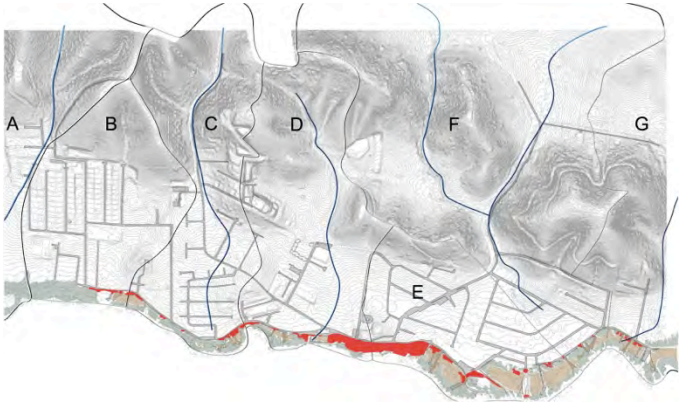
In the process of analysis we put together layers of information to identify the tensions and problems in La Parguera. The tensions and problems identified wer:e lack of coherent connection, fragmented ecosystem and infrastructure and lack of identity. With these significant tensions we pin pointed the subwatershed with the greatest tension and the first areas to implement the green infrastructure.



ANALYSIS

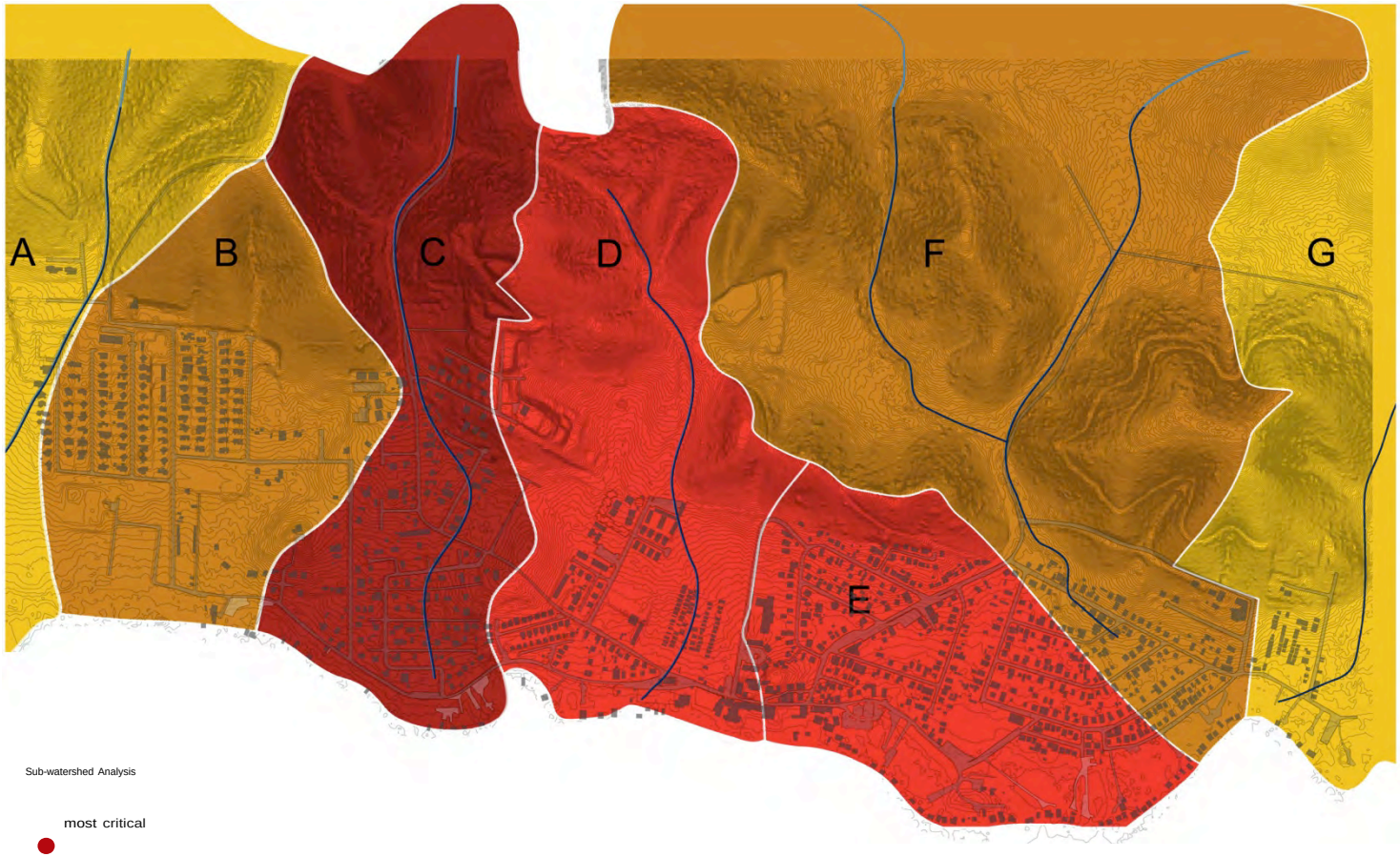


STORMWATER FLOW. HARDSCAPE.

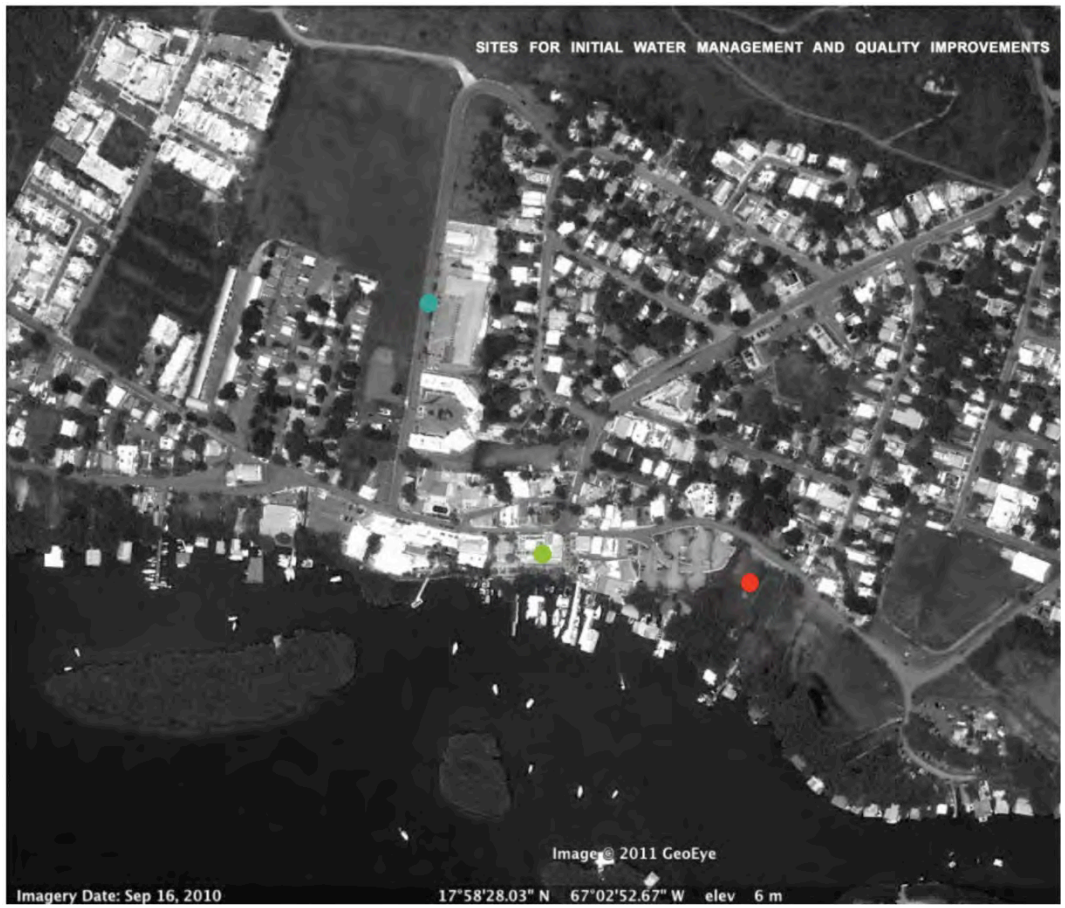


ECOlOGICAL FRAGMENTATION.

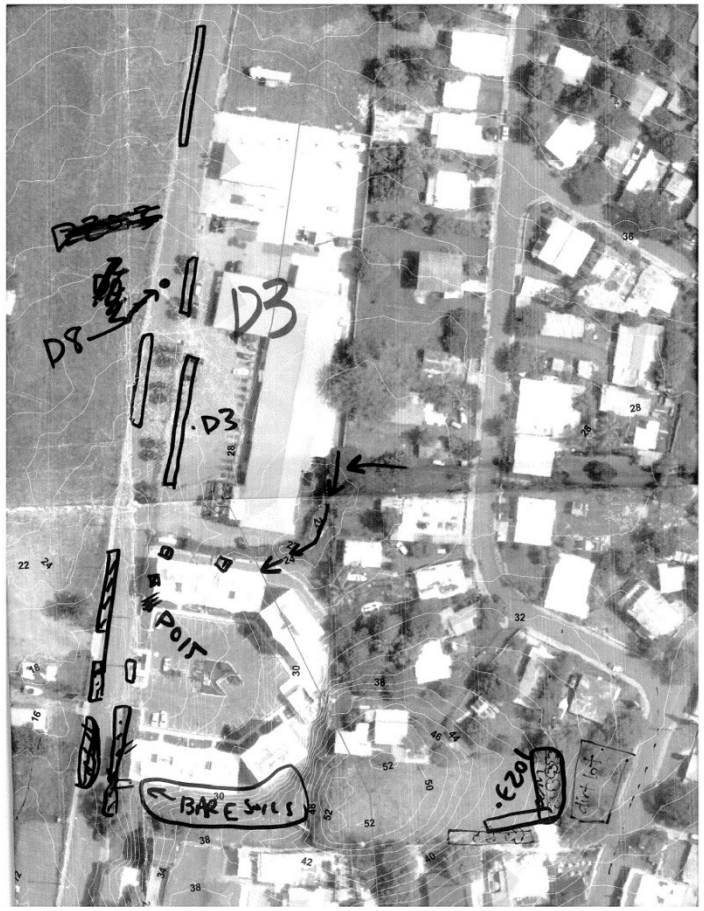
ANALYSIS


A
B
C
D
E
F
G
Sub-watershed Analysis
most critical
less critical

3 SITES 3 INTERVENTIONS 1 WORKING LANDSCAPE

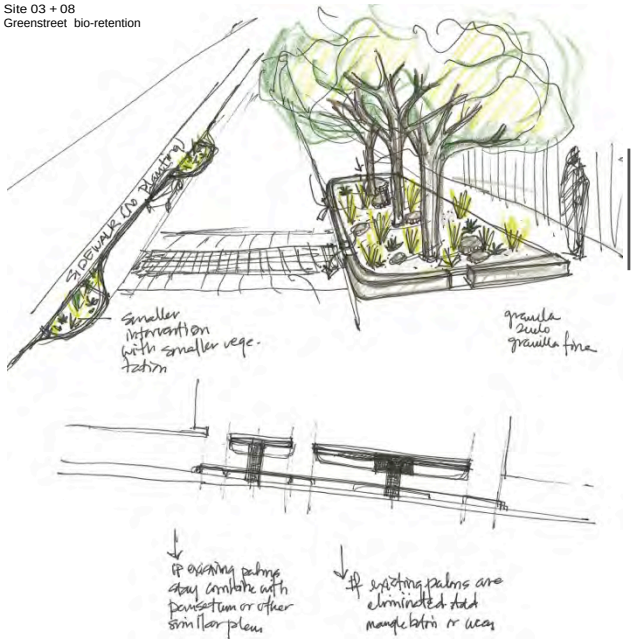


SITE 03 + 08 | GREEN STREET 810-RETENTION



SITE 03 + 08 | GREEN STREET 810-RETENTION

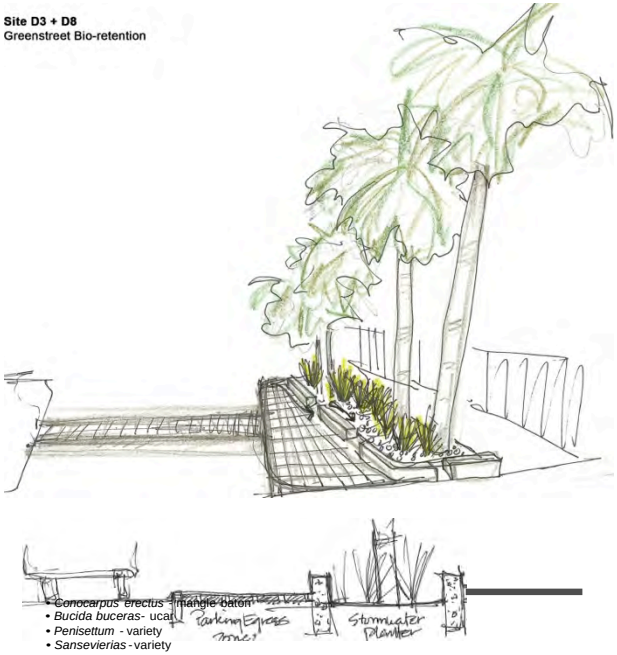
Site 03 + 08
Greenstreet bio-retention



Preliminary materials:
·gravel
·topsoil
•limestone

Preliminary plants if existing palms are removed:

Site D3 + D8
Greenstreet Bio-retention

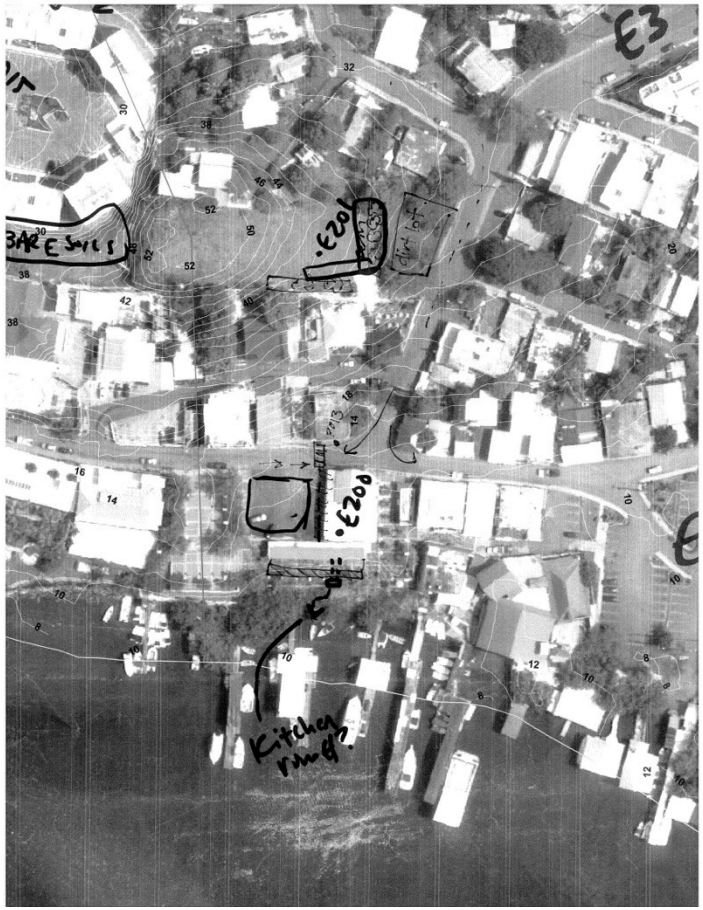


• *Conocarpus erectus* - mangle baton
• *Bucida buceras*- ucar
• *Penisettum* - variety
• *Sansevierias* - variety

Preliminary materials:
• gravel
• topsoil
• limestone - variety
• permeble pavement for selected areas

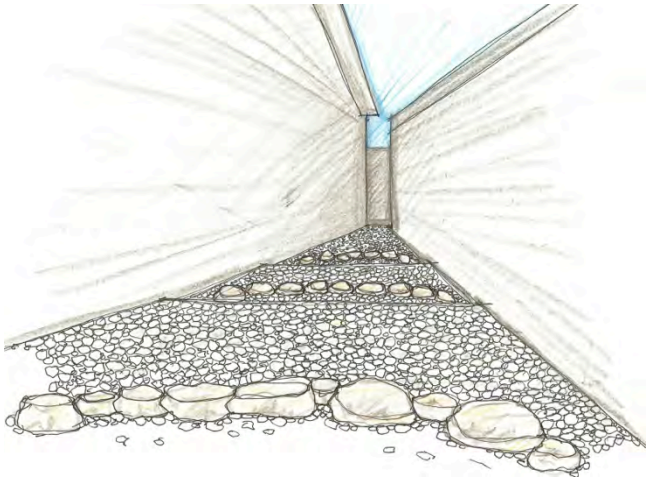
Preliminary plants if existing palms remain:
• *Chrysoba/anus /caco* - icacos
• *Penisettum* - variety
• *Sansevierias* - variety

SITE E200: SAND FILTER



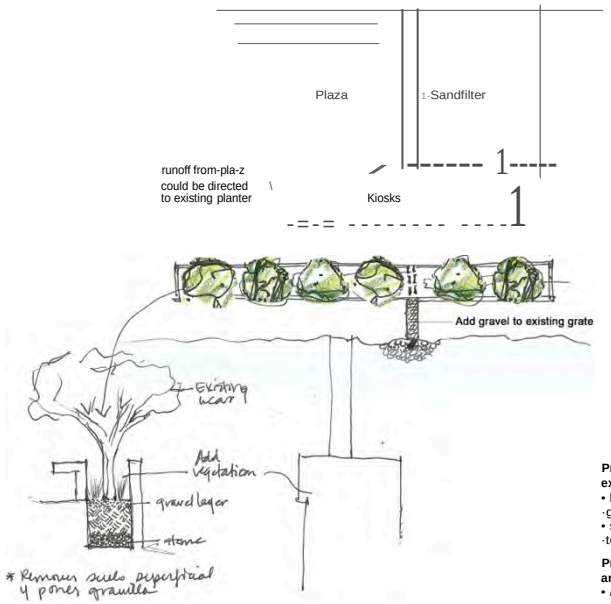
SITE E200: SAND FILTER

Site E200
Sandfilter between plaza and building



Preliminary materials:
• limestone rocks - different sizes
• gravel
·sand

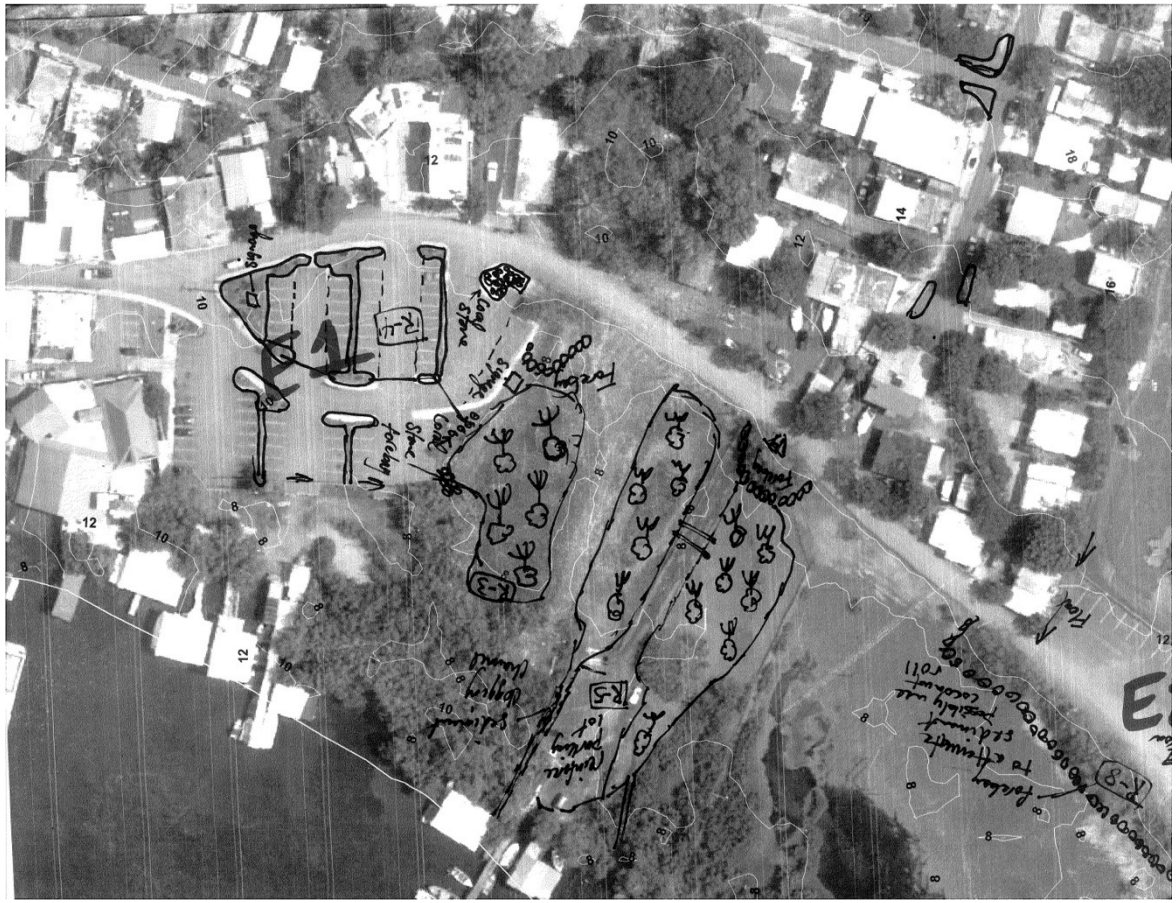
Site E200
Plaza and Kiosks



Preliminary materials for existing planter:
• limestone rocks - different sizes
·gravel
• sand
·topsoil

Preliminary plants if existing palms are removed:
• *Bucida buceras*- ucar
• Herbaceous plant that will help evaporation

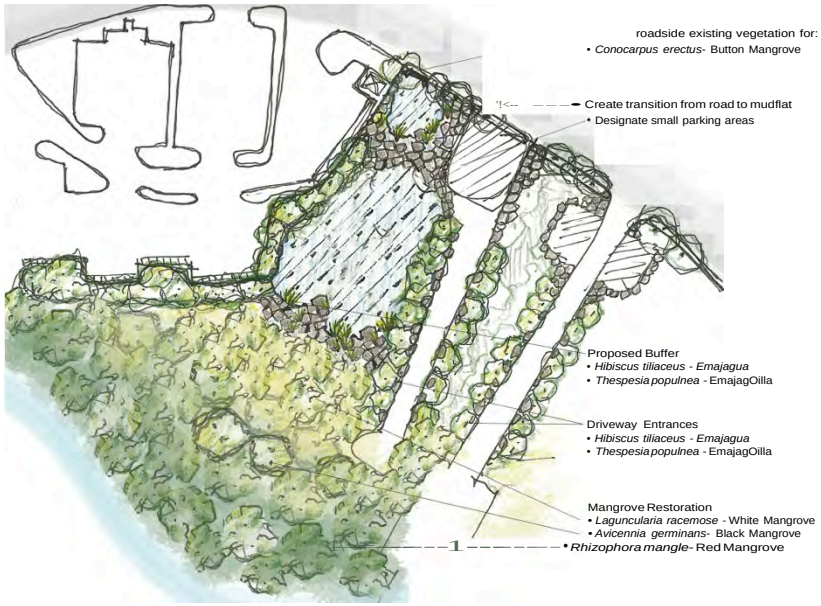
SITE E3 + E5: MANGROVE RESTORATION + FORE BAY

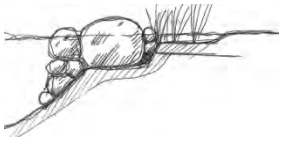


SITE E3 + E5: MANGROVE RESTORATION + FORE BAY

SITE E3 + E5

Site E3 + E5
Mangrove Restoration and Forebay General Plant Palette





• Create transitions in depth of forebay to allow the growth of different species.

• Create transition from road to mudflat

Mangrove Distribution According to Distance from Sea to Land

Rhizophora mangle - Red mangrove
GROWING HABIT- Perennial tree, Evergreen. Distinguished by its erect and aerial roots that forms a dense brush. Forms pure colonies when in direct contact with sea in quiet coasts. Reaches heights of 10 meters or more and 30 em in diameter or more.
HABITAT- Common in mangrove swamps around coastal areas, near river mouths. Provides shelter and nesting for aquatic birds. Estuarine systems.

Avicennia germinans - Black mangrove
Evergreen tree. Stems up to 30cm of diameter, 16 meters long. More salt tolerant than other mangrove species.
HABITAT- Coastal lagoons and swamps, estuarine systems. Provides nesting and shelter of wildlife.

Laguncularia racemosa- White mangrove
GROWING HABIT- Evergreen tree; reaches up to 20 meters high, produces pneumatophores.
HABITAT- Mangrove swamps in coastal areas. Provides shelter for wildlife.

Conocarpus erectus - Button mangrove
GROWING HABIT- Evergreen tree; generally up to 3-5 meters high but it can reach 20 meters.
HABITAT- Mangrove swamp forests and sometimes on rocky and sandy shores. Estuarine systems. Provides shelter for wildlife.

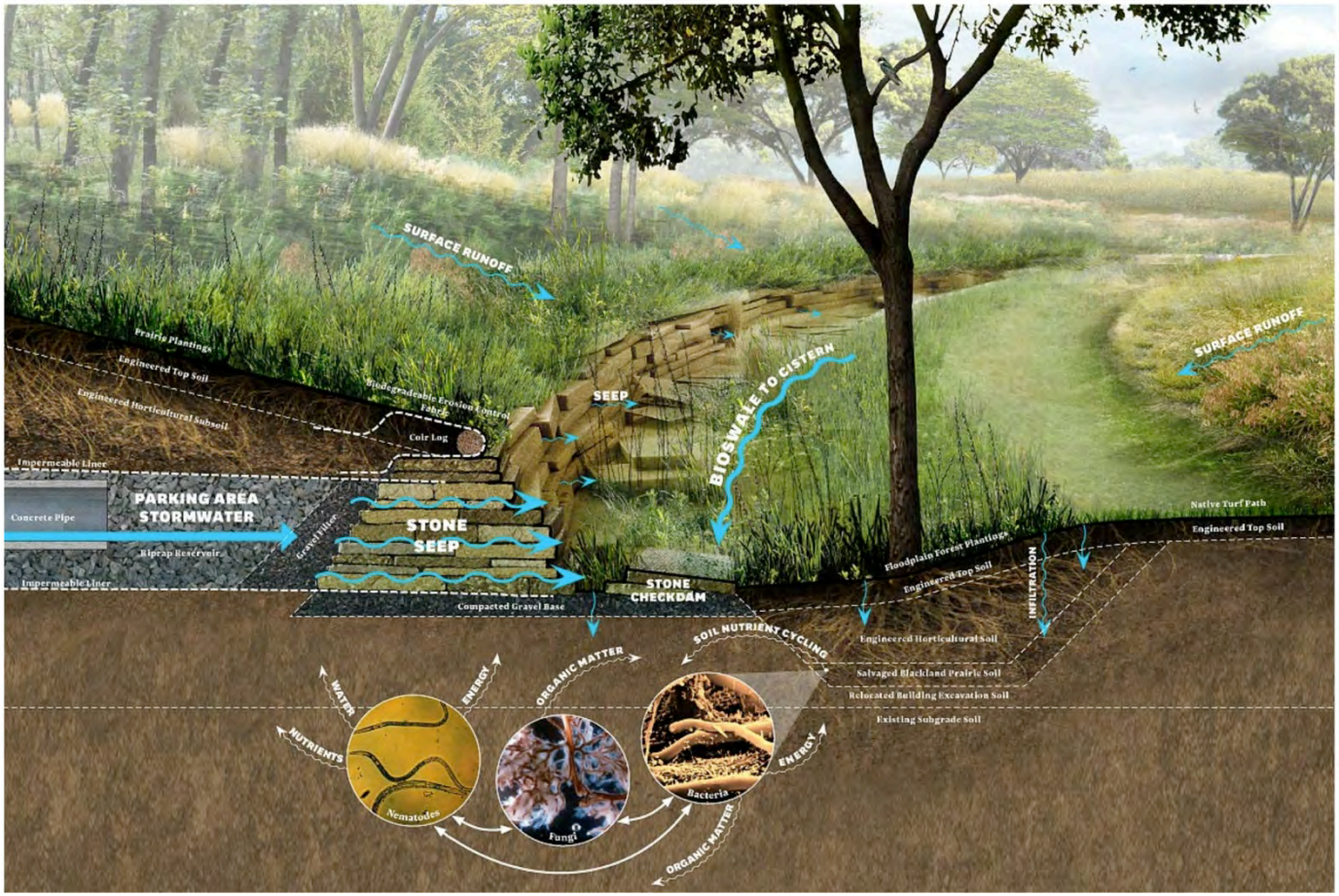
Roadside, Parking Area and Mangrove Entrance Trees

Thespesia populnea- Emajaguilla (Portia tree, Spanish cork, Otaheita)
GROWING HABIT- Shrub/tree of coastal woods, up to 30 feet high. Trunk of 20 em diameter; dense crown.
HABITAT- Coastal woods and

Hibiscus pernambucensis - Emajagua
GROWING HABIT- Shrub or tree; to 15 m tall.
HABITAT- In brackish swamps and inner margins of mangrove, ascending to the humid mountains.

Stahlia monosperma - Cobana negra
GROWING HABIT- Perennial tree. Evergreen. Stems up to 20 meters high.
HABITAT- Coastal woodlands and borders of mangroves. Threatened with extinction.

EXAMPLE PROJECTS



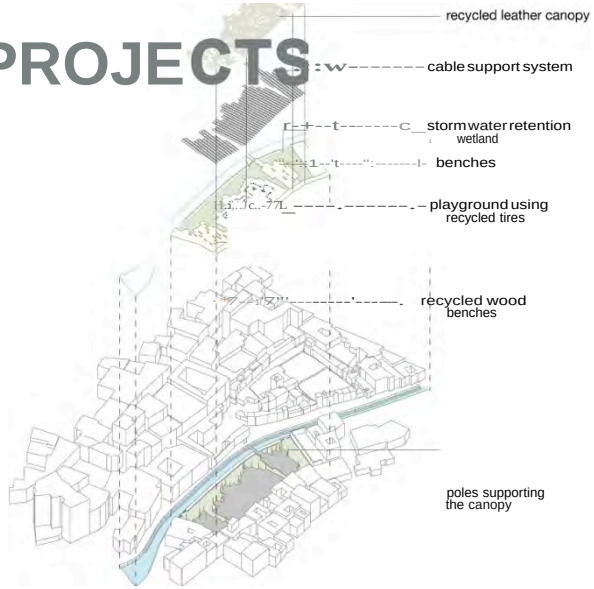
G. W. BUSH PRESIDENTIAL CENTER
DALLAS, TX (2008-0NGOING)D
MICHAEL VANVALKENBURGH ASSOC.

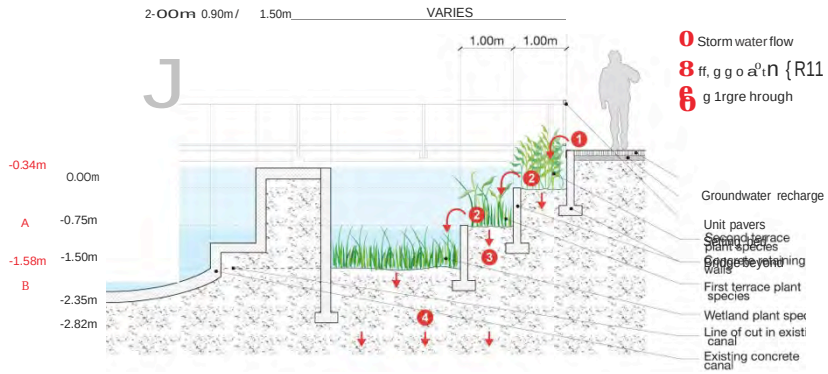
EXAMPLE PROJECTS

Utilizing Fez, Morocco as a case study, we envisioned a strategic plan that simultaneously restores an

demic to aging medieval fabrics such urban river and addresses issues en-

as the scarcity of open space, overcrowding, a weak economy, and the destruction of natural resources and places of cultural and historic significance. We choreographed a phased implementation strategy in which measures for enhancing water quality become both the locus and agent for addressing social and economic concerns.



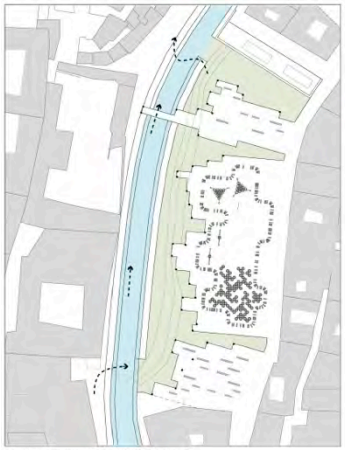


A: 25 Year Flood Line
B: Average Water Level

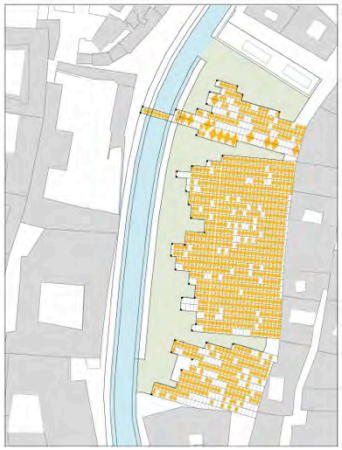
First terrace plant species
Juncus bufonius
Phragmites australis
/soetes velata
Lotushispidus

Second terrace plant species
Rumex bucephalophorus
Ormenis mixta
Silene gallica
Agrostis sa/mantica

Wetland plant species
Ranunulus peltatus
G/yceriafluitans
11/ecebrum verticil/alum
Lythrum borysthenicum



PLAN LEVEL 0/ PLAYGROUND



PLAN LEVEL +3.8M/ CANOPY

VIEW OF PLAYGROUND

EXAMPLE PROJECTS

PORTLAND, OREGON.

GOWANUS CANAL SPONGE PARK, BROOKLYN, NY | OLAND STUDIO

CONCLUSION

The site's unique character, divers ecological value and one of kind touristic attractions will continue to draw and captivate the public. For these and many other reasons we believe in the protection of the ecological habitat through the use of different alternatives among them green infrastructure. Therefore, this Master Plan is a vision that describes and identifies the key challenges, opportunities and the possible solutions to enable the objectives established. With correct management and enhancement La Parguera has the opportunity to continue to captivate its visitors and residents while protecting its attributes.