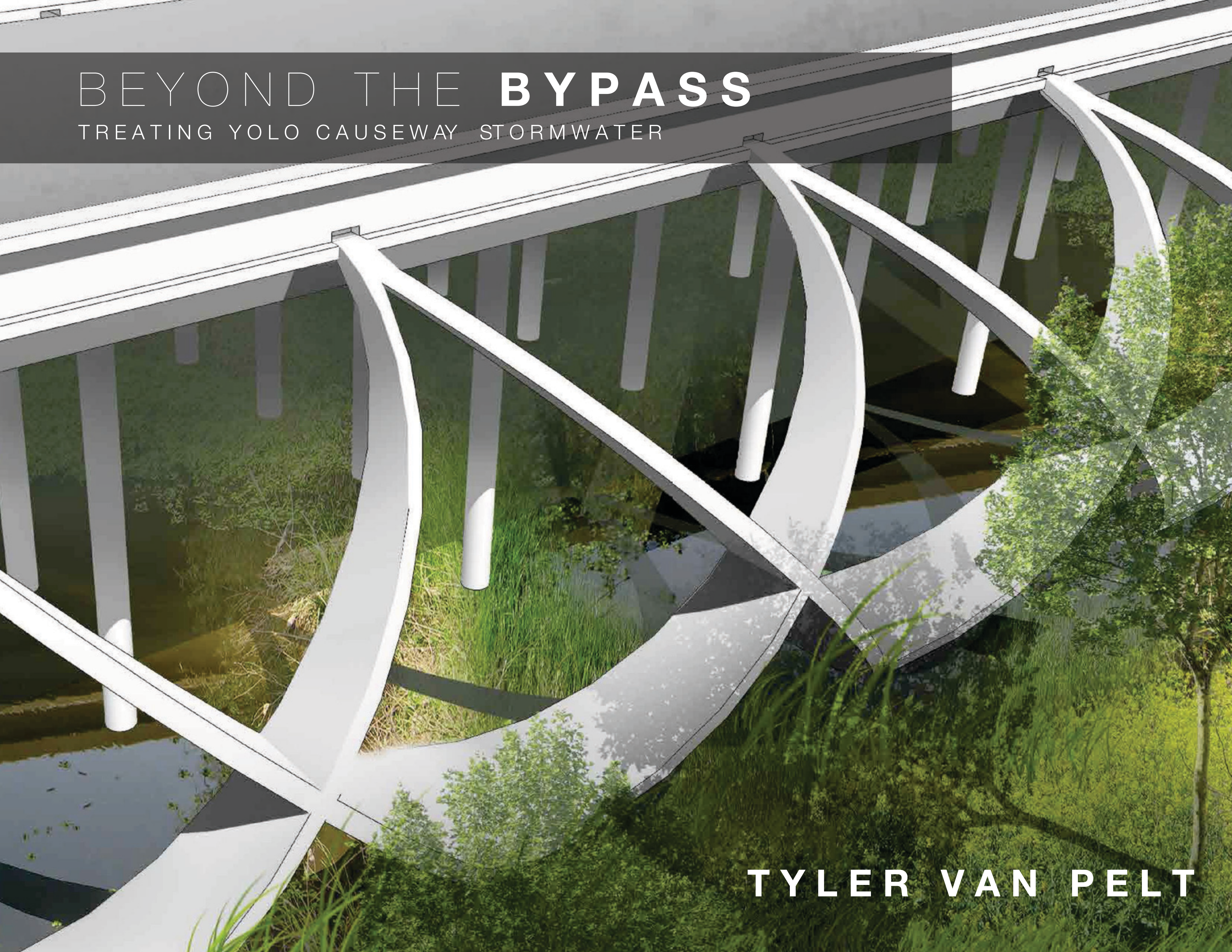
BEYOND THE **BYPASS**

TREATING YOLO CAUSEWAY STORMWATER



TYLER VAN PELT

UNIVERSITY OF CALIFORNIA, **DAVIS**
SENIOR THESIS, 2013

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TREATING YOLO CAUSEWAY STORMWATER

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Presented to the faculty of the Landscape Architecture Department of the University of California, Davis in partial fulfillment of the requirements for the Degree of Bachelors of Science in Landscape Architecture.

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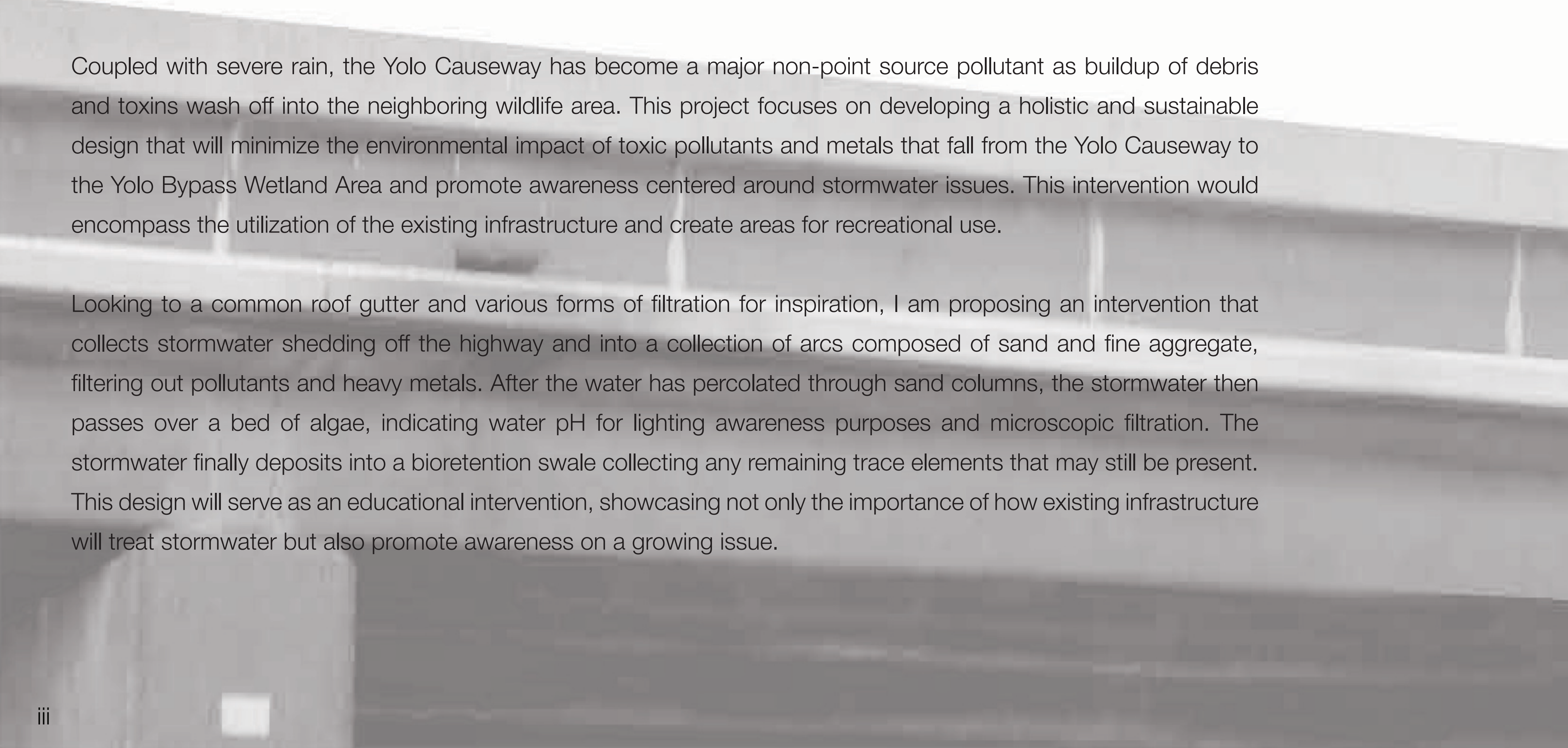
ABSTRACT

Like it or not, human induced pollutants coupled with rain presents a series of unnatural issues and challenges in today's society. Research has shown the detrimental effects of toxins, and heavy metals that wash off roadways each year after heavy periods of rain. Many of these pollutants eventually end up in wetland and aquatic ecosystems with damaging effects on wildlife.

Coupled with severe rain, the Yolo Causeway has become a major non-point source pollutant as buildup of debris and toxins wash off into the neighboring wildlife area. This project focuses on developing a holistic and sustainable design that will minimize the environmental impact of toxic pollutants and metals that fall from the Yolo Causeway to the Yolo Bypass Wetland Area and promote awareness centered around stormwater issues. This intervention would encompass the utilization of the existing infrastructure and create areas for recreational use.

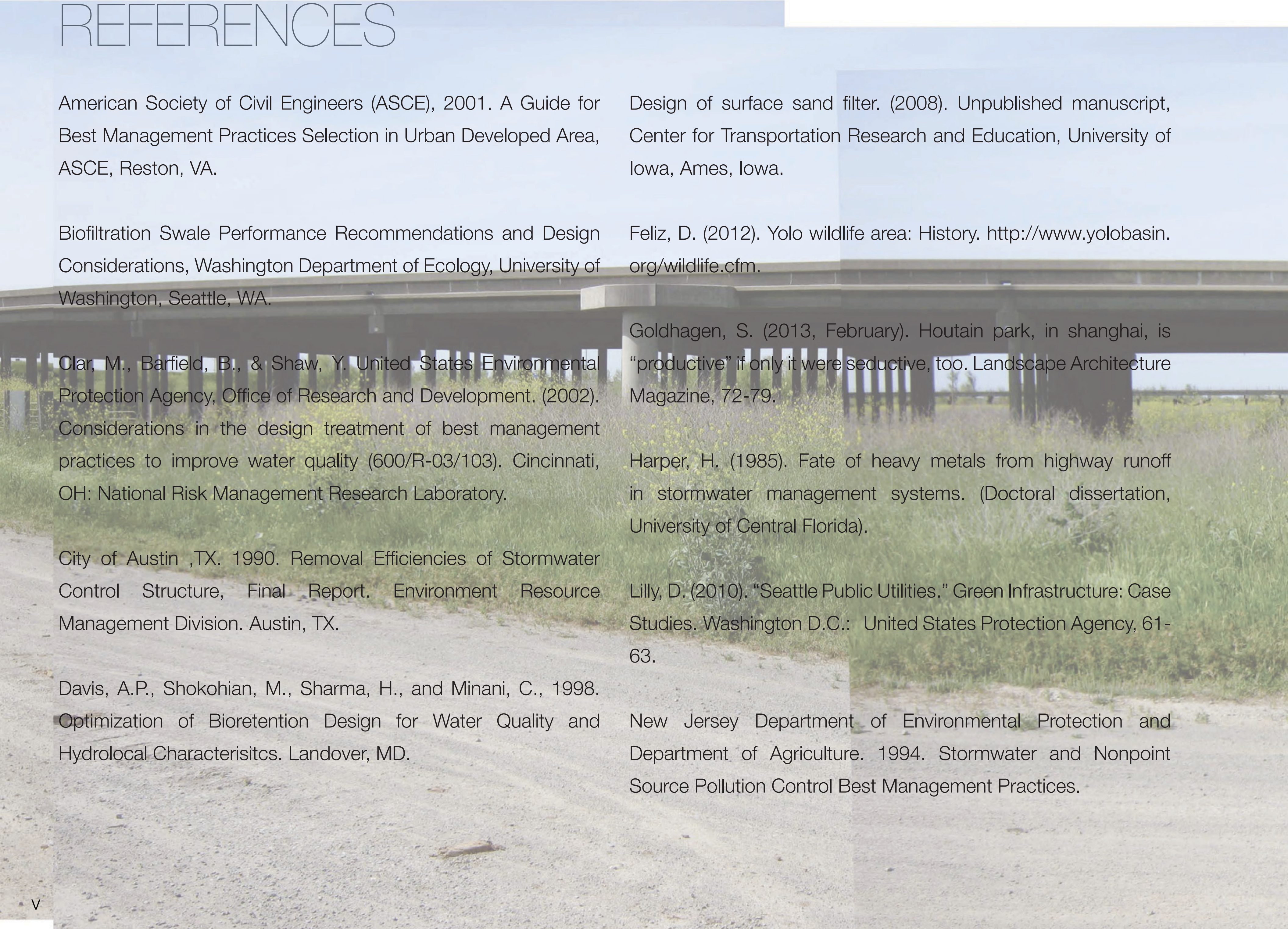
Looking to a common roof gutter and various forms of filtration for inspiration, I am proposing an intervention that collects stormwater shedding off the highway and into a collection of arcs composed of sand and fine aggregate, filtering out pollutants and heavy metals. After the water has percolated through sand columns, the stormwater then passes over a bed of algae, indicating water pH for lighting awareness purposes and microscopic filtration. The stormwater finally deposits into a bioretention swale collecting any remaining trace elements that may still be present. This design will serve as an educational intervention, showcasing not only the importance of how existing infrastructure will treat stormwater but also promote awareness on a growing issue.



ACKNOWLEDGEMENTS

I would like to thank my committee members for guiding me through this crazy endeavour. I wouldn't have been able to do this without any of your amazing design and ecological insight. I would especially like to thank my parents for always encouraging me to keep going and my roommate Alex for pushing me when I could no longer push myself. Most importantly, I would like to thank my classmates for not only teaching me what landscape architecture has to offer but providing me with the most amazing 3 years of my life. I owe any and all of my future success to my LDA family.

REFERENCES



American Society of Civil Engineers (ASCE), 2001. A Guide for Best Management Practices Selection in Urban Developed Area, ASCE, Reston, VA.

Biofiltration Swale Performance Recommendations and Design Considerations, Washington Department of Ecology, University of Washington, Seattle, WA.

Clar, M., Barfield, B., & Shaw, Y. United States Environmental Protection Agency, Office of Research and Development. (2002). Considerations in the design treatment of best management practices to improve water quality (600/R-03/103). Cincinnati, OH: National Risk Management Research Laboratory.

City of Austin ,TX. 1990. Removal Efficiencies of Stormwater Control Structure, Final Report. Environment Resource Management Division. Austin, TX.

Davis, A.P., Shokohian, M., Sharma, H., and Minani, C., 1998. Optimization of Bioretention Design for Water Quality and Hydrolocal Characterisitcs. Landover, MD.

Design of surface sand filter. (2008). Unpublished manuscript, Center for Transportation Research and Education, University of Iowa, Ames, Iowa.

Feliz, D. (2012). Yolo wildlife area: History. http://www.yolobasin.org/wildlife.cfm.

Goldhagen, S. (2013, February). Houtain park, in shanghai, is “productive” if only it were seductive, too. Landscape Architecture Magazine, 72-79.

Harper, H. (1985). Fate of heavy metals from highway runoff in stormwater management systems. (Doctoral dissertation, University of Central Florida).

Lilly, D. (2010). “Seattle Public Utilities.” Green Infrastructure: Case Studies. Washington D.C.: United States Protection Agency, 61-63.

New Jersey Department of Environmental Protection and Department of Agriculture. 1994. Stormwater and Nonpoint Source Pollution Control Best Management Practices.

Schueler, T. 1994. Developments in sand filter technology to improve stormwater runoff quality. Watershed Protection Techniques.

Stiffler, L. (2013, January). Are rain gardens mini toxic cleanup sites. Retrieved from http://www.co.thurston.wa.us/stormwater/utility/docs/Are Rain Gardens Mini ToxicCleanup Sites, Lisa Stiffler, Sightline Institute.pdf.

United States Environmental Protection Agency, (1999). Storm Water Technology Fact Sheet: Sand Filters. EPA 832-F-99-007. Office of Water.

Urbonas, B. (1998). Stormwater sand filter sizing and design. Denver, CO: University of Colorado at Denver. Retrieved from http://www.udfcd.org/downloads/pdf/tech_papers/Sand-flt-paper.pdf.

Washington State Department of Transportation, (2006). Compost amended vegetated filter strip performance monitoring project. Seattle, WA: Herrera Environmental Consultants.

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INTRODUCTION

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PRECEDENTS

DESIGN

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INTRODUCTION

FIGURE 1.1

For thousands of years, humans have looked for ways to effectively utilize, harvest, and store fallen rain water. The Romans constructed an intricate network of aqueducts, bringing snow melt from distant regions to their expanding empire, supplying households and farms with potable water. These systems of aqueducts were some of the first known cases of rain water collection on a large scale.

Today, engineers and designers are still looking for ways to manage and utilize precipitated rain water. However, unlike the Romans, engineers and designers today face the added challenge of being plagued with a variety of pollutants and debris that have accumulated on impermeable surfaces such as rooftops, highways, bridges, and other forms of modern day infrastructure. Today's vast expanse of impermeable surfaces, coupled with

RIGHT/BOTTOM: Green streets are an example of stormwater management practices coupled with existing infrastrucuture


FIGURE 1.2

vehicular traffic, have created a toxic concoction of pollutants and heavy metals, arising from a combination of concrete, asphalt, auto fluids, and debris as water passes through a network of drains, pipes, and gutters that often end up in natural ecosystems with detrimental consequences. The California Water Resource Control Board (WRCB) and Environmental Protection Agency (EPA) have regulated stormwater runoff throughout California, developing holistic strategies with landscape architects and engineers in the hopes of reducing the harmful pollutants found in stormwater runoff. Recognizing the opportunity to combine infrastructure and stormwater management, designers are capitalizing on California's existing infrastructure to treat stormwater runoff before it is introduced to natural systems.


FIGURE 1.3

RESE

ARCH

BELOW: *A bioswale and retention basin in a Portland, OR shopping center*

FIGURE 2.1

BIOSWALES

Bioswales and rain gardens are best management practices (BMP) developed in the 1990's as new methods for holistically treating stormwater pollutants. These new forms of BMP remove stormwater pollutants, such as metals, hydrocarbons through physical and biological processes after flowing over impervious surfaces such as concrete and asphalt. Bioretention processes includes absorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (Clar, Barfield & Shaw, 2002).

Bioretention swales are a flexible form of BMP in that their size and shape can be adapted to different situations and constraints. Overall, bioretention methods remove 93 to 98 percent of metals (Clar, Barfield & Shaw, 2002). Swales can be implemented for median strips, parking lot islands, and large reclamation ponds. However, bioretention swales are not an appropriate BMP at locations where the water table is high and the surrounding soil stratum is unstable or impermeable. In cold climates the soil may freeze, preventing runoff from infiltrating soil horizons.

FIGURE 2.2

FIGURE 2.3

Some of the more common and widely utilized mediums seen in bioswale designs include: grass buffer strips, sand columns, ponding areas, organic mulch layers, planting soils, ground covers and native plants ("Compost amended vegetated," 2006). These mediums are important in the development and use of bioretention basins and swales as they reduce stormwater velocity and, in turn, distribute pollutants uniformly throughout the treatment area. Designated ponding areas are graded to capture and hold large volumes of stormwater that percolate into subsoils.

Each of the components of a bioretention area is designed to perform a specific function. Organic mulch reduces infiltration velocity, soil and vegetation breakdown metallic elements, and inorganic material such as sand provide a substrate for microorganisms to breakdown hydrocarbons. Porosity and infiltration must be maintained at a constant percolation rate allowing both microbial activity and solarization (breakdown of oils and hydrocarbons). Temporary storage of excess stormwater is

TOP/LEFT: Rain gardens and bioswales utilized in residential designs for stormwater treatment

FIGURE 2.4

TOP: A rain garden located in a Seattle, WA parking lot and directly adjacent to a wildlife preserve

held within ponding areas, allowing particulate matter to settle. If the holding area contains impermeable clay, sand and organic matter are used to yield faster water infiltration and reduced stormwater runoff ("Compost amended vegetated," 2006).

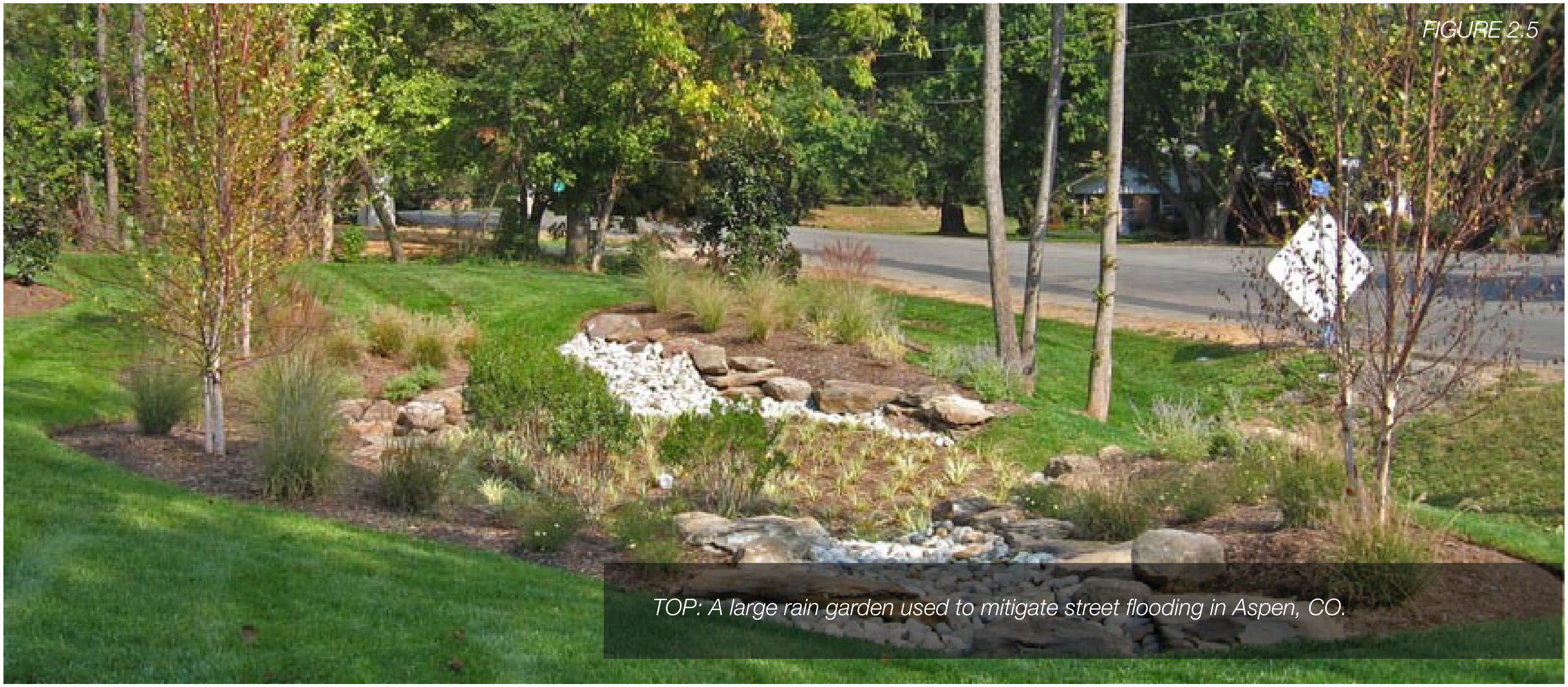
The layout of a bioretention basin and bioswale are determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered. Sites with loamy sand soils are especially appropriate for bioretention swales due to their ideal porosity (Davis, A.P., Shokohian, M., Sharma, H., and Minani, C., 1998).

The process of biofiltration in a rain storm consists of "flushes" of stormwater and debris. The first stormwater flush is the initial runoff volume that typically contains higher pollutant concentrations and hydrocarbons (Davis,1998). Multiple bioretention areas may be required for larger drainage areas. The size of a bioretention area is a function of the drainage area and the stormwater runoff. The size should be 5 to 7 percent of the drainage area multiplied by the rational method runoff coefficient, "c", determined for the site. The maximum recommended ponding depth of the bioretention area is 6 to 12 inches (Davis,1998). The maximum drainage area for one bioretention area is determined by the amount of sheet flow generated by a 10-year storm. Flows greater than 30 to 40 gallons per second could potentially erode stabilized areas. In this case, designers and engineers must look at ways to slow the velocity of moving water to minimize soil erosion (Davis,1998).

The appropriate planting soil should be backfilled into the excavated bioretention area. The soil should have infiltration rates greater than 0.5 inches per hour, which is typical of sandy and loamy soils. Silt and clay loams generally have rates of less than 0.27 inches per hour and a relative neutral pH for microbial activity (Davis, A.P., Shokohian, M., Sharma, H., and Minani, C., 1998).

Adequate contact time between organic and inorganic surfaces must be provided for pollutant removal. Soil characteristic such as texture, particulate size, and composition can effect porosity and infiltration rates decreasing the necessary time for microbial activity to take place. Pollutants removed by absorption include metals, phosphorus, and some hydrocarbons. Filtration occurs when stormwater runoff passes through bioswales composed

FIGURE 2.5



TOP: A large rain garden used to mitigate street flooding in Aspen, CO.

of sand and soil, acting as a screen to separate out large and small pollutants. Particulates removed from stormwater include inorganic matter such as zinc, lead, phosphorus, mercury, and suspended solids (Harper, 1985). Plant growth is sustained by the uptake of nutrients from the soil while microbial activity within the soil also contribute to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of organic matter such as petroleum. Aerobic microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated.

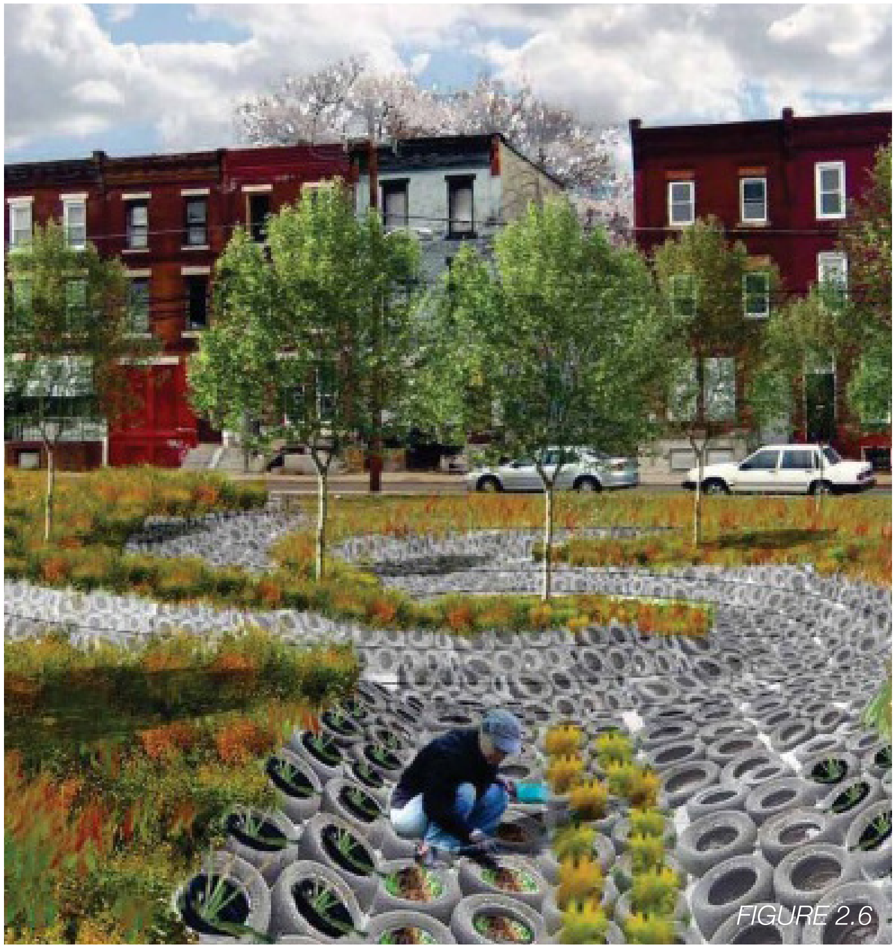


FIGURE 2.6

RIGHT: A conceptial rendering depicting recycled tires as a method for reducing soil erosion as well as a substrate for plants.

ABOVE: A bioswale for stormwater mitigation purposes.

Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension. Volatilization also plays a role in pollutant removal. Oils and hydrocarbon pollutants can be removed from wetlands via evaporation or by aerosol formation under windy conditions. Solarization of oil particulates have also been studied. Research has shown promising results that suggest the use of solar energy and sunlight will breakdown oils and gasoline (University of Washington, 2009).

WETLAND POLLUTANTS

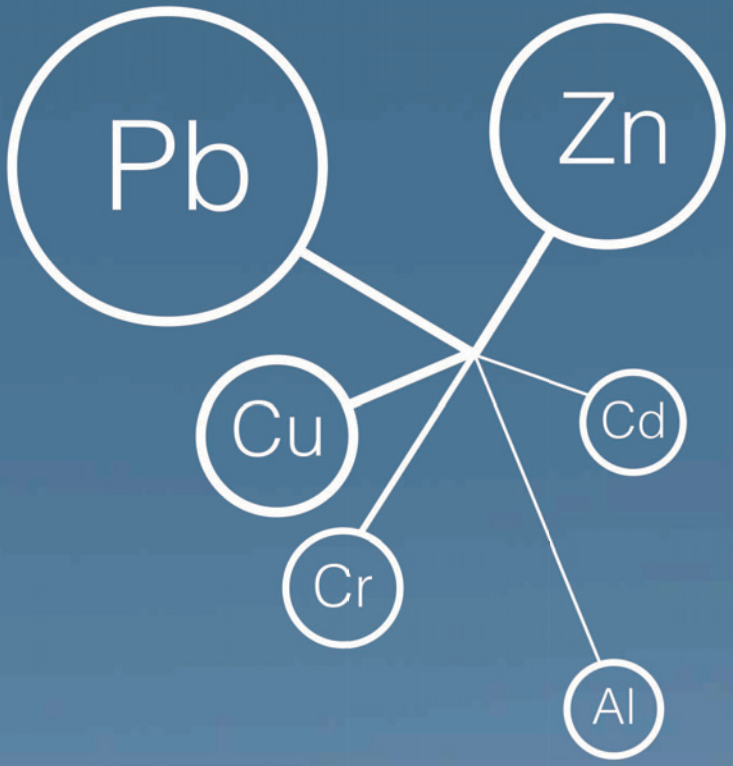
Many of the harmful metals that accumulate within our aquatic and wildlife ecosystems typically proliferate from many of the impermeable surfaces created in today's cities such as roofs and highway paving. Among the toxic metals found in highway stormwater runoff, lead and zinc are the most abundant trace elements. These heavy metals account for approximately 90-98 percent of the total metals found. Other metals found in smaller amounts include copper, cadmium, chromium, and aluminum (Harper, 1985). These highway pollutants arise from a variety of sources. Gasoline and grease are the primary sources for lead and zinc within stormwater. Tire wear contains large quantities of zinc and small traces of cadmium while moving engine parts contribute various amounts of copper and chromium. Paint contributes the least metal particulates but contain a variety of metals such as aluminum, cadmium, copper, zinc, nickel and iron. Other heavy metals have been reported to originate from concrete, asphalt and steel from highway signs (Harper, 1985).

RIGHT: Rock salt, utilized to reduce ice formation on roadways, is one of the most common pollutants in colder climates.

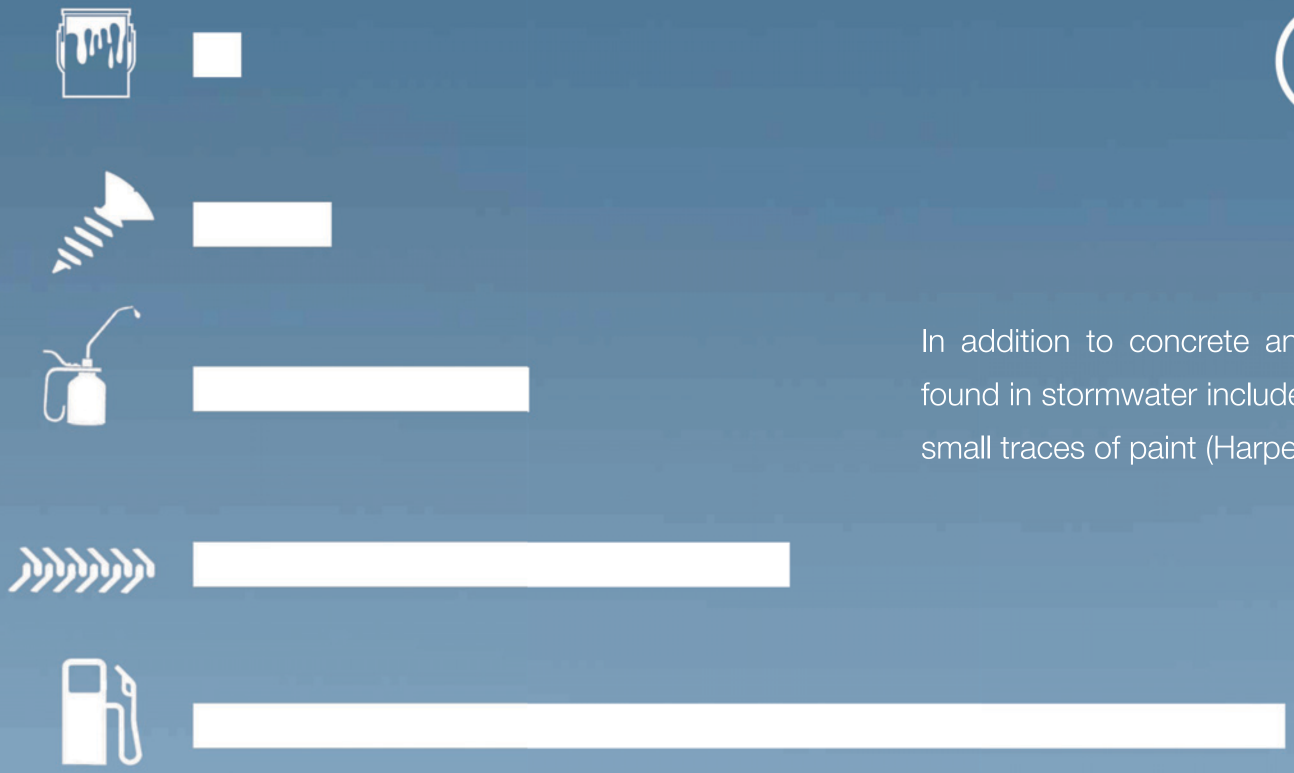
FIGURE 2.8

In a recent study at Washington's Department of Ecology, researchers have identified stormwater runoff as the main source of the heavy metal pollutants and hydrocarbons entering Puget Sound. Ecology officials estimate that lead is the most abundant element washing into aquatic ecosystems. Heavy metals have devastating effects on the environment, damaging the health of wildlife. Heavy metals affect bird eggs as well as brain development in other species of fauna (University of Washington, 2009).

Lead and zinc are the most abundant trace elements in stormwater. Other heavy metal pollutants include copper, chromium, cadmium and aluminum but in much smaller quantities (Harper, 1985).



In addition to concrete and asphalt, sources of heavy metals found in stormwater include, gasoline, tire wear,oil, car parts and small traces of paint (Harper, 1985).



PETROLEUM POLLUTANTS

Oil and grease from leaking cars, engine parts and gas pump spills are the most prevalent hydrocarbons of runoff pollution. Scientists in Austin, Texas performed experiments to monitor the hydrocarbons found in stormwater systems and the effect BMPs have on mitigating these pollutants. More than 70 soil samples were collected from more than 50 rain gardens throughout the city and found "all soil concentrations were about one thousand times less than regulatory action levels" (City of Austin TX, 1990). However, this discovery lead to a new question. Where are the hydrocarbon pollutants going?

Scientists performed experiments with naphthalene, a common pollutant found in bioretention basins. After introducing naphthalene-contaminated water through multiple rain gardens, scientist found many of the petroleum pollutants were adsorbed by soil microorganisms and then biodegraded by the plant matter. "Biodegradation typically destroys the contaminant rather than simply retaining or transforming the contaminant" (Stiffler, 2013). In conclusion, these researchers found that 90 percent of petroleum pollutants were biodegraded within several days.

TOP RIGHT: Oil reacting with sunlight and water on a concrete surface.

FIGURE 2.9

Heavy metals, hydrocarbons and petroleum pollutants are an unfortunate consequence of today's modern world of impermeable surfaces. However BMP's such as bioretention basins and green infrastructure are being embraced as a solution to a growing problem. These natural processes can greatly absorb polluted runoff and dangerous heavy metals, keeping the foul chemicals out of wetland habitats and aquatic ecosystems (Stiffler, 2013).

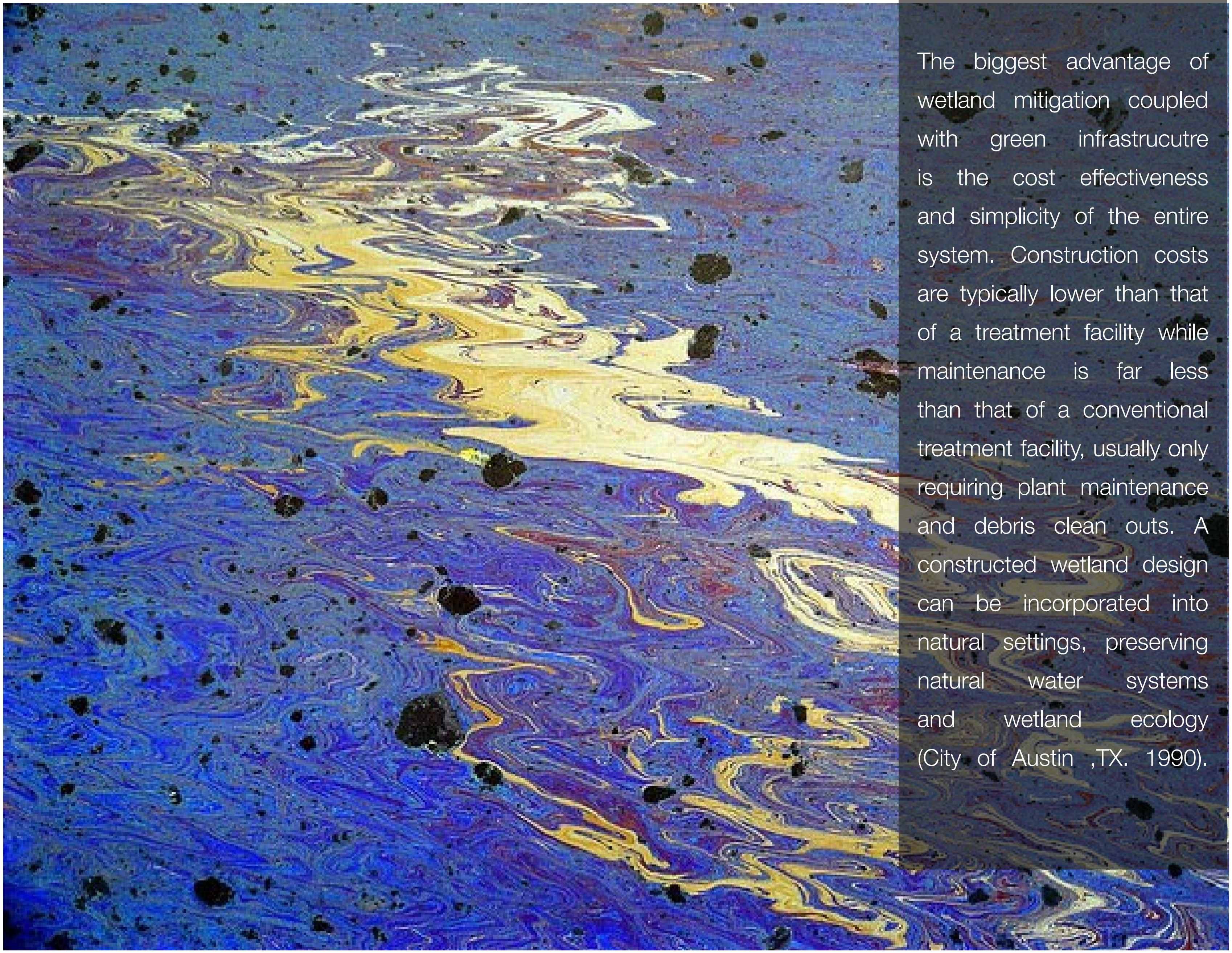


FIGURE 2.10

The biggest advantage of wetland mitigation coupled with green infrastrucutre is the cost effectiveness and simplicity of the entire system. Construction costs are typically lower than that of a treatment facility while maintenance is far less than that of a conventional treatment facility, usually only requiring plant maintenance and debris clean outs. A constructed wetland design can be incorporated into natural settings, preserving natural water systems and wetland ecology (City of Austin ,TX. 1990).

SAND FILTRATION

Sand filtration is a water purification method that uses small, inorganic materials such as sand and charcoal to separate particulates and also serve as a substrate for microbial growth. This form of purification has existed for thousands of years and recently enhanced for present-day stormwater manangement. Sand filtration works along the premise of allowing stormwater to pass over a large surface area of microorganisms that capture and utilized contaminants. A common misconception is that mediums, such as sand, filter pollutants from stormwater, when in fact the organisms living on the medium break down these pollutants, yielding treated stormwater (Design of surface, 2008).

Smaller sand grains provide more surface area and therefore a greater decontamination of the inlet water, but also require more pumping or potential energy to drive the fluid through the bed. Most filtration systems use sand grains in the range 0.6 to 1.2 mm for slow perculation. Larger sand grains can be used to overcome issues of clogging but should never exceed 2mm in size (Design of Surface (2008).

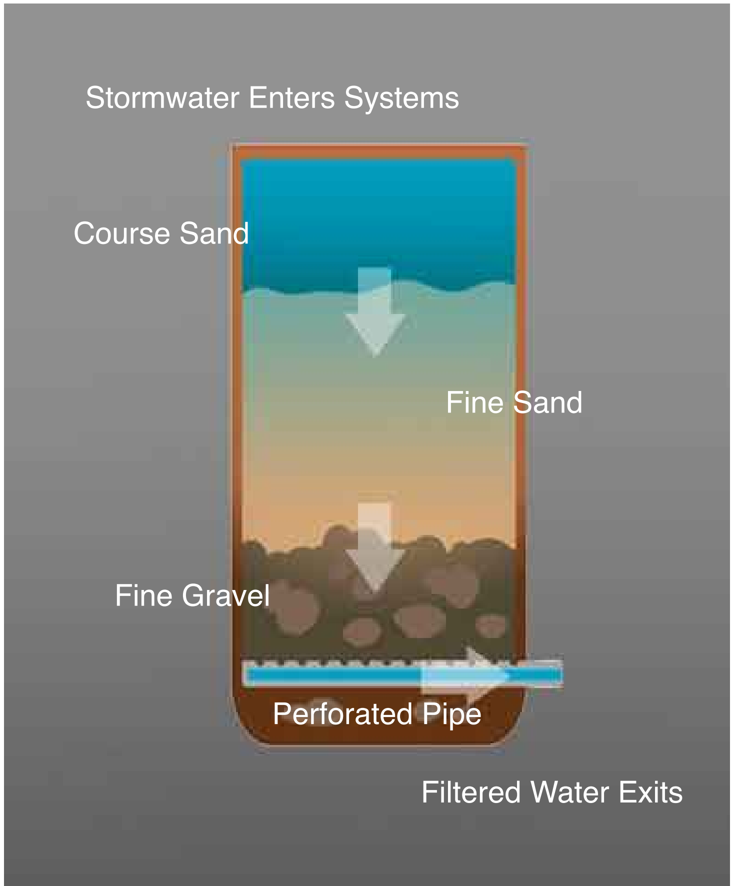


FIGURE 2.11

RIGHT: An illustration depicting the different layers within a sand colum filtration

SURFACE SAND FILTRATION SYSTEM

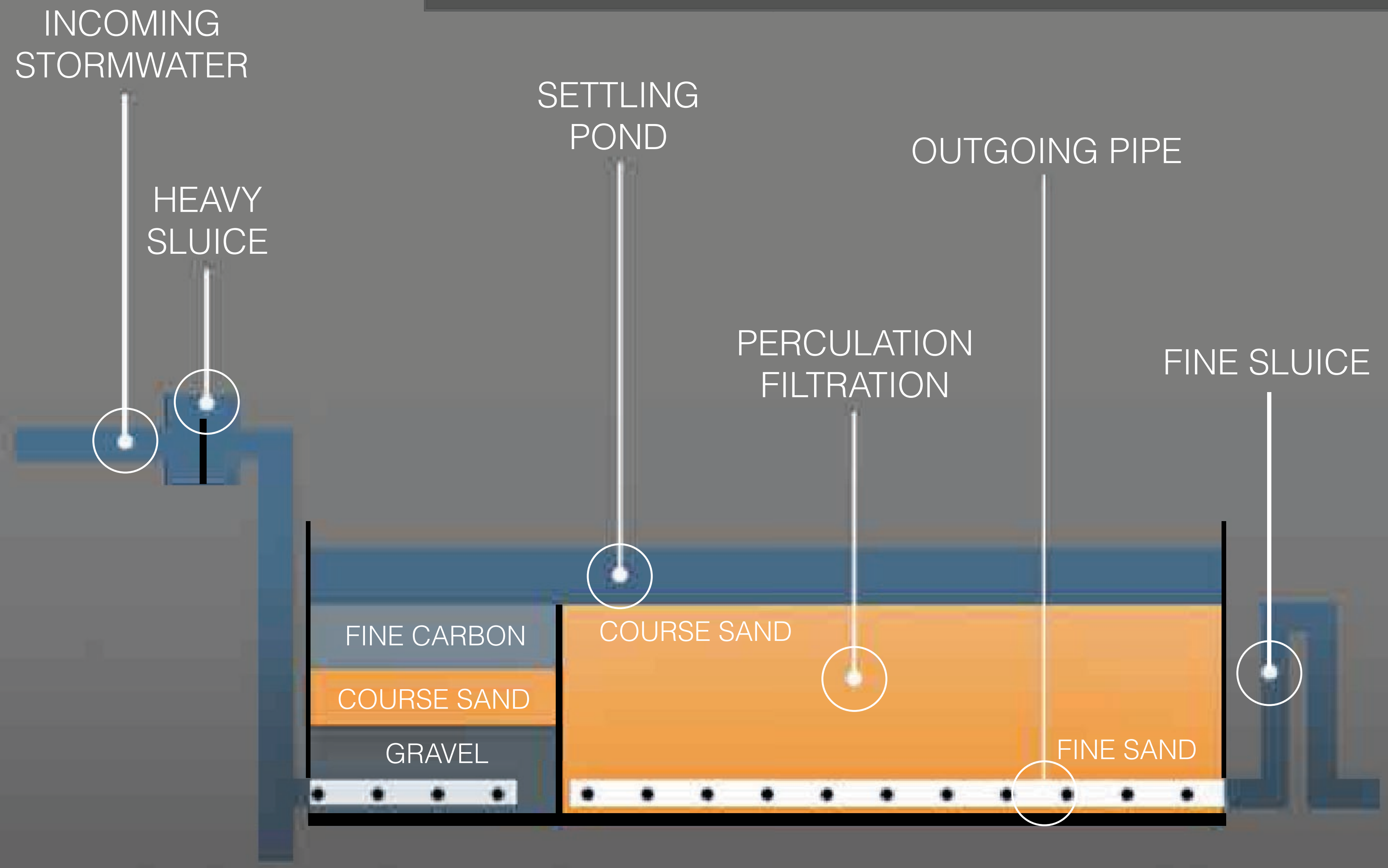


FIGURE 2.12

Particle charge and attraction also play a role in sand filtration. As fluid comes in contact with the porous sand particulates they are captured by several mechanisms such as direct collision, adhesion, cohesion, surface charge attraction, and diffusion. These methods create a small electromagnetic charge as water passes over the inorganic material capturing contaminates with particulate solids that are then broken down by microbial activity. Metalic elements may be added to filtration systems to adjust ionic charges. During this processes, known as coagulation, small amounts of charged cations such as calcium and aluminum are added to attract small, negatively charged ions. Acidic balance is an important aspect of sand filtration as this balance can effect the amounts of pollutants attracted to particulates. By adjusting particle surface charge and sand pH, sand filtration will better capture and retain trace elements such as lead and zinc. Sand filtration removes 80-90 percent of heavy metals, pollutants and oils in stormwater (Urbonas, 1998).

FIGURE 2.13

Sand Filtration is operated either with upward flowing fluids via a pump or downward flowing fluids via gravity. Pressure sand bed filters that flow upwards through sand particulates are used in industrial applications and are often referred to as rapid sand bed filters (Schueler, 1994).

A critical design point is to assure that fluid is properly distributed across the sand substrate with no fluid paths where contaminated water can freely flow through the system (Schueler, 1994).

While sand filtration is an excellent system for treating stormwater, this system can become clogged with floc and debris over a period of time and intense use. Cleaning-out are necessary and involve scraping off several inches of sand within the top layers of the system to assure adequate flow rates. In some countries the sludge scraped out of these systems are used as soil amendments for agricultural purposes (Schueler, 1994).

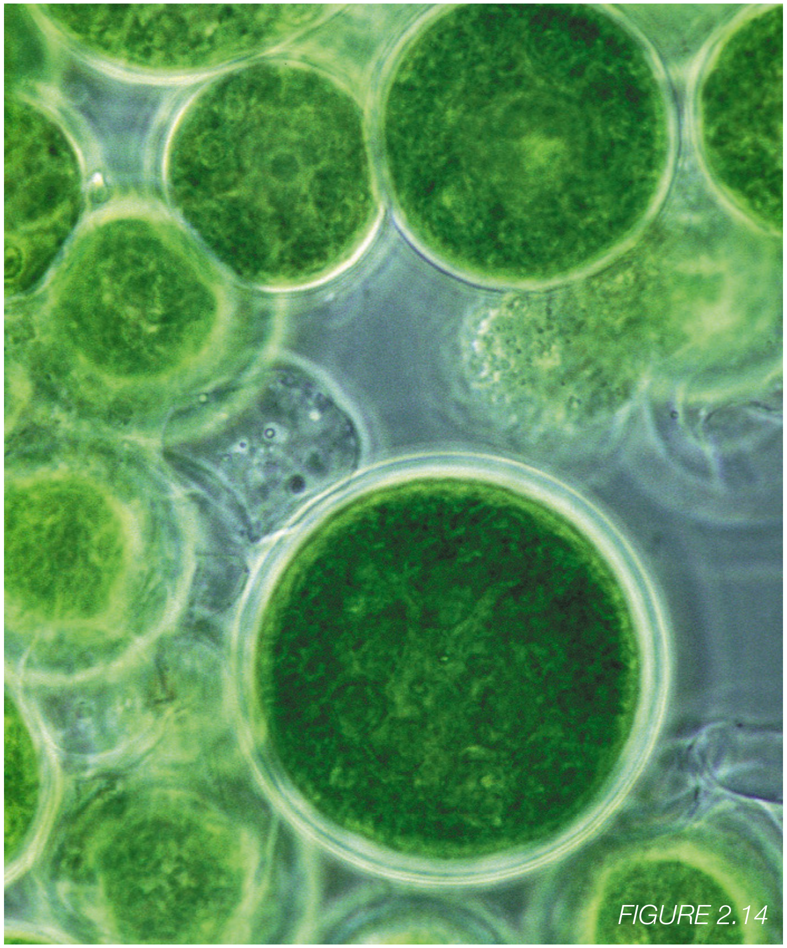


FIGURE 2.14

RIGHT: Algae growth and microorgansims live on the surface of sand particulates, breaking down pollutants and metals

GREEN INFRASTRUCTURE

RIGHT: Previously a series at mining pits, Landmark Lusatian by Stetan Giers is now used as a recreational park.


FIGURE 2.15

Green infrastructure is a new term in the field of landscape architecture, originating in the United States in the mid-1990s. This new thought highlights the importance of the natural environment and its coexistence with society's existing and remanent utilities (Lilly, 2010). Green infrastructure is a conceptual framework for understanding the precious services nature provides society, showcasing its wide range of benefits including, but not limited to, decreased stormwater runoff. At all levels of scale, green infrastructure provides real ecological, economic, and social benefits. Green infrastructure programs are managed by the Environmental Protection Agency (EPA) as well as commercial landscape architecture firms. These groups generate new ideas and practices that reduce stress on traditional stormwater drainage systems as well as storm sewers which are used extensively throughout U.S. cities (Lilly, 2010).

ABOVE: A sustainable green roof at the Ford Premier Auto Group Headquarters in Irvine, CA.

FIGURE 2.16

PRECE

DENTS

HOUTAN PARK

Houtan Park is a well know example of a regenerative living landscape. Located adjacent to Shanghai's Huangpu riverfront, this narrow stretch of 14-hectares was previously a series of steel factories and a shipyard, and later utilized as a landfill for post industrial waste material. Recognizing an opportunity to build a park that would highlight wetland ecology, storm water management and flood prevention, Turnescapes (the firm responsible for Houtan Park's master plan) designed a park that would address issues ranging from stormwater management to ecological needs as a result from Shanghai's booming economy and population (Goldhagen, 2013).

Sarah Goldhagen,a contributing author for Landscape Architecture Magazine,explains that initially the site was littered with industrial debris and polluted water. The prominent site design challenge was to transform this degraded landscape into a safe and pleasant public space for recreational and wetland use while providing flood control from China's prominent periods of heavy rain.

TOP RIGHT/RIGHT: Houtan Park offers numerous areas for visitors to walk and relax while learning about stormwater treatment.

FIGURE 3.1

FIGURE 3.2


FIGURE 3.3

RIGHT: Houtan Park is a linear wetland that is situated on the banks of the Shanghia River.

Turnescapes primary objective was to create a green "expo", demonstrating green technologies and infrastructure while showcasing the transformation of post industrial spaces to recreational use. Through the center of the park, a linear constructed wetland approximately one mile in length was created as a living machine, treating contaminated water from the Huangpu River and neighboring cities (Goldhagen, 2013). Regenerative design strategies used to transform the site into a living system consisted of a series of terraces inspired by Shanghai's agricultural heritage. These terraces mitigate flood control, produce food such as rice, treat stormwater and provide an educational example of environmental water management. Different species of wetland plants were selected to absorb different pollutants, while the multiple terraces capture heavier metals and debris. The treated water is used safely throughout the park for non-potable uses while the remaining treated water is directed to the Houtan River.

ABOVE: Pathway along the Houtan Wetland Park

FIGURE 3.4

While Houtan Park has the elements of a successful wetland design project, Sarah Goldhagen argues that there are crucial elements that are lacking. Aesthetic characteristics that usually entice visitors to the site are missing, such as outdoor lighting and maintained landscape plants. The park is considered visually unattractive, even with its modern materials and features such as bridges and viewing platforms . The unkept image, an original design choice by Turnescapes, was implemented to keep a natural look. However this site is a little too unkept for many and is considered an eyesore for many visitors (Goldhagen, 2013).

FIGURE 3.5

ABOVE: Houtan Park is a linear wetland that is situated on the banks of the Shanghia River.

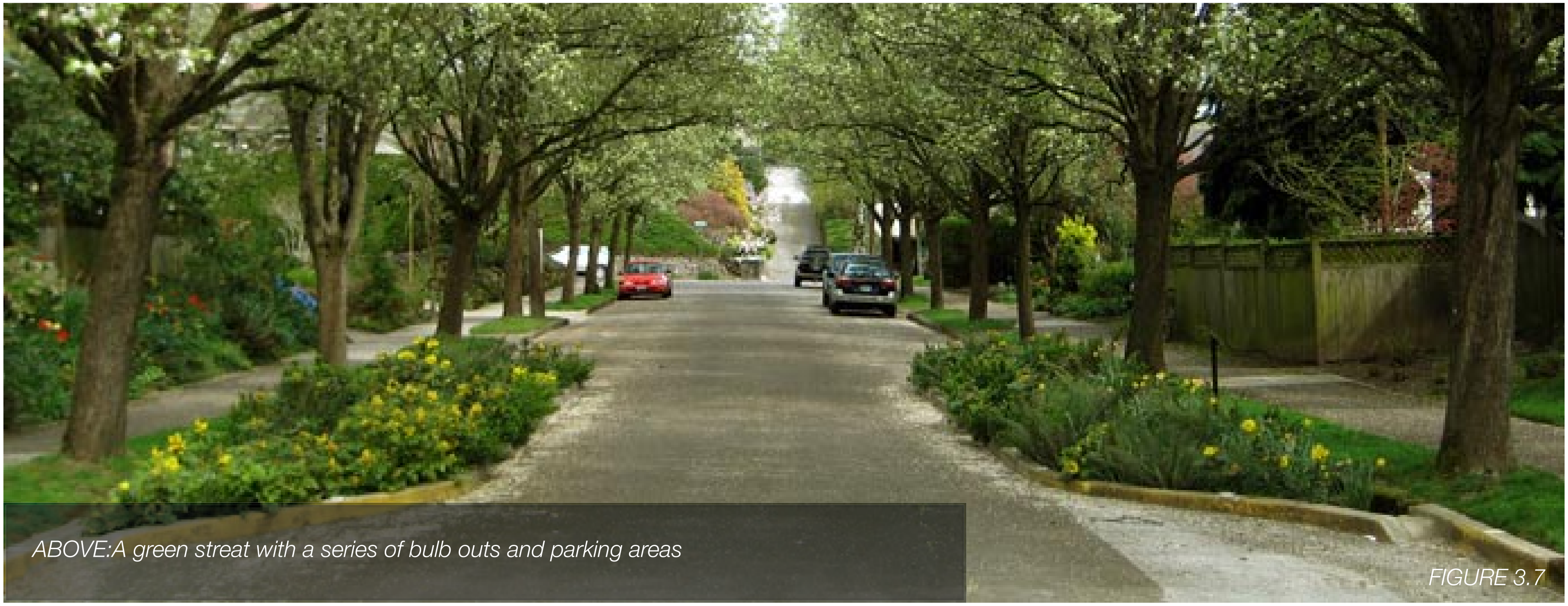
SW 12TH AVENUE

BELOW: Parking area with adjacent rain garden

Green streets are a successful design solution, minimizing the impact on natural drainage systems by managing stormwater runoff at the source through the use of bioretention basins and vegetative swales. The captured runoff allows heavier sediments to fall to the bottom of the basin where it is filtered by plants, natural decomposition, sunlight and evapotranspiration. Further filtering takes place as the runoff seeps through the underlying soils before reaching groundwater. Plants serve as a first layer of water filtration and provide a certain degree of "greenery" and visual attractiveness to the site. By capturing, absorbing and slowly releasing fallen rainwater, stormwater takes longer to flow downstream and into the natural environment. This decrease in time reduces the concentration of toxic chemicals entering the natural ecosystem, making green streets a successful form of ecological infrastructure.

FIGURE 3.6

The SW 12th Avenue Green Street project, located adjacent to Portland State University in Oregon, is a unique stormwater intervention. For the past several years, Portland has been a pioneer in stormwater management practices, promoting a more natural and holistic approach to "green street" design. These interventions are implemented in under-utilized landscape areas between the sidewalk and street curbs, which are then redesigned as a series of stormwater planters capturing, cleansing, and releasing street runoff. By disconnecting the street's initial flow of stormwater, which feeds directly into the Willamette River, water is instead diverted into a series of planters that treat and manage the water onsite. SW 12th Avenue stands as a significant functional component, not only managing stormwater runoff but also providing a sense of "greenery" to Portland's university district. Today, an estimated 180,000 gallons of stormwater managed by this new, highly successful stormwater management system (EPA, 1999). It has proven to be a pioneer in best management practices and highly regarded as the future in stormwater treatment.



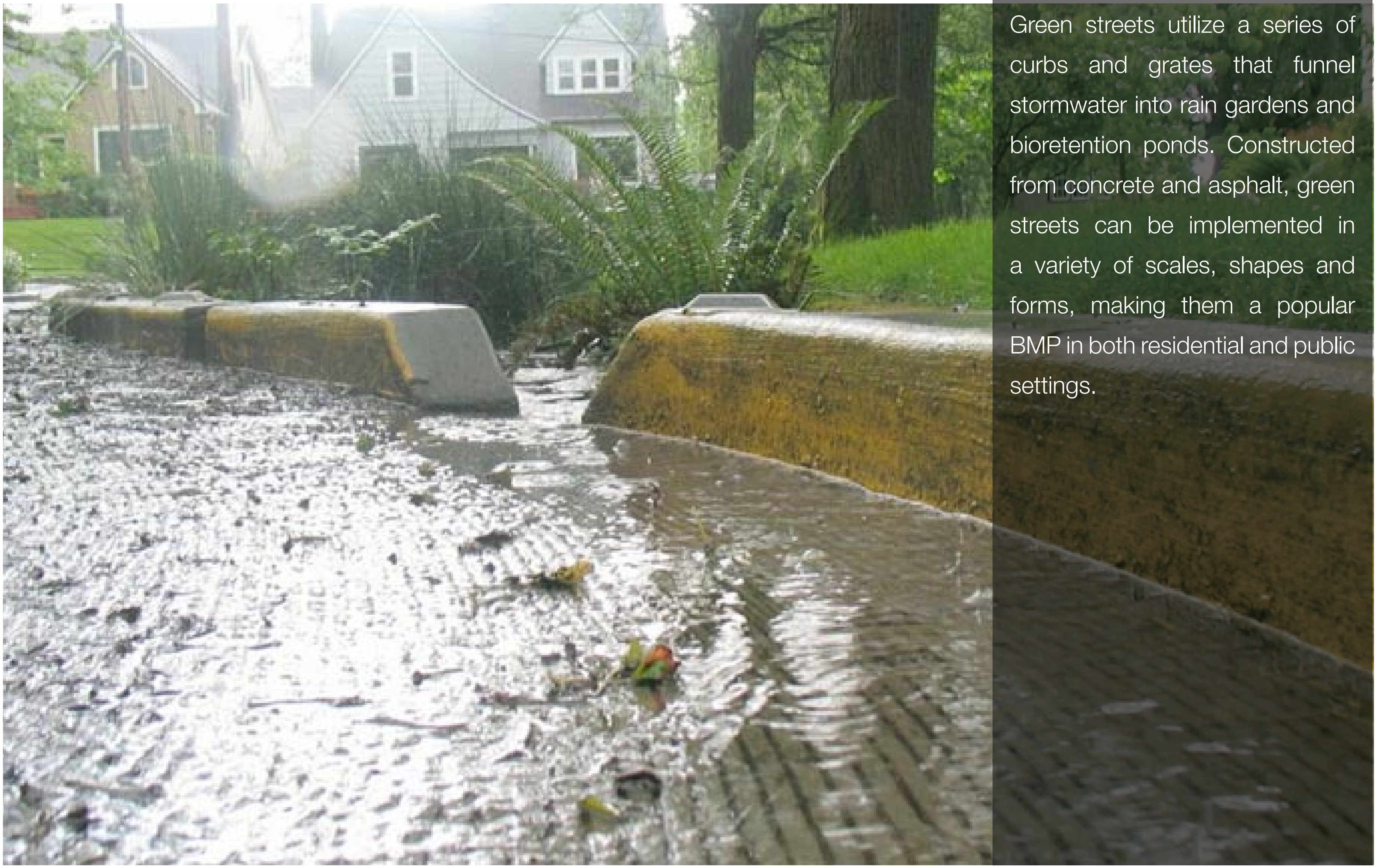
ABOVE:A green streat with a series of bulb outs and parking areas

FIGURE 3.7


FIGURE 3.8

The SW 12th Avenue is a successful project because it can be applied to so many different types of streets at varying scales. Several proposals have been developed that center around the creation of a “green highway” that would collect major pollutants and treat them in a series of plant beds. Many of the same elements utilized in SW 12th Avenue’s green street could be implemented in a green highway design but simply on a much larger scale. Vegetative plant beds would need to be large enough to accommodate the volume of highway runoff and stormwater pollutants.

ABOVE: A gutter that feeds directly into a rain garden collection system



Green streets utilize a series of curbs and grates that funnel stormwater into rain gardens and bioretention ponds. Constructed from concrete and asphalt, green streets can be implemented in a variety of scales, shapes and forms, making them a popular BMP in both residential and public settings.

FIGURE 3.9

MURASE ASSOCIATES

One of Seattle’s most prominent landscape architecture offices is Murase Associates. This firm provides instrumental landscape planning and has created a series of wastewater treatment projects throughout Seattle, WA and Portland, OR. These improvements have linked multiple public and municipal facilities that treat stormwater pollutants while educating visitors on the importance of natural filtration systems.

RIGHT: Algae growth and microorgansims live on the surface of sand particulates, breaking down pollutants and metals

FIGURE 3.10

COLUMBIA BLVD WATER TREATMENT PARK

A man made wetland and riparian ecosystem were developed from the existing infrastructure that was once a natural wetland. These constructed wetlands treat water prior to being released into the environment, eliminating metals and pollutants from entering the adjacent riparian habitat. The site promotes pedestrian use with an included environmentaly conscious parking area and water garden that promotes the original natural wetland ecosystem. An educational demonstration area sits across from the plant office. Site tours are offered to the public to promote awareness regarding stormwater treatment (Murase Associates, 2010).

FIGURE 3.11

FIGURE 3.12

FIGURE 3.13

WATER POLLUTION CONTROL LABORATORY

The Water Pollution Control Laboratory was established in Portland, Oregon to monitor the quality of Portland's stormwater and educate visitors on the importance of natural and constructed wetland systems to mitigate pollutants from stormwater runoff.

An innovative flume directs stormwater from the roof to a detention pond that is planted with aquatic and native plants. These plants holistically enable the sedimentation and biofiltration process and treat many of the stormwater pollutants before returning clean water to the Willamette River. A series of bioswales located on the site also serve as a method of treating stormwater runoff by allowing pollutants to slowly percolate down into the subsoil where they are degraded by microbial activity. The existing riverbank was restored with minor modification that allow for the implementation of rain gardens and smaller bioswales. A pier jets out over the bioretention pond, allowing visitors a unique view of the site while promoting stormwater awareness through visual signs and diagrams located on the pier
(Murase Associates, 2010).

RIGHT: Algae growth and microorganisms live on the surface of sand particulates, breaking down pollutants and metals.

FIGURE 3.14

FIGURE 3.15

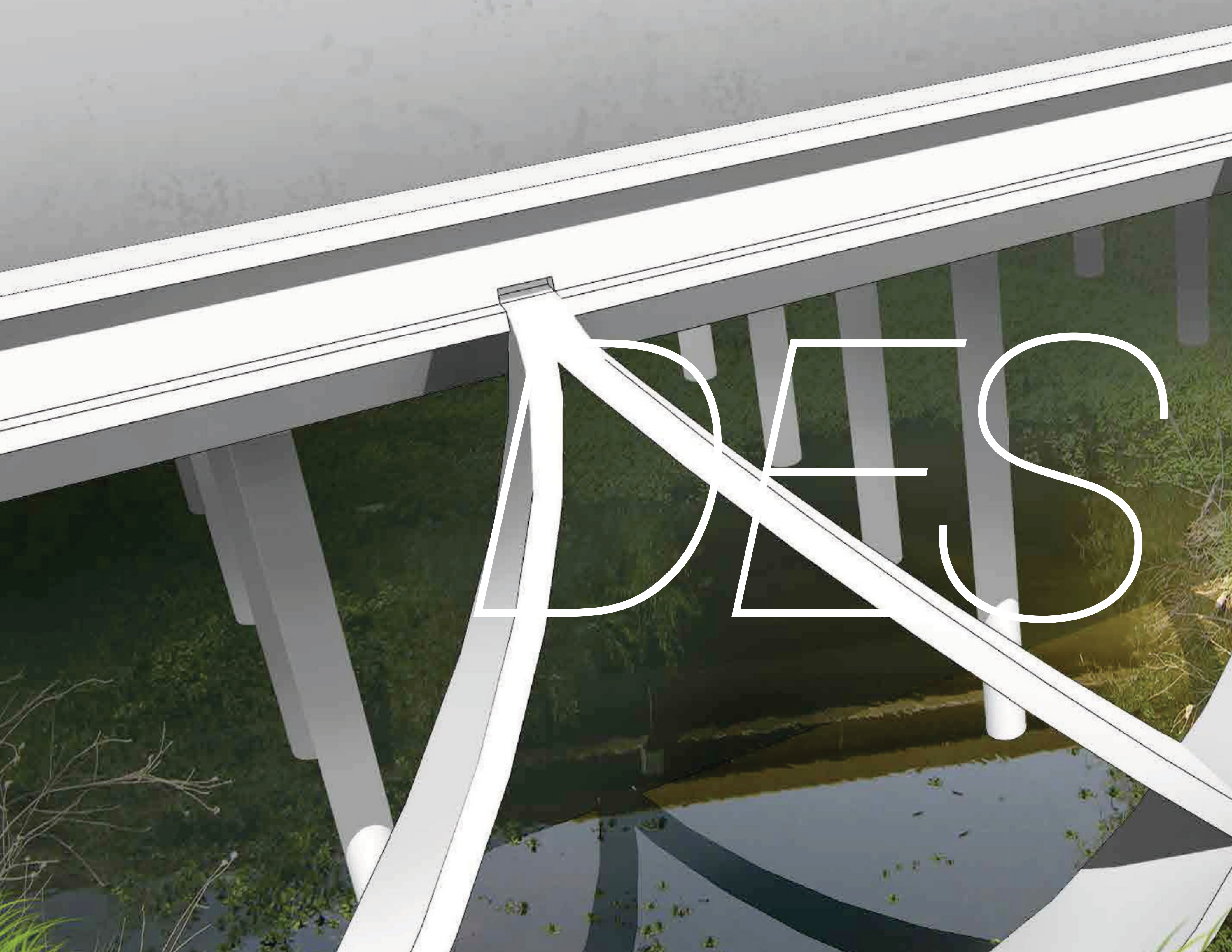
FIGURE 3.16

FIGURE 3.17

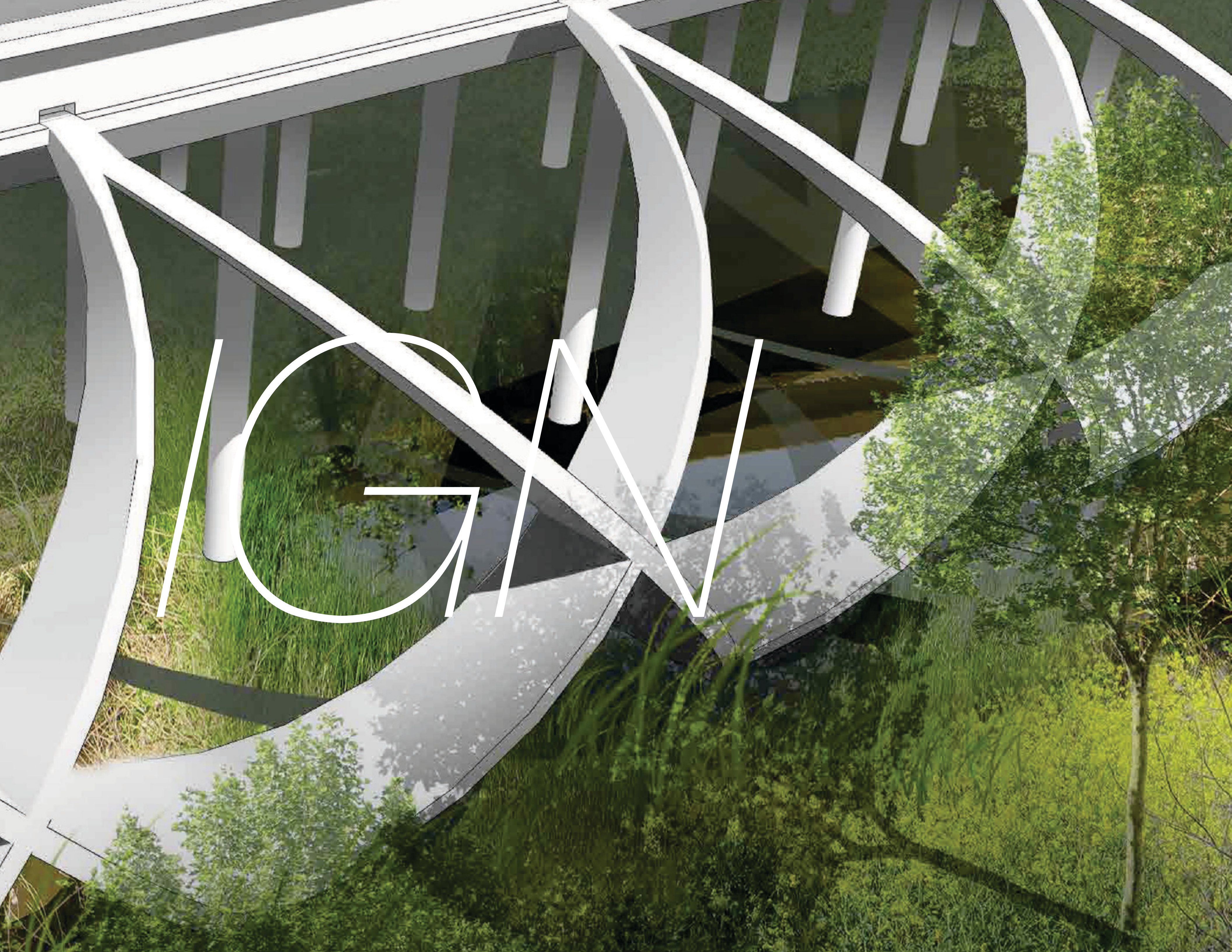
WILLAMETTE RIVER WATER TREATMENT PARK

Seattle's Murase Associates developed an innovative landscape design that blends stormwater management systems and existing infrastructure in a water treatment improvement project. The Willamette River Water Treatment Plant and Park utilizes several design elements to promote stormwater management practices. These elements include native species of plants, interpretive displays, and an 800-foot concrete and stone wall to help direct rain water. The focus of this project is the water feature which draws and recirculates water from the Willamette River during the stormwater treatment process. This extended runnel is located adjacent to the treatment plant and provides a unique educational opportunity for visitors to observe a natural stormwater treatment process utilizing native vegetation within existing infrastructure. The water deposits into a series of ponds with emergent vegetation providing wildlife habitat and stormwater treatment along the edge of the Willamette River (Murase Associates, 2010).

ABOVE: Circulating water at the Willamette River Water Treatment Park provides visitors with tangible examples of water treatment.



DES



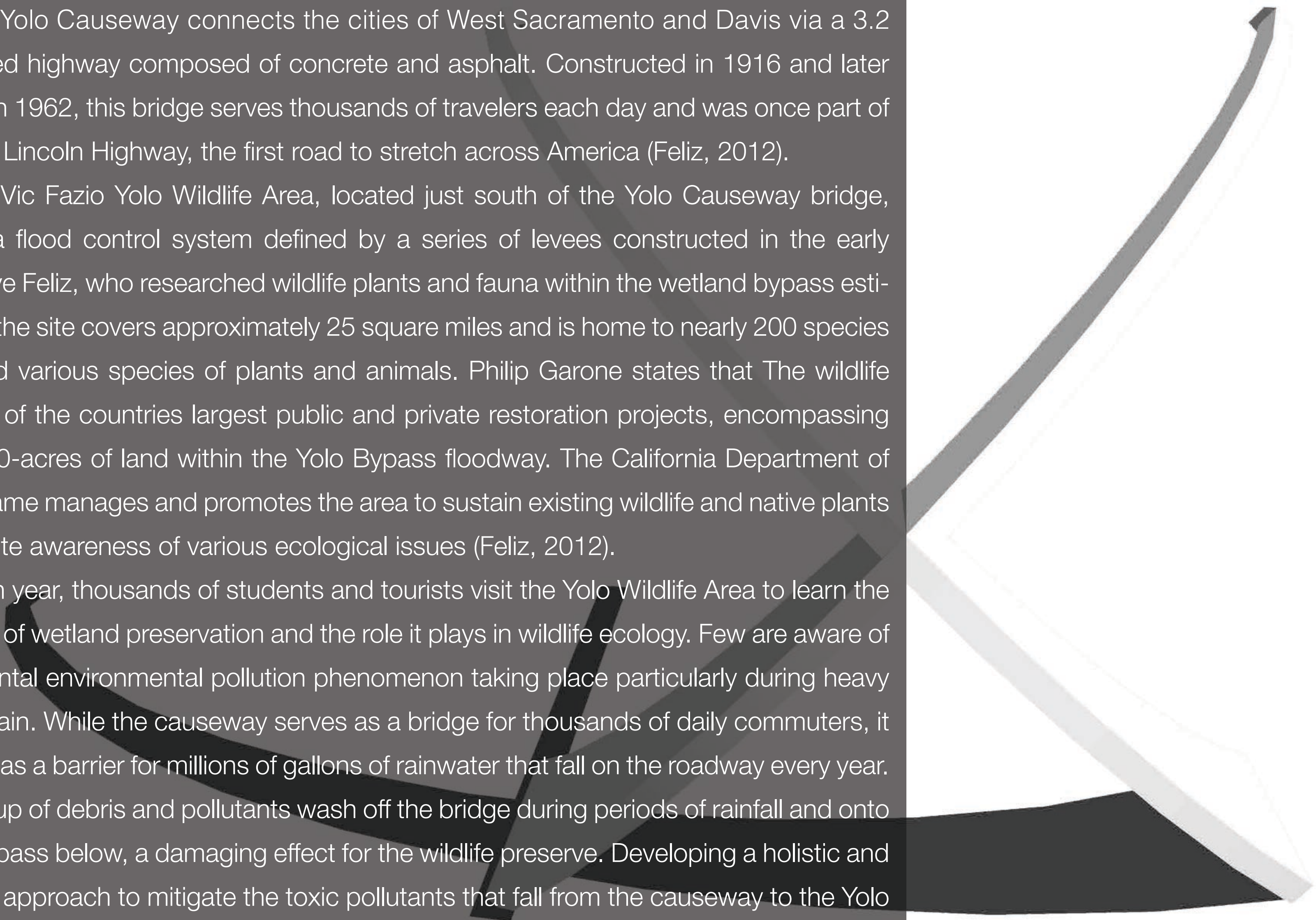
IGN

INTRODUCTION

The Yolo Causeway connects the cities of West Sacramento and Davis via a 3.2 mile elevated highway composed of concrete and asphalt. Constructed in 1916 and later expanded in 1962, this bridge serves thousands of travelers each day and was once part of the famous Lincoln Highway, the first road to stretch across America (Feliz, 2012).

The Vic Fazio Yolo Wildlife Area, located just south of the Yolo Causeway bridge, serves as a flood control system defined by a series of levees constructed in the early 1900's. Dave Feliz, who researched wildlife plants and fauna within the wetland bypass estimates that the site covers approximately 25 square miles and is home to nearly 200 species of birds and various species of plants and animals. Philip Garone states that The wildlife area is one of the countries largest public and private restoration projects, encompassing nearly 3,700-acres of land within the Yolo Bypass floodway. The California Department of Fish and Game manages and promotes the area to sustain existing wildlife and native plants and promote awareness of various ecological issues (Feliz, 2012).

Each year, thousands of students and tourists visit the Yolo Wildlife Area to learn the importance of wetland preservation and the role it plays in wildlife ecology. Few are aware of the detrimental environmental pollution phenomenon taking place particularly during heavy periods of rain. While the causeway serves as a bridge for thousands of daily commuters, it also serves as a barrier for millions of gallons of rainwater that fall on the roadway every year. Toxic build up of debris and pollutants wash off the bridge during periods of rainfall and onto the Yolo Bypass below, a damaging effect for the wildlife preserve. Developing a holistic and sustainable approach to mitigate the toxic pollutants that fall from the causeway to the Yolo Bypass wetland below would be recognized as a potential stormwater intervention utilizing the Yolo Causeway Bridge.



HELIX

A STORMWATER INTERVENTION

FIGURE 4.1

SITE CONTEXT

FIGURE 4.2

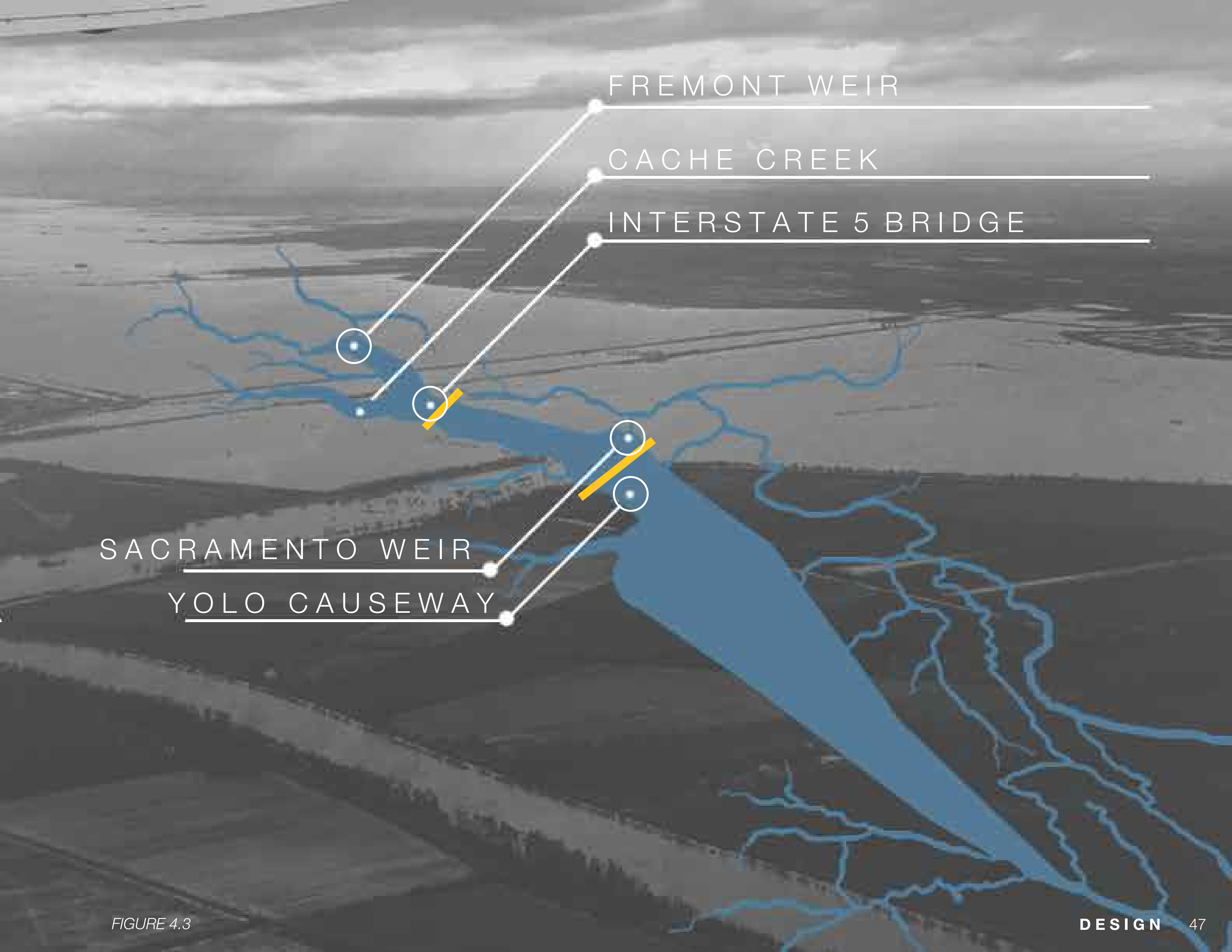
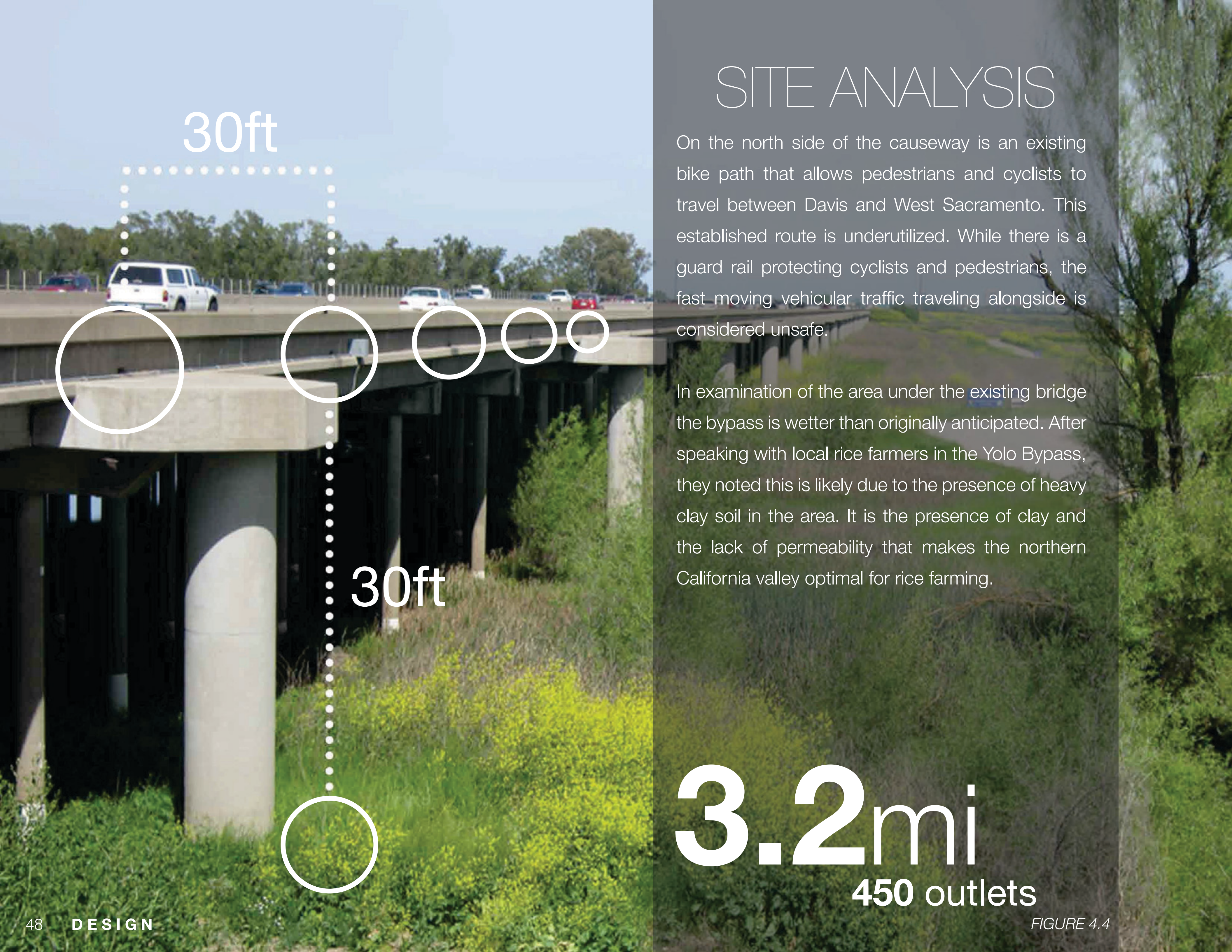

FREMONT WEIR
CACHE CREEK
INTERSTATE 5 BRIDGE
SACRAMENTO WEIR
YOLO CAUSEWAY

FIGURE 4.3



SITE ANALYSIS

On the north side of the causeway is an existing bike path that allows pedestrians and cyclists to travel between Davis and West Sacramento. This established route is underutilized. While there is a guard rail protecting cyclists and pedestrians, the fast moving vehicular traffic traveling alongside is considered unsafe.

In examination of the area under the existing bridge the bypass is wetter than originally anticipated. After speaking with local rice farmers in the Yolo Bypass, they noted this is likely due to the presence of heavy clay soil in the area. It is the presence of clay and the lack of permeability that makes the northern California valley optimal for rice farming.

3.2mi

450 outlets

FIGURE 4.4

Litter and debris are a significant problem along the Interstate 80 causeway. The outlets that allow for stormwater drainage are approximately 6 inches tall and 12-18 inches wide. These dimensions prevent larger pieces of debris and litter from washing from the bridge or clog the outlets and prevent water from properly draining.

Pedestrian and bike access to the causeway is difficult. There is a parking area for the Yolo Bypass Wild Life Area but there are no paved pedestian walkways from the parking lot to the existing pedestrian and bike trail on the bridge.

BELOW: One of the many stormwater outlets on the causeway bridge

FIGURE 4.5

ABOVE: Existing bike path on the north side of the causeway

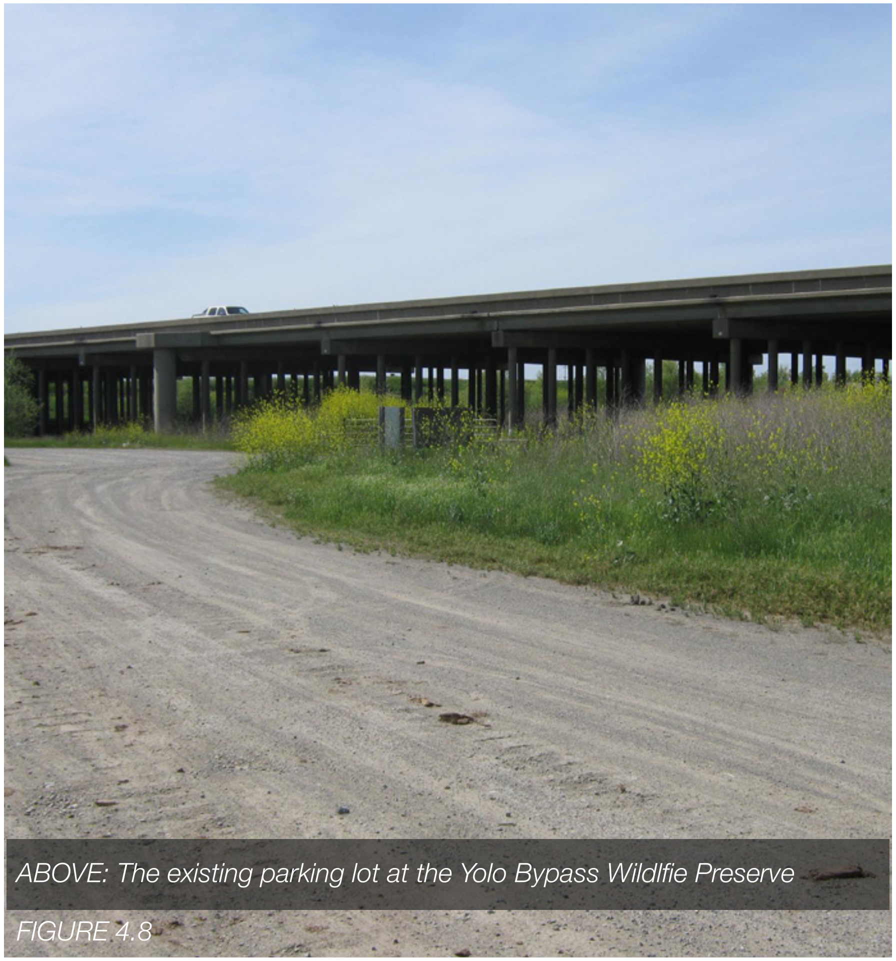
FIGURE 4.6

EXISTING CONDITIONS

FIGURE 4.7

The causeway stretches 3.2 miles between the eastern and western levees in the Yolo Bypass flood plain. Along the causeway on both the north and south facing concrete guard rails, are a series of outlets to shed stormwater off the bridge quickly and efficiently. These outlets are spaced approximately 30 feet apart while a median in the middle of the bridge divides the traffic into east and west movement. The causeway is crowned from the median, allowing for split drainage during periods of rain. The support structure for the causeway is a series of concrete piers spaced roughly 30 feet apart. On the south side of the bridge there is a 60 foot gap between the causeway and the existing rice fields.

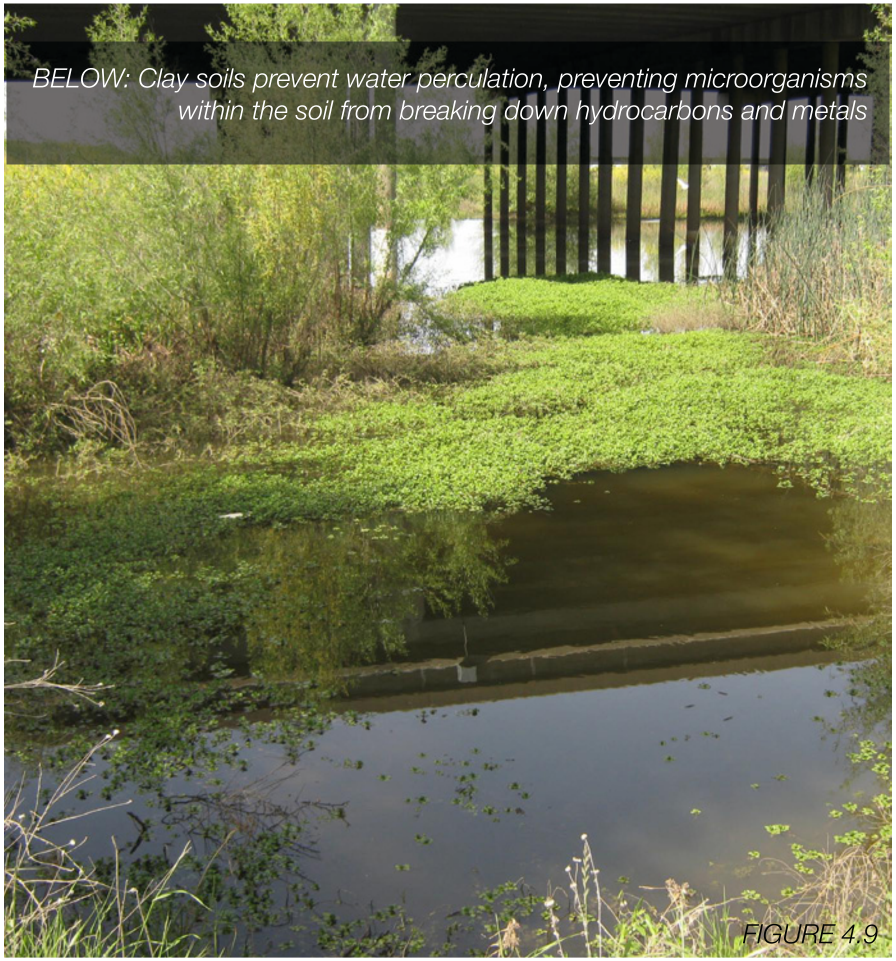
ABOVE: Even during the dry seasons, the wildlife area remains relatively wet due to the presence of clay soils.



ABOVE: The existing parking lot at the Yolo Bypass Wildlfie Preserve

FIGURE 4.8

There is currently no overhead roadway lighting on the bridge. This was an engineering choice made early in the construction process assuming sufficient light would be available from the high volume of vehicular traffic throughout the night. While this is a solution to cut costs, the lack of lighting creates a hazard for drivers. Because there is no direct overhead lighting, oncoming car lights can disorient drivers from the opposite direction.

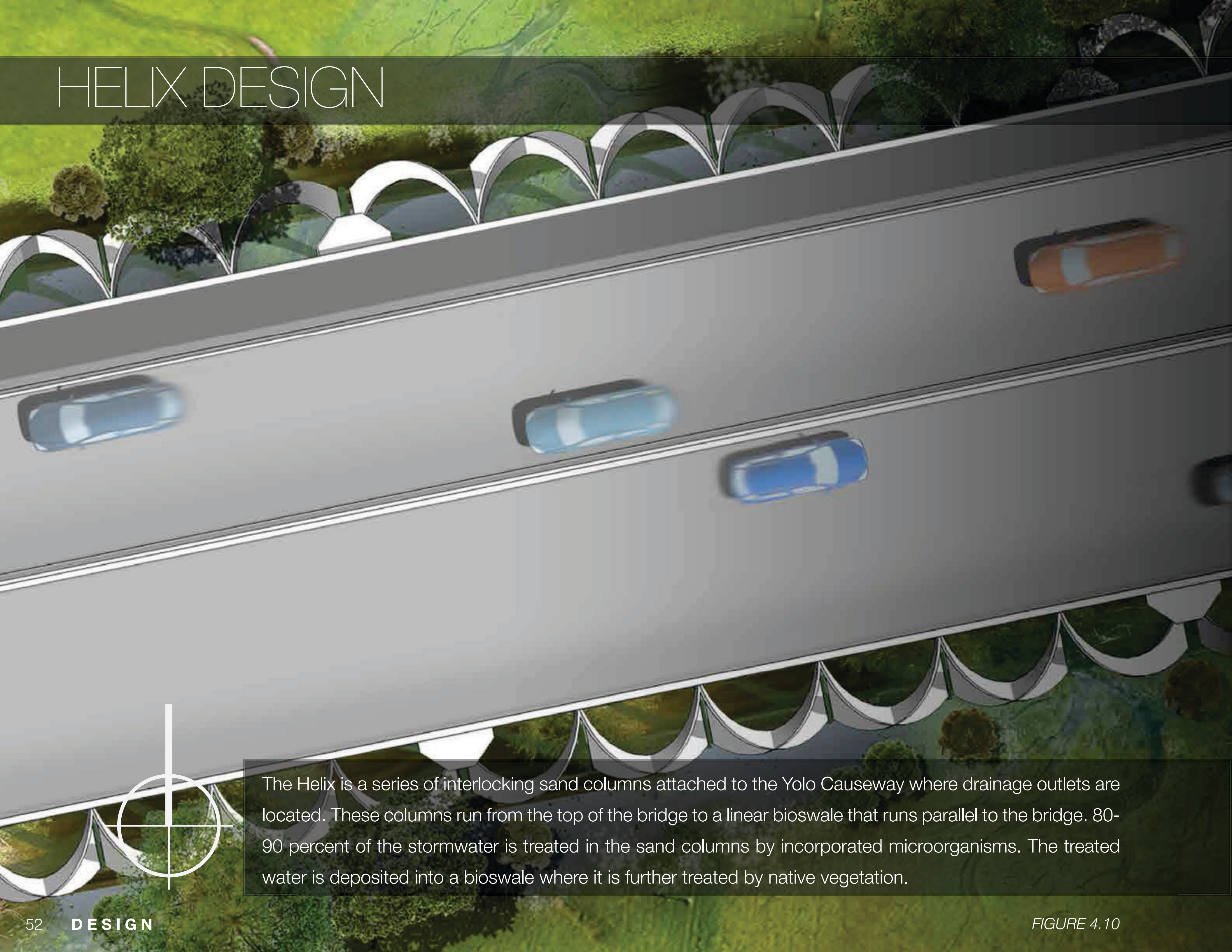


BELOW: Clay soils prevent water perculation, preventing microorganisms within the soil from breaking down hydrocarbons and metals

FIGURE 4.9

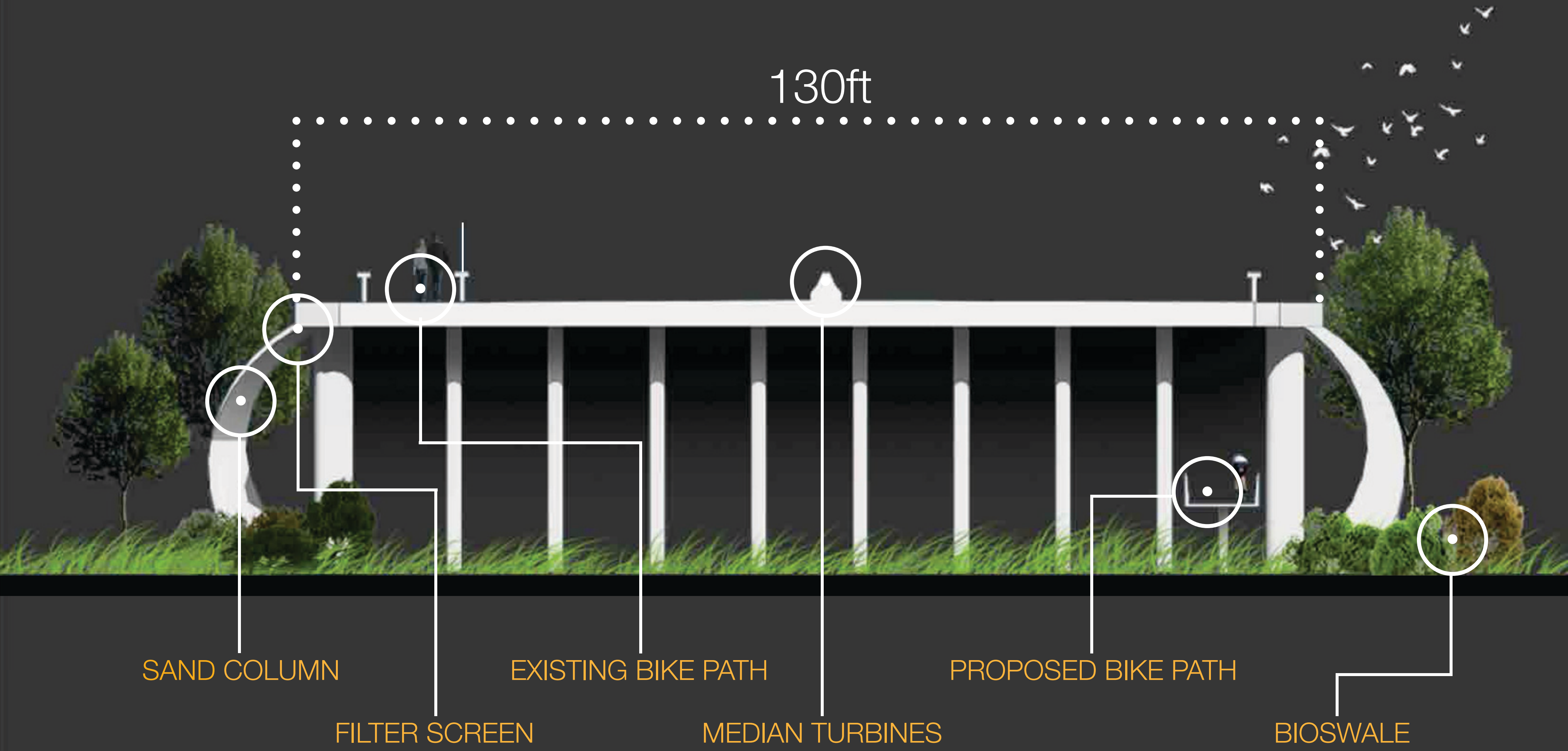
The causeway is composed mostly of steel and exposed concrete and asphalt. While concrete is utilized for the guard rails and bike path, asphalt is used for highway paving due to its inexpensive cost and ability to be resealed and repaired.

HELIX DESIGN



The Helix is a series of interlocking sand columns attached to the Yolo Causeway where drainage outlets are located. These columns run from the top of the bridge to a linear bioswale that runs parallel to the bridge. 80-90 percent of the stormwater is treated in the sand columns by incorporated microorganisms. The treated water is deposited into a bioswale where it is further treated by native vegetation.

FIGURE 4.10



The Helix protrudes from the existing Yolo Causeway by 13 feet. This dimension is critical as farm land is situated 60 feet from the bridge. A linear bioswale is sunk below the existing grade between the Helix and rice fields on the south side. The Helix is 30 feet tall and funnels water from the top of the bridge down into the proposed bioswale. An elevated path serves as a new bike trail under the causeway.

FIGURE 4.11

RECREATIONAL USE

Some of the most successful projects engage spectators with the environment. By actively engaging visitors with the space, onlookers are presented with a unique experience while also promoting the space as a recreational destination. The Helix creates several opportunities for recreational use that will promote not only the site and wildlife area but the intervention itself and it's holistic approach to treating stormwater. This recreational space may be utilized during both the wet and dry seasons.

ABOVE: A kayaker's perspective of the Helix

FIGURE 4.12

The Helix site would introduce a new bike path to coexist with the current path along the causeway. The current bike path is underutilized, however, the new bike path moves under the bridge and adjacent to the Helix intervention. Cyclist can view the wildlife area, free of speeding cars and exhaust pollutants.By offering a an alternative path for cyclist and pedestrians to travel along the causeway, more people may be inclined to ride their bikes on this newly developed path. The existing bike path would remain as a means of travel when the bypass is inundated with flood water.

Creating a dock would allow kayakers access to the flooded bypass area, providing a unique perspective of the Helix and causeway. Kayakers would be able to get up close to the Helix struts and better observe how these components can benefit the bypass ecosystem.

BELOW: A rendered image depicting the proposed bike path underneath the bridge

FIGURE 4.13

STORMWATER AWARENESS

Promoting both stormwater and ecological awareness for the Helix intervention is a challenging endeavor. The design objective was to create a way for travelers on the causeway to be more aware of the surrounding ecosystems without the use of mirrors, signs or sounds. Conceiving an intervention that would promote awareness related to stormwater pollution such as metallic elements and soil pH is the primary educational focus of what could be promoted for those traveling over the causeway. Lighting of the Helix will be used to create awareness about stormwater pollutants. A series of lights placed within the constructed bioswales would illuminate the Helix structure. Via a gradient of colors, soil pH resulting from algae growth on the the underside of the Helix struts.

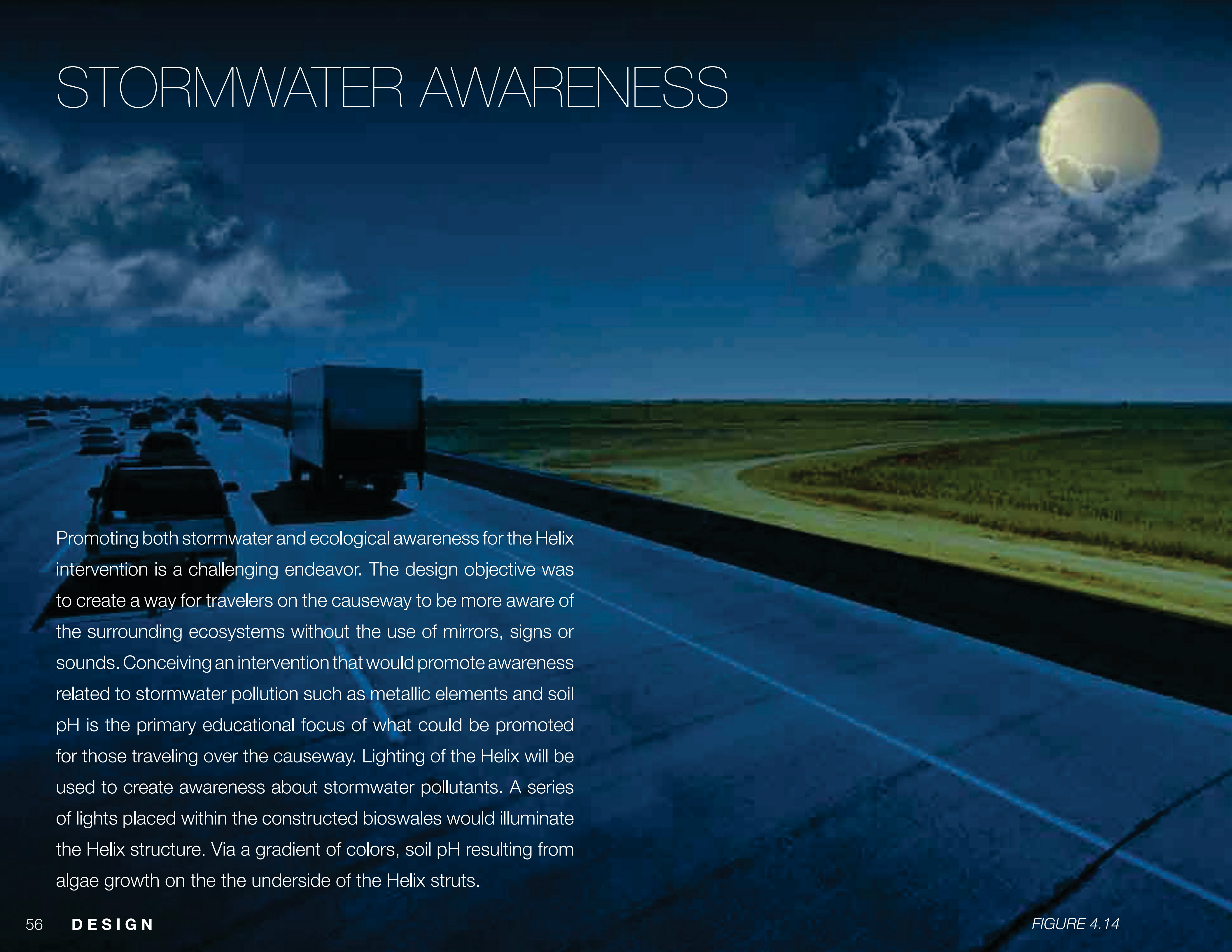


FIGURE 4.14

FIGURE 4.15

FIGURE 4.16

ACIDIC

NEUTRAL

LEFT/ABOVE: Renderings depicting the subtle glow from the Helix. The lights would change based on soil pH.

BIOSWALE

A birds-eye perspective of the Helix filtration structure.

FIGURE 4.17

The Helix also minimizes soil erosion amongst the existing rice fields by means of channeling flood currents into a more linear flow pattern.

DIAGRAM 4.18

A linear bioretention basin would run parallel to the Yolo Causeway and serve as a final treatment process for the stormwater that sheds off the bridge. These treatment basins would be sunken below the existing grade as to not impede current flooding conditions.

A plan rendering depicting how the retention basin is sunken below the Causeway Bridge.

FIGURE 4.19

FIGURE 4.20

Some of the proposed native California plants including Ceanothus, Western Redbud, Golden Poppies, various species of Salvia, oak trees and Sypringa

Native California plants create a visually appealing landscape. Strategically planted trees provide shade for smaller shrubs if required.These plants would not have to be completely drought tolerant either, due to existing clay soils creating wet and boggy conditions.

FILTRATION PROCESS

A simple screen serves as the first form of filtration, separating larger debris and pollutants.

Sand filtration allows stormwater to pass through layers of fine sand breaking down 80-90% of hydrocarbons and oils.

Algae growth along the underside of the Helix detect and treat low levels of heavy metals such as copper, nickel, mercury, silver, or cadmium. Present metals are indicated by a series of floodlights on the Helix, glowing different colors based on changing soil pH.

Bioretention basins are a holistic method for treating stormwater pollutants through physical and biological processes. Bioretention filtration processes include adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization.

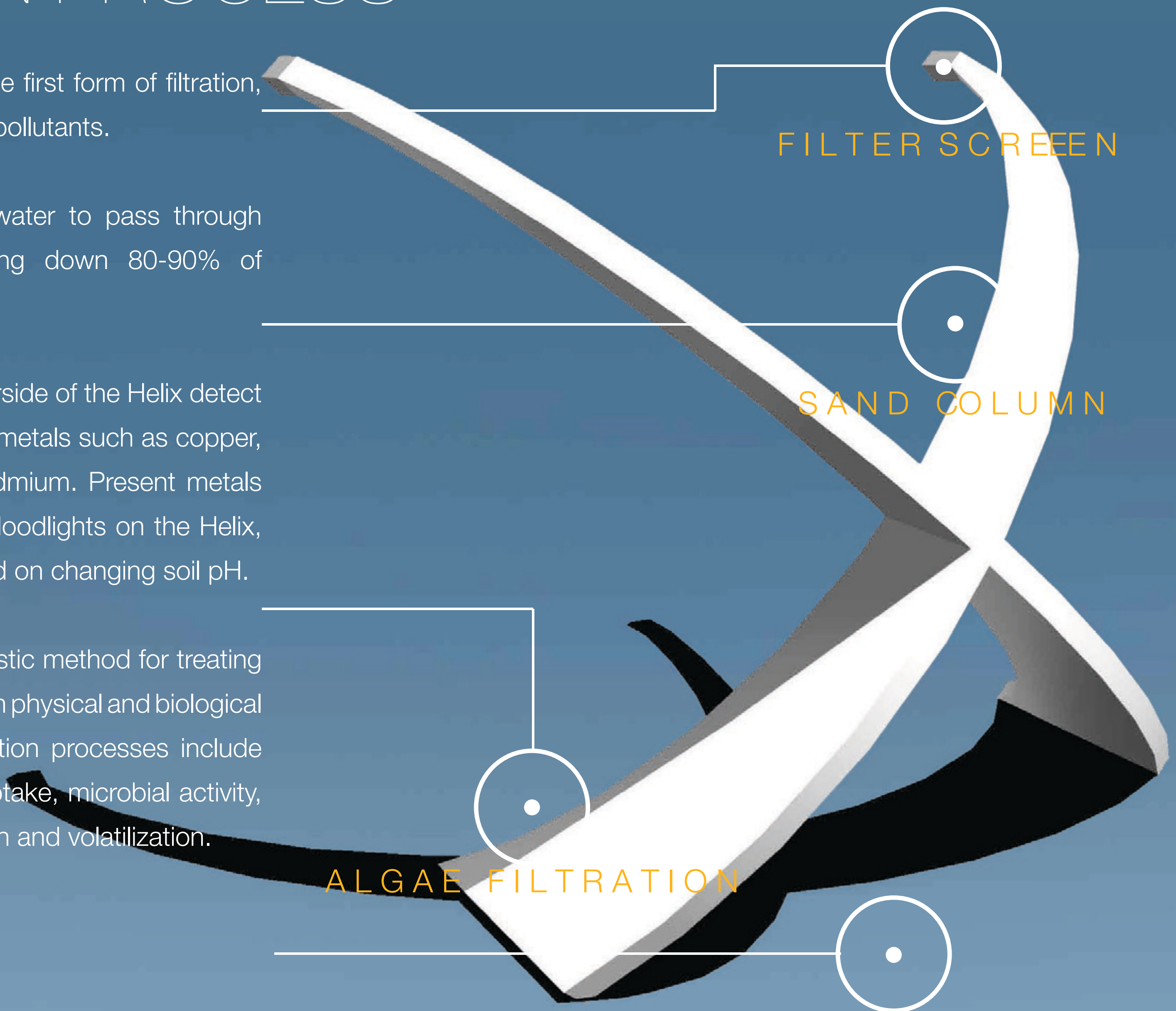


FIGURE 4.21

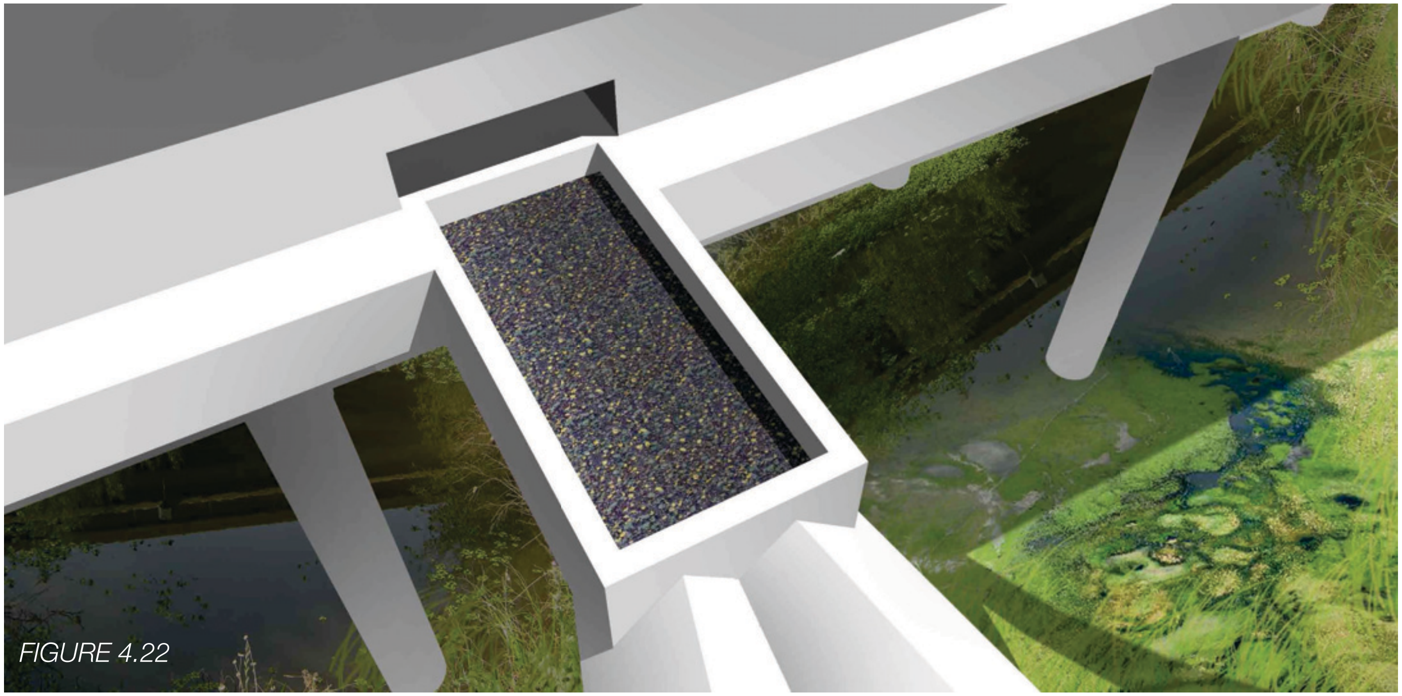


FIGURE 4.22

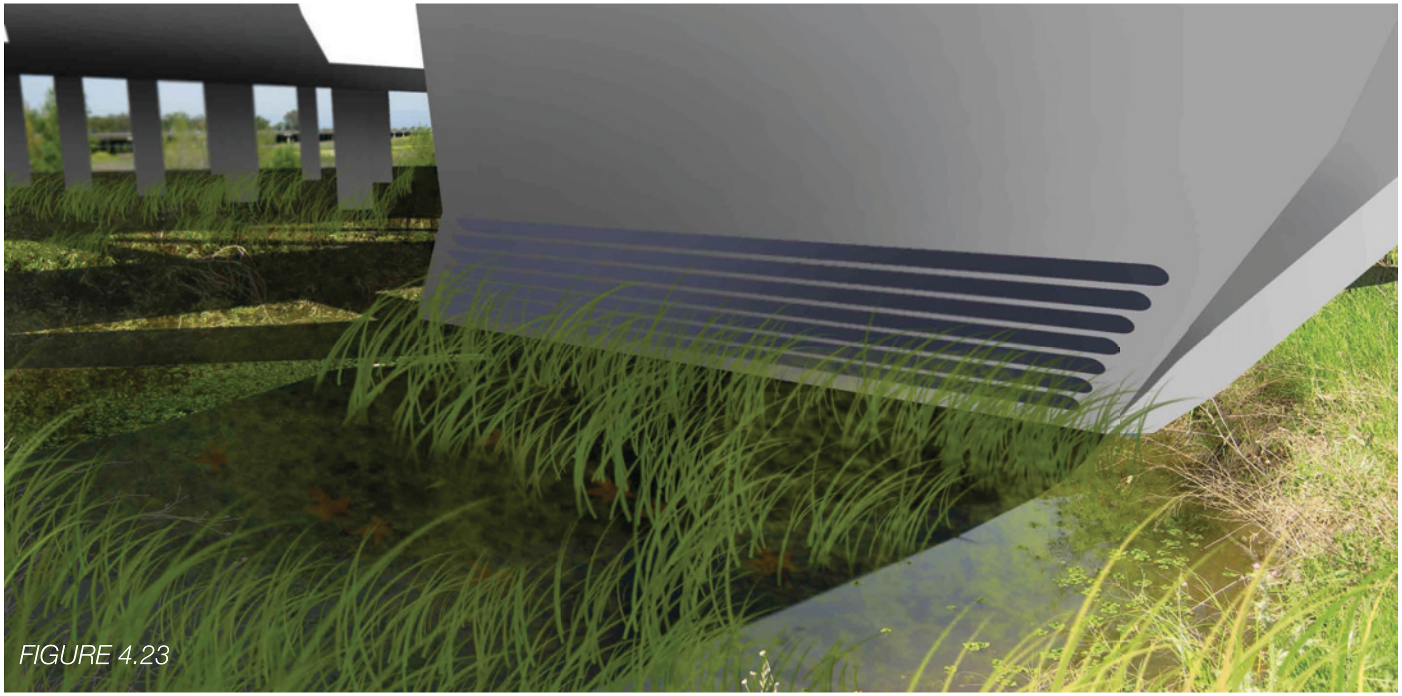
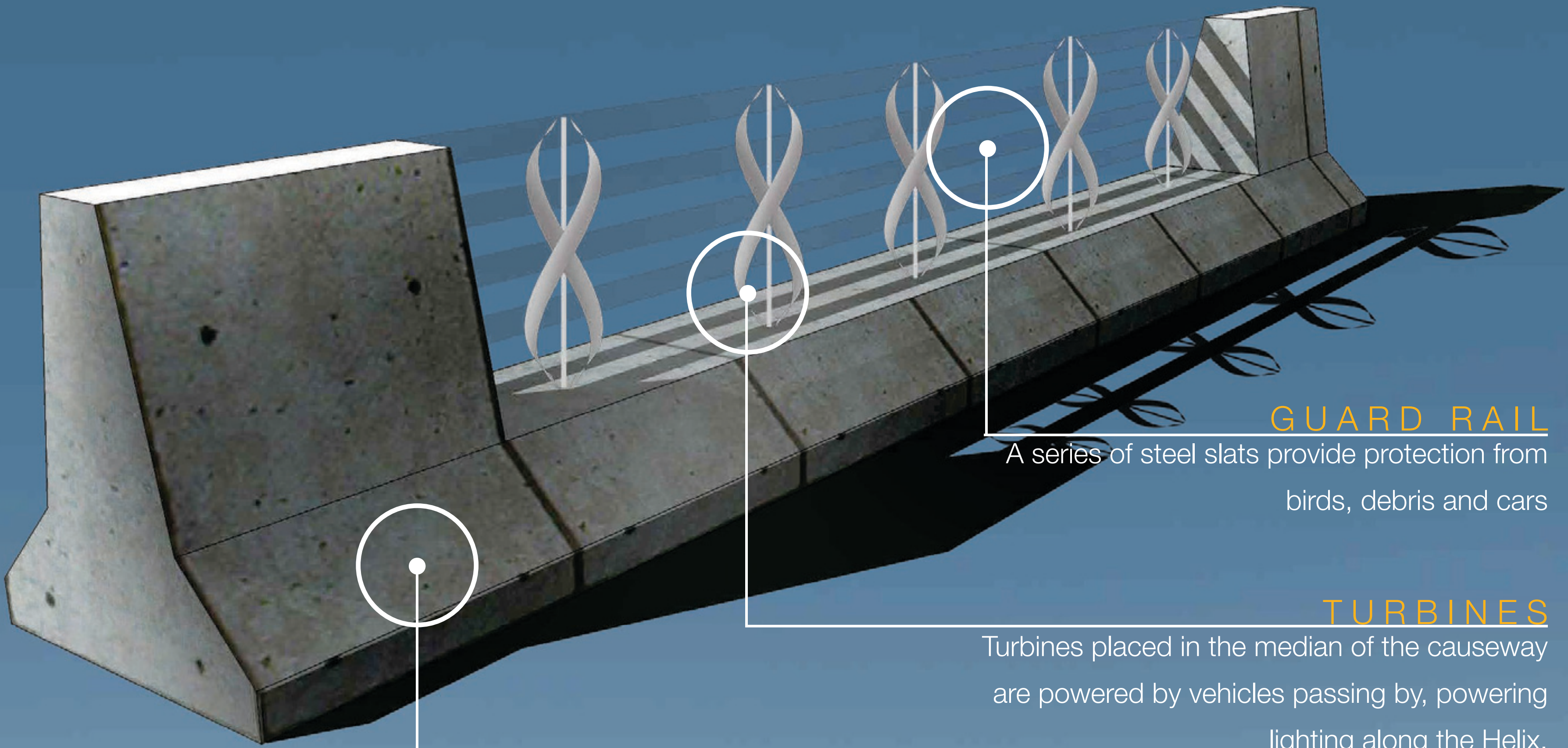


FIGURE 4.23

A box with layers of aggregate screen larger particulates as a first form of stormwater filtration. This box also serves as an overflow regulator should the sand column become inundated.

Outlet ports on the bottom of the Helix not only serve as a means for treated stormwater to leave the sand columns but also provide a substrate for algae growth. Small sensors on these ports provide information to a series of lights that change color based on soil pH and metalic elements present.

FEATURES



GUARD RAIL

A series of steel slats provide protection from birds, debris and cars

TURBINES

Turbines placed in the median of the causeway are powered by vehicles passing by, powering lighting along the Helix.

ELECTRICAL HOUSING

Electrical wiring would be housed in the concrete median and feed directly to the Helix.

FIGURE 4.24

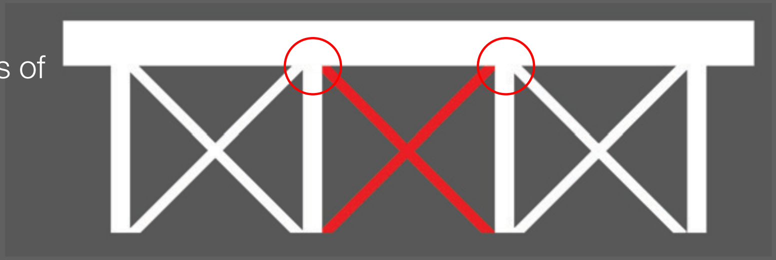
A series of lights placed within the Helix would be powered by the turbines located on the median of the roadway. These lights would provide a soft glow at night.

FIGURE 4.25

MAINTENANCE

1. Over time the Helix sand columns may become saturated with debris, pollutants and algae growth. Sensors indicate when components need replacement.

2. The Helix structure is attached to the bridge with a series of pins for easy removal.



3. An attachment in the middle of the Helix allows for quick removal via crane situated on the bridge.

4. Existing vegetation may need to be replaced if damaged during Helix maintenance.

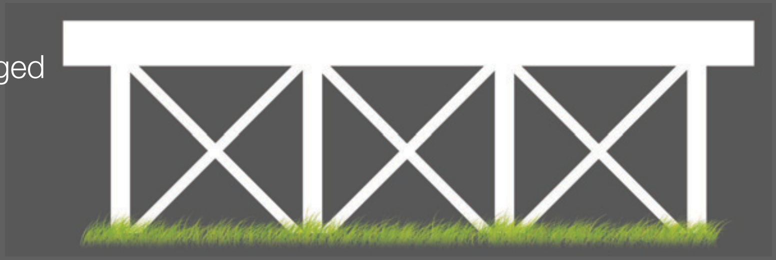


DIAGRAM 4.26

THANK YOU!!