REPORT

Title (As it appears on the award document)
Design and evaluation of Best Management Practices (BMPs) for urban stormwater quality improvement in South Texas

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Abstract

Urban stormwater runoff water quality is increasingly becoming a major contributor to nonpoint source water pollution for 21st century development. It can not only become a cause of flooding if not properly managed during storm events, but also is a cause of water pollution through runoff containing sediment and materials. The increase in population and fast social development at the border of US and Mexico imposes a serious water quality problem in the Arroyo Colorado area. The uncertain storm water runoff without treatment and management will potentially cause big impairments to the watershed. Therefore, a one year dataset (January 2004 through August 2005) for Green Valley Farm colonia was analyzed to assess the environmental effects of rural storm water runoff. Although the analysis period is short, the analysis showed that several important parameters of storm water quality run beyond the EPA standards, which would be addressed adequately if it had been covered by the related storm water management policy. Furthermore, more comprehensive and in depth analysis (including longer periods) of storm water run off in rural areas of South Texas are essential to trigger an adequate environmental regulation. Natural and semi-natural water and wastewater treatment technologies can provide effective water quality improvement and quantity control. Over the past several years, best management practices, including detention basins, biofilters and constructed wetlands, have been very successful in removing total suspended solids

and pollutants from wastewater. A sequential treatment system including a forebay, pond, and wetland has been proposed to incorporate the merits of these approaches and improve runoff water quality for South Texas. Hydraulic detention time, attached growth media and vegetation were three important parameters identified in the designs to help optimize system performance.

Problem and Research Objectives

Urban stormwater is a major non-point source of aquatic pollution, causing widespread environmental degradation and potential health risk (Novotny and Olem, 1994; Marsalek et al., 1999). The runoff contains significant loading of heavy metals, petroleum hydrocarbons, pesticides, sediment, and nutrients (Hall and Anderson, 1988; Davis et al., 2001). If contaminated stormwater is not properly managed during storm events, the pollutants such as non-biodegradable metals can accumulate in the local ecosystem, leading to adverse effects on human health and the environment, such as acute toxicity and potential carcinogenic damage (Wong, 2006; Wu and Zhou, 2009). Therefore, accurate characterization of frequency, volume and sediment load of urban storm water during rainfall events is vitally important for urban landscape development, drainage patterns design and water quality prediction.

Along the border of the US and Mexico, quick urbanization and population growth have triggered fast pace development of industrial and municipal sectors. These activities have imposed heavy environmental and ecological burdens in these areas and have thus caused serious air, water and solid waste pollution. The Arroyo Colorado and Rio Grande are important environmental and economic resources for South Texas. However, both were listed as impaired, identified in the 2008 Texas Water Quality Inventory and 303(d) listed for depressed dissolved oxygen, bacteria, mercury in edible tissue and PCBs in edible tissue (Texas Commission on Environmental Quality, 2008). Thus, as part of a prudent watershed protective plan, it is essential to implement some Best Management Practices (BMPs) for urban water quality improvement in South Texas to mitigate the impact of non-point pollution, such as urban stormwater, on watershed quality.

Even with this heightened awareness, the acquisition of adequate data for stormwater runoff for BMPs mitigation designs and modeling is still a challenge. It is until recently that some facts concerning storm water have been brought for the first time to academic discussion, for example, the first flush (Deletic, 1998; Stenstrom and Kayhanian, 2005). Currently, the complexities among land use, storm events and urban water quality are still poorly understood. Innovative approaches for developing comprehensive and field applicable datasets of stormwater quality management and in depth analysis are especially needed for South Texas (Leecaster et al., 2002).

In an elevated effort to improve our understanding of these storm events, this investigation studied the water quality at Green Valley Farm colonia, which was collected from January 2004 to August 2005. The analysis was designed to evaluate the adequacy of the current water monitoring plans, improvement of stormwater quality monitoring in the future and provision of more information for policy making. This research examines and evaluates analytical and statistical methods to accurately and effectively characterize this regional stormwater quality data, and its usefulness for design and model regional stormwater detention facilities for semi-arid coastal areas.

Thus, it is very important to accurately characterize the frequency, volume, sediment and materials loading of storm water during rainfall events for project design and policy making. In an effort to improve our understanding of these events, we propose to use continuous flow monitoring to survey the critical parameters including flows (flow rate, temperature), nutrients (nitrogen, phosphorus, chlorine, sulfate), bacteria (*Escherichia coli*, Enterococcus), and others (pH, dissolved oxygen, TDS and TSS) for the best management practices designs and model calibrations, and collect the data to make the time-flow, time-concentration and time-mass loading curves.

Based on these results, we will design some innovative best management practices for urban water quality improvement in South Texas, such as baffle box, free water surface wetlands, bioretention cells, treatment swales and others. Modeling of small scale urban BMPs presents challenges in the development of accurate models including fundamental water quality treatment processes. Thus, water quantity and quality will be monitored and evaluated after comparing the volume and concentration at the inlet and outlet of the BMP designs. A mathematical descriptive model of each BMP will be developed and validated using these data.

In order to improve the quality of large volumes of stormwater, various best management practices (BMPs) have been employed to control runoff volume and pollution loading, such as retention and infiltration systems used for collection, and infiltration and transport of stormwater into groundwater systems (Walsh, 2000). Performance evaluation and modeling of existing BMPs is critical for project management, public acceptance and future BMP designs. Although individual reports of BMPs are useful in specific locations, for various BMPs with a robust change of physical, chemical and/or biological operating processes, comparative analysis and dynamic modeling of water quantity and quality is needed to provide a more comprehensive knowledge basis for predicting and planning water quality treatment and innovation (Scholes et al.; Barrett, 2008).

The detention basin, retention pond, wetland basin and wetland channel are mainly structural types of BMPs. The differences among these types are the size and shape of pond and wetland. However, they have very similar structures: forebay, pond and wetland. Usually the forebay, as the first part of a pond and wetland system, is underestimated for its importance in the total water treatment process. Although the pond and wetland have different hydrologic, hydraulic and botanic characteristics

(Wong, 1999), they can be used sequentially in a complementary manner. At many northern temperate locations, pond-wetland systems have demonstrated reliable long-term performance (Kadlec, 2003). Thus, the extension to a forebay-pond-wetland system is proposed and investigated to illuminate the specific functions of different sections and their complementary performance toward water quality improvement, even with the challenges presented through a semiarid climate application such as South Texas

Materials/Methodology

Water quality monitoring evaluations in the semi-arid South Texas (Arroyo Colorado Watershed) and dataset development applications

The study area, near the US-Mexico border, is of the fastest growing urban areas in the nation. The largest city in Hidalgo County, Texas, city of McAllen, which is located in the Rio Grande Valley, is representative of this investigation. The population was 106,414 during the 2000 census, while the McAllen–Edinburg–Mission Metropolitan Statistical Area had a population of 569,463; rapid growth pushed the metropolitan area's population to 710,514 by 2007, which is about 25% population increase in 7 years' period (United States Census Bureau, 2007).

A dataset for the water quality monitoring is presented here. The precipitation information of McAllen was charted in Figure 1 and Figure 2 (National Weather Service, Mcallen, 1971-2000). McAllen has a distinct dry season (from November to April) and wet season (from May to October). Moreover, two high volume peaks (May or June, and September) provides the opportunity to examine seasonal variations in the first flush characteristic. Besides the study of extreme storm events, the impact of different storm intensity (precipitation >= 0.01, 0.1, and 1 inches) on the urban storm water quality is another important research topic.

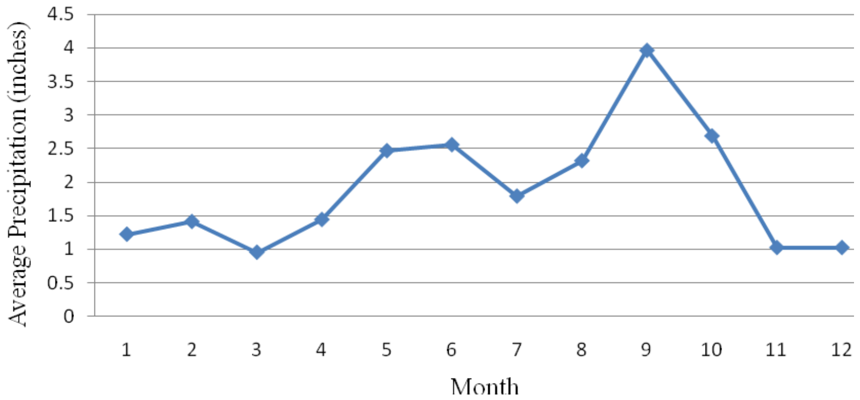

Figure 1. Monthly average precipitation (inches) in McAllen, Texas (National Weather Service, McAllen, 1971-2000).

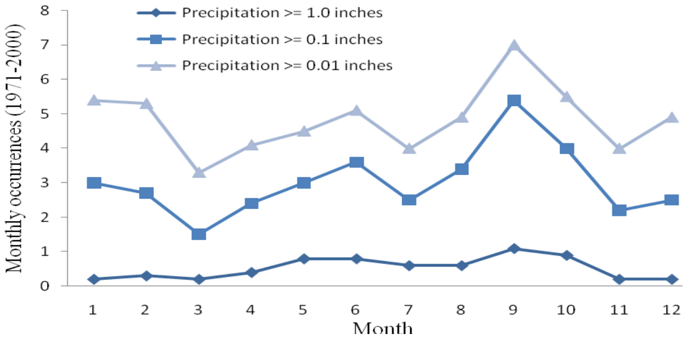

Figure 2 Average monthly occurrences when precipitation >= 0.01, 0.1 and 1 inches in McAllen, TX (National Weather Service, McAllen, 1971-2000).

Within the study area, a monitoring dataset from area within the Arroyo Colorado Watershed was evaluated. This dataset from Station 18196 (26.136862N, 97.54839W) during January 2004 through August 2005 was collected by a special research team of the Nueces River authority to monitor water quality in Green Valley Farms colonia in Cameron County, Texas (Fig. 3). The total base flow monitoring points are 19, and another two high flow events, high flow 1 on March 17, 2004, and high flow 2 July 21, 2005. The materials and methods of dataset collection can be found in a final report on the surface water monitoring and flow data collection study for the Cameron county special study (Sam, 2005).

Figure 3. Location of monitoring Station 18196 in Cameron County near McAllen, Texas USA from Google Earth.

Water quality monitoring follows the protocol of the latest version of TCEQ’s Surface Water Quality Monitoring Procedures (2003) (Texas Commission on Environmental Qualify, 2003). Instantaneous field measurements in the selected monitoring database include three major categories that cover 35 parameters in the Table 1 (Sam, 2005).

Table 1. The monitoring parameters for the Cameron county special study

Categories	Parameters
Water flow rate	flow stream, flow, flow method
Water quality indexes	water temperature, transparency, turbidity lab; specific conductance, oxygen dissolved, pH, alkalinity; total non filterable, volatile non filterable, ammonia, kjeldahl; nitrite nitrate, total phosphorus, ortho phosphorus, total carbon; turbidity, chloride, sulfate, enterococcus, pheophytina, TDS; chlorophyll-a
Water environmental indexes	air temperature, days since precipitation event, rainfall in 1 day; rainfall in 7 days, wind direction, wind intensity, present weather; water surface, water color, water odor

Due to deep water and rapid current velocities, flow data from the two high flow events were determined by approximation (Sam, 2005). The flow rate of high flow event 1 was 146 cubic feet per second (cfs), and the flow rate of high flow event 2 was 40 cfs.

Design and implementation of a forebay-pond-wetland system for urban stormwater treatment in South Texas

A sequential treatment system including forebay, pond, and wetland has been proposed to incorporate the benefits of each natural system based treatment technique and develop optimization strategies for the entire system performance (Fig. 4).

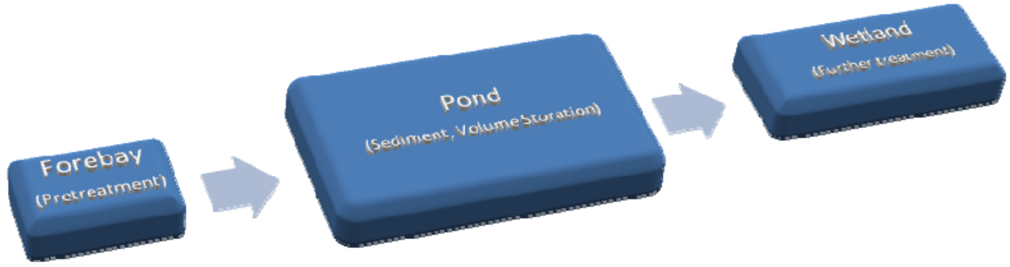

Figure 4. Schematic diagram of forebay-pond-wetland system

A forebay is a small reservoir connecting the channel and basin or other BMP facility. It serves to dissipate inflow energy, store some flow volume and trap coarse solids, and thus is usually used for pretreatment. In order to improve pollutant removal efficiencies, several accessory structures are often added such as oil and grit separators, and baffle boxes and screens. More important, the pretreatment function of forebay can reduce the sediment cleaning frequency of pond and wetland, make the maintenance easier and extend the operational life of BMPs. However, due to the small areas often available and the diversity of forebay design situations, there are no detailed accepted handbooks on forebay design and planning as of yet. Some findings from pond and wetland surveys in North Carolina have suggested that forebay designs should include separate energy dissipation and sedimentation sections (Johnson, 2007). For runoff pretreatment, the design must be flexible according to the specific location and objectives.

In stormwater management, ponds are constructed basins with greater depth and without the vegetation of wetlands. Ponds typically have two parts, a permanent pool and a temporary pool. This treatment approach has two main functions, water storage and solid sedimentation. Water interception with this system can decrease the impact of peak flow during heavy storm events on subsequent wetland structures, and balance the loss of pervious surface area for infiltration. The primary treatment process in ponds is physical sedimentation, but also biological and chemical uptake, and other pollutant transformations can be significant (Wong et al., 1999). Solid sedimentation is governed by particle size, flow velocity and hydraulic retention time. Some contaminants are heavily associated with solid particles such as phosphorous or carbonaceous materials.. When the solids settle, these contaminants are also removed from the water column. Some microbes in water and pond bottoms can digest these pollutants as substrates. However, the sediment accumulation and heavy metal enrichment at pond bottoms are important for the safety design, operation and maintenance (Färm, 2001).

The wetlands approach to water quality treatment includes the natural wetland and constructed wetland. This approach provides many ecosystem services, such as water management, biological habitat, aesthetics and educational parks (Costanza et al., 1997). Natural wetlands also play an important role in watershed water management and regional biodiversity protection. Constructed wetlands mimic natural wetlands, but their implementation avoids damage to natural wetlands. Due to the multi-functional nature of wetlands, more and more artificial wetlands are being constructed as one type of BMPs. Constructed wetlands also are often classified into two types: surface flow wetlands (SFW) and subsurface flow wetlands (SSF). Wetlands use a combination of physical, chemical and biological processes to remove pollutants. Similar to the pond, solids can be settled by gravity, and some contaminants can react or be taken up by biota.. Vegetation can stabilize the bed surface, provide a filtration effect, transfer the oxygen, influence the flow and particles and finally increase the removal rate (Brix, 1997). Fecal bacteria, BOD and suspended solids in the secondary effluent from domestic wastewater were removed effectively in the constructed wetland experiments located in Kentucky, USA (Karathanasis et al., 2003). Vegetation management, such as the use of hummocks and harvesting, can be important for achieving and maintaining the optimal treatment function of wastewater treatment wetlands (Thullen et al., 2005). The depth distributions and vegetation density are vital parameters in determining the mixing extent and treatment performance (Carleton and Montas, 2007). However, particle sizes and flow characteristics are important factors in influencing particle trapping efficiency (Deletic and Fletcher, 2007).

Principal Findings

Water quality monitoring evaluations in the semi-arid South Texas (Arroyo Colorado Watershed) and dataset development applications

The threshold between base flow and high flow is set as 20 cfs (Figure 5). Concentration and mass loading of some common index of water quality between the base flow and two high flow events are shown in Table 2 and Table 3. Storm events result in high flow and thus high mass loading, which brings the complex relationship between pollutant concentration and flow rate. Therefore, Event Mean Concentrations (EMCs), which is based on the bimodal or mixture distributions, were applied to estimate the total mass loading (Nueces River Authority). Due to the potential significant complexities, time effect is not included for this investigation.

Figures 6 and 7 illustrated the relationship between flow rate and five water quality indexes, dissolved oxygen, total nitrogen (Kjedahl), total phosphorus (Wet method), E nterococcus and TDS (Residue, total filterable dried at 180 °C, mg/L). In addition, the high flow doesn’t bring high pollutant concentration as original imagine except dissolved oxygen and enterococcus, due to the accumulation effect of pollutant and dilution effect of high water flow. In other words, the pollutant accumulation speed during the dry period is constant and long-term, and storm event can’t wash off the pollutant more than the total accumulation amount. In addition, the increase of total nitrogen, total phosphorus and TDS will boost the bacteria counts and deplete the dissolved oxygen.

According to site specific criteria established by the Texas Commission on Environmental Quality (TCEQ), enterococcus and TDS concentrations were always higher than the standard during base flow and high flow (Grum et al., 1997). Total nitrogen was lower than the criteria during base flow, however, the dissolved oxygen was lower than the criteria during high flow.

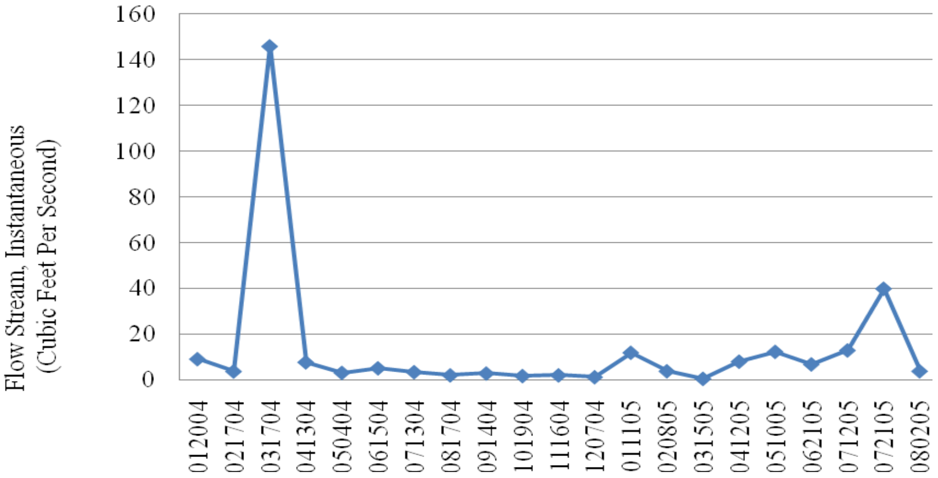

Figure 5. The instantaneous flow stream (cubic feet per second) from Jan. 2004 to Aug. 2005.

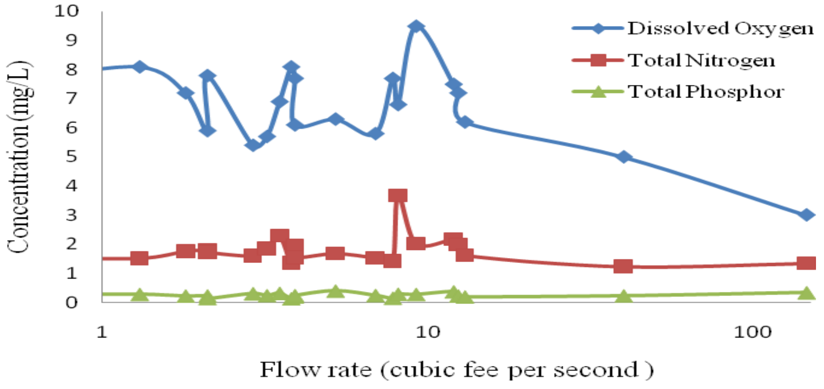

Figure 6. Dissolved Oxygen, Total Nitrogen and Total Phosphorus versus

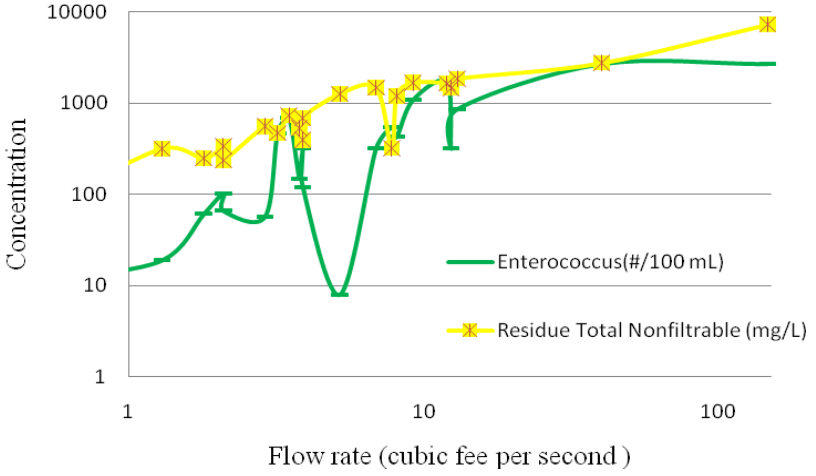

Figure 7. Enterococcus and TDS versus Flow rate

Software *Statistic 8* was employed to do the correlation analysis of the flow rate and other five indexes. Some data was adjusted, transforming >600 to 600 in enterococcus. Using the $p<0.05$ as the correlation analysis standard, the flow stream rate has a significant positive relationship with enterococcus and negative relationship with TDS at the base flow (Table 4). The data (just two high flow events) were not sufficient to complete a statistical analysis to show the difference between the base flow and high flow. However, Figure 5 preliminarily indicates that high flow leads to lower total nitrogen and dissolved oxygen concentrations; while Figure 6 indicates that high flow leads to higher enterococcus and TDS concentrations.

The purpose of this project was to provide hydrological and water quality data to monitor the effects of base and high flow storm events on the quality of flowing water in the drainage ditch in this rapidly developing area, and supply constructed wetland project for a treatment (Sam, 2005). However, there were several shortcomings in this available dataset which need elaboration.

The frequency of one sample per storm event is not sufficient to evaluate the storm. A more rigorous method for monitoring is to characterize sample adequately. However, time and cost will always restrict the amount of sampling. Some researchers proposed that sampling seven storms annually was the most efficient method for attaining small confidence interval width (Leecaster et al., 2002). However, more consideration needs to be given to the inherent sampling, storage and analytical uncertainties contained within these measurements (McCarthy et al., 2008). Thus, it is important to design monitoring programs for water quality based on field experience with realistic datasets (MacDonald et al., 2008). Furthermore, in order to identify the characteristics of runoff, the number of sampling events should be sufficient to illustrate the trend, especially in the period after the dry season to include the effect of first flush.

Runoff should be considered as the sum of base flow and rainfall on the ground (Figure 8). Therefore it is necessary to study the relationship of precipitation and stormwater flows. The rainfall gauges (weather station) should be established near the monitoring sites. The precipitation information from National Weather Service and US Geological Survey is critical but not enough. Basic statistics of storm events should comprise total rainfall, maximum intensity, antecedent dry day, event duration, and average rainfall intensity.

More importantly, stormwater link the atmosphere, land and river systems by precipitation and transportation (Figure 8). Therefore, in the project, factors such as weather, climate change, air quality, land cover and social-economic municipal, should be considered to investigate the relationship with the water quality and quantity.

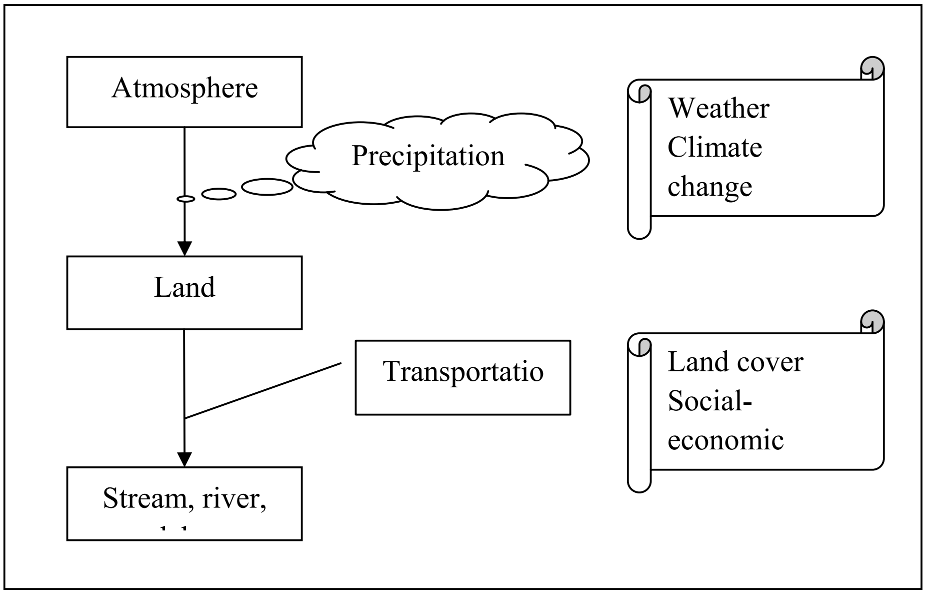

Figure 8. Schematic diagram of runoff complexities for sampling designs

Weather forecasting is a critical element for sampling planning. Based on the long term (5 day) forecasts by the US Weather Service, a research team can prepare to sample base flow and storm water quality. 24 samples of base flow (one hour interval) will be collected one day each month. If possible, one storm event per month will also be sampled. The procedure will cover the seasonal variation. The sampling interval before and after the rain is prepared for one hour, and then 10-15 minutes during the storm events. Different storm levels (precipitation >= 0.01, 0.1, and 1 inches) also will be considered in sampling. The selected water quality parameters for base flow include the total suspended solids, TDS, turbidity, conductivity, pH, chemical oxygen demand, dissolved oxygen, ammonia, total Kjeldahl nitrogen, total phosphorus, fecal coliform (Table 1). Mercury in edible tissue and PCBs in edible should also be given more attention (Texas Commission on Environmental Qualify, 2008). Without regard to the financial limitation, more organized data will support the statistic analysis and cover possible uncertainty and variation.

Complexities exist among the volume of runoff, concentration of (pollutants and time; furthermore, the uncertainties of rainfall and land use transformations also have significant influences. Therefore, a comprehensive and dynamic analysis should cover the influences of storm, flow rate, pollutants concentration and mass loading. Continuous monitoring of water quality will also add values. Typically, one piece of monitoring dataset or one storm event is not sufficient to characterize the water quality of runoff of the whole year. More modeling parameters, time-volume, time-concentration, and time-mass loading, should come into play.

The objective of monitoring determines the methods of data collection and sampling protocols. The original report of the Green Valley (Sam 2005) plotted the general water quality index against flow rate changing with time. However, this analysis did not illustrate the correlation analysis among the flow rate, water quality and environment factors. And it also lack enough data to identify the characters of storm water and its impact on the water quality, no matter the relationship between the stormwater quality and land use.

In addition, these data should be integrated into some application models, such as SWAT (soil water assessment tool), APEX (Agricultural Policy EXtender) and SWMM (Storm Water Management Model). However, most of these models usually focus on the flow rate change caused by storm event, the stormwater quality is less in such models. New samples strategies and deep data mining will be needed to provide useful information to control and manage the stormwater.

It is strongly recommended that necessary monitoring criteria be updated from the traditional water quality monitoring system. More data and higher frequencies of monitoring through the adequate modeling, supply more accurate characterization of the water quality of run off in the conditions of both routine dry and storm events.

Table 2. The concentration index of water quality for base flow, high flow 1 and high flow 2

Water quality index	Mean	Standard deviation	High flow 1	High flow 2	Criteria [8,9]
Flow rate (cfs)	5.4579	3.9185	146	40	
Oxygen, Dissolved (mg/L)	7.03	1.05	5	3	4.0
Nitrogen, Kjeldahl, Total, (mg/L as N)	1.85	0.51	1.23	1.34	0.44
Phosphorus, Total, Wet Method (mg/L as P)	0.25	0.07	0.234	0.34	0.8
Enterocci (#/100 mL)	387.37	444.64	> 600	600	200
TDS, Residue,Total Filtrable (dried at 180^{o}C, mg/L)	2863.16	1727.95	1730	1070	2000
Transparency, Secchi Disc (meters)	0.11	0.05	0.20	0.10	
Specific Conductance,Field (µmhos/cm @ 25 ^{o}C)	4856.84	2428.87	3160.00	2060.00	
pH (standard units)	7.87	0.19	7.90	7.20	6.5-9.0
Alkalinity, Total (mg/L as $CaCO_3$)	207.32	41.53	132.00	124.00	
Residue, Total Nonfiltrable (mg/L)	158.26	49.92	69.00	50.00	
Residue, Volatile Nonfiltrable (mg/L)	22.37	5.87	10.00	6.00	
Nitrogen, Ammonia, Total (mg/L as N)	0.07	0.05	0.08	0.11	
Nitrite Plus Nitrate, Total (mg/L as N)	1.85	2.66	0.98	1.69	
Phosphorus, Dissolved Orthophosphorus(mg/L as P)	0.00	0.01	0.00	0.23	
Carbon, Total Organic (mg/L as C)	6.68	1.87	8.11	11.10	
Chloride (mg/L as Cl)	1149.84	801.13	693.00	416.00	700
Sulfate (mg/L as SO_4)	611.47	312.84	395.00	199.00	700
Pheophytin-a (µg/L Fluorometric Method)	8.48	4.38	4.20	0.00	
Chlorophyll-a (Phytoplankton µg/L, Chromo-Flouro)	35.05	16.94	21.00	9.80	
Turbidity (Lab Nephelometric Turbidity Units, NTU)	151.65	54.02	68.50	61.20	

Table 3. The mass loading index of water quality for base flow, high flow 1 and high flow 2

Water quality index	Mean	Standard deviation	High flow 1	High flow 2
Oxygen, Dissolved (Mg/L)	38.67	29.26	200	438
Nitrogen, Kjeldahl, Total, (Mg/L As N)	10.60	8.89	49.2	195.64
Phosphorus, Total, Wet Method (Mg/L As P)	1.39	1.14	9.36	49.64
Enterocci (#/100 ML)	3297	5285	108000	87600
TDS, Residue,Total Filtrable (Dried At 180 °C),Mg/L	12204	7016	69200	156220

Table 4. The correlation between the flow rate and dissolved oxygen, total nitrogen, total phosphorus, Enterocci and TDS during base flow

Index	Flow rate	Dissolved oxygen	Total nitrogen	Total phosphorus	Enterocci	TDS
Flow rate	1.0000	.0748	.2794	.0933	.7164*	-.5336*
Dissolved oxygen	.0748	1.0000	.0130	-.1996	.2515	.1482
Total nitrogen	.2794	.0130	1.0000	.3263	.3058	-.2444
Total phosphorus	.0933	-.1996	.3263	1.0000	.2582	-.0277
Enterocci	.7164*	.2515	.3058	.2582	1.0000	-.3751
TDS	-.5336*	.1482	-.2444	-.0277	-.3751	1.0000

* It shown that the correlation analysis of two indexes was at $p<0.05$.

Design and implementation of a forebay-pond-wetland system for urban stormwater treatment in South Texas

There are two forebay-pond-wetland systems being constructed in the City of McAllen, Texas, USA. The construction of the McAuliffe School BMP is already complete (Fig. 9), and the design and implementation of the Morris School BMP is underway (Fig. 10).

The McAuliffe School BMP design has four parts, one forebay, two ponds and one wetland. The forebay is a small scale grass swale, with a screen inserted between the inlet and forebay. The two ponds have enough volume to detain a high intensity storm event. The wetland is primarily a subsurface flow wetland. Design draft of the McAuliffe school wetland is shown in Figure 11.

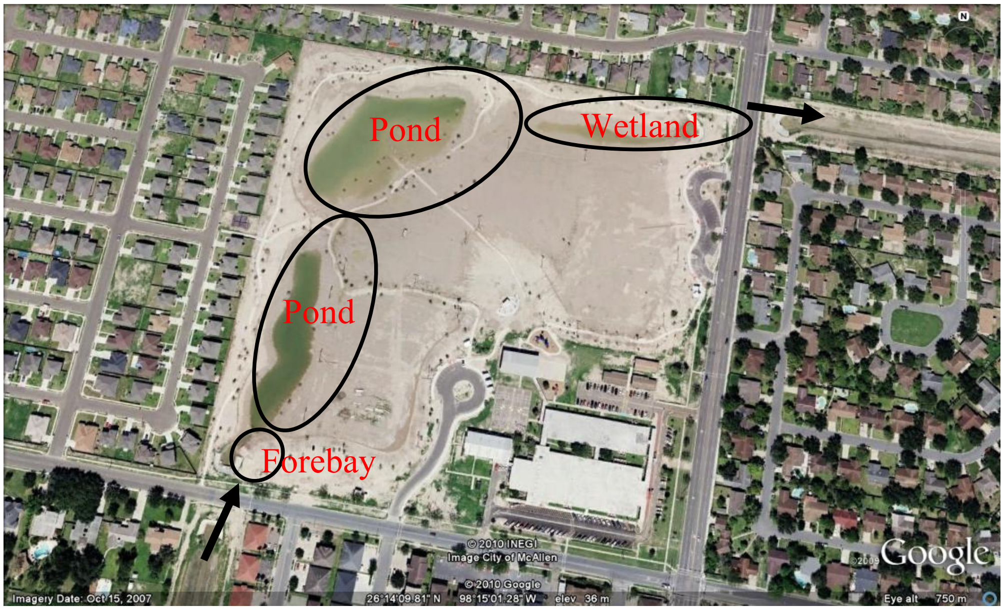

Figure 9. Aerial imagery of the McAuliffe School BMP, Feb. 10, 2009

The Morris School BMP is proposed to have three parts, one forebay, one pond and one wetland. One baffle boxes will be installed in the channel, which can remove sediment, floatables, suspended particles, and associated pollutants from storm water. The wetland will adopt the surface flow wetland type. Design draft of the Morris school wetland is shown in Figure 12.

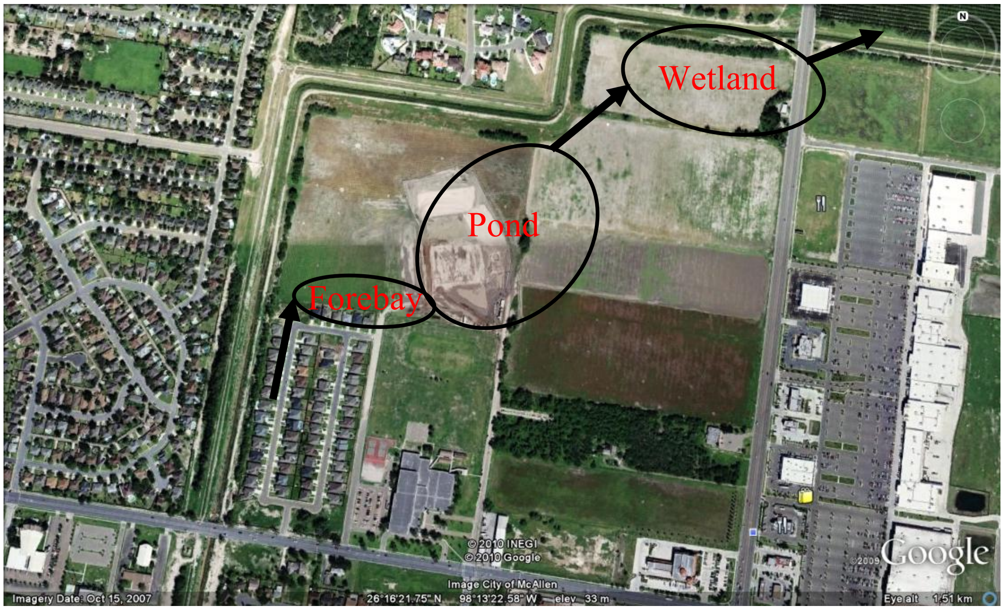

Figure 10. Aerial imagery of the Morris School BMP, Feb. 10, 2009

In order to remove contaminants in storm runoff, a forebay-pond-wetland system has been proposed and implemented at two locations in South Texas, USA. The forebay area is used as pretreatment step to increase the total performance and service life of pond and wetland. Both the ponds and constructed wetlands were designed to settle suspended solids and allow for some decay of active contaminants and nutrients. The ponds also have a significant volume storage function. Native vegetation has been planted in the wetland areas to enhance its positive role in the removal of sediment and pollution.

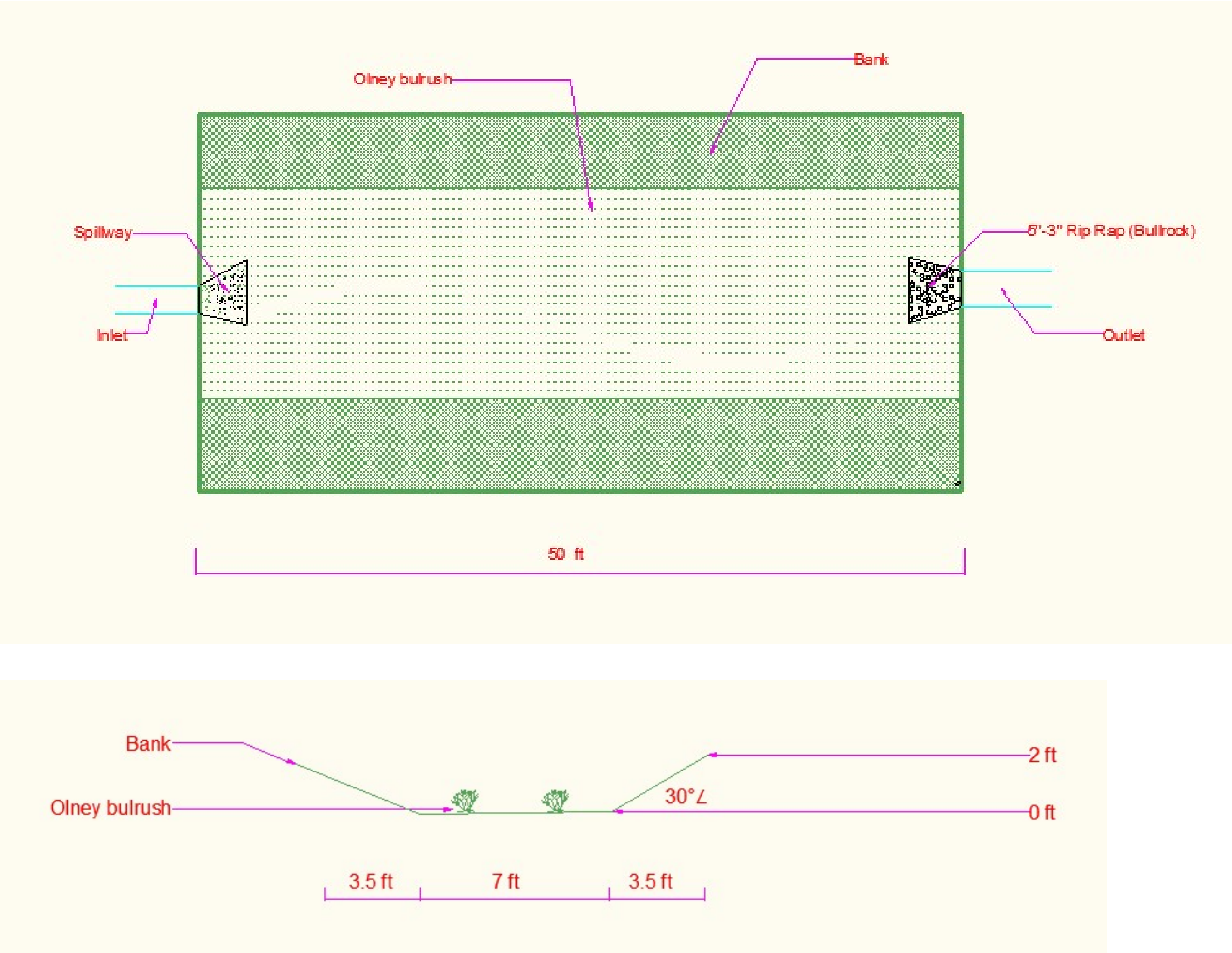

Figure 11. Design draft of the McAuliffe School Wetland

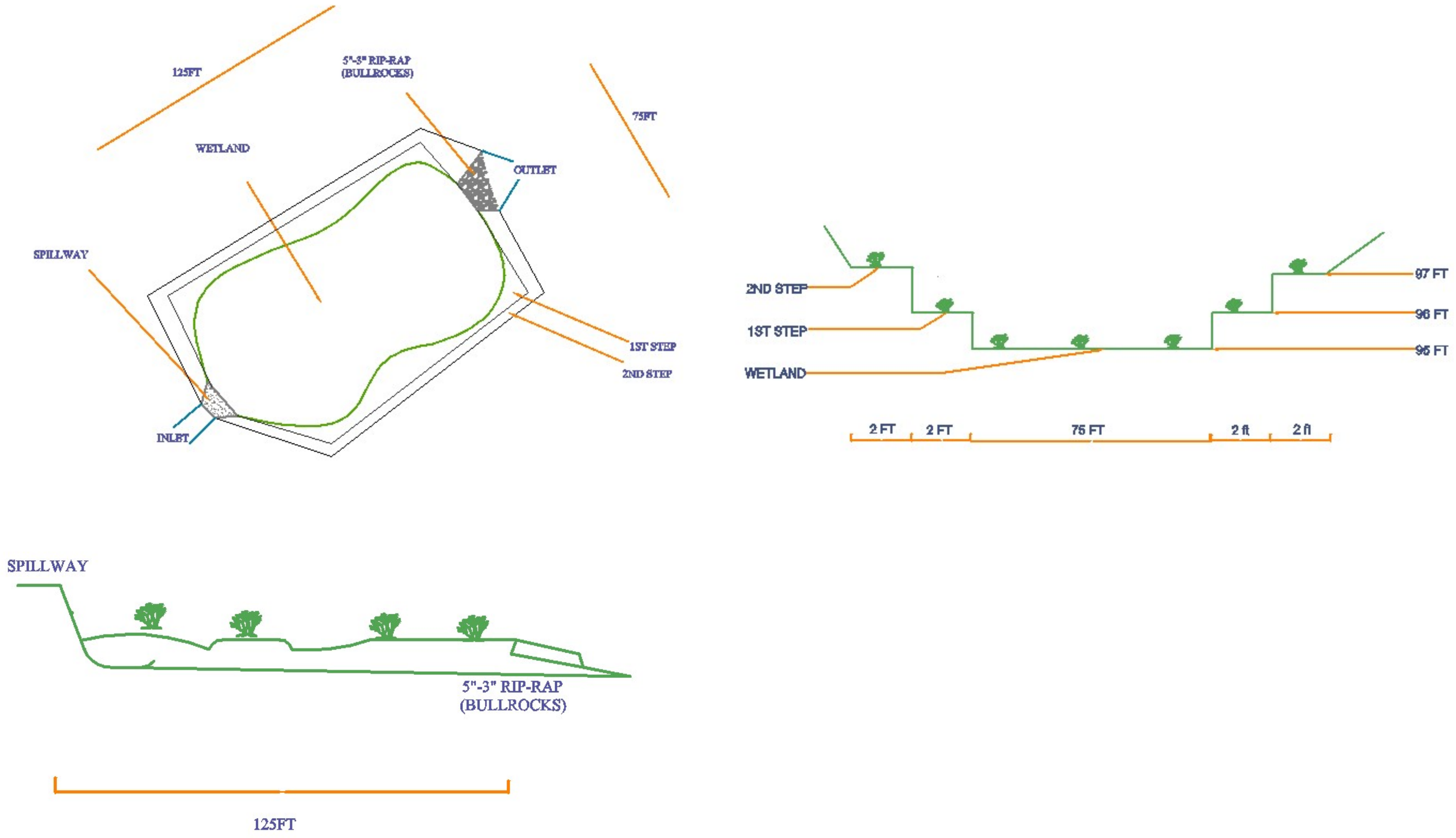

Figure 12. Design draft of the Morris School Wetland

Significance

The complete analysis of Green Valley Farm colonia dataset will provide a full picture for stormwater pollution in South Texas area. In addition, in the background of global climate change, proper management of urban stormwater also can decrease the risk of flood and increase the infiltration to groundwater. Thus, our project will be a pioneer work on the sustainable management and planning of urban stormwater in semi-arid area like South Texas.

Proposed of sequential treatment (forebay-pond-wetland) and design of some Best Management Practices (wetland) would be installed in McAllen city. Descriptive models of each BMP would be developed and validated using continuous flow monitoring data. The BMP designs and performance evaluation will be presented to stakeholders and recommended for incorporation into the South Texas Arroyo Colorado Watershed Protection Plan to improve regional water quality.

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