THE CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM, THE LANDSCAPE ARCHITECT AND POTENTIALS FOR PHILIPPINE USE

by Enrico G. Flor

Abstract

The earth's resources are dwindling and it is time for landscape architects to act as the fulcrum of environmental conservation, development, sustainability and design. Among the foreign sustainable technologies being studied right now are constructed wetlands for wastewater treatment. Its main role is to improve water quality, but it also provides lateral benefits such as scenic, recreational, wildlife, cultural and aesthetic, among others. Furthermore, the existing technologies seem to be adaptable in the Philippine setting such as the various plant materials used. With the participation of the landscape architect, the multi-use character of any constructed wetland project in the Philippines can be explored further. However, further studies are required to validate the performance of constructed wetland systems in the local setting. Once done, and with the participation of the landscape architect, another sustainable and scenic technology will be available to the people. Also, by advocating and incorporating the technology for local use, the landscape architect would have pushed further the relevance of his profession beyond aesthetic considerations.

INTRODUCTION

Some future trends and ramifications to future practice. It was just in the later half of the twentieth century that public awareness to finite resource supply and the need for resource sustainability was globally internalized. It might seem timely for our generation; on some aspects, it seems too late. Consider the following facts in Table 1 and 2.

Fortunately for the future generations, environmental activism is in full swing. Although the modern environmental movement as we see it today started in the late 50's and early 60's, a lot of this was influenced by figures of the late 19th and early 20th century who were attuned to the land. Among them were Henry David Thoreau, John Muir, President Theodore Roosevelt, and Aldo Leopold.

Leopold's revered status in land sustainability mainly stems from his *land*

Table 1. Some indicators of the Philippine environment (Carandang and Rebugio, 1999)

Resource	Status
Forests	Only 18.6 % (or 5.59 M hectares) of the forestlands are natural; the rest are in different stages of development or degradation
Virgin forests	Only 14 % (or 2.89 M ha.) are virgin
Population	There are about 75 M Filipinos today

Table 2. Indicators of our current environment (National Park Service, 1998)

Resource	Status
Tropical forests	Shrinking by 11 M ha./year
Topsoil	26 B tons of topsoil are lost in excess of new soil formation annually
Plant and Animals	Extinction rates estimated at several thousands per year; one-fifth of all species may disappear over the next 20 years
Lakes	Thousands of lakes in the industrial north are now biologically dead; thousands more are dying

ethic. His articles, published in magazines and journals, and posthumously in *A Sand County Almañac* (1949), gave people an inkling of what this land ethic was supposed to be. Simply put, it "enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land."[1] By this simple statement, Leopold has bestowed upon man stewardship responsibilities towards the land and its resources.

By the early 50's and 60's, figures such as Stewart Udall, Rachel Carson, and Ian McHarg were already incorporating ecological sensitivity and concepts into their works. It might be that the increased sense of urgency was a reaction to the expansive gain science and the atomic age had achieved since the Second World War. The oil crisis of the 70's, the sudden recognition of smog, and the now apparent urban sprawl only intensified the situation. By the 80's, citizen's concern and rebellion (as personified by the Flower Children during the former decade) had matured into bold, sometimes rash, actions as represented by the "Save the Whales" movement, GreenPeace, and the environmental "counter-terrorism" of Earth First.

Edward Flaherty, a member of the American Society of Landscape Architects (ASLA), practitioner of the profession and part time academe, recognizes the legitimacy of this phenomenon and has incorporated it into his vision of the practice for the 21st century entitled the *Project Process 21*. He concedes that "...environmental activism is here to stay"[2] and has recommended that **landscape architects** act as the fulcrum of environmental conservation, development, sustainability and design rather than remain as figures in the background waiting for clients to avail of their services.

Government/world response. With the growing recognition that world security is heavily linked to environmental integrity, environmental policy became a legitimate universal concern among nations at the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden.[3] However, actions to curb rampant resource usage (but justifiable by market economics) was not elevated into a worldwide, collective issue until the UN Conference on Environment and Development Agenda 21 in Rio de Janeiro on June 14, 1992.[4] Suddenly, there was the primacy of the concept of sustainable development.

The Philippines was quick to respond to the UN Agenda 21 challenge, submitting the Philippines Agenda 21 five years later. However, measures and implementations remain weak. For example, Presidential Decree No. 1586 or the Establishment of an Environmental Impact Statement System provides no programmatic process for the Environmental Impact Assessment (EIA). Department of Environment and Natural Resources Administrative Order No. 37 series of 1996 (DAO 37) was issued to revise the regulatory framework for the conduct of the EIA system, but many loopholes still exist, such as the exclusive listing of projects. This makes other projects which are not in the list but nonetheless affecting the environment, free from securing and complying with an Environmental Compliance Certificate (ECC).[5]

How shall the Landscape Architect respond? How indeed? To put the discussion in context with the profession, let us look at how the various professional associations define the landscape architect. The International Federation of Landscape Architects (IFLA) defines the landscape architect's role as "...one who designs and plans aesthetic layouts...,studies site conditions...,designs landscapes...,prepares working drawings..., and supervises landscaping...".[6] The definition is straightforward, and emphasis is on the professional's responsibility in pre-design and design.

On a more interesting note, ASLA stretches the domain of the professional even more, as follows:

> *...the profession which applies artistic and scientific principles to the research, planning, design and management of both natural and built environments.....with concern for the stewardship and conservation of natural, constructed and human resources. The resulting environment shall serve useful, aesthetic, safe and enjoyable purposes...*[7]

ASLA noticeably inserts a responsibility akin to the land ethic concept, more than the usual responsibilities of the landscape architect. As our resources dwindle and our actions slowly shift to sustainable use of the land, ASLA seems to have responded well to face the foreboding trend.

But even before ASLA had legitimized it into its formal definition of the

Table 3. Performance of sewage treatment constructed wetlands[1]

Contaminant	Removal Efficiency (%)	Comment
Biological Oxygen Demand (BOD)	70-90	less for low influent BOD
Ammonia	70-90	loading <10kg/ha-day; Hydraulic Retention Time (HRT) 3 to 5 days
Total Nitrogen	75-95	loading <10kg/ha-day; HRT > 5 days
Phosphorus	30-50 0-90	variable, function of soil variable
Metals (Cu, Zn, Cd) **(Fe)** **(Mn)**	>97 median 96 median 83	one pilot project study of 10 constructed WWT study of 10 constructed WWT
Pathogens	82-100 90-99	 California constructed WWT studies
Total Suspended Solids	>70 60-90	HRT> 5 days for natural wetlands

profession, pioneering Ian McHarg had already voiced out the landscape architect's unique position to make a difference to and for the land:

> *...where the landscape architect commands ecology, he is the only bridge between the natural sciences and the planning and design professions, the proprietor of the most perceptive view of the natural world at which science and art has provided. This can be at once his unique attribute, his passport to relevance and productive social utility.*[8]

The gauntlet has been thrown down, by Mother Earth with her dwindling resources, by Aldo Leopold, by ASLA, by Ed Flaherty and the Project Process 21, by McHarg. Should landscape architects of the future concern themselves of the usual projects? Should we turn a blind eye to government failings or difficulties in implementing ecologically sustainable actions? Or should we act, according to our technical expertise so as to aid the existing institutions achieve this ideal?

And so, we have the topic of constructed wetlands and its local applicability. The following is a basically a rudimentary literature review of the technology. It is also a supposition that current constructed wetland technology is applicable and relevant to the nation. Finally, by the said supposition it hopes to alter the notion that the landscape architect has concerns limited only to the aesthetic aspect of exterior space design. It will attempt to bring to fore the relevance of the landscape architect to the land, the nation, the society and those from future generations that will ultimately inherit the earth from us. It is a personal response to the call made by Mother Earth, Leopold, ASLA, Flaherty and McHarg.

THE CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM

Definitions. A wetland is defined as:

> *land having the water table at, near or above the land surface or which is saturated for a long enough period to promote wetland and aquatic processes as indicated by hydric soils, hydrophitic vegetation and various kinds of biological activity which are adapted to the wet environment.*[9]

Also,

> *areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static, free flowing, fresh, brackish or salty, including areas of marine water the depth of which at low tide does not exceed six meters.*[10]

The above definitions have such a wide scope that it is not surprising that the Philippine government classifies mangrove swamps, fish ponds, and rice paddies under the term 'wetlands'.[11]

To be more specific, a constructed wetland is "...a designed and man-made complex of saturated substrates, emergent and sub-emergent vegetation, animal life, and water that simulates natural wetlands for human use and benefit,"[12] specifically, "...with the intent of managing water quality".[13]

Usage. By managing water quality, Eastlick refers (but not exclusively) to the following usage[14]:

1. *Wastewater treatment.* Constructed wetland systems has been used as secondary and tertiary treatment of domestic and municipal sewage, both in North America and Europe (see examples on Table 3).
2. *Storm water treatment.* Used to remove sediments, nutrients and other contaminants from urban run-off, and surface drainage from industrial and agricultural land.
3. Other applications: *acid mine drainage, contaminated leachates, industrial wastewater.*

Technology overview. The contamination removal ability of constructed wetland wastewater systems is facilitated by natural processes. Wetland processes involve a complex interaction of water, soil, microbes, plants and animals. The key processes are:

1. oxidation, chemical and biological reduction and other biochemical processes occurring on the biofilms on dead and living plant surfaces.
2. volatilization of hydrocarbons and lighter organic compounds

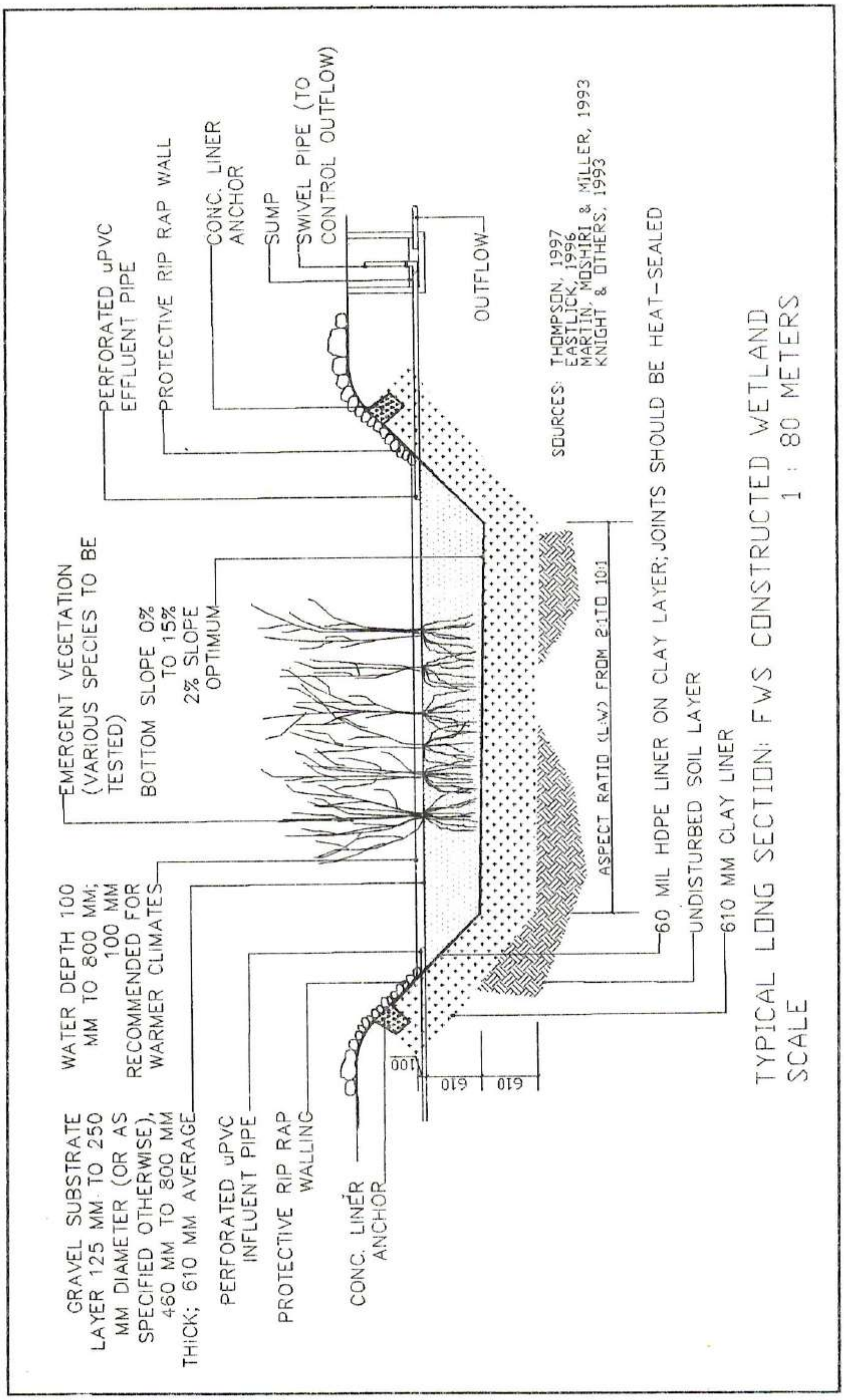
GRAVEL SUBSTRATE LAYER 125 MM TO 250 MM DIAMETER (OR AS SPECIFIED OTHERWISE), 460 MM TO 800 MM THICK; 610 MM AVERAGE
PERFORATED uPVC INFLUENT PIPE
PROTECTIVE RIP RAP WALLING
CONC. LINER ANCHOR
WATER DEPTH 100 MM TO 800 MM; 100 MM RECOMMENDED FOR WARMER CLIMATES
EMERGENT VEGETATION (VARIOUS SPECIES TO BE TESTED)
BOTTOM SLOPE 0% TO 15% 2% SLOPE OPTIMUM
PERFORATED uPVC EFFLUENT PIPE
PROTECTIVE RIP RAP WALL
CONC. LINER ANCHOR
SUMP
SWIVEL PIPE (TO CONTROL OUTFLOW)
OUTFLOW
100
610
610
ASPECT RATIO (L:W) FROM 2:1TO 10:1
60 MIL HDPE LINER ON CLAY LAYER; JOINTS SHOULD BE HEAT-SEALED
UNDISTURBED SOIL LAYER
610 MM CLAY LINER
SOURCES: THOMPSON, 1997
EASTLICK, 1996
MARTIN, MOSHIRI & MILLER, 1993
KNIGHT & OTHERS, 1993
TYPICAL LONG SECTION: FWS CONSTRUCTED WETLAND
SCALE 1 : 80 METERS

Figure 1

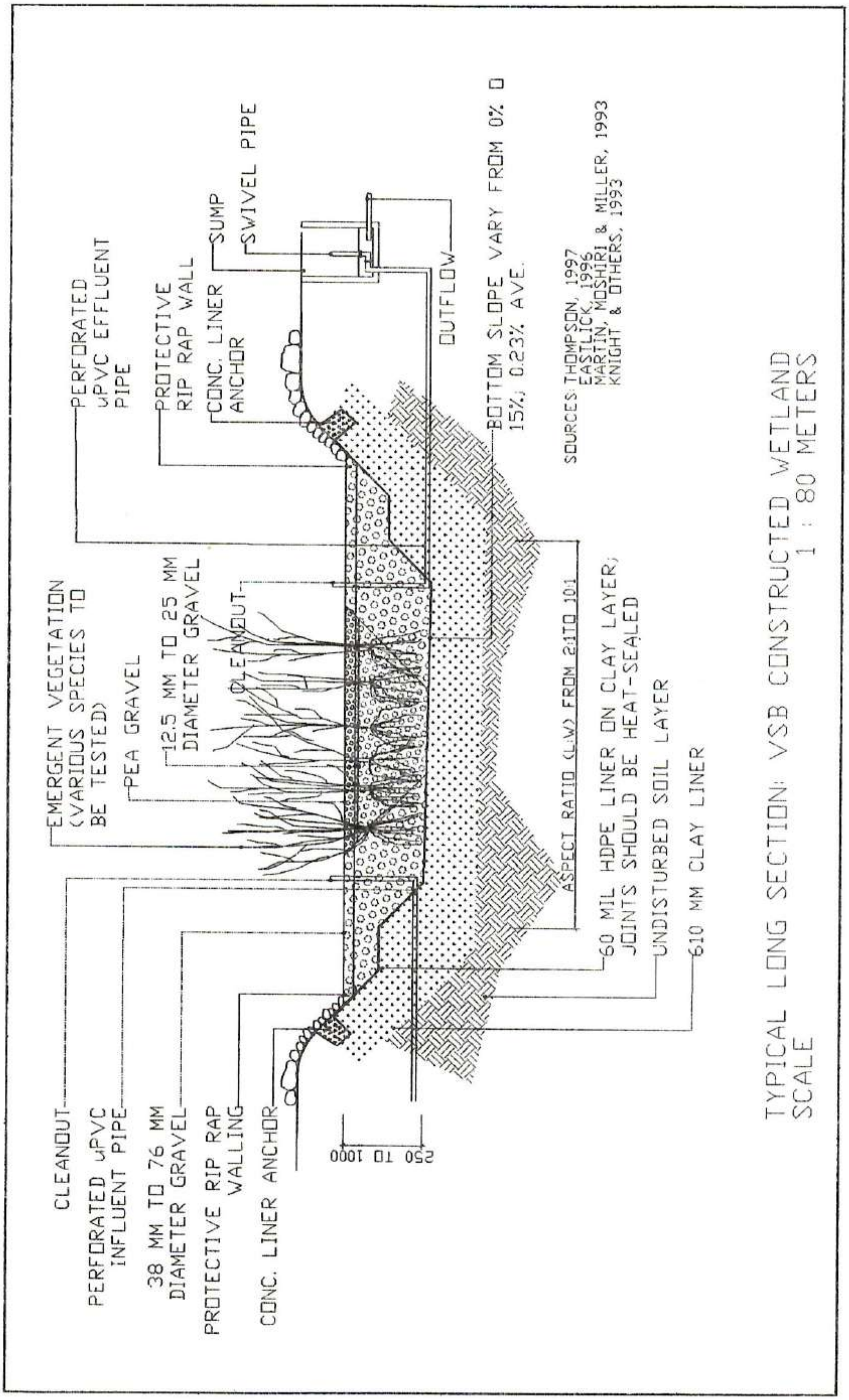
CLEANOUT
PERFORATED uPVC INFLUENT PIPE
38 MM TO 76 MM DIAMETER GRAVEL
PROTECTIVE RIP RAP WALLING
CONC. LINER ANCHOR
250 TO 1000
EMERGENT VEGETATION (VARIOUS SPECIES TO BE TESTED)
PEA GRAVEL
12.5 MM TO 25 MM DIAMETER GRAVEL
CLEANOUT
PERFORATED uPVC EFFLUENT PIPE
PROTECTIVE RIP RAP WALL
CONC. LINER ANCHOR
SUMP
SWIVEL PIPE
OUTFLOW
BOTTOM SLOPE VARY FROM 0% O 15%, 0.23% AVE.
ASPECT RATIO (L:W) FROM 2:1TO 10:1
60 MIL HDPE LINER ON CLAY LAYER; JOINTS SHOULD BE HEAT-SEALED
UNDISTURBED SOIL LAYER
610 MM CLAY LINER
SOURCES: THOMPSON, 1997
EASTLICK, 1996
MARTIN, MOSHIRI & MILLER, 1993
KNIGHT & OTHERS, 1993
TYPICAL LONG SECTION: VSB CONSTRUCTED WETLAND
SCALE 1 : 80 METERS

Figure 2

3. adsorption of contaminants
4. sedimentation
5. chemical precipitation (settling out of metals and phosphates)
6. pollutant removal through plant uptake or incorporation into the plant biomass. Note that efficiency of removal through uptake is only 15% of all the nutrients removed.
7. accumulation of detritus and wetland soil, thereby facilitating long-term storage of pollutants[15]

Constructed wetland types. Current constructed wetlands for wastewater treatment come in two types: the (a) free water surface (FWS) system and the (b) vegetated submerged bed (VSB) system.

The FWS system is the most common type in North America. Contaminants are removed from water slowly flowing through dense stands of emergent wetland (aquatic) vegetation. The low velocity enhances sedimentation and filtration. Biofilms on plant surfaces transforms pollutants into harmless forms.[16] Because of the visible water body, emergent vegetation, and the tendency to harbor habitat for waterfowl, this system is usually the more scenic of the two (see Figure 1). The open water is also the cause for its most significant problem, especially when used nearby communities, because it tends to support a mosquito population.[17]

Meanwhile, the VSB system avoids several of the problems related to the FWS systems. The adsorption capacity is increased because of more surface area offered by the washed gravel bed where the emergent plants are anchored and into which wastewater flows through. Consequently, the footprint of the actual treatment area is lesser. Insects and odors are greatly reduced too. Because of this character, the VSB system lends itself easily to domestic applications. This is more commonly used in Europe, although it is also recommended by the Tennessee Valley Authority (TVA) [18] (see Figure 2).

Some words on pondscaping and vegetation. A multi-use constructed wetland goes beyond planting a thick stand of wetland vegetation, although this is possible if the singular role of wastewater/storm water treatment is considered. Pondscaping allows for buffering, barrier, protection from wind, storm water detention, and incorporation of an aesthetic value.

A variety of species should be used. This is consistent with the biodiversity concept where the species population becomes more resilient to environmental shocks. Plants are selected based on native species observed to inhabit nearby similar landscapes. Because of this, designing constructed areas will usually entail the survey and use of existing native vegetation. Besides, any introduction of any non-native species is worth studying lest it reacts negatively to the native population.[19] Naturalized vegetation should eliminate the need to install irrigation systems and minimize maintenance costs such as lawn mowing.

Review of some existing wetland projects. Below are some existing projects that show the possibilities of a multi-use constructed wetland facility:

1. **Hawaii Makaloa Project, Hawaii Island and Maui Island.** This project is a collaboration between the Bishop Museum's

Amy B.H. Greenwell Ethnobotanical Garden and the U.S. Geological Survey (USGS). The main wetland material would be makaloa (*Cyperus laevigatus*), a sedge ethnobotanically important to the indigenous Hawaiian culture as weaving material for mats. Other than wastewater treatment, the constructed wetland also controls coastal eutrophication, reclaims freshwater, and offers habitat for some wildlife. The principal investigators/consultants of the project is a sanitary engineer and a biologist, together with Hawaiian ethnobotanists.[20]

2. **Waterworks Gardens, Renton, Washington.** The project is an 8 acre wetland/terrestial landscape of native flora. It is located next to the 85 acre East Division Water Treatment Plant of Renton, Washington. Other than its main guise as public art and facility, it also filters polluted storm water, thus giving the Renton plant more chances to concentrate on municipal sewage. The design is a bit grotesque, a bit whimsical (an acknowledgment of the principal designer's background as an artist), but successfully draws people near to a facility that is usually shunned simply because it treats waste. To the visitor's surprise and education, treatment facilities can be without odors, have really clean water, and is even a fun public place. Besides the artist, the principal consultants include a landscape architectural firm, engineers, and wetland scientists.[21]

3. **City of Arcata Wastewater Treatment Facility and Marsh and Wildlife Sanctuary, Humboldt Bay, California.** This FWS wetland system is the tail end of a series of treatment marshes, which act as a secondary treatment unit for the Arcata Wastewater Treatment Facility. It also has a "salmon ranch" which utilizes the treated sewage. The treated water thereafter is released to Humboldt Bay.

   Much of the effort was made possible by citizens' involvement. Their efforts have produced a constructed wetland facility that also provides recreation space for hiking, jogging, biking and picnicking; offers habitat for freshwater vegetation, saltwater vegetation, various fowl and fish. Major players in its construction are the City government of Arcata and the Humboldt State University.[22]

POSSIBILITIES FOR PHILIPPINE USE

Landscape architects should be part of the design team for any local constructed wetland project. Past experiences has proved the importance of landscape architects in wetland design. For example, the landscape architect has provided leadership to develop solutions; translating technical, mitigation and management requirements into design solutions.[23] This echoes McHarg's statement made almost 27 years ago, that "...the landscape architect...is the only bridge between the natural sciences and the planning

Table 5. Vegetation with ornamental value which were used in constructed wetland studies and candidate local alternatives.

Species	Common Name	Source	Candidate Alternatives	Common Name	Source
Canna flaccida	Canna Lily	15	*Canna flaccida, C. Indica*	Canna Lily	6
Colocasia esculenta	Taro, Elephant's Ear	15	*Colocasia esculenta*	Taro, Elephant's Ear	6
Eucalyptus camaldulensis	Murray Red Gum	9	*Eucalyptus camaldulensis*	Murray Red Gum	6
Eucalyptus teriticornis	Red Gum	9	*Eucalyptus teriticornis*	Red Gum	6
Iris pseudacorus	Water Iris	15	*Iris sp.*		6
Iris virginica	Blue Flag Iris	16	*Iris sp.*		6
Melaleuca leucadendra		9	*Melaleuca leucadendra*		6
Melaleuca quinquenerva	Paperbark Tree	9	*Melaleuca quinquenerva*	Paperbark Tree	6
Nymphaea capensis		9	*Nymphaea nouchali*	Lawas	7; 6
Nymphaea gigantea		9			
Pistia stratiotes	Water cabbage	15	*Pistia stratiotes*	Water cabbage	7; 6
Sagittaria latifolia	Arrowhead	15			
Typha domingensis	Cattail	15	*Typha angustifolia*	Cattail	6
Typha orientalis	Cattail	15			
Typha latifolia	Cattail	16			
Zartedeschia aethiopica	Cala Lily	15	*Zartedeschia aethiopica*	Cala Lily	6

and design professions, the proprietor of the most perceptive view of the natural world at which science and art has provided. This can be at once his unique attribute, his passport to relevance and productive social utility." [24]

Then there is the relevance of a multiple value design approach; value

Table 6. Other studied species.

Species	Common Name	Source	Candidate Alternatives	Common Name	Source
Azolla sp.	Azolla	16	***Azolla sp.***	Azolla	6
Arundo donax	Giant Reed	16	***Arundo donax***	Giant Reed	6
Echinochloa crusgalli var. frumentacea		11			Personal observations
Echinochloa crusgalli	Barnyard Millet		***Echinochloa crusgalli***	Barnyard Millet	4
Eclipta prostrata		9	***Eclipta prostrata***		Personal observations
Eichornia crassipes	Water hyacinth	13	***Eichornia crassipes***	Water hyacinth	8
Fimbristylis autumnalis		11	***Fimbristylis littoralis***		Personal observations
Lemna sp.	Duckweed	12	***Lemna sp.***	Duckweed	
Panicum repens	Torpedo grass	17	***Panicum repens***	Torpedo grass	4
Paspalum distichum	Couch Grass	16	***Paspalum distichum***	Ginger Grass	4
Phragmites communis	Common Reed	9	***Phragmites communis***	Common Reed	8
Phragmites australis		16			
Scirpus cyperinus	Woolgrass Bulrush	9	***Scirpus grossus***		8
Scirpus validus	Softstem Bulrush	16			

added benefits from constructed wetlands have been the key factors in the acceptance of a wetland project, water treatment being an ancillary benefit![25]

Plant materials for wetland use. Several of the species tested are present or have candidate alternatives here and now. Table 5 and 6 shows a shortlist of plants that have been used in constructed wetland studies. I have also taken the liberty of scanning literature which show existence of the necessary species or candidate alternate species for local use. It is just a matter of testing and verifying if they shall perform in the same capacity, or exceed them which is will be an ideal situation for both the research and practical aspect of constructed wetlands.

Current limitations in its application. There is a need to conduct a definitive research to gauge performance of constructed wetlands in the Philippine setting, address existing problems such as mosquito infestation, and its design to accommodate the multi-use, multi-benefit concept. Right now, attempts are being made to link with the Environmental Engineering Program of the College of Engineering for a study on constructed wetlands. Currently, the study is limited to the use of *Phragmites sp.* in reed beds. For now, the multi-use possibilities of the constructed wetland seems to receive minimal consideration. More attempts should be made to convince researchers and other support institutions to consider the other ancillary benefits that landscape architects see. May I also cite this from an article: "Most engineers look at the wetland site as serving a single purpose. The contribution of the landscape architect is to plan for multiple land use - recreation, environmental education and wildlife habitat as well as water purification."[26]

CONCLUSIONS AND RECOMMENDATIONS

There are existing foreign models ready for use and testing. With some study and will, we can use them and test their efficacy in the local context. This is most applicable for VSB systems, which lends more to domestic applications. However, any undertaking should be done in coordination with a sanitary/environmental engineer and other technical experts. In fact, as in all of designs that attempt to address sustainability, a multi-disciplinary team is in the offing. In fact, this is a must in a large scale constructed wetland project. There are still a lot of technical requirements that must be met to make the system functional.

There is no over-emphasizing the study of the technology prior to actual applications. The stakeholders (the public and the future generations) are many, the ecology is fragile, and the responsibility of the landscape architect is great and not just a simple chore to be outweighed by economic demands.

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