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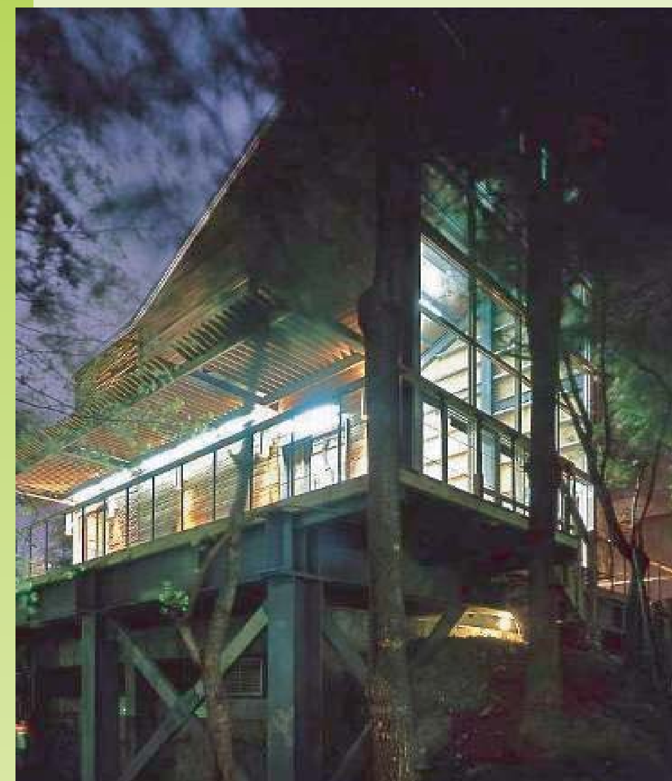

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Content

News Brief

Technical Paper

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	Kuang-Chih Chang, WRA, ROC.
Executive	Chi-Chang Liu
Telephone No.	+886-2-2771-2171 ext 2647
FAX	+886-2-87719190
Website	http://www.ntut.edu.tw/~wwwwec

International Forum –

The Current Status of Ecological Engineering Development in the United States

Date: October 19. 2007 (Friday) 13:30 ~ 16:00
Location: Conference Room, 5F of Civil Engineering Building, NTUT

Table.1 Agenda

Time	Subject	Speaker	Moderator
13:30 ~ 14:00	**Check in**		
14:00 ~ 14:15	Opening Remarks	Sen-Teng Chen, Vice-President of PCC	Prof. Jen-Yang Lin WERC, NTUT
14:15 ~ 15:30	The Current Status of Ecological Engineering Development in the United States	Steven C. McCutcheon Ph.D., P.E., M.ASCE	Prof. Walter Chen Department of Civil Engineering, NTUT
15:30 ~ 16:00	**Discussion**	Prof. Walter Chen (Department of Civil Engineering, NTUT) Prof. Jen-Yang Lin (WERC, NTUT)	

Brief Description of Presentation

The establishment of a new society called the "American Ecological Engineering Society" (AEES) was first discussed at a workshop on ecological engineering in Columbus, Ohio in May 1999. Fifteen US universities were represented at that meeting. It was agreed at the workshop that ecological engineers throughout North America should pursue the idea of a U.S. society, particularly to begin the process of organizing academic programs and ultimately certification for this new field in North America. The AEES was established in 2001 and has been promoting the development of sustainable ecosystems that integrate human society with its natural environment for the benefit of both by fostering education and outreach, extending professional development and associations, raising public awareness, and encouraging original ecological engineering research.

Dr. McCutcheon, who is past-President of AEES, presented to us a detailed review of the recent development of ecological engineering in the United States. WERC expects Dr. McCutcheon's speech will help stir new ideas and thoughts about ecological engineering in Taiwan and a tighter link of such practices in Taiwan with the emerging trends in the international arena.

The audience asked many interesting questions and had a good discussion with Dr. McCutcheon. Some highlights are presented below.

Question 1:

From your viewpoint, what would you suggest regarding a closer working relationship between civil engineering and ecological engineering?

Answer 1:

For the time being there is no best way to suggest. Actually, part of the purpose for my visit to Taiwan this time I visited Taiwan is to see how in Taiwan civil and ecological engineering are linked. In my opinion, we should integrate the basic knowledge of civil and ecological engineering into the methods and guideline sections of our construction manuals of practices when we train our entry-level engineers.

Question 2:

Are there highway bridge projects in the United States that incorporate ecological engineering methods?

Answer 2:

Yes, we have done it in some projects. Even though for some projects the results are not as good as we expected, I think with civil engineers doing comprehensive, integrated planning the results should get much better.

Figure. 1 Sen-Teng Chen, Vice-President of PCC, giving the opening remark.

Figure. 2 Seminar in session.

A Brief Resume of Dr. Steven C. McCutcheon

Education:

B.S. Auburn University (with honor) Auburn, Alabama, 1975

M.S. Vanderbilt University Nashville, Tennessee, 1977

Ph.D. Vanderbilt University Nashville, Tennessee, 1979

Professional:

Phytoremediation and applications of plant biochemistry, Ecological Engineering, Watershed and fishery habitat restoration, Stream temperature modeling, Sorption kinetics, etc.

Experience:

ASCE Director, Region 5

Past President, American Ecological Engineering Society

Faculty of Engineering, University of Georgia

Steven C. McCutcheon, P.E. is a renowned U.S. EPA Senior Environmental Engineer. The Torrens Award winning editor of the Journal of Environmental Engineering was the Georgia Section president-elect, vice-president, director, and E-Week Government Engineer of the Year. As branch president in Mississippi, Steve was a 1984 Young Civil Engineer in Government. He earned numerous awards, including NSPE Engineer of the Year-EPA. Other service includes Civil Engineering Program Evaluator for ABET, eight Institute committees, outside consulting, and expert testimony. Having also taught at Georgia, Clemson, Tulane, and Vanderbilt, he published 225 books and other publications. Ph.D. and M.S.: Vanderbilt, B.S.C.E.: Auburn.

Reference:

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2. http://www.scientificjournals.com/sj/all/AutorenProfil/AutorenId/5118
3. http://www.epa.gov/athens/staff/members/mccutcheonstevenc/
4. http://www.asce.org/inside/bio_McC.cfm

International Forum－

Sustainable Transportation and Sustainable Environment: Highlights of Road Ecology

Date: November 30, 2007 (Friday) 13:00 ~ 15:20

Location: Conference Room, 5F of Civil Engineering Building, NTUT

Host: WERC, Chinese institute of Landscape Architect in Taiwan and Observer Ecological Census Consultant Co, Ltd.

Agenda

Time	Activity	Speaker	Moderator
13:00 ~ 13:20	**Check in**		
13:20 ~ 13:30	Opening Remarks	Prof. Jen-Yang Lin WERC, NTUT	
13:30 ~ 15:00	Sustainable Transportation and Sustainable Environment: Highlights of Road Ecology	Professor Alison M. Barry Dept. of Env. Horticulture, UC Davis	Prof. Jen-Yang Lin WERC, NTUT
15:00 ~ 15:20	**Discussion**	Prof. Alison M. Berry (UC, Davis) Prof. Jen-Yang Lin (WERC, NTUT) Prof. Mitchell Lin (Dept. of Construction Engineering, KMIT) Prof. Walter Chen (Department of Civil Engineering, NTUT)	

Brief Description of Presentation

Roads are important for their providing links to the outside world for people. WERC organized today's forum to focus on road ecology issues, which involves the establishment of a bio-diversified and natural eco-environment and the use of econlogical engineering methods to achieve sustainability of road ecology. The invited speaker, Professor Alison Berry, who is Director of the Road Ecology Center, UC Davis, presented a lecture on recent developments in road ecology in the United States. WERC hopes the presentation and discussion will help bring about new localized concepts regarding road ecological engineering and build a closer link between the trends in international road ecology with those in Taiwan.

After the lecture, the audience had a good discussion with Prof. Barry. Some highlights are presented below.

Figure.1 Professor Alison M. Berry lecturing

Figure.2 Seminar in session

Question 1: Which construction project, tunnel or bridge, has a lower impact on an eco-system, especially in the mountainous areas?

Answer 1: Bridges are attractive because they provide passages for both human and animals. However, if trucks can use the tunnel, there would be some saving of time and the impacts on the other roads can be reduced just like your case of north-coast route and Syue-shan tunnel. Both bridge and tunnel could work from a broader viewpoint. (Interpreter's note: The decision should be made based upon the balance of transportation needs and regional ecological conservation. The species in the adjacent eco-system needed to be protected is another important factor in selecting tunnel or bridge in the road planning.)

Question 2: There are almost 100% impervious pavements in major cities such as New York, Chicago, and L.A. Are there methods or ideas available to the local government to reduce the heat island effects caused by the impervious pavement in the cities?

Answer 2: It's possible to plant vegetation to reduce the heat island effects by providing shades and also by changing the microclimate. Besides, vegetation can provide moisture to prevent the city's air from becoming too dry and vegetation can absorb some pollutants as well. The use of reflective paints can be helpful too.

Question 3: Do you have any future plans to build ecologically friendly roads in cities or rural areas in California?

Answer 3: One elevated highway in San Francisco fell down in 1990 due to an earthquake and it has just been removed without rebuilding. The people there enjoyed the landscape without roads. I think we should encourage people to use public transportation instead of just building more roads. An example forrural areas is that we can build ecological roads with small trenches crossing the roads as corridors for little animals to pass.

Question 4: In California, who fund and carry out the road ecology research? Are the results of the research implemented in the construction projects becoming construction codes?

Answer 4: We have different sources of funding, mainly from the Department of Transportation (Caltran). The Department has over a hundred environmental biologists to handle these large projects. Research studies are mostly done by different scholars of the UC Davis such as graduate students, post-docs, research scientists, and some environmental consultants and by the Department of Transportation itself. The results of these research studies are useful for acoustic scientists, GIS-based connectivity mapping, etc. Some non-government organizations (NGO) also fund the research.

Question 5: Is there any research regarding the road kill or the survey of the road kill? Are there passages or corridors for birds to pass the roads and highways?

Answer 5: Crossing structures passing over or under the roads are solutions for mitigating road kill events. If you can document the road kill events, you can identify the hot spots where animals pass.

Trees can provide such corridors for birds and birds will go where they can.

Question 6: Can you give us some ideas about how historically ecology was considered when there were no biologists in Caltrans? What is the mechanism for the budget to evolve so that different professionals couyld be integrated into Caltrans?

Answer 6: We used to design highways or roads with specific budgetary constraints and the main goal is to build the roads in an efficient way. That’s the first criterion. However, increasingly, individuals become more aware of the importance of the environment with the progress of education. Besides, we have regulations such as air quality act, water quality act, endangered species act, etc. that the Department of Transportation is required to satisfy such regulations.

A Brief Resume of Professor Alison Barry

Education:

B.A.(magna cum laude) Anthropology Radcliffe College 1970

M.S. Botany Univ. of Massachusetts 1978

Ph.D. Botany Univ. of Massachusetts 1983

Experience:

Professor, Dept. of Env. Horticulture, Univ. of California, Davis	1999 - present
Program Director, Metabolic Biochemistry, National Science Foundation	1998 - 1999
Assoc. Professor, Dept. of Env. Horticulture, Univ. of California, Davis	1991 - 1998
Asst. Professor, Dept. of Env. Horticulture, Univ. of California, Davis	1984 - 1991
Postdoctoral Associate, Dept. of Biology, Carleton Univ., Ontario, Can.	1982 - 1984
Research Assistant, Harvard Forest, Harvard University, Petersham, Ma	1979 - 1982

Research interests

Prof. Barry's current research focus mainly on the nitrogen-fixing plants, primarily trees and shrubs nodulated by the soil actinomycete, Frankia (for example Alnus, Ceanothus, Cercocarpus, Purshia) and some legumes.

1. Assessment of the role and mechanism of nitrogen-fixing plants in N accretion in semiarid ecosystems and agroecosystems.

2. Plant-microbe interactions in symbiotic biological nitrogen fixation.

Reference:

http://www.ucdavis.edu/index.html

http://www.cc.ntut.edu.tw/~wwwwec/

Love My Hometown and My Water－

Taipei source water special region visit and clean-up activities

Date: October 21. 2007 (Sunday)
Location: Shang Guei-shan bridge and Sai Guei-shan bridge waterfront areas
Host: Taipei Water Management Office, WRA, MOEA
Sponsor: Taipei Feitsui Reservoir Administration
Administration: Water Environment Research Center (WERC), NTUT

Description:

This WERC-sponsored activity included both a learning experience and an action item for the participants. We want to let people have a close look of the source of their water and get to realize that the good water is the result of previous hard work on maintaining its quality. The same hard work needs to be done from generation to generation so the good water resource can be sustained.

During our visit we found some picnic crowd doing BBQ. We used this opportunity to educate them about the importance of source water protection. We were also glad for the fact that on this day the amount of trash picked-up was only half than that collected in previous visits. This shows people's awareness of the need for water resource conservation and protection is increasing.

The activity was very successful. But how do we keep improving non-government organization (NGO) and citizens participation is still our goal.

Figure 1 Introducing Feitsui Reservoir facts by a narrator.

Figure 2 Trash pick-up at the riverbank.

Figure 3　Picture-taken after the pick-up is completed.

“Young Foot Soldiers for Source Water Protection”－ Public Outreach Activities

1st Deployment:

<u>Date</u>: September 26. 2007 (Wednesday)
<u>Location</u>: Wulai Elementary and Junior High School, Wulai Wastewater Treatment Plant and Wulai County Lansheng Bridge.

2nd Deployment:

<u>Date</u>: September 29. 2007 (Saturday)
<u>Location</u>: Pinglin Junior High School, Pinglin Wastewater Treatment Plant and Pinglin County Shueiyuan Bridge.

Description:

Public education on water resource conservation should start at a young age, especially regarding the grass root work in source water protection regions. WERC therefore chose Pinglin and Wulai elementary and junior high schools as key schools for cultivating “young foot soldiers for source water protection”. WERC hosted two training courses, first one on September 26 at Wulai, and the second on September 29 at Pinglin.

The contents of the training courses include visiting a wastewater treatment plant and introduction of water quality analysis. Students learned the basics of the wastewater treatment processes from their site visit and through presentations by the waste treatment plant personnel. They also learned the purpose and fundamental techniques of water quality sampling and had hands-on experience on measuring basic water quality parameters such as pH, dissolved oxygen, turbidity and temperature. At the end of these training sessions, the young students felt they had learned something new and important and proudly proclaimed “we are young foot soldiers for source water protection”.

Figure 1. Director of Wulai wastewater treatment plant showing students around.

Figure 2. Water quality analysis lesson taught in the Wulai County Lansheng Bridge.

Figure 3. Director of Pinglin wastewater treatment plant showing students around.

Figure 4. Water quality analysis lesson taught at the Pinglin wastewater plant.

Figure 5. Student-teacher classroom discussions.

Figure 6. Learning about water quality analysis.

Figure 7. Young foot soldiers visiting the Pinglin wastewater treatment plant.

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Conservation Practices in Reservoir Impoundment and Buffer Zones in Taiwan

Yueh-Chi Kuan[1], Kuang-Chih Chang [2]

[1]*Deputy Assistant Engineer, Water Resources Agency*

[2] *Deputy Director of Conservation Division, Water Resources Agency*

Abstract

Due to the global climate change, the frequency of drought and severe storm events is increasing in the Taiwan region. Furthermore, extreme rainfall tends to concentrate more in certain areas. These changes have caused greater than before impact on reservoirs, which are the major water supply source in Taiwan. Situated at the juncture of the Philippine and Eurasian plates, Taiwan has poor geomorphologic conditions and a weak geological structure at many reservoir sites. A major earthquake in 1999 further worsened these conditions; resulting in more frequent serious disasters after heavy rains. In an era of ever declining freshwater availability, how to effectively remedy the current situations and move toward a sustainable water resource management has become a very important task for the water authorities. In the present paper, the use of various conservation practices, such as buffer strips, in reservoir impounding and buffer zones in Taiwan will be described. The objective is to promote public awareness of conservation practices in reservoir watersheds and to provide a comprehensive reference for future studies.

Keywords: buffer zone、impounding zone、water-supply reservoirs, watershed conservation practices, buffer strips.

我國水庫蓄水範圍及保護帶之保育

近年由於全球氣候變遷，台灣地區乾旱及豪雨頻繁，且降雨有集中趨勢，對於水庫集水區之衝擊與影響，將比以往更為劇烈。同時，台灣地處於菲律賓與歐亞板塊的交界帶，各水庫集水區地形及地質結構原本不佳，歷經 921 地震後，其地質構造更加鬆動及脆弱，遇雨成災之情形更為頻繁，在水資源日益短缺的時代，如何有效改善現況並朝向永續經營的目標邁進實為當前重要的課題，本文擬就國內目前水庫蓄水範圍及保護帶保育作概略介紹，以期一般人對水庫集水區保育工作有更深入的了解與認識，並期作為未來其他相關研究之參考依據。

關鍵詞：蓄水範圍、保護帶、水庫集水區

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Introduction

Reservoirs are the major sources of water in Taiwan. In recent years, global climate change might have contributed to the increase in the frequency of drought and severe storm events in the Taiwan region. Furthermore, extreme rainfall tends to concentrate more in certain areas. These changes have caused greater than before impact on reservoirs, which are the major water supply source in Taiwan. Situated at the juncture of the Philippine and Eurasian plates, Taiwan has poor geomorphologic conditions and a weak geological structure at many reservoir sites. A major earthquake in 1999 further worsened these conditions; resulting in more frequent serious disasters after heavy rains. In an era of ever declining freshwater availability, how to effectively remedy the current situations and move toward a sustainable water resource management has become a very important task for the water authorities.

Reservoir watersheds are large and involve complex land use types. An effective watershed conservation program will require the close coordination and collaboration of governmental agencies responsible for water resources, civil engineering and forestry management. A major problem authorities must deal with is the continuing siltation of many reservoirs due to natural as well as man-made factors. For example, the total effective storage volume of the forty major reservoirs upon completion was about 2.3 billion m^3. In a 2005 survey, that number was down to a little less than 2.0 billion m^3. The siltation rate was estimated as 9 million m^3 per year. The siltation speed must be slowed down in order to enhance the sustainability of water resource utilization in Taiwan.

In the present paper, the use of various conservation practices, such as buffer strips, in reservoir impounding and buffer zones in Taiwan will be described. The objective is to promote public awareness of conservation practices in reservoir watersheds and to provide a comprehensive reference for future studies.

Reservoir Impoundment Area and Buffer Zone: Definitions and Relevant Literature

Reservoir Impoundment Area (RIA) is defined by the current regulations as the inundated area (backwater area included) at the designed maximum high water level (MHWL) of the reservoir. The RIA also includes an area of a specified width above the MHWL waterline around the circumference of the reservoir, which is defined as the buffer zone (BZ). (Figure 1 below).

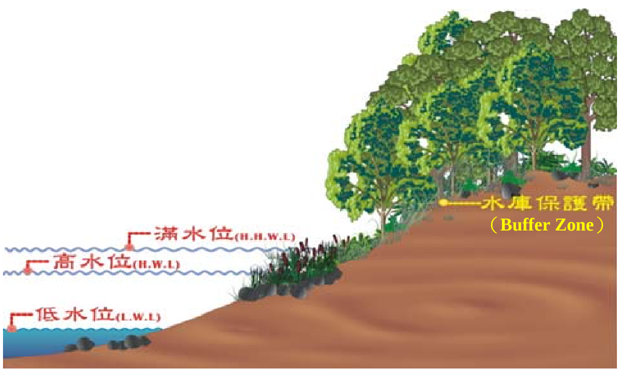

Figure 1. Definition sketch of reservoir impoundment area including the buffer zone.

The RIA has a direct impact on the reservoir in terms of siltation and water quality. Therefore, it is very important to implement conservation practices in the RIA in order to provide needed protection for the reservoir.

According to the Water/Soil Conservation Act, the buffer zone (BZ) should have a width of 30 to 50 meters. Private lands in the buffer zone should be purchased by the government, while public-owned lands should be designated for conservation uses. Any public land being rented for private use should have the lease terminated and the land returned for conservation purposes. If the area above the BZ is forested, it should be designated as a protected forest region under relevant forestland regulations.

The basic concept of setting aside the impoundment area as a means of protecting the integrity of a reservoir is easily understood. However, at the present time the specific width of the buffer zone and the appropriate conservation practices for implementation in the BZ are still topics of interest to researchers as well as practitioners.

A brief summary of some relevant literature regarding buffer width, both from Taiwan and overseas is presented below.

- Ting et al. (1879, 1981,1984), based on a series of field tests, suggested that a 30 m wide forest buffer strip is needed to retain particulate-bound pesticides, and a 60-m one for dissolved pesticides.
- Hsieh et al. (1989) conducted field tests at Te-Chi Reservoir in Central Taiwan and found that to effectively control fertilizers from entering the reservoir, at least a 20 m wide forest buffer is needed.
- Lin (1997) documented results obtained by international researchers based on field tests using natural or artificial rainfall. Also, analyses of vegetative buffer strips by using models such as CREMS, GRAPH, WEPP, etc. were described.
- Franklin (1992) suggested a buffer strip width of 30 m for water temperature control; 80 m for sediment reduction, and 100 m for maintaining and enhancing bio-diversity.
- Chen (1996) found that a 10 m buffer strip could trap a significant amount of nutrients, and a 30 m one could help control reservoir eutrophication.
- Alon (1998) considered buffer strip width should be around 15 – 20 m. Many forest experts; hydrologists and ecologists consider a width of 60 – 100 m as appropriate.
- Many researchers in the United States (e.g., Barfield et al., 1979; Dillaha, 1989, and Smith, 1989) suggested that vegetative buffer strips are very effective in controlling nonpoint source pollution from agricultural areas.

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It is our opinion that the choice of the buffer strip width should be based on the consideration of a number of factors such as local topography; geological conditions; the importance of the reservoir in question, and pollutant source and characteristics. The current 30 – 50 m width adopted in Taiwan should be reviewed and either increased or reduced if necessary.

Functions of a Buffer Zone

In general, a buffer zone with its conservation practices serves the following basic functions:

1. Storing water
2. Consolidating the soil column
3. Intercepting sediment transport
4. Filtering nutrients and toxicants
5. Enhancing habitat corridors

The buffer zone vegetation contributes to the increase in surface roughness and infiltration rate due to macrospores created by the root system of the vegetation. The plant root system also helps reinforce the local soil structure and increase its strength.

The fact that vegetative buffer strips can serve as sediment traps is well documented in the literature. In order to augment local buffer strip performance data, Wu (2005) performed field experiments on sediment removal rates for buffer strips with widths of 3, 6 and 9 m; slope of 9%, 40% and 60%, and with two types of grasses. From May to October, 2005 a total of 21 storm events were sampled. The results are shown in Table 1 below.

The Water Resource Agency plans to use the total annual amount of sediment reduction as an index for evaluating the benefits of implementing conservation practices in the impoundment and buffer zones of a reservoir. The monetary benefit can be estimated by, for example, comparing the cost of buffer strip installation and the savings obtained due to less dredging associated with the sediment accumulation in the reservoir.

Table 1 Average Sediment Trap Efficiency of Vegetative Buffer Strips

Slope \ Buffer Width	Average Sediment Trap (%)－ *Paspalum notatum Flugge*			Average Sediment Trap (%)－ *Axonopus affinis Chase*		
	3m	6m	9m	3m	6m	9m
9%	83.75	77.41	81.60	78.00	84.41	83.70
40%	92.81	93.73	90.86	86.26	94.29	93.55
60%	86.51	74.41	81.46	89.22	90.04	87.68

（Source：Wu，2005）

Implementation of RIA and BZ Conservation Practices in Taiwan

Governmental programs on implementing conservation practices in the reservoir impoundment area and the buffer zone are managed by a number of agencies in accordance to vested authorities and expertise. For example:

- Hillslope management (excluding the RIA and BZ) – the Soil and Water Conservation Bureau of the Council of Agriculture
- National forest (excluding the RIA) – the Forestry Bureau of the Council of Agriculture
- Reservoir Impoundment Area or RIA (including the buffer zone) – the Water Resources Agency of the Ministry of Economic Affairs
- Roads – transportation agencies

The conservation work for an RIA and BZ is part of the larger task for the entire watershed of a reservoir. For the many large, important water-supply reservoirs in Taiwan, the governing reservoir administrations regularly review the progress of the various conservation programs and make changes and/or revisions as needed. The overall goal is to prolong the useful life of a reservoir so that its effective storage volume can be fully utilized. Furthermore, the Agency regularly provides emergency funds for reservoir watershed disaster relief and also allocates funds for outreach programs on disaster prevention and water resources conservation.

The Water Resources Agency is a major sponsor in Taiwan for water resources research, especially in the areas of watershed management, source water protection and in recent years the application of ecological engineering methods in water resources projects.

Traditionally, hillslope protection and restoration projects rely mainly on constructing retaining walls, etc. using reinforced concrete as the major engineering material. The main advantage of such engineering methods is a speedy construction and a higher structural strength. However, in recent years, there have been numerous landslides and mudflow incidents in the mountainous regions in Taiwan that led to many thorough investigations by scholars and experts. A major conclusion from these investigations is that in addition to the 1999 major earthquake, man’s activities such as excessive development in the watersheds played a significant role in causing more frequent landslide and mudflow disasters.

In response to the experts’ findings and recommendations, the government made the decision a few years ago to modify the traditional approach to implementing public works projects, especially those related to water and environmental areas. The Public Works Council of the Executive Yuan adopted the concept of “ecological engineering methods”, which promotes the use of more natural materials and less concrete in engineering projects. In river restoration projects, a “watershed approach”

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championed by the United States has been incorporated.

From an ecological point of view, engineering projects, which are needed for men's economic advance should be done in a way that minimizes their impact on nature. There is no standard model regarding how ecological engineering methods should be incorporated. Its application should take into account the local geographical, cultural and ecological situations. The government's approach at the present time is to use ecological or "soft" engineering methods for projects in the buffer zone as much as possible, while in other areas having little impact on reservoir water quantity and quality, work can be postponed to allow nature to recover by itself.

A Case Study

A typical example of the use of "soft" engineering approach is described below, which is the restoration project for landslide areas at the Tseng-Wen Reservoir in Southern Taiwan. The total project cost was NT$8.13 million. Main features of the restoration work included the construction of intercepting ditches to divert runoff from the landslide areas and the use of ecological engineering methods to stabilize the bare land and planting by hydro-seeding.

Figures 2-5 illustrate the site during various phases of the restoration project.

Figure 2. Before restoration

Figure 3. During planting

Figure 4. Three months after planting

Figure 5. Six months after planting.

Conclusions

In order to illustrate the core value of a sustainable development; to maximize a country's limited resources; to reduce the gap between past economic development and environmental protection, and to bring harmony between economic growth and the living environment, we should pursue a development style that is sustainable and integrated with nature. With respect to a sustainable management of abundant water of good quality, we should follow the principle of "equal weight to ecological conservation and development" in order to reach the ultimate goal of a sustained resource utilization.

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Technical Paper

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Role of Stream Restoration on In-Stream Water Quality in An Urban Watershed – A Case Study

Ariamalar Selvakumar[1] Anthony N. Tafuri[1] Richard Field[1]

[1] *Urban Watershed management Branch Office of Research and Development U.S. Environmental Protection Agency, 2890 Woodbridge Avenue Edison, NJ 08837*

Abstract

This study addresses the effectiveness of stream bank and channel restoration techniques on improving benthic macroinvertebrate indices and in-stream water quality within an urban watershed. The project involved monitoring before and after restoration of 1,800 linear feet of degraded stream channel in the North Fork of Accotink Creek in the City of Fairfax, Virginia. Restoration, which was completed in June 2006, included installation of native plant materials along the stream and bioengineering structures to stabilize the stream channel and bank. These actions were intended to restore the stream channel to a stable condition, thereby reducing stream bank erosion and sediment loads in the stream. In-stream samples were collected and analyzed for physical, chemical, and biological (macroinvertebrates, bacterial indicators) parameters to document the changes in stream quality as a result of the restoration. The preliminary results of the sampling and monitoring are summarized in the paper.

Keywords: Stream Restoration, Continuous Monitoring, Urban Stormwater Runoff, Water Quality, Best Management Practices.

溪流復育在都市集水區溪流水質中所扮演之角色一研究案例

本項研究討論的是都市集水區中河岸及河道復育技術對於提升水體大型無脊椎動物指數與溪流水質的效果。本項研究工作包括對位於維吉尼亞 Fairfax 市的 Accotink 河 North Fork 支流 1800 英呎長沖蝕嚴重的河岸及河道復育前後，監測其水體水質之改變。

復育工程於 2006 年六月完成，其中包含：沿岸原生植物種的植栽及穩定河岸、河道之生物工程。這些工作目的為使河岸恢復於穩定狀態，因而減少河岸的侵蝕及河川中之沉積負荷。水體水樣收集後經過物理、化學及生物（大型無脊椎動物指標、細菌指標）分析參數變化了解河川水質的改變。本文將對初步的採樣和監視結果加以概述及討論。

關鍵詞：河川復育、連續性監測、都市暴雨逕流、水體水質、最佳化管理作業措施

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Introduction

Since the inception of the Clean Water Act (CWA) in 1972, the U. S. Environmental Protection Agency (U.S. EPA) has made great efforts in restoring and preserving the physical, chemical, and biological integrity of the Nation's waters. However, nearly half of the nation's assessed surface water resources remain incapable of supporting basic aquatic values or maintaining water quality adequate for recreational swimming or drinking water supply. In the National Water Quality Inventory 2000 Report, states estimated that approximately 30% of identified cases of water quality impairment are attributable to stormwater runoff (U.S. EPA, 2002). Over the last few decades, the U.S. EPA established several regulatory programs to address the various point and non-point sources. However, less emphasis was placed on non-point source (NPS) pollution, which includes runoff from urban and agricultural areas.

Land development and urbanization processes impact receiving streams by adversely altering watershed hydrology in several ways. The conversion of natural forested lands to impervious surfaces associated with land development results in an increased volume of surface runoff because less water is able to infiltrate into the ground. This leads to more water entering the stream by surface runoff rather than groundwater pathways. Surface runoff is also routed to the stream channel more quickly than water that is infiltrated, or that is intercepted by plants and trees. This routing to the receiving stream is expedited by curbs, gutters, and stormwater pipes, which convey water rapidly from impervious surfaces to nearby streams. Consequently, stream flows in urbanized watersheds increase in magnitude as a function of impervious area (Schueler, 1995).

Natural streams follow meandering patterns, which dissipates energy and minimizes scouring of the streambed and banks. Increased stream flows impact the natural stream channel morphology, which affects the physical, chemical, and biological integrity of the stream (Natural Resources Conservation Service, 1998). Stream channels respond to increased stream flows by increasing their cross-sectional area through widening of the stream banks and down-cutting of the stream bed. This, in turn, triggers a cycle of stream bank erosion and habitat degradation (Schueler, 1994). Stream bank erosion can lead to bank instability and increased sediment loading downstream. This increased sediment load may cause water quality degradation, negatively impacting fish, benthic invertebrates, and other aquatic life in the stream. Channel instability and the loss of instream habitat structure, such as the loss of pool, run, and riffle sequences, also results from increased stream flows leading to degraded habitat for aquatic life. Klein (1979) noted that macroinvertebrate diversity drops sharply in urban streams in Maryland as a result of increased imperviousness. In addition to the physical damage done to the streams, stormwater runoff may bring many forms of pollution which can have a significant impact on the biological community. Normally, a healthy system will have a large variety of species but smaller number of individuals within each species. A stressed system will have a smaller number of species dominated by those that are tolerant to the stress and these organisms often dominate the invertebrate populations. Sensitive aquatic insect species, such as stoneflies, mayflies, and caddis flies are replaced by species, such as chironomids, tubificid worms, amphipods, and snails that are more tolerant of pollution and hydrologic stress. One way to mitigate these stream impacts to the greatest extent possible is to use effective stormwater best management practices (BMPs).

The overall objective of this project is to investigate the effectiveness of stream restoration techniques on improving biological and in-stream water quality in an impaired stream of an urban watershed. This objective is being achieved by collecting physical, chemical, and biological data and monitoring improvement in water quality and biological conditions in the receiving stream before and after stream restoration.

Methods and Materials

Study Location

The Accotink Creek in Fairfax, Virginia was selected as the study location. Accotink Creek and its tributaries within the City of Fairfax are important natural resources that provide recreational and aesthetic values that enhance the quality of life in the City. The headwaters of Accotink Creek originate within the City of Fairfax and flow southeast through Fairfax County to its confluence with the Potomac River at Gunston Cove, which then flows into the Chesapeake Bay. As a tributary to the Potomac and Chesapeake Bays, Accotink Creek has very strict water quality criteria. All state waters are designated for recreational uses and therefore must meet these water quality standards. The Accotink Creek headwater watershed has uncontrolled urban runoff that has resulted in:

- the deepening and widening of the creek's channel,
- sediment removal from the stream reach and deposition downstream, and
- streambank instability.

A large volume of runoff from impervious surfaces is the primary cause of stream degradation in the Accotink Creek watershed. Many of the fish and other aquatic life, which are important for the Creek's viability, began to disappear in recent years (http://www.fairfaxva.gov/environment/streams.asp,10/25/2005). Consequently, the City of Fairfax proactively developed a watershed management plan when faced with major water quantity and quality problems (The Louis Berger Group, 2005). Overall, the stream health, calculated using the physical, biological, and habitat assessment, is

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fair to poor in the majority of the City; erosion potential remains at a very high level, sedimentation is a problem, and down-cutting streams threatens City utilities and surrounding property. The amount of stormwater runoff generated under existing conditions is almost double the runoff that would be generated under 100% forested conditions (The Louis Berger Group, 2005). The Fairfax County Stream Protection Strategy Baseline Study conducted by the Department of Public Works and Environmental Services (DPWES) concluded that the benthic macroinvertebrate community health in the Accotink Creek was poor; habitat conditions were very poor; and fish taxa richness was low (DPWES, 2001).

Accotink Creek was listed as impaired on Virginia's 1998, 303(d) Total Maximum Daily Load (TMDL) priority list due to violation of the State's water quality standard for fecal coliform (VADEQ, 1998). As part of the TMDL study, the U.S. Geological Survey (USGS) Virginia District conducted ribotyping (DNA fingerprinting) on fecal coliform samples from Accotink Creek. The dominant bacterial sources were geese (24%), humans (20%), and dogs (13%). Other sources identified included ducks, cats, raccoons, sea gulls, cattle, and deer (USGS, 2003).

Along with other BMPs, the management plan called for streambank restoration as an important method of improving water quantity and quality. Fairfax chose to focus on areas which stood to gain the most benefit from the use of BMPs and have attempted to coordinate improvements with their overall watershed strategy by utilizing regional and holistic approaches where possible.

The Accotink watershed covers approximately 3,400 acres (5.3 mi2) of drainage area within the Fairfax City limits. The majority of the soils in the City are well-drained and moderately coarse- textured, with moderate infiltration rates; percent imperviousness is about 35% (DPWES, 2001). Elevation in the City of Fairfax watershed ranged from 425 ft above mean sea level (MSL) at its highest point to 285 ft above MSL at the point Accotink Creek flows out of the City. The City is characterized by commercial and high- and low-density residential development that accounts for greater than 60% of land uses.

Restoring Accotink Creek was necessary to reduce loss of property, restore public safety, stop the destruction of downstream habitat, and restore aquatic life native to Fairfax. In the spring of 2002, the city completed stream restoration improvements on the North Fork of Accotink Creek from Stafford Drive to Lee Highway. The current project consisted of stream restoration of a segment of 1,800 ft of the North Fork of Accotink from Lee Highway to Old Lee Highway in City of Fairfax, Fairfax County, Virginia (Figure 1). The actual construction started in April of 2006 and was completed in June of 2006.

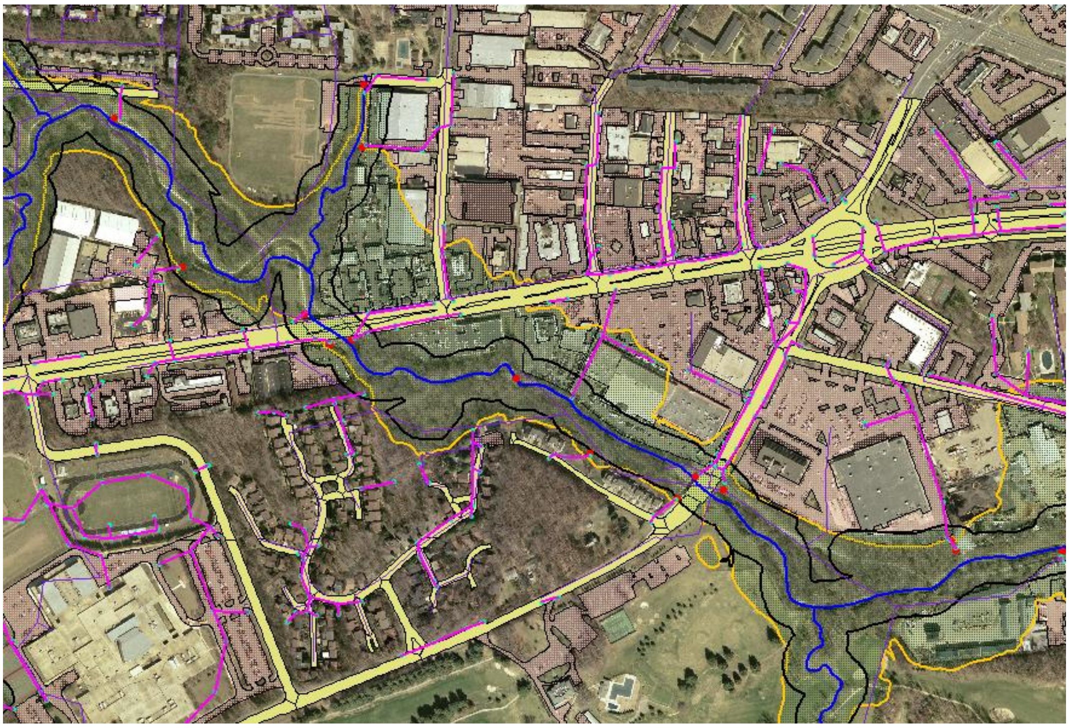

Figure 1 GIS coverage of Accotink Creek showing the stream restoration (light green), riparian corridor (outlined in black), parking lots (stippled-red), roads (yellow), stormwater lines (pink) inlets (cyan) and outlets (red), 100-year flood plain (orange) and sewer lines (purple).

Stream restoration used coconut-fiber matting on sloped areas where willow (Salix nigra) stakes were planted. Imbricated rock boulders were placed in highly eroding areas to stabilize stream banks and eliminate undercutting. Root wads of felled trees during channel reconstruction were used in some portions of the stream bank both to divert flow and add natural habitat to the stream reach. This use of natural materials was cost-effective, because trees, which would otherwise need disposal, were used as a construction material in place of costly purchased materials. Rock veins were individually placed to divert stream flow from the edge of the channel to the center of the stream. In some locations, rock veins reduced stream slope, promoted pool formation, and added aquatic habitat and structure. These actions were intended to restore the stream channel to a stable condition and reduce stream bank erosion, thereby reducing sediment loads in the stream. The project costs approximately $170 per linear feet.

Water Quality Monitoring

Standard water quality parameters (pH, conductivity, temperature, turbidity, dissolved oxygen), total suspended solids (TSS), suspended sediment concentrations (SSC), particle size distribution, etc.), chemical (i.e., nutrients), and biological (i.e., fecal coliform and E. coli) parameters were measured upstream and downstream of the restoration from 2005-2007. Both dry and storm event samples were collected. This water quality monitoring enabled the quantification of physical, biological, and chemical changes in the receiving water. Area-velocity flow meters combined with other monitoring probes (American Sigma, Loveland, CO) installed at two selected locations recorded average flow depth, velocity, water temperature, conductivity, and pH at 15-min intervals. Depth was measured using differential pressure (bubbler) or pressure transducers. Twin 1 MHz piezoelectric crystals were used to measure Doppler-based velocity. Internal electronics combine the measured values using the stream cross-section to compute an associated flow rate. In addition, a YSI (Yellow Springs Instruments, Yellow Springs, OH) probe placed at the upstream border of the restoration reach were used to measure water temperature, specific conductivity, turbidity, dissolved oxygen, and pH also at 15-min intervals.

The USGS placed a similar YSI continuous water-quality monitoring device recording turbidity, specific conductance, pH, and water temperature at the downstream border of the stream restoration. The instrument was connected to data logging and telemetry equipment that transfered all data and is available on the internet. The USGS collected 28 water-quality samples over a wide range of flow conditions and the samples were analyzed for E. coli and suspended sediment concentrations (SSC). The utility of continuous water quality monitoring may demonstrate that this method of data collection will prove to be an innovative, cost-effective tool for detecting in-stream water quality improvements that can measure the effects of larger-scale watershed management. Relationships often exist between the water quality parameters that can be measured with sensors and other contaminants of interest. For example, turbidity values typically correlate well with both suspended sediment and bacteria concentrations. The regression analyses can be used to estimate continuous concentrations of target water quality constituents analogous to the standard methods for developing continuous discharge records.

Macroinvertebrate sampling

Biological integrity above, within, and below the restoration area before and after restoration were evaluated using benthic macroinvertebrate populations and habitat assessments. An area of 0.5 m x 0.5 m (0.25 m2) upstream of the net was sampled using the 0.5 m wide kick net. Using the toe or heel of the boot, the upper layer of cobble or gravel was dislodged and the underlying bed scraped. Larger substrate particles were picked up and rubbed by hand to remove attached organisms prior to kicking. Eight collections were completed in riffles of each selected stream location. The eight kick-net samples of a single location were composited into one sample for a total sample area of 2 m2. Samples were preserved with 70% ethanol before sending to EPA Region 3's Wheeling Laboratory for analysis.

Invertebrates retained on a 500 μm sieve were identified to the genus level in most cases. Taxa richness and invertebrate biotic indices such as the Virginia Stream Condition Index (VASCI), Hilsenhoff Biotic Index (HBI), and matrices of (dis)similarity were applied to determine sample and site differences. VASCI is a single numerical score based on the elements of the structure and function of the bottom-dwelling macroinvertebrate assemblage. HBI is based on family-level identification of stream arthropods. These indices are measurement of biological integrity.

Macroinvertebrate sampling was conducted three times before restoration to establish the pre-existing condition. Macroinvertebrate sampling is being conducted quarterly for at least two years following restoration.

Results

Water Quality Monitoring

A sample of continuous monitoring data for pH, conductivity, and temperature recorded by the flow meter is shown in Figure 2. It can be seen that the conductivity was higher in February due to snow and freezing events requiring street salting. Temperature of the creek water changed with the season and the wet weather flow events. The highest temperatures were observed in July; pH ranged between 5 and 10.

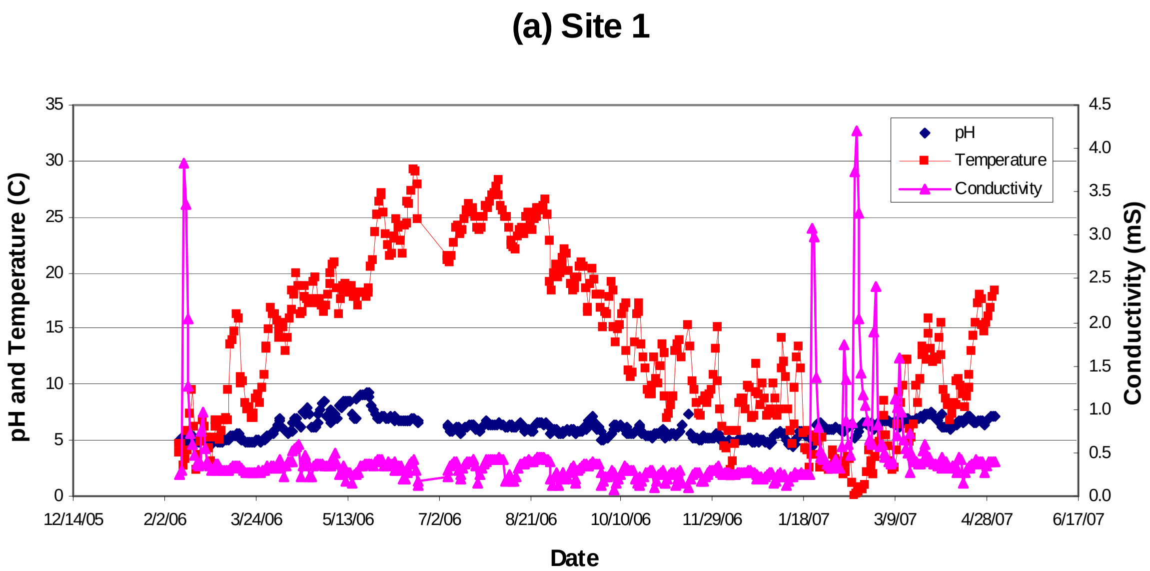

Figure 2 An example of continuous monitoring data.

Results of the discrete samples collected before and after restoration in both up-stream (Lee Highway) and down-stream (Old Lee Highway) locations are shown in Table 1. Five wet weather (two before restoration and three after restoration) and four dry weather (two before restoration and three after restorations) sampling events were conducted with full suite of analyses. Data indicate wet weather concentrations of total phosphate, total nitrogen, ammonia, and COD were higher than the dry-weather concentrations typically. Total phosphate (TPO4) and nitrogen (TKN) concentrations increased after restoration, while ammonia (NH3) concentrations decreased after restoration; however these changes are not great to associate with restoration activities. Also, these results can not be separated from possible seasonal variations until further monitoring can be completed. There was little overall change in COD concentrations; however, event to event variations were dramatic. The one way ANOVA statistical analysis indicated that there was no statistically significant difference between before and after restoration and as well as upstream and downstream of the restoration. This suggests that local restoration in and around streams is insufficient for improving the water quality of the stream.

Table 1 Results of Water Quality Analysis

	Date	Flow Condition	Upstream (Lee Highway)				Downstream (Old Lee Highway)			
			COD	TPO_4	TKN	NH_3	COD	TPO_4	TKN	NH_3
Pre –Restoration	**3/1/06**	Dry	0.16 (0.56)	0.03 (<0.01)	0.07 (<0.01)	0.03 (<0.01)	1.88 (0.34)	0.02 (<0.01)	0.09 (0.01)	0.03 (<0.01)
	4/5/06	Wet	14.93 (0.39)	0.02 (<0.01)	0.40 (0.02)	0.08 (<0.01)	19.44 (2.31)	0.03 (<0.01)	0.39 (0.02)	0.11 (<0.01)
	5/2/06	Dry	7.61 (0.34)	0.04 (0.06)	0.20 (0.02)	0.01 (<0.01)	10.33 (1.11)	0.04 (<0.01)	0.54 (0.05)	0.10 (<0.01)
	5/9/06	Wet	61.66 (0.88)	0.35 (0.04)	0.58 (0.04)	0.19 (<0.01)	68.01 (2.04)	0.13 (<0.01)	0.44 (0.02)	0.07 (0.01)
Post -Restoration	**6/20/06**	Wet	28.86 (1.21)	0.06 (<0.01)	0.61 (0.01)	0.06 (<0.01)	22.25 (0.88)	0.07 (0.01)	0.65 (0.01)	0.06 (<0.01)
	9/21/06	Dry	15.24 (0.92)	0.06 (<0.01)	0.32 (0.03)	0.08 (<0.01)	28.45 (0.35)	<0.01 (<0.01)	0.37 (0.01)	0.03 (0.01)
	10/13/06	Wet	11.08 (0.67)	0.28 (<0.01)	0.49 (0.02)	<0.01 (<0.01)	12.48 (0.85)	0.32 (0.01)	0.50 (0.03)	0.01 (<0.01)
	11/16/06	Wet	72.52 (0.94)	0.24 (<0.01)	0.83 (0.04)	<0.01 (<0.01)	67.08 (2.31)	0.22 (<0.01)	0.95 (0.05)	<0.01 (<0.01)
	12/14/06	Dry	7.69 (1.26)	0.04 (<0.01)	0.18 (0.01)	0.001 (<0.01)	6.02 (0.70)	0.04 (0.01)	0.218 (0.02)	0.01 (0.02)

Note: Restoration was completed on June 6, 2006

Brackets indicate standard deviation

Based on USGS data, plots were developed for turbidity vs. suspended sediment concentration (SSC) and E. coli (Figures 3 and 4, respectively). A correlation appears to exist between turbidity and SSC (R2 = 0.90). Similarly, a correlation is apparent between turbidity and E. coli, but is not as strong as with suspended sediment (R2 = 0.58).

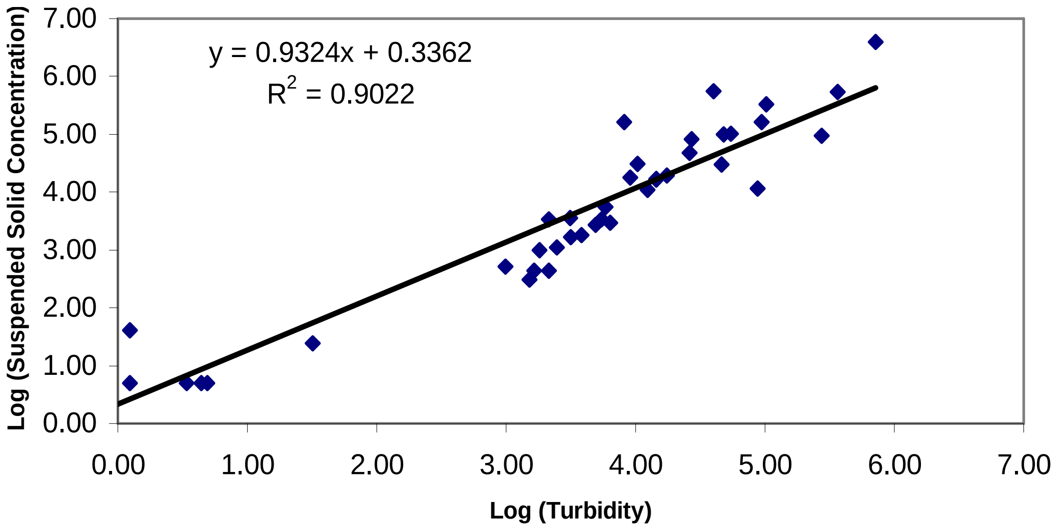

Figure 3 Correlation between turbidity and suspended sediment concentrations.

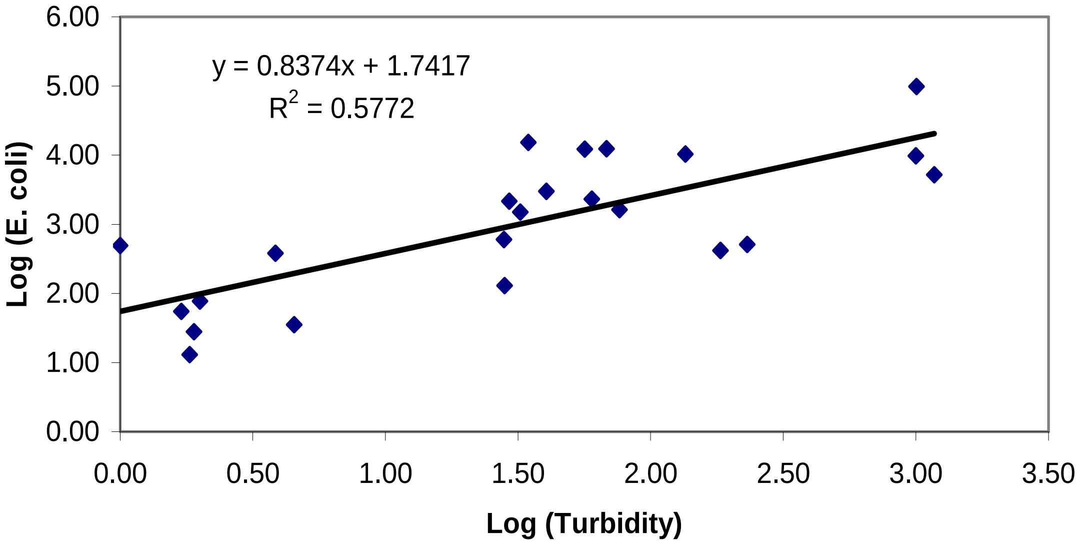

Figure 4 Correlation between turbidity and E. coli concentrations.

Macroinvertebrate Sampling

The results for VASCI and HBI indexes are shown in Figures 5 and 6, and Table 2. Benthic invertebrate data collected to date indicate areas within the restoration have VASCI scores that are not significantly different than before the restoration. Controls show substantial variability before and after restoration. The VASCI score at control site A was much lower than expected in the pre-restoration sampling event. This may be due to seasonal variability and relate to the velocities experienced in this stream that remain unchanged with this management strategy. Control site VASCI scores following restoration are intended to provide an attainable goal for sites B, C, and D within the current restoration reach. Parity between all sites of VASCI scores above 36 during the same season of the year would indicate a successful restoration for benthic macroinvertebrate habitat.

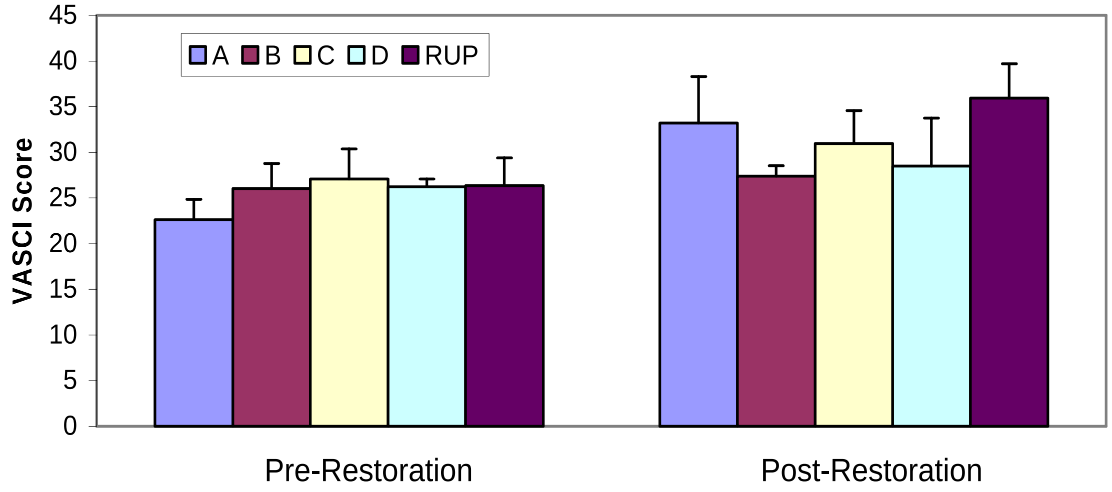

Figure 5 Virginia Stream Condition Index (VASCI) Scores for before and after the Accotink Creek stream restoration.

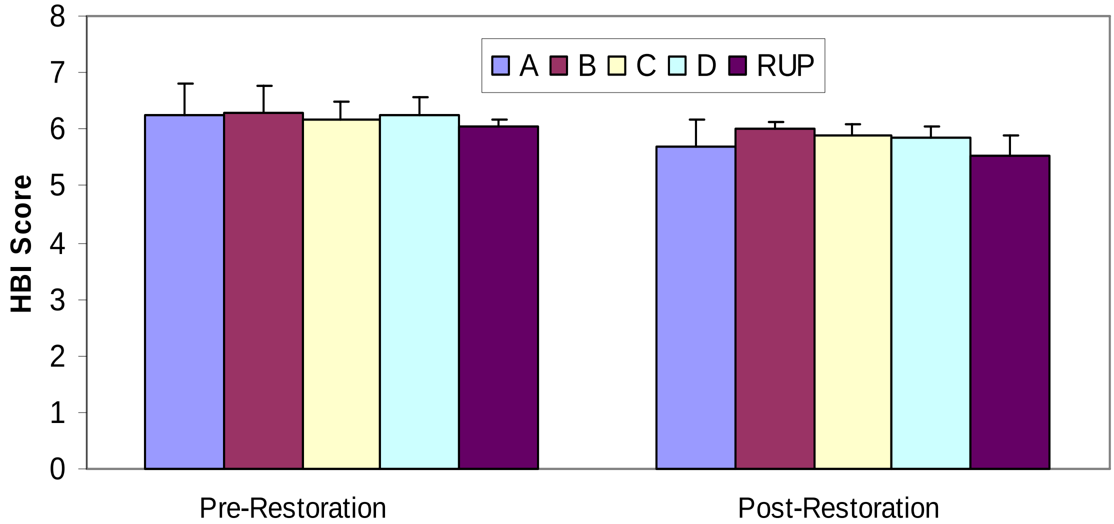

Figure 6 Hilsenhoff Biotic Index (HBI) Scores for before and after the Accotink Creek stream restoration.

Macroinvertebrates are important indicators in stream restoration as they affect the stream condition and fish population, which in turn affect the entire creek ecosystem. As can be seen in Table 2, macroinvertebrate abundance did not change significantly even though their composition changed after restoration. There was no significant difference in total number of macroinvertebrates between the upstream and restored sites. When the fall season data were compared, there was also no difference in total numbers.

Table 2 - Results of Macroinvertebrate Analysis

Pre-, during, Post-Restoration	Date	Species	Site A (~120 m North of Lee Hwy) Upstream	Site B (~200 m South of Lee Hwy) Restoration Area	Site C (~300 m North of Old Lee Hwy) Restoration Area	Site D (~200 m South of Old Lee Hwy) Downstream	Site RUP (~50 m West of Bridge at River Road) Upstream
Pre-Restoration	11/03-04/2005	VASCI	21.2	29.1	24.3	25.9	
		HBI	5.91	5.87	5.94	6.06	
		Total # of Invertebrates	119	112	109	122	
Pre-Restoration	12/07-08/2005	VASCI	21.5	25.1	30.7	25.6	28.5
		HBI	6.03	6.17	6.03	6.13	5.95
		Total # of Invertebrates	109	81	105	103	119
Pre-Resoration	3/13-14/2006	VASCI	25.2	23.9	26.3	27.2	24.2
		HBI	6.86	6.82	6.53	6.59	6.13
		Total # of Invertebrates	51	17	110	42	92
Post-Resoration	9/21/06	VASCI	36.8	28.2	33.5	32.2	38.6
		HBI	5.38	5.90	5.75	5.71	5.28
		Total # of Invertebrates	122	115	114	138	122
Post-Resoration	11/15/06	VASCI	29.6	26.6	28.4	24.8	33.3
		HBI	6.00	6.09	6.03	5.98	5.79
		Total # of Invertebrates	119	111	116	117	107

Note: VA SCI – Virginia Stream Condition Index

HBI - Hilsenhoff Biotic Index

Except for March 2006, all the sites had the same total number of macroinvertebrates and there was no statistically significant difference in total macroinvertebrate abundance over all the sampling dates (Table 3). There was also no significant difference in the total number of macroinvertebrates between the upstream, downstream, and restored sites. The upstream, downstream, and restored areas have similar percent dominance values. The most dominant species at these sites were Chironomidae, Hydropsychidae, Naididae, and Lumbriculidae. 84.3% of the upstream site samples, 93.7% of the restored area samples, and 91.3% of the downstream samples were composed of these four families. All other families were relatively rare, most composing of less than 1% of the total collected species.

While there were no differences in the total number of species, there were more Chironomidae in all sites than Hydropsychidae before restoration. After the restoration, it was reversed as there were more Hydropsychidae than Chironomidae.

Most of the samples were collected in the fall season except for one sample in winter. There was a statistically significant difference between seasons. The total number of macroinvertebrates in winter was much lower than the numbers in fall. There was also no statistically significant difference in the total number of species.

Table 3. Total Number of Macroinvertebrates

Pre-, during, Post-Restoration	Date	Species	Site A (~120 m North of Lee Hwy) Upstream	Site B (~200 m South of Lee Hwy) Restoration Area	Site C (~300 m North of Old Lee Hwy) Restoration Area	Site D (~200 m South of Old Lee Hwy) Downstream	Site RUP (~50 m West of Bridge at River Road) Upstream
Pre- Restoration	11/03-04/2005	Chironomidae	79	45	72	40	
		Hydropsychidae	31	59	33	77	
		Naididae					
		Lumbriculidae	3	1		1	
	12/07-08/2005	Chironomidae	98	55	65	67	76
		Hydropsychidae	6	14	29	30	32
		Naididae		1	2	3	
		Lumbriculidae	3	9	1	4	4
	03/13-14/2006	Chironomidae	27	8	72	23	69
		Hydropsychidae	1	1	3	1	9
		Naididae	10	2	22	10	
		Lumbriculidae	12	5	5	4	
Post- Restoration	09/21/2006	Chironomidae	30	7	15	13	31
		Hydropsychidae	52	102	80	106	46
		Naididae	1				
		Lumbriculidae	1		1	1	
	11/15/2006	Chironomidae	25	15	4	7	16
		Hydropsychidae	67	93	90	106	71
		Naididae	7	1	4	1	
		Lumbriculidae	4	1	1	1	3

Conclusions

Preliminary data indicate that there is a good relationship between turbidity and suspended sediment concentrations (R2 = 0.90) and a reasonable relationship between turbidity and E. coli concentrations (R2 = 0.58). It is hoped that by continuously monitoring Accotink Creek and developing correlative relationships, the overall water quality trends before and after stream restoration in this impaired urban stream can be assessed. Macroinvertebrate abundance did not change significantly even though their composition changed after restoration. There was no significant difference in total number of macroinvertebrates between the upstream and restored sites. There was also no statistically significant difference in water quality parameters before and after restoration. It can be seen that local restoration in and around streams is insufficient for improving the water quality of the stream. The same observation was made by other (Laeser and Stanley, 2004). To be effective, the restoration must be implemented at watershed scale than the current practice of direct structural modification to channels at the site level.

Disclaimer: Any opinions expressed in this paper are those of the author(s) and do not, necessarily, reflect the official positions and policies of the U.S. EPA. Any mention of products or trade names does not constitute recommendation for use by the U.S. EPA.

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Ecological Campus Development at the National Taipei University of Technology

Jen-Hui Tsai [1], Mei-Chu Kang [2]

[1]*Associate Professor, NTUT Graduate School of Architecture and Urban Design, and Director, Heuristic Structure- Cognitional Model Research Lab.*
[2]*Doctorate candidate, NTUT Graduate School of Architecture and Urban Design*

Budding Stage of Eco-Campus Planning Concept (1980-1999)

Development of eco-campus in National Taipei University of Technology (NTUT) was first introduced around 1980 by the dean of General Affairs, dean of general affairs, Sun Guo-Shun (currently president of Min Hwei College of Health Care Management), for the purpose of adding humanities corners and improving campus environment. Such a humanistic concern plays the role of a deep structure in development of eco-environment. Consequently, we (including the faculty of College of Humanities and Sciences) in 2003 began to urge that eco-environment be expanded to humanistic eco-environment.

In 1980 the administration bought a large number of stones, adorned the Chinese banyan garden and other spots of the campus with water scenes, and planted various vines on the walls of several buildings (Guanghua Hall, Civil Engineering Hall and Materials and Mineral Resources Engineering Hall). The green fences, with the bird nests they contain, became the outward image of an eco-campus (Figure.1). Though part of it was casually eliminated during building renovation later, and so far there is no guarantee of its future existence, the waterscape of Chinese banyan garden with its diverse plants is still an important basis of humanities activities.

Figure.1 NTUT Eco-Campus Image

Department of Architecture Garden in 1989 (Figure.2) was the first space that integrated design education with practices and took both humanistic activities and ecology into consideration. It was actually designed and constructed by students. On the flooded vacant lot at the entrance were laid river sands and flat red bricks to permit evaporation. The concept of permeable pavement had not been introduced then. In 1994 Department of Architecture was relocated to the new building (Design Hall) next to a wet and shaded vacant lot, which was later turned into the "Innovation Science Garden" designed and constructed by students of the architecture design program (Figure.3). To preserve the original environmental features, again, only flat bricks were laid. Since the place was rarely used by students, we were hopeful that moss would show up here. It was not to be so because the canteen was temporarily located here, and the place was used to stack shelves. Currently, ferns are being planned.

In 1996 the NTUT School Plaza was designed and built in front of the library (Figure.4), and was later named "Humanities Plaza." Upon completion, vines were planted. At present, creeping figs have covered the half-perforated wall that connects the plaza and the Chinese banyan garden. The openings of the wall were so arranged to allow branches of the red cedars behind to stretch out. The third education building had also been covered by Boston ivy. This core of humanities had been approaching the image of green valley. One of the red cedars of the plaza was preserved (but later replaced by a Chinese banyan, which was larger). For the pavement of the entire plaza, only the summer glare was taken into account. The issue of water permeation was not considered. In the future we should have a chance to cover the plaza with permeable pavement.

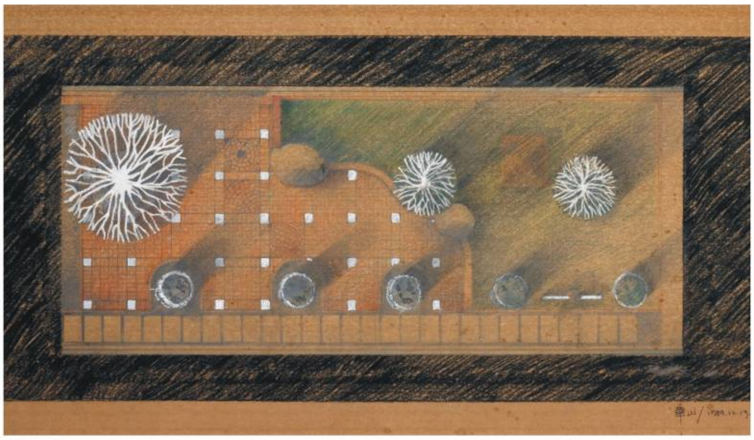


Figure.2 Department of Architecture Garden

Figure.3 Construction of Innovation Science Garden

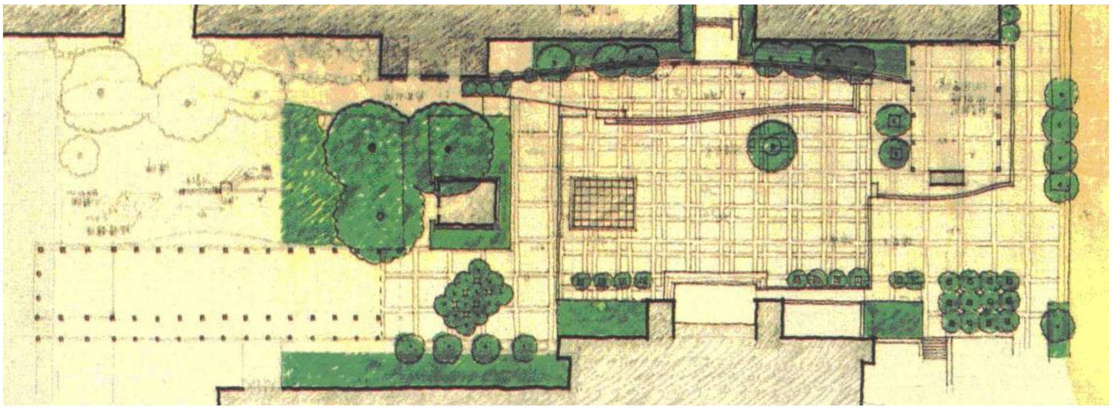


Figure.4 Layout of Humanities Plaza

Eco-Campus Planning Concept Integration Stage (2000-2002)

Upon its inception in February 2000 NTUT Water Environment Research Center began to introduce water ecology issues. First, “FY 2000 Research Program sub-Project 3: Water and Green Environment Planning,” funded by Ministry of Economic Affairs Water Resources Bureau, marked as the beginning of NTUT’s endeavor to construct the planning concept of eco-campus in response to the green fence of Xinsheng South Road. The following idea was proposed: “An open eco-campus space must be connected to the urban area through ecological interface.” As the “gateway to urban ecology,” this project on the one hand allows urban ecology and landscape to the campus by penetrating its walls and boundaries and on the other hand makes a way for the eco-campus concept of NTUT to expand and encompass the surrounding urban area. This is Taipei City’s shortcut to eco-city. Such a connecting eco-waterscape can serve as paradigm for all open spaces and urban interfaces.

NTUT campus has been through various planning stages. There have been many campus-related projects, but most were based on independent thoughts and failed to take the overall campus planning concept into consideration. Therefore, responding to the “Innovative Campus Development Project” solicitation made by Ministry of Education Advisory Office in August 2002, this Research Lab proposed “Innovative Campus Overall Planning - National Taipei University of Technology Eco-Campus Planning.” Through the overview method, this project reviewed the initial form planned for each node of the campus and introduced the concept of eco-planning in an attempt to comprehensively integrate different ecologies within the campus including the plants, species and uses. In the same year the lab received one year of research funding and began to integrate related projects. Following organizational transformation of NTUT, the project has been redirected toward green architecture. At present, the image of a green eco-campus has begun to take shape.

Eco-Campus Construction Stage (2003-2007)

(I) Green Campus Building and Campus Restructuring Plan－NTUT Reform Project

In the “Green Campus Building and Campus Restructuring Plan－NTUT Reform Project” implemented by Ministry of the Interior Architecture and Building Research Institute under the “Challenge 2008 Water and Green Program,” NTUT carried out four offspring projects in 2003: “Site Revegetation, Wall Revegetation and Rainfall Eco-Reservoir Project,” “Site Water Conservation Improvement Project,” “Integrated Opto-Electronic Exterior Shade and Energy Conservation Improvement Project” and “Air Conditioning Energy Conservation Improvement Project.” Responses to the eco-reservoir and the permeable pavement in front of the Design Hall were overwhelming. The “Eco-Reservoir” (Figure.5) was an eco-indicator environment. There was no consensus in the beginning. Those involved were torn between absolute concept and local concern. Even more challenging was the extremely low tolerance of the administrative status quo, which proved to be almost lethal to the eco-environment project. Permeability is determined by the bottom material of the reservoir. The final compromise called for a mixture of red clay and 1/20 cement. If the construction went well, the permeability was expected to be lower than 1/100. Meanwhile, setting up the eco-reservoir and building the water eco-space could soften the campus space. One year after completion of the project, there had been numerous visits of nightingales to the small area of the pond; white egrets also showed up every now and then to surprise many (Figure.6). The “Permeable Pavement” (Figure.7) was employed for the site mainly because many Taipei residents had had the unpleasant experience of walking on a splashing pavement. A completely splash-free pedestrian pavement would make walking a pleasant experience even in the rain. Experiences as such motivated the use of permeable pavement. Besides tangible benefits, its psychological effect on users is also part of the momentum.

(II) NTUT Eco-Campus Construction Project

During Ministry of Education’s implementation of “FY2003 Project for Subsidizing Development of Sustainable Universities,” this research office based on its accomplishment in “Innovative Campus Overall Planning - National Taipei University of Technology Eco-Campus Construction Project” submitted “National Taipei University of Technology Eco-Campus Planning,” which was chosen among many entries and funded for implementation. For this project, NTUT carried out 4 offspring projects: “Eco-Balcony and Wall Revegetation Project,” “Campus Waterscape Project,” “Technology Greenhouse (Eco-Green Architecture)” and “Opto-Electronic Shade Project.” The concept of “Eco-Balcony” (Figure.9&10) is: “Since mankind has occupied a large area of land that belongs to the living creatures, it would only be ecologically ethical to return the balcony as part of its repayment to the creatures as habitat. Birds get to fly this eco-balcony to another eco-balcony, completing another dimension of eco-city in the air. The first of its kind in Taiwan, this eco-balcony is set up on the 8th floor of the eco-balcony. Except necessary maintenance, it is off-limit to all, so that the birds will not be disturbed.”

The concept of “Wall Revegetation” (Figure.8) is: “Utilize the grey water emitted from the Design Hall to water the vines of the exterior wall in order to form a green fence.” “Campus Waterscape” (Figure.11) was completed in 2000 to fulfill a dream. It influenced not just humans. Nightingales and white egrets were seen on the sidewalks of Zhongxiao East Road nearby. It has connected the eco-reservoir with the outside world making regional ecology more enriched and diversified.

“Eco-Green Architecture” (Figure.12, 13 and 14) incorporated design, practice and international cooperation and completed integration of ecology and humanities. In accordance with Taiwan’s hot and humid climate, it utilized environmental conditions to plan a comfortable indoor environment that is in harmony with nature and energy-effective. Students were allowed to participate in the planning and construction of the project as a way of realizing the “learning in doing” concept of architecture education. They also acquired the idea of eco-green architecture through this project. The Eco-Green Architecture is situated between the Campus Waterscape and the Eco-Reservoir to demonstrate the fact that ecology and humanities are one. Ministry of Education encouraged NTUT to apply the concept behind this building to the new Education Research Building of which the ground-breaking was about to take place.

Figure.5 Bird’s Eye View of Eco-Reservoir

Figure.6 Surprised Visit of the White Egret on the Dry Wood of the Eco-Reservoir

Figure.7 Permeable Pavement in Front of the Design Hall

Figure.8 Design Hall Wall Revegetation

Figure.9 Eco-Balcony Section, Illustrated

Figure.10 View of Eco-Balcony

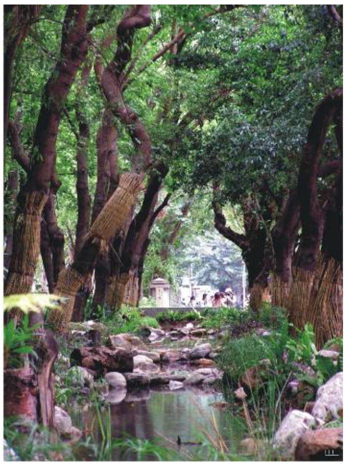


Figure.11 View of Campus Waterscape

Figure.12 View of Eco-Green Architecture

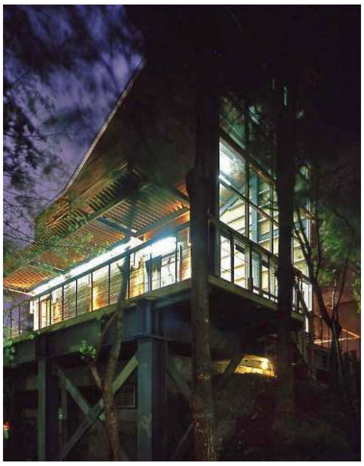
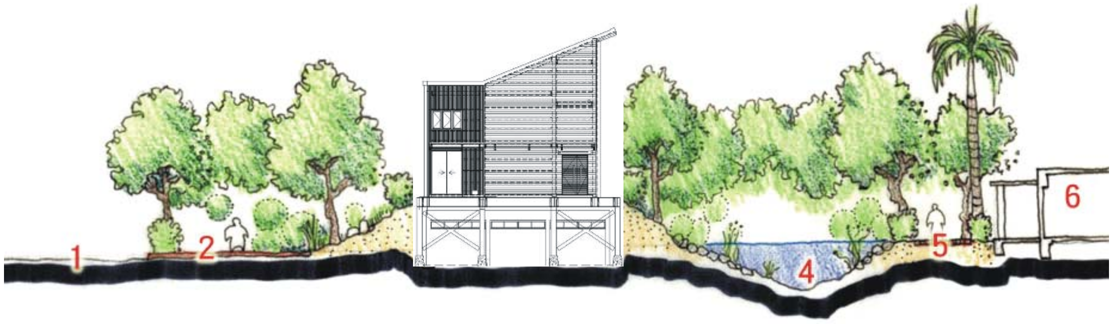


Figure.13 Night View of Eco-Green Architecture



1. Zhongxiao E. Rd. Vehicle Lane
2. Eco-Sidewalk to Expand Experience of Space Esthetics
3. Eco-Green Architecture
4. Eco-Reservoir Landscape
5. Eco-Sidewalk
6. Revegetation of the Roof of Convenient Store

Figure.14 Section of Relationship of Eco-Green Architecture and Surrounding Eco-Environment, Illustrated

（III）Xinsheng Axis Landscape and Rice Garden Reconstruction

The historical axis on campus, Xinsheng axis underwent landscape restructuring (Figure.15) because of construction of the underground garage. Graduate School of Architecture and Urban Design mobilized the entire school to tale part in planning and design. The planning concept is firmly founded on eco-campus development. The project is currently under construction. The fact that many parties (NTUT, architect, PCM, contractor, etc.) are involved makes the final outcome unpredictable.

Placed at the Conde Square in front of the Design Hall, the Rice Garden became a reality as a result of this Research Lab's implementation of the sub-project, "Campus Scene Innovation Experiment," under NTUT College of Design's Innovation College Development Project finded by the Ministry of Education in 2006. The architecture design programs of NTUT Graduate School of Architecture and Urban Design was involved in the participation-type design process, in which students were invited to take part in the entire process from planning to construction. The approach was a fulfillment of the architecture education idea of "learning in doing" and NTUT's education concept that upholds both theory and practice. The project was completed in July 2007. The concept it introduced integrated history and humanities at the MRT exit near the campus (Figure.16). This is the best spot to advocate humanistic eco-campus. Each year when the rice crops ripen (Figure.17, 18) we intend to celebrate it as an important event on campus.

Prospect for Development of Humanistic Eco-Campus in the Community

NTUT west-side sidewalk from the MRT station at the southwest corner to the northwest corner is an important passage that connects with the second largest MRT station and with the Guanhua section, which represents technology, education and humanities. Based on the eco-street planning concept of Water Environment Research Center that extends the city-friendly interface of Zhongxiao East Road.

Figure.15 Simulation of Xinsheng Historical Axis Landscape

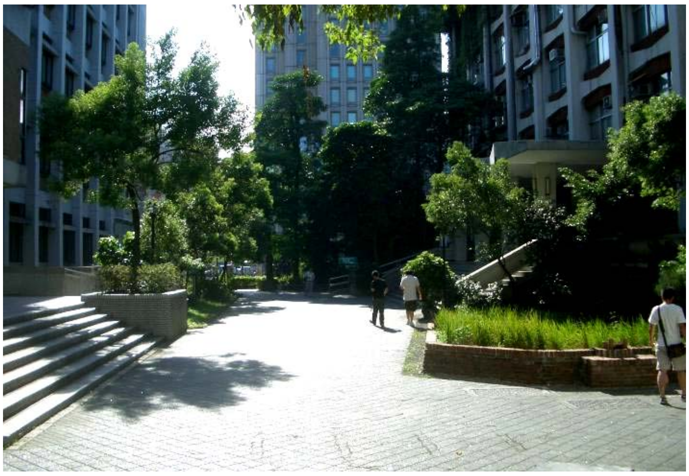


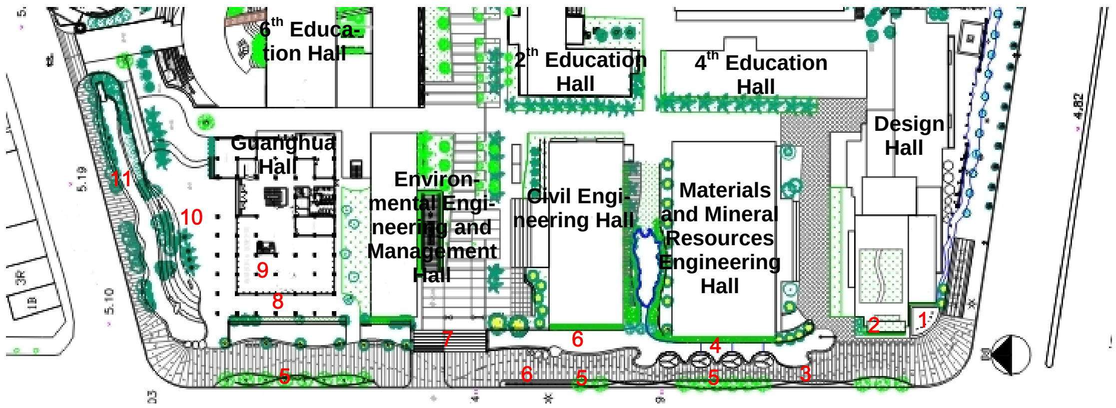
Figure.16 Rice Garden that integrates history and humanities at the MRT exit near the campus

Figure.17 Professor Jen-Hui Tsai harvested the first fruit of the Rice Garden.

Figure.18 The Ripening Rice Garden in front of the Design Hall

Waterscape, NTUT in 2006 continued to carry out the proposal to build water eco-space along Xinsheng South Road and Bade Road. The undertaking called for removal of the wall of this section and construction of a water corridor in its place representing technology and ecology. It converted the wind power from the depressurizing hole of MRT into regenerated energy that activates the waterscape as a public artwork to indicate arrival of the train. This technological and ecological water-corridor concept integrates water resource environment, public arts and technology. Through observing the street that serves as the urban-campus interface, it looked for traces of urban living esthetics in NTUT's eco-campus planning and became the spokesman for eco-city. This project has completed an urban water environment that carries the image of technology, ecology and humanities (Figure.19, 20 & 21). It also attempts to connect MRT with Huashan Culture Park, whose completion in the future can be expected to set off this district for another round of development. The campus display was completed on November 2, 2007. Currently NTUT is seeking construction funding from government agencies.

Ecological environment encompasses all that live in the same environment. Human lives, of course, are no exception. More importantly, humans ought to take the initiative to show care and manage the environment on a long-term basis. Such a care for the environment is an expression of humanities. We can also say that humanities are concerns for nature. Eco-environment is instrumental in enhancing the humanities of the campus. Development of a humanistic eco-environment cannot be treated as an ordinary project, in which the administration is responsible for proposal preparation, construction, maintenance and management, and environmental users only play the role of the consumers. A successful eco-campus, or eco-community or even eco-city, must be built through long-term humanistic concerns of local residents. A humanistic eco-campus in the community should be goal of NTUT's future campus development.



1. Street corner nodes that gather runoff systems on campus.
2. Intensifying the effect of 3D eco-revegetation.
3. Street arts that integrating the city and campus.
4. Natural resources used to incorporate public facilities.
5. Water eco-street that extends Xinsheng green axis.
6. Building urban waterscape via technological approaches.
7. Opened Xinsheng gate that connects with the street.
8. Technology showcase of NTUT campus.
9. Technology platform for interchange between academic theory and practice.
10. Guanghua image that integrates water and technology.
11. Water source image of Liugongzhen restoration.

Figure.19 NTUT Xinsheng South Road Eco-Water Corridor Layout

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Figure.20 NTUT Xinsheng South Road 3D Eco-Revegetation, Illustrated

Figure.21 Waterscape of NTUT Xinsheng South Road Eco-Corridor, Illustrated

Conclusions

Taiwan's efforts in ecological environment have begun to bear abundant fruit in recent years. The government's endeavor in "Challenge 2008 Water and Green Program" signifies it's time for harvest and review, for formulating the direction for the next wave. Eco-campus design is an important link in the nation's effort to construct an eco-environment. As NTUT's important indicator in eco-campus development, "Zhongxiao East Road Campus Waterscape" took 7 years to complete, from conceptualization, planning, competing for budget and winning the support of the administration to communicating with sponsors during the construction, participating to landscape contest and appearing in international magazines. During the time we had many partners, who walked us through frustrations and kept us on the right track. All of us shared a common trait: "We were all gifted with significant degrees of imaginations. Otherwise an image not yet realized would always leave us hanging in the heart." Every one of us has a green shoot in the heart waiting for watering in order to sprout and grow. In the process of constructing an eco-campus in NTUT, this shoot has budded and begun to spread. It is growth of the entire body forming an undercurrent of enormous support.

Tough as it is, each ecological system requires at least a decade to establish a balance. Careful pampering, therefore, is necessary. Yet, it can never rival the demand for administrative efficiency. Constraints of the accounting system and inadvertent damages are ever present. Most devastating of all are those in power who are not interested in thorough understanding. An unsubstantiated comment can destroy a vine that has been climbing harmlessly for 30 years. Boston ivy attaches itself to the surface to the exterior wall only lightly through its suckers. Yet it was uprooted only because some said it would harm the structure. Humanistic care is demonstrated in the concept that we should try what we can to preserve nature if what it brings about is worth cherishing. This is where delicate culture begins. Another victim of misjudgment is balsam, which has been banned for groundless conviction of wasting too much water. Yet it is doing just as well in dry land. What should be the verdict then? Different values may result in different cultures, and we need to be extremely careful.

Architecture education includes knowledge sharing and application practice. Inheriting the spirit of its predecessor – technical college – NTUT stresses both theory and practice. In the teaching process, it therefore often sees the campus environment as a place for design maneuver. Shaping of a physical environment allows students to experience how a concept is realized. Yet a significant gap continues to exist between paper-based exercises in the classroom and structuring of a physical environment. How to invite the industries, including alumni, architects, contractors and material vendors, to discuss construction details and processes with students in class is a great challenge. Participation in construction is another issue yet to be overcome.

This Research Lab is committed to eco-campus planning and management. In addition to the dedicated efforts of the graduate students, the senior author is grateful to the approval and policy support of the administration whose funding has made implementation of many projects possible. I am also indebted to Professor Lin Jen-Yang for introducing NTUT to the concept of water ecology. In the 21st century when environmental protection is assuming ever-increasing importance, NTUT needs to appreciate what has been accomplished and manage the eco-campus it has with more delicate care. The primary task right now is to formulate guidelines within the administrative system to sustain such endeavors.

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國立台北科技大學生態校園建構之發展歷程

一個成功的生態校園，或生態社區甚至生態都市，皆應是居民長期的人文關懷所營造出來的。因此，一個社區人文生態校園應是國立台北科技大學（以下簡稱北科大）未來校園發展的願景。北科大生態校園建構之發展，主要分為四個時期：一、萌芽期（1980-1999 年)。二、整合期（2000-2002 年)。三、實踐期（2003-2007 年)。四、願景期（2007 年-迄今)。

校園生態設計是國家生態環境建構中重要的一環。每個人心中皆有一顆綠芽，只等待著被澆水成長茁壯，北科大生態校園於建構過程中，此綠芽已慢慢成長蔓延，這是一種整體的成長，它形成了一股潛伏的巨大支持力量。面對環境保護日益重視的廿一世紀，北科大未來更要珍惜既有成果並將生態校園作更精緻化的經營，於行政體系內制定相關綱領，將之制度化乃當務之急。

關鍵詞：都市生態、生態校園、水與綠規劃設計、都市生態河流

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