PRINCIPLES FOR SUCCESSFULLY INCORPORATING ECOSYSTEM RESTORATION INTO STORMWATER MANAGEMENT

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ABSTRACT

Combining stormwater management with ecosystem restoration continues to gain popularity and many communities overseas and in New Zealand are actively supporting development of stormwater parks (public spaces that blend stormwater quality treatment and flood attenuation with wildlife habitat and recreational opportunities).

Historically, population growth and urbanisation, especially in coastal areas, has significantly increased pressures on natural resources. Increases in imperviousness, encroachment into floodplains, alteration of stream channels, riverine flood protection schemes and other changes have greatly influenced hydrologic characteristics of rural and urban catchments. These changes have also affected the state of receiving waterbodies in terms of environmental, cultural, social and economic values. Unfortunately, many alterations have been undertaken in past decades without regard to long-term or cumulative impacts.

Current stormwater and catchment management projects tend to be direct reactions to past development practices with flood relief and improvements in water quality being the two largest drivers, but habitat improvements can also be included.

This paper identifies and reviews key principles needed for successfully incorporating ecosystem and wetland restoration into stormwater management practices. This paper also presents several cases where elements of ecosystem restoration have been incorporated into stormwater management to address catchment management issues.

KEYWORDS

Stormwater, wetland, ecosystem, stream, restoration, urban, catchment, management

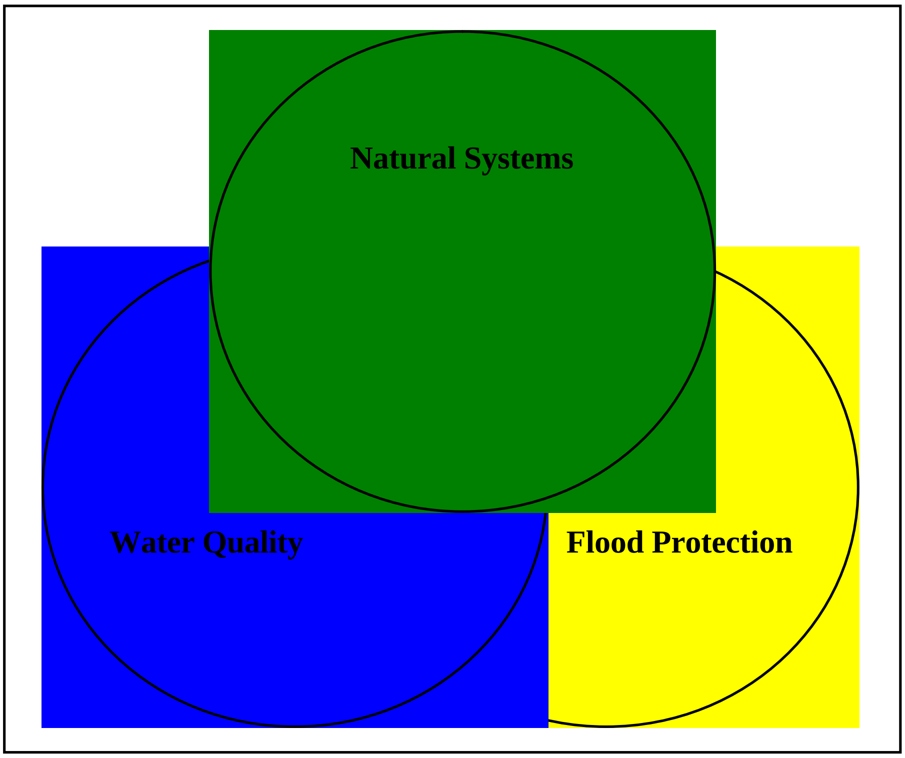
1 INTRODUCTION

A sustainable and holistic approach to incorporating ecosystem restoration into stormwater management encompasses a blend of the following three base elements:

1. Natural Systems;
2. Water quality; and
3. Flood protection.

The natural systems element represents the habitat values that streams and wetlands and potentially, stormwater ponds can provide. The natural systems element also includes the adjacent transitional and upland areas, which together with the wetland areas and riparian habitats form a more wide-ranging bionetwork. Natural system considerations can also be extended to include connectivity issues between wetlands and other catchments. The water quality element encompasses the benefits that stormwater treatment ponds and wetlands can provide to the receiving environment. The flood protection element relates to the flood storage and stormwater discharge attenuation capacities of ponds, wetlands and overflow (floodplain) areas. Blending all three elements (Figure 1) forms the basis for a comprehensive approach to stormwater ecosystem management.

Figure 1: The Three Elements of Stormwater Ecosystem Management



Water features are highly valued and can be found at the centre of many cultures. Most commonly, wetland ecosystems provide habitat for aquatic flora and fauna, and water quality benefits through the removal of pollutants from waterways. However, wetlands (natural or constructed) can provide additional benefits. Specifically, wetlands can provide significant recreational opportunities and serve as landscape amenities. Constructed wetlands offer opportunities to provide flood attenuation. Constructed wetlands can also be specifically designed for industry to provide treatment of wastewater discharges to meet consent requirements and in many cases can do so for less cost than other more maintenance-intensive treatment alternatives. Constructed wetland systems seek to imitate natural water quality treatment processes whilst delivering economically and environmentally sustainable outcomes for stormwater catchment management and waterway restoration projects.

Within the last 200 or so years, many of these benefits were often not realised and not protected by industrialised societies around the world. Wetlands, stream gullies and floodplains were actually viewed as nuisance landscape features suitable only for the tipping of rubbish. In some cases, wetlands were drained to transform them to pasture or arable lands or for residential and commercial developments. Consequently, wetlands were destroyed and the benefits of these areas were lost. For example, surface water quality was degraded, habitat values were degraded, habitat connectivity was severed, native bird and fish populations were displaced and flood storage was diminished. At the same time, increases in imperviousness and culverting of stream channels compounded impacts to wetland habitats and floodplains by significantly altering catchment hydrology. Generally, peak flow rates have increased while dry weather (or base) flow rates have decreased. These changes have created flooding and water quality issues.

To recover the natural functioning of catchment hydraulics, significant modifications need to be undertaken to improve the way in which surface water flows through the catchment to the ultimate receiving waterbody.

2 COMBINING THE ELEMENTS

Conventional water management practices tend to consider stormwater ponds, flooding issues and wetland restorations in isolation and without a view to bigger, more comprehensive catchment management issues. In order to combine the key elements of natural systems, water quality and flood protection, the industrialised, piecemeal approach to catchment management needs to be left behind for a more natural and holistic appreciation for watershed dynamics extending from the headwaters to the oceans. This will require a change in mindset. The traditional engineering approach of planning, design and construction needs to be expanded. Greater collaboration is required between the stakeholders, including stormwater practitioners, engineers, biologists, landscape architects, landowners / managers, farmers, consenting agencies and the end users. Each stakeholder has their own understanding of what a watershed restoration project should be or should look like and understanding the goals and interests of other stakeholders benefits the project as a whole.

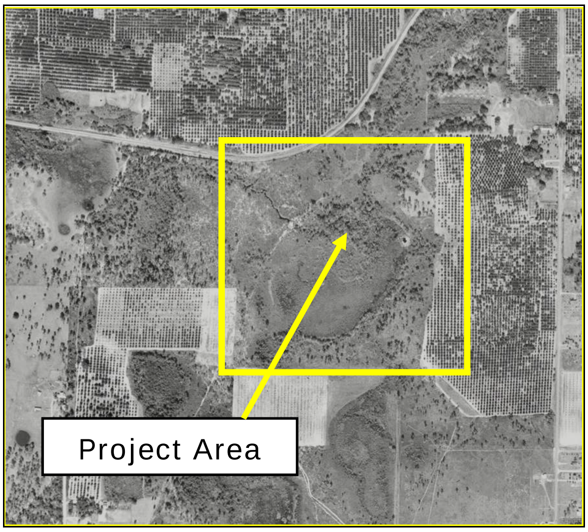
2.1 DEFINING PROJECT OBJECTIVES

A comprehensive approach to combining wetland restoration with stormwater treatment requires at least a basic understanding of the issues and options within a catchment. Identification of project goals requires stakeholders to go beyond addressing symptoms of environmental degradation, flooding, or poor water quality. Rather, solutions that address the causes of the problem need to be provided. Conversely, issues viewed in isolation often miss the underlying causes of the problems. For example, residential flooding on one area may be a symptom of larger catchment management issues, such as filling of floodplains or culverting of streams elsewhere in the catchment. One could elevate a house above flood levels, but without addressing conveyance impacts, flooding will still occur. Similarly, a dry wetland in one location may be a symptom of excessive groundwater withdrawals in another area of the catchment. In this case, other surface waters could be routed to the wetland to rehydrate it, but without addressing over-pumping the lowered groundwater tables will continue to impact the wetland's hydrology.

To help define the project objectives, stakeholders must specifically identify the causes of problems within the catchment and address those causes. Project goals should be clearly identified, realistic and measureable. The goals should also be specific enough to address the previously identified issues. Since natural systems are inherently dynamic systems, project objectives can be established to consider a range of outcomes rather than one finite target.

According to the Society for Ecological Restoration (SER) International (2004), ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Often, flood issues relate directly back to ecosystem degradation. The Kapok Wetland and Floodplain Restoration Project in Clearwater, Florida, USA is one dramatic example where an ecosystem was restored. In this case, a 12 hectare wetland was partially drained and filled for the construction of a residential development in the late 1960s or early 1970s (Photograph 1). The stream that fed the wetland was channelised. The result was that homes within the development were regularly flooded by even minor storms. Furthermore, habitat benefits provided by the wetland were destroyed and water quality benefits were gone.

Photograph 1: Kapok Wetland and Floodplain Restoration Project, Clearwater, Florida



1950s – Pre-Development

2004 – Post-Development

In the Kapok project, the objectives were clear—the residents needed to be relocated and the wetland needed to be restored. Ultimately, funding was appropriated due to the repeat flood occurrences, and with the consent of the residents, local, state and federal governments bought the affected properties and relocated the residents. Additional funding was secured to restore the floodplain by removing the affected homes and excavating out the fill material (Photographs 2 and 3). Wetland areas were re-established and the stream channel returned to a more natural state. This project encompassed all three key elements of flood protection, natural systems and water quality.

The Kapok project also incorporated public access elements (discussed below) that became part of a cycleway extending from the Gulf of Mexico to Tampa Bay. The area is now a local park and is appreciated by the local residents as well as the broader City of Clearwater community.

Photograph 2: Kapok Wetland and Floodplain Restoration Project, Clearwater, Florida

Source: Google Earth, Retrieved 25 March 2010

Photograph 3: Kapok Wetland and Floodplain Restoration Project, Clearwater, Florida

Source: City of Clearwater, Photo date: November 2005.

2.2 CONSIDERATION OF END USE

Considering the end use of the project will help establish the project objectives. Project constraints (e.g. funding sources or consent requirements) may prescribe a primary focus for the project. Typical project purposes include:

- Ecosystem restoration
- Wetland restoration
- Stormwater treatment
- Stormwater attenuation
- Floodplain restoration
- fish and game habitat creation
- Landscape amenity

Opportunities to combine a number of these items to balance a range of economic and environmental issues for catchment management and waterway restoration projects should be investigated. A stormwater pond designed for water quality treatment at a new development can be incorporated into the landscape to serve as a focal point for the community. With properly planted riparian margins, stormwater ponds can also provide some habitat benefits while meeting consent requirements for water quality treatment. Constructed wetlands may be better at providing habitat benefits and can be more aesthetically pleasing.

2.3 STORMWATER PARKS

Stormwater parks are gaining popularity overseas as well as in New Zealand. These areas are focused on providing stormwater treatment, but are combined with wetland creation and stormwater attenuation to provide whole-catchment benefits. Stormwater parks can be located throughout the catchment, but have greater water quality treatment benefits when located towards the bottom of the catchment. Additionally, since they are public lands, the areas are being used as public green spaces for passive recreation often incorporating walking/cycling trails, kayak launches, board walks and picnic areas.

Incorporating educational signage at specific locations within the park also increases public awareness of the stormwater park's benefits. The Waiatarua Reserve in Ellerslie, Auckland, has restored a large wetland area, provides significant water quality benefits, flood attenuation benefits and serves as a passive recreational area. The Manawa Wetland Reserve (Figure 2) in New Lynn, Waitakere City is another example of a stormwater park with multiple benefits (water quality, native habitat, passive public recreation). Similarly, the City of Winter Haven, Florida, USA, has created a number of stormwater parks (Photograph 3). Due to their broad scope, the Winter Haven stormwater park projects have found significant financial support across a wide range of funding agencies. The parks have also met with broad public support.

Figure 2: Manawa Wetland Reserve, Waitakere City, New Zealand

Source: http://www.waitakere.govt.nz/cnlser/pbr/pdf/manawa-concept-plan.pdf, Retrieved 22 March 2010.

Photograph 3: South Lake Howard Nature Park, Winter Haven, Florida

Project Twin Streams in Waitakere City is a great example of a project encouraging public involvement. Waitakere City Council and EcoWater have undertaken Project Twin Streams, an urban sustainability project which aims to restore 56km of Waitakere stream banks through an integrated community development approach. In addition to riparian area restoration, the project also fits in with other stormwater initiatives in Waitakere. The Project Twin Streams catchment area takes in the Oratia, Waikumete, Opanuku, Pixie and Swanson streams in Waitakere. The catchment covers an area of approximately 10,000 hectares and has a population of 100,000 people. The project is mainly funded by the Auckland Regional Council with additional resourcing from Waitakere City Council.
(Source: http://www.waitakere.govt.nz/AbtCit/ne/twinstreams.asp retrieved 8 October 2009.)

Project Twin Streams has multiple objectives, but its main objective is to improve the streams and waterways within the catchment. The project is doing this in a number of ways, such as replanting of stream banks and purchasing some properties which are situated within the streams' natural corridor. The riparian plantings can improve the quality of stormwater runoff (sheet flow) before it enters the streams. Implementation of additional stormwater treatment alternatives, such as stormwater ponds and constructed wetlands, can further improve the quality of the receiving waterbodies.

3 CONSIDERATIONS FOR AN INTEGRATED APPROACH

3.1 SITE SELECTION

Often, project objectives are constrained by the available sites. Sometimes the site selection has already been done and only one site is available. However, if an entire catchment is to be reviewed, many factors need to be considered. Site size, location (including the site's location within the greater catchment), topography, elevation and hydrology all play a part in defining the project objectives. Be realistic about what may be accomplished at a particular site. Match site characteristics to the type of wetland system that may be created. Compare the site to similar reference sites and model your plans on existing, healthy wetland systems. Consider whether the site is a former wetland or if a new wetland is to be excavated. Identify a consistent source of water that can be drawn upon to keep the area wet. Consider how ownership of the lands may impact the project. There are a number of factors that go into the selection of potential stormwater ecosystem sites.

3.2 HYDROLOGY AND HYDRAULICS

Getting the hydrology right at the project site is critical to the success of stormwater ecosystem projects. Numerous publications detail ways in which wetlands can be rehydrated, so details will not be presented here; however, it is still important to mention that designers must understand how water flows through a system in order to achieve the objectives of the project. The types of systems suitable for a particular area will depend on whether the system is a saltwater or freshwater system, the level of tidal influence, the frequency and duration of inundation and groundwater levels.

Stormwater management regulations vary from one jurisdiction to another, but generally will indirectly prescribe the ultimate size of a stormwater pond by requiring that a specific volume of water be treated and that post-development flows be attenuated down to pre-development discharge rates. One benefit of stormwater ponds specifically designed for such purposes is that the hydroperiods (i.e. the frequency, depth and duration of inundation) and the design high and low water levels are known without significant pre-construction water level monitoring. This enables landscape architects to select the proper vegetation types at the right elevations.

3.3 USE OF HABITAT MOSAICS

Habitat mosaics in a restored system are necessary to ensure the success of an ecosystem restoration project over time. Habitat mosaics include the use of a number of habitat types including open water areas, low marsh, high marsh, transitional areas, uplands, islands, etc. Part of this includes overlap between planting zones. Over the short term (on the order of a few years), installed plants will have the opportunity to establish themselves and adjust to the hydrology of the area. Site managers will also be able monitor if the plants were installed in the right place. In the long term, a variety of habitats will be available and the system can adjust itself to a more natural succession of habitats.

Another important aspect to habitat mosaics is to incorporate buffers between developed areas and waterbodies, including streams, wetland and open water. The buffer areas should be vegetated to help stabilise shorelines, diffuse overland flows, trap gross pollutants and reduce sedimentation of the waterbody. Properly planted vegetated buffer strips have also been shown to considerably reduce contaminant loading of waterways (Miselis, 2009).

The Kapok project (introduced above) used habitat mosaics by incorporating a number of distinct areas within the project boundaries (Photograph 2). Specifically, the project includes open water, deep pools, low marshes, high marshes, overflow areas, transitional areas, upland areas and islands.

3.4 USE OF REFERENCE SYSTEMS

Appropriate hydrology and planting schemes will vary with local climate. Therefore, it is important to use reference systems when designing your project. Understanding the performance of similar existing systems near your project can help with establishing proper hydrology, plant selection and types of systems at the new project site.

It is important to get the right plant in the right place. Staff in government agencies and consultancies are available to assist you with designing your project’s planting scheme. A number of resources are also available on the internet. Good examples include Environment Bay of Plenty’s Wetland Restoration Guide (2007) and Environment Waikato’s Restoring a Wetland web site. When sourcing plants, be sure to use local nursery stock to help improve survival rates and enhance local biodiversity.

3.5 PRACTICAL CONSIDERATIONS

If a stormwater wetland is proposed, the designer should include a sediment sump and a skimmer to capture floatables prior to entry into the wetland. This is especially applicable if the discharges into the wetland originate in developed or paved areas. This reduces sedimentation of the wetland and retains floating rubbish within the sediment forebay for easy collection and disposal. While water quality benefits may be realised through the use of typical wet ponds, the vertical riser overflow structure with scruffy dome proves to be a barrier to fish passage. Accordingly, designers should consider alternate water control structures to improve fish passage. A number of design resources are available to address fish passage, for example the Auckland Regional Council’s Technical Publication 131 (2000).

Public access to completed sites should be encouraged and maintained. However, in order to address safety issues and to minimise impacts of the restored ecosystems, careful consideration of how this access is provided needs to be undertaken during the design phase of the project. Maintaining access is critical to generating public awareness of watershed issues. Furthermore, generating continued community involvement helps establish a certain pride and sense of stewardship of the completed project, which in the long run, will help ensure the continued success of the project.

4 OWNERSHIP AND STEWARDSHIP

Ownership of the stormwater and ecosystem restoration project needs to be clearly established early in the project. Typically the owners will be responsible for operation and maintenance requirements of the completed system. While owners are readily identified, stewardship of the project is often developed through good community relationships.

4.1 PROJECT CHAMPION

Often when identifying and organising the stakeholders, one project champion emerges from the participants. More than activists, project champions are the people that have a strong vision towards the overall wellbeing of the catchment. It often takes the tenacity and perseverance of a project champion to facilitate identification of project objectives, get the commitment of the stakeholders and landowners, seek the project funding and obtain the authorisations to see the project implemented. Project champions are often local or regional government staff, but have also been local residents with a strong sense of civic pride and duty. It is often the project champion that first identifies the specific needs of a catchment and the potential for improvements.

4.2 COMMUNITY INVOLVEMENT

Community involvement is critical to the success of a stormwater / ecosystem restoration project. This involvement needs to start at the project inception, be maintained throughout project development and be continued even after the project is finished.

Continued community and public involvement in the stormwater ecosystem project helps build a sense of ownership and fosters stewardship of the area. Often, members of the general public “adopt” sections of the completed project to look after. It is not uncommon to see some people out on their daily walks along waterways picking up bits of trash that may have washed up. They see the areas as part of their domain and can get great satisfaction and a sense of civic pride by keeping areas clean. Organised volunteer days can bring in hundreds of people to look after riparian areas, either through organised riparian planting activities or coastal cleanup days.

Keeping the community involved and informed can also help with maintaining good relationships between project sponsors and area residents. For example, in the case of the Kapok Wetland and Floodplain Restoration Project, a neighbour whose back yard abutted the project site was initially adamantly opposed to the project. He absolutely did not want this stormwater park in his back yard. As he gained understanding of the project goals through liaison with the project sponsors, the neighbour’s initial resistance changed. The neighbour has since become one of the most vocal proponents of the project.

4.3 MONITORING AND MAINTENANCE OF COMPLETED SYSTEMS

Monitoring and maintenance of the completed project is necessary to ensure that the project is working as planned. Successes as well as deficiencies need to be identified.

Newly planted vegetation may initially require periodic watering, so they will need regular monitoring until they are established. Consent requirements may also require monitoring of specific parameters. Monitoring reports should include success rates of the planted vegetation, monitoring of water levels to ensure proper hydroperiods, and monitoring of the site, especially near the inflow points for any erosion. Operation and maintenance (O&M) requirements of the completed system will depend on the system itself. Monitoring and management of pest plants and pest animals should also be considered part of the regular O&M scheme. Lessons learnt from one project need to be documented so that they can be incorporated into subsequent projects.

5 CONCLUSIONS

Traditional approaches to catchment management have often segmented projects into specific categories such as flood reduction projects, water quality improvement projects, or wetland restoration projects. The divided approach has certain applications, but a more comprehensive and holistic approach is to blend the three elements of water quality, flood protection and natural systems whenever possible. Accordingly, engineers, ecologists, landscape architects, land owners/managers and other stakeholders need to collaborate on the combined projects to achieve multiple benefits at one site. Additional benefits can be realised through community involvement from the inception of the project. Project objectives need to be plainly defined and should involve all the stakeholders to gain consensus. Understanding the water management issues within the catchment is also critical to defining the project goals. This includes understanding the hydrology of selected project sites. The project objectives should be clearly identified, realistic and measureable. Habitat mosaics need to be incorporated into the design to provide for diversity and flexibility. Monitoring of the completed project is necessary to identify what worked and what did not so that lessons learnt can be incorporated into the subsequent projects.

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