Sustainable Office Parks - Stormwater Case Studies

Processes and Design Considerations
By
Mary Myers, Ph.D. Acting Chair of Temple University- Ambler College Landscape Architecture – Horticulture Department

Fornebu, Norway: Stormwater as a central focal piece and recreational amenity

Astebol, Svein Ole, Hvitved-Jacobsen, Thorkild, and Oyvind Simonsen. July 2004. *Sustainable stormwater management at Fornebu—from an airport to an industrial and residential area of the city of Oslo, Norway.* Science of the Total Environment. Vol. 334-335. 1 December 2004. pp 239-249.

In 1998 Oslo, Norway's Fornebu airport (3.1 sq. km), was closed allowing for conversion to a new use. The land, which includes 7 km of shoreline on the scenic Oslo fjord, is proposed to be a residential and commercial development with 6,000 residences and 20,000 workplaces.

Photo of the Oslo Airport at Fornebu before closing (Photo: Fjellanger Widerøe AS)
Astebol, et. al. 2004

The stormwater objective of the project is to replace conventional urban drainage pipes with swales, filter strips, wetlands and ponds and use natural processes for treatment. The program for the project outlines ambitious environmental objectives for the development which included establishing residences around a centrally located park and *using stormwater as a central element within the park*. (*Italics* Myers.) The notion is to use the stormwater in open situations in order to increase its potential as a recreational amenity and focus, and also (in conjunction with vegetation) to increase biodiversity. In this last objective, the plan is similar to the Pittsburgh, PA and Ithaca, NY case studies included in this report.

Fornebu's planning team recognized that pollutant problems associated with stormwater from roads and urban areas impact plants and animal communities. Water quality was an important consideration and best available technologies (BAT's) were used to prevent unacceptable pollution of surroundings. (Although Fornebu was an airport with associative pollutants, such as oil, heavy metals and deicing chemicals, monitoring indicated that at least for the central area, pollutant concentrations in groundwater were not in excess of levels "typically found in urban stormwater (Astebol, et al. p. 244)".

Another goal is to maintain hydrological regime in sensitive natural areas and the use of natural conditions for flood control. A significant component of the plan is the use of vegetated areas to for transport, storage and flood control and the establishment of open drainage systems (swales, filterstrips, ponds). An overarching objective is to infiltrate storm water locally wherever possible.

<u>Stormwater Design</u>

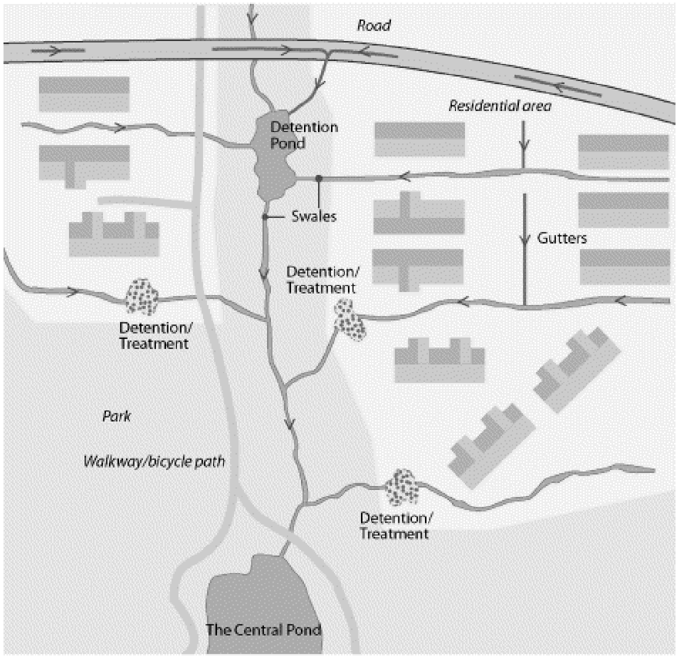
Two principles guided the stormwater design:

1. Vegetation is used as an important part of the stormwater system
2. As much stormwater as possible is managed on the surface (Astebol, et al. p. 249)".

In support of these objectives, Fornebu's master plan centers on a park containing a large pond fed by swales and other open systems, including open pond systems. Stormwater is transported in gutters in areas with hard surfaces and leads into grassy swales which in turn flow into main channels within the vegetated areas. Channels in green areas are designed as streams. (Astebol, et. al. p. 245). Concern regarding the appearance of the swales when dry (most of the time) resulted in keeping the dimensions small. Grassy covered dry detention ponds were designed with restricted outflow at the bottom so that the tanks are slowly emptied into the channel system after filling. Stormwater from impermeable surfaces is treated in wet detention ponds, swales and filter strips prior to emptying into the vegetated areas.

The authors acknowledge that the open solutions face challenges during winter when ice can block discharge from the hard surfaces and gutters ice over. Special measures would be needed to keep the channels open (the authors did not specify what these measures might be).

A large vegetated area is situated around the open water features as a buffer during extreme flood events. Channels were designed for a 1 year storm for channels and 20 year storms for detention pond systems (calculations based on 1967-1996 rainfalls).



Stormwater Layout for Fornebu showing large central pond, detention treatment ponds near road and roof areas, open channels and central pond (Åstebøl , et.al., 2004)

The large central pond is designed to look like a lake. Its main challenge will be eutrophication which is partly compensated for by providing adequate size and depth (unspecified). The critical aspect noted by the authors is the effect of oxygen concentration upon aquatic life. The designers proposed aerating the pond during summer and also establishing rooted aquatic plants that compete for nutrients with algae.

The central pond outflows into an open channel within a green corridor in a protected area prior to emptying into the fjord.

The authors claim "The solution has clear advantages compared to a conventional system in …(that): pollution is removed and retained, the ecological value of the urban area is improved, sensitive downstream areas (wetlands) are protected, and open water surfaces have a positive effect on recreation and outdoor well-being (Astebol, et.al., p. 255)". The authors calculated that the surface based storm water design would cost 30% less than traditional piped solutions to build, and would cost about the same to maintain/operate.

Guidelines and regulations for fertilizers and pesticides

Fornebu is in the process of developing regulations for fertilizer and pesticide applications in its public park. The regulations will also be relevant for private property. Car washing, oil leakages are also regulated along with construction materials and outdoor structures whose materials, such as copper plated roofs which lead to high copper concentration in the run off will also be regulated.

The identified objectives for Fornebu's stormwater were:

- "utilize the stormwater runoff as a resource in green areas for increased well being, recreation and biological diversity (a water-in-city concept)
- Reduce stormwater pollution loads and observe water quality standards in downstream located green areas as well as protect biota in two important designated wetlands
- Develop a cost effective drainage system
- Establish a system that can manage the normal wet weather situations as well as flood events (Astebol, et al. p 240)".

North Rhine, Germany: the need to calculate water budget

Gobel, et.al. (2004) *Near-natural stormwater management and its effects on the water budget and groundwater surface in urban areas taking account of hydrogeological conditions.* Journal of Hydrology, Vol 299, issues 3-4, pp 267-283.

This case study published in 2004, focuses on the possibility that surface storm water infiltration may cause rising groundwater tables in urban areas. The study utilized computer modeling to simulate groundwater conditions and found that "both precipitation and infiltration rate are the most influencing factors concerning groundwater surface. ..problems have to be expected in areas with low hydraulic conductivities (Gobel, p. 267)."

Gobel, et al, (2004) identify near natural stormwater management's aim as delaying surface runoff mainly through temporary storage in soil or on a green roof. The precipitation is considered as three parts: one part evaporates via soil and plants, one part is added to groundwater for recharge and one part is drained off after being detained for a period. The study discusses North Rhine, Westphalia's (Germany) mandate that property owners infiltrate any stormwater occurring on their land, to use for irrigation or to discharge locally into water courses. There are cost savings in reduced sewage pipes and treatment costs. Further, the authors point out that the retention effect of the soil or infiltration installation, "runoff peaks can be stored on an interim basis on the spot" reducing floodwater runoffs into water courses. If ground water recharge is increased in paved or sealed areas, the low water runoff into water courses is increased with greater evaporation when rainwater infiltrates through vegetated surfaces. (Gobel, p. 268).

The authors recommend calculating the water budget to ensure adequate, sustainable depths to ground water table. The water budget of an area "is characterized by a balance between the stormwater arising, the evaporation, the surface runoff and the groundwater recharge (Gobel, p. 170)." The authors are concerned about urban areas which are highly covered, in their terms "sealed" from infiltration. In Germany 12.3% of the total land area is sealed. "Complete infiltration of this surface runoff (from the sealed areas) through stormwater infiltration installation increases the amount of new ground water formed. It may even rise above that for the natural unsealed state. If stormwater infiltration is applied to whole sections of roads or urban districts, the result may be a rise in the groundwater surface in the relevant influence areas (Gobel, p. 170)." This in turn could cause basement subsidence or buoyancy of buildings and mobilization of contaminants or pollutants form contaminated sites.

Earth Centre, Doncaster, UK: 400 acre model of sustainable design
Epstein, Dan (2001) 'Éarth Centre and Global Issues'. *Sustainable Development International.* P.27 – 31.
Bush, Helen. (2000) 'Earth Centre: an International Centre for Sustainable Development and Living.". http//www.eaue.de.
European Environmental Press. 2000. "Conservation of Europe's Water". http//www.eep.org

Earth Centre, located in South Yorkshire, England was built as a demonstration model of sustainable design. It was financed primarily by the UK Millennium Commission (50 million pounds, with 14 M. coming from other sources). Construction began 1997. Epstein (2000) states that Earth Centre "was and is intended to be a major public resource for sustainability…a living laboratory where sustainability is brought together, explored and presented in one place in practical, tangible and inspiring ways (Epstein, p.28)." It was intended to attract tourists, especially families, schoolchildren, designers and developers.

The 400 acres was the site of two colleries (Denaby Main and Cadeby) which operated from 1870 until 1986. Reasons for selecting this location included economical land purchase; desire to assist the depressed economy of the region which had seen a general decline in heavy industry and loss of thousands of jobs; location within easy reach of millions of people; and easy access to multiple modes of transportation (auto, rail, bicycle and foot.). People using less polluting forms of transit, such as rail, foot or bicycle receive a 40% discount on their entry ticket. I visited the site in March 2002 as a conference attendee.

Living Machine at Earth Centre, Photo on left – Bill Thompson, *Landscape Architecture Magazine,* p.68. Photo on right, M.Myers

One of the most relevant aspects of Earth Centre for Fort Washington Office Park is its approach to wastewater. The goal is to treat all wastewater on site through biological processes and to conserve water. Toilets in the conference building use a low pressure vacuum system which moves waste through the pipes very quickly—effectively scouring the pipes. A minimum amount of water is needed to flush the toilets—about 10% of that of a conventional system. (Bush, p.2). A Living Machine treats water from toilets, basins and kitchens through a series of settling and filtering processes which employ bacteria and plants. After most solids are settled out in an underground tank, sewage water is filtered through a series of eight tanks, a biofence and wetland prior to being re-used as irrigation water for the adjacent vegetable and flower gardens. The sewage system is set up to clean the waste of 3,000 inhabitants—the size of many small towns or villages in England.

Fibrous roots of plants (both tropical and indigenous) provide a surface area for the bacteria to cling to. About 10% of the cleansing work is done by plants, 90% by the bacteria. A diverse root system is very important. Open aerobic tanks use air diffusers which aerate the water for the aerobic bacteria and keep the solids moving. Fluid is then disinfected with ultraviolet light and moves into the visually attractive bio fence. The bio fence (designed by John Mortimer) uses bacterial nutrients and light to produce algae—hence the bright green color of the fence. The algae consume the remnant bacteria in the wastewater before it passes to the wetland. The water in the wetland is combined with water from the Don River to be used as irrigation. There was no detectable odor in any step of the process when I visited Earth Centre. The Living Machine appears to be a greenhouse filled with plants and edged with gardens. The storm water wetlands are designed as attractive bogs. The aesthetic appeal of the project is one of its great successes.

Photo on left – Children in vegetable garden near living machine learn that waste = food
Bill Thompson, *Landscape Architecture Magazine.* Photo on right – biofence developed by John Mortimer Algae is separated from the water at the end of the process in another settlement tank and used as manure in the gardens. http://home.bt-webworld.com/cellpharm/products.htm

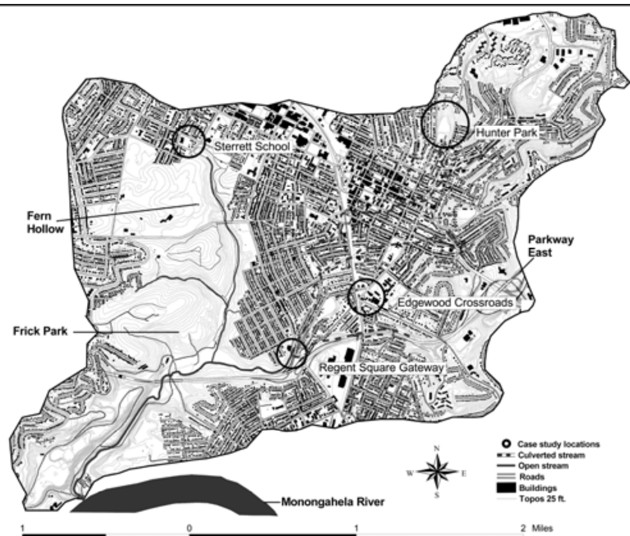
Unfortunately, despite serving as an excellent model of sustainable design and providing about 100 jobs, Earth Centre never apparently gained wide acceptance by the local inhabitants. I speculate that a reason for this might be that the design does not reflect the proud mining history of the town. When I visited Earth Centre in 2002, there was virtually no evidence of the cultural heritage of the mines. The pits were sealed off and planted over with minimal signage. Over 100,000 quick growing trees (Willow, Alder, Birch) were planted to improve the contaminated soils. Visual links to the natural context, such as the River Don and Pennine Hills are strong but cultural links to the nearby town or former mine are weak.

Nevertheless, Earth Centre's design is unique in many regards. It contains many gardens, including vegetable gardens; places for children to interact with natural habitat; farm animals, a museum, large solar canopy which provides energy for the café and conference center. Biodiversity has increased due to habitat restoration and the creation of *new* (*Italics* Myers) habitats, such as wetlands, meadow and woodland. According to Bush, at the time it was developed, Earth Center was one of only 25 Living Machines in the world. It serves as an example of how to create clean, useable water from waste through biological processes.

Pittsburgh, PA: design strategies and policy approaches for an urban watershed
Pinkham, R., Collins, T., (2002) "Post-Industrial Watersheds: Retrofits and restorative redevelopment (Pittsburgh Pennsylvania) in France , R.L., (ed.) *Handbook of Water Sensitive Planning and Design.* Lewis Publishers, London

The "Post-Industrial Watersheds" study describes the process (and results) of design charette for Nine Mile Run, an urban watershed in Pittsburgh, PA. In 1993 the Pittsburgh City Planning Commission proposed culverting the stream which drains 5 municipalities and ultimately draining into a 240 acre brownfield. The brownfield, located in the lower floodplain of the creek, is slag detritus from the steel manufacturing industry. Carnegie

Mellon University STUDIO for Creative Inquiry and the Rocky Mountain Institute responded to the proposal by developing a series of charettes (1997-98) to encourage public dialog on the project and to propose alternative strategies. The final charette included landscape architects, engineers, architects, artists, planners and policy analysts, as well as local citizens. Measures to retrofit streets and properties in the upper watershed resulted to "infiltrate, detain and treat runoff…and to develop policy action plans (Pinkham and Collins, p.4)."



Four sites within the Nine Mile Creek, Pittsburgh, PA watershed. "Additionally, urban forest through the watershed is increased in order to "reduce runoff, moderate urban climate, improve air quality and reduce noise. A dense vegetative structure, such as trees, shrubs, and native ground covers, absorbs more rainwater than a turf slope and is more resistant to erosion during intense storms (Pinkham and Collins, P. 15)."

Four sites were designed which adapted techniques, construction and stormwater management to the local fine textured soil and unstable geology. Two year - 24 hour storm data, within a construction budget of $2/gallen of hydraulic capacity were used as a basis for infiltrating and detaining site runoff. General storm water approaches that were used on several of the sites included:

- "Capturing roof runoff in tanks or cisterns for irrigation
- Disconnecting pavement and roof drainage from sewer lines and directing it to adjacent vegetated soil or to infiltration basins
- Engineering infiltration basins –water gardens, dry wells and subsurface recharge beds
- Planting trees
- Rehabilitating soils to increase infiltration rates and pollutant neutralizing microbial activity
- Reconfiguring drives, parking lots and streets to increase pervious, vegetated soil
- Using porous pavements
- Routing runoff through vegetated surface channels "swales" to slow velocity, remove pollutants and infiltrate into the soil

- Daylighting historic streams by excavating culverts and creating naturalized open channels (Pinkham and Collins, p. 7)

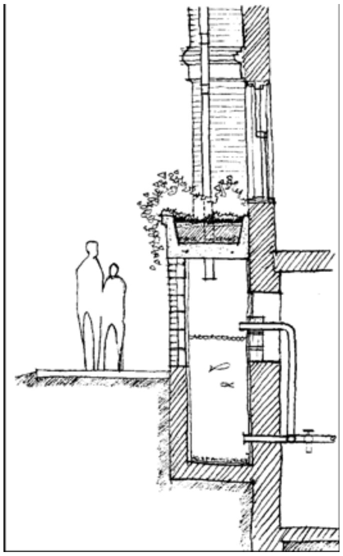
Two approaches which are particularly relevant to Ft. Washington are: using and celebrating storm water through creative design that goes beyond conventional bmp design; and using an ecological approach to vegetation.

Public education through artful design

In a dense suburban situation of high visibility an educational piece was developed. A bowl shaped amphitheater with a porous block bottom retains and infiltrates storm water.

The demonstration infiltration basin station. The basin provides a community gathering place. During large storms, it captures runoff, which percolates into the subsoil within one to two days. (From Ferguson, B.K., Pinkham, R., and Collins, T., *Re-Evaluating Stormwater: The Nine Mile Run Model for Restorative Redevelopment,* Rocky Mountain Institute, Snowmass, CO, 1999.)

During rainfall, the depression diverts flood waters off the street and surrounding plaza, fills and then slow drains over a 1-2 day period through an infiltration bed beneath the plaza. On dry days, the plaza is a communal gathering spot. Another creative design uses visible cisterns within transparent water walls on the outside of buildings to demonstrate the flow of roof water through vegetation and into chambers which ultimately empty back into the buildings to be used as gray water.



Cisterns for collecting roof waters in the form of a transparent "water wall" alongside the Sterrett school building.(From Ferguson, B.K., Pinkham, R., and Collins, T., *Re-Evaluating Stormwater: The Nine Mile Run Model for Restorative Redevelopment,* Rocky Mountain Institute, Snowmass, CO, 1999. With permission.)

Additionally, urban forest through the watershed is increased in order to "reduce runoff, moderate urban climate, improve air quality and reduce noise. A dense vegetative structure, such as trees, shrubs, and native ground covers, absorbs more rainwater than a turf slope and is more resistant to erosion during intense storms (Pinkham and Collins, P. 15)."

The following design strategies may be very helpful in considering an approach to Fort Washington Office Park:

- "*Make components multifunctional.* For instance, storm water has traditionally been moved off city roofs and streets through a single purpose system of underground pipes. Instead it can be kept on the surface, recreating a creek that was lost, or infiltrated into the soil to recharge the groundwater and nourish vegetation –in either case providing ecosystem benefits such as wildlife habitat and stream baseflow support, human benefits in experience the beauty and wonder of natural systems and financial benefits in reduced municipal costs of maintaining hidden infrastructure.

  Whenever an important component of a project appears to be an undesirable 'cost', seek ways to shape it so that it acquires additional desirable benefits.

- *Use every square inch.* The solution to a watershed wide problem has to be onsite, on every site, because there is nowhere else to go. Every square inch of a retrofit project.. should be used for positive, multiple functions. The cumulative community benefits are enormous.

- *Use freely available natural processes.*

> Freely available natural processes are capable of working of the great benefit of a watershed restoration. Vegetated soil absorbs rain water and the chemical and microbial processes of these will capture and degrade most pollutants that may be present. The infiltrated water recharges groundwater tables and restores flows to streams. These processes reduce peak flows and erosion, eliminate sewer overflows, prevent and mitigate pollution and sustain watershed ecosystems…This is a 'smarter, cheaper' approach to infrastructure because it puts nature to work and reduces the work humans must do…(Pinkham and Collins, p.26)."

Policies resulting from the charrette included (among others):

- "Establishing a permanent coordinating body with the authority and financial security to plan and maintain the watershed's interrelated infrastructure, natural processes and urban water use., seek ways to shape it so that it acquires additional desirable benefits.

- Restore the watershed's hydrologic and ecological processes in a manner that utilizies and supports infrastructure rehabilitation and community redevelopment—including restoring natural stream, wetland and forest habitats in critical areas (Pinkham and Collins, p. 22)."

These management bodies should also be considered for Fort Washington Office Park to follow up on the strengths and weaknesses of the design strategies, to inspect, maintain, and if necessary, adjust and improve the storm water design.

U.S. Environmental Protection Agency's Green Campus, Research Triangle Park, North Carolina
US Environmental Protection Agency. November 2001. *The Greening Curve: Lessons Learned in the Design of the New EPA Campus in North Carolina.*
http://www.epa.gov/rtp/ems/emps.htm

The campus of the Environmental Protection Agency in the Research Triangle Park, Raleigh-Durham, North Carolina was a brand new campus on a "virgin" site. The original program called for over 1,000,000 square feet of building and parking for 2,500 cars on a 65 acre site. Upon evaluation of the environmental impacts of the campus, adjustments were made to reduce the parking requirements and the site was enlarged to 133 acres. These measures were part of a conscious effort to be an example of environmentally sensitive design.

EPA Campus, Research Triangle Park, Raleigh Durham, NC (http://www.epa.gov/rtp/ems/emps.htm)

The site was an undeveloped tract of abandoned farm land which had evolved into a pine/hardwood forest and wetlands. It was the agency's desire to minimize disruption of the existing ecosystems while accommodating the needs of the building and sitework (EPA, p. 38). The Agency "believed that its facility could be come a functional model for the greening of other public and private sector facilities and help advance sustainable design and construction as an industry-wide practice (EPA, p. 22)."

An important aspect of the process was the clear articulation and integration of environmental goals as *project requirements* (*italics* Myers). This allowed environmental goals to permeate and guide the design process—a relatively unusual approach for an American office park at the time (mid 1990's). An example of adjustments made to reduce site disruption was the increase of building height from 3 to 5 stories in order to reduce site coverage. Road width was narrowed from 4 lanes to 2 lanes to preserve trees and minimize grading and impervious cover. (This measure also saved money.) Traditional curb and gutter design was replaced with BMP's such as grassy swales and bio-retention. Each decision required the design team "to challenge components of the original design criteria (EPA, p. 38)."

Alternative design studies illustrated impacts. For example, an all surface parking approach would have covered an additional eight acres and required greater clearing of the forest and disruption of drainage patterns and wetland. A compact design using a combination of parking structure and surface parking had financial costs but environmental benefits. Some fire lanes were designed using permeable grass pavers, rather than standard paved road way.

Improving water quality-
The EPA was concerned about water quality. The pre existing lake and wetland areas served as "features to control runoff and filter contaminants (EPA, p. 41)." Additionally, a new pond and ten biofiltration sites for stormwater retention, sediment collection and filtration (before water was released down stream) were built. (Bioretention is defined by

the EPA as “a depressed, heavily vegetated area using plants and soils to remove pollutants from stormwater runoff. Various physical and biological processes including absorption, transpiration, filtration and decomposition occur in the root zone to improve water quality (EPA, p. 43).”

Native plants and adapted species were used in landscaping in order to reduce the fertilizer/herbicide applications.

Incentives for carpooling and mass transit were incorporated to reduce airborne hydrocarbon, particulate and heavy metal (Mercury) contaminates. Surface parking was also reduced in order to decrease the amount of paved areas draining to creeks. The EPA considered use of oil-grit separators to capture contaminates and pre-treat surface water prior to its leaving the site. However, bioretention ponds and bioswales were viewed as cheaper and more effective water treatment strategies, with higher contaminant removal efficiencies and lower maintenance. “Grassy swales were used to encourage runoff to ‘sheet flow’ over vegetated areas, naturally filtering contaminants suspended in the runoff as the water passes through the vegetation and percolates through the soil…Curbs and gutters were still used in small areas where absolutely necessary to prevent extensive tree clearing or to control traffic…Bioretention areas use subsurface compost and plantings to accelerate the filtering of contaminants. (EPA, p. 42).”

<u>Landscape</u>
New plants were either native or adaptive species that could survive the local climate, soils and water availability. The use of adaptive species reduces the need for pesticides, herbicides, fertilizer and irrigation. Fifteen acres were planted with wildflowers and native warm season grasses instead of the traditional lawn associated with office park campuses. This low maintenance alternative is more diverse than lawn and more supportive of wildlife habitat.

The EPA used the National Pollutant Discharge Elimination System requirements as a standard for discharge. NPDES permits are required for construction sites larger than 5 acres in size.

The EPA lists the following as key issues to consider for stormwater design:

- “Work with natural drainage systems
- Minimize the use of impervious paved surfaces
- Plan on-site stormwater retention where natural filtration is insufficient
- Protect existing water sources from soil erosion and other sources of contamination
- Maximize use of passive and natural methods for treating stormwater, such as sheet flow across vegetated areas and bioretention (EPA, p. 42).”

The EPA took a comprehensive approach to the design and environmental impacts of its new campus by measuring its ecological footprint and then developing measurable goals for reducing the footprint.

Footprint
Consumed >620 Billion BTUs of Energy (FY03)
The annual equivalent of ~ 6,970 average NC homes

Used 2,656 Boxes of Paper from Store Stock (FY03)
A stack of paper ~1 mile high
Does not include paper purchased by Credit Card holders from non-EPA sources

Commute Over 7,000,000 Miles Annually
~300 times around the earth
~4% of employees use TTA/van pool
~6% of employees car pool

Generated ~98.5 Million Gallons of Waste Water Contaminated with Trace Amounts of Mercury (FY04)

Environmental management programs (EMPs) to reduce the campus' impact:

Paper use
O/T - 5% reduction per year for 5 years in paper used from store stock based on the FY04 base line

Energy use
O/T - Main Campus: 20% reduction from FY04 base line in 3 years
O/T - Human Studies: 10% reduction from FY04 base line in 3 years

Waste water contaminants (Mercury)
O/T - No permit violations

Fuel use/vehicle emissions
O/T - 100% increase in car/van pooling and TTA participation over FY04 baseline in 2 years
O/T - 100% replacement of existing GOV fleet with "green" vehicles (alternative fuel/hybrids) in 5 years

developed an EMP to increase:
Green Purchases
O/T - 100% "green" purchase (where options exist) in 3 years of the top 10 commodity items purchased in RTP"

(EPA, 2001)

Bioretention as a site amenity and for wildlife habitat
Laboratory and parking lot design, Cornell University
France, Robert and Craul, Phillip (2002) "Retaining water: Technical support for capturing parking lot runoff (Ithaca, New York" in France , R.L., (ed.) *Handbook of Water Sensitive Planning and Design.* Lewis Publishers, London

Robert France teaches landscape ecology at Harvard. Philip Craul is a well known soil scientist. This case study emphasizes the role of expert advice (from the likes of hydrologists, ecologists and soil scientists) as a foundation for landscape architectural design. The design of a bioretention-wetland system to treat parking lot runoff and also serve as a recreational amenity is the focus of the work.

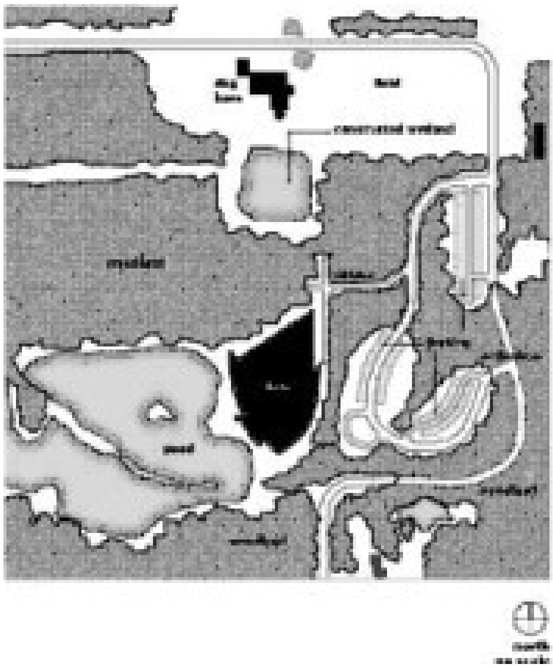
The authors quote an earlier study (Bannerman and Dodds, 1992) in pointing out that runoff from commercial and industrial parking lots "accounts for one fourth to two thirds of the suspended solids, total phosphorous, total copper and total zinc loads for the commercial/industrial areas studied (France and Craul, p.2). " Another important point is that the first portion of a storm cycle has the greatest impact upon water quality and therefore it is important to treat the first flush of runoff, close to its source. "The more distant runoff treatment efforts are placed from the source, the more effort in terms of cost and maintenance is required to operate them (Richman et.al., 1997 in France and Craul, p.2)."

France and Craul (2002) propose the following strategies to stormwater management:

- "Minimization of directly connected impervious areas
- Maximization of permeability
- Employment of access streets
- Plans for alternative modes of transportation
- Integration of drainage systems with natural landforms and topography (France and Craul, P. 2)

The authors recommend integrating drainage and filtration considerations in the initial stages of a design, as was done in the Fornebu case study. This saves money by reducing earth work and also promotes and aesthetically pleasing, multi functional design (i.e. recreation, drainage, landscape restoration).

A twelve acre site in Ithaca, NY, including a manmade lake, barn, and fire pond was designed as Ornithology Lab with a new building and parking for 190 cars. The design included vehicular/pedestrian systems, stormwater management areas, and the design of soils and plantings for wetland mitigation and bioretention areas. All runoff from the built areas (building and parking lot) is filtered through bioretention swales that flow between "islands" of parking that are surrounded by wetland. These new treatment areas are also meant to double as wildlife habitats. Plants and soil in the swales will remove contaminants from the parking lot runoff. Cleansed water then flows into a 1.5 acre wetland and thence to the existing lake.

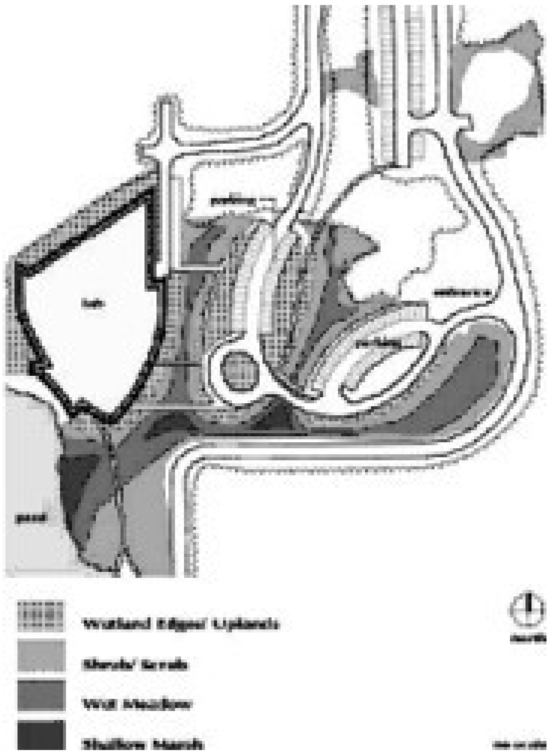


Schematic design plan showing intended site development. (Adapted from preliminary design plans by Susan Childs Associates.) Francis and Craul, p. 6

The bioretention swales were designed for 2 year-24 hour design storms of 3”. The authors estimated that 24,000 square feet of bioretention area would be required for storage. Their site plan allowed for triple that amount, 77,000 ft 2 of combined bioretention and wetland which would allow runoff form the design storm to spread out to a depth of 1 inch—virtually eliminating flooding.

The landscape architects chose plant species for the bioretention and wetland areas that ware able to withstand flooding and provide phytoremediation of contaminants. Lists of potential species from the Prince Georges County Guidelines (1993) were reviewed with lists of native wetland plants for New England to “select the mesic species known to thrive in this north-temperate bio-region (Frances and Craul, p 10).” Since the design was for an ornithology lab and bird sanctuary, priority was given to species attractive to birds.

The site was divided into four zones: shallow marsh (Sweet flag, water plantain, sedges, turtlehead, arrow, pickerel weed, skunk cabbage); wet meadow (Speckled alder, red chokeberry, silky dogwood, redosier, winterberry, marsh marigold, joe pye weed, cinnamon fern, common cattail, blue vervain); shrub/scrub wetland (red maple, larch, white oak, river birch, American cranberry, cranberrybush viburnum; and wetland edge/upland (Red maple, Black gum, white pine, shadblow, sweet pepperbush, witch hazel, blueberry).



“Detailed schematic site design plan showing new ornithology laboratory building and parking lot “islands” surrounded by bioretention swales and treatment wetland. (Adapted from preliminary design plans by Susan Childs Associates.) Dark gray = shallow marsh; medium gray =wet meadow; light gray = shrub/scrub wetland; and stippled area = wetland edges and “island”uplands. (Francis and Craul, p. 8).”

<u>Definitions of stormwater management techniques (from Francis and Craul, p.3)</u>

- Extended detention ponds: ponds detaining stormwater runoff for a short period of time, allowing pollutants to settle out.
- Stormwater wetlands: Constructed, shallow pools supporting the growth of wetland plants and maximizing pollutant removal through plant uptake.
- Infiltration swales and basins: Shallow trenches lined with porous material enabling the filtration of cleansed stormwater into the water table.
- Multiple-pond systems: combining a variety of pond designs such as extended detention, permanent pool, shallow wetland, and infiltration, providing reinforcement of pollution removal abilities
- Sand filters: divert the first flush of runoff into a sand bed, at which time the filtered water is collected in an underground drainage system and conveyed to a stream or water body. This method is particularly well suited to treat parking lot runoff.
- Grassed swales: collect and filter runoff in concave earthen depressions, frequently used to remove pollutants
- Filter strips: level vegetated strips of land intercepting overland sheet flow running off from development areas—not especially effective in treating high

velocity runoff and should be used in conjunction with other management techniques or in low density development areas.

Definition of Bioretention

Bioretention is a method to manage and treat stormwater runoff by using plants and a conditioned planting soil bed to filter runoff temporarily stored in shallow swales. Water purification occurs through both physical filtering and biological (plant and microbe) uptake processes. (Francis and Craul, p.3)

Maintenance concerns:
Bioretention swales and retention basis both require inspection on an annual basis and after each major storm event the first year. (Francis and Craul, p.3)

Relevance of the case studies to Fort Washington Office Park Redesign

Storm Water Implications
Fornebu's plan and program allows for a completely new and ecologically based approach to a damaged site. Fornebu is similar to Ft Washington Office Park in that it proposes to mix uses and accommodate a variety of strategies to improve water quality downstream. It proposes to regulate onsite fertilizer, pesticide applications and to regulate car washing and oil leakages associated with transportation. FWOP might consider "Self regulatory" ordinances, at the very least in its common areas.

Many of the case studies, including Fornebu, Norway, Nine Mile Creek, Pittsburgh. PA and the Ornithology lab, Ithaca approach storm water design at a multi functional level, viewing storm water as a potential recreational, aesthetic and ecological asset to be celebrated. This design approach stresses visibility of stormwater and the idea that wherever possible, the hydrologic cycle should be honored. Rain and snow should enter streams both directly and laterally via slow infiltration through soil. Precipitation should feed vegetation and then be transpired back into the atmosphere. Wherever possible, stormwater and its processes should be visible and understood by the occupants of Ft. Washington, as well as the public in general. It could become a regional or national model of retrofit design.

Design strategies might include:

- Stormwater treated as an amenity for the office park. Instead of shunting it offsite via an expensive (and invisible) underground system of pipes, storm water could become a visual asset. Green bioswales and roofs, interconnected ponds and cascading waterfalls are some of the landscape amenities that celebrate, detain and conduct stormwater. These "green" amenities would replace some of the vast expanses of parking comprising the current landscape experience of FWOP.

- An internal walking-bicycle loop associated with the storm drainage comprised of mini-greenways (such as bioswales) and including overlooks and connections to Sandy Creek. Such a loop could link offices and internal restaurants with plazas (such as the amphitheater in Pittsburgh) and accommodate a pleasant walking experience amidst greenery.

- External connections linking to the nearby residential and town areas and encouraging visitors—especially pedestrians and bicyclists—into the office park should also be considered in conjunction with the stormwater design. The residential edge has potential for landscape or ecosystem restoration as it is a large wooded zone. The edge has traditionally been viewed as separating or buffering FWOP and adjacent neighbors. It ought to be viewed as uniting them via a shared park or greenway.

- Public and occupant education via artful display of stormwater, in cisterns, walls, bioswales, ponds. Unobtrusive educational signage might be included, i.e. (within pavement—or at the edge of new plantings).

Follow up management and monitoring are employed at the EPA campus and other sites. Monitoring of water quality, as well as, flora and fauna in the stream/ storm water corridors, informs maintenance and allows for understanding of the design's hydrologic and biological functioning. Long term monitoring should be incorporated in FWOP's plan for future development. Short term, regular monitoring is essential for any storm drain system, FWOP will be no exception.

Measurable goals for pollutant reduction and water quality improvement and working *back* from those goals is a logical approach that was employed by the EPA Campus. That campus measured its 2003 ecological footprint and set targets for reducing the footprint. While the goals were not specific to stormwater, the approach is transferable to water concerns. FWOP could establish measurable goals as to the percentage of environmental improvement it wishes to undertake, (i.e. improve water quality of water leaving FWOP to enter Sandy Run Creek 25% over 2007 level; increase site biodiversity 30% above 2007 level; reduce water leaving the site by 50%, reduce flood damage to existing FWOP buildings and roads by 50%, and so on.). Such goals could guide design strategies in a logical way.

Acceptable aesthetic appearance based upon proper design and effective maintenance is critical to local acceptance. FWOP should address storm water as an open space amenity to be integrated with other open space uses, such as transportation.

<u>Waste water Implications</u>
Earth Centre's small scale biological approach to treating waste water should be considered if FWOP decides to change its sewage treatment plant. Earth Centre uses bacteria and plants to clean water in a greenhouse like environment. Water is then exposed to UV light, algae (in the biofence) and directed to a created wetland. From there it is clean enough to be used for irrigation (on food crops) or sent into the local river. The

system requires a plant manager and at least one other staff member to monitor and adjust the system as needed. It is a matter of observing and understanding the biological processes and ensuring that the water at the “end of the line” is sufficiently clean. Such a system served as visitor draw to Earth Centre and could be used as an educational/promotional component of the office park. The greenhouse environment could be developed as a café and winter amenity with appealing horticultural displays. It could also serve as a means of bonding with the community by demonstrating environmental responsibility. Staff could provide tours to local school children and planning officials.

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