A WINNIPEG CONSTRUCTED WETLAND: INCITING CURIOSITY, FACILITATING LEARNING AND FOSTERING ENGAGEMENT

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ABSTRACT

In urban areas, traditional lake-style retention ponds do little to remediate pollutants such as sediments, pesticides and fertilizers contained in stormwater. As an alternative, some neighborhoods now feature naturalized constructed wetlands, often located in large open public spaces such as schoolyards. These settings can offer opportunity for physical engagement and education.

Can these constructed wetlands function both as stormwater detention facilities and outdoor classrooms? If teachers can foster engagement and curiosity, learning becomes intrinsic - an end in itself rather than a means to short term reward. Landscapes can be a means to this end, providing open-ended and meaningful learning opportunities that can inspire children to learn, play and discover.

The intent of this practicum is to redesign an existing, lake-style retention pond adjacent to a south Winnipeg schoolyard, integrating ecological, recreational and educational functions. The pond will be transformed into a functioning wetland ecosystem, community amenity and outdoor classroom.

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Winnipeg has more than 90 stormwater retention ponds covering over 160 hectares of land. These ponds have the potential to be key players in reducing nutrient loads in Manitoba's rivers and lakes. Unfortunately, only a handful of ponds are designed to sequester significant amounts of nutrients and other pollutants. In their report to the Minister for Water Stewardship, the Lake Winnipeg Stewardship Board recommended, "all new stormwater retention ponds should be designed to maximize nutrient retention without compromising stormwater management needs"(Lake Winnipeg Water Stewardship Board 2006, p.8).

In addition to their stormwater management functions, retention ponds have the potential to act as community amenities and educational resources. As Carr and Lynch (1968, p.1283) argued, "act[ing] experimentally and see[ing] the results of those actions is the most effective way to learn". They posited that this engagement is more likely in the "spatial environment" rather than in an institutional setting. Similarly, in his influential 1938 book Experience and Education", educational theorist and author John Dewey argued for the benefits of engagement and experiential learning, proposing that it is the responsibility of educators to provide conditions that foster experience and exploration (Dewy 1998,). Although in Winnipeg's naturalized stormwater retention ponds, considerable design effort has been put forth to create functional wetland systems, little effort has been made to engage users in a wetland experience. Typically, pathways skirt the upland slopes and a solid ring of vegetation prevents any access to the water. How can naturalized retention ponds function as stormwater detention facilities, community amenities and outdoor classrooms?

The intent of this practicum is to redesign an existing, traditional lake-style retention pond adjacent to a schoolyard in south Winnipeg, integrating ecological, recreational and educational functions. The pond will be transformed into a functioning wetland ecosystem, community amenity and outdoor classroom and may serve as a model for other stormwater retention ponds. This school ground wetland will be a place of engagement and education.

Because of its sheer number of retention ponds (many of which are on or near school sites), Winnipeg is an excellent location for this project. Projects with similar scope could be executed in dozens of sites across the city. Stormwater is a particularly important topic in Manitoba. In fact, the Lake Winnipeg Stewardship Board recommended that Lake Winnipeg and its watershed's health issues should become a mandatory component of the provincial school curriculum (Lake Winnipeg Water Stewardship Board 2006).

This first chapter of this document will present background information summarizing the various stormwater-related issues facing the city of Winnipeg and the province of Manitoba, including the condition of Lake Winnipeg, the effects of urban stormwater and the problems associated with Winnipeg's current retention pond models. A description of naturalized stormwater retention pond design best practices and the processes at work within them will follow this summary. Planting strategies will then be examined, not just for optimum wetland function but also for habitat creation. Finally, Chapter 1 will examine the viability of retrofitting existing riprap-lined retention ponds. This background information will provide the rationale behind the site design described later in Chapter 5. The second chapter will examine the importance of outdoor education. This examination will include a look at some of the evidence showing the positive effects of utilizing outdoor learning and play, as well as a synopsis of various educational models and theories pertinent to the idea of fostering engaging educational experiences. Having established the benefit and need for engaging outdoor spaces, Chapter 3 will look at several successful precedents. A conscious focus by the designers in developing a layering of functions and activities is key to creating dynamic and open-ended outdoor learning environments. Lessons taken from these projects will be incorporated into the site design that is the focus of this practicum, starting with a site analysis in Chapter 4 and a full description of the design in Chapter 5.

CHAPTER 1: Background - stormwater treatment and habitat creation:

Lake health issues facing Manitoba

The effects of excess nutrients in Manitoba's Lakes, particularly Lake Winnipeg, have been well documented. In February 2003, the Province of Manitoba introduced an action plan to address the threat of increased nutrient levels in Lake Winnipeg. This plan included a goal of reducing nitrogen loading by 13 per cent and phosphorus loading by 10 per cent. It also included the creation of the Lake Winnipeg Stewardship Board. Gathering input from scientists and stakeholders, the board released a comprehensive report in 2006, containing recommendations in 32 key areas affecting the health of the lake (Lake Winnipeg Water Stewardship Board 2006). Despite these recommendations, Lake Winnipeg's condition is "far worse" than the state of the Great Lakes during their pollution crises crisis in the 1960's (Rumble 2011).

The causes of Lake Winnipeg's problems are numerous and complex. A decrease in nutrient outfall due to hydro-electric power generation, changes in the structure of Delta Marsh (the 19,000 hectare marsh described as the kidneys of Lake Winnipeg (Goldsborough 2015), reduction in plant diversity caused by invasive species, and agricultural runoff and nutrient input from stormwater and sewer systems have all contributed to excessive algae blooms (News Room. Market Wired 2013). The City of Winnipeg has been a major source of pollutants – mostly in the form of phosphorous and nitrogen. A 2003 study found that Winnipeg accounts for 8% of all phosphorous and 11% of all nitrogen loading into Manitoba's rivers and streams. (Cowan 2003). Much of this nitrogen and phosphorous ends up in Lake Winnipeg and much of it comes from urban stormwater. Can the city's new and existing stormwater infrastructure help mitigate its damaging effects on Lake Winnipeg?

The effects of urban stormwater

As urban areas develop, replacement of natural vegetation with more impermeable surfaces such as roads, roofs, and parking lots leads to runoff rainwater with significantly increased volume and rate of flow. Typical storm water handling strategies involve collecting water in grates and catch basins and moving it quickly through the storm sewer system where it is eventually deposited into rivers and streams. These increased flows can overwhelm and erode stream banks and increase flood threats. Stress is put on waterways not only through increased stormwater *quantity* but also by decreased water *quality*.

Quantity issues

Large rainfall events are common in Winnipeg. The large volumes of water entering storm sewers can overwhelm the capacity of the stormwater system. There are two significant environmental problems caused by increased stormwater quantity; sewer outfalls into rivers and increased turbidity. Quantity issues feed directly into quality issues. Large stormwater volumes are particularly troublesome in areas of Winnipeg with combined sewers. Combined sewers move both sewage and stormwater in the same pipes –pipes which once fed directly into the Red River. Under normal conditions, the combined sewers now feed into sewage treatment plants. However, in order to prevent backflow into houses during heavy rainfall events, the outfalls into the rivers remain in place, blocked only by small weirs in the pipes. When water levels are high in the sewer pipes, the combined sewage and stormwater mixture flows over the weirs and into the river system (see figure 1). There are 79 sewer outfalls into Winnipeg's rivers. Combined sewers make up 31% of the city's sewer system (City of Winnipeg 2015). The City of Winnipeg reports that sewage spillage into the Seine, Assiniboine and Red rivers occurs, on average, 22 times per year. As the amount of impermeable surfaces increases due to development and expansion of infrastructure, water moves more rapidly into the storm system, increasing the likelihood of flooding and sewage outflow into rivers. As many models predict more extreme rainfall events as a result of warming temperatures, it is possible that sewage release into the river system could become more frequent (Sauchyn n.d.)

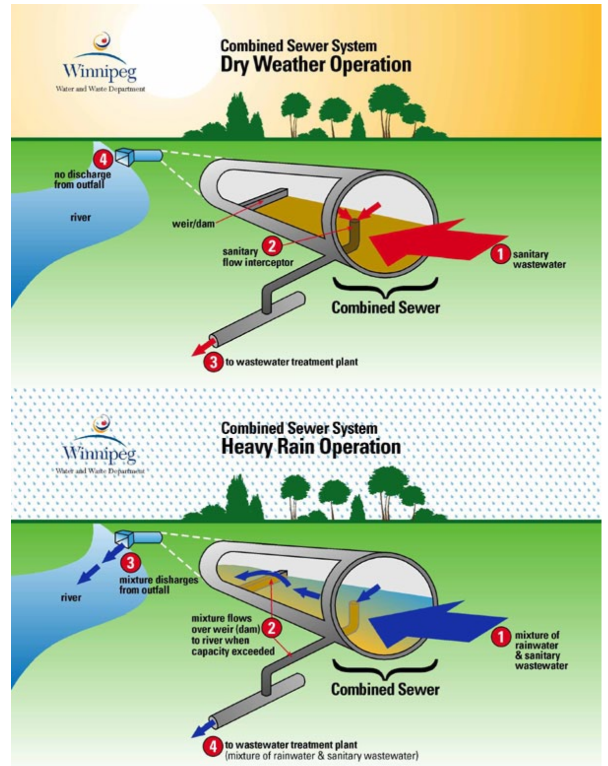


Fig. 1. Large storm events cause outfall over weirs in sewer pipes directly into Winnipeg's rivers. (City of Winnipeg 2015)

A second detrimental effect of high stormwater volumes is increased turbidity. As stormwater moves over land it picks up organic and inorganic particles such as silt, fossil fuels, animal waste, fertilizers and metals. These pollutants remain suspended in the water column. Increased total suspended solids (T.S.S.) and the resulting increase in turbidity has been shown to have several detrimental effects on downstream water bodies. Turbidity decreases light penetration into the water column, reducing the ability of some aquatic plants to photosynthesize and grow. This inhibition of aquatic plant growth not only makes nutrients more available for algal growth near the surface, it also eliminates habitat and

food for aquatic organisms. Suspended solids have also been shown to clog gills of fish and the breakdown of organic solids also reduces oxygen levels (Government of Ontario 2003). Turbidity problems are exacerbated by large influxes of stormwater flowing into rivers and lakes. When water exits storm sewers and enters water bodies already swollen from rain, bank erosion also increases, further exacerbating turbidity. A 1993 study of riverbank stability in the U.S. Pacific northwest showed a strong correlation between riverbank instability and the amount of impervious surface in the watershed (Booth and Reinalt 1993).

> <u>*Toronto's Stormwater Quality*</u>
>
> *A study conducted by the Ontario Ministry of the Environment of typical comparing pollutant levels in Toronto stormwater against Ontario's Provincial Water Quality Objectives showed elevated concentrations of metals including lead (up to 2.2 times the provincial objective), silver (up to 50 times the provincial objective), copper (up to 92 times the provincial objective), zinc (up to 8.8 (times the provincial objective) and cadmium (up to 120 times the provincial objective). Phenolics were also found to be almost five times recommended levels. (Government of Ontario 2003)*

Stormwater retention ponds help to detain water that would otherwise flow directly into catch basins and storm drains. In this way, they increase the capacity of sewers and water bodies on a neighbourhood level and throughout the entire stormwater system. Not only does slowing the water flow into sewage treatment facilities and rivers alleviate capacity issues, it also allows time for suspended particles to settle out, trapping them in the sediment of the pond instead of moving them into rivers and lakes.

Quality issues

Just as detrimental to lake health is diminished water *quality*. Water quality issues affecting Manitoba's lakes (particularly Lake Winnipeg) can be categorized as pollutant related and nutrient related. Urban stormwater has been shown to contain higher than accepted levels of suspended solids, nutrients, bacteria, heavy metals, oil and grease, and pesticides (Government of Ontario 2003). Elevated levels of metals (particularly heavy metals such as iron, zinc,

> <u>*Retention pond design: lake-style vs. naturalized*</u>
>
> *A University of Minnesota analysis of the effectiveness of "detention only" ponds vs. naturalized detention and treatment ponds demonstrated an across the board increase in pollutant removal in the detention and treatment model. For example, total phosphorous reduction in the treatment ponds averaged 46% compared to only 19% in the detention only ponds (Weiss and Hondzo 2004). In another study, long term testing of water quality in a Michigan constructed wetland found a 59% reduction in suspended solids, an 84% reduction in phosphorous and a 90% reduction in nitrogen when comparing inlet and outlet water quality. (Tetra Tech, Inc. and Kris Bass Engineering 2015). Clearly, if stormwater retention ponds are to function as part of a wider lake health strategy, proper design and implementation will be critical.*

copper, cadmium and lead) have been shown to bioaccumulate in food chains, altering the physiology of higher order organisms such as fish and mammals (Saeed and Saker n.d.). Phenolics, present in many pollutants including car exhaust, detergents and pesticides have been shown to have detrimental effects on the nervous systems of freshwater species such as rainbow trout and leopard frogs. The Canadian Water Quality Guidelines for the Protection of Aquatic Life recommends phenol levels no higher than 4 μm/L (Environment Canada 1999). Levels in the Ontario Ministry of the Environment stormwater study, however, tested at over 19 mm/L (Government of Ontario 2003).

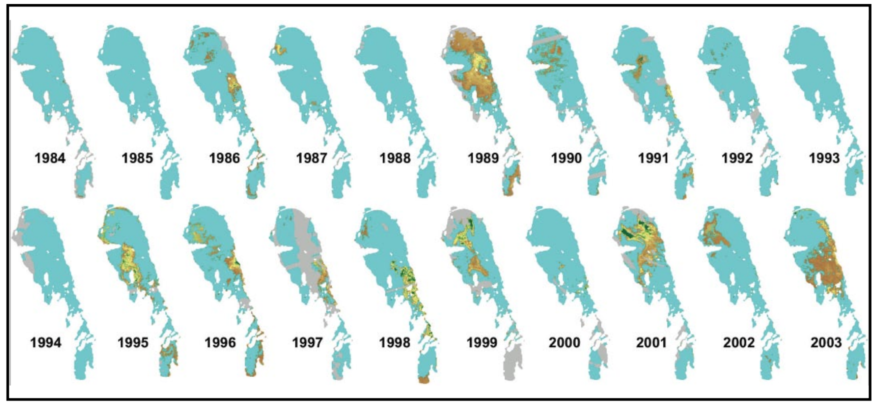


Fig. 2. A general pattern of increased frequency and severity of algae blooms in Lake Winnipeg (Lake Winnipeg Water Stewardship Board 2007)

Despite these numerous pollutant related problems, excess nutrient levels are the major stormwater quality issue affecting Manitoba's lake health. As excess nutrients flow into Lake Winnipeg from industrial sites, agricultural lands, golf courses, and stormwater, algal populations explode - leading to unsightly and potentially dangerous algae blooms. The province of Manitoba's State of Lake Winnipeg Report (2011) found that "huge surface blooms of cyanobacteria have increased both in frequency and severity in the north and south basins since the mid-1990s" (see figure 2). Algae blooms inhibit wildlife and plants, negatively affect recreational opportunities,

<u>*Understanding Nitrogen to Phosphorous Ratio*</u>

Examining nitrogen to phosphorous ratio (N:P ratio) is a way of predicting algal growth. The optimum N:P ratio for algae growth is 16:1. When the ratio is higher than 20:1, phosphorous becomes the limiting factor to growth. When the N:P ratio is below 10:1, the water body is phosphorous limited (State of Lake Winnipeg Report 2007). In the case of eutrophic lakes like Lake Winnipeg important to keep in mind that a low N:P ratio does not mean that there are low levels of nitrogen but rather that there are high levels of phosphorous. N:P ratio can be used to predict the type of algae growth that will occur. Blue-green algae can convert or "fix" atmospheric nitrogen into a useable form, so nitrogen limited lakes (i.e., lakes with high phosphorous levels) are more susceptible to blue-green algae blooms. This fact is important, as blue-green algae also produces toxins.

From 1994 to 2007, The Red River was responsible for, on average, 68% of the total phosphorous entering Lake Winnipeg and only 37% of the total nitrogen limited (Lake Winnipeg Water Stewardship Board 2006). It is not surprising then, that the south basin of Lake Winnipeg is typically nitrogen limited (N:P averages 10:1) while the north basin is phosphorous limited (average N:P of 42:1) (Lake Winnipeg Water Stewardship Board 2006).

and disrupt commercial fisheries. Many algae species also produce neurotoxins, potentially harming human health. Although the lake's watershed is large and complex, the high concentrations of nutrients in the south basin of Lake Winnipeg indicate that the majority of phosphorous and nitrogen entering the Lake is coming via the Red River. In fact, Environment Canada states "phosphorus levels are consistently above water quality guidelines for the protection of freshwater plants and animals in the Red River" (Government of Canada 2015). With 8% of all phosphorous and 11% of all nitrogen loading into Manitoba's rivers coming from the City of Winnipeg, it is clear that Winnipeg stormwater accounts for a large proportion of the 5,380 tonnes of phosphorus (68 % of the lake's annual total load) and 90,701 tonnes of nitrogen entering Lake Winnipeg from the Red River every year (Lake Winnipeg Water Stewardship Board 2015) In fact, the Lake Winnipeg Water Stewardship Board recommended in their final report that all new retention ponds in Winnipeg be designed to sequester nutrients as well as manage stormwater volumes (Lake Winnipeg Water Stewardship Board 2006).


Fig. 3. A typical Winnipeg lake-style retention pond

Current models of retention pond design in Winnipeg

Most retention ponds in Winnipeg feature large open tracts of water surrounded by a shoreline of riprap limestone (see figure 3). This shoreline, combined with steep slopes down to the water line (typically around 15%) is difficult to walk on, discouraging interaction with the water. Preventing access to retention ponds goes beyond design and into policy. The City of Winnipeg warns residents "not to use retention ponds for any purpose including any form of recreation that may cause contact with the water" (City of Winnipeg Water and Waste n.d.). Such warnings are not without justification. A 2003 test of Winnipeg retention ponds showed fecal coliform (FC) levels of up to 4600 per 100 ml. When compared to the Ontario provincial objectives for wastewater discharges of 200 FC per 100 ml, it is clear that this water is not safe for human contact (Wakelin, Elefsiniotis and Wareham 2003). The high FC levels in Winnipeg retention ponds can be attributed to the presence of Canada geese (Wakelin, Elefsiniotis and Wareham 2003). The large open tracts of water with little to no vegetation surrounding them are ideal for geese. A goose is capable of excreting 10^7 fecal coliform bacteria daily. With hundreds if not thousands of geese on each pond, the potential dangers to pond users and downstream water bodies are abundantly clear (Wakelin, Elefsiniotis and Wareham 2003)

A 2012- 2013 study of geese populations in 115 Winnipeg sites - including 89 retention ponds - estimated numbers of over 120,000 during peak migration (peak migration includes migrants as well as resident geese)(City of Winnipeg Naturalist Service 2015). Fouling of retention pond water is not the only negative effect of such high populations. Goose feces on sidewalks and greenspaces adjacent to retention ponds can render them almost unusable. Geese can also be hazardous to motorists and air traffic.

In an effort to reduce the numbers of resident geese, whose numbers have increased steadily, volunteer groups supported by the local, provincial, and federal governments are now destroying eggs found in nests close to major roads. In 2011 over 1000 eggs were removed and destroyed from nests along Bishop Grandin Boulevard in South Winnipeg. In 2013, over 1500 eggs were destroyed along nearby Kenaston Boulevard, despite protests and petitions from animal right's activists (CBC News 2013). Fortunately, it has been shown that landscape design can also be a valuable tool for reducing resident goose populations. Counts performed by the City of Winnipeg have found much lower goose populations in naturalized ponds, as geese prefer the easy access to water and open sight lines provided by the mowed turf grass and riprap of traditional ponds (City of Winnipeg Naturalist Service 2015).

Activity	Traditional Storm water Pond	Naturalized Storm water Pond
Upland vegetation maintenance	$320/ha, 10x/year *Equates to $3200/ha/yr*	$6500/ha every 5 years (i.e. upland native grass burn) *Equates to $1300/ha/yr*
Remove shoreline debris	$300/year	n/a
Remove floating debris	$300/year	n/a
Herbicide weed control Aquatic weed harvesting	$1000/ha, 1-3x/year* $1,200/ha + $350, 1-3x/year*	n/a n/a
Shoreline vegetation maintenance	$0.18/m shoreline every 5 years	n/a
Inlet/outlet pipe maintenance	$500/year	$500/year
Revetment replacement	$8000 every 25 years	n/a
Operation, technical & maintenance support	$300/year	$300/year
TOTAL ANNUAL COST	*$10,048 / ha*	*$2,100 / ha*

Fig. 4. Retention pond maintenance costs (Native Plant Solutions 2013)

Traditional lake-style retention ponds are often plagued by algae problems. High levels of phosphorous in runoff from surrounding landscapes, combined with an absence of plant buffers (upland, emergent and submergent plants that would otherwise absorb much of the excess nutrients), often leads to explosive algae blooms. In the 2003 Winnipeg retention pond study, Wakelin et al found levels of chlorophyll *a* rose from an average of 8 μm/L to 53.8 μm/L in just five months, indicating exponential algal growth.

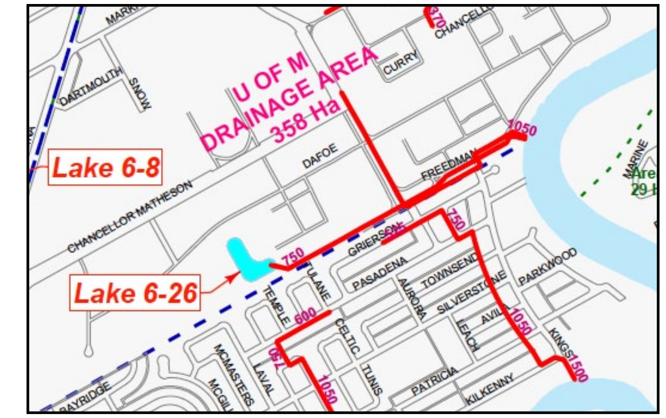


Fig. 5. Outfall to the Red River is 1000 m away from the Smart Park pond (City of Winnipeg).

This algae growth is troublesome for two reasons. On a local level, the ponds become inundated with algae, which is unappealing, potentially unsafe and requires herbicide treatment and/or manual harvesting, adding to the City's maintenance costs. According to data compiled by Native Plant Solutions, herbicide treatments and manual harvesting cost Winnipeg a combined $1550/ha per treatment (Native Plant Solutions 2013). This means that for a typical 2.5 ha pond treated three times per year, herbicide and harvesting costs alone could add up to over $11,500 per year over and above other maintenance such as shoreline cleaning, periodic dredging and mowing of surrounding turf grass (see figure 4) . Second, and more importantly for lake health on a regional scale, high levels of chlorophyll *a* indicate that nutrients, rather than being held in sediments or macrophyte tissues, are instead being suspended in the water column, where they will eventually make their way into the Red River and Lake Winnipeg.

Traditional lake-style ponds are doing very little to alleviate Lake Winnipeg's most serious problem. A study comparing performance of two wetlands in Winnipeg - a traditional lake-style pond at Smart Park on the University of Manitoba campus and a naturalized constructed wetland in the Royalwoods neighbourhood in South Winnipeg - illustrates the deficiencies inherent to traditional lake-style designs. Nitrogen (N) to phosphorous (P) ratio in the Smart Park pond never rose above 4:1, where in the Royalwoods site N:P ratio averaged 20:1. The Smart Park pond's high phosphorous levels indicate that very little of it was being absorbed and sequestered by macrophytes and in fact, phosphorous levels were 30 times higher in the traditional style pond (Native Plant Solutions 2013). As noted previously, blue-green algae is capable of fixing atmospheric nitrogen, therefore its growth is limited by phosphorous availability. Compared to the Royalwoods naturalized wetland, algal biomass was 18 times higher and blue-green algae biomass was over 2200 times higher. Some blue-green also produceneurotoxins. Regardless of detention time, with phosphorous concentrations that high and with the outlet to the river only 1000 m away (see figure 5), large quantities of phosphorous would inevitably enter the Red River. While alleviating stormwater *quantity* issues and allowing for particle settling, traditional, open water lake-style ponds such as this one, clearly do not do enough to effectively address water *quality* issues.

Naturalized retention ponds: form and function

In their 2006 report on the state of Lake Winnipeg, the Lake Winnipeg Stewardship Board recommended the widespread adoption of naturalized constructed wetlands for stormwater retention and nutrient sequestration (Lake Winnipeg Water Stewardship Board 2006). As described, performance comparisons of typical riprap lined lake-style ponds and naturalized retention ponds have shown that, unlike lake-style ponds, natural ponds effectively sequester nutrients, metals and other pollutants. Despite their natural appearance, these wetlands are complex systems relying on several specific mechanical, natural and maintenance processes to function correctly. The basic strategy is simple: retain captured stormwater for as long as possible, so that natural processes can remove as many pollutants as possible before releasing them downstream.

Figures 6 and 7 are drawings adapted from multiple sources including the Government of Ontario's Stormwater Management Planning and Design Manual, the Environmental Protection Agency's Stormwater Design Principles, Robert L France's *Wetland Design* and examination of local projects designed and installed by Native Plant Solutions (a for profit arm of Ducks Unlimited) .Following is a description of the design guidelines and devices involved in naturalized retention pond design for stormwater remediation and habitat creation.

1. An ideal **pond surface area** is 2-4% of the area draining into it. This can be reduced to 1-2% in designs incorporating a sediment forebay (France 2003). However, the larger the pond is relative to its catchment area, the more effective it will be. Studies have shown that a pond surface area that is 5% of its catchment area will capture and retain up to 80% of total suspended solids entering via stormwater (Marsalek, Wat and Henry 1992).

2. **Residence time** should be a minimum of 14 days. Nitrogen removal is most effective with a residence time of at least 20 days (France 2003). Variations in the pond-bottom topography, islands and curvilinear shorelines increase residence time.

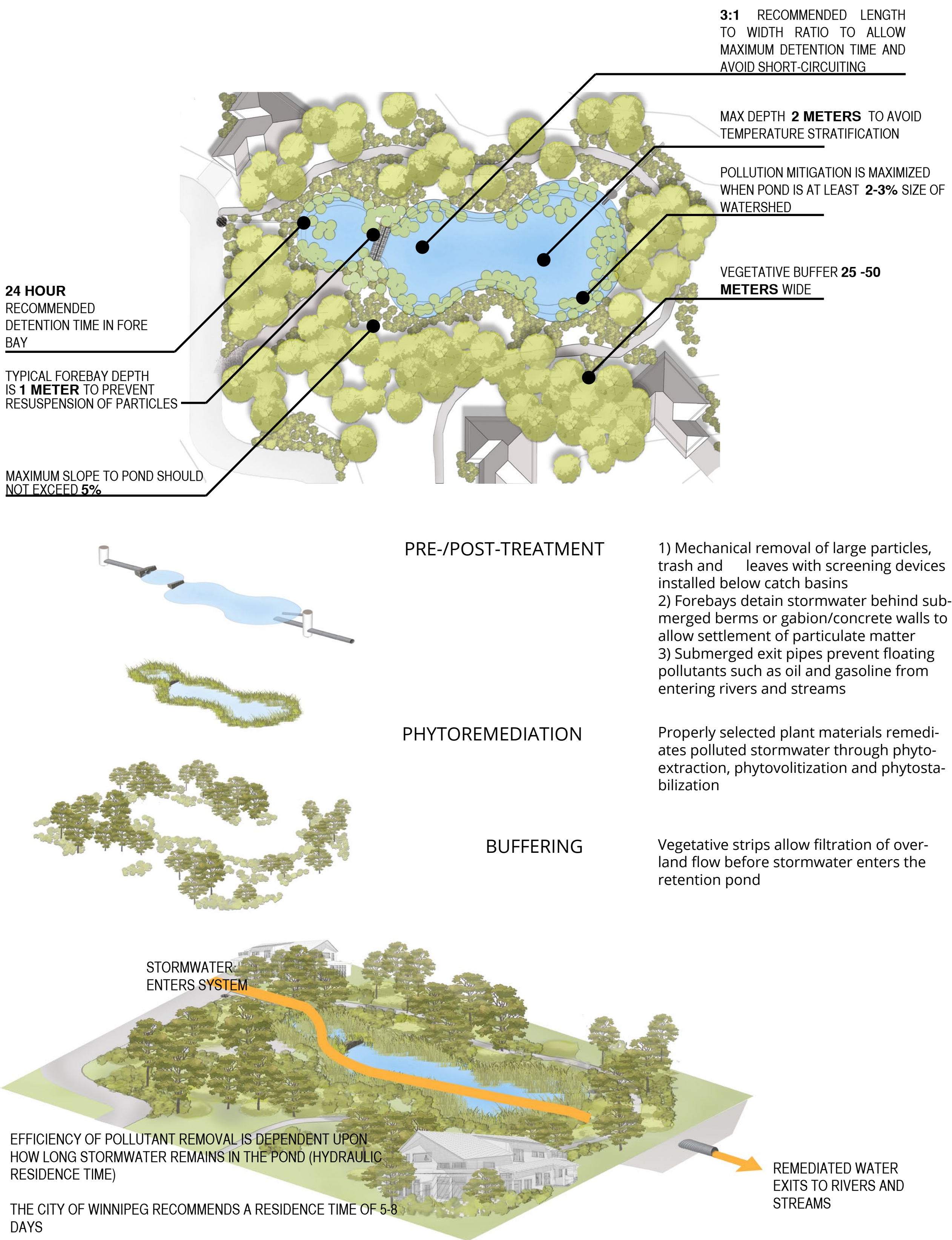
3. **Pretreatment** involves the mechanical removal of large particles, trash and leaves with screening devices installed below catch basins and other infrastructure feeding into the pond. Other pretreatment strategies include vegetated filter strips, pretreatment swales and deep sump catch basins.

4. **Outlet structures** also have screens or traps to catch any debris. Outlet pipes are typically well below the water surface and are angled upward to maximize detention times and prevent floating contaminants such as oil from leaving the pond. There is typically also a maintenance pipe set lower to allow for complete draining of the pond. Both outlet pipes have gate valves to control flow.

5. **Forebays** detain stormwater behind submerged berms or gabion/concrete walls to allow settlement of particulate matter. Forebays are designed to be accessible for large machinery, making periodic maintenance much easier and more cost effective than cleaning the entire pond. Dredging of forebays usually occurs every 2-5 years depending on the volume of materials entering the pond (France 2003). Typical forebay depth is approximately one metre to allow for easy dredging. Ideal detention time in the forebay should be at least 24 hours.

6. **Length to width ratio** is typically 3:1 or greater. This length allows for sufficient residence time. Creating an irregular and serpentine shape to ponds also promotes proper water circulation and prevents "short circuiting", a situation in which currents move some water quickly through the pond while other areas remain relatively stagnant (Marsalek, Wat and Henry 1992). Longer shorelines created through the use of serpentine curves also allow for up to 20% more habitat areas (France 2003). Serpentine shorelines are also important for waterfowl nesting. Small bays with limited vision to other areas of the pond allow birds to create territories that are quite close together yet visually isolated (Barnes 1998)

7. Pond **depth** is typically 2-2.5 metres. Deeper ponds run the risk of temperature stratification where cooler water becomes trapped underneath a layer of warm water with very little mixing. For habitat creation, having a maximum of 40% open water greatly increases the amount of cover, food and nesting areas for wildlife in the pond (Barnes 1998).



Figs. 6 and 7. General design guidelines for naturalized retention ponds

8. In areas that have open water, floating platforms and nest boxes on poles can provide opportunities for wildlife.

9. A varied **topography** including berms, dips and, if possible, emergent islands will lengthen treatment time. Emergent islands also reduce wave action from wind and provide habitat for wildlife. Deep areas should be in isolated pockets and not continuous through the length of the pond. This will prevent short-circuiting, with cool water moving quickly along the pond bottom to the outlet. Including islands in the pond design is particularly important for bird habitat, protecting nests from raccoons, dogs, cats and other common suburban animals (Barnes 1998)

10. For stability, **slopes** into the pond should never exceed 3:1. For safety purposes and access for wildlife, maximum slopes should not exceed 5:1 and ideally should be closer to 10:1. There should be no sudden drop offs, especially around the water line (France 2003).

11. Upland **buffer plantings** should be a minimum of 25 metres wide to intercept contaminants entering the pond via overland flow. Plants should be selected to provide habitat (i.e., nesting, food and cover) and stabilize slopes(France 2003).

Mechanisms at work

In naturalized retention ponds, there are a series of mechanical, biological and chemical processes working together to sequester and neutralize pollutants, with different processes occurring in different areas (see figure 8). The breakdown of pollutants such as pesticides by microbial activity combined with sunlight (photolysis) or water (hydrolysis) occurs independent of the presence of plants. Once broken down, the non-toxic by-products can then either be absorbed and held in plant tissues, or settle into the sediment. For these processes to be effective, water needs to stay in the pond for a minimum of fourteen days (U.S. Environmental Protection Agency 2012). Particle settling is another key process at work in all retention ponds (i.e., sedimentation). Stoke's Law states that large particles in water - particularly silt and clay particles - will tend to settle more quickly than smaller ones. A University of Minnesota study of retention ponds across the U.S. found that they are effective in removing, on average, 65% of silt and clay particles from the water column (Gulliver 2010). This sedimentation is why ponds must be periodically dredged and why the use of forebays in pond design is so important. It is when these mechanical and chemical processes are paired with the biological processes of phytoremediation, however, that constructed wetlands become truly powerful tools for remediating stormwater. Phytoremediation is the “removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater”(U.S. Environmental Protection Agency 2012). Three key plant processes are involved:

1. Phytostabilization: Some contaminants can, without altering their chemistry, be held within or around plant roots. This limits their ability to leach through the soil or be washed into rivers and lakes (U.S. Environmental Protection Agency 2012).
2. Phytoextraction: Contaminants (especially metals) are absorbed by plants and held in leaves and stems. Harvesting of plants may be necessary to prevent re-release of contaminants from decaying plants. However, if sequestered pollutants are released

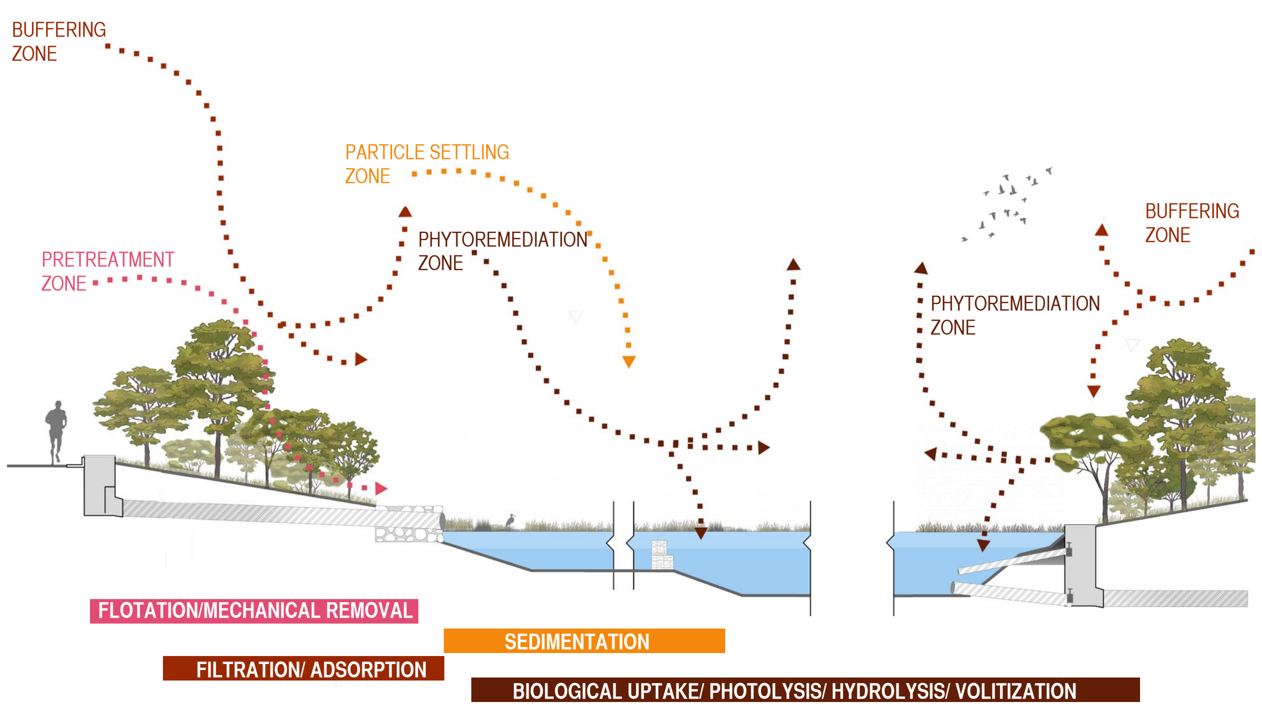


Fig. 8. Different remediation processes at work in different areas of the pond.

by decaying plants, they are quickly absorbed as new plant growth begins - although theoretically there could be a tipping point where uptake limits are reached. If dead plant material is removed from the pond, the sequestered contaminants are removed with it. Harvesting of dead plant material is already being done at Delta Marsh on Lake

Winnipeg, where removal of cattails (*Typha spp.)* shows enormous promise, not just for removing nutrients sequestered in plant tissues but also for processing the dead plant material into biofuel. Experimental harvesting of cattails yielded 14.7 tonnes per hectare of plant material (double the amount of a poplar or willow stand within the same area) (Goldsborough 2015). Furthermore, the increased light availability resulting from the cattails’ removal significantly increased the biomass of the plants emerging the next year (Goldsborough 2015).

3. Phytovolatization: Some plants can absorb contaminants and release them in less toxic, gaseous form through transpiration. This process usually happens with the aid of various microorganisms. Dissolved biodegradable material is removed from the wastewater by decomposing bacteria and fungi living on the surface leaves, stems and roots of aquatic plants. The broken down material is then absorbed by the plants or released as carbon dioxide and water (U.S. Environmental Protection Agency 2012). Plants not only provide a matrix for microbial activity, they also release oxygen, accelerating the decomposition process.

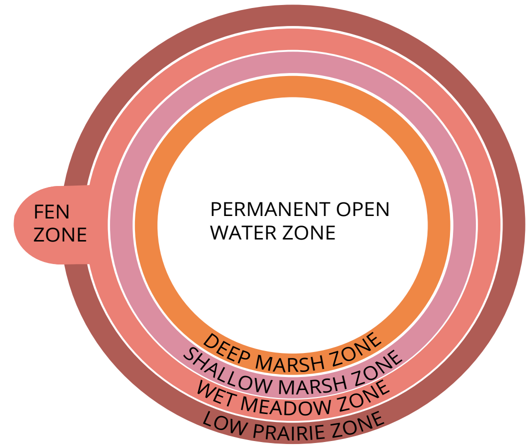
Clearly, plants can play an important role in the function and productivity of constructed wetlands. However, effective stormwater remediation and habitat creation can only be achieved through prudent plant selection.

Zone	Water Level or Elevation	Allocation of Surface Area
Open Water	Greater than 3 feet deep	30–40%
Submerged	1 to 3 feet deep	10–20%
Emergent	0 to 1 foot deep	10–20%
Wet meadow/marsh–lower	0 to 6 inches above the permanent pool	10–20%
Wet meadow/marsh–higher	6 inches above the permanent pool to high water leve	10–20%
Upland Above high water level	Above high water level	Varies

Table 1. Planting zone allocation (France 2003).

Planting strategies

Planting plans for constructed wetlands are best developed based on zones that are defined by moisture content and amount of time with surface water. Stewart and Kantrud (1971) created a classification for prairie wetland systems based upon the permanence and salinity of water in the wetland. They also identified key indicator species for each zone (see fig 9). According to their criteria, a naturalized retention pond would be classified as a Class V pond with permanent open water (submergent plant species), a deep marsh zone (may have surface water for the entire year and features emergent species), a shallow marsh zone (usually wet but without surface water in late summer and fall, supporting wet meadow and emergent species), a wet meadow zone (has surface water only for a few weeks every spring and for a few days after rainfall events and supports wet meadow and edge species) and a low prairie zone (has surface water briefly after heavy rainfall events and houses edge and prairie species). Table 1 shows the recommended percentage of the pond surface area that should be allocated for each zone to allow for maximum phytoremediation and habitat creation (France 2003). Class V wetlands are excellent models for stormwater remediation because a large percentage of the plants representative of Class V ponds have large root systems capable of fostering aerobic and anaerobic microbial processes, making them excellent bioaccumulators (Stewart



Wetland Zone	
Low Prairie:	**Primary Species:** *Agropyron sp., Aster ericoides, Poa pratensis, Potentilla anserina, Salix sp.*
	Secondary Species: *Andropogon gerardii, Stipa viridul*
Wet Meadow:	**Primary Species:** *Glyceria grandis*, *Glyceria boreali, Aster simplex, Aster ericoides, Calamagrostis inexpansa, Calamagrostis canadensis, Scirpus cyperinus, Eleocharis sp., Mentha arvensis, Stachys palustris, Carex sp., Juncus sp., Eriophorum sp., Sium suave*
	Secondary Species: *Poa palustris, Potentilla anserina*
Shallow Marsh:	**Primary Species:** *Sparganium hyperboreum, Carex antherodes, Carex aquatilis, Beckmannia syzigachne, Scirpus sp., Scolochloa festucacea, Eleocharis sp., Equisetum fluviatile, Calamagrostis canadensis*
	Secondary Species: *Lemna sp.*
Deep Marsh:	**Primary Species:** *Typha latifolia, Typha augustofolia, Schoenoplectus tabernaemontani, Schoenoplectus acutus*
	Secondary Species: *Scolochloa festucacea, Carex antherodes, Menyanthes trifoliate, Utricularia sp., Myriophyllum exalbescens, Potamogeton sp., Hippuris vulgaris*

Fig. 9. Diagram adapted from Stewart and Kantrud's (1971) Class V wetlands and key species associated with each zone.

and Kantrud 1971). Cattails (*Typha spp.)*, wheat grasses (*Agropyron spp.*), willows (*salix spp.*), reed grasses (*Calmagrotis spp.*), rushes (*Juncus spp.*) and many sedges (*Carex spp.*) are all key species for phytoremediation (Marsalek, Wat and Henry 1992).However, a planting plan focused on phytoremediation must also include upland bioaccumulators such as clover (*Trifolium spp.*), lupines (*Lupinus spp.*), fescues (*Festucs spp.*) and poplars (*Populus spp.*) (Marsalek, Wat and Henry 1992). The drawing on the following page (figure 10) illustrates the various wetland zones and plant species for each zone that are suited to Winnipeg's Zone 3 climate.

If a retention pond design goal is habitat creation as well as phytoremediation, the plant palette must also promote and reflect the habitat diversity needed to host a wide array

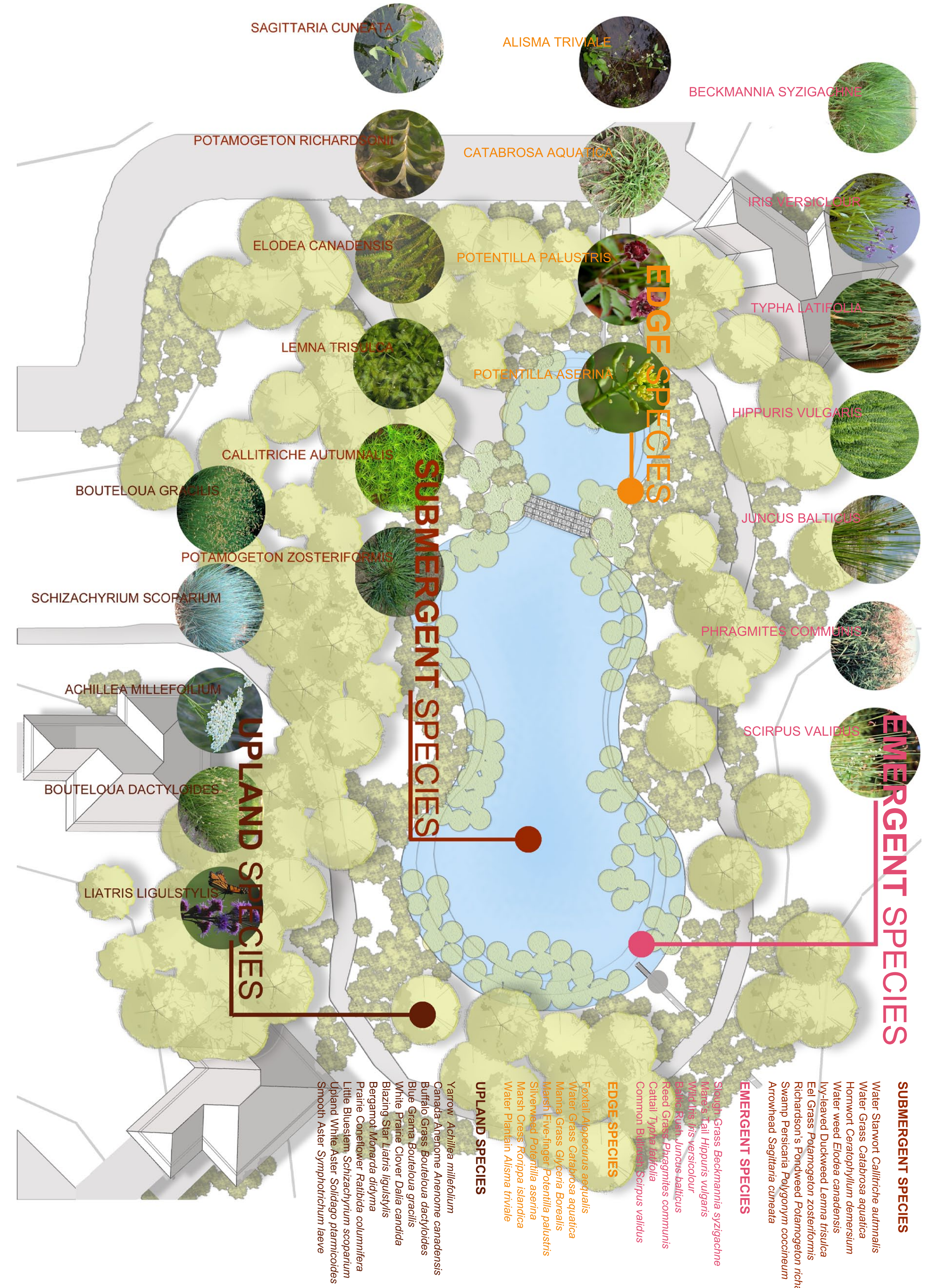


Fig. 10. Wetland species suitable for Winnipeg (Zone 3).

of species. Retention ponds are particularly suited to providing habitat for birds. Many bird species naturally nest and feed in wetland areas. Furthermore, retention ponds are often set in suburban neighbourhoods without continuous wildlife corridors. Birds are best suited for moving between habitat patches. Table 2 shows a number of bird species observed in the Winnipeg area and the conditions they require.

NAME	SEASON	NESTING	FOOD
Northern Pintail	Summer	Depressions on ground	Seeds
Red-winged Blackbird	Summer	In shrubs/grasses near water	Insects
Marsh Wren	Summer	In shrubs/grasses near water	Insects
Yellow Warbler	Summer	Shrubs/trees	Foliage cleaner
Killdeer	Spring/summer	Scrapes in ground	Invertebrates
Sandpipers	Spring/summer	Scrapes in ground	Insects
Marbled Godwit	Spring-fall	Marshy ground	Insects
Sora	Spring-fall	Floating	Seeds
Clay-coloured Sparrow	Summer	Shrubs/trees	Seeds
American Goldfinch	Spring/fall	Shrubs	Seeds
Vesper sparrow	Spring/summer	Grassland	Seeds/insects
Gadwall	Spring-fall	Depressions on ground	Plants
White Breasted Nuthatch	Year round	Deciduous trees	Seeds/insects

Table 2. Manitoba bird species and their habitat requirements

To provide the diverse conditions needed to accommodate a wide range of species, the planting plan must include plants suitable for emergent, open water, upland and treed areas (France 2003).

As a food source for birds and as consumers of mosquito larvae, providing fish habitat is also an important design consideration. Underwater elements such as submerged logs and cooler shaded areas are crucial for fish (France 2003). Retention ponds can support a wide variety of fish. A 2007 survey of fish species in various Winnipeg waterbodies found carp, sticklebacks, bullheads, saugers, fathead minnows, black crappie, white sucker, northern pike and bass in retention ponds throughout the city (Penner 2007). Although exposure to contaminants entering the pond through stormwater could potentially affect the health of resident birds and fish, the overall benefit of creating habitat outweighs risk. A study of red-winged blackbirds nesting near a naturalized pond in Washington, D.C. found no difference in hatching success compared to the national average (Sparling 2004).

Retrofitting

Realizing the naturalized retention ponds' potential ecosystem services (stormwater remediation, flood prevention, carbon sequestration, wildlife habitat, recreation and education) is more complex than planning traditional lake-style ponds surrounded by turfgrass. Is retrofitting these spaces a viable option? It will not be enough to simply change the shoreline and adjacent slopes by adding plants. The entire system must be assessed from input to outlet. This includes inflow water quality, flow velocities (i.e., residence time), area footprint, topography and outlet structures.

Improving the quality of water entering the pond can do much to reduce the stress and demand put on plants within the pond. Measures may include maintaining or creating new drainage swales, employing bioswales, planting buffer and filter strips and installing oil/grit separators (Marsalek, Wat and Henry 1992). Stormwater passing through 15 m vegetative buffer strip can shed up to 71% of its pollutant load before it even enters the pond (Marsalek, Wat and Henry 1992). The implementation of a forebay (typically not present in traditional retention pond design) will also trap many of the sediments and their associated contaminants, preventing them from entering the pond proper.

The overall shape and size must also be addressed when retrofitting. Adding shallower emergent planting zones and barring the creation of deeper areas, the overall footprint must be increased if the same volume of water is to be retained in the pond. Moreover, as previously discussed, shoreline shape can greatly affect water movement patterns and habitat availability. Topography (both within and around the pond) also must be addressed. Continuous deep zones present in traditional stormwater ponds must be eliminated to prevent short-circuiting. Construction of islands, shallow planting zones and submerged berms will also increase habitat potential. Slopes into the pond must be gentler to allow buffer vegetation to intercept pollutants. Outlet structures may have to be altered (typically a reduction in pipe diameter and/or elevation) to increase residence time (Marsalek, Wat and Henry 1992).

Another issue surrounding retrofitting ponds is acceptance from property owners. Lot boundaries typically extend into the pond, so the owner's consent is needed and many homeowners mat not understand the issues and advantages of naturalized systems, preferring the aesthetics of traditional, lake-style ponds.

Chapter 2: Education and the outdoors

Without continuous hands-on experience, it is impossible for children to acquire a deep intuitive understanding of the natural world. A critical aspect of the present-day crisis in education is that children are becoming separated from daily experience of the natural world, especially in larger cities.

From Natural Learning: Creating Environments for Rediscovering Nature's Way of Teaching
by Herb Wong and Robin Moore

The importance of outdoor environments

There is much speculation on the negative effects of children's separation from the outdoors. Proponents of outdoor learning and play such as Richard Louv argue that a need for interaction with the natural environment is as "hard-wired" into our brains as the need for interaction with other people (Rivkin 1997). Schoolyards have the potential to provide educational opportunities directly through dedicated classroom space and educational infrastructure, and indirectly through exploration and play. As children, my friends and I spent hours after rainstorms playing in ditches – building dams, diverting flows and racing stick "boats". Through engagement, play and manipulation of our environment, we were unconsciously observing and learning about stormwater movement, engineering, and erosion.

Experiential learning can reinforce more passive, visual learning. A range of studies have shown that the mental and sensory stimulation outdoor environments provide foster "important developmental activities such as play, creative forms of play, and exploratory thinking" (Taylor, Kuo and Sullivan 2001 p. 58). Well-designed outdoor environments provide the privacy and loose structure necessary for children to manipulate their environment – fostering the cooperation, creativity and problem solving skills necessary for the self-discovery crucial in childhood (Chawla 2015).

A large body of research looking at individuals with Attention Deficit Hyperactivity Disorder (ADHD) has shown that inattention and impulsivity have been observed to decrease following exposure to natural views and environments (Taylor, Kuo and Sullivan 2001). Behaviours associated with Attention Deficit Disorder (ADD), including poor academic performance, aggressive behaviour, lack of impulse control and poor peer relationship development, have been reported to decrease significantly with increased exposure to the natural environment (Taylor, Kuo and Sullivan 2001). Further, Taylor et al. reported no significant behaviour changes between more physical outdoor activities (e.g., sports) and less physical ones (e.g., fishing), suggesting the benefits are more than simply "burning off" excess energy. Given the side effects of medication used to treat ADD and ADHD (National Institue of Mental Health 2015), preliminary findings of research examining the effectiveness of less intrusive interventions, such as outdoor play, is important in shaping the development of non-medicinal interventions to support children with these diagnoses.

In addition to the mental and psychological benefits of outdoor environments, natural learning and play have been shown to have positive effects on the body, both in terms of reduced stress and increased physical fitness. A study on the outcomes of a schoolyard greening renovation by Keltz et al. found blood pressures were significantly lower in children exposed to naturalized schoolyards, indicative of reduced stress (Chawla 2015). Testing in Finland of the physical fitness of children with access to natural play environments showed significantly higher fitness levels when compared to children with access only to traditional schoolyard play equipment (Chawla 2015).

Learning in outdoor classrooms has also been shown to be highly beneficial. Outdoor learning is effective because it encourages children to "act experimentally" and find cause-and-effect relationships (Carr and Lynch 1968). A 2010 study comparing the learning outcomes of grade three and four environmental science units found children exposed to an outdoor learning environment had significantly higher testing scores than their classroom-only counterparts on topics such as "reasons for animal endangerment, benefits of living in insect colonies, predator-prey relationships, plant and animal communities, components of habitats, animal defenses, and animal homes" (Cronin-Jones 2000 p. 203).

Another important aspect of outdoor learning environments is the fact that children are often there during break times and outside of school hours – effectively increasing learning opportunities. A series of behavioural mapping activities performed in four Australian schools – one with a naturalized play area and three without – classified 40% of observed behaviours in the naturalized site as "cognitive activities", while the other schools did not exceed 10% (Malone and Tranter 2003). The naturalized school ground was also the only site where cognitive play was categorized as "interacting with the environment" or "exploring the environment" (Malone and Tranter 2003 p.292). These findings indicate that learning was happening spontaneously, independent of direct teaching.

Early 20th-century psychologist and philosopher, John Dewey, was one of the first proponents of the value of experiential learning. In his short but hugely influential book *Experience and Education* (first published in 1925), Dewey posits that, by its nature, education is the imposition of knowledge upon children and that without experience, children participate little in the educational process (Dewey 1998). According to Dewey, experience can only be acquired by students when they are granted the freedom to think freely and the freedom to move about their environment. In short, a teacher's responsibility is to create conditions for positive learning experiences and facilitate consolidation of experience into knowledge.

Dewey emphasized the importance of situation, continuity and interaction in the learning process. Children take experience from one situation (e.g., the classroom) and bring it to the next (e.g., the schoolyard). Therefore, effective teaching must facilitate continuity and transfer of knowledge from the classroom to the wider world. He argued that passive learning does not provide this continuity, as it is experience that cannot be easily transferred to novel situations. Conversely, outdoor learning environments provide teachers with a means to transfer classroom experience to the "real world", fostering positive experience and engagement. Learning goals are transformed from simple recall of facts to critical thinking and problem solving.
Steven Carr and Kevin Lynch (1968) built on Dewey's ideas when they described the learning possibilities inherent in urban form. According to Carr and Lynch, the world outside of institutional settings offers the opportunity to "act experimentally" (p.1283). This interaction, they argued, is the best way to learn and develop and that individuals learning away from traditional classroom models "become more competent in some way, more highly organized yet more responsive, more engaged in a significant interchange with the environment"(p.1270). When designers create engaging conditions, learning becomes more meaningful and effective.

Outdoor learning focused teaching models
Many educational theories and programs have expanded on Dewey's philosophies. the mandate of the Biological Sciences Curriculum Study (BSCS), a non-profit organization founded in 1973 and affiliated with the University of Colorado, for example, is to provide teaching strategies for the Sciences (Biological Sciences Curriculum

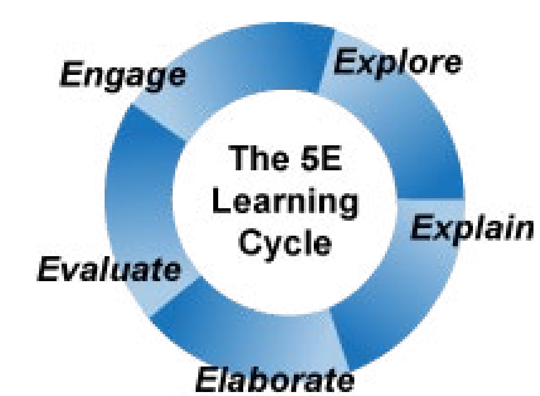


Fig. 11 BSCS 5e's teaching model (Ergopedia 2016.)

Study 2013). The program creators developed the "5E's" teaching model: Engagement, Exploration, Explanation, Extension and Evaluation (see figure 11). The model is cyclical - the teacher first engages the students' interest and then lets them explore the topic themselves. Students are then asked to explain their findings - the teacher supplements the explanations with correct facts and terminology. This new knowledge can then be applied to new areas (e.g., pollution studies in a local pond can be applied on a regional scale). Two steps in the model, Engagement and Exploration are particularly suited to study outside the classroom. By letting children become engaged and explore independently, they draw on their own past experience in shaping new ideas. Similar to Dewey's formulations, the goal is a continuous consolidation of experience into knowledge.

"Connecting the Dots", another teaching model focused on outdoor learning, has been developed by the Ontario-based not for profit, Learning for Sustainable Futures (LSF). Promoting teaching of sustainable practices, citizenship and eco-literacy, Connecting the Dots adopts seven key strategies*: Learning Locally*, *Integrated Learning, Acting on Learning, Real-World Connections, Considering Alternative Perspectives, Inquiry, Sharing Responsibility for Learning with Students* (Kozak and Elliott 2011). Four of these seven strategies are particularly suited to outdoor learning.

LSF asserts that, in addition to the numerous benefits of outdoor learning described previously, *Learning Locally* (i.e., in the schoolyard or immediate surroundings) awakens children to their environment and inspires citizenship and community involvement (Kozak and Elliott 2011). An additional benefit is the low cost, as no busing is required The second key strategy, *Integrated Learning*, allows children to pursue a particular concept or idea across multiple subjects, allowing them to see interrelationships between different subject areas and the complexity of various issues. Rather than focusing on subjects, learning instead becomes focused on themes, often taking the form of a long-term project. The third "strategy dot" suited to outdoor learning is *Real World Connections*. This approach requires children to tackle questions in a hands-on fashion, becoming familiar with making observations, measuring, surveying and monitoring. Introducing real data and data gathering techniques, gives students a sense of authenticity. They feel as if they are working towards something real as opposed to just performing an exercise. Similarly, the fourth learning strategy, *Inquiry*, poses the curriculum as questions to be answered explored. As in the scientific method, insight is gained by posing questions and then devising a means to answer those questions. (Kozak and Elliott 2011).

Herb Wong's "switchboard" model (see figure 12) provided teachers with a framework for developing lesson plans. It also allowed teachers to evaluate and account for classroom time spent outdoors (Moore and Wong 1997). Different aspects of education, gathered into five categories – ecological concepts, teaching-learning modes developmental skills, the learning cycle and interdisciplinary learning – are connected across a "switchboard" of Activity. I believe "Engagement" could also be substituted for Activity. Engagement is the engine that drives students to test their skills and move through the various stages of learning, ultimately developing new skills and, perhaps more importantly, a passion for learning.

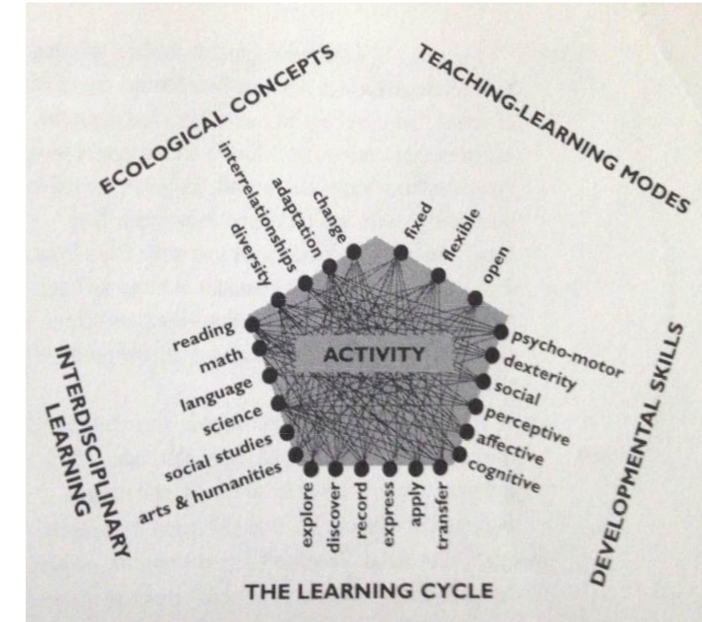


Fig. 12. The Education Swithchboard (Moore and Wong 1997).

These teaching philosophies and many more are centered around one key concept – *engagement*. Engagement is about more than getting good grades. Engagement gives students ownership of their environment and their education. It makes students feel as if they are working towards something meaningful. Outdoor classrooms are ideal vehicles for fostering engagement. They can immerse students and allow them to see that they are part of the natural world, and that their actions can have tangible effects.

Taking shape: incorporating engagement into landscape design

If a teacher's role is to engage students with their surroundings, how can landscape architects make students' surroundings engaging? How can we shape schoolyards not just as outdoor classrooms but also as places for engaging play, where education can happen without teachers? Evergreen is a not-for-profit organization focusing on greening many aspects of urban life, one of which is education. Evergreen states that education and design for education must allow for physical, emotional, cognitive and social development (Campbell 2013) In their design guide, Landscap*e and Child Development*, Evergreen provides a checklist of elements to include in an engaging naturalized schoolyard. These elements include gathering spaces, active spaces, experimental spaces, individual spaces and ecological spaces (Campbell 2013). Perhaps aimed at lay people rather than designers, these guidelines may be too prescriptive. Compartmentalizing the schoolyard into different areas as in figure 13 may not provide the layering of functions that creates a rich and engaging outdoor space. Rather than adopting a prescriptive approach to schoolyard design and development, the role of landscape architects should focus on providing opportunities for students and teachers to conceptualize and create their own uses.

Karen Malone and Paul Tranter (2003), offered the following guidelines for school ground evaluation; *sensory stimulation* (i.e., the benefits children gain from a diverse environment including textures, colours, shapes, movement, etc.,), *response feedback* (i.e., creating a responsive and malleable environment which provides sensory feedback to the child), and *affordances* (i.e., the possibilities that allow for growth and development by creating places for doing, thinking, feeling, and being).

In a set of recommendations developed after conducting a five-year, multidisciplinary study of 16 outdoor spaces for children aged two to five in greater Vancouver, professor of

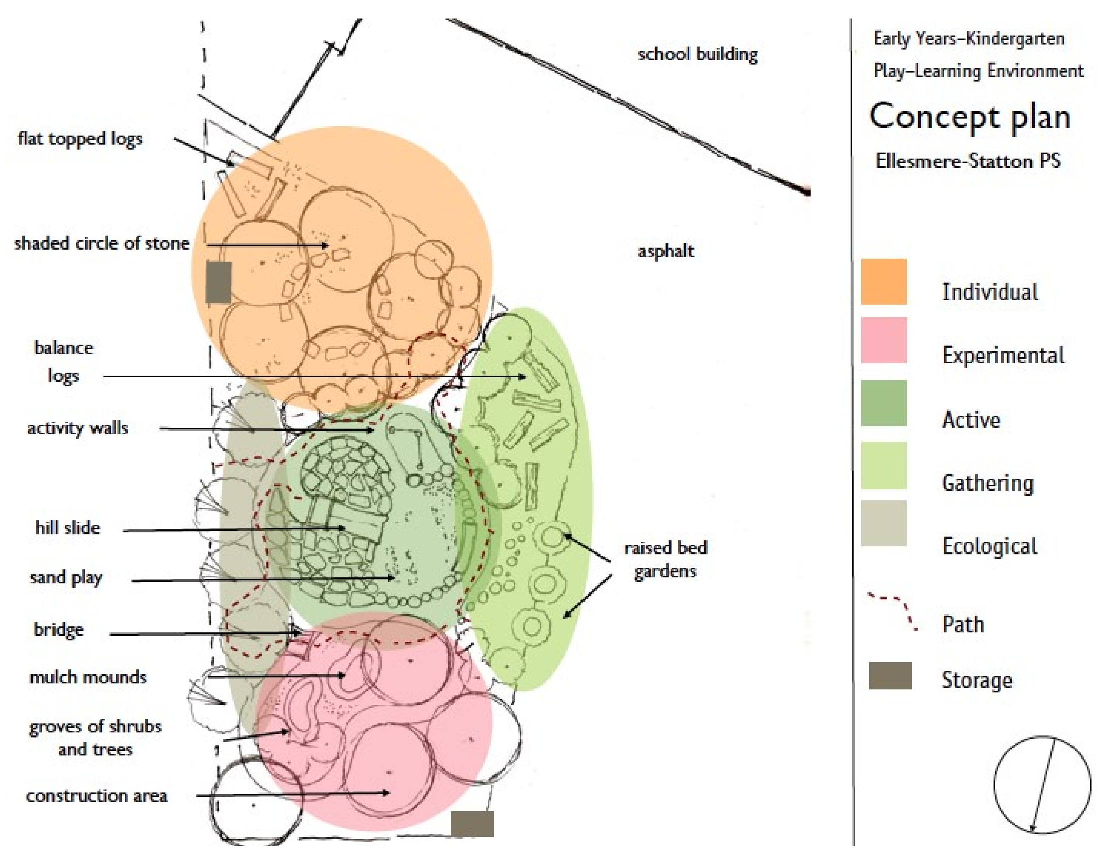


Fig. 13. Evergreen's prescriptive design model (Campbell 2013).

architecture and landscape architecture Susan Herrington describes goals for the *nature* of spaces rather than the *form* of spaces. Herrington states that the findings are also relevant for older children (Herrington, et al. 2008). To achieve these goals, seven key elements must be analyzed and addressed; – character (i.e., overall feel and design intent), context (i.e., position of the outdoor space relative to its surroundings), connectivity (i.e., the visual, physical, and cognitive experience of the space), change (i.e., diversity in the space through different areas, colours from changing seasons, etc.), chance (i.e., flexibility in the landscape, allowing children to manipulate their environment), clarity (i.e., the design should work with children's scale and movement patterns), and challenge (i.e., room in the landscape to allow children to push themselves and refine their skills).

These and many other studies point towards the creation of dynamic open-ended spaces where children are not told how or where to play. Designers should provide opportunities for children to create their own play and learning *experiences* as well as their own play and learning *spaces* through manipulation of their surroundings. This open-endedness, the marriage of imaginative play, learning, physicality, and social development, is what creates truly engaging spaces. Carr and Lynch (p.1287) eloquently describe a well-designed schoolyard:

> "*An environment for growth would be more exposed, accessible, and diverse, more open both physically and psychologically, more responsive to individual initiative and control. It would invite exploration and reward it; it would encourage manipulation, renovation, and self-initiated changes of many kinds. It would contain surprises and novel experiences, challenges to cognition and action. It would not be the most efficient and safe environment*".

Chapter 3: Lessons from Previous Work

Several projects have informed the design described in Chapter 5. By layering play and education, or stormwater management and education, these spaces show the potential of schoolyards to provide a multi-layered experience to engage students and teachers through natural processes.

The Washington School Environmental Yard

In 1972, two University of California Berkeley professors - Robin Moore (Landscape Architecture) and Herb Wong (Education) began a partnership to design and chronicle the transformation of an asphalt schoolyard into a naturalized education/play space. The resulting book, *Natural Learning (1997),* describes the educational theory, community involvement, and environmental and budgetary constraints that shaped this design and its over many years. The book demonstrates the power of interdisciplinary partnerships.

Fig. 14. Washington School before the Environmental Yard (Moore and Wong 1997)

The redeveloped 1.5-acre asphalt covered schoolyard at Washington Elementary in Berkeley California (see figure14) was named the Environmental Yard. The project began in 1972 with tree planting and the construction of a small pond. By 1976, the Yard supported a full time outdoor education resource teacher (Moore and Wong 1997) The design process was participatory, garnering input from students, school staff and the community to develop three zones: an asphalt play area, an area with peripheral play structures and community amenities and a half-acre naturalized space that includes a redwood forest, food and ornamental gardens, and an aquatic area containing two ponds connected by a stream and waterfall (Moore and Wong 1997)(figure 15).

To evaluate the Yard's importance to its users, students were asked to draw "mental maps" indicating which area of the Yard they best recalled. These "mental maps" were later compared to "behavioural maps" which depicted how the space was used during visits to the Yard. Despite the fact that behavioural mapping showed that the three Primary Zones (Natural Resource Area, Main Yard and Asphalt) were used almost equally (Moore and

Fig. 15. Three distinct areas were created. Traditional asphalt play, traditional play structures and the naturalized play space. (Moore and Wong 1997).

Wong 1997), the mental maps indicated that children *perceived* the natural areas as by far the most memorable, especially the ponds. (see figure 16). Years later, a former student described the Yard's importance "the plant and animal life were really an important part of the play. I don't kill bugs, not even spiders. I know that has a direct correlation to the Yard, because we learned how to respect all the life there." (Moore and Wong 1997, p.12).

During renovations to the school in 1995, a large portion of the environmental yard—including thirty mature shade trees, the outdoor stage, and the orchard—was demolished in favour of a basketball court and large lawn. The removal of such an influential and beloved landscape illustrates the dedication required from staff, parents, students and the community to maintain and protect these valuable spaces. However, inspired by the old Environmental Yard, parents and school staff pushed for and realized a new master plan for an inspiring outdoor classroom space, which was completed and approved in 2011.

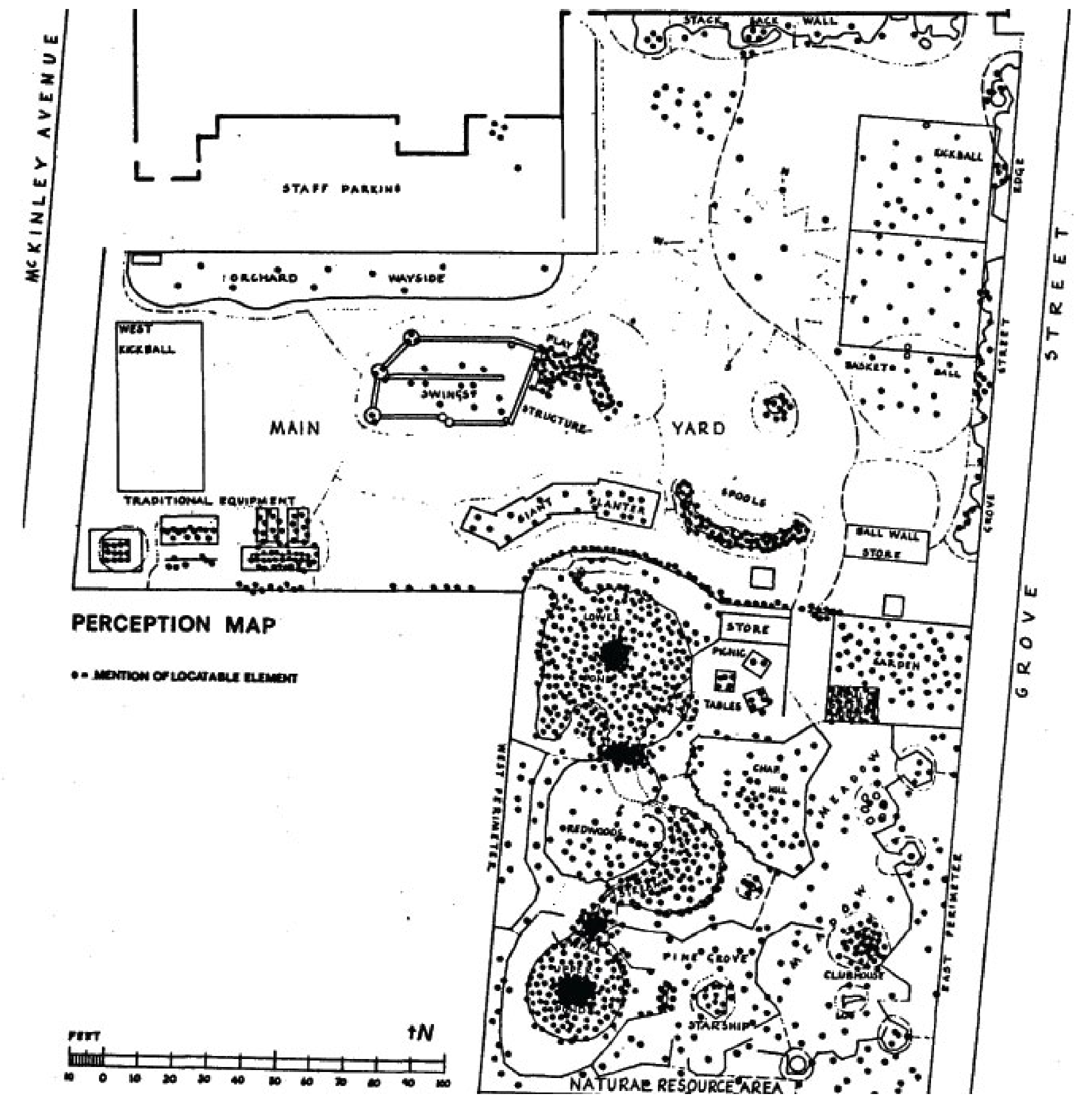


Fig. 16. Mental maps of the schooyard showed a high affinity for the naturalized areas, even though observational mapping showed play was equally split between all areas (all images Moore and Wong 1997).

Stormwater management and education

The numerous benefits of outdoor classrooms and naturalized schoolyards have been well documented. The next question is how these outdoor classrooms might offer functional and engaging educational experiences related to stormwater management. Studies examining a variety of these outdoor classrooms and recreational resources can demonstrate how vital ecosystems can serve dual purposes, drawing in some cases, hundreds of thousands of visitors each year. The following precedent studies describe the location, function, design considerations, flora and fauna, and the ways in which each park uniquely engages visitors to successfully provide an educational and recreational experience.

Ralph Klein Legacy Park
Location: Calgary, Alberta
Site Area: 30 hectares
Client: City of Calgary
Designers: Carson . McCulloch Associates
Budget: $36 million

Located on the east side of Calgary Alberta the Ralph Klein Legacy Park, and the adjoining Shepard Wetlands, are the largest constructed wetlands in Canada (a combined 156 hectares), with a capacity of 6 million cubic meters of water (City of Calgary 2011). Opened in 2010, the wetlands channel water from the adjacent Western Headlands Canal during stormwater events. The water enters two forebays where large particles and heavy metals settle into the sediment. The water then moves into one of five wetland cells where nutrients and other pollutants are removed and utilized by aquatic and marginal plants. A series of berms within the wetland cells are strategically placed to slow the movement of the water. The organic smell and the colour of the water leaves little doubt to visitors as to the function of the wetlands.

Fig. 17. Informational board painted by local artist.

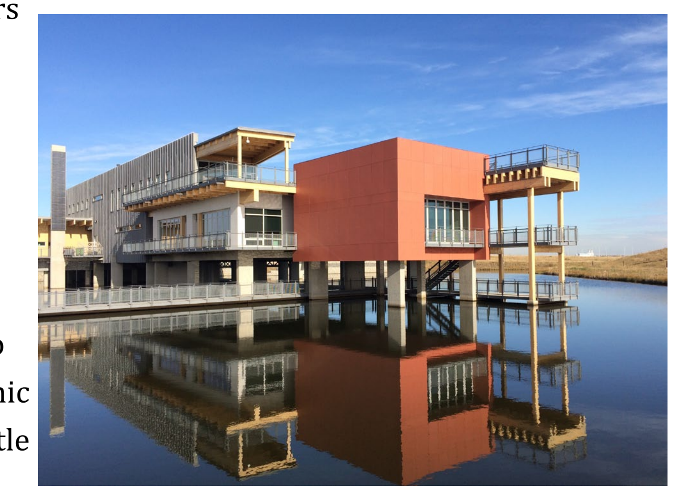


Fig. 18. The architecture of the classroom building sits directly in the wetland (City of Calgary 2011).

Informational boards about local fauna dot the landscape (see figure 17). Birds have begun to colonize the site, which is still in the establishment phase (46 recorded species {City of Calgary}). As seen in figure 19, Ralph Klein Legacy Park hosts a wetland education center (photograph in figure 18), an experimental community orchard designed to test the suitability of various fruit species to Calgary's climate, and series of large monoliths that, according to their sculptor Beverly Pepper, "are meant to herald the uniqueness of the wetlands" (City of Calgary 2011). The wetland education or "EcoAction School" is part of the Environmental Education division of Calgary's parks department (City of Calgary 2011). The school space is available for teachers of grades 1-12 to bring their students for a full week of intensive environmental education focusing on wetland ecology/biology and sustainability issues. This facility allows students to be fully immersed in the landscape they are studying. A landscape that could have been designed as simply a stormwater holding tank is instead a diverse and engaging community resource.

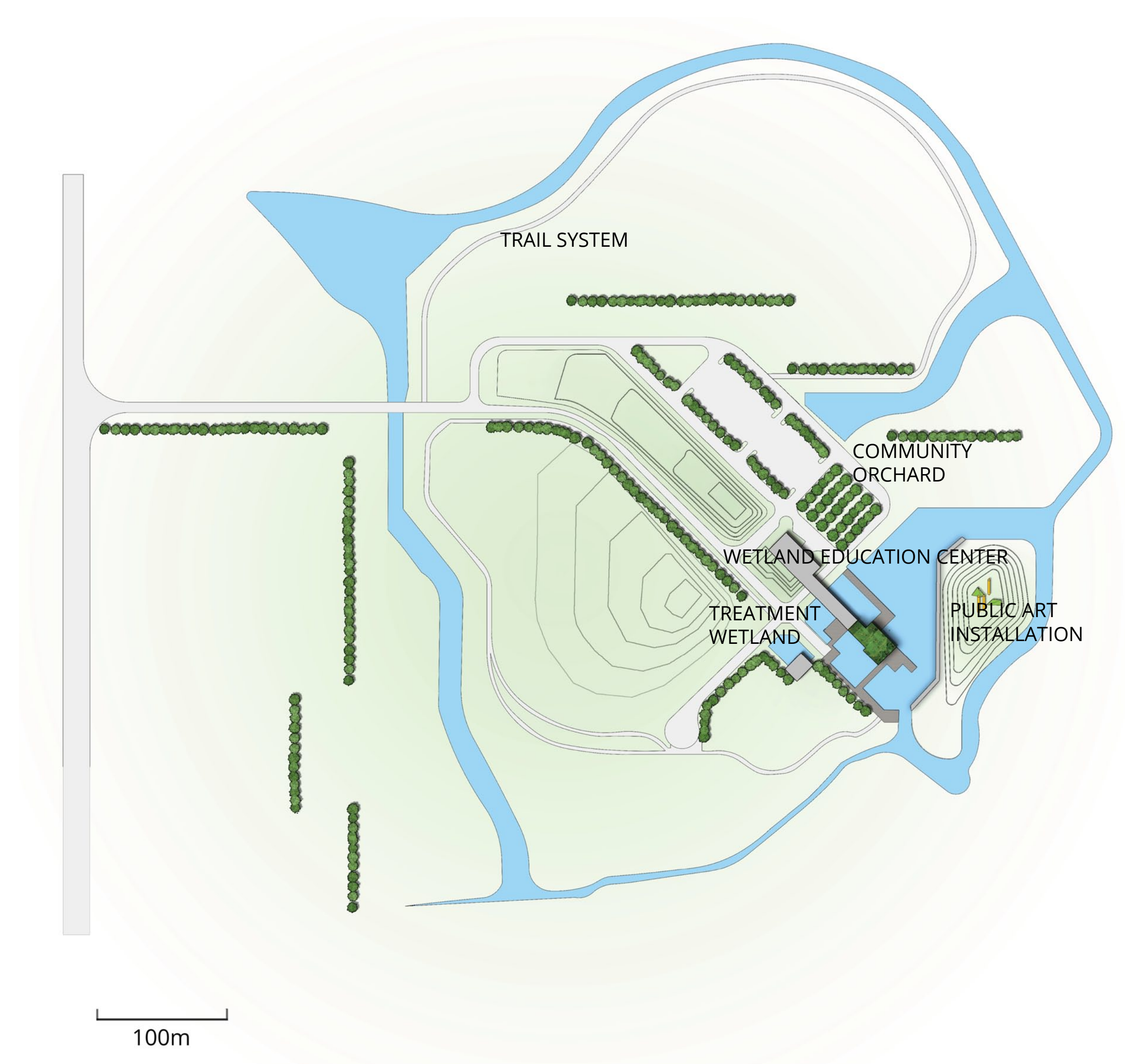


Fig. 19. Site plan of Ralph Klein Legacy Park

Sidwell Friends School – Washington, DC

Location: Washington DC
Site Area: 15 acres
Designers: Andropogon
Client: Sidwell Friends School
Budget: $ 4 million (Landscape)

Sidwell Friends is an exclusive private school located in Washington DC. A 2007 building expansion included an “outdoor living laboratory” designed by Adropogon. It incorporated green roof technology, a habitat pond, a terraced wetland and a rain garden. These landscape elements, along with various in-building technologies allow all wastewater to be treated on-site, saving about 3,000 gallons of water per day (Landscape Architecture Performance Series 2012). Treatment begins in holding tanks housing anaerobic bacteria. The wastewater is then moved outside and into a series of terraced wetlands where plant processes and gravitational force further clean the water, eventually resulting in the water’s re-use as grey water for toilets and irrigation (Pruned 2014). Wastewater is invisible, flowing below gravel and plant materials to ensure student safety. Stormwater is also retained on-site – first in the rain garden and then in an underground cistern, which feeds the habitat pond. When water levels become high in the pond, water is moved back into the rain garden, simulating a flood plain environment (Pruned 2014).

The school addition was designed to showcase the central wetland and rain gardens as the heart of the campus (see figures 20 -22). Decks outside the classrooms overlook the pond and stormwater processes are exposed. The pond becomes a resource; boulders and seating walls allow it function as an outdoor classroom, as well as a spot for socializing. Over 80 species of native plants provide habitat for insects, birds and amphibians (Landscape Architecture Performance Series 2012).

It is the layering of functions – stormwater management, wastewater treatment, education, habitat creation and social gathering – that makes this schoolyard a truly engaging space. Visitors and students can experience the same space in many different ways. The system functions as an “event landscape [where] natural processes are co-opted into a cybernetic amalgam of landscape, architecture, geology, biology and institutional pedagogy. This eco-machine is made to perform out in the open for the edification of the elite who, in their dirty, smelly, real-world engagement with the landscape, will hopefully turn into great stewards of the earth” (Pruned 2014).

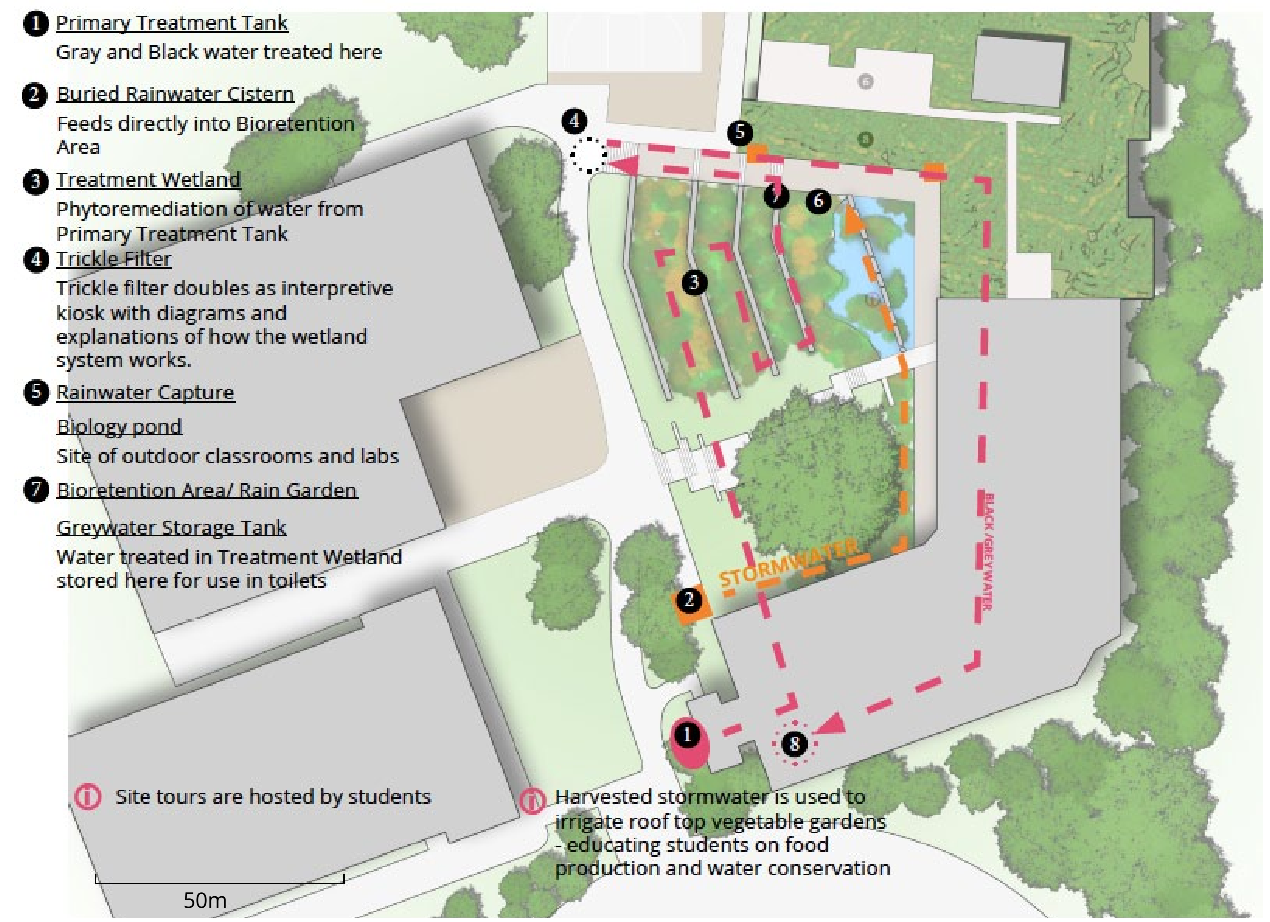


Fig. 20. Paths of water treatment at Sidwell Friends School

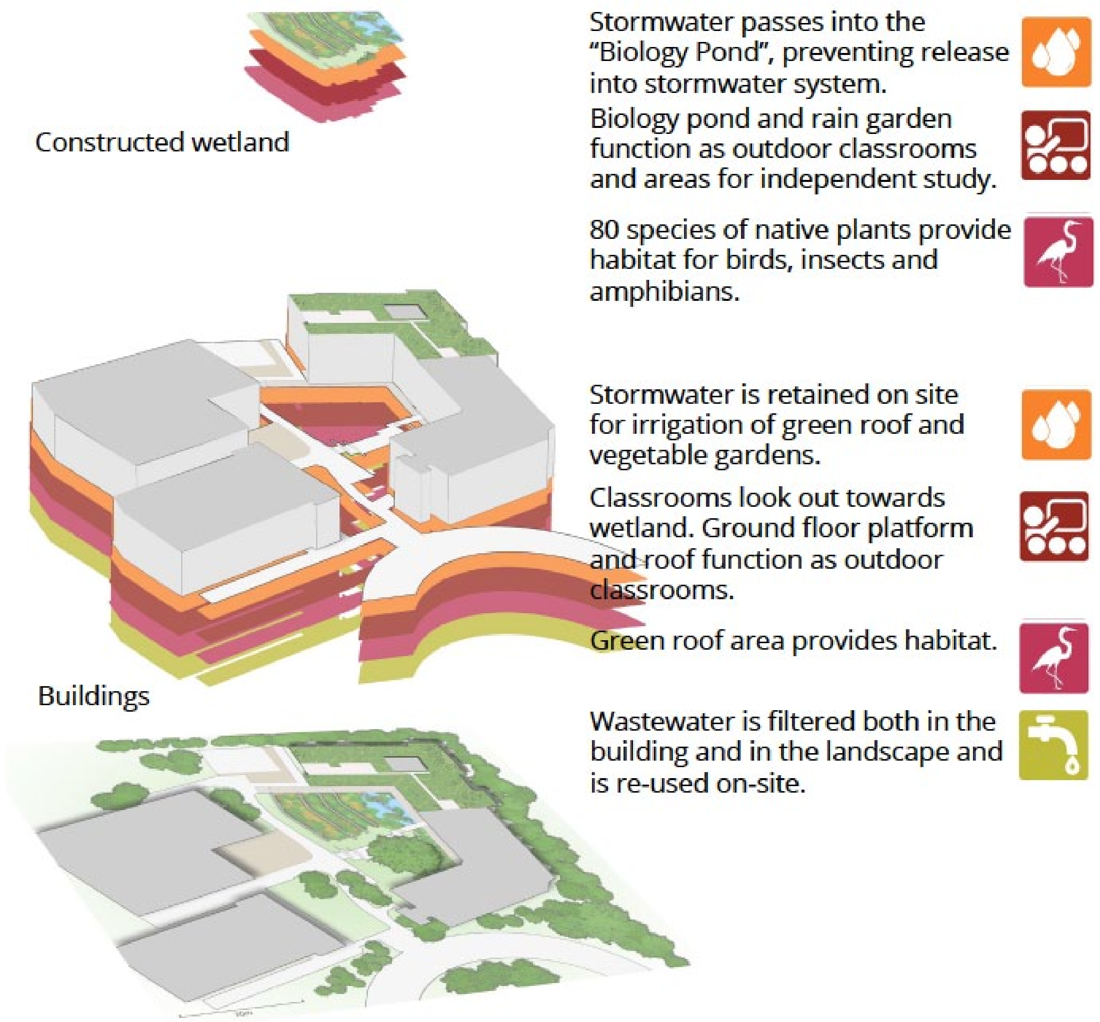


Fig. 21. Sidwell Friends School features a layering of landscape functions.

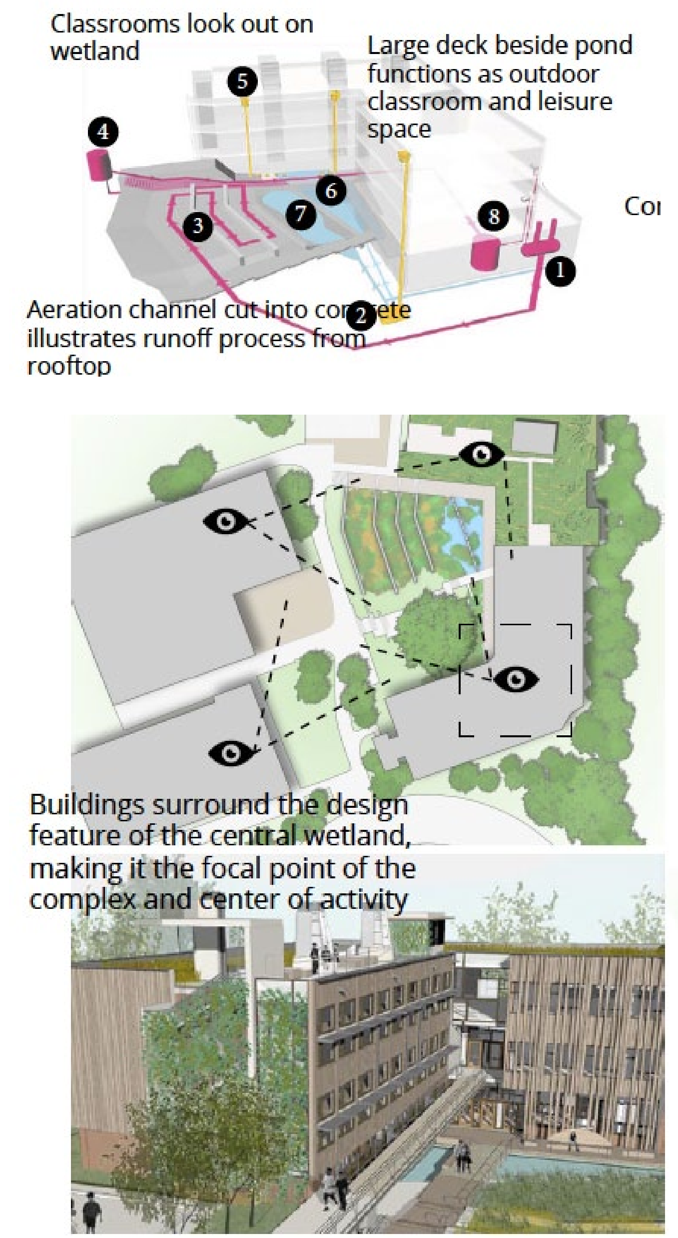


Fig. 22 Sidwell Friends School . Diagram (top) from The American Institue of Architects (2016) . Rendering on bottom right from Landscape Architecture Foundation [1] (2012).

Hong Kong Wetland Park

Location: Hong Kong | *Site Area: 61 hectares*
Client: Government of Hong Kong | *Designers: Urbis*
Budget: $HK 70 million

Hong Kong Wetland Park, located at the norther part of Tin Shui Wai, New Terrotories, Hong Kong was originally intended for stormwater management and as a refuge for migrating birds. The design mandate for this project was changed to provide for educational and recreational opportunities (Landscape Institute 2014). A visitor center and a series of floating boardwalks now provide access for thousands of people and has become a major tourist attraction. As at Sidwell Friends School, Hong Kong Wetland Park's layered functions provide a richness of experience. Recreation, education, habitat creation and stormwater management are woven together and processes are made visible.

Hong Kong Wetland Park is home to a variety of native plants, insects and animals. A "stream walk" includes a waterfall and rock pools with differing bank materials and vegetation; a "succession walk's" varied moisture conditions create a vegetation gradient from floating, to emergent, to wet woodland plants; a "mangrove walk's" boardwalks bring visitors into the preexisting wetland condition (Landscape Institute 2014). There are also bird blinds and a "wetland at work" where traditional Chinese wetland crops such as rice, Chinese Arrowhead and Water Spinach are grown. These plants are not harvested but instead left as food for fauna (Landscape Institute 2014).

Visitors are thus guided through a series of wetland ecosystem landscapes by several kilometers of trails and boardwalks. The park is also home to the Wetland Interactive World, which houses museum-like displays of various wetland features and the Wetland Discovery Center- a laboratory that offers wetland themed classes for student groups (Hong Kong Wetland Park 2014).

The educational programs, which incflude teacher training, self-guided and fully guided tours, job shadowing and wetland education classes have been extremely popular with over 74,000 people taking guided tours in 2012 and over 7,000 students attending educational workshops (Hong Kong Wetland Park 2014) . In addition to educational activities, continuous ecological monitoring and studies ensure that water quality and habitat are suitable not only for migratory birds but also for the resident insects, fish and mammals. At least 400,000 people visited the park in 2012, 37,000 were tourists (Hong Kong Wetland Park 2014).The Landscape Institute counts over a million annual visitors. The impressive number of park visitors is testament to the power of a well-planned educative landscape.

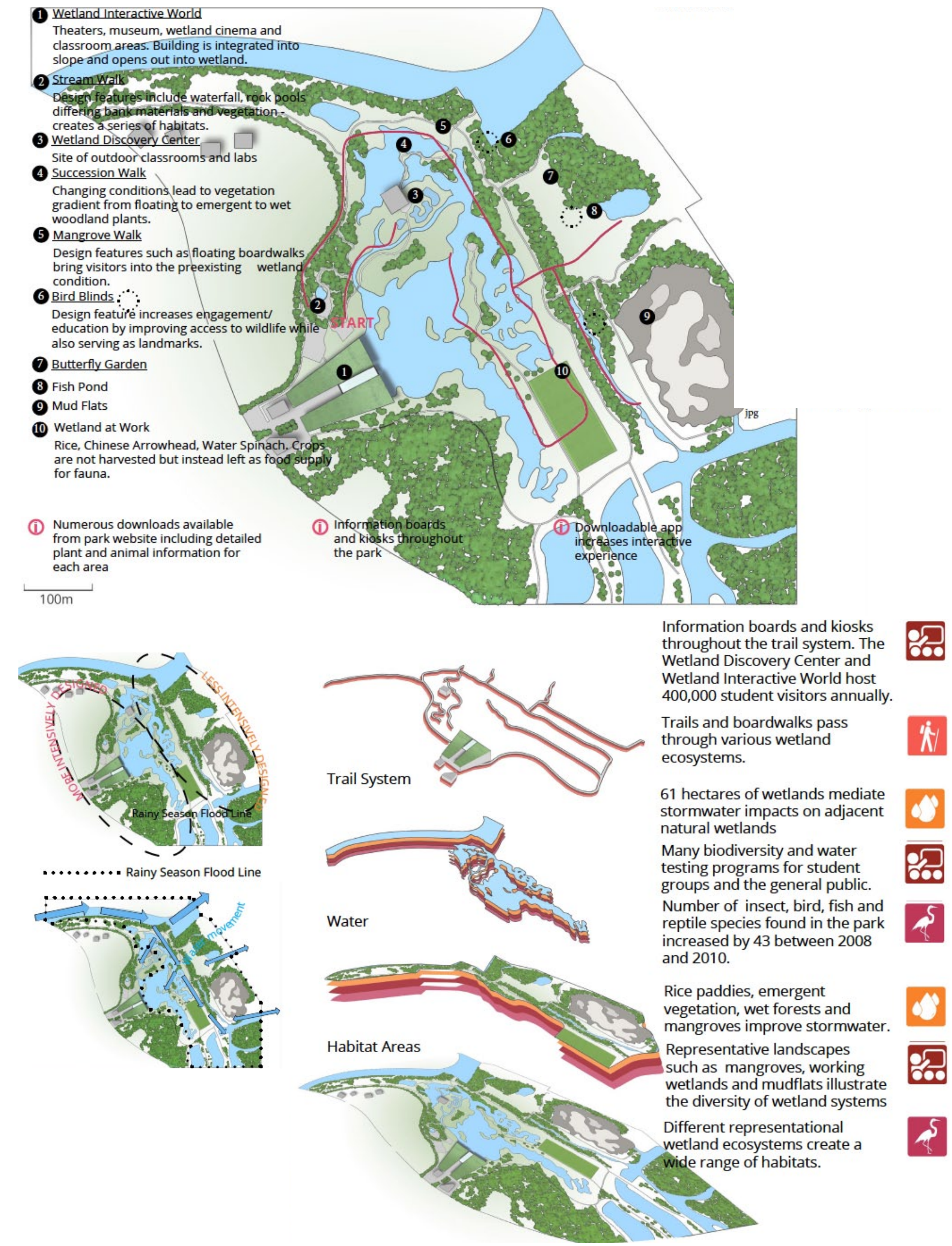


Fig. 23 Hong Kong Wetland Park

Magnuson Park

Location: Seattle, Washington | *Site Area: 154 acres*

Client: City of Seattle | *Designers: The Berger Partnership PS*

Budget: $14.6 million

Located in Seattle Washington, Magnuson Park creates a series of functional wetlands over what was once 12 acres of impervious pavement. The park sits on a former naval airfield, used for over fifty years and resulting in soil both polluted and extremely compacted, polluted water that emptied into Lake Washington. Because remediating these soil conditions was deemed too expensive, the architects focused on improving the quality of water emptying into Lake Washington by directing all surface runoff into a series of filtering wetlands (Landscape Architecture Foundation [2], n.d.).

The Berger Partnership designed the site with a balance not only between cut and fill but also between habitat creation and recreational opportunities for area residents. Close to 5,000 native plants were installed, including 725 trees, creating an environment which supports a variety of animals such as the Pacific Chorus frog, whose population numbers have increased by 255% since the development of this wetland (Landscape Architecture Foundation [2], n.d.). Leaky berms, willow wattles, log weirs, and rice paddies, each performing different remediation tasks, were included in the design. The shape of the wetland area was carefully designed such that concrete construction near the sports fields gradually transitions to organic forms near the lake. The wetlands can hold 5,000,000 gallons of water and the play fields act as part of the stormwater treatment process - the base material under the synthetic fields retains water and releases it slowly into the wetland ponds. Water entering Lake Washington has 94% less suspended solids and 99% less fecal coliform than it did in tests performed prior to construction (Landscape Architecture Foundation [2], n.d.).

The varying shapes and forms embedded in the design, combine into a wetland system interconnected with the 6.5 km trail system that passes through remnant forests and historic buildings. These features serve to engage visitors in the remediation processes and habitats at work. Educational programming at the wetland park includes summer and winter camps, family nature walks, bird watching, teen educational programs and grades k-6 field trips. The park offers three different k-6 field trip experience options, including bird watching, wetland education and "life in a garden", in which students learn about plants and soils. At Magnuson Park, a multi-use sport and recreational park environment simultaneously functions as a model of environmental remediation and an educational experience for students and families.

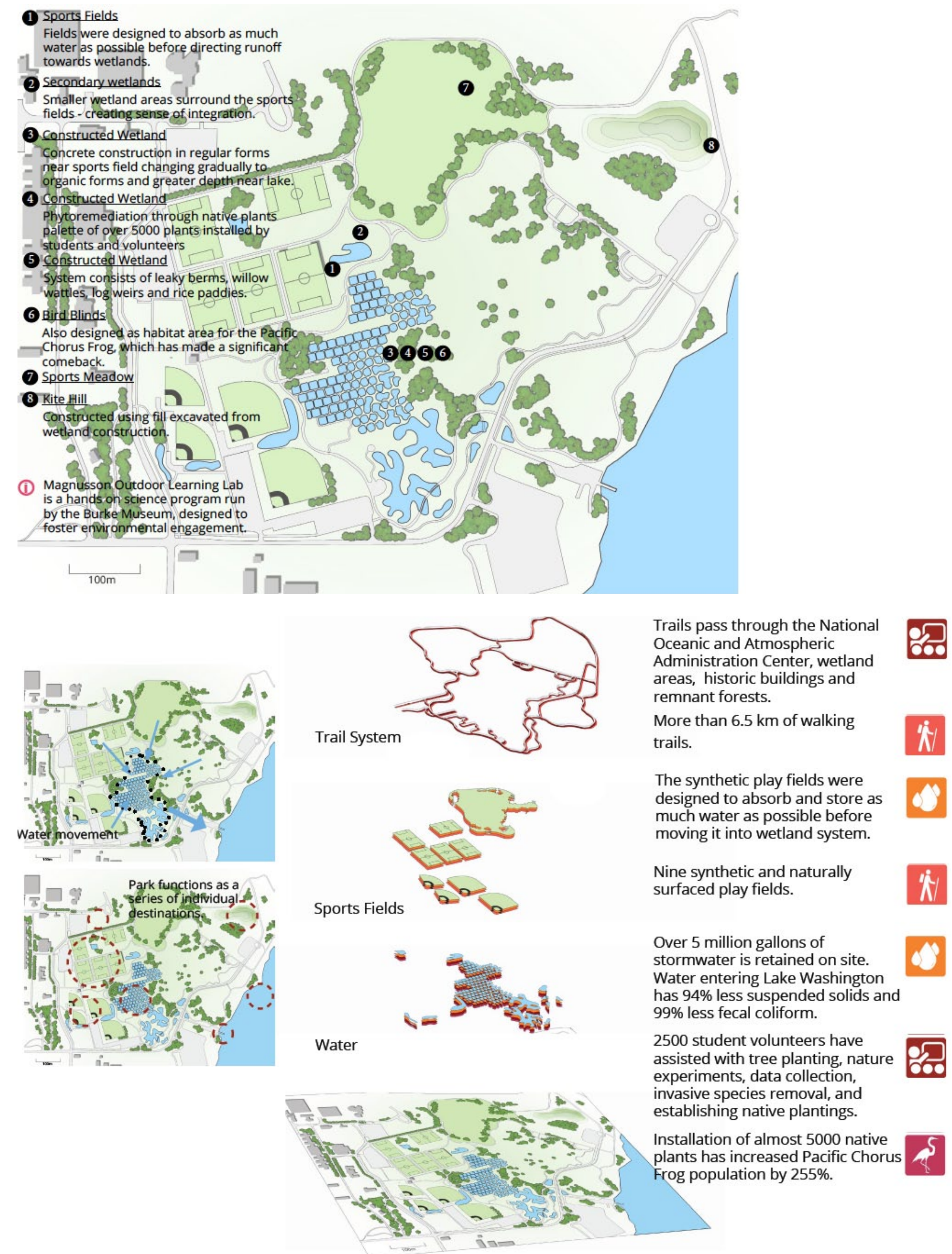


Fig. 24. Magnuson Park

Clearly, these projects encompass a wide range of geographies, scales, budgets, cultures, programs, and environmental conditions, but common elements make them successful. First and foremost, the multi-use/multi function designs all provide habitat, education, and recreational opportunities along with their ecosystem services. With recreation, ecosystem processes, and education brought together, opportunities for learning emerge. Through observation and conversation between peers and families during visits to the parks learning can occur in passive and informal manner. Alternatively, through attending programs designed to showcase the educational components of the parks, formal and active learning can occur. This layering of functions offers return on investment for the communities (e.g., increase in visitors to all of the parks, increase in clean green spaces for locals and visitors, increased educational forums for students and community members) and the environment (e.g., population recovery of the Pacific Chorus frog at Magnuson Park and removal of pollutants from stormwater at Ralph Klein Legacy Park). Finally, the international recognition received by each park (as demonstrated by visitor numbers) indicates that there is a public appetite for, as well as a local and global community connection with, these multi-use wetland spaces.

Chapter 4: Site Analysis

The site for this study is a retention pond and its surrounding lands, adjacent to École Christine L'Esperence in River Park South near the intersection of Dakota Street and John Forsyth Road. Dakota Street is a major commuter route (see figure 25). The lands are owned and maintained by the City of Winnipeg Parks Division and the Franco-Manitoban School Division. The total site area encompasses approximately 14.5 hectares (ha).

Fig. 25 Ecole Christine L'Esperence

Neighbourhood Context

River Park South is a suburban residential neighbourhood in southeast Winnipeg. (see figure 26). Housing is almost all single family, though there are a few condominium developments. The average selling price for a single-family residential house in 2014 was $329,000 – well above the Winnipeg average of $285,000 (Winnipeg CMA 2014). Most houses around the selected site were built in the mid-1990's. The street layout is typical of Winnipeg's subdivisions from this time period, with wide, winding primary roads feeding into numerous bays and cul-de-sacs.

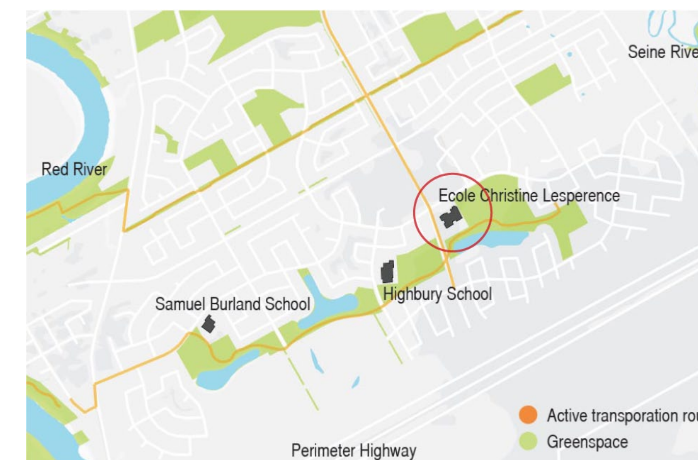


Fig. 26 Neighbourhood context

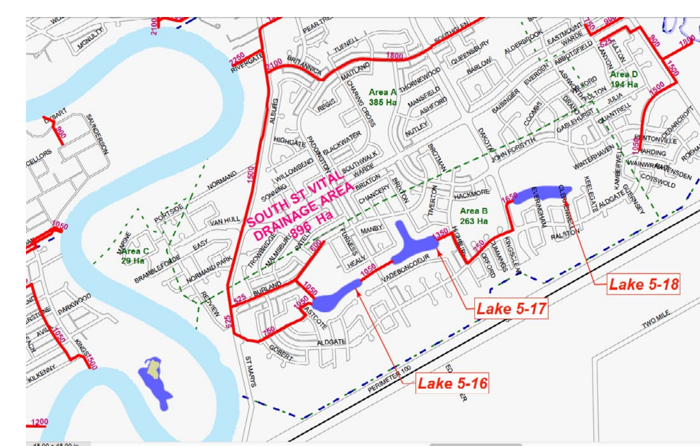


Fig. 27 Connection to other ponds and the Red River

Existing Conditions

The pond, classified as Lake 5-18 by the City of Winnipeg, covers 2.4 ha of land with a volume of approximately 6.8 million litres (L). In summer the water surface is close to 3 metres (m) below upland areas. In the spring and after heavy rainfall events, the water is significantly higher. Slopes down to the pond from the upland areas range from 5:1 to 17:1. There is an inlet structure on the pond's east end and an outlet structure on the west that leads to two similar ponds downstream and eventually to the Red River (see fig 27and 28). The pond design is the typical open-water, riprap-lined style of ponds built in the 1990's and suffers from the problems associated with that model an discussed in Chapter 1. In spring and fall migratory geese gather in the hundreds, covering the sidewalks and sports fields with feces (see figure 29). In summer, the pond is green with algae. The southern shore of the retention pond is lined with single-family houses. As property lines technically extend into the water, the southern shore must be treated as a no-work zone.

Sports fields and path network

4.5 ha of sports fields separate the north side of the pond from John Forsyth Road, one of the neighbourhood's major feeder roads. The fields are heavily used in summer for soccer and flag football, although there are no bleachers or shelters of any kind. Because of the fields, permanent seating in that area may not be feasible. As is typical in Winnipeg, the site is very flat (1-2% slope). Three turfgrass drainage swales feed overland into the pond drain the fields. There are a few small groves of ash trees in poor-to-fair condition sprinkled between the fields. The site is part of the neighbourhood's active transportation route, spanning from close to St. Anne's Road to St. Mary's Road (marked yellow in figure 30). The Dakota Street bike lanes also terminate at John Forsythe Road. Despite the geese problems and lack of shelter or shade, the pathways are well-used from spring to fall. In winter, the City does not clear snow and excessive drifting caused by the site's exposure to prevailing northwest winds make the sidewalks impassable. Surfacing is asphalt, in generally good condition, with a width of 1.75 m. The site has three benches immediately off the sidewalk overlooking the lake and three more along the pathway connecting John Forsythe Road to the primary walking path.

The school

École Christine L'Esperence is a French-only K-8 school that is part of the Franco-Manitoban School Division (see figure 31). Enrolment last year was 498 students. There is also an on-site daycare. The school covers 6300 square meters (sm). Play areas include two

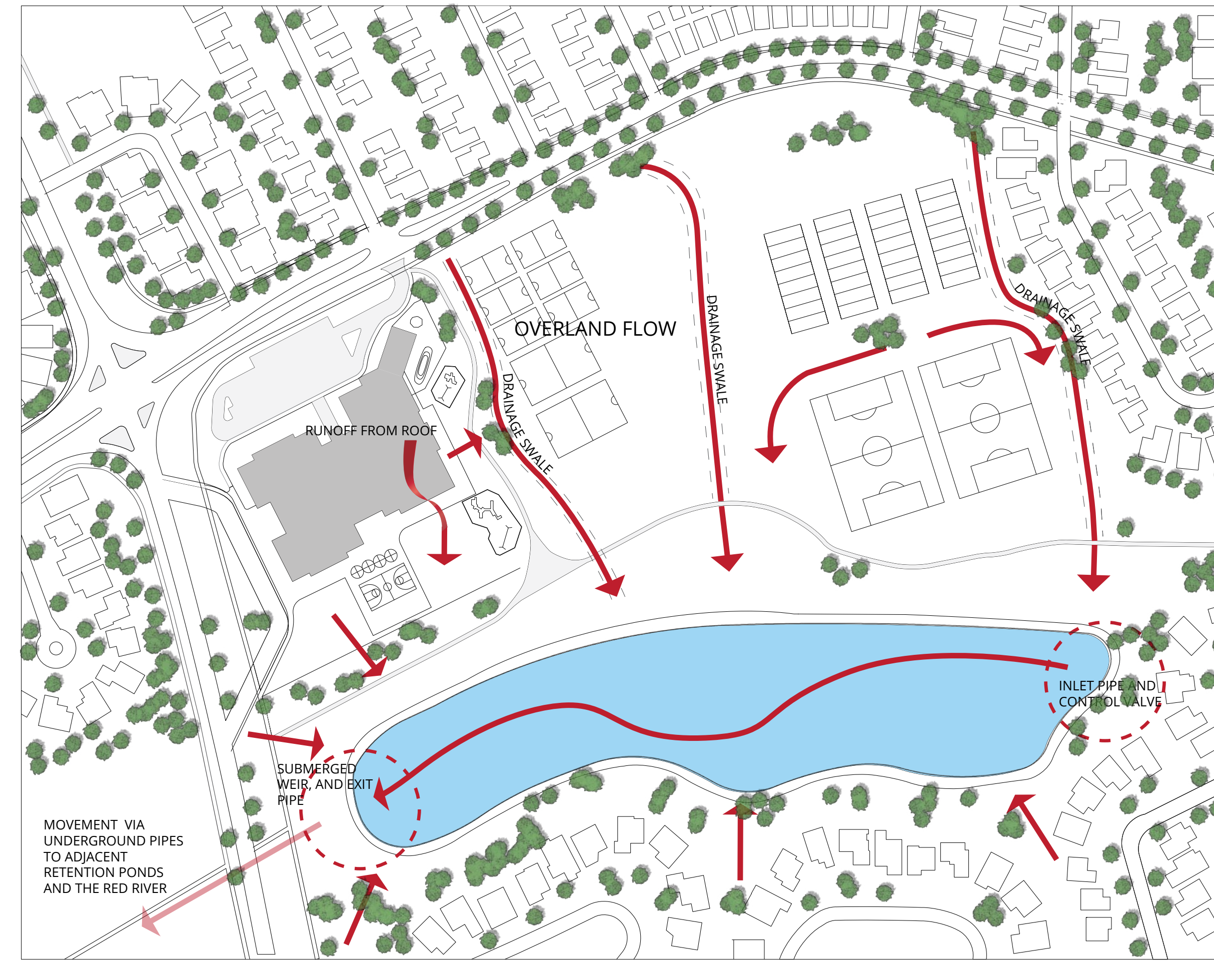


Fig. 28. On-site water movement

modular play structure areas with pea-gravel surfacing covering 750 sm. The schoolyard also features 2400 of asphalt play areas including basketball, four square and hopscotch, as well as a small gravel-covered ball-play area (see figure 32) There is also a small fenced play area for the daycare on the north side of the building facing the parking lot. Another fenced play area for the daycare on the east side features a sand pit surrounded by boulders and a small grassy berm. Fencing on the schoolyard's south side separates the school property from the City green space. The fence seems to function as a boundary during lunch and recess, as children do not pass it. The school play equipment is used frequently outside of school hours, as it is one of the few

Fig. 29. Geese feces and feathers cover the areas around the pond.

Fig. 30. Pathway system

playgrounds in the immediate area. The before and after school drop off area is on the west side off Dakota Street. The pathway system (running between St. Mary's Rd and near St. Anne's Rd) is well-used by students walking to and from school (see figure 30).

Site vegetation

Vegetation is almost exclusively turf grass, which is generally in fair condition. Boulevard plantings are exclusively Ash and are in poor-fair condition. As previously mentioned, there are other small clusters of Ash planted throughout the site (see figure 33). Cattails (Typha spp.) have begun to colonize the southern shore of the pond along the private residential properties.

Impermeable surfaces and runoff

The total site including the school building, parking lots, asphalt play areas and pathways has a total of 13,425 square meters of impermeable surfaces (see figure 34). Winnipeg averages 415mm/ year of rainfall. On 13,425 square meters of impervious surfaces, that equates to 5570 cu. meters or 5.5 million litres of stormwater runoff per year. Parking lots are drained into catch basins, which are presumably fed into the retention pond. There are several large downspouts on the building, from which the water is directed into swales and into the pond.

Fig. 31 Ecole Christine L'Esperence

Pond footprint

The retention pond in its current state covers 2,4 ha and holds approximately 6.8 million L of water. It is recommended that a naturalized constructed wetland have only 30-40% deep areas (over one metre). The remainder should be comprised of submerged vegetation (300mm depth) emergent vegetation (150-300 mm depth) and wet meadow/marshy areas (France 2013). To handle the same volume of water, the footprint of the pond would have to be significantly increased. Figure 34 shows the existing pond footprint and the required pond footprint. In addition to the increased surface area of the pond, a number of key factors determined the overall shape of the pond (see fig 35). First, as much as possible of the sports fields' surface area had to be retained. Second, the private property on the south side of the pond could not be encroached upon. As a result, the south shore

Fig. 32. Site play areas

Fig. 33. Trees are a monoculture of Ash

remains virtually untouched in the final design (figure 35). Finally, the best practice design guidelines described earlier also influenced the pond footprint. These practices include employing an undulating shoreline to slow water movement and increase habitat, isolating deep areas into pockets spread throughout the pond to prevent short circuiting and using islands to increase habitat and slow water movement. The length to width ratio averages around 2.8:1, which is just shy of the 3:1 ideal. The volume of the new pond is 49,000 cubic meters, approximately 1000 cubic meters more than the existing pond. As figure 34 illustrates, the projected pond footprint would have extended well over the existing pathway and deep into the schoolyard. As a result, a retaining wall is required in some areas.

Constraints and *Opportunities*

This site has the potential to be a valuable educational and recreational resource for the community. However there are some significant constraints any design for the site must overcome First, the pond is part of a network of ponds. Purified water will simply be passed into another traditional style retention pond where it will mix with polluted water. Hopefully, in coming years all traditional ponds will be remediated, eliminating this issue. Second, as noted above, the private property on the south side of the pond precludes naturalization of the entire site (see figure. Third, the site is very exposed and there is a huge amount of impermeable surfacing which may make planting hard to establish. However, the biggest obstacle is that school staff has expressed no interest in the design process. A collaborative effort would result in a more meaningful design.

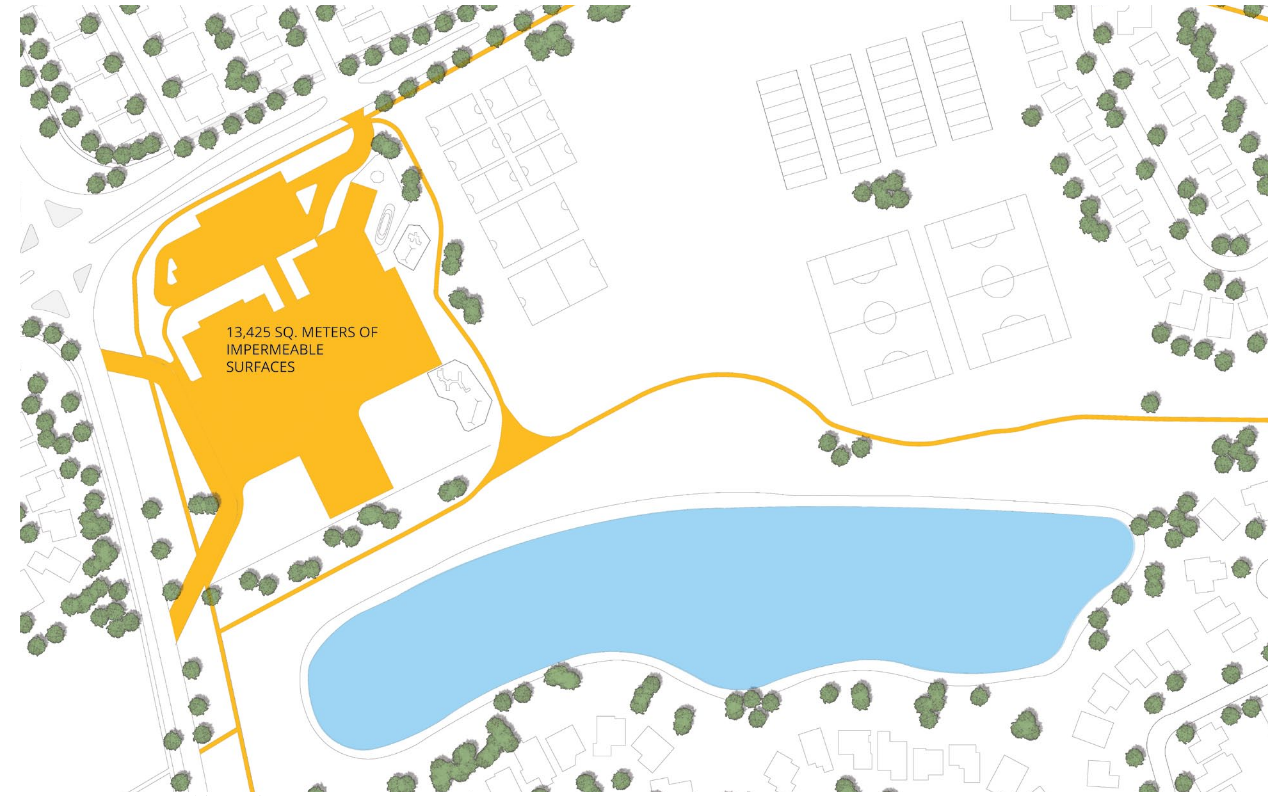


Fig. 34. Impermeable surfaces

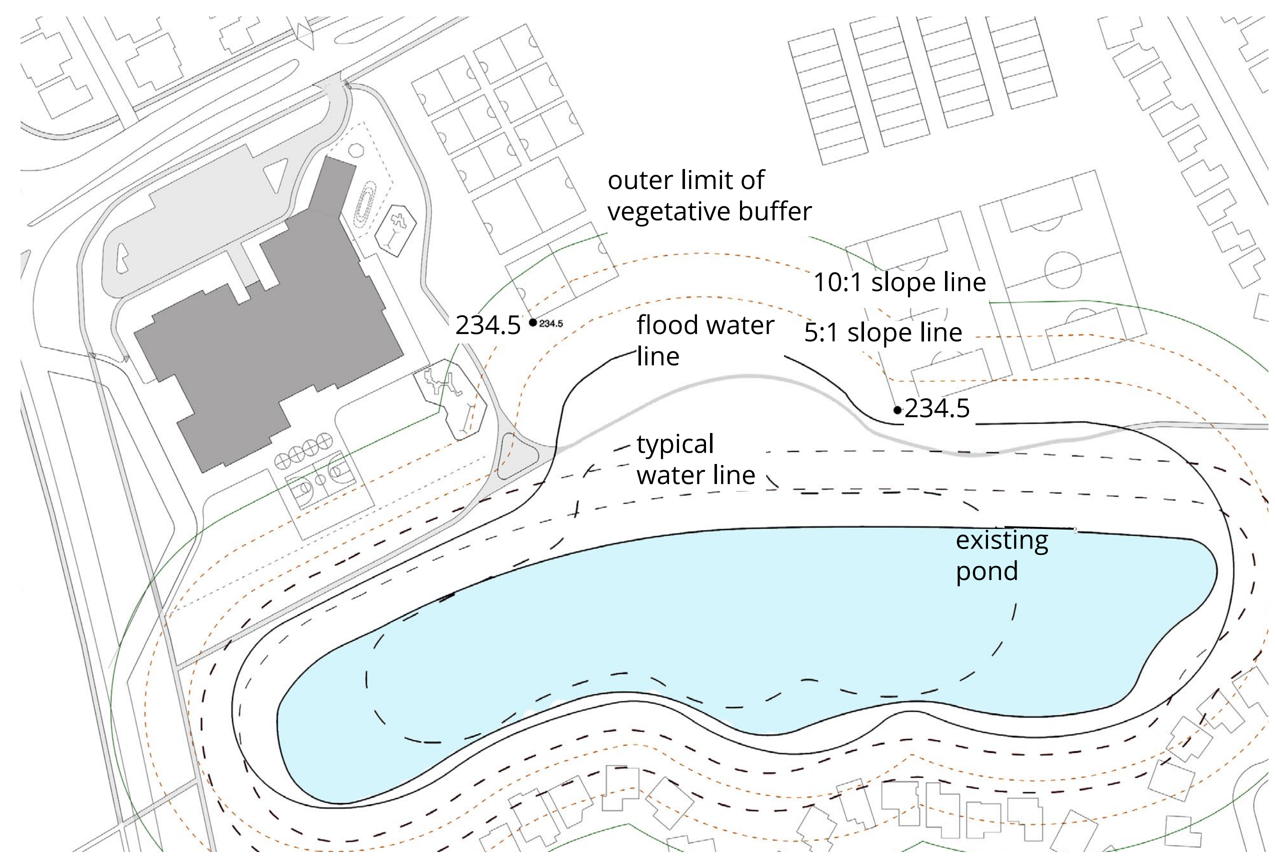


Fig. 35 The pond footprint required to handle the same volume of water. Retaining walls will be required in some areas

There are large amounts of impermeable surfaces feeding overland into the pond. They create an opportunity to for children to follow the path of stormwater from downspout to water body. Also, due to these large volumes of surface water entering the ponds, a protective vegetative buffer and conversion of the grassy swales into vegetated bioswales would greatly improve water quality in the pond. For all the shortcomings of the site in its present state, the pond is a completely untapped educative tool which could provide an interesting opportunity to extend the wetland system through the site. Wetland processes could be made visible for exploration, education and play. This design could serve as a model for similar sites in the neighborhood and city.

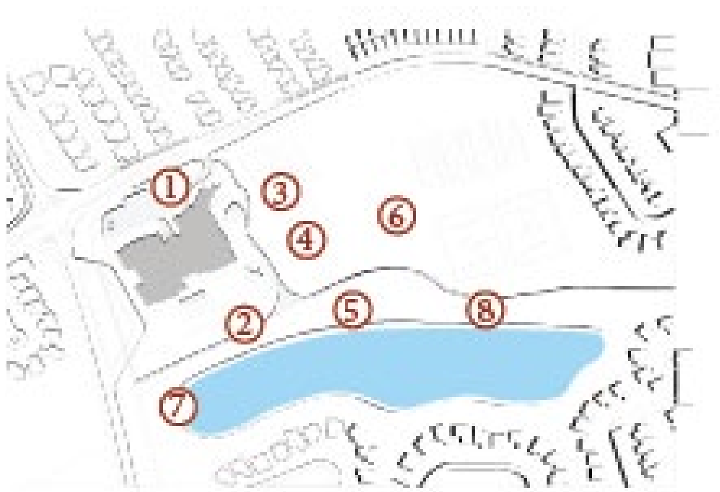
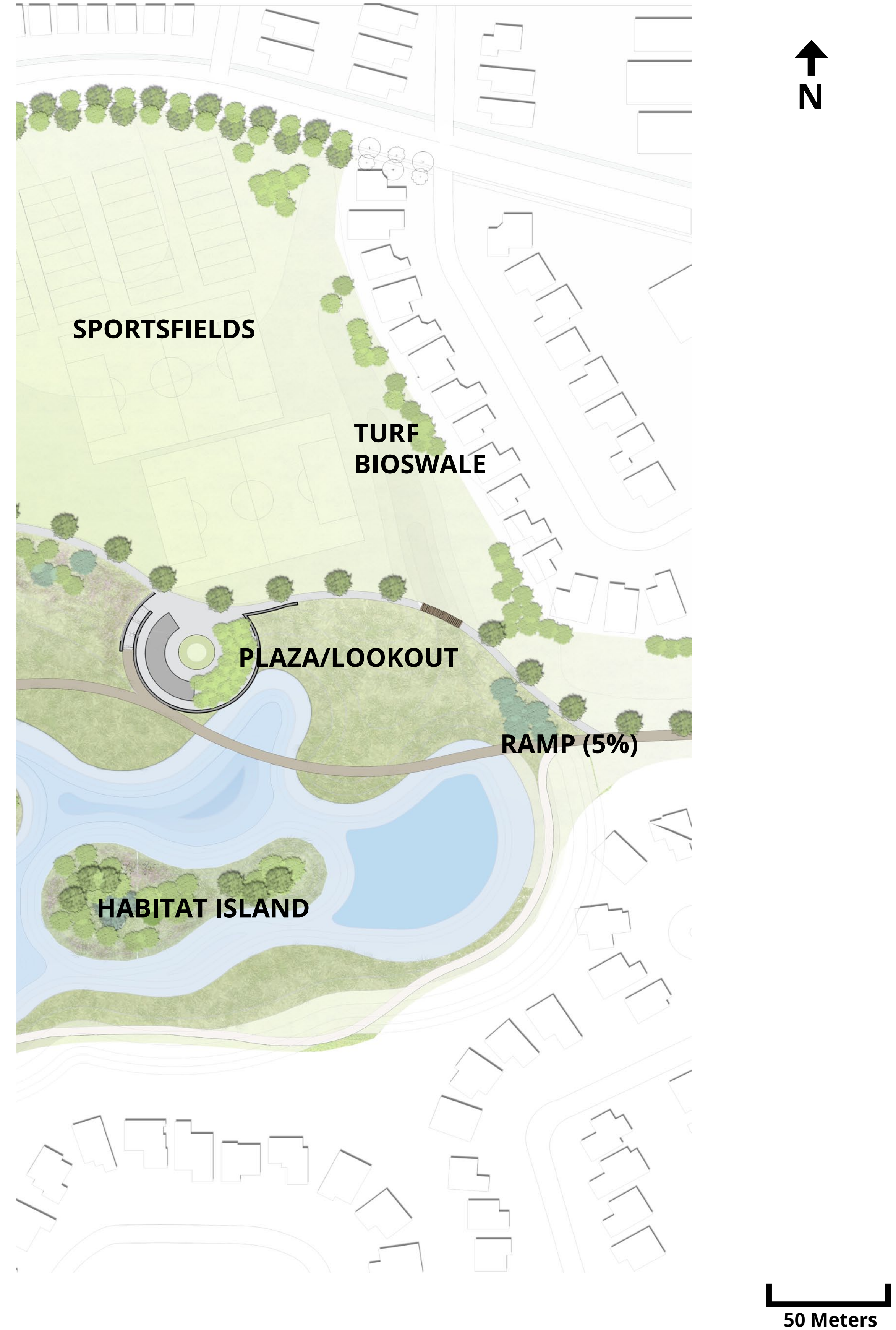


Fig. 36. Site photos (opposite page) illustrate the predominant turfgrass and asphalt landscape.


JOHN FORSYTHE RD.
TURF
BIOSWALE
VEGETATED
BIOSWALE
SCHOOL
WETLAND
AREA
PLAY AREA
BOARDWALK
DAKOTA STREET
LEARNING ISLAND
OBSERVATION
PLATFORM
WETLAND
AREA
RAMP (5%)
LOOKOUT


N
SPORTSFIELDS
TURF
BIOSWALE
PLAZA/LOOKOUT
RAMP (5%)
HABITAT ISLAND
50 Meters

The overall design for site is focused on creating opportunities for users to enter and become engaged with the wetland condition at a hands-on level. This engagement is dependent upon accessiblity created through manageable slopes, stairs, ramps, platforms and boardwalks. Due to the large scope of the project, the overall site design was addressed only on a conceptual design level, resolving the final pond layout, site grading and wetland planting strategy but not other site features such as boardwalks, ramps, plazas and walls. A detailed design was produced for one area, the existing schoolyard play area, which is described in later sections of this document.

The conceptual design (figure 37 divides the wetland into zones based on elevation and moisture levels, including open water, low emergent zones, high emergent zones and upland buffers. Site amenities are woven into this framework. As with Hong Kong Wetland Park, the key site amenity is the boardwalk winding its way through the various wetland conditions and connecting to the upland path at the east and west shores. As an educational tool, the boardwalk would allow students and visitors to immerse themselves in the wetland experience. As a safety precaution, the boardwalk is laid out to pass over deep

Fig. 37. Conceptual design


Fig. 38. The boardwalk leading through diverse wetland conditions

water as few times as possible. A detailed design would likely include guardrails at least over those deep-water areas and bumpers along both sides for its entire length to protect against wheelchairs and strollers rolling over the edge.

A second key site amenity is a large circular plaza/picnic area on the north shore, overlooking the pond. With views over the key habitat areas, this plaza could function as an outdoor classroom and gathering space during school hours and also as a sheltered sitting space for spectators to gather in during games on the sports fields. The plaza features a large roof over much of the its western half and a bosque of trees to the east. As drawn, the covered area could hold as many as 30 standard picnic tables, providing ample seating for tournaments and multi-team events. The center of the circle contains a grassy berm as a perch for watching games or as a play area for younger children whose siblings are playing on the field. As with the upland path near the schoolyard, the location of the plaza necessitates the use of a gabion wall. A stairway connects the upland path with the boardwalk below. Again, it is important to note that the design of this area is conceptual and many details would have to be resolved in the final design including tree species and spacing, surfacing, and construction of the shelter.

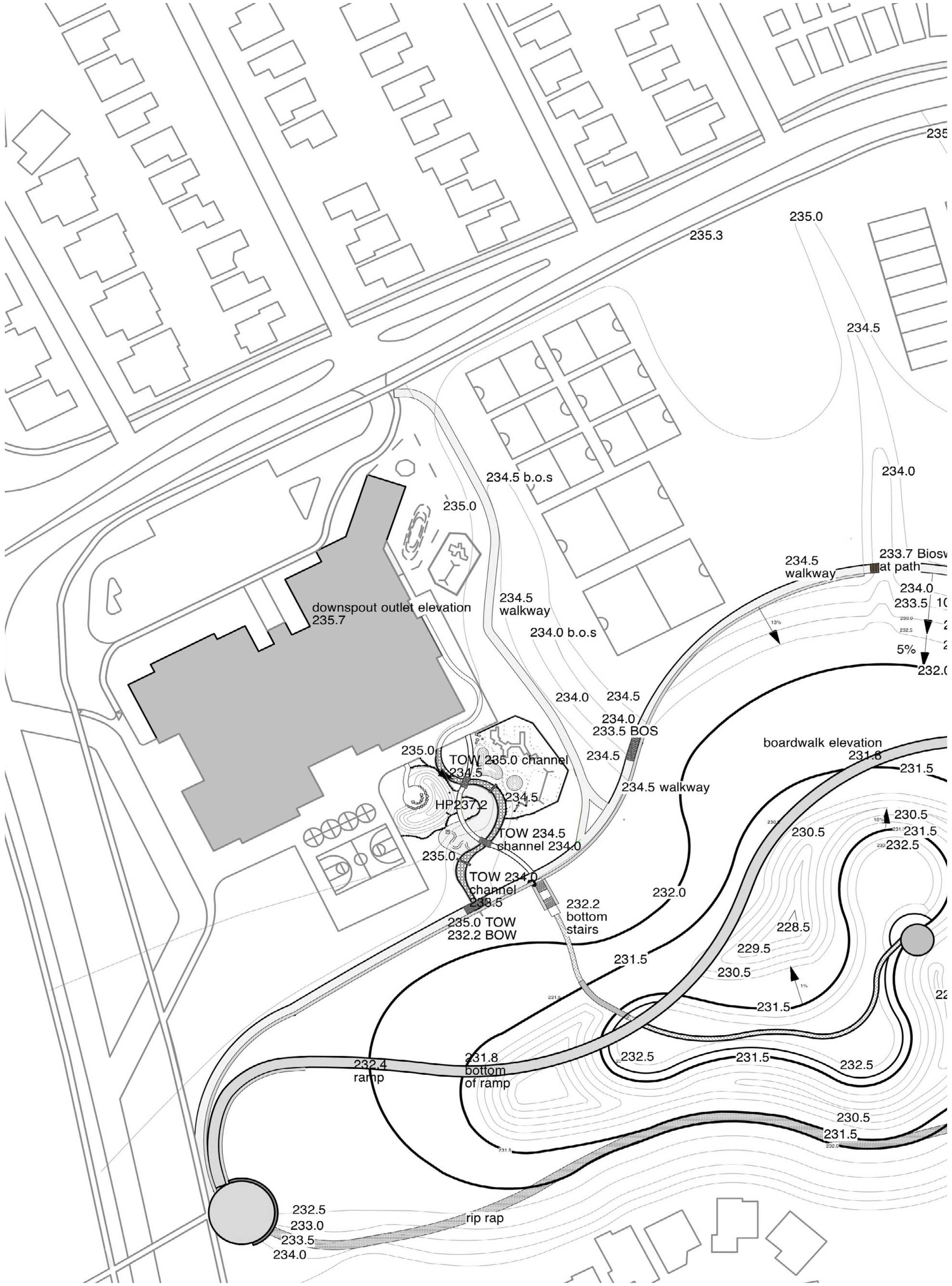
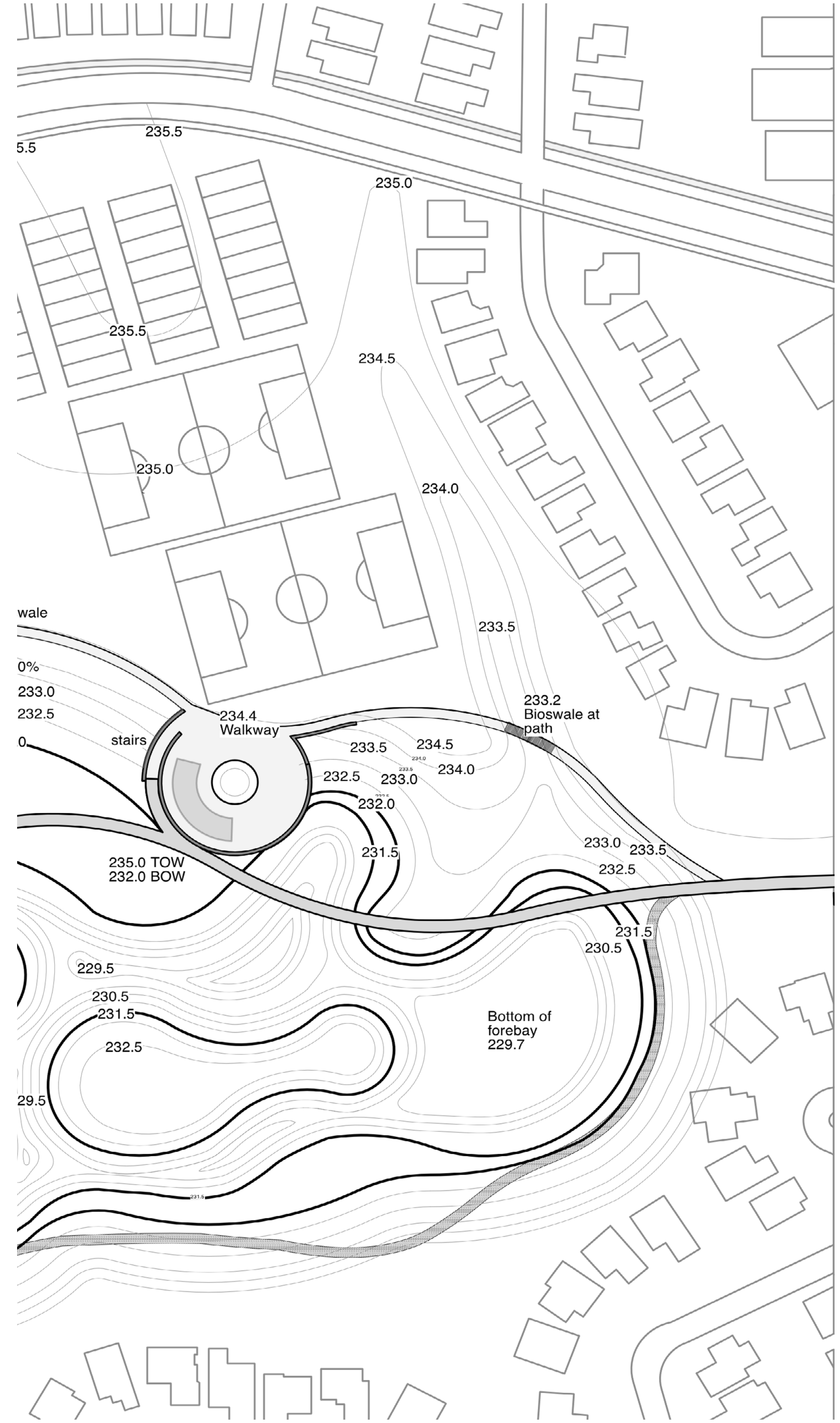


Fig. 38. Grading plan



The two islands in the middle of the lake (see figure37) each perform different functions. The "habitat island" has no connection to the boardwalk or any landforms. This separation provides for valuable nesting areas for bird species that are protected from humans and domestic animals. With an area of over 2800 square meters and a highpoint close to 1.5 meters above the typical water level, there is the opportunity to provide for a wide range of suitable bird habitats. These habitats must include a range of plant types but also areas of open mud for foraging and deadfall for nesting. Table 2 in Chapter 1 is a list of bird species observed at Oak Hammock Marsh and Fort Whyte, two large wetland parks in the Winnipeg area. Included in the table are the food and nesting requirement for each species. By including these habitat requirements, a final, detailed design would create suitable conditions for selected species such as Northern Pintail and Red-Winged Blackbird.

The second island has direct access from the boardwalk and from a set of stairs leading from the schoolyard. The island would give students and visitors access to a viewing platform looking towards the habitat island (figure 39). The islands also provide remediation services. They provide a substrate for phytoremediating plants and also slow water movement through the pond – increasing residence time. Similar to Magnusson Park described in Chapter 3, stormwater management and habitat creation are layered.

Fig. 39. Looking from the observation platform towards the habitat island

Another key feature of the conceptual site plan is the incorporation of the existing grass swales into the overall stormwater management system. The swales in the center and on the east side of the sports field remain as turf grass swales, although they are slightly deeper to hold more water. Although keeping the swales as turf grass as opposed to vegetating them, would reduce their stormwater remediation efficiency, ease of maintenance and access to the fields makes turf grass a more logical choice. The swale on the west side of the sportsfield, however, is converted to a vegetated swale. Not only do these changes increase the landscape's capacity for buffering the pond, the swales would provide an excellent educational opportunity right out the school door.

As can be seen in the grading plan (figure38), the swales pass under small sidewalk footbridges and enter the pond. The slope from the sidewalk to the pond ranges between 5 and 10%. Compared to the existing slopes, which are up to 17%, accessing the pond would become much safer. To make the pond truly accessible, there are ramps on the east and west ends of the boardwalk, which have a 5% slope – greater slopes would necessitate incorporating landings as rest stops. As previously mentioned, the projected pond footprint would have extended well over the existing pathway and deep into the schoolyard. Therefore, a gabion retaining wall is necessary, with a significant three-meter drop from the sidewalk to the wetland below (see inset figure38). Because of their large footprint, and resistance to failure even when settling occurs, gabion walls are ideal in wet conditions. The porous nature of gabion walls also eliminates hydrostatic pressure against the wall. The grading plan reflects the topographical changes that are the basis of the planting scheme. However, detailed design of the pond area would further manipulate the slopes to create dips and plateaus and provide a more varied and engaging landscape, not simply through topographical variation but also by creating more variation in the vegetation.

Figure 40 illustrates how the plant palette for this design is adapted from the various elevation-dependent growth zones described in Stewart and Kantrud's classification of prairie wetlands (see chapter 1). Because of the significant overlap in representative species between the shallow marsh and wet meadow zones, the two zones were consolidated into "emergent and edge species" in the planting plan. Similarly, Stewart and Kantrud's low prairie zone is classified as "upland planting" in the planting plan. It is important to note that construction of the wetland would create zonation not solely through elevation changes (i.e. moisture regimes) but also through soil structure. The lake bottom and deep marsh zones would require little soil amendment, with the associated plants well adapted for growth in high clay content. Conversely, the upland areas would be heavily amended, with up to 40% organic matter.

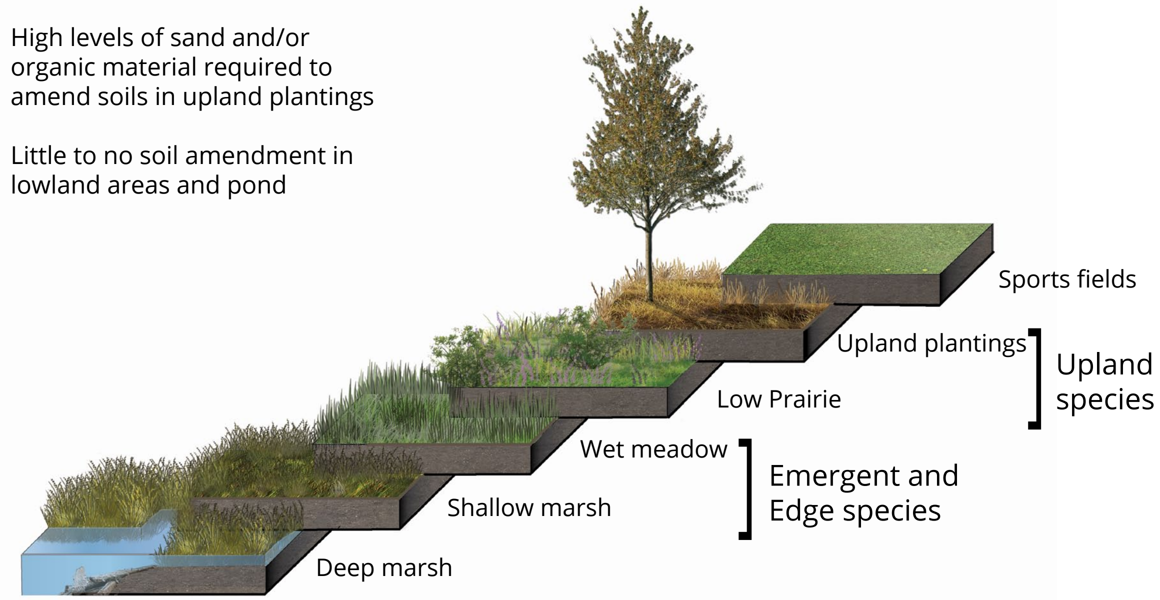


Fig. 40. Elevation zones

As described briefly in Chapter 1, the plant palette illustrated in figure 42 (page 62) is a Winnipeg specific (Zone 3). Plants are categorized as submergent species (e.g. pondweed and duckweed), emergent species (e.g. cattails, rushes and sedges), edge species (e.g. manna grass and foxtail) and upland species (e.g. little bluestem, yarrow, coneflower and liatris). Some of these species would form key remediation roles. Cattails are the phytoremediation powerhouses of constructed wetlands due their high biomass, rapid growth and ability to sequester heavy metals and other pollutants. Grasses play an important role in stabilizing slopes through their extensive root systems. Their seeds also provide a valuable food source for foraging birds. Other plants are important for insects. Yarrow and coneflower, for example, attract butterflies.

Seeding would be done by dividing the planting area into the various zones described above, the zones would then be drill-seeded with their respective seed mixes (figure 41). More highly visible areas and areas where greater diversity is required (e.g. next to paths, on the islands) would also be planted with perennial plugs to give them a chance to establish before the more competitive grasses take hold. The grid pattern in figure 41 also illustrates the areas to receive additional planting. The areas would be divided up into 5m x 5m grids – each zone with a specific planting plan. Those grids could than be easily repeated over the large area. As the landscape develops, plant distribution would be determined by microclimates within each zone. For example, even within the upland planting zone, lower areas may be dominated by more moisture-loving plants such as anemone and coneflower, while yarrow and liatris would thrive in the driest soils. By

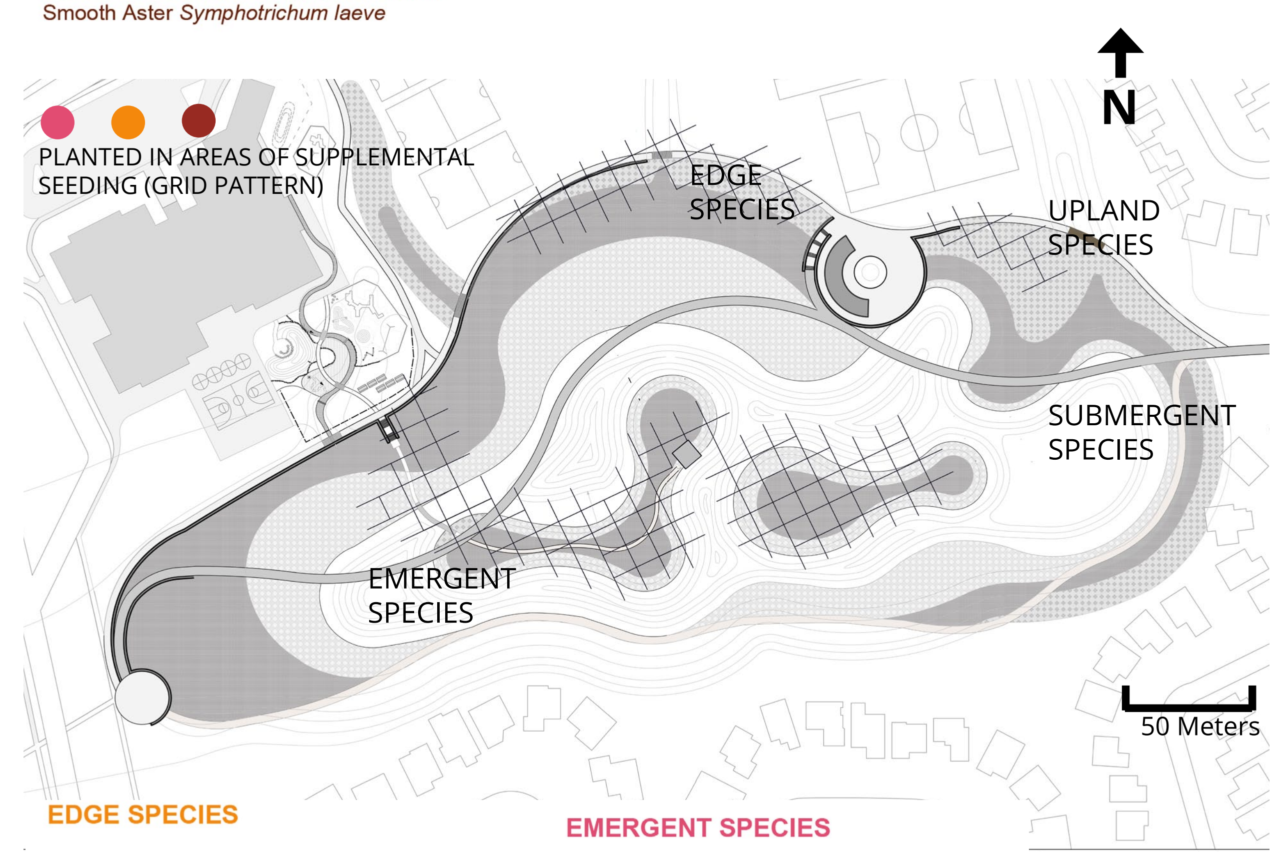
employing a diverse plant palette, a landscape emerges that can achieve far more than stormwater remediation. By planning for habitat creation, beauty and phytoremediation, a multi-layered and engaging educational space takes shape.

UPLAND SPECIES

- Yarrow *Achillea millefolium*
- Canada Anenome *Anenome canadensis*
- Buffalo Grass *Bouteloua dactyloides*
- Blue Grama *Bouteloua gracilis*
- White Prairie Clover *Dalia candida*
- Blazing Star *Liatris ligulstylis*
- Bergamot *Monarda didyma*
- Prairie Coneflower *Ratibida columnifera*
- Little Bluestem *Schizachyrium scoparium*
- Upland White Aster *Solidago ptarmicoides*
- Smooth Aster *Symphotrichum laeve*

SUBMERGENT SPECIES

- Water Starwort *Callitriche autmnalis*
- Water Grass *Catabrosa aquatica*
- Hornwort *Ceratophyllum demersium*
- Water weed *Elodea canadensis*
- Ivy-leaved Duckweed *Lemna trisulca*
- Eel Grass *Potamogeton zosteriformis*
- Richardson's Pondweed *Potamogetor*
- Swamp Persicaria *Polygonym coccine*
- Arrowhead *Sagittaria cuneata*



EDGE SPECIES

- Foxtail *Alopecurus aequalis*
- Water Grass *Catabrosa aquatica*
- Manna Grass *Glyceria Borealis*
- Marsh Five-finger *Potentilla palustris*
- Silverweed *Potentilla aserina*
- Marsh Cress *Rorippa islandica*
- Water Plantain *Alisma triviale*

EMERGENT SPECIES

- Slough Grass *Beckmannia syzigachne*
- Mare's Tail *Hippuris vulgaris*
- Wild Iris *Iris versicolour*
- Baltic Rush *Juncus balticus*
- Reed Grass *Phragmites communis*
- Cattail *Typha latifolia*
- Common Bullrush *Scirpus validus*

Fig. 41. Planting zones and strategic planting of perennial plugs

Fig. 42. Constructed wetland plant palette for Winnipeg

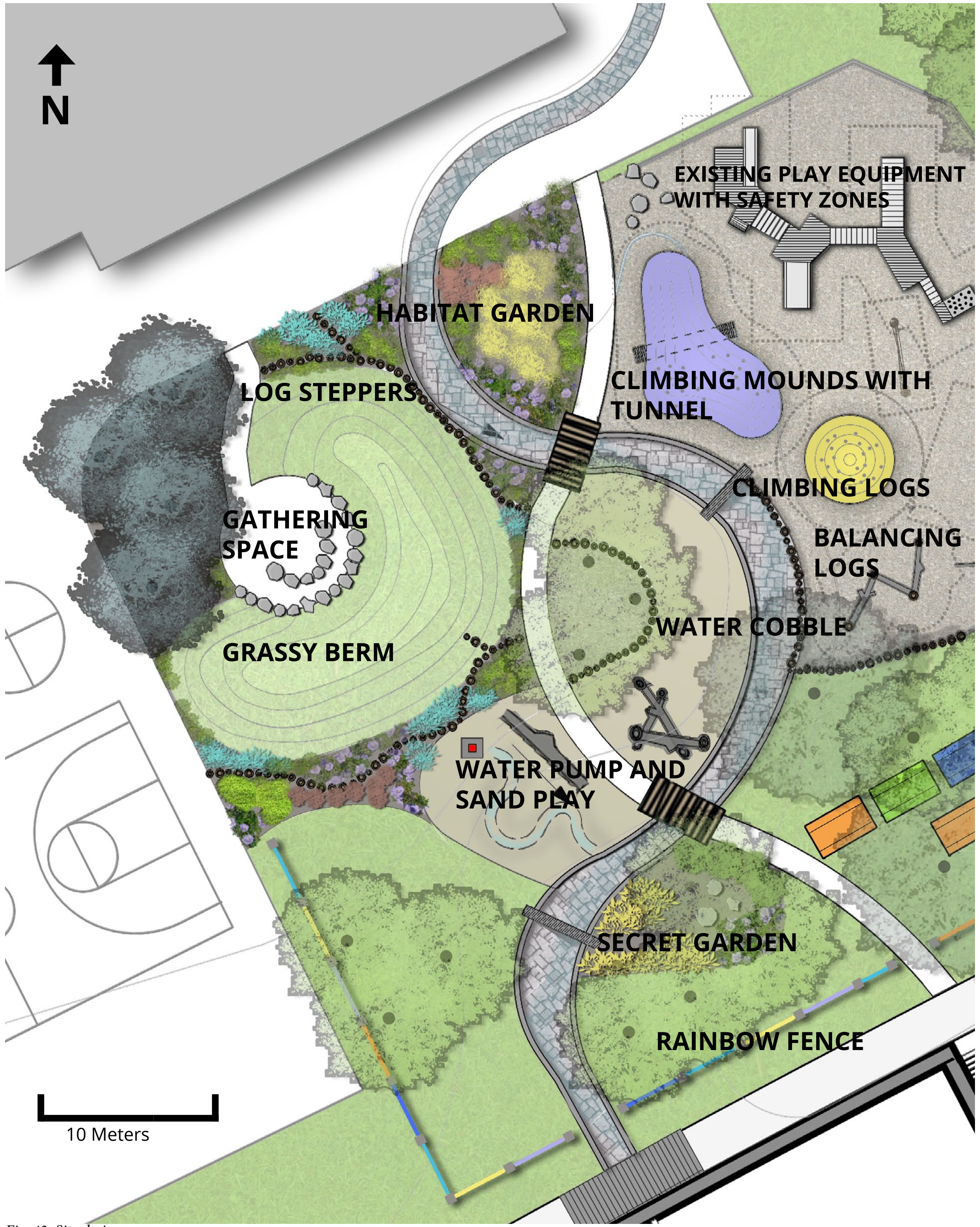
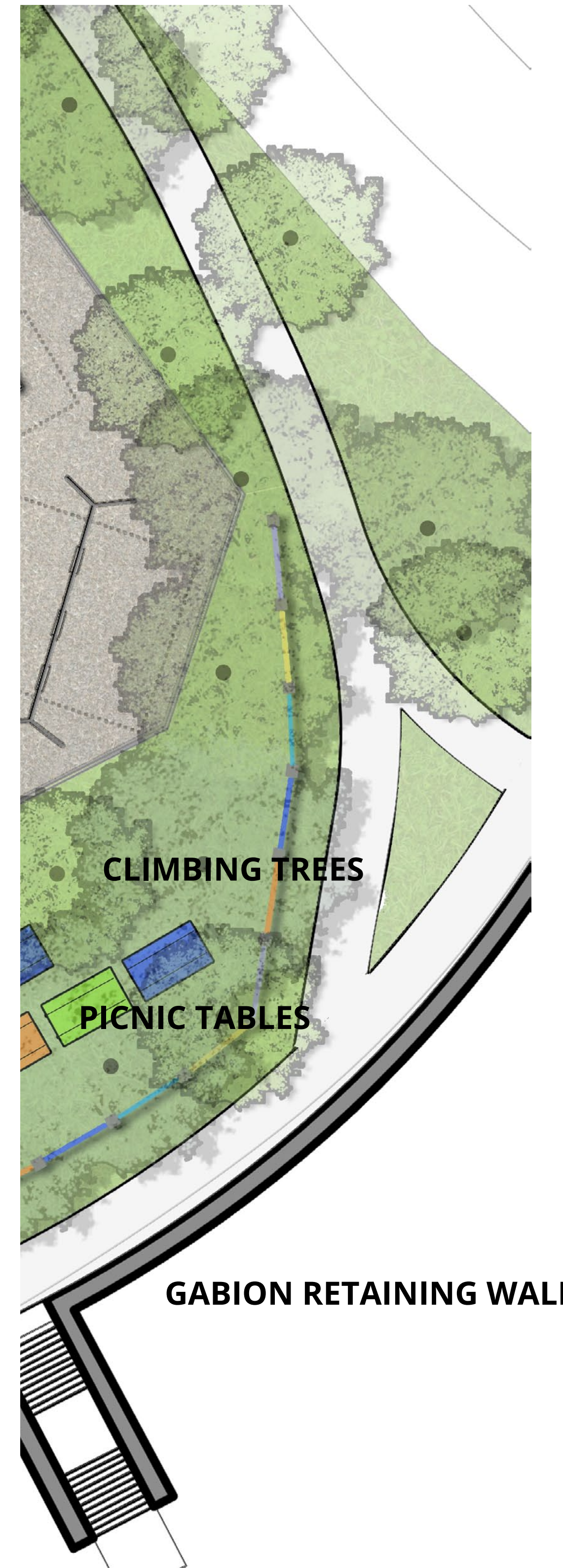


Fig. 43. Site design



The area chosen for a more developed design is a large lawn area adjacent to the existing play structures on the south side of the school, overlooking the retention pond (figure 43). This location was selected because, although ideally the boardwalk and constructed wetland would be used during recess and lunch for independent play and learning, realistically it is more likely that those areas would be considered off limits without supervision. The schoolyard provides an opportunity to integrate the school grounds and everyday play with the nearby constructed wetland. This integration is achieved through several design elements.

The design's focal point is the "water cobble" - a cobblestone-lined channel that takes water from two large, existing downspouts and moves it out to the retention pond. The winding channel allows children to follow the path of stormwater and manipulate it along the way. Because the water is from the roof, it would be free of the pollutants such as oils and biological waste present in stormwater from streets and other ground level sources. The water cobble would start as an inlay cut into the asphalt, and gradually cut deeper into the ground, as the 5% slope of the water channel is much steeper than the 2-3% slope

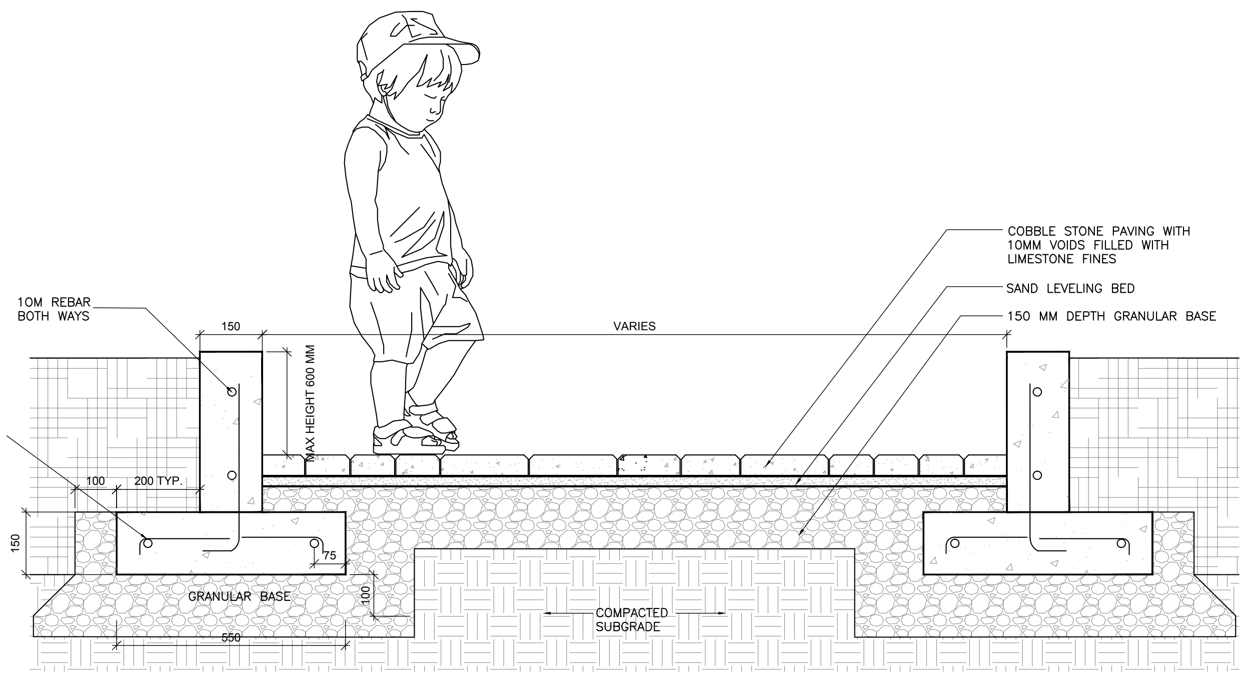


Fig. 44. Water cobble

of the surrounding play area. This grade difference necessitates the use of cast-in-place concrete retaining walls along the side of the channel (figure 44). The wall would step down as needed to ensure that the drop from the top of the wall to the cobblestone never exceeds 600 mm, which would require railings. As is evident in the grading plan (figure 45), the play and learning area drains toward the water cobble. Similar to the stormwater features of Sidwell Friends School (see chapter 3), the water cobble becomes a way for educators to make stormwater processes visible. In order to ensure that the water cobble does not split the area in half, a path from the school towards the wetland is intertwined with channel, providing crossings via footbridges and balancing logs. To add to the water-play experience, a hand pump in the sand play area would allow children to experiment with water movement, creating dams and channels while the water makes its way toward the cobblestone channel.

A second wetland area recreated in the play and learning area is the habitat garden, which incorporates many of the upland species present in the retention pond area (figure 46). The species used were selected primarily based on their importance for birds and

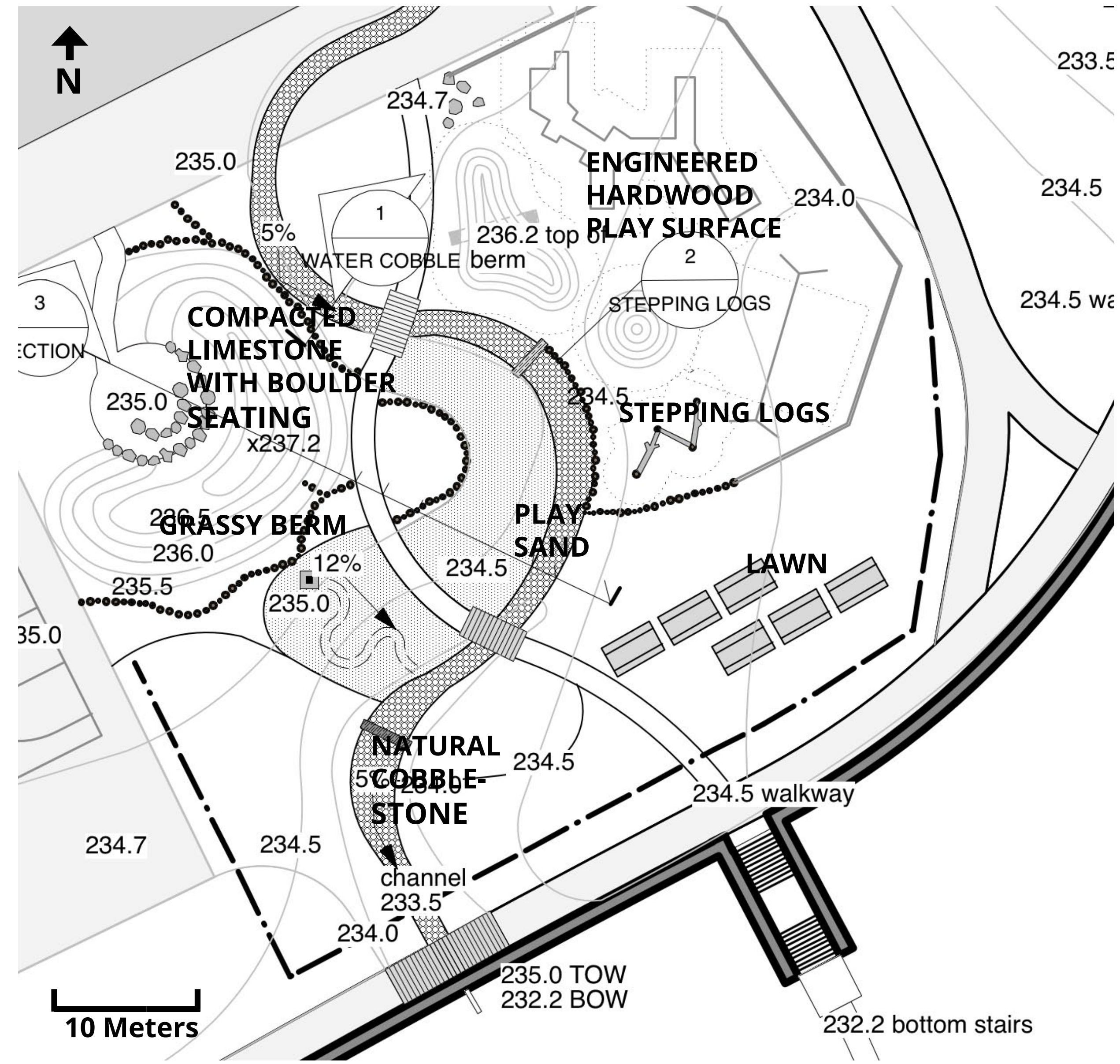


Fig. 45. Play and learning area grading plan.

insects. Perennials such as Tickseed (*Coreopisis grandiflorum*) and Joe Pye (*Eupatorium dubium*) are important food source in summer while shrubs such as Arrowwood (*Viburnum dentatum*) and Dogwood (*Cornus sericea*) provide berries for overwintering birds. Plants are also used to define spaces; a grassy berm and a stand of spruce trees create a separation between the outdoor classroom and the rest of the schoolyard. Elsewhere, tall grasses and shrubs create a "secret garden" and the branch structure of White Willow (*Salix alba*) is perfect for climbing - adding vertical spaces to the site . Other plants were selected to be the focus of curiousity and play. For example, the soft texture of Lamb's Ear (*Stachys byzantium*) and the spiky rosettes of Hens and Chicks (*Sempervivum tectorum)* allow children to explore the different shapes and textures each plant possesses.

TREES

Fraxinus mandschurica
Malus x "Thunderchild"
Sal - Salix alba
Sr- Syringa reticulata
Sac - Sorbus aucuparia

SHRUBS AND PERENNIALS

Ag- Andropogon gerardii
Am- Achillea millefolium
Ca- Calmagrostis acutiflora
Cg- Coreopisis grandiflorum
Cs- Cornus sericea
Dd- Dianthus deltoides
Ea- Euonymous alatus
Ed- Eupatorium dubium
Ep- Echinacea pupureum
Hs- Helichtotrichon sempervirens
Jh- Juniperus horizontalis
JhH- Juniperus horizontalis "Hughes"
Ll- Liatris ligulistylus
PoD- Physocarpus opulus "Diablo"
Pp- Picea pungens
Pt- Prunus tenella
Rf- Rudbeckia fulgida
Sa- Symphorocarpus albus
Sb- Stachys byzantium
Sm- Syringa meyerii
Sn- Sambucus nigra
St- Sempervivum tectorum
Vd- Viburnum dentatum
Vo- Viburnum opulus "nanum"

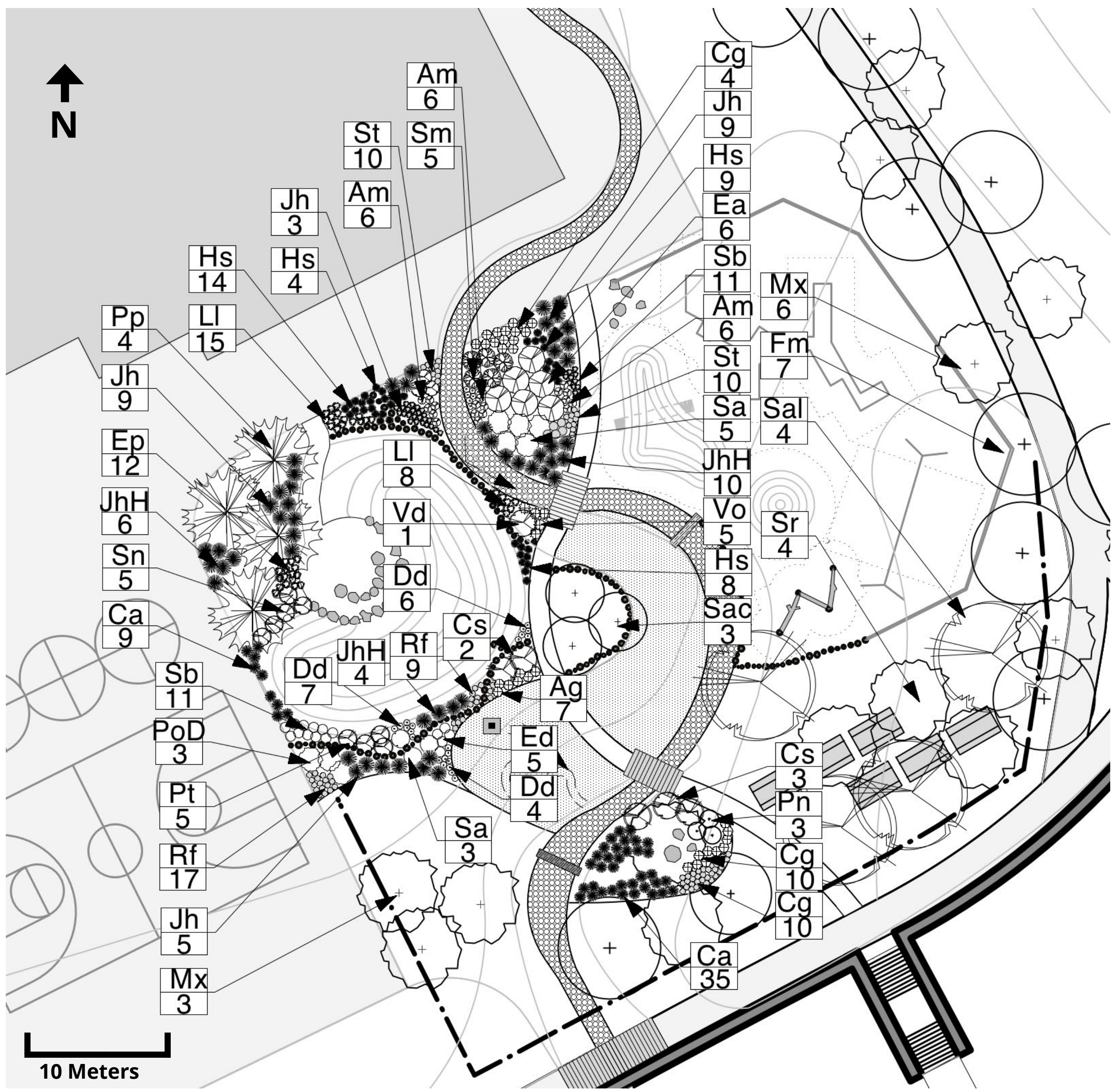


Fig. 46. Play and learning area planting plan.

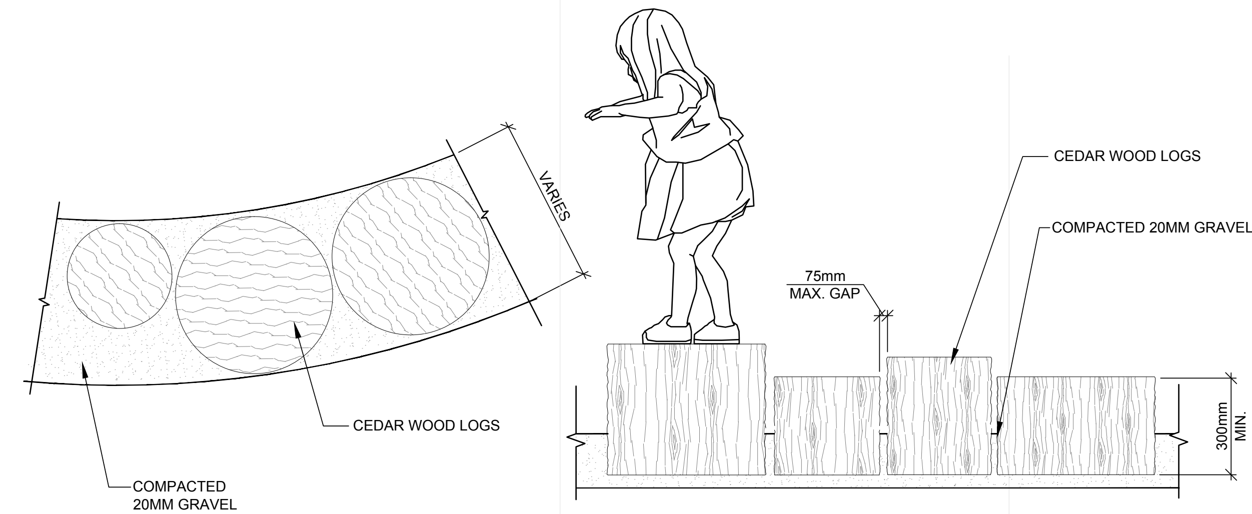


Fig. 47. Log steppers

Despite the focus on naturalization, traditional play equipment is still an important part of schoolyards. The existing play structures are retained, although the surfacing would be changed from pea gravel to engineered hardwood, which is the new City of Winnipeg standard for fall protection surfaces. Other play elements, such as balancing logs, climbing mounds, tunnels and log steppers increase the play value. The log steppers (see figure 47) also function as an edge material, helping to define spaces. By including play within the habitat gardens and stormwater channel, it becomes a mechanism of fostering engagement and independent learning.

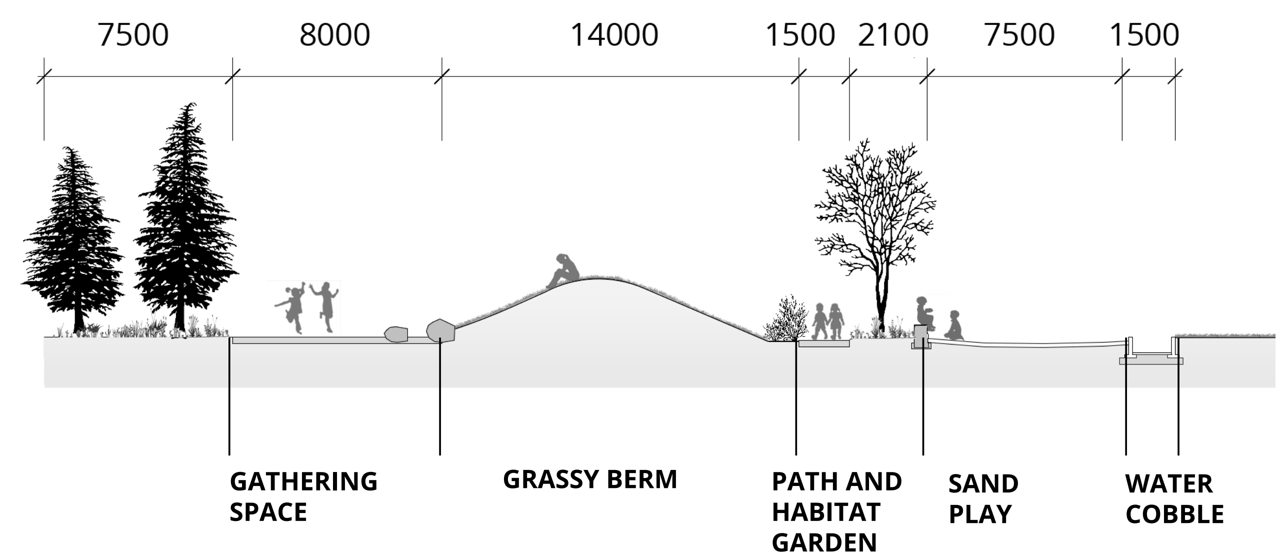


Fig. 48. Section through the play and learning area showing the schoolyard as a series of activity spaces

One of the successes of the Environmental Yard in Berkeley California was its multiple gathering and play spaces supporting a wide variety of games and activities. This schoolyard design attempts to do the same. Figure 48 illustrates how the area is divided into a series of activity spaces, each with a different character. Other important elements of play and learning space in this design are a colourful fence and picnic tables. The former, although only a partial fence, could function as an informal barrier if staff is reluctant to have children play independently around the pond. The picnic tables would serve as a gathering place during free time, as well as a writing area for outdoor classes.

If teachers can foster engagement and curiosity, learning becomes intrinsic - an end in itself rather than a means to short term reward. Landscapes can be a means to this end, providing open-ended and meaningful learning opportunities that can inspire children to learn, play and discover, whether as part of a structured class activity or independently.

Wetlands are some of the most biologically rich ecosystems on earth and their value in protecting the beaches, rivers and lakes we love is clear. They are, however, not fully understood and embraced by much of the general public, often being regarded as "swamps" that need to be drained and filled in order to be developed. Unfortunately, this process has been mostly completed in Winnipeg, with very few (if any) natural wetland spaces remaining. Naturalized retention ponds, bioswales and other constructed wetlands provide the next best option for stormwater remediation and wetland habitat creation. If landscape architects, in partnership with biologists, ecologists and engineers, can develop engaging wetland spaces, particularly in urban areas, children and the public in general will be able to see their value, not simply as important cogs in regional watershed protection but also as multi-layered and rewarding stand-alone landscape experiences.

Fig. 49. The "water cobble", habitat garden and outdoor classroom/gathering area.

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