Nurturing Landscapes: Creating educational rainwater management systems on school grounds

by

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BEnvD, University of Manitoba, 2007
MA, University of Victoria, 2015

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Abstract

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This research poses two questions: How, through collaboration and thoughtful design practices, can rainwater management systems on school grounds be developed as resources for learning? And, what can these systems contribute to the development of more sustainable urban rainwater management? The research was conducted through a literature review, the analysis of three case studies and a pilot project. The research points to the potential for schools to act as a centralizing figure, enabling a community collaboration to occur with the aim of implementing educational rainwater projects. This process generated knowledge, spread awareness and built relationships among the community. The school's participation in this process was key to creating place-based, engaging design solutions. The rainwater systems must be multi-functional and contribute to the learning environment by building on the school's educational philosophy. The four projects offer different scenarios for creating rainwater management systems that engage students through both hands-on learning and play.

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Acknowledgments

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Dedication

This thesis is dedicated to Ray and Cheryl Orr, who have always encouraged me to be creative, follow my dreams and believe in myself.

Chapter 1: Introduction

I have been drawn to the idea of creating functional, living water systems on school grounds since second year design school at the University of Manitoba's Faculty of Architecture. For my final project, I redesigned a schoolyard to include wetlands that would filter grey water from the school. The conceptual project I created back then was the beginning of this exploration. One of the things that draws me to designing water systems for children and youth is that it requires a sense of playfulness, an interplay between function, fascination and joy. I believe that bringing together natural systems, water and grade-school education is critical to creating environmental stewards for the future. These systems must attempt to harness the spirit of childhood in bringing life and vitality to school grounds

The design of urban environments creates opportunities and impediments to living healthy lifestyles, with no group experiencing these consequences more than children. Childhoods once characterized by ample time actively engaged in the outdoors are now shifting indoors. Children have more strict guidelines on their time and less independent mobility. Childhood has become more sedentary and dominated by technology and media with less time for unsupervised, free play and far less exposure to the natural world than previous generations (Louv, 2008a). This shift has been connected to the development of mental and physical illnesses such as attention difficulties and obesity (Louv, 2008b). While these issues are complex and solutions must come from many directions, contemporary urban design has played an instrumental role in fomenting these concerns. While urban design issues like busy streets and lack of access to natural places require long-term solutions, school grounds are places where we can alter children's everyday environments to include more nature and provide more opportunities for positive development (R. C. Moore & Cooper, 2008). Many schools in North America are including more nature in their school grounds and teaching practices. This shift presents some challenges but contributes to the overall development of healthier cities.

Designing healthier cities requires the integration of human and natural systems; a key element in this is how we manage rainwater. Cities all over the world are implementing new solutions to urban rainwater management to deal with increased demands on aging infrastructure and the environmental degradation caused by the traditional underground-pipe approach (Bedan & Clausen, 2009). New designs seek to manage water on a site-by-bite basis in natural features (often called rain gardens) that absorb, filter and infiltrate rainwater, contributing to less demand on the underground system and healthier urban ecosystems (Davis, 2008). To be effective, these solutions must be implemented on a watershed scale (Roy et al., 2008). This type of large-scale change, however, takes time and requires a number of other shifts to occur to facilitate the change and to maintain the system in the long-term.

Creating educational rainwater management systems on school grounds has the potential to contribute to this shift in a number of ways; if done well, it also has the potential to improve the quality of outdoor learning environments. While many schools are implementing greening projects, including water and natural features on school grounds remains a controversial issue. Each school presents a number of challenges and opportunities that must be worked through to produce effective solutions. This research seeks to understand the important elements in creating educational rainwater management systems on school grounds and what these systems can contribute to the development of sustainable urban rainwater management.

1.1 Background

In his award winning book, *Last Child in the Woods,* Richard Louv coins the term “nature deficit disorder” to describe the common threads that he has observed among urban children living lives cut off from the natural world. Louv's findings indicate that the shift to indoor, technology dominated, highly structured and supervised childhoods lacking in regular opportunities to learn and play outdoors are contributing to modern health epidemics such as obesity and attention disorders. A generation of children disconnected from the natural world also creates a future population that is detached from environmental issues and has little understanding of the function and importance of natural systems (Louv, 2008a, 2008b).

Studies have shown that play in the natural environment not only improves physical and emotional health but that the natural world is a main source of developmental learning for children (Barbour, 1999; R. C. Moore, 1986; Rowe & Humphries, 2012; Thomson, 2007). Even small amounts of nature in a child's environment have a measurable impact on attention functioning and the amount of time spent actively engaged in outdoor learning and play (Taylor, Kuo, & Sullivan, 2001). Currently, space specifically set aside for children in the urban environment more closely reflects 'safe and orderly' adult objectives for appropriate, easily supervised playtime than it reflects a child's natural inclination to investigate, push boundaries and dig their hands into the unknown (Malone & Tranter, 2003; Thomson, 2007) While the urban environment should include many places where children can access 'wild' nature, spaces specifically designed for children's play need to be less contrived, more natural and offer a diversity of experiences (R. C. Moore & Cooper, 2008).

An increasing number of forward thinking schools around the world are integrating more nature into their school grounds and curriculum. Studies have shown that experiential, and outdoor education makes children more enthusiastic about learning and helps them to understand and retain lessons from a wide array of subject matter (Lieberman & Hoody, 1998). In addition to this, heading outdoors for some lessons improves concentration in the indoor classroom (Cronin-Jones, 2000; Lieberman & Hoody, 1998; Malone & Tranter, 2003). At recess time, a diversified play environment that includes play structures, play fields *and* natural features offers more play opportunities to more children. With an increase in diversity in school grounds, and especially the addition of natural features, there is a documented decrease in alienation, schoolyard bullying and the need for discipline and supervision among other improvements (Evans, 2001; R. C. Moore, 1996; Tranter & Malone, 2004).

Unfortunately, in most Canadian schools learning is primarily seen as an indoor activity. However, certain schools have been using their landscape as an extension of the learning environment for decades (Grant & Littlejohn, 2001; R. Moore & Cosco, 2007; Rowe & Humphries, 2012). Many schools that formerly did not consider the schoolyard as an asset to education are pursuing greening projects that range from small garden plots to the entire reconstruction of the school grounds into diversified play and learning spaces (Danks, 2010). Undertaking greening projects in cooperation with students teaches children and youth in ways that cannot be replicated in the classroom, in addition to creating a unique sense of place and community at the school (Grant & Littlejohn, 2001).

1.2 Rainwater systems on school grounds

Regardless of geographic location or how large or small a school is, water should be a central component in the design of a green school ground (R. C. Moore, 1986). With natural and artificial water systems interlaced throughout the entire school building, schoolyard and beyond, the educational, greening and sustainable design opportunities are substantial (Danks, 2010). Watershed education and knowledge of ecology are of paramount importance in creating a future population capable of handling the environmental challenges we currently face and those ahead (Stone & Barlow, 2005).

With the push to improve urban rainwater systems, schoolyard rainwater projects are on the rise. As schools have limited time and resources to implement sizable projects, community members, professionals and organizations are using schools as places to implement projects that align with their values, and advance their own learning, while improving school grounds. The growth in the community that results from implementing these projects is substantial, and if well executed, the growth in the school and improvement in the school ground can create opportunities for learning into the future.

1.3 Thesis objectives

This research seeks to support the forward movement of educational rainwater management systems on school grounds.

My research questions are:

1. How, through collaboration and thoughtful design practices, can rainwater management systems on school grounds be developed as resources for learning?
2. What can these systems contribute to the development of more sustainable urban rainwater management?

1.4 Methodology

The following topics were explored in the literature review:

- Urban rainwater management issues and solutions
- Urban ecosystems and landscape design
- Greening school grounds and educational landscapes

Selection of case studies

Three case studies were selected for this research. In landscape architecture, case studies are used to flesh out design ideas and to highlight exemplary projects and concepts worthy of replication. Case study analysis is an appropriate approach to describe and evaluate a project and its process as it is based in real-life situations. Within this, emerging concepts and ideas can be tested and refined (Francis, 2001).

To maintain a consistent natural and cultural perspective that is relevant to schools in Victoria, BC, the case studies are all located within the Pacific Northwest. The case studies all push into new territory with rainwater management systems that have been integrated into the school ground and are in some way a part of the learning environment of the school. The school types vary with one standard public school, one special-focus public school and one private school. This decision was based on the desire to explore a variety of educational approaches. The schools are: Victoria West Elementary School in Victoria, BC; Da Vinci Arts Middle School in Portland Oregon; and Bertschi School in Seattle Washington.

Several other schoolyard rainwater systems were considered for this research. These are: Mt. Tabor Elementary School in Portland, Oregon; Glencoe Elementary in Portland, Oregon; Skyview Jr. High School in Bothell, Washington; and Clearwater School in Bothell Washington. These projects were not selected for the following reasons: The projects at Mt. Tabor Elementary and Glencoe Elementary were not created for the purpose of education but rather to manage large amounts of water from the surrounding community. Skyview Jr. High School holds a 6.5 acre outdoor education centre with rainwater treatment facilities. This was too unusual to be relatable for most urban schools. Clearwater School is a private school with an alternative approach to education. The project at Bertschi School was selected as the private school representative instead of this school due to the more urban context and the more sophisticated approach to design. From a pragmatic perspective, the three case studies that were selected had a wealth of information available online.

Data collection

Data collected on the case studies is based on Francis' (2001) description of data collection for case studies in landscape architecture. Initially, two levels of data were compiled for the research. Level one data collection was conducted on each of the seven case studies that I was considering for the research to evaluate the compatibility of the projects as case studies for individual analysis and for cross case study analysis (Yin, 2009). This data was collected from information available online.

Level one data collected was:

- Grade levels serviced by the school ex: K-6
- Type of school, ex: public school
- Location and context
- Student population
- Main project team members
- Goals of the project
- Brief description of design elements

After the three case studies were selected, level two data collection was completed. To draw from triangulating data sources (Yin, 2009), three different data collection methods were used within each case study.

The data collection methods were:

1. **A document analysis:**

- Available documentation online (websites, publications from the school, news stories etc)
- Any other documents available from the school and/or the landscape architects

2. **Semi-structured interviews with key participants:**

- Interview questions were tailored to each project and individual and fell into 7 categories (see Appendix A for consent forms and Appendix B for interview questions):
    - General

    - Key participants and roles
    - Design process
    - Conceptual design
    - Implementation
    - Use
    - Maintenance
- Interviewees:
    - Bertschi School:
        - Julie Blystad – Current science teacher, works with the rainwater system, was involved in the design process
        - Stan Richardson – Building operations manager, represented the school on the design team
    - Da Vinci Arts Middle School:
        - Dan Evans – Former science teacher, largely undertook the project with his students
        - Jason Heiggelke – Current science teacher and water garden steward
    - Victoria West Elementary School:
        - Jana Dick - Vice principal, and Brenda Cook - Former secretary and rain garden steward
        - Deborah LeFrank – Landscape architect

3. Physical documentation of the site:

- At each school I was given a tour by one of the interviewees. After the tour I conducted my own brief site analysis, observing the site and taking photographs. This was done when no students were present due to ethical issues.

The data collected from these sources was organized into the following categories:

- Watershed information
- Municipal approach to rainwater management

- Value/Costs
- Funders
- Goals
- Constraints
- Opportunities
- Detailed description of the physical project characteristics
- Description of the design process

Case study data analysis

A series of questions were created to analyze the projects (Appendix C). These questions fell into the following categories:

- Basic project details
- How the design process served as an educational tool
- How the school participated in and informed the project
- What outside and contextual elements shaped the project
- The project design
- How it is used and maintained

Case study profiles and a comparison chart were then created. This step pulled out the critical details for each project but left out many details that were later pulled forward in the discussion chapter.

Pilot project

The results of the literature review, data collection and analysis were used to inform a pilot project conducted at Oak and Orca Bioregional School in Victoria, BC ("Oak and Orca Bioregional School," n.d.) (see Appendix D for consent forms). I acted as lead landscape architect and project manager with the support of my advisory committee and industry partner whom are well versed in landscape architecture, urban rainwater system design and community engagement. The project included a participatory design process tailored to the educational goals of the project and the specific needs of the school (Clark, 2007; Francis & Lorenzo, 2005). This led to the design and construction of an educational rainwater system. This experience broadened my understanding of how to apply the ideas from the research to the schoolyard context.

Chapter two: Literature review

This literature review is about the progress of cities towards healthier rainwater management with a special focus on the potential for social change presented by school grounds. The design of rainwater management systems on school grounds is a topic that has not been explored in depth in the literature. In fact, very little has been published on this topic. However, much has been published on related topics that can frame and inform the research. This literature review looks at urban rainwater management issues and solutions, how the human experience must be taken into consideration in designing urban ecosystems and the design and use of green school grounds.

2.1 Urban rainwater management issues and solutions

Urban rainwater management issues

Cities, and particularly in the Pacific Northwest, manage a large amount of rainwater. Impervious surfaces that shed water, such as buildings, roads, sidewalks and compacted areas (this can include lawns) increase the volume and velocity of rainwater runoff. They also hold urban pollutants that are then washed into the underground rainwater system and into receiving environments. Cities range from roughly 30% impervious cover (in residential suburbs) to 100% impervious cover (in downtown cores). Even small increases in impervious surface can impact stream health with as little as 10% increase causing a measurable impact and 30% increase causing degradation (Arnold & Gibbons, 1996).

In natural environments water runoff from rain events is about 10%, 50% of the rainwater is absorbed into the ground either flowing through soils in a process called interflow, or recharging groundwater through deep infiltration. (Arnold & Gibbons, 1996). When water moves through land (interflow and groundwater) as opposed to over it (runoff) water is stripped of bacterial, nutrients, chemicals and dirt and is left clean and clear to flow into streams (Marsh, 2010). Interflow and groundwater storage can be observed in the summer time when creeks continue to flow with water when it is no longer raining. By contrast, in an urban environment with 30-95% impervious cover, runoff is increased to 55% and infiltration is decreased to 15% (Arnold & Gibbons, 1996).

This change in landscape surface and hydrology causes a number of environmental impacts: The increase in volume and velocity of water causes “flashiness” in urban streams destroying streamside and in-stream habitat and resulting in wider and straighter stream channels. Flash events cause erosion, and the silt and sand picked up from the urban environment settles to the bottom, covering over important habitat features like pools, pebbles, rocks and logs. Due to lack of groundwater recharge, urban streams also suffer drought periods.

Rather than having impurities filtered out of water, a continuous stream of environmental toxins are washed from impervious surfaces into receiving environments. This is referred to as nonpoint source pollution and can contain herbicides, pesticides, fertilizers, heavy metals, oil and silt to name a few (Paul & Meyer, 2001).Particularly problematic is the “first flush” that occurs after a prolonged dry period where pollutants build up on roads and are then washed into local streams, creating a pulse of high concentrations of pollutants. In addition to these issues, aquatic ecosystems are extremely sensitive to the temperature of water; water coming off of an urban environment is warmer in the summer and colder in the winter (Arnold & Gibbons, 1996; Hough, 2004; Paul & Meyer, 2001). This destructive pattern, seen globally, has been dubbed “urban stream syndrome” (Walsh et al., 2005) and provides some, but not all, of the motivation behind the international shift towards improved urban water management.

Other major factors in the push to improve urban rainwater systems are capacity issues and the high costs of maintaining and upgrading underground pipe systems.

With ever expanding development and the addition of more impervious surface, increasing pressure is put on existing rainwater infrastructure. In high rain events the system can back up, flooding water into streets and basements. Some cities have combined sewer overflow systems (CSO), which means that sewage, rainwater and industrial wastewater are combined into one pipe. During heavy rain events when the system reaches capacity, wastewater is dumped directly into receiving environments (Paul & Meyer, 2001; US EPA, n.d.) In addition to these issues, here in the Pacific Northwest, climate change predictions state that we can expect drier summers and wetter, stormier winters (Mote & Salathé Jr, 2010), which puts more pressure on existing rainwater systems.

Urban rainwater management solutions: Low-impact development

Low-impact development (LID) refers to a new approach to managing urban rainwater. LID takes many shapes including green roofs, rain gardens, bioswales, permeable paving, restored urban streams, and increased vegetative cover in cities (Dietz, 2007). The term 'facility' is used to describe a discreet rainwater feature that is used to hold and/or infiltrate water. Each application of this new approach to infrastructure design will be site specific and draw on any number of the above listed elements. The main goals of low-impact development are site-based water management and improved water quality, these corresponding to less demand on the underground pipe system and healthier urban streams. Optimistic targets are often to meet pre-development runoff rates (Roy et al., 2008). While LID is usually implemented on a site-by-site basis, to be effective each piece is a part of a larger, watershed scale plan (Bedan & Clausen, 2009; Davis, 2008).

Rain gardens, also known as rainwater facilities, infiltration trenches or bioretention cells, are increasingly being seen as a effective solution to urban rainwater problems (Davis, Hunt, Traver, & Clar, 2009). Rain gardens usually have overflow and/or under drains to send excess amounts of water into the rainwater system. The water that does enter the rainwater system, however, is of higher quality and is much lower volume than it would be otherwise. Rain gardens are filled with living soil, usually a mixture of compost and sand that is high in nutrients and living organisms that break down pollutants. Rain garden soil both holds moisture (due to large amount of organic material) and drains well (due to the sand). Rain garden plants have deep root systems, allowing for water to flow into the ground while simultaneously being taken up by plants. The plants are both water loving and drought tolerant so they can withstand seasonal fluctuations without the need for large amounts of watering in the summer (Bakeman et al., 2012; Davis et al., 2009; Lanarc Consultants Ltd, Kerr Wood Leidal Associates Ltd., & Goya Ngan, 2012).

A number of factors go into the design and maintenance of a rain garden. From a pragmatic perspective, a well-designed rain garden is designed with knowledge of the contaminants that will be entering the system, water volumes and watershed characteristics and goals. For example, a rain garden can be specifically designed to manage metals, hydrocarbons and oil coming off of a busy street (Hunt, Davis, & Traver, 2012). The amount of impervious surface and volume of rain that the rain garden is managing will determine the size and depth. Depth increases storage capacity while surface area increases pollutant removal. Site-specific infiltration rates help determine how much water a rain garden can manage over a period of a few days and contributes to sizing. Watershed characteristics will also help determine goals, for example, here in Victoria where rainwater is discharged directly into the ocean, our environmental concern is more about water quality than water volume. However, as our rainwater system is already overloaded, water volume is also an issue (Davis, 2008; Hunt et al., 2012).

Aside from improved water management, rain gardens can bring additional value including increasing biodiversity and habitat and beautifying cities. From an experiential perspective, rain gardens should be designed to suit each site and fit within the cultural context of the city (Echols & Pennypacker, 2008; Lyle, 1999;

McHarg & Mumford, 1969). This includes planning for maintenance, monitoring and public education (Roy et al., 2008).

A study done by Roy et al (2008) identifies 7 impediments to the implementation of sustainable urban water management: uncertainties in the performance or cost, insufficient engineering standards and guidelines, fragmented responsibilities, lack of institutional capacity, lack of legislative mandate, lack of funding and effective market incentives, and resistance to change. This list points to the complexity of creating large-scale change in the urban environment. For one thing to change, many other related factors must shift as well. The authors make several recommendations to begin to address these issues, most relevant to this research is the final recommendation: to educate and engage the community through demonstrations. Raising awareness and support for LID can have a snowball effect that can help influence the other needed changes (Roy et al., 2008).

Rainwater management in the City of Victoria

The City of Victoria is currently undertaking upgrades to its rainwater infrastructure. The current underground pipe system is aging and in need of expansion and repair, the City has estimated that the costs of these upgrades are roughly 362 million dollars (Engineering and Public Works Dept, 2010). To begin the process of upgrading the system, the city is implementing a rainwater utility and incentive program. Property owners will pay based on the specifics of their property size and percentage of impervious cover. A rebate of up to 50% is available to those who install LID techniques on their property ("Stormwater | Victoria," n.d.).

The City of Victoria and the CRD are well behind neighbouring cities in the Pacific Northwest in developing best practice guidelines for new developments and currently have nothing substantial available. However, the city has been prioritizing site-based water management and guidelines are in the works. A number of high profile rain gardens have been installed throughout the city.

2.2 Urban ecosystems and landscape design

Ecosystem services and the urban environment

The Millennium Ecosystem Assessment (Assessment, 2001), created by environmental organizations around the world, identified 4 categories of "ecosystem services" to better define and place value on the role that ecosystems play in human health. These are: provisioning (ex: production of food and water); regulating (ex: control of climate and disease); supporting (ex: pollination of crops and nutrient cycling); and cultural (ex: spiritual and recreational). Ecosystem services are often assigned economic value in order to give credence to natural systems in planning, policy-making and design (Daniel et al., 2012).

Since 2001 the notion of ecosystem services has expanded; among other approaches, it is now used to help determine goals for ecological restoration and design. Perring et al (2013) expand on the idea as it relates to novel ecosystems in the urban environment. In this context, ecosystem services include: carbon sequestration and storage; air quality; flood regulation and water quality; spiritual/psychological/health; education/recreation; and biodiversity maintenance (Perring et al., 2013). Creating a hierarchy of goals for achieving different ecosystem services can help identify what restoration or ecological design approach is most suitable for different situations (Lovell & Johnston, 2009).

Cultural services: A key consideration for cities

Cultural services (in this I include spiritual/psychological/health and education/recreation) can often be dismissed as intangible by comparison to the other stated ecosystem services. However, these factors are highly influential on decision-making and the success of integrating natural systems into cities. Daniels (2012) defines cultural services as ecological function that is linked to "cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreational and ecotourism (Daniel et al., 2012)." In seeking to use the concept of ecosystem services, and in specific cultural services, to serve as a guide for designing LID in the city, I will look more closely at aesthetic values, sense of place and educational values.

Landscape aesthetics and urban ecology

"For *Homo sapiens*, the aesthetic pleasure derived from landscape experience is both a reflection of evolutionary history and a key driver of contemporary environmental behaviour, including land use, development policies and real estate markets (Gobster, Nassauer, Daniel, & Fry, 2007, p. 961)." Individual and collective landscape aesthetics are triggered by emotional responses to our surroundings. Gobster and Nasssuaer (2007) define this as "a feeling of pleasure attributable to directly perceivable characteristics of spatially and/or temporally arrayed landscape patterns". They refer to this as the "perceptible realm", the scale at which we experience our day-to-day lives. It is at this scale that we make value judgments and create change that may or may not align with healthy ecological function which occurs at a variety of scales from micro to macro (Gobster et al., 2007). For example, landscapes that are perceived as attractive are more likely to be preserved, created and/or cared for, while landscapes that are perceived as unpalatable or indistinct are avoided or improved upon, often regardless of ecological significance (Gobster et al., 2007; J. Nassauer, 1995).

Landscape aesthetic, however, can evolve based on knowledge, and sensitive design solutions can help bridge the gap to more closely align aesthetics and ecology. While the expectation of a 'tidy' and 'manicured' urban landscape has had a stronghold for quite some time, interest in urban nature is growing. As people become more educated on the value of urban ecosystems and appreciation for the nourishing qualities of the natural environment grows (Matsuoka & Kaplan, 2008), expectations are shifting to embrace a slightly 'messier', more diverse landscape aesthetic. However, like other forms of aesthetic appeal it is not overarching. Designers need to be sensitive in integrating natural systems into the urban environment that will both appeal to urban residents and provide ecological function. In certain parts of the city, this may mean creating a frame that the natural feature sits within, be it a garden-like or mown grass edge around a wetland or a concrete seat wall around a rain garden (Nassauer, 1995). A good designer will create LID that both aesthetically suits and enhances the urban landscape and functions from an ecological perspective (Echols & Pennypacker, 2008).

Creating a sense of place while improving urban ecosystems

Sense of place is the unique character that comes from the sincerity of expression, enhancement and celebration of the natural and cultural elements of a specific place (Kellert, Heerwagen, & Mador, 2008; Mang & Reed, 2012; Van der Ryn & Cowan, 2007). This takes on different faces in different parts of a city and its surrounding landscape. Sense of place can be cultivated through sensitive planning and design practices and public participation in place making (Moore & Cooper, 2008). The widespread implementation of LID into the city lends a great opportunity for creating and enhancing sense of place (Echols & Pennypacker, 2008). The application of LID will take on different faces throughout the urban mosaic, from naturalized green corridors snaking through neighbourhoods to rain gardens surrounded by decorative paving in public plazas (Gobster et al., 2007). Each project should be carefully designed to draw on the natural resources of place through the enhancement of existing features, the use of native plants and the expression of natural cycles and flows inherent to that place (Pickett & Cadenasso, 2008; Spirn, 2011; Van der Ryn & Cowan, 2007) For example, if the site is a migratory butterfly path, food plants for butterflies can be used; if butterflies have important cultural significance, this can be expressed artistically or in some other appropriate way.

While cultural expression in LID seems less straightforward than expressing natural features, the urban environment is a human ecosystem and all designs must involve the integration of human systems in order to be successful. Cultural expression comes from involving communities in the design process, developing public amenities in tandem with LID and creating places that have meaning to the community so to develop a sense of ownership, understanding and care for that place (Kellert et al., 2008; Lyle, 1999; Mang & Reed, 2012; Matsuoka & Kaplan, 2008; Spirn, 2011; Van der Ryn & Cowan, 2007).

2.3 Greening school grounds and educational landscapes

LID for education

This brings us to the main topic of this thesis: creating rainwater systems that teach, and where better but on school grounds. This is a complex subject and one that touches on many different areas of research including: design process, developmental learning, learning through play, hands-on learning, the challenge of getting kids out of the classroom, the design of educational buildings and landscapes, the design of schoolyard rainwater systems and of course, safety, liability and regulatory issues.

The greening school grounds movement

This research falls under the umbrella of a larger movement: the greening school grounds movement, an international effort to improve the quality of outdoor learning environments. In Canada, a not-for-profit group called Evergreen is the main proponent of the movement providing online resources, funding, design services, research, community engagement and a learning centre in Toronto ON. Other similar groups exist in other parts of the world: Learning Through Landscapes in the UK, The Center for Ecoliteracy in the United States, Movium in Sweden and many others (Dyment, 2005). The main ideas behind the movement are hands-on learning; learning through play; loose parts; living things; natural shapes and materials; positive risk and safety; and longevity, flexibility and change ("Evergreen," n.d.-b).

Design process: Participatory design

A participatory design process looks to engage the primary stakeholders and users as members of the design team. Within this, the goal is to create outdoor spaces that are developed from a deep understanding of the users' values, needs, goals and potential. When well executed, this process also creates more meaningful landscapes where the users take ownership and become stewards. The designer's challenge is to engage the users in a meaningful way, merging the users' ideas with their own professional expertise to create places that are thoughtful, creative and functional ("Evergreen - All Hands in the Dirt: A Guide to Designing and Creating Natural School Grounds," n.d.; Mang & Reed, 2012).

Involving students in the design process

Involving students in the design process is a crucial component of educational schoolyard design. This engagement not only helps designers understand the students' needs and ideas; it educates the students on what is being installed and why; it helps students to feel like they have a say and that their ideas matter; and it can produce creative design solutions that help improve landscapes for students (Francis & Lorenzo, 2006). There are many different ways to involve children in the design process, what is important is that children's involvement is respected and that they are enabled to make meaningful contributions. This means being reflexive as the process unfolds. Frances and Lorenzo (2002) outline 7 realms of children's participation leaning towards what they call "proactive process" as the ideal method of engaging children. The approach looks to empower children to work with adults to reinvent childhood; it is part communicative and part educational. Working with children can be more involved than working with adults and designers must be specially trained to accomplish this type of engagement (Barker & Weller, 2003; Francis & Lorenzo, 2002, 2005). Involving children in the design process also brings up a host of ethical issues such as power dynamics and consent. These issues must be carefully worked out in advance and monitored as the process unfolds (Barker & Weller, 2003; Francis & Lorenzo, 2002).

Creating healthy outdoor learning environments for schools

Learning through play is critical to healthy child development (Cobb, 1959; Kellert, 2002; Louv, 2008). The outdoor environment of schools has been sorely neglected in both funding and appreciation towards the power that it holds in children's education (Moore & Cooper, 2008). Most independent socializing throughout the day will take place on the school ground. This is also where children are given free will to play on their own accord, developing their understanding of themselves, their peers and the world around them (Malone & Tranter, 2003). Malone and Tranter (2003) identify 3 types of schoolyard play as it relates to child development: physical, social and cognitive. Most schoolyards are focused on physical play and include asphalt, play fields and play structures. Physical play helps develop motor skills, coordination, fitness and healthy bodies. Children may socialize while engaging in physical play but social spaces are thought of more as places where children can sit together or alone. Children may be talking, engaging in cooperative play, watching others or simply daydreaming. This helps build social skills, sense of self and understanding of others. Cognitive play is most closely related to environmental learning as children are learning about their environment, how it works and how they fit within it. This includes building things, exploring, experimenting and creating. Loose parts, natural spaces and dynamic features that can change and be manipulated all contribute to cognitive learning.

It is not surprising that studies show that the diversity in school grounds directly correlates to the diversity of activities in which children engage (Fjørtoft & Sageie, 2000; Malone & Tranter, 2003; Moore, 1986). Not only does this create more opportunities for developmental learning, it improves socializing. For example, school grounds that are geared towards physical play promote competition, children with more physical ability dominate while others may feel left out or appear unskilled to their peers while play spaces that promote cognitive learning encourage cooperative play and creativity (Malone & Tranter, 2003). With a lack of diversity in the school ground there is a document increase in bullying, alienation, behavioral issues and need for supervision (Dyment, 2005; Malone & Tranter, 2003; Moore & Cooper, 2008).

While research states that hands-on, outdoor learning is more relatable, memorable and relevant to learners (Cronin-Jones, 2000; Janet E. Dyment, 2005; Lieberman & Hoody, 1998; Rowe & Humphries, 2012), getting students out of the classroom into an outdoor learning environment remains a challenge under the current public school system. Dyment (2008) lists 5 key barriers to outdoor learning in Canadian public schools: fear and concern for health and safety; teacher's confidence and expertise; requirements of school curricula; shortages of time, resources and support; and wider changes. However, Dyment's research found that many of these barriers are more related to the notion of field trips off of the school campus. Providing an outdoor learning environment at the school itself was shown to help overcome some of the challenges.

Creating educational environments that teach

Creating green school grounds must be looked at in two ways: developing an overall master plan and creating smaller, hands-on greening projects. A master plan looks at important structural elements such as circulation, drainage and site programming. The master plan also helps draw out future goals and ensures that smaller projects will fit within the larger plan. Larger moves should be carried out with the help of professionals and will support the smaller, more internalized greening projects and activities (Moore & Cooper, 2008). Smaller greening projects often include building new features (like garden beds), creating new things within an existing feature and maintaining existing features.

School grounds as an extension of the learning environment are much more integrated with the internal workings of the school than traditional school grounds. The educational philosophy of the school has shown to have major implications to the development and use of the school ground, be it for hands-on learning or simply for play (Malone & Tranter, 2003). Proponents of the greening school grounds movement encourage teachers to include greening projects in their teaching practice; many resource guides have been released to aid in this process (Evergreen, n.d.a, 2008; National Wildlife Federation, n.d.). Within this, greening projects are typically tied in with a particular person or group associated with the school at the time. Embracing change (or at least some degree of change) is important. The expectation that things will always stay the same hampers growth and creativity; a school ground that is alive with various projects and makes room for new ideas remains an activated space (Danks, 2010).

Cole (2014) takes the conversation to the next level to explore the development of 'Green Teaching Buildings' (GTB). She argues for 'whole-school sustainability', which goes beyond the technical improvement of schools to include social, psychological and cultural practices. A GTB is described as a 3 dimensional textbook and seeks to engage students in a number of formal and informal ways. For a GTB to work well, it must align with the school's educational practices, however, when designed properly, a GTB can and will alter the habits of the users and the way the school functions. The author breaks the creation of teaching elements down into factual information (like signage), physical engagement (elements that can be engaged, manipulated and impacted), social interaction (encourages and provides meaningful space for interactions that encourage sustainability culture) and social norms (creating and using positive social norms to influence behavior through design). Cole describes the type of learning that can occur in a GTB as 'embodied learning', experiencing the learning environment through space and time. This approach involves regular engagement in a variety of ways with the opportunity for conscious decision making and stewardship (Cole, 2014; Orr, 2002).

Water on school grounds

Designing a rainwater system for a school ground has many more layers than a rainwater system elsewhere; it is both a rainwater system and an educational system layered with the challenges and opportunities inherent to each school. Creating opportunities for intentionally engaging with water on school grounds is a contentious issue and one that most schools in North America have stayed away from in greening projects. However, water management is a central issue to creating functioning urban ecosystems and in creating functional schoolyards (Danks, 2010). Water management goals must be integrated with many other goals that are fundamental to a schoolyard setting such as play, opportunities for directed learning, durability, functionality, aesthetic appeal, legibility and safety among many other site design and school specific details (Moore, 1986; Moore & Cooper, 2008).

Safety and risk management

The Canadian Standards Association is the body that certifies playgrounds. When a playground is CSA certified, it means that it has followed strict guidelines to lessen the risk of physical injury. While these standards are useful for pre-fabricated play structures, the rigid thinking that goes into these standards is exactly what we are trying to break through to create more creative, engaging and place-specific designs. However, with licensing requirements we must still fit within the current system. CSA standards both encourage water play and discourage it, stating that: "Standing/ponding water presents an attractive "play" item that can result in serious or life-threatening injury, therefore, drainage is essential. Attention shall be paid to supplying drainage during planning, renovation, and those specific periods when standing/ponding water is present (Canadian Standards Association, 2008, p. 15)."

However, in a section about supervised play areas the CSA standards state: "When possible, play areas should provide access to water to promote creative, social, and intellectual (cognitive) development. Play facilities that encourage playing with water are recommended. These can take the form of play streams, water channels, faucets, or manual pumps (Canadian Standards Association, 2008, p. 94)." So as we can see it comes down to the issue of liability and the fear of providing a recognizable risk in an under-supervised play space.

In the book Managing Risk in Play Provision, Ball et al. (2008) state that: "…a paddling pool, even if shallow, involves a very low but irremovable risk of drowning (even with parental supervision), but this is normally tolerable. The likelihood is typically extremely low; the hazard is readily apparent; children benefit through their enjoyment and through the learning experience of water play; and finally, further reduction or management of the risk is not practicable without taking away the benefits (Ball et al. 2008, p. 112)." Benefits and risks must be assessed and managed to produce healthy and challenging play spaces for children. Healthy risk is an important part of growing up, and one that we can plan for in an intelligent way (Ball et al., 2008). This is not to say that every schoolyard rainwater project should have ponding water, just that the opportunity to engage with water should not be dismissed outright but be planned for appropriately.

In addition to physical injury, other issues of concern are muddy children, vandalism and water quality. These issues must be thought through and resolved in the design process. Water features are also more difficult (and probably more costly) to maintain.

Conclusion

Urban rainwater systems and green school grounds are in a very similar place right now; some change is happening but it is slow and a bit piecemeal. Many different aspects must shift, in both cases, to support a change in the landscape. Much research has been done on the design of urban rainwater systems; less research has been done on the issues presented by implementing it on a watershed scale and the systemic and societal change that must occur to support that change. School grounds are in a similar position. In recent decades gaps have been filled in terms of understanding child development on the school ground. Research very much supports children's need to interact with nature and learn through hands-on experience. However, many systemic, practical and social issues impede the growth of school grounds in this direction. This literature review points to the complexity of creating lasting change in the urban environment. This is not to say that we should not try to change things. On the contrary, the individual ideas explored by researchers must be applied to challenge societal norms and to identify needed shifts to accommodate important change.

Chapter 3: Case studies

This chapter summarizes the three case studies selected for the research:

1. Bertschi School, Seattle Washington
2. Da Vinci Arts Middle School, Portland Oregon
3. Victoria West Elementary School, Victoria, British Columbia

Information for each case study has been summarized as follows:

- School details
- Basic project details
- Design team members
- Location within the urban watershed
- Description of school and context
- Project background
- Description of the rainwater system
- How the rainwater system is used for education
- How the project is maintained
- Design process diagram
- Location of the rainwater system within the school ground
- Descriptive diagrams/maps/plans provided by the project team
- Site photos

3.1 Case study 1: Bertschi School's Living Building Science Wing

School details:

Location: 2227 Tenth Avenue East, Seattle WA

School type: Elite private school

Grade range: Preschool-5

Student population: 230

The project:

Value (for the entire living building project minus consultants fees which were pro bono): Not clearly stated, roughly $1,000,000

Timeline: 2007-2011

Design team:

The Restorative Design Collective:

Project Manager & Architectural Design: KMD Architects

Landscape Architecture: GGLO

Civil Engineering: 2020 Engineering

Geotechnical Engineering: GeoEngineers

Structural Engineering: Quantum Consulting Engineers

Mechanical/Electrical/Plumbing: Rushing

Sustainability Consultant: O'Brien and Company

Food Systems Consultant: Back To Nature Design LLC

PublicRelationsServices: Parsons Public Relations

Preconstruction/Construction Services: Skanska

Bertschi Operations Manager: Stan Richardson

Bertschi Science Teacher: Julie Blystad and Bertschi students

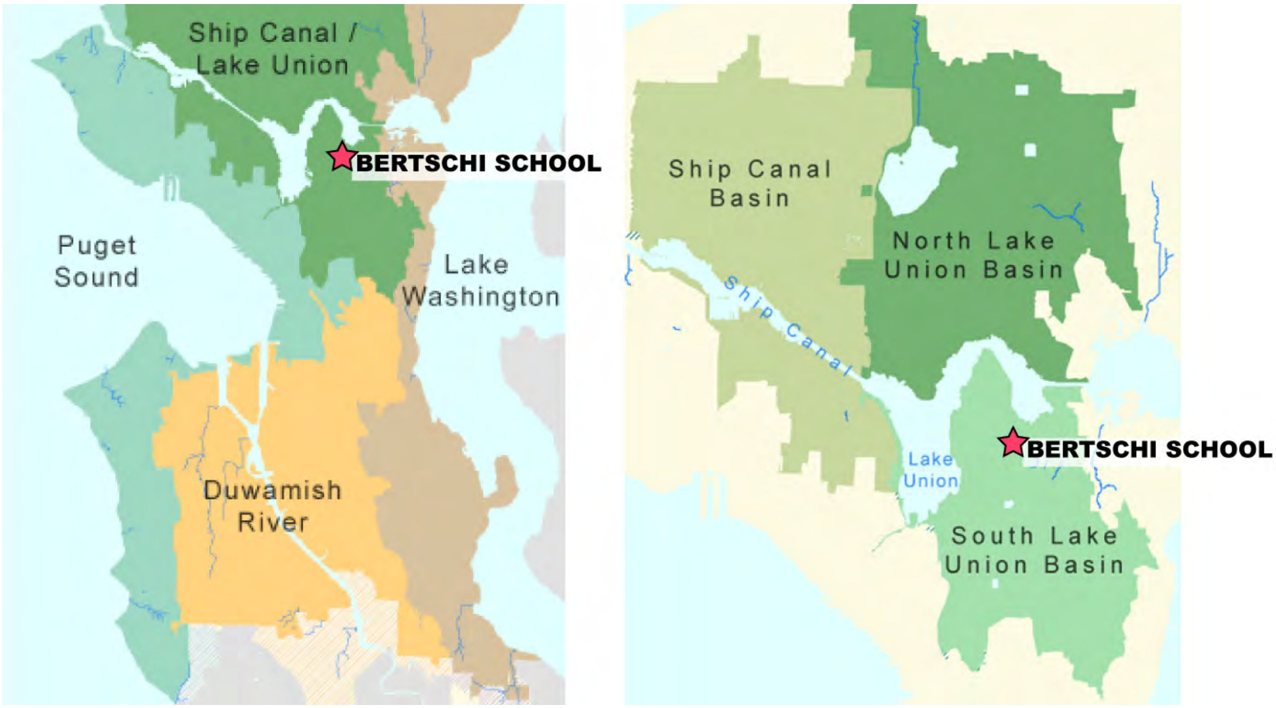


Figure 3.1: Location of school within the watersheds of Seattle (Seattle's urban watersheds, n.d.)

Interviewees:

Stan Richardson - Building operations manager

Julie Blystad - Science teacher

Bertschi School is located in an affluent urban neighbourhood with mixed commercial and residential use. The school consists of several buildings, outdoor play areas and gardens clustered together on a small site. The entire site is designed to extremely high levels of sustainability with a LEED building and a Living Building. The schoolyard is highly managed and controlled by the school; play areas are typical with hard play surfaces and play structures, natural features for outdoor learning are separate from play areas. The school provides progressive, alternative education. Tuition at the school is $23,000/year and the student to teacher ratio is 7:1. The school strives to create a positive learning experience to suit the needs of each student with community-based projects and hands-on learning. Their entire campus, while small, reflects the most up-to-date technology and contemporary thinking in education and sustainability.

The project:

The Restorative Design Collective, a group of the leading sustainable design professionals in Seattle, formed with the specific intent of building a living building; Bertschi's Living Building Science Wing is the product of this collaboration. "The Living Building Challenge™ (LBC) is a building certification program, advocacy tool and philosophy that defines the most advanced measure of sustainability in the built environment possible today and acts to rapidly diminish the gap between current limits and the end-game positive solutions we seek ("LBC | Living Future," n.d.)." The entire design team worked pro bono, using the project for professional development and to demonstrate the potential for sustainable building. While the school's needs were central to the project design, the Living Building Challenge framed the project, demanding the most advanced sustainable design practices be applied on all levels. The project also addresses the desire to create educational facilities that communicate how the building functions, manages resources and connects to natural systems. Since the project was built, teaching practices at the school have evolved to utilize the new resources.

The rainwater system:

Water is collected from the Living Building yard, the Living Building roof (partially green roof, partially metal roof) and the adjacent church building into two cisterns with a combined capacity of 4700 gallons. Water collected from the roofs runs down a pipe in the classroom labeled "rainwater", through a plexi-glass covered channel in the floor of the classroom that is decorated with the local salmon species, and into the "potable" water cistern. This water is used inside the building for all non-potable water uses, students can access water from the cistern through a hand pump. A digital screen indicates how much water is in the potable cistern. When this cistern is full, the water runs through a concrete trough that encircles a small outdoor classroom and into a below ground outdoor cistern. A floating measurement stick indicates how much water is in the outdoor cistern. Water from the rest of the building site also flows into this cistern. When it is full, the outdoor cistern overflows back through the trough and into the rain garden. Although the LBC stipulates that rainwater must not be discharged into the stormwater system, due to regulatory issues, the rain garden is hooked up through an overflow drain. In summer months, water from the cisterns is used sparingly for irrigation, just barely lasting the summer.

How the rainwater system is used for education:

The rain garden and an ethnobotanical garden run along the north edge of the school ground and can be seen from the science classroom. The outdoor space is garden-like and well maintained and includes garden art and stones labeled with plant names and QR codes that bring up information about the plants. The garden is not accessible during recess but is used regularly during class time. The function of the rainwater system is communicated clearly and playfully so the students not only understand what is happening but are drawn to and excited by it. Lessons involving the rainwater system are rich and relatable, students learn about local water issues through monitoring the rainwater system, raising salmon and releasing them into a stream; they learn about nutrient cycling through creating compost, spreading it in the garden and eating food from the garden; international water issues are taught through pumping water from the cistern and carrying it around the schoolyard in buckets; history, ecology and cultural relationships with land are taught through the use of the plants in the ethnobotanical garden. Each year the 5th grade class does an art project with a professional artist, many of these are located in the garden.

Maintenance:

The grounds person at the school maintains the outdoor portion of the rainwater system, which receives as many resources as are needed. The school places great value on their school ground as it is highly tied in with the teaching practices at the school. Changes to the garden are controlled by the school, therefore, teachers do not get to make changes or do experiments of their own that would alter the structure of the garden.

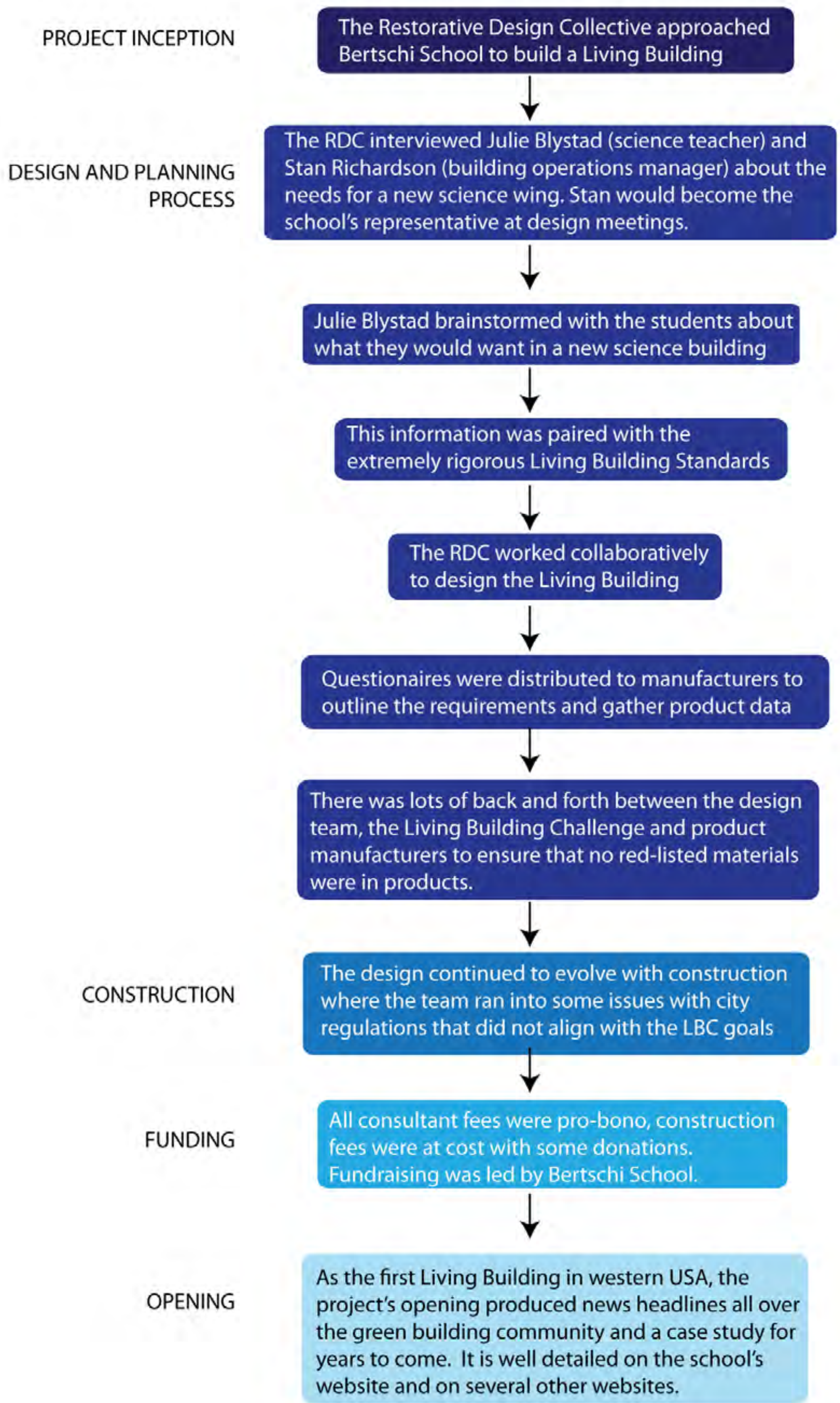


Figure 3.2: Diagram of Bertschi's process

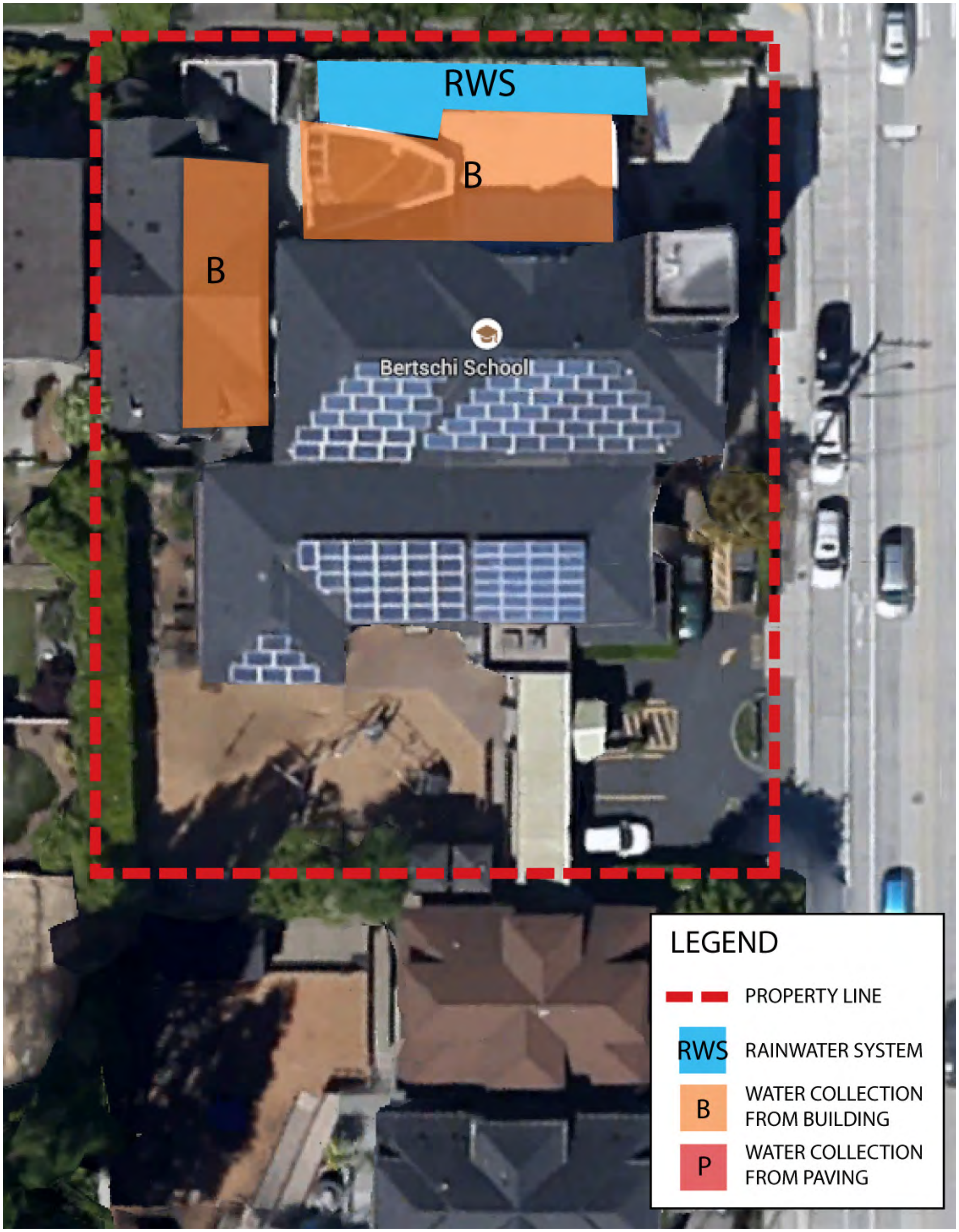


Figure 3.3: Location of Bertschi's rainwater system and water collection areas.

(Google, 2014a)

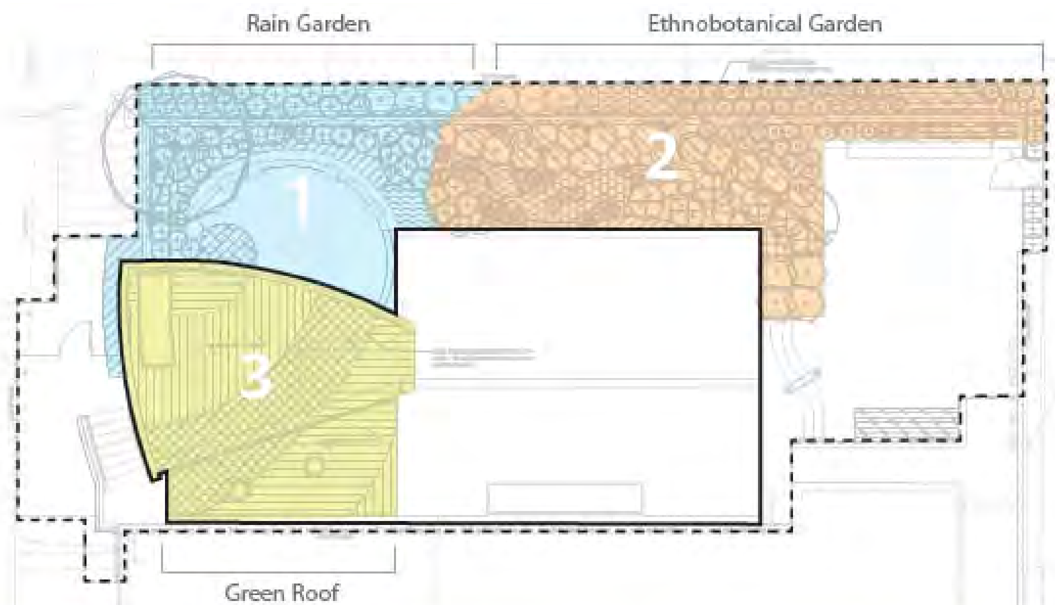


Figure 3.4: Garden layout (GGLO, 2011)

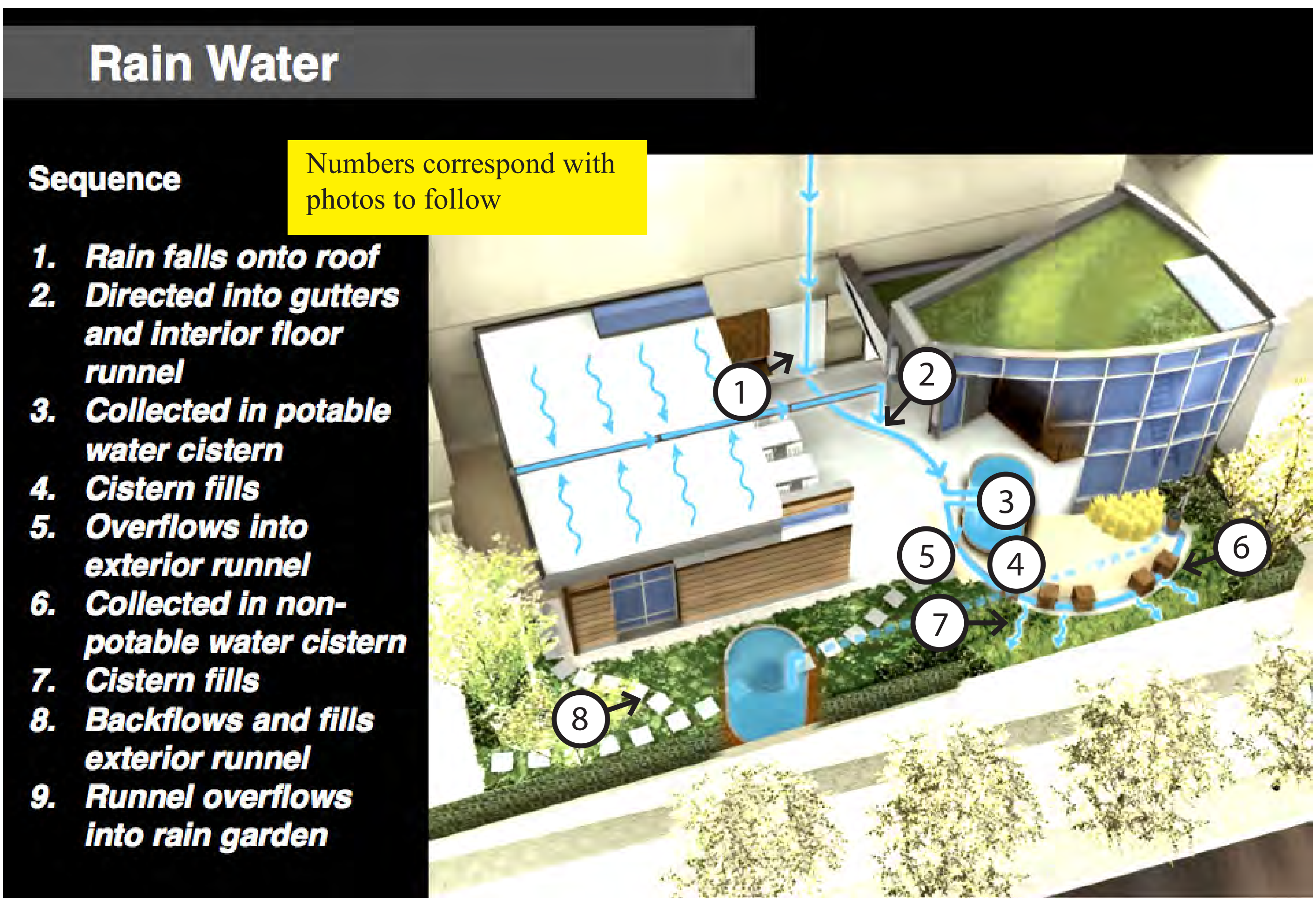
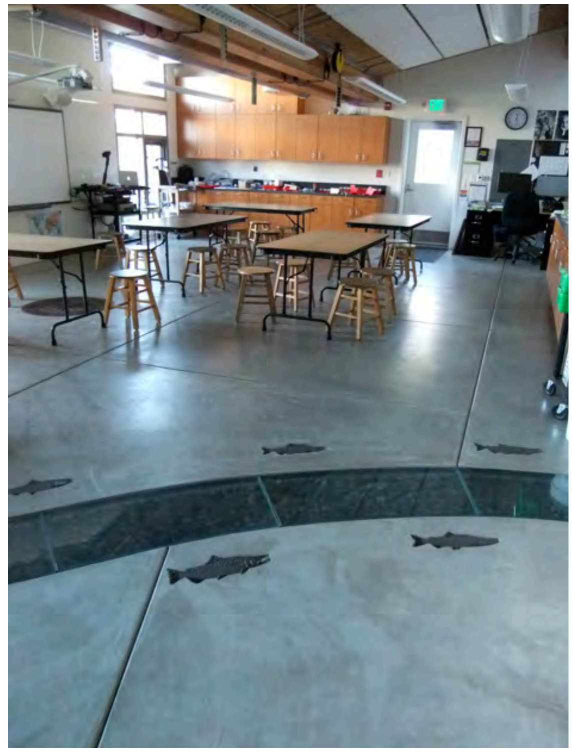


Figure 3.5: Rainwater system diagram and photo key (GGLO, 2013a)

1 Figure 3.6: Rainwater leader coming from the roof into the runnel in the floor



2 Figure 3.7: Runnel in the floor with 5 local species of salmon

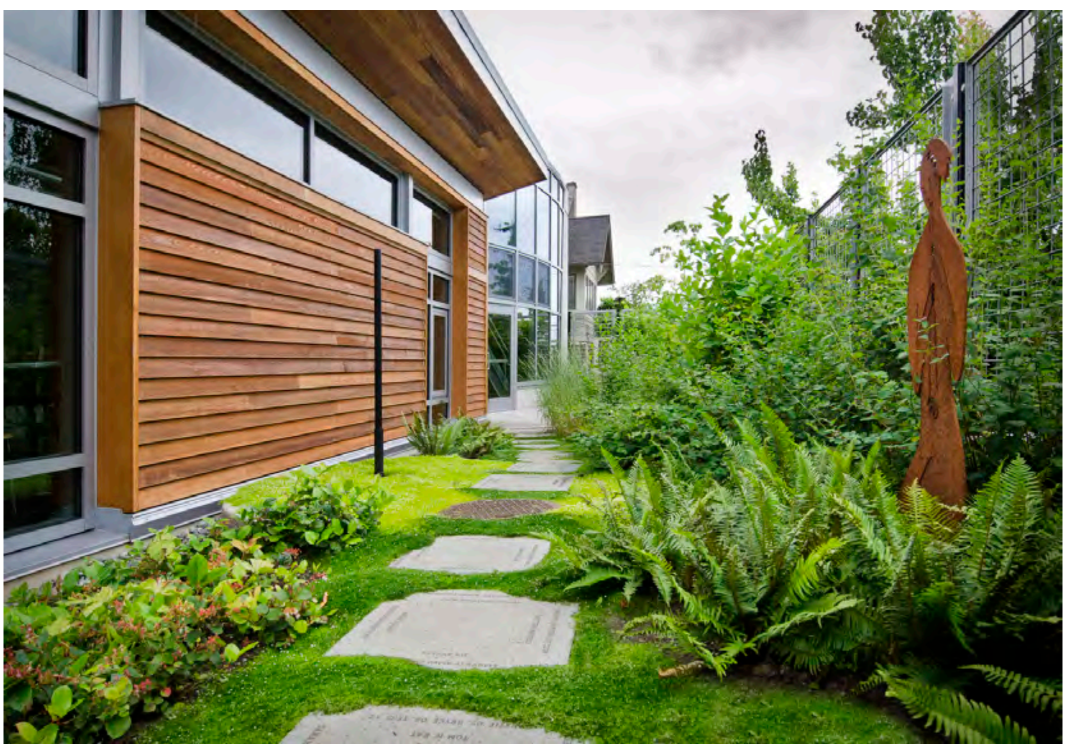
3 Figure 3.8: Water monitor system for the "potable" rainwater tank

4 Figure 3.9: Water pump allows students access to water in the "potable" tank

5 Figure 3.10: A decorative wine-bottle rain chain drains a section of the roof into the outdoor runnel

6 Figure 3.11: The rain garden, ethnobotanical garden and the below ground outdoor cistern with water level measurement stick (GGLO, 2013b)

7 Figure 3.12: When both cisterns are full, water backs up into this runnel, pouring into the rain garden. This area of permeable concrete serves as an outdoor classroom.



8 Figure 3.13: Looking back towards the ethnobotanical garden (GGLO, 2013c)

3.2 Case Study #2: Da Vinci Arts Middle School's Living Water Garden

School details:

Location: 2508 NE Everett St, Portland OR

School type: Focus option public school - Arts focus

Grade range: 6-8

Student population: 460

The project:

Value: $78,729.00

In-kind: $39,504.00

Costs: $39,225.00

Timeline: 1999-2003

Design team:

Urban Water Works

Keepers of the Water

Da Vinci School Science Teacher Dan Evans

Da Vinci students students

Unspecified professionals

Interviewees:

Dan Evans - Former science teacher and water garden creator

Jason Hieggelke – Da Vinci science teacher, currently in charge of the water garden

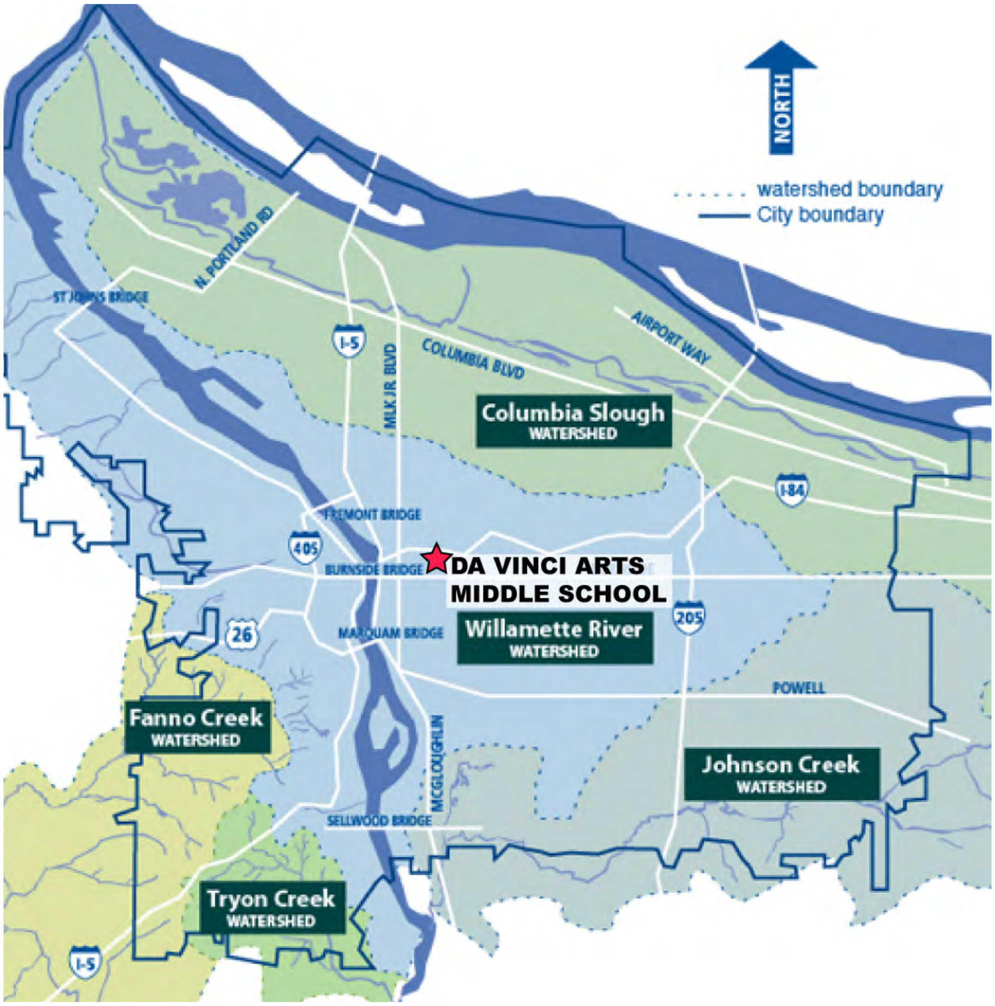


Figure 3.14: Location of school within the watersheds of Portland (Watersheds of Portland, n.d.)

Da Vinci Arts Middle School is located in a low-income neighbourhood but draws students from all over the city. The School is run out of a traditional school building with several portable classrooms and a large schoolyard with play fields, asphalt, sculptures and the water garden. Arts (music, drama, dance and visual art) are integrated throughout the curriculum; entry into the school is through a lottery. While Da Vinci is a public school, the arts focus is apparent throughout the school building and grounds with many special features not seen in a typical public school. The outdoor features are all built by groups of students through class work, many of them with science teacher Dan Evans who facilitated the rainwater project.

The project:

At Da Vinci, two not-for-profit groups, Keepers of the Water (KotW) and Urban Water Works (UWW), worked with Dan Evans and Da Vinci students to create the Living Water Garden. The project was financially supported by a grant from the Bureau of Environmental Services that stipulated that they manage runoff from a 10,000ft^2 of impervious surface. The grant stipulations combined with the goals of KotW and UWW of creatively implementing urban rainwater solutions framed the project, which was taken on by the school who added their own educational objectives. Dan Evans fully integrated the project into his science class, focusing a year on researching rainwater, a year on designing the system and a summer on construction. A number of professionals made in-kind contributions to the project to support the effort. Over the 3-year process, Dan pushed boundaries with the school district, negotiating to find compromises between the school district's values and the ideas that the team wanted to implement.

The Water Garden:

The Water Garden is situated in a formerly abandoned tennis court in the schoolyard, a high fence encloses the space. The fence protects the Water Garden from vandalism and over-use and enabled the design team to include many features that they couldn't have in a less controlled space. The space appears naturalized and park-like with a pathway snaking through trees and planting leading to a pond. It includes a bridge, a cob gazebo, several sculptures and artistic features and a solar panel that circulates water through a flowform to aerate the pond. The pond is the Water Garden's prized feature and hosts much biological activity including a yearly return of tree frogs, ducks and fish.

Water from 2,840ft^2 of portable classrooms is collected into two cisterns with a combined capacity of 5000 gallons. In summer months, the water is used for irrigation and in winter months, the cisterns overflow into the lined pond; which also receives water from a 2,640ft^2 asphalt play area. When it reaches capacity, the pond overflows into a swale, which snakes through the Water Garden and connects to the "wetland". A 4,600ft^2 parking lot also drains into a bioswale, which connects to the wetland, bypassing the pond due to water quality issues. The Water Garden has enough carrying capacity to manage most rain events, however, during high rain events the wetland overflows into a soakage trench located below the play field.

The Water Garden at Da Vinci is the only case study that is not connected to the city's rainwater system and has proven effective at managing all rain events thus far. Altering the school ground to redirect water to the desired location required some troubleshooting as the main school building drains internally, creating a challenge to meet the required square footage of impervious surface for the grant. However, with some creative solutions the design team was able to redirect nearly 10,000ft^2 of impervious area to the water garden.

How the Water Garden is used for education:

The teachers control access to the water garden; students are allowed in during recess when a teacher supervises. Under the supervision of Dan Evans, students went out weekly to learn in the garden and add new features, Evans included this work within his science class. Since Evans retired, Jason Hieggelke, the school's current science teacher, is in charge of the garden. In recent years getting the students out to the water garden for science class has become less frequent. Hieggelke states that this is due to high student to teacher ratios and a demanding curriculum. However, the water garden is used regularly for drawing, painting, photography, biology and nanotechnology; seasonal change is observed and flowers are dissected in science class. The pond is teeming with life and is a major source of learning and experimentation. Many small and large projects happen within the water garden from adding and maintaining plantings to running a living machine.

Maintenance:

Once a year the school organizes a garden clean-up day where the school community helps with maintenance. Twice a year, the Bureau of Environmental Services contracts a landscape crew to maintain the garden; the school district dictates what they would like done. The school district wants the garden to be more open and have, in the past, instructed the landscape contractor to cut down all the undergrowth. The teachers at Da Vinci disagree with this and want as much biological diversity as possible in the garden. The conversation has shifted over the years; when the garden first went in the school district did not want any food plants due to liability issues, now food gardens in schools are encouraged. Currently the garden is naturalized with plant succession occurring due to increased shade from trees. The garden has undergone many changes over the years and remains an activated learning space.

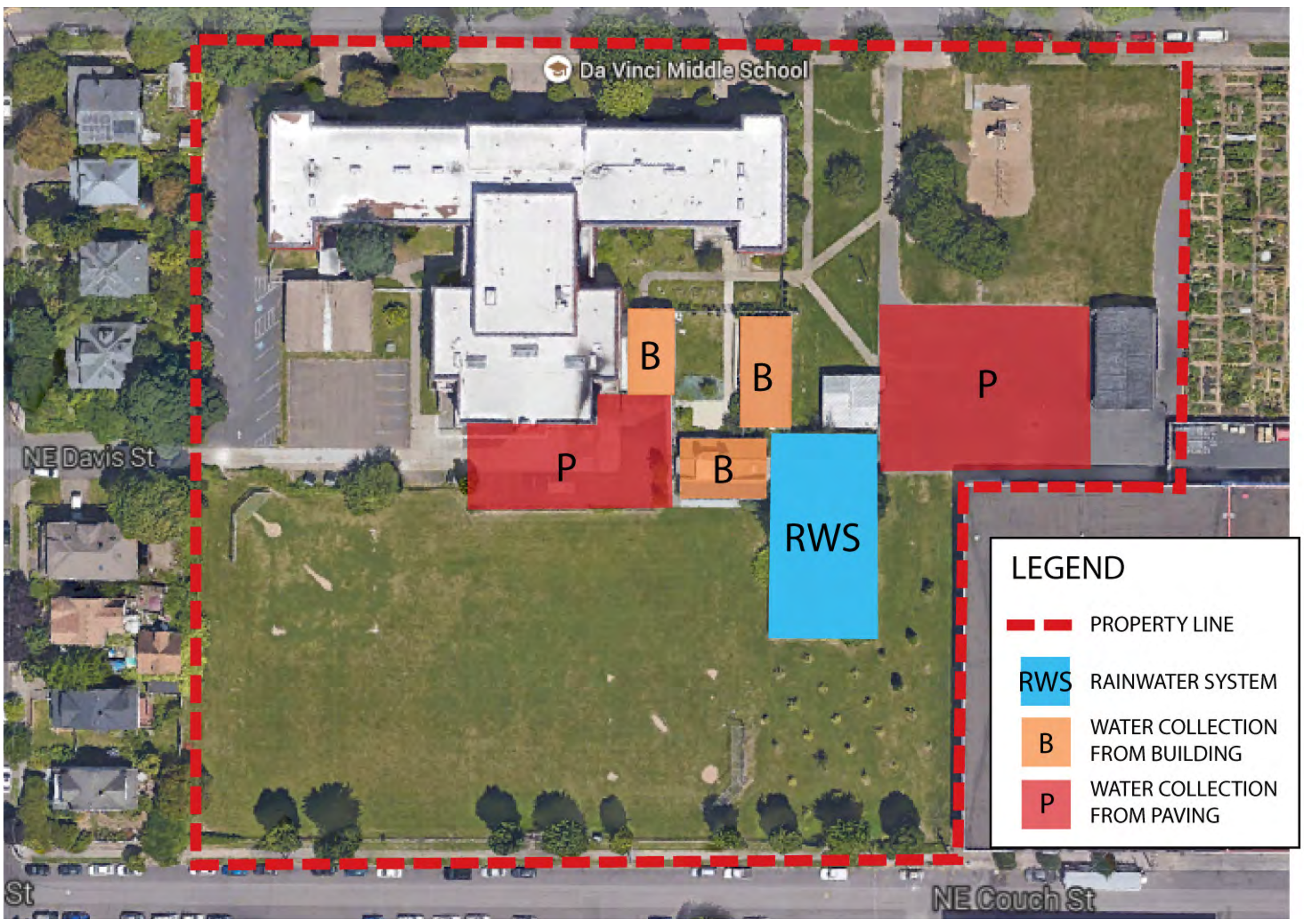


Figure 3.15: Location of Da Vinci's rainwater system and water collection areas (Google maps,2014b)

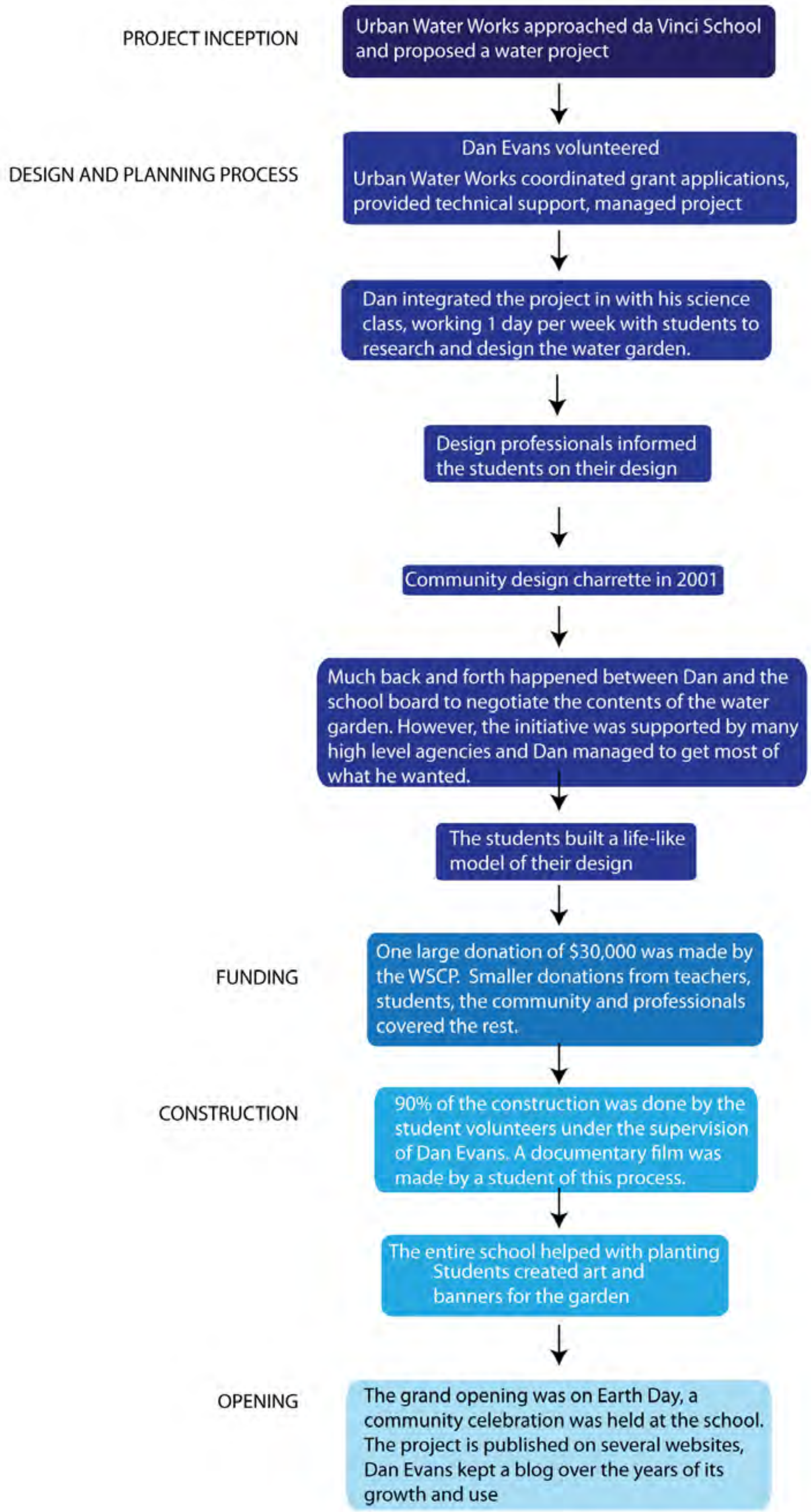


Figure 3.16: Diagram of Da Vinci's process

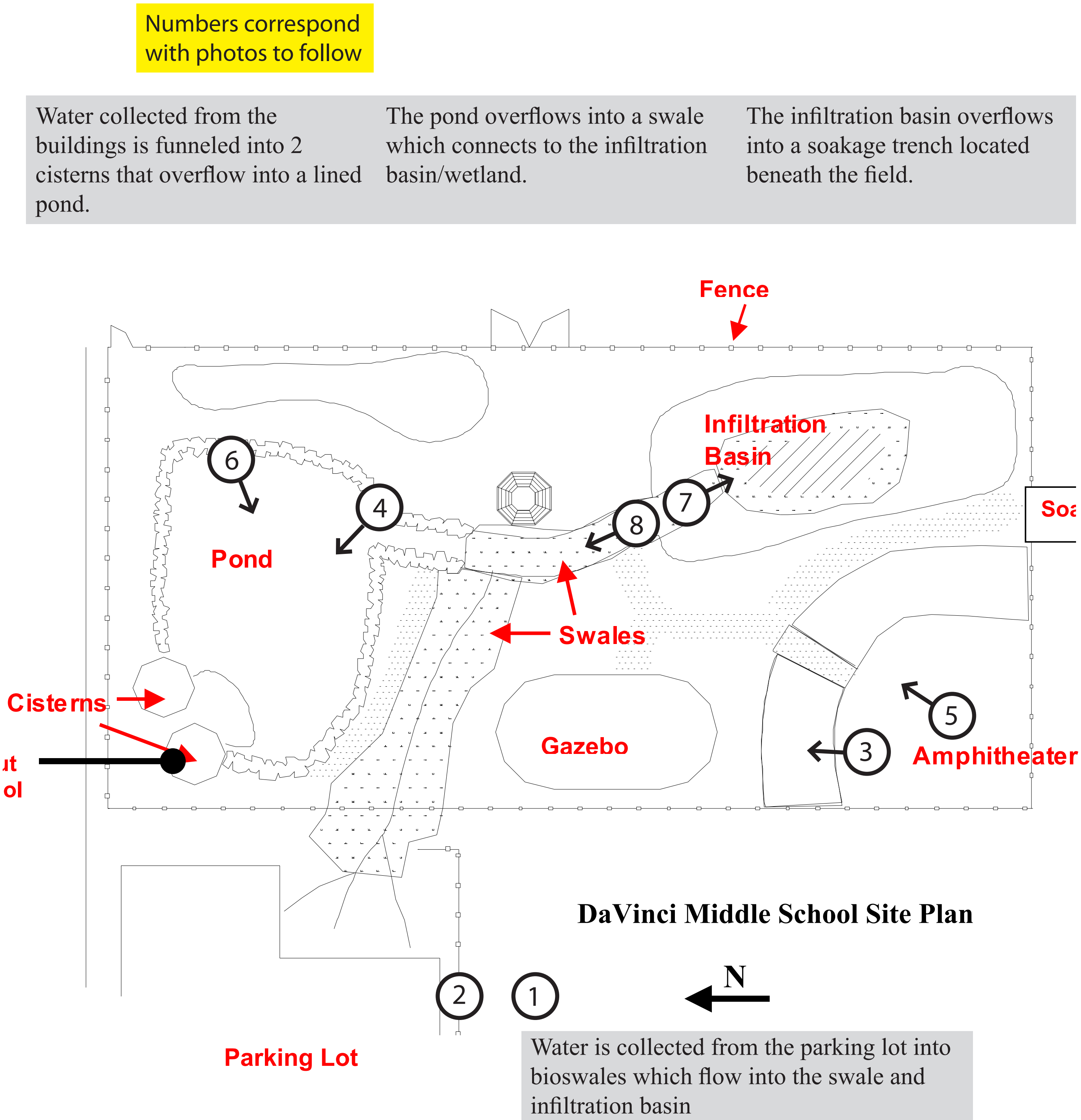


Figure 3.17: Water Garden diagram and photo key (Portland Public Schools, 2003)

1 Figure 3.18: Water from the parking lot collects into a bioswale which overflows into the swale and to the wetland, bypassing the pond to keep out pollutants from cars.

2 Figure 3.19: Some of the water collected off the building adjacent to the water garden goes to the bioswale while most goes to the cisterns and the pond.

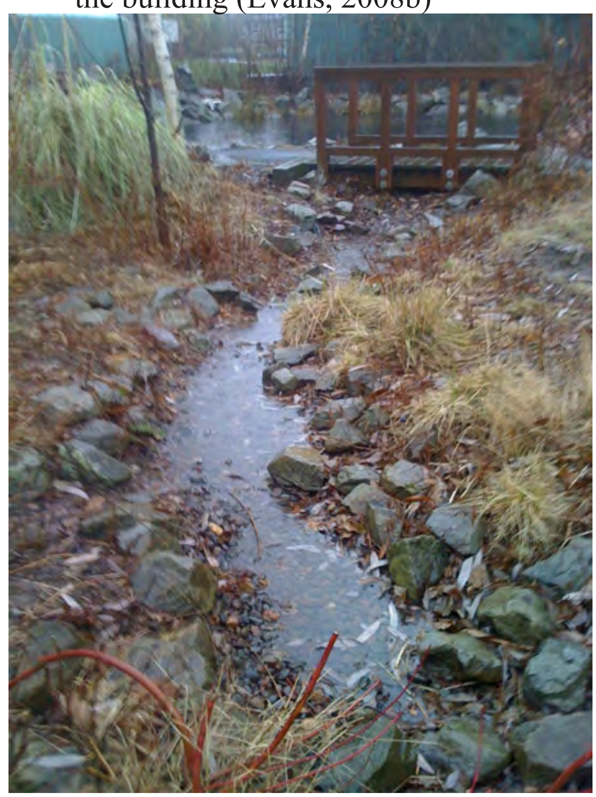
3 Figure 3.20: Solar panels, donated by Portland Electric, pump water through the flowform to aerate the water in the pond.

4 Figure 3.21: The pond hosts much biological activity including pacific tree frogs that return each year to breed. The flowforms have three tiers and are located in the center of the rocks.

5 Figure 3.22: Looking into the water garden from the entrance (Evans, 2008a)

6 Figure 3.23: Looking across the pond to the building (Evans, 2008b)

7 Figure 3.24: Looking towards the wetland with soakage trench in the field behind (Evans, 2008c)



8 Figure 3.25: Looking up the swale towards the pond (Evans, 2008d)

Figure 3.25: Art in the water garden: Da Vinci being a special focus arts school, the water garden is coloured with creative touches made in various art classes.

3.3 Case Study #3: Victoria West Elementary School's Project Urban Rain Garden, Victoria BC

School details:

Location: 750 Front St, Victoria BC

School type: Standard public school

Grade range: K-5

Student population: 200

The project:

Value: $83,308.81

In-kind: $55,973.53

Costs: $27,335.28

Timeline: 2006-2007

Design team:

Leadership Victoria students

Landscape architecture: LeFrank Landscape Architecture

Engineering: Neil Neate

Vic West Elementary students and teachers

Interviewees:

Jana Dick – Victoria West Elementary Vice Principal

Brenda Cook – Former secretary of Vic West Elementary and rain garden steward

Deborah LeFrank – LeFrank Landscape Architecture

Figure 3.26: Location of school within the watersheds of the CRD, the school drains to the ocean (CRD, n.d.)

Vic West Elementary is located in a middle class neighbourhood. It is a standard public school that experiences all of the typical challenges that public schools do: a demanding and inflexible curriculum, high teacher to student ratios and very little support and funding for grounds improvement and maintenance. The school is housed in a typical elementary school building. Before the rain garden was built the yard consisted of mostly asphalt with one small play structure. Teaching practices at the school are typical of public schools with most learning happening in the classroom and a small amount of outdoor lessons/activities.

The project:

Victoria West's "Project Urban Rain Garden" is the product of an 8 month educational program designed to train community leaders: Leadership Victoria: Today's Leaders of Tomorrow (LV). Within this, the project had a team of students who collaborated to brainstorm and implement the entire project. The project was funded by a large number of small cash donations, material donations and in-kind professional contributions. While their goal was to create an educational rain garden for the school, their approach largely centered on collaboration, community building, and outreach. As the project did not have a major funding source, the many project contributors were an important part of the collaborative effort. The LV team facilitated several creative projects to promote the project and engage the community including a 50x50' canvas artistic interpretation of the rain garden that an artist painted with the students. While community engagement was high, the Leadership Victoria group focused on educational and community building activities that did not contribute to the design or help build the school's relationship with the actual rain garden. This is reflected in the quality of the design and the school's engagement with the project over the years (this will be further explored in the discussion chapter). While building the rain garden was a major accomplishment and it remains an asset to the school, this project is a good example of where energy needs to be placed in order to create a design that addresses the complexities of schoolyards.

The rainwater system:

The rain garden is situated in a central courtyard with views from several indoor spaces. A decorative metal fence that is locked at night encloses the garden. Short seat walls decorated with student made mosaics separate the garden from the concrete ground, which holds a pergola and a number of benches. The garden is planted with entirely native plants, many of which are quite large and unruly. The garden also has bare spots where teachers and parents have planted things in the past that have not been replanted.

Rainwater from a 2,700ft^2 section the school's roof is collected into a downspout and falls down a metal sculpture and into the rain garden, a line of river rock distributes the water into the rain garden. The catchment area does not represent a large percentage of the school site, however, as the schoolyard is largely flat, to manage more of the site water, several rain gardens would have to be located throughout the schoolyard. The rain garden is designed to manage a 5-year rain event.

How the rain garden is used for learning:

The garden is used daily for free play during recess, on occasion, teachers bring the students out to the garden for writing activities, aboriginal story telling, painting and music classes. The students also raise butterflies in the classroom and release them into the garden. During recess, children like to run around and through the garden. Many of the plants are large and the students like to hide behind them and create tunnels. This practice, however, does not work for the school and the students are instructed not to go in the garden. Parents also socialize in the garden as they wait to pick up their children.

Maintenance:

The school does not have a specific person who is in charge of the garden. The school's former secretary, Brenda Cook managed the garden for a number of years. In this time she had a difficult time recruiting volunteers to help with maintenance or getting funding for needed materials. When the rain garden first went in the school district "wanted nothing to do with it", offered little support but allowed its inclusion in the school ground. Over the years Cook worked with the school district to pick up plant trimmings and provide mulch; however, this was infrequent. The rain garden currently has no main steward within the school and no overarching plan. Parents and teachers have made additions to the garden over the years, some more successful than others. One teacher grew peas for a year; cow parsnip and pampas grass were planted and removed due to health and safety concerns. Since Brenda retired the garden has not been regularly maintained and is currently in need of a good deal of work.

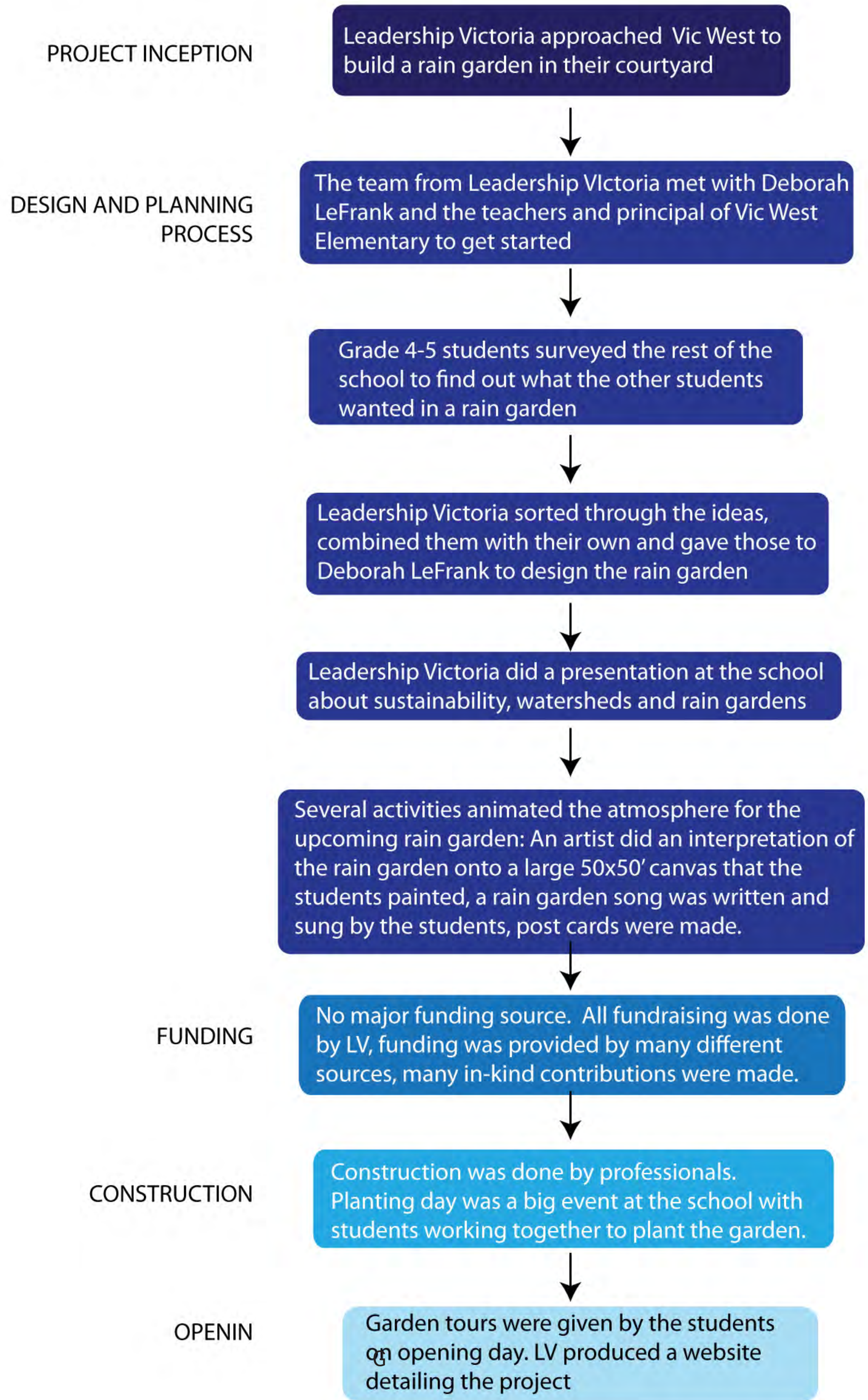


Figure 3.27: Diagram of Vic West's process

Figure 3.28: Location of Vic West's rainwater system and water collection areas (Google maps, 2014c)

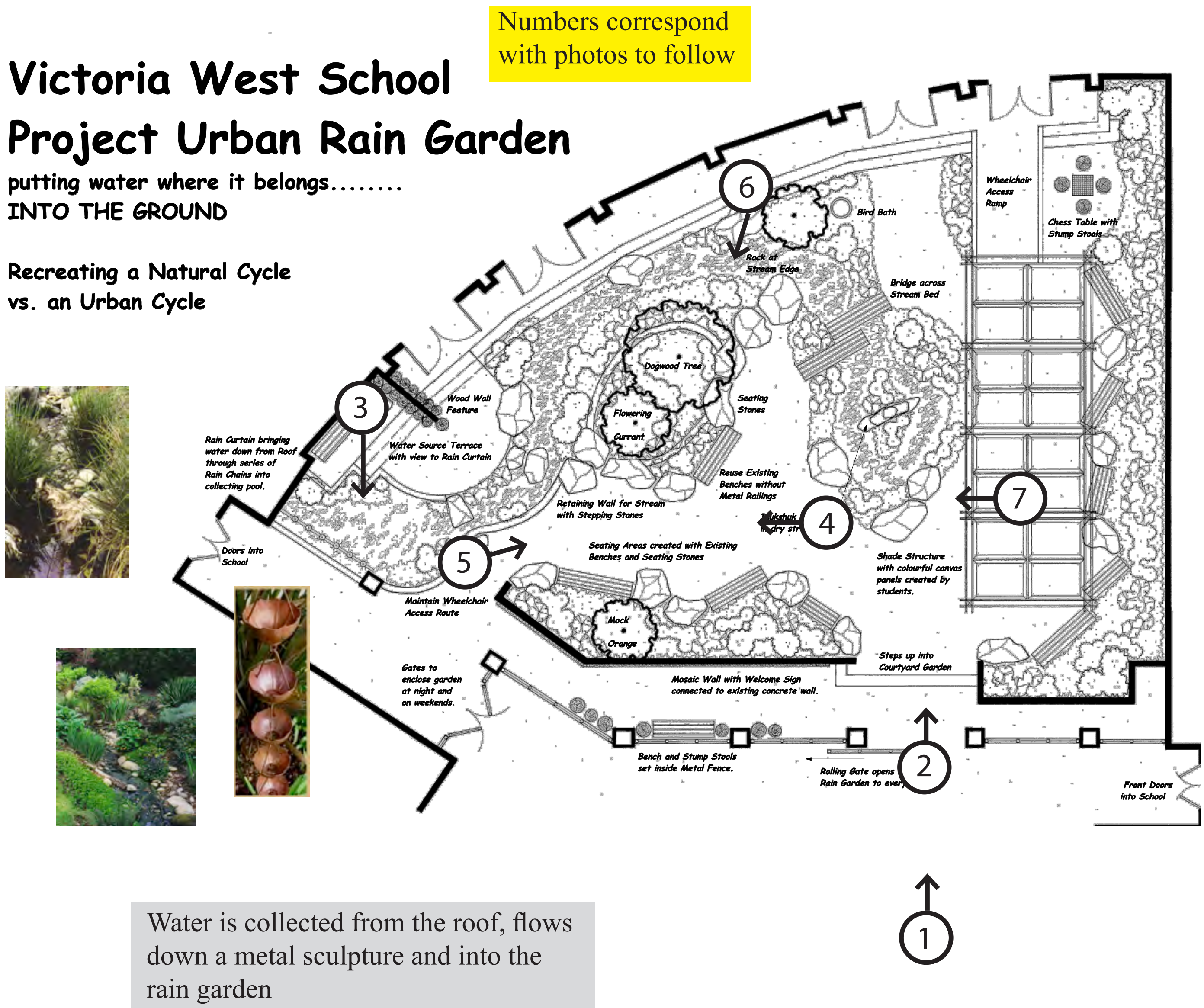


Figure 3.29: Water Garden plan and photo key. Note: this plan shows a different edge treatment and rain sculpture than what was built (LeFrank, 2007)

1 Figure 3.30: Decorative metal fence enclosing the garden

2 Figure 3.31: Just inside the fence looking into the garden

3 Figure 3.32: The rainwater sculpture has been almost entirely obscured by plants, this was the only angle I could see it from

4 Figure 3.33: The rain garden on the right with rainwater sculpture obscured by plants

5 Figure 3.34: The garden includes many nice places to sit

6 Figure 3.35: Rain garden enclosed in concrete wall

7 Figure 3.36: Bird bath in planting wth bare areas in front

3.4 Case study comparison

To compare the case studies to one another, I have created a table that draws out key factors that shaped the projects and outlines how they are used. These factors are explained in this section and elaborated on in the discussion chapter. Topics in the table are in italics.

External factors

Each project involved *key groups and individuals* whose priorities largely shaped the project. This had an influence on what direction the project went and where energy was placed in the design process. Each project was associated with a *program* that also shaped the direction the project went.

The school

From the perspective of the school, the *school type* and *education philosophy* created a starting point for the projects. This was indicative of a number of things including how many resources the school would have to put towards the project, how they might engage with the project from a teaching perspective and whether a school district would be involved or not. The *school's approach to their yard* indicates what the schoolyards included before the projects were built and how the school engaged with the outdoor space. The projects were built upon this existing framework.

The *school's contribution to the design* was important in developing a relationship between the school and the project and in drawing out how the project could build on the school's educational philosophy. *How the school's objectves shaped the project* outlines the secondary goals that were unique to each school.

The project

Whether the project was accessible to students during recess or if it had controlled access was a major design determinant. This determined the level of supervision that would be present while the students were in the space. Spaces with open access during recess, for example, would have to be designed for free play in addition to other uses. Spaces with controlled access could include many features that open play spaces could not due to supervision issues and use patterns.

Whether the project can be seen from indoors or not is an additional bonus as students can observe and enjoy the project even when they are not directly engaged with it. This can also help improve indoor classroom quality.

The *features that help the rainwater system read* without the assistance of a teacher are important in communicating the function of the system to the students and in drawing their interest to the project on a regular basis. Features that come alive when it rains and those that change and grow throughout the seasons help to create a deeper understanding and connection to the rainwater system over time.

As these projects seek to push boundaries, it is inevitable that *commonly held fears, conflicting regulations, and safety concerns* will come up that must be worked through. This is an important part of the process of growth, compromise and change.

Use

The *students' interaction with rainwater* is an area that has been particularly contentious in the past. Looking at how the projects handled this is a key component of designing schoolyard rainwater systems.

How the project is used for hands-on learning relates back to the school's educational philosophy and how they use their yard. This section looks at a few examples of how the projects have helped to expand on these two factors with hands-on outdoor learning. *How the project is used for play* sheds light on what opportunities it presents for daily use and learning through play. Designing for this use offers many challenges that are not present in spaces that are solely used for directed learning.

Maintenance and change

How the project is maintained is an important factor in planning and design. Looking at how the case studies handled this and what issues they have ran into is an important part of learning how to create solutions that are suitable to the maintenance resources of each school.

How the project has changed over the years indicates how the school is engaging with the project in the long term, whether and how they organize themselves around the use of the garden and how that has shaped the garden over time.

Case study comparison table

External factors		**Bertschi School**	**Da Vinci Arts Middle School**	**Vic West Elementary**
	Design team leader/most influential	The Restorative Design Collective - a diverse group of sustainable design professionals from Seattle.	Keepers of the Water and Urban Water Works initiated the project. However, Dan Evans, a strong willed, energetic science teacher at Da Vinci had the most influence.	Leadership Victoria - community leadership program. An 8 month program to educate community leaders in green and social change initiatives.
	Associated programs	The Living Building Challenge - provided design guidelines	The Willamette Stormwater Control Program - provided funding and goals	Leadership Victoria: Today's stewards of tomorrow - provided the structure that created the project
	External goals	Build a living building	KotW & UWW: Support the implemenation of creative solutions to urban water issues.	Learn about leadership through undertaking a hands-on project.

Table 3.1: Case study comparison table: external factors

The school		Bertschi School	Da Vinci Arts Middle School	Vic West Elementary
	School type	Elite private school	Special focus public school	Traditional public school
	Educational philosophy/ approach	Kids learn and explore in an inter-disciplinary, integrated “real world” environment; each lesson is tailored to the level of the specific child; life-long learning is modeled through professional growth as educators.	The school seeks "innovative ways to integrate the arts throughout the curriculum, provide focused arts instruction, and create a rich, inquiry-based learning environment with high standards of academic excellence (Da Vinci website)."	"The school offers many excellent programs with a strong focus on literacy. As well, the school actively promotes and develops good citizenship and student responsibility through its focus on appropriate student behaviour (Vic West website)."
	Approach to the use of their yard	The yard contains a diversity of well maintained learning and play features from educational gardens to play structures, every aspect of the campus appears intentional.The yard is used for education on a regular basis.	The schoolyard includes large art and environmental projects among other more typical schoolyard elements like asphalt and play fields. Many of the features were created by students in class.	Before the rain garden project was built the entire schoolyard was paved except for one small play structure. The schoolyard is primarily used for recess.
	How did the school contribute to the design?	Stan Richardson represented the school in design meetings. Julie Blystad was interviewed to determine her needs as a science teacher. She spoke to students about their ideas and passed them along to the design team.	For the first year, Dan Evans conducted the project once a week in his science class. The second year, students volunteered once a week after class, and the project was built in the summer of the third year. With the support of Dan, KotW and UWW, the students designed and built the entire project.	The school gave suggestions as to how they'd like to use the space. Students gave suggestions as to what to include in the garden. The school was involved in a number of other educational, celebratory and promotional events for the project that did not contribute to the design.
	How the school's objectives shaped the project	Legibility of systems and opportuntities for educational engagement throughout the design.	Hands-on learning approach to the project implementation.	Greening of the courtyard, creation of a 'quiet' space

Table 3.2: Case study comparison table: the school

The project		Bertschi School	Da Vinci Arts Middle School	Vic West Elementary
	Access	Controlled access, the outdoor portion of the project is separate from the main play space. Students go outside during class time. Some portions of the rainwater system are located inside the classroom.	Controlled access, the project is located in an old tennis court enclosed by a high fence. Students go in during class time and at recess when a teacher is willing to supervise.	Fully accessible during school hours, available for use during recess, and locked in the evening.
	Views from indoors	Views from the science classroom.	No views from indoors.	Viewed from many classrooms.
	What features help the rainwater system read on its own?	Water runs down a pipe in the classroom labeled "rainwater" through a plexi-glass covered channel in the floor of the classroom. A digital screen indicates how much water is in the potable cistern. Outside, water runs down a rain chain, through a runnel, a fountain and into the irrigation cistern, which has a floating measurement stick indicating how much water is in it. When it is full, the irrigation cistern overflows into the rain garden.	The cisterns are located next to and attached to one of the buildings that collects water. A solar panel in the water garden powers a pump that sends water in the pond through a flowform for aeration. When the pond overflows it travels through a channel towards the "wetland". Water collected from the parking lot flows through a bioswale along side the building to connect with the channel. All components are visibly connected.	Water runs off the roof onto a sculpture and down into the rain garden. A rock channel distributes the water throughout the garden.
	What fears, regulations and safety concerns came up?	The LBC stipulates that no water should be discharged into the stormwater system, however, the city required that they be connected. A water filtration unit was installed to filter and reuse greywater, this too was against regulations. The system is not currently in use.	Originally the district was against them growing any food plants. They were weary allergic reactions and of attracting bees. Lots of push back about what they think is maintainable. Concerns about the aesthetics of the garden.	The project did not push any limits in terms of design features. However, a small wooden bridge was removed due to slipping concerns. Certain plants were removed due to parent concerns. Parents complained about glass pieces coming off the mosaic.

Table 3.3: Case study comparison table: the project

Use		Bertschi School	Da Vinci Arts Middle School	Vic West Elementary
	Student interaction with rainwater	Yes, students use a hand pump to access the water from the cistern for a variety of reasons. Water can also be touched and played with as it moves through the outdoor runnel and fountain.	Yes, students interact directly with the water in the pond by taking samples, going in to do maintenance and for assessing what is living in the pond.	No, the students do not interact with the water.
	How is the project used for hands-on learning?	Before they had to seal it up due to heat loss, water samples were taken from the channel in the classroom for testing. The water pump is used to teach students about water issues in developing countries. QR codes in the garden bring up a profile page for each plant. The garden has both ethnobotanical and food plants. The students monitor the water system.	The water garden is used for drawing, painting and photography, biology and nanotechnology. Flowers are dissected, seasonal change is observed. The pond is a major source of learning and experimentation. One year they implanted tree frog eggs and now each year they return to the pond. Student projects are ongoing in the garden.	Teachers take the students out to the garden on occasion for writing activities, aboriginal story telling, painting and music classes. They talk about life cycles, raise butterflies in the classroom and release them in the garden.
	How is the project used for play?	It is not used for play.	It is not used for play.	The project is used daily for play. Students play with the plants, socialize, read and walk around the garden at recess. Students are not allowed to enter the planted area or walk on the walls that enclose the garden.

Table 3.4: Case study comparison table: use

Maintenance and change		Bertschi School	Da Vinci Arts Middle School	Vic West Elementary
	How is it maintained?	The system is maintained by the grounds people at the school. The school has strict rules about what the garden looks like. Students have a composting program, each year they spread their compost on the garden.	One teacher is in charge of the garden, for years students went out regularly to maintain the garden. Now they do a garden clean up once a year with the school community. The Bureau of Env. Services sends a clean-up crew twice a year which has caused problems as they disagree on what the aesthetic of the garden should be. The school wants it wild while the district wants it neat and tidy.	For years the school's secretary maintained the garden on her own. She had difficulty getting volunteers to help and the school district refused to put anything into it. When she retired there was no one to take it over. The plants are large and need a lot of maintenance. Now the garden has been unmaintained for some time and is in need of work. Overgrown plants and bare patches.
	How has the project changed?	The garden has not undergone change aside from maturing. This is due to the fact that the school has strict regulations about what the grounds look like and teachers are not allowed to conduct their own projects that alter the yard in any way.	A living machine was installed and ran for 6 years. 2 portable classrooms that collected water were torn down and a new one was installed, this one designed to work with the rain garden. Various teachers carry out their own projects including art, planting and larger changes to the garden.	Some teachers have created their own projects within the garden, one teacher planted peas, another planted cow parsley which was later removed due to a complaint by a parent. A parent planted pampous grass which was later removed due to a complaint.

Table 3.5: Case study comparison table: maintenance and change

Conclusion

The three case studies represent a broad look at different school types and approaches to design in schoolyard rainwater systems. Upon close inspection, the projects are all quite different from one another in execution, design and use. While each schoolyard rainwater project will be different, looking at case studies in-depth can create a higher starting point for future projects, offering valuable insight into design process and design ideas. These case studies created a platform for the pilot project and details are explored further in the discussion chapter.

Chapter 4: Pilot project at Oak and Orca Bioregional School

From March to December 2014, I conducted a design-build pilot project at Oak and Orca Bioregional School. The case studies and literature review were used to develop a body of research and data to inform the pilot project. While research can support change, implementation is where we look at the ideas in a real-world context. This is an interesting component of this particular subject as no academic research that I am aware of has been done specifically on rainwater systems on school grounds. Creating a base of research that supported what I did in this pilot project was important; equally important was relaxing and embracing the often unpredictable qualities of the school environment. I had to actively loosen up to apply the ideas from the research to what I was doing. One important lesson I learned in this process is that there are no solid answers, only ideas, intentions and the context that we seek to apply them to.

The limitations of this project are that it is indeed a special project with a large amount of community resources and time poured into it. However, as I shall explore in the discussion chapter, this is common among all the case studies. This type of special effort is greatly beneficial to the community and is necessary to produce the kind of change that we are aspiring to create in the urban environment.

Figure 4.1: Location of school within the watersheds of the CRD, water from Oak and Orca drains to the ocean (CRD, n.d.)

4.1 Basic project details

School details:

Location: 2738 Higgins St, Victoria BC

School type: Non-profit private school

Grade range: Preschool-12

Student population: 55

The project:

Value: $30,000

In-kind: $14,500

Costs: $15,500

Timeline: March 2014-December 2014

Design team:

University of Victoria Graduate Student Catherine Orr

★ with support from Murdoch de Greeff Inc and Kevin Connery

Oak and Orca Principal Kara Woodcock, teachers and students

Partnerships and Funders:

Mitacs - A university-industry partnership grant

The Real Estate Foundation - Provided funding for the Mitacs grant

Murdoch de Greeff Inc (MDI) - 8 month Mitacs intership at their office

The City of Victoria - Helped finance the project and build the rain garden

The CRD - Helped finance the rain garden

VanCity - Helped finance the project

Finding the right school:

Choosing a school to work with had a significant impact on the direction that the project went. My interests lead me to Oak and Orca Bioregional School. The school is governed by a volunteer board made up of mostly educators and parents; this meant that decision-making was internal and we did not face the systemic blocks that I would have faced had I chosen to work with a public school. Oak and Orca has a strong educational philosophy that supports the work that they do. Their approach aligned with the ideas that I was most interested in exploring including hands-on learning, learning through play, environmental education, connection to place and consensus based decision-making (this related to my desire to engage the school through participatory design). In addition to this, their yard was in great need of repair, specifically due to drainage issues.

The design-build process:

This chapter is laid out chronologically in the order that the project was undertaken:

- March 8th: Pre-design meeting with Kara Woodcock, Principal
- March 18th: Information package and consent forms to parents
- March 26th: Design meeting 1 with the educators (including Kara)
- April 3rd: Workshop 1 with students
- April 24th: Design meeting 2
- April 29th: Workshop 2 with students
- May 21st: Design meeting 3
- May 30th: Bioregional Fair at the school – presentation to the school community
- June-October: Design development
- July 25th: Presentation to Oak and Orca Board Members
- September 23rd: Workshop 3 and casual presentation to parents
- September-October: Construction planning
- Mid October-mid November: Construction
- November 13th: Workshop 4 with students
- 3rd week of November: Students and school community help with final stages of construction

- December 7th: Opening day

4.2 Site analysis

I began the project by conducting a site analysis. A detailed site analysis is imperative to any design process and helps develop familiarity with the site, the users and the context. These three factors should be understood in relation to one another and not separately (White, 1983). Data collected will vary based on the goals of each project but should be thorough and reach far beyond the footprint of the site to include the neighbourhood, city and watershed.

The site plan

Measuring out the site features and producing a site plan aided in developing a more detailed understanding of the site characteristics, this plan also acted as a base that we would work off of in the design meetings and the workshops (figure 4.2).

Oak and Orca Bioregional School is located in a highly urbanized, high traffic neighbourhood in Victoria. The school is run out of two residential houses and operates on a low budget. The schoolyard at Oak and Orca is loosely managed; it contains many loose natural materials that children play with, trees, gardens, managed and unmanaged natural spaces, small built play features and a sizable asphalt pad. The older of the two properties, the ‘Green House’ on the east side, was in need of repair in many places and had already been targeted as the location for the rainwater system. At first glance, the yard appeared eroded in some areas and overgrown in others. However, I soon began to understand that Oak and Orca’s loose approach to their yard allowed the students to interact with the space with more freedom and creativity. So began my deepening understanding of the schoolyard at Oak and Orca.

LEGEND

1	Green House
2	White House
3	Off limits/underused
4	Main entrance/Parking/Bike parking
5	Main play area: Asphalt, food gardens, monkey bars, small hill
6	High school area: Food gardens, grass, storage
7	Preschool area: Planted areas, grass, small play features

Figure 4.2: Oak and Orca's site plan before the rainwater system was installed

Figure 4.3: Key to site photos for the rainwater system area

Figure 4.4: Site photo 1: Looking north across the asphalt to the Green House

Figure 4.5: Site photo 2: The food garden, play house and upper play area

Figure 4.6: Site photo 3.1: Sinking monkey bars and water logged lower play area

Figure 4.7: Site photo 3.2: Water draining into the lower play area

Figure 4.8: Site photo 4: Looking south at the play area with poorly graded pathway in front

Figure 4.9: Site photo 5: Covered seating area below deck with visible water drip line

Information collected for the site analysis in advance of meeting with the school was:

- Watershed
- City neighbourhoods
- Greenways
- Neighbourhood places nearby
- Circulation around the site
- Location of utilities
- Site layout and characteristics
- Site hydrology
- Legal property description
- Future plans nearby (this includes the rebuild of Higgins St, the street that the school sits on)
- Climate and bioregion

Plans generated from this information were:

- Site plan (figure 4.2)
- Hydrology plans (figures 4.10-4.12)

The hydrology plans

Using the site plan as a base, I assessed the site hydrology, which is represented in three plans: drainage basics, water flow diagram and problem areas.

The Drainage Basics Plan (figure 4.10) depicts 1m contours and connections to the storm drain through the two houses and a catch basin. The site has a significant slope and falls about 6m from north to south. The 1m contours depict how water flows across the land but do not depict more detailed drainage patterns. The Green House suffered from 3 failures in stormwater infrastructure:

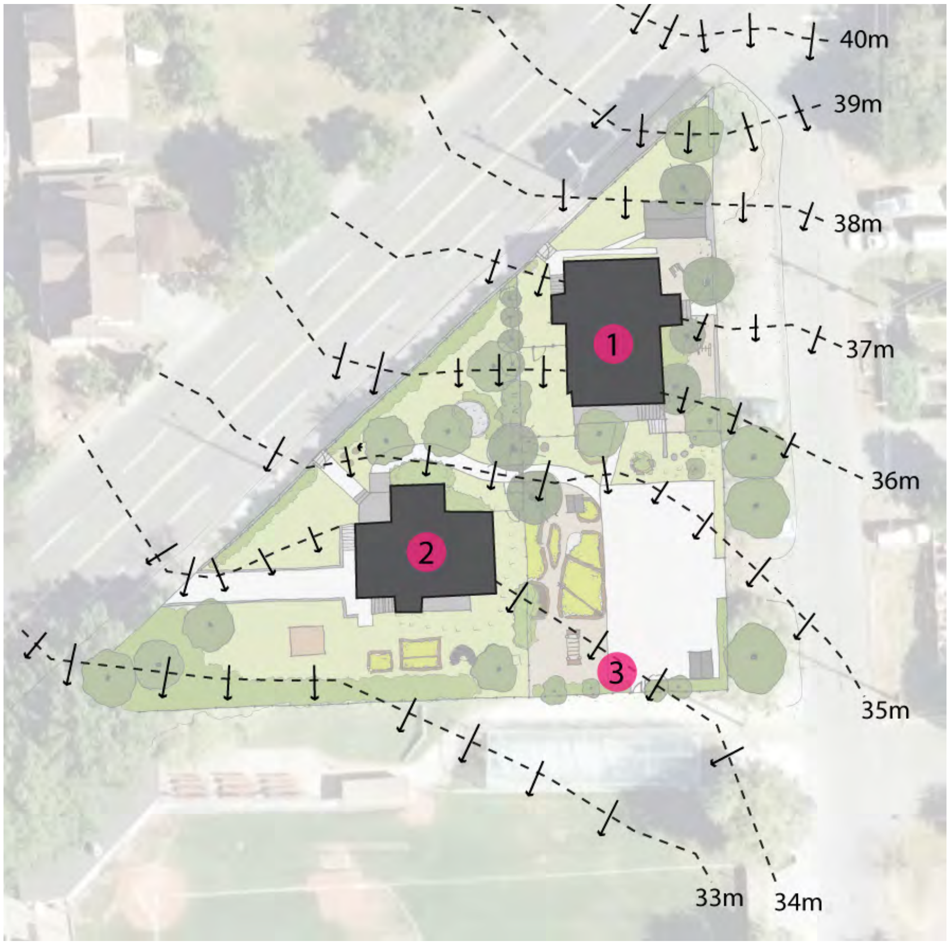
1. Higgins St. did not have curbs and therefore the water that ran off the road ran directly into the school property.
2. The gutters on the Green House were completely non-functional and in need of replacement.

3. The catch basin at the southwest end of the asphalt area was completely plugged, causing water to drain into the play area to the west and into the park to the south.

The Water Flow Plan (figure 4.11) looks more closely at how water flows in, through and out of the site. It depicts water pathways, accumulation into larger pathways and puddles. The drainage on the White House (west side) property was in good shape, aside from some erosion and muddy areas north of the house. The Green house was a different story with water flowing off of the road, house and asphalt, and through the highest traffic areas in the school ground creating numerous puddles, muddy areas and erosion problems.

The Problem Areas Plan (figure 4.12) points to the main issues:

1. At the north end of the property, a frequently used pathway was flooded by poorly managed gutters.
2. A 2nd level deck covers a seating area below, which is the sole covered area in the yard. There was no gutter on the edge of the deck causing water to flow onto the ground below. The ground here was sloped towards the house creating a muddy puddle and affecting the quality of the seating area (figure 4.9).
3. A small hill was eroded and muddy from use and water running from above.
4. A large puddle accumulated in the middle of the pathway due to poor grading (figure 4.8).
5. A heavily used play area was eroded and muddy (figure 4.5, 4.6, 4.8).
6. As the low point on the property, the south end of the site suffered the most damage. This area hosts the school's beloved monkey bars (figure 4.6, 4.7). The site conditions here were such that the monkey bar area became a collection point for much of the water that flowed through the site. The sitting water had undermined the footing of the monkey bars and they were no longer safe for use and therefore blocked off.



LEGEND

1 Connection to downspout severed due to broken gutters

2 Gutters and connection to downspout in good shape

3 Catch basin plugged

1m interval contour line

Direction of water flow

Figure 4.10: Hydrology plan: Drainage basics

LEGEND

	Observed water pathways
	Large amounts of water flow
	Water flow direction
	Puddle

Figure 4.11: Hydrology plan: Water flow diagram

LEGEND

1	Flooded pathway
2	Flooded seating area
3	Eroded and muddy hill
4	Large puddle in pathway
5	Eroded and muddy play area
6	Puddles and water damage to play structure

Figure 4.12: Hydrology plan: Problem areas

4.3 Design process

Advance Meeting with Kara Woodcock

Kara Woodcock is the principal and founder of Oak and Orca Bioregional School. Before beginning the process with the rest of the school community, I met with her to go over her concerns, ideas and observations about the school ground. From this meeting I produced a map outlining our conversation as it related to the different areas of the school ground (figure 4.13). In this meeting we began the process of building trust and understanding between the two of us.

Figure 4.13: Kara Woodcock's ideas and comments about the schoolyard

Design Meeting 1: March 26th

Participants: Teachers and Kara

Goals:

- Introduce the project
- Give background on the research
- Collect information on how the school currently works
- Collect information about educational philosophy, ideas and aspirations for the yard
- Collect information on how they see the project working

Key lessons and/or observations:

- The teachers were very interested in creating rainwater features that would provide ‘emergent learning opportunities’ - features with embedded meaning that can be discovered and explored in a many different ways.
- Having an interactive water channel where the students could experiment and play was an important idea, as was improving the current drainage issues.

Products/Outcome:

- Several site analysis maps looking at the social dynamics of the yards were generated (figures 4.14-4.16) (see Appendix E for mapping exercise handout)
- A questionaire drawing out the school’s educational approach and ideas for the yard was filled out
- Information collected was compiled for my use in analyzing the site; developing the Master Plan for the site; creating design guidelines; and the first iteration of the design for the rainwater system.

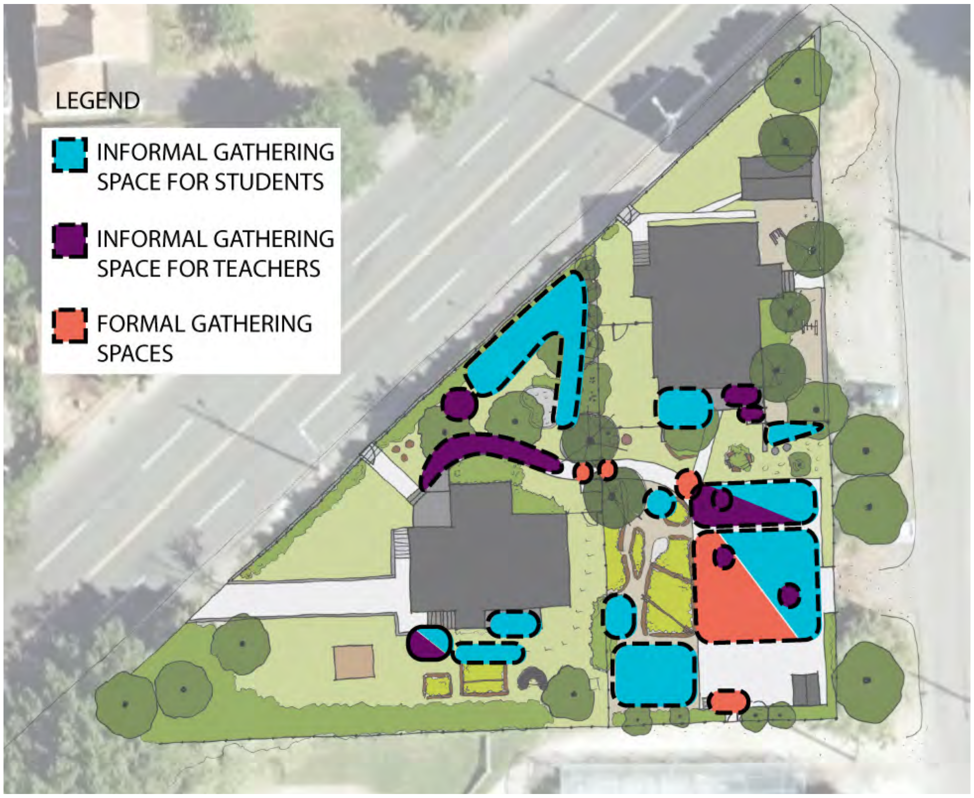


Figure 4.14: Gathering spaces map generated from mapping exercise with educators

Figure 4.15: Play areas map

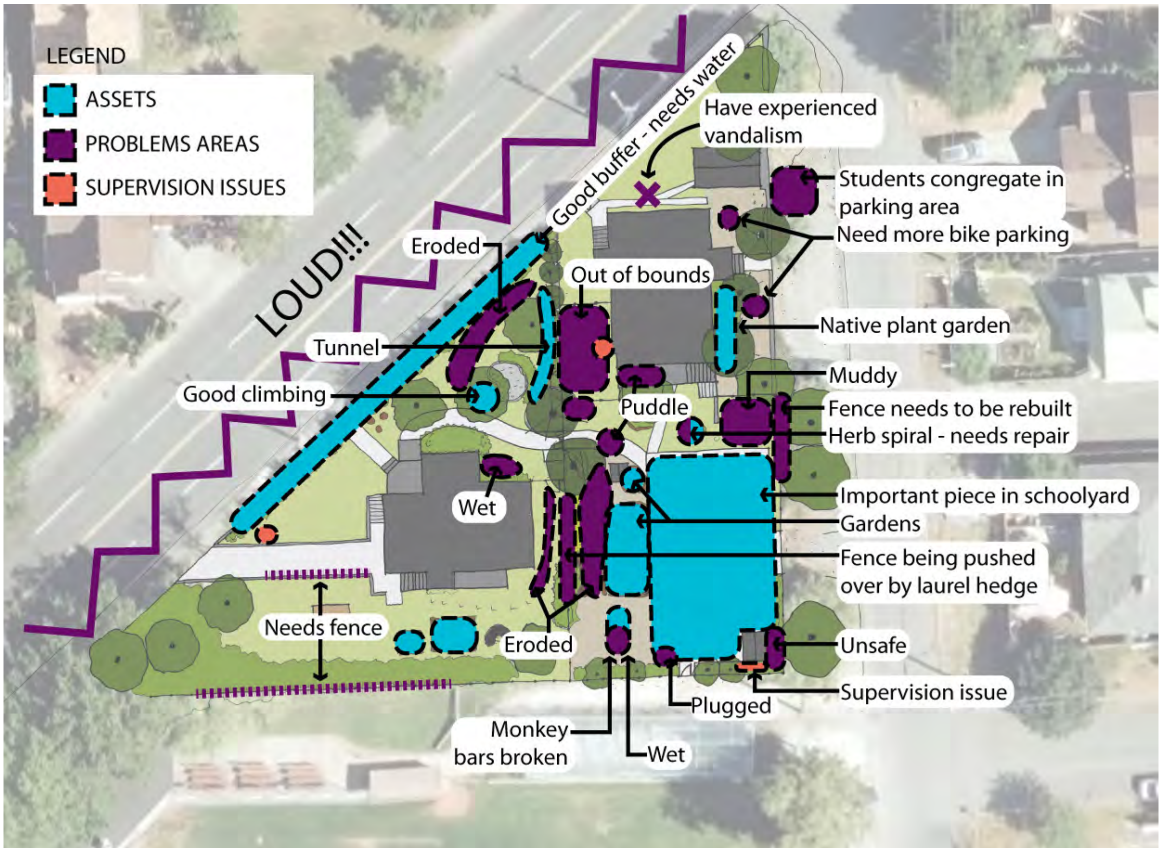


Figure 4.16: Problems, assets and supervision issues map

Workshop 1: April 3rd

Participants: All students

Goals:

- Inform and educate the students about urban rainwater management and our project
- Allow them to make their unique contribution to the site analysis through a mapping exercise
- Engage them with water and design through a channel building exercise

Key observations/lessons:

- Asking the students to map and talk about their experience of the yard was immensely engaging for everyone and really got the project off to a good start with the students.
- A homemade rain garden model was used to explain how the stormwater system works and how rain gardens work. This type of visual and interactive model was ideal for teaching the students about something that they largely could not see.

Products/Outcome:

- Two maps were created (one by the older students and one by the younger students) depticting their experience of the schoolyard (figure 4.18)(see Appendix F for legend)
- Developed students' understanding and interest in the project
- Information collected was used for analyzing the site and developing my understanding of how the children, view, play and interact with the yard.

Figure 4.17: Students inputting their information into the group map

Figure 4.18: Group map generated by the older students

Figure 4.19: The water channel built by the students

Figure 4.20: The younger students building their water channel

Assimilating the information into design guidelines and a Master Plan

After the first design meetings and workshop, the site analysis was completed. The school's drainage and erosion problems were largely clustered along the west side of the Green House property. As it turned out, this was the ideal location for the rainwater system, the soft landscape would be easy to work with and the play area was in need of rebuilding. The area was currently used for learning and play in a variety of ways that would need to be preserved or recreated.

From here, design guidelines (Appendix G) were established to frame the school's educational approach as it relates to the project. The guidelines provided a framework for a master plan (Appendix H) for the site to be drafted. The first iteration of the rainwater system fit within the master plan (figure 4.21).

In this plan (figure 4.21), the rainwater system stretched from the middle of the Green House to the south end of the yard. I began exploring how we would design the interactive water channel (what I would eventually call the play-swale), at this point it was a graded swale with a pond liner shaped and held in place by two-person boulders. Loose materials would be used in the swale for water experiments and play. The water would then move through a short rock swale, into a trench drain through the pathway, through the play area and into a rain garden at the far south end of the site. I imagined that we could fix the play area's erosion problems and channel the water in one solution: a granular swale deep enough to manage the water flow with large flagstone pavers for walking on. In this iteration the monkey bars would be rotated and reinstalled and part of the main garden removed. At this point my assumption was that we would attempt to recruit volunteers from the school community to help us build the majority of the project. For this reason, I tried to keep the design within the bounds of what I thought would be feasible for a group of volunteers to accomplish, in other words, nothing overly complicated from a construction perspective.

Figure 4.21: Rainwater system concept plan 1

Design Meeting 2: April 24th

Participants: Teachers and Kara

Goals:

- Present and discuss the design guidelines, master plan and first iteration of the rainwater system design

Key lessons and/or observations:

- The teachers were very excited about all of the ideas that were brought to the table.
- Everyone agreed on the location of the rainwater system on the west side of the Green House property.
- Many ideas were put forward in the master plan and the boundaries of what we would actually build had not yet been established.

Products/Outcome:

- Information collected from this discussion was used to advance the design of the rain water system.

Workshop 2: April 29th

Participants: All students

Goals:

- Build on exercises from the previous workshop
- Give students an idea of what we were going to build
- Allow the students to explore their own ideas through making models of rainwater systems with the same components that we were looking at building.

Key observations/lessons:

- The students were immediately bubbling with ideas when I showed them the inspirational images (Appendix I) about what I was asking them to design. Some were more engaged than others in the model making, this is inevitable.
- Several of the older students who did the workshop in the morning came to help the younger students in the afternoon. The models created in this, their second attempt, were exponentially better than the first. This demonstrated that the students who were more engaged wanted the opportunity to explore their ideas further.

Products/Outcome:

- One specific idea from this exercise was used in the actual design was the method of collecting water at the bottom of the channel in buckets.
- Other lessons learned were more towards my understanding of how the children experiment and play.
- Most of the students were very engaged in the project.

Figure 4.22: Building their rainwater system models

Figure 4.23: Younger student presenting her ideas to the group

Design Meeting 3: May 21st

Participants: Teachers and Kara

Goals:

- Finalize the design (as much as possible considering that community contributions would shape much of what was to come, or so I thought at the time) (see Appendix J for the concept design I was working with at this time)
- Go over the logistics of getting the school community involved in donating materials and building the project
- Discuss the upcoming project presentation at the school's annual Bioregional Fair.

Key observations/lessons:

- I was incorrect in my assumption that the design could be finalized so quickly. Details were sketchy as at that point my assumption was that our small budget would not accommodate a full-scale construction and that we would need to build the project with mostly volunteers, which meant that volunteer contributions of skills and materials would shape much of what would be built.

Products/Outcome:

- The uneasiness I felt towards the idea of building the project with mostly volunteers was not resolved in this meeting. I would soon come to terms with the fact that this was not the right approach to building the project due to two main factors: 1. I was not experienced enough to direct the volunteers. 2. The school community had not initiated the project so willingness to participate was limited.

Presenting the project at the Bioregional Fair

The school community came out for the Bioregional Fair and a small group gathered to hear my presentation (see Appendix J for concept plan and photo). My goals were to tell them a bit about the research, what we had been doing with the school, what we hoped to build, and to recruit volunteers for the project. The presentation was very informal and we had several small discussions as we moved along. While it was a good opportunity to inform and educate the school community on what we were doing, I did not recruit many volunteers. This was the clincher; I needed more funding and a better construction plan.

4.4 Producing the final design

Design evolution - Input from various sources

Over the course of the summer and early fall, the design evolved based on my own ideas and input from a number of different sources. These were:

- Kara Woodcock (principal) – I met with Kara several times over this period, she was the main decision maker at the school so it was imperative that I work closely with her. Kara had been running the school for 15 years and had a good handle on what would work with the kids and what would not. Her ideas were both pragmatic and imaginative. She wanted to make sure that the design would be playful, interactive, and functional. It was Kara who was adamant that we include the interactive water play-swale. At this point, Kara was feeling confident about the project and informed me that the school could contrtibute a few thousand dollars.
- Educators at the school – Many of the educators at the school remained engaged,

adding their comments and ideas as the design evolved.

- Murdoch de Greeff Landscape Architects – I was fortunate enough to have input from the local experts on rainwater system design, Scott Murdoch and Paul de Greeff. While I was developing the design ideas, their input helped me frame them in a way that I could be confident would work. They were particularly helpful in designing the rain garden.
- Kevin Connery – On the research committee for this thesis, Kevin was supportive throughout the entire design process. His input was particularly important as I moved the design from conceptual ideas to construction.
- The City of Victoria - The City of Victoria made an in-kind contribution of $3000 of construction work to the project. As the city was to build our rain garden and connect us to the stormwater system, I had several conversations with different people at the city about the design of the rain garden.
- Community partnerships – As previously noted, the project had several community partnerships that supported it in various ways. Arranging these and coordinating them meant more funding or in-kind contributions to the project. This also meant that I could hire a contractor to help build the project.

Design evolution - Producing the final design

Note: This description is condensed and contains only the main changes, see Appendices J, K and M for design evolution

Over the course of the summer and early fall, the cistern moved to the southwest corner of the house and the entire design shrunk down (figure 4.24), bumping the play-swale from beside the house into the main play space. This was due to budgetary reasons and a desire for the cistern to be visible in the yard. I also felt that the rainwater system was occupying too much space in the previous design. We had the gutters on the Green House replaced but were only able to collect water off of half the house. On Paul de Greeff's suggestion, I explored the idea of building a custom cistern made out of a metal road culvert (figure 4.25). Paul suggested that this approach could be cheaper. After looking more closely at how we would do it, I decided that the custom cistern would be more expensive and overly complicated to build and instead selected a 1000-gallon off-the-shelf cistern. The cistern needed a platform to sit on; Kara suggested that this platform could be circular and double as a bench for the students. The water would then go under the pathway through underground pipes and re-emerge at the top of the play-swale. This decision was mostly due to budgetary constraints and practical issues. Initially I disliked the idea of having the water disappear from sight, I wanted the students to be able to make the connection visually. However, in the end this meant that the rainwater system did not occupy too much space in the yard and that several unnecessary features could be cut from the design.

The play-swale received hours of design work and several different iterations. In the end I settled on building it out of concrete since it would be in the main play area and needed to be durable. I sat down with Scott Murdoch, who is a landscape architect and a stream biologist, to talk about how a stream flows and where we would place weirs in a stream. This information was used to inspire the design of the play-swale, which swerves back and forth and draws its shape from cut banks (erosion areas) and point bars (deposition areas) among other things.

I explored a number of different ways of moving water from the top of the play area to the rain garden including a mixture of bioswales and rock swales. At the Bioregional Fair, a parent who is a landscaper told me that rock swales become impossibly weedy and difficult to maintain. When the design shrunk down it became possible to use a single bioswale to connect the play-swale with the rain garden.

The rain garden was another area that received hours of design work. The amount of effort put into understanding each component of the design paid off when changes had to be made on-site based on site conditions that were unknown at the time of design (see rain garden detail figure 4.26).

Grading the play area and the rainwater system was a significant challenge due to the drop we wanted to create at the base of the play-swale to collect water in buckets (see grading plan figure 4.27, see Appendix L for existing grades, excavation grades and design details). This feature affected the entire design and adjacent areas as the original site sloped down evenly and we now wanted to create two levels with a step between them.

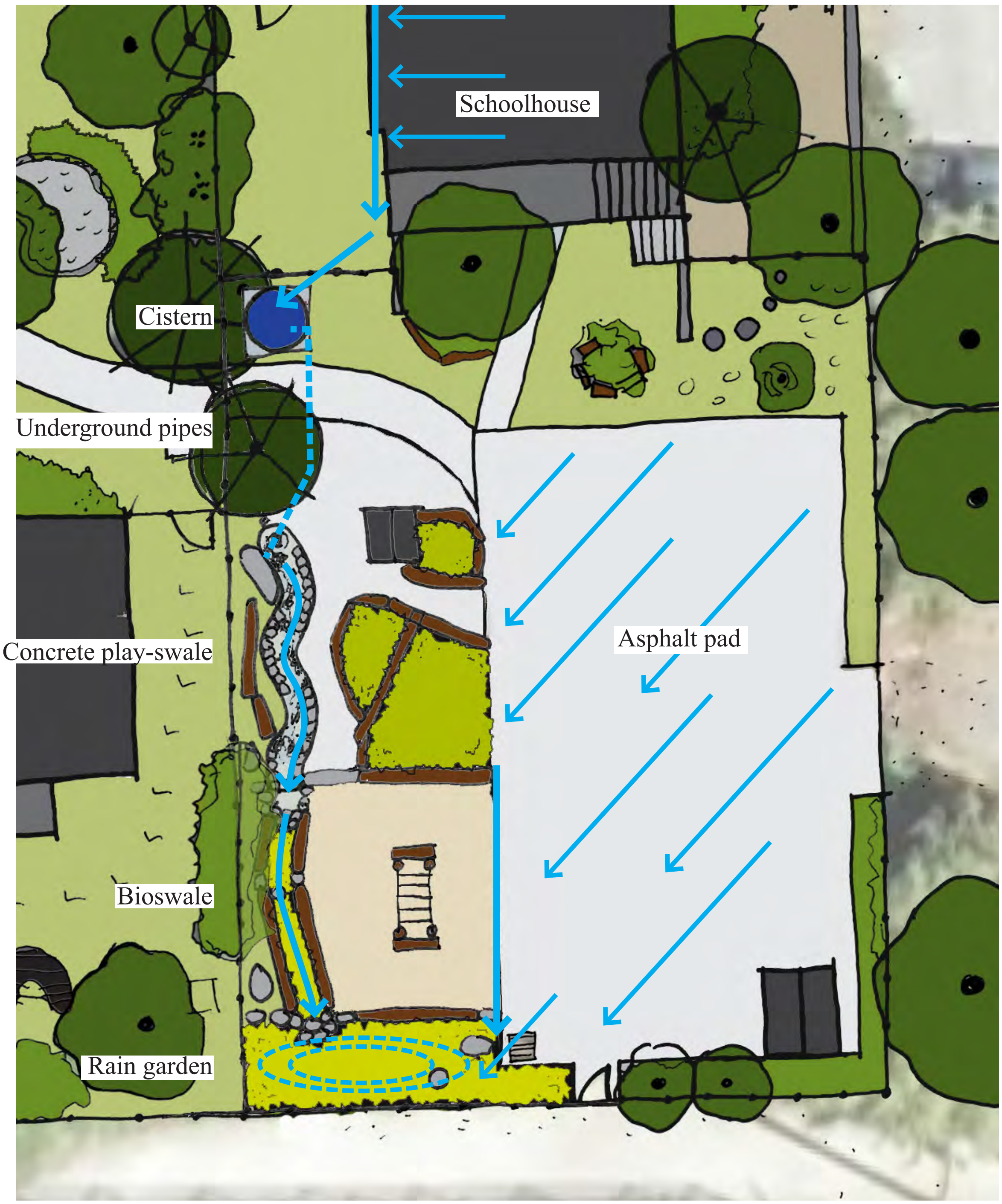


Figure 4.24: Simple illustration of the final design

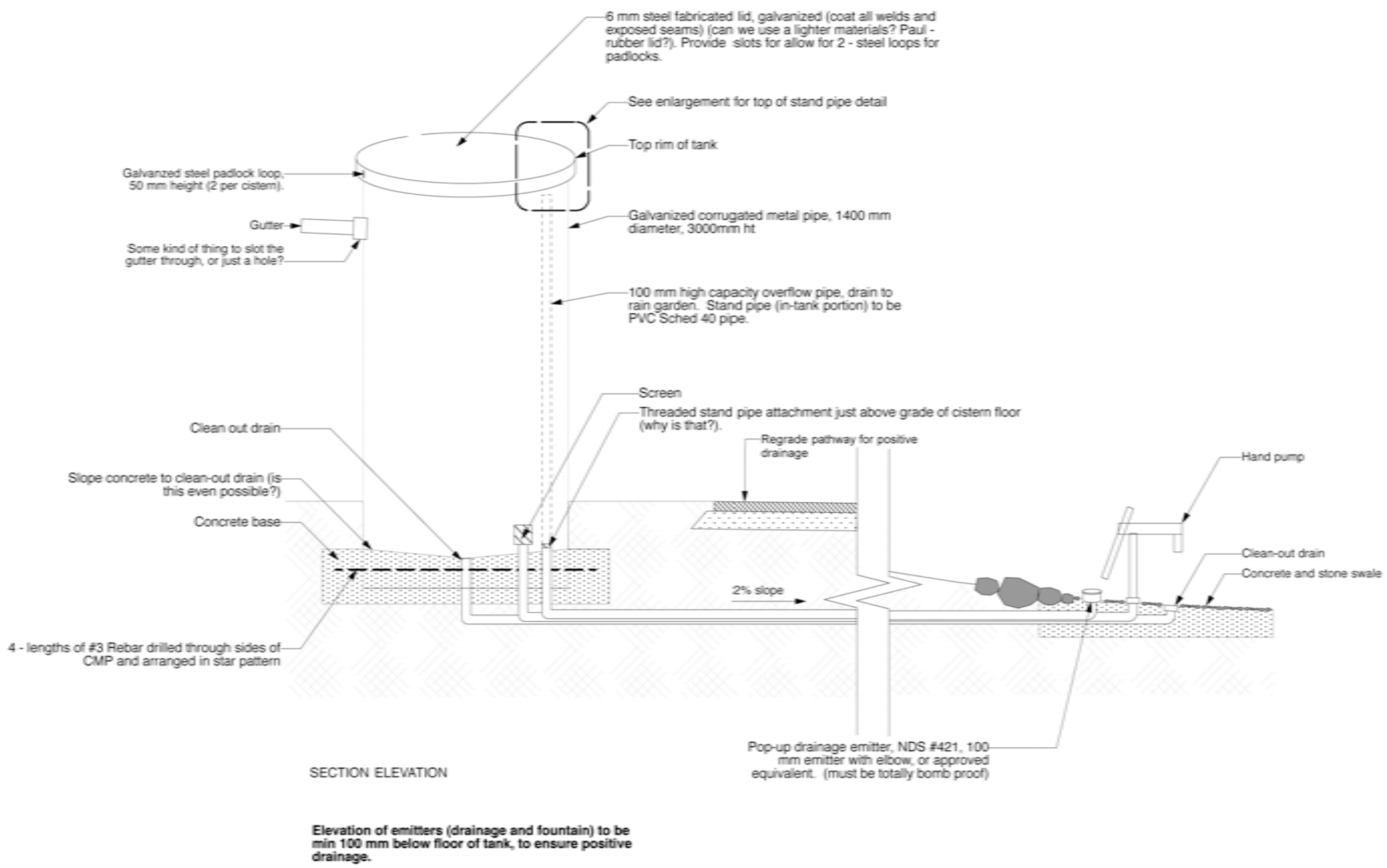


Figure 4.25: Rejected custom cistern detail

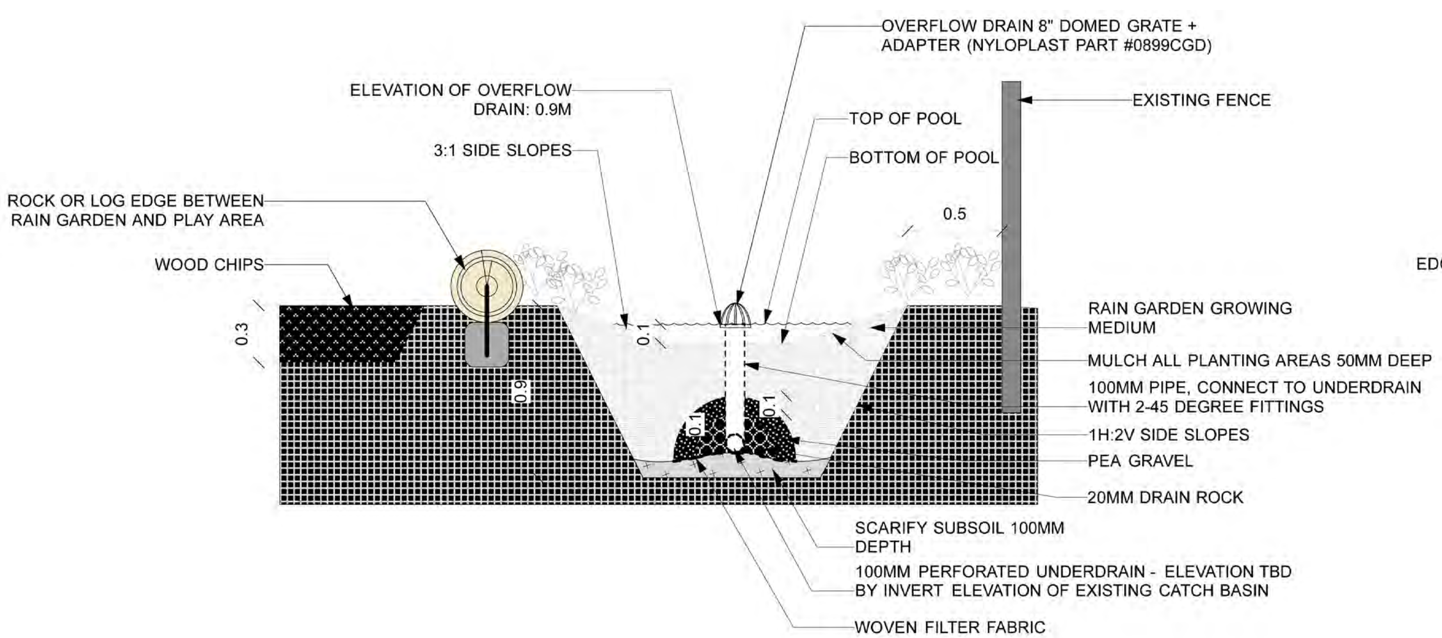


Figure 4.26: Rain garden detail

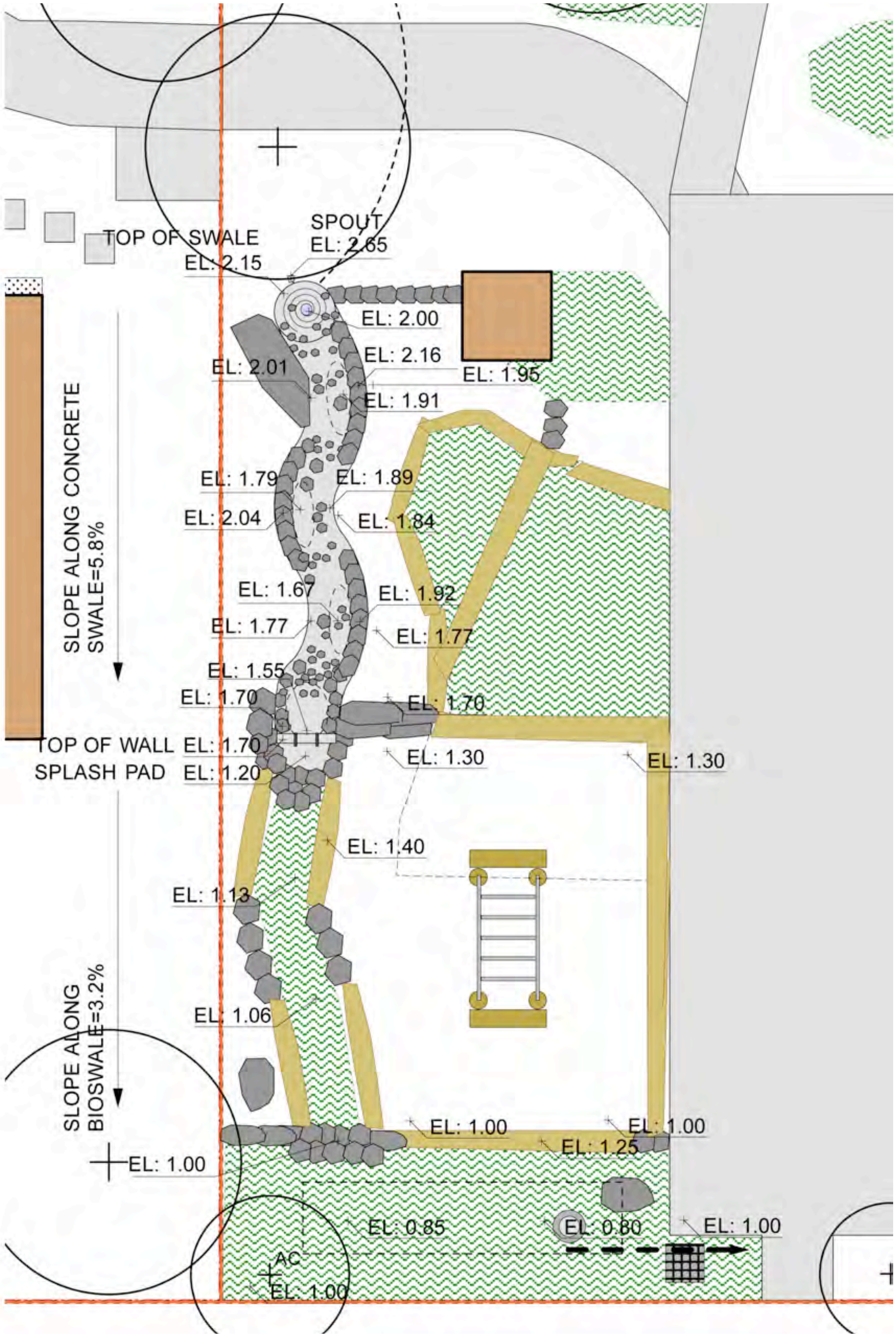


Figure 4.27: Final grading plan

Workshop 3: September 23rd

Participants: About 15 students of different ages

Goals:

- Re-engage the students in the project after being gone for the summer.
- Using the construction drawing as a guide, have the students lay out the design in the schoolyard with flagging tape.
- Using the final presentation board (Appendix M), speak about the final design with the students and the parents.

Key observations/lessons:

- While all of the students enjoyed the learning activity, the younger students still did not understand what was about to happen to their yard, this exercise made more sense to the older students.
- As the parents arrived to pick up their children the design was laid out in the yard and the presentation board was up, this was a great way to talk to them about what was about to be built.

Products/Outcome:

- The school and school community were now aware that construction would start soon and had seen what we were planning to build.

4.5 Construction

Construction started October 14th, I hired a one-man contractor to work with me (see Appendix N for team photo). My role was both boss/manager and labourer. Building the project was an immense learning experience for me. As the construction process unfolded, the students watched day-by-day as changes were made to their yard. Points of excitement were when we first brought in an excavator to dig up the yard and when large quantities of materials were delivered, like when a dump truck of large rocks thundered onto the paved area just outside the yard. Every day I made an effort to speak to the students and point out what we were building. Under controlled circumstances, the students were regularly brought into the construction zone to check things out.

Coordinating with the city to do the underground work for the rain garden was a good learning experience for everyone involved. The construction crew had never installed a rain garden before, the plumbing inspector had never inspected one and I had never installed one although I had drawn many for previous projects and had done an extensive exploration for the design of this rain garden.

Figure 4.28: Excavating the trench for the underground pipes

Figure 4.29: The underground pipes leading into the play area

Figure 4.30: Laying out the play-swale.

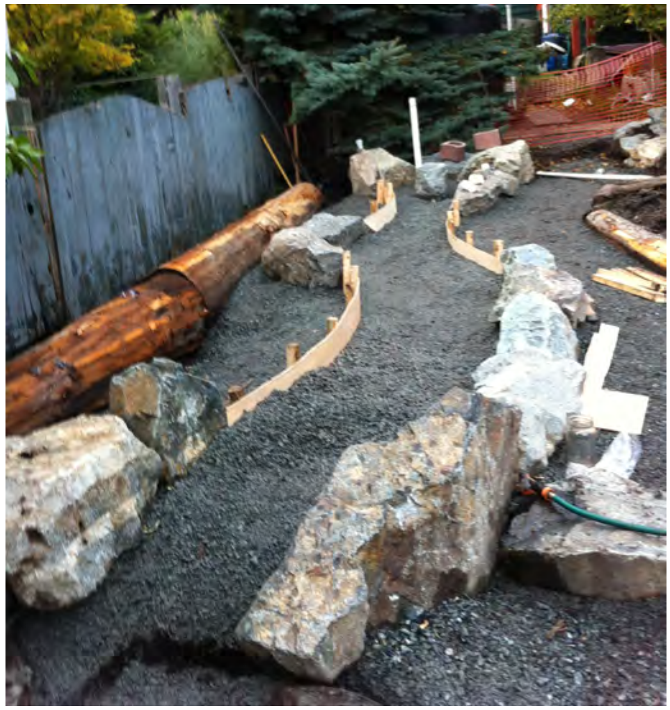


Figure 4.31: The base work for the concrete play-swale

Figure 4.32: Concrete with embedded stones and the bioswale behind


Figure 4.33: The City of Victoria installing the drainage for the rain garden


Figure 4.34: The under drain and overflow drain completed

Workshop 4: November 13th

Participants: About eight younger students

Goals:

- Re-engage the students in the project after being shut out for construction.
- Build stepping stones for the rain garden
- Allow the students into the construction zone to test the completed play-swale for the first time

Key observations/lessons:

- After watching the construction for several weeks the students were very excited to have the opportunity to participate in building something. The steppingstones activity allowed the students to make their own unique contribution to the garden.

Products/Outcome:

- Beautiful stepping stones and very proud children

Figure 4.35: Making the stepping stones (Univeristy of Victoria, 2014)

Figure 4.36: Water running down the play-swale for the first time (Univeristy of Victoria, 2014)

Figure 4.37: The completed stepping stones placed in the rain garden before it was planted

Community build days

Once the majority of the construction was complete, I organized several days where the students and the school community came to help with spreading soil and woodchips, packing down the soil, planting the gardens, and some other small jobs. Involving the school and school community in the finishing jobs was an excellent way to engage them in construction without compromising the quality of structural features. While each student in the school planted at least three plants, many of the younger students were very enthusiastic about planting and planted upwards of ten or more.

Figure 4.38: A parent and students helping spread woodchips

Figure 4.39: Students helping spread woodchips and "having a dance party" to pack in soil

Figure 4.40: The younger students were particularly interested in helping with planting. The child in the red, Gabriel, planted about 15 plants.

4.5 The final product

Note: See diagram (figure 4.41)

Oak and Orca's Rainwater System begins with rainwater being collected from the school's roof into a 960 gallon cistern. The cistern has two outlets: The upper outlet is the cistern's overflow, when the cistern is full water escapes through this outlet, flows down a pipe and emerges from the bubbler rock at the top of the play-swale. The lower outlet allows for the controlled release of water from the cistern. This water can be used in three different ways: Through the tap at the cistern itself, through the tap at the top of the play-swale and through the bubbler rock.

The pipes that connect the cistern with the play-swale run underground.

The bubbler rock can produce a geyser when water pressure builds up. This can be happen either when the exit hole is plugged for a few seconds or when it is raining hard and pressure builds up in the system. The water then flows down the play-swale, which is designed for creative play and experimentation (see discussion chapter for more detail). At the bottom of the play-swale is a small weir that includes two pipes. This is an area where water can be pooled by plugging the pipes. When not plugged, buckets can be placed at the end of the pipes to collect water.

The water then flows into a bioswale and through to the rain garden.

The majority of the site, including the paved area to the east, drains to the rain garden. An existing catch basin receives some water, which is also piped into the rain garden. The rain garden contains an underdrain and an overflow drain, which are tied in to the city's stormwater system. The rain garden contains the same specialized plants and growing medium as the bioswale with the addition of other water loving native plants along the edges. The bioswale and the rain garden together are designed to contain a two-year rain event.

I had developed a list of native plants that would add biodiversity to the garden and have ethnobotanical value. Many of these, however, were not available in nurseries and I had no time to invest in wild harvesting. Plants such as: showy milkweed (Asclepias speciosa), harvest bordiaea (Bordiaea coronaria) and Dewey sedge (Carex deweyana) had to be stricken from the list. The majority of the plants in the gardens, however, are small to medium sized native plants and all have ethobotanical uses. A few of the plants that I had originally wanted were not available at the nursery and we had to settle for substitutions that were not native to our region but to regions further south from Washington to California (see Appendix O for plant list).

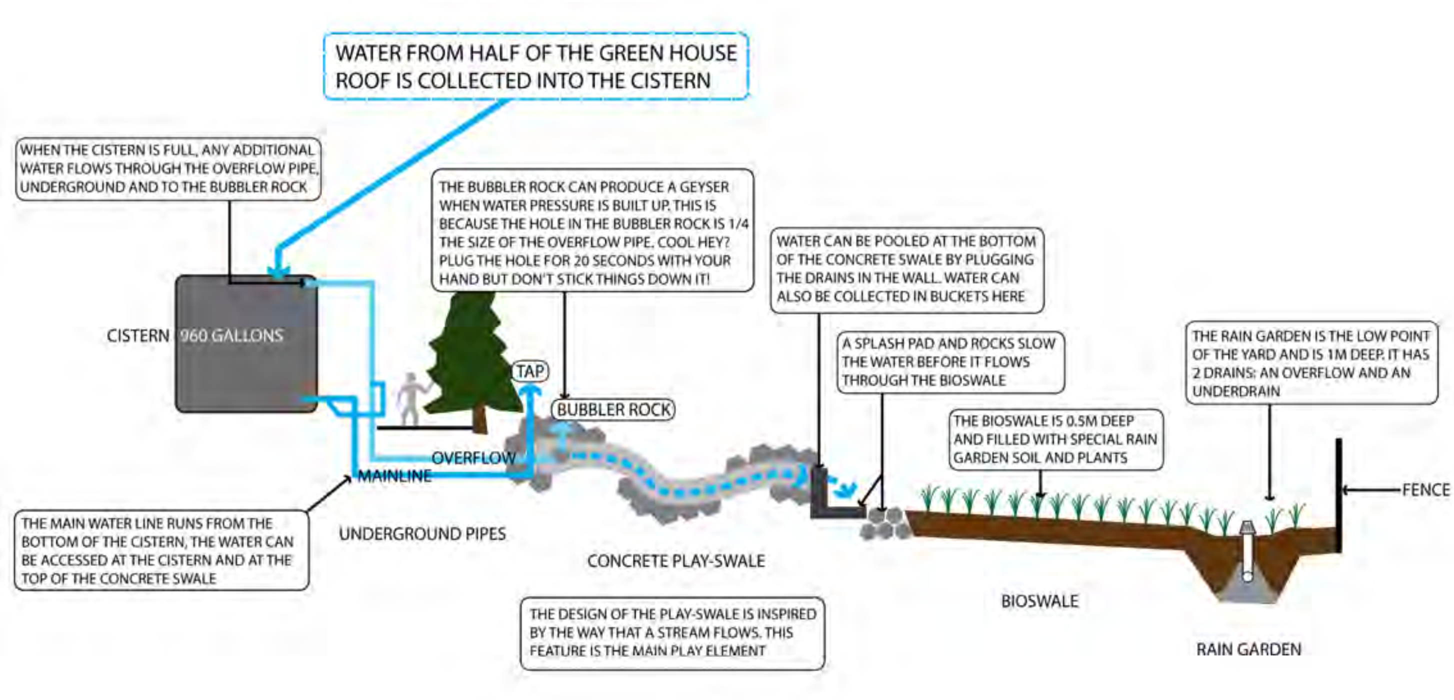


Figure 4.41: Diagram of the rainwater system (see Appendix P for more detail)

Figure 4.42: The cistern with protective wooden enclosure around the pipes, repaved pathway with improved grading and underground pipes.

Figure 4.43: Children playing with the geyser

Figure 4.44: Looking south down the play-swale

Figure 4.45: Rainwater running down the play-swale with children playing shortly after it was installed

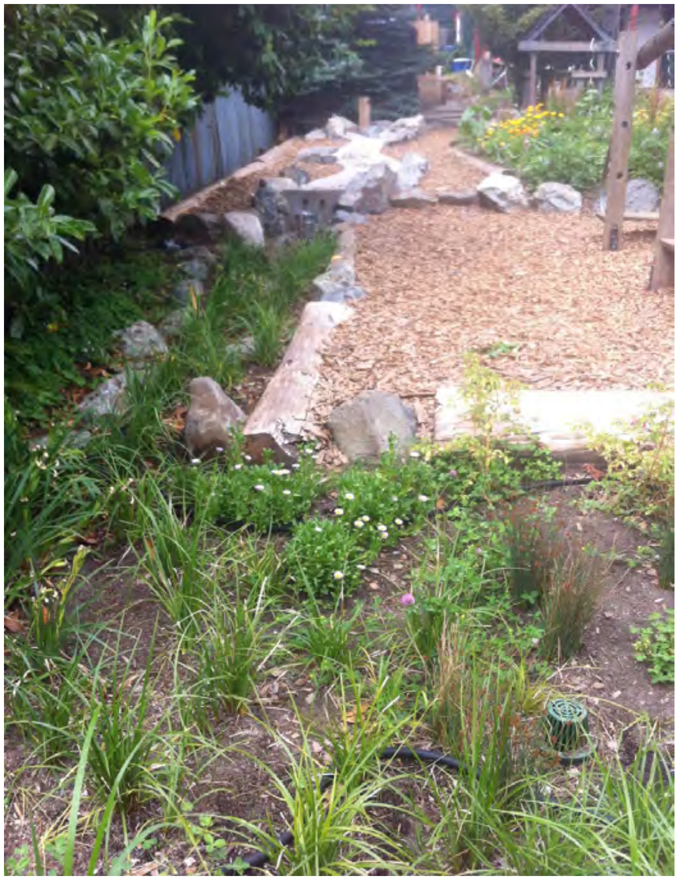


Figure 4.46: Looking north through the rain garden, along the bioswale and concrete swale

Figure 4.47: The rain garden, July 2015

Extra projects within the schoolyard

Building the rainwater system also meant rebuilding the majority of the play area as the adjacent features were in poor shape and since we wanted to re-grade much of the site, it was important to create a cohesive whole within the play area. In addition to this, several changes were made to the school ground. This is where the master plan proved to be a good part of the process; we had done some visioning and once the construction resources and spare materials were on-site, we were able to undertake some other changes to improve the yard (see figures 48-52).

Figure 4.48: Rock seats for the high school students

Figure 4.49: Pavers under deck

Figure 4.50: A willow tunnel was built in the White House schoolyard. This was a part of the project from the beginning but external to the rainwater system.(see Appendix Q)

Figure 4.51: A number of extra boulders were used in this area and woodchips were placed throughout the play area.

Figure 4.52: The entire play area and gardens were rebuilt and the monkey bars were reinstalled.

4.6 Opening day

Opening day was held on December 7th. A large group including many of the project partners turned out to celebrate the opening of the project. To my surprise, 3 news articles were written about the project (See Appendix R for invitations and Appendix S for news articles). The publicity around the opening day was important for spreading awareness in the larger community. Since then, two different parties have contacted me about the project.

Figure 4.53: The CRD presenting the school with the “Watershed Warden” badge

Figure 4.54: Kara giving Eric, the contractor, a thank you card after her speech

Maintenance and use

The rain garden will need to be watered once a week during drought periods for the first 2 years, after that, aside from in times of extreme drought, watering will be minimal. The cistern will need to be flushed out yearly due to the potential of bacteria building up over the summer. There are a few options for how to handle this all of which are outlined for the school in a maintenance calendar. Invasive plants have already started to creep in around the edges of the garden; the school will likely clear these out periodically. Ideally the school would add new mulch to the rain garden on an annual basis. Involving the students in maintenance is important and was already worked into the school's weekly lessons as the school has been tending vegetable gardens for quite some time.

Conclusion

The project at Oak and Orca expanded my understanding of the dynamic qualities of school grounds and how we might apply the concepts that I had been working with in the research. For me, implementing the ideas I was exploring was the most important part of the research. Implementation is really the crux of the issue; well-intentioned people and organizations do research, create guidelines and make suggestions as to how to improve the quality of school grounds. Generating ideas and doing research is usually removed from a context that gives real feedback. Implementation is the real challenge. Not all ideas work out as you had hoped but these missteps hold valuable lessons. You must be flexible and develop a deeper understanding of the ideas that you are trying to implement and how they could work within a particular context. I am grateful to Kara Woodcock and Oak and Orca Bioregional School for embracing this project and allowing me to help shape their wonderful little school. The project will now take on a life of its own with many valuable lessons still to come.

Figure 4.55: The project partners (minus the Real Estate Foundation and Mitacs), Eric and I at the opening.

Chapter 5: Discussion

This research poses the questions of how, through collaboration and thoughtful design, rainwater systems on school grounds can be developed as resources for learning. And, what can these systems contribute to the development of sustainable urban rainwater management. Within the case studies and pilot project I was seeking to understand the key components that go into creating successful change: school grounds being both a key place, and an immensely challenging place, to implement change. The effect that these projects have is not just the legacy that is left behind at the school but the change that is created within the people who participated in the project. Understanding how key components of the project contribute to the greater whole can help us understand how these projects were successful, where there were challenges or shortcomings, how we might use this information to move forward, and why rainwater systems on school grounds are worth our continued investment.

The 3 case studies and 1 pilot project (from here on referred to as the 4 case studies) offer an analytical perspective of 4 different scenarios. Within the case study research I did not observe children directly or interview children about their experience of the projects. This provides a limitation on truly understanding how they relate to the rainwater projects. However, the teachers that participated in the process represented the children's perspective. As well the pilot project was used to deepen my understanding of how children learn and relate to their outdoor space. The pilot project offers many important lessons and discussion points. However, at this point the installation is too new to develop an in-depth understanding of the contribution it makes to the school ground and the challenges that may come up in the future.

This chapter is broken down into three sections: collaborators, design process and working with authorities; rainwater system design; and landscapes that teach.

5.1 Collaborators, design process and working with authorities

This section looks at the people and processes that created the projects. One reason why these four projects stood out as worthy case studies is that they shared a strong sense of purpose that framed each project's goals. Two main groups and their objectives framed the approaches that were brought to the projects: the project proponent/champion and the school. While the primary goal of creating sustainable urban rainwater systems were common to each project, each project's leading proponent brought their own objectives and backgrounds. The educational philosophy and objectives specific to each school brought another layer of meaning to the projects (see case studies table P. 63 & 64 for project objectives). Other contributors were less central to the outcome of the projects but were critical to their success and to spreading awareness in the larger community.

The design process included an educational mission on several levels and involved a great deal of people from students to municipalities. Student participation, generating critical information, and building capacity in both the designer and the school were important elements in the design process. Each team approached this differently with varying levels of success. Perspectives gained from working with the school districts and municipalities offer some insight into larger goals, concerns and fears.

Project proponent/champion

In all 4 case studies the main person/group running the project volunteered their time and used the project for professional development and/or education. The goals that were brought to the table by each project proponent included what they themselves were interested in developing their knowledge on. In this way these projects can have a compounding effect (Roy et al., 2008) in that while they require a large investment from the groups and individuals implementing them, they generate knowledge, build skills and relationships, and are portfolio builders, all of which contributes positively to future work. This is arguably one of the big contributions to social change that these projects can make. The project at Bertschi can act as an example to illustrate this point. Immense professional development occurred in the members of the Restorative Design Collective. While all of the professionals on the team worked within the sustainable design field, none had had the opportunity to push the limits of design to create a living building. Undertaking this ambitious project built skills, knowledge and relationships among the group. The product of this effort acts as a case study that other professionals can look to for guidance and that the RDC can draw upon in future work.

Stan Richardson, Operations Manager at Bertschi, commented on this while giving me a tour of the school:

> It’s very much an integrated design process. You can’t do a building like this without everybody working closely together. Since everybody was donating their time, that was a pretty amazing process. Never seen a team of designers so engaged, doing it because they wanted to do it, not just making a paycheck. (S. Richardson, personal communication, January 23, 2014)

The importance of the project proponent/champion and what they draw from the project was an unexpected conclusion that came out of the research and, on a broader scale, can be related to research done by Daniel et al. (2012) and Roy et al. (2008). Daniel et al. (2012) lists educational benefits as a cultural service that ecosystems provide. When I first approached this research, I imagined the benefits of rainwater systems on schools grounds as being mostly educational for the students. However, the case studies demonstrate that the individuals implementing the projects often learn as much or more in the process than the students do. Roy et al. (2008) describe the creation of LID demonstration projects as having the potential to create a snowball effect that can help influence other needed change. The increased capacity and knowledge produced within this primary group is one such example of the potential for demonstration projects to acts as agents of change.

Other contributors

Through this research it has become apparent that many community members want to contribute to their community in meaningful ways. All 4 case studies were made possible by the support of funders, donors, in-kind contributors and volunteers. While this group was typically involved in distinct pieces of each project, their support is a statement of values. Investing in these projects engages people in the conversation about the issues that are being challenged and connects people with one another. The project at Vic West presents a telling example: with no primary funding source, the project had a total of 14 cash funders and 22 in-kind donations. This type of community engagement is key to spreading awareness, educating and community building.

The school

The educators', students' and (to a lesser extent) school community's participation in the design process proved to be key in creating a good design that the school could take ownership over, use as an educational resource, and maintain. Pivotal is the design process's ability to understand and draw out the school's potential and to build capacity within the designer(s) to create something with that potential. This means that the school must inform the design on both pragmatic and philosophical levels. This contribution builds capacity within the school to grow into the new features in the yard: to imagine them, and then to take ownership and explore them once they are built.

Three of the four case studies, Bertschi, Da Vinci and Oak and Orca, explored a lengthy, iterative design process that involved research and probing into the school, the site and the subjects of rainwater, rainwater system design and education. This approach to design process represents the most current thinking in sustainable design, the theory of which is outlined in a number of leading design philosophies such as ecological design (Van der Ryn & Cowan, 2007) and regenerative design (Mang & Reed, 2012). These authors argue for the inclusion of ecology in design, of a collaborative process and of developing a deep understanding of people and place.

The critical links that were created in these 3 projects that were lacking in the Vic West project are that the landscape responds to the internal workings of the school, draws on potential, and is rooted in an understanding of how the school functions on a philosophical, pragmatic and functional level. At Vic West, the Leadership Victoria team acted as a middleman between the school and Deborah LeFrank, the project landscape architect. Their design process missed the critical step of thoroughly understanding the school's needs, ideas and how the schoolyard functions and could function. The result is a design that has little character, was not properly designed for the programmatic use of the space and has not been properly maintained or engaged with for many years.

This reinforces Malone and Tranter's (2003) argument that the school's education philosophy has major implications to the development and use of the schoolyard. With an indoor classroom approach to education and little value placed on the learning that occurs during recess, Vic West's philosophy towards their outdoor space was underdeveloped. The approach taken by the design team did little to develop this any further, resulting in a missed opportunity to help the school evolve their educational philosophy to embrace their outdoor environment in a more meaningful way.

Student participation in the design process varied among the case studies. All 4 case studies fit into Francis and Lorenzo's (2002) study of the seven realms of children's participation. An interesting comparison can be drawn between the projects at Vic West and Da Vinci. Vic West falls into what Francis and Lorenzo refer to as the "learning realm" where environmental learning is the main focus of children's participation. The authors argue that while this approach can lead to learning and social change, it does not change or improve children's environments. This aligns with the outcome of the project; while the children benefited from the educational activities that took place alongside the project, their needs were not well integrated into the design.

The project at Da Vinci falls into the "proactive realm" where children are empowered to work with adults to envision their environment (Francis & Lorenzo, 2002). Because of the activated participation that took place, the water garden at Da Vinci is integrated into the life of the school. The project spawned a number of creative side projects as well, including art projects for the garden, a documentary film about the construction of the garden and on going additions to and experiments within the garden. Francis and Lorenzo acknowledge that this approach is not always possible, but Da Vinci demonstrates that this is indeed an ideal approach to build capacity within the school to use the project as an interactive tool for learning.

School districts

Working with school districts can be challenging, as they are often the enforcers of rules and regulations, for better or for worse. Da Vinci's school district 's concerns regarding liability around bees, allergic reactions to food plants and the aesthetics of the water garden represented common fears held by public institutions towards school ground innovations. Rickinson (2004) identifies fear for health and safety resulting in litigation as a barrier to outdoor learning. The author states that fears spike around incidents that are published in the media, these rare incidents creating a risk adverse culture that depletes public schools' ability to provide interesting outdoor experiences for students (Moore & Cooper, 2008; Rickinson, 2004). While most of these incidents occur on field trips off of school property, their affect is felt in the school district's hesitation to include ecologically diverse environments on school grounds.

Dyment (2005) argues that green school grounds can be designed to mitigate concerns and facilitate outdoor learning. Many unfounded fears can be trumped by the desire to provide an important learning experience for students. Over the past 12 years since the project at Da Vinci was built, ideas have shifted. While allergies to bee stings remain a concern, growing food on school grounds has become a desirable practice. At Da Vinci, and at other schools engaged in growing plants that attract bees, the potential for bee stings is managed through preventative planning and design (Dyment, 2005).

The school district's concern about the aesthetics of the water garden reflects a concern for how the school is perceived by the public and school community. The school district wishes to portray an aesthetic of care (Gobster, Nassauer, Daniel, & Fry, 2007), which to them means a clean, garden-like approach as opposed to the ecological approach that the school wishes to have. This is a prime example of Gobster et al.'s (2007) argument that aesthetics and ecology do not always align. However, the author's also state that aesthetic can evolve based on knowledge. Looking at the issue in a longer time frame, schoolyard projects like the water garden at Da Vinci that seek to improve the quality of urban ecosystems and push back against unreasonable, fear-based responses may help contribute to a shift in perception in the value and beauty of urban nature. Dan Evans commented on this as he gave me a tour of the water garden:

> …for a while there the district hired a group that would come in and clean it out. Boy they sure did. Jason and I got so upset with them. They didn't know, they wanted everything underneath the trees just "cleaned up", and I'm going NO! NO! I've been waiting all year for that to come up! (D. Evans, personal communication, January 24, 2014)

Local governments

In general the local governments associated with each case study were supportive of the projects. With Da Vinci and Oak and Orca, the municipalities were directly involved in creating the project. The City of Portland is seen internationally as a leader in implementing progressive rainwater management strategies. Da Vinci is one project among many forward thinking schoolyard water management projects that the City's Bureau of Environmental Services (BES) has supported and continues to support in maintenance. Many of Portland's school projects manage large amounts of water and offer a degree of experimentation in design.

The BES tackles several of the impediments to large-scale implementation of sustainable water management that Roy et al. (2008) identified in their research:

- insufficient engineering standards and guidelines;
- lack of funding; and,
- resistance to change.

While Portland already has design guidelines, the projects are used to increase knowledge and refine details. These projects demonstrate that schools and municipalities can work together to achieve shared goals as the schools want the rain gardens but have no resources, and the municipality wants to invest in LID but needs space to do it. Implementing these projects on schools grounds also increases understanding of the issues, contributing to less resistance to change.

5.2 Rainwater system design

This section elaborates on the primary goal that was shared between all of the case studies: to create sustainable rainwater systems on school grounds. My original assumption about schoolyard rainwater systems was that they were demonstration projects used for education rather than managing a significant amount of water. On the contrary, all four case studies manage a significant amount of water. Much supportive research exists on the design of rainwater systems and all of the case studies align with the approach of managing rainwater through the use of rainwater facilities. What makes these projects different from applications elsewhere, however, is that school grounds add a layer of complexity in terms of the physical and social landscape. This section takes a closer look at how the rainwater systems were designed.

Creating regenerative relationships between people and place

Whether the school ground is new or existing has a great impact on what is possible in designing rainwater systems; in both cases, however, the inhabitants of the space must adapt their approach of relating to the campus and the natural systems around them. Having natural systems present in the urban landscape requires a greater sense of responsibility and stewardship. Relationships between people and place is the central focus in regenerative design: regeneration occurring when design reaches beyond simply managing and conserving resources to tap into the potential for growth in the interaction between human and natural systems (Mang & Reed, 2012). Using design to harness, reveal and engage with natural process can create important relationships between the school and the rainwater that flows through and nourishes the system. This is not purely on functional and educational levels, but can include joy, connection to nature and play (Kellert, 2008; Matsuoka & Kaplan, 2008; Van der Ryn & Cowan, 2007).

The rainwater system at Bertschi demonstrates the potential for managing rainwater in new construction. Their approach creates a critical link between the inhabitants of the school and the natural systems that flow through the building. Rainwater is treated as a resource, collected from the entire site and used throughout the building and landscape for non-potable water purposes and education. Rainwater flowing through the system is expressed in a multi-sensory, celebratory and educational manner. The school constantly monitors the water system and adapts water usage to accommodate the amount of rain that falls in a given season and plan for future use. The rainwater system at Bertschi is a part of a larger system that links the rainwater that falls on the site with the building operations and the educational activities of the school.

Unlike Bertschi however, the majority of the time we are working with existing school buildings and grounds that have been designed for traditional water management. Cole (R. J. Cole, 2012) discusses part of the shift from traditional design practices to regenerative practices as the change from site-scale concerns to watershed-scale concerns. Accompanying this, however, is a change in mindset in both the design team and the client. Traditional water management approaches are typically a linear system, sweeping water out-of-sight and dumping it elsewhere. This approach is based on the single purpose of removing water from the site, which causes environmental destruction in the physical landscape and reinforces a worldview that sees us as separate from nature. It is therefore, the whole system that must shift, both the built system that was created by the former mindset and the mindset itself (R. J. Cole, 2012). Working to transition existing school grounds to include LID can present challenges. However, understanding the goals as changing both a built system and a mindset can help frame the problem to create balanced solutions.

The design team at Da Vinci created a balanced approach of managing water from a significant portion of the site and creating important relationships between the water garden and the people at the school. Capturing water off of the school building was cost prohibitive as the building drains internally. The design team, however, was able to create a regenerative system within the yard. The water garden is ecologically functional and regenerative in itself. Provided that the solar pump continues to work, the system could function and grow without the help of people. However, the educational activities in the garden continue to feed it, creating new things and adding complexity to the ecosystem. For example, each year, Pacific tree frogs (*Pseudacris regilla*) that were introduced to the pond by the science class return to the pond to breed. It is the richness of the ecosystem that continues to draw in the educational activities; the system's regeneration, therefore, occurs through both natural processes and educational activities.

Planning the rainwater system: Pragmatic design considerations

While many variables go into the design of schoolyard rainwater management systems, three important variables have a large influence on what can be built and where:

1. site characteristics;
2. hydrology; and,
3. how accessible the rainwater system is to students throughout the day.

Each school will present a different set of conditions to respond to and result in design solutions specific to each.

Water quality, collection, storage and students' interaction with water

Three out of the four case studies collect and store water in cisterns for use in a variety of ways. The cistern is typically placed close to the building from which it is collecting water. Visually, the cisterns are a good signal that there is a rainwater system at work. Da Vinci and Oak and Orca both have above ground cisterns that announce the intentions of the space and help communicate the function of the rainwater facilities. Vic West does not have a cistern and on first inspection, the average person would likely assume that the rain garden is just a green space.

Da Vinci and Bertschi both have roughly 5000 gallons of water storage capacity; both use this water for irrigation throughout the summer. Oak and Orca has 960 gallons of water storage capacity, which is not sufficient for irrigation during the summer, resulting in the school deciding to use it for education in the play-swale instead. All three schools with cisterns have measuring devices that tell them how much water is in the cisterns. This is an important tool in monitoring water use and using water collection as a learning tool. In these three cases, students interact directly with the water that is collected into the cisterns.

There are a number of methods used to maintain the highest water quality possible in the cistern. Bertschi's metal roofs are the ideal surface for collecting rainwater with as little contaminants as possible (Mendez et al., 2011). Leaf eaters can be attached to gutters to keep leaves and large particles out of the water system and first flush diverters can be used to divert the first several gallons of water, which holds the most contaminants, into the stormwater system. Annual maintenance practices ensure that bacteria and pathogens do not build up in the cistern.

However, existing site conditions vary greatly, and with limited budgets, the end use of the water is a factor in how high of quality the water needs to be. At Oak and Orca, the school's roof is asphalt shingles, and water collected off of this type of roof is not recommended for watering food gardens but is considered fine for outdoor use and watering non-food gardens (Mendez et al., 2011). A first flush diverter was not recommended at Oak and Orca as the catchment area is small and the rains in Victoria are often short, meaning that in spring, summer and fall, the cistern would collect very little water with a first flush diverter (Owner of Water Tiger: Water purification and rainwater harvesting, personal communication, November 12, 2014).

The students' interaction with the water is similar to that of splashing in a puddle and students are required to wash their hands every time they go inside, so the small amount of known contaminants in the water were not an issue for the school. Each school has a different set of circumstances that must be assessed in decision-making around water collection, storage and use.

Moving water around the site: the "in-between" spaces

The case studies have a variety of functional, expressive and educational features that move water around the site and connect one feature to another. Some of these are purely function (like the underground pipes at Oak and Orca), some are used for expressing the flow of water through the system (like the metal sculpture that water flows down from the roof and into the rain garden at Vic West), and some are natural features (like the bioswales at Da Vinci).

The functional elements, typically pipes, are not a visual part of the system but require thoughtfulness in design. With the potential that the pipes could become clogged, easily accessible clean-outs must be designed into the system. To that end the pipes should not include 90 degree angles but rather 2, 45 degree angles so that a drain snake can get through.

The features that express water flow are key features in drawing the students' attention to the rainwater system. These are often where the students have the opportunity to interact directly with the water. Arguably, these features are what bring the projects to life from an experiential perspective. At Oak and Orca, the play-swale has made rainy days fun for the students. When the cistern is overflowing into the play-swale, students are outside playing with the water geyser, making dams, collecting water in buckets and dumping it back down the play-swale.

Bioswales are trenches filled with living soil and rain garden plants, and are used for moving, absorbing and infiltrating water. In so doing they also increase the capacity of the rainwater system to manage water. Da Vinci and Oak and Orca both have bioswales, features that aid in communicating the natural function of the rainwater system and offer further engagement for students.

The rain garden/main rainwater facility and other gardens

Three case studies include rain gardens and one, Da Vinci, has an ephemeral wetland and infiltration gallery. These features, being the end point of the rainwater system, are located at the lowest point in the system. At Oak and Orca, the rain garden is located at the lowest point in the yard and manages water from ¾ of the property. However, collecting such a large percentage of the property to one point is not always possible. At Vic West, the rain garden is located directly below the water source, a portion of the school's roof, and is enclosed in concrete so water does not escape into the adjacent areas.

Whether the rain garden has controlled access or not has an influence on how much the rain garden needs to be protected from trampling. Bertschi and Da Vinci both have controlled access and in both cases, the natural features sit flush with the ground and are adjacent to pathways that students can use to access them. Vic West and Oak and Orca do not have controlled access, and in both cases, use built features to separate the rain garden from the play area.

Creating intentional access point into the garden is important for student interaction with the garden. Oak and Orca has rocks and stepping-stones intentionally placed in the gardens for access, which children enjoy walking on. To date, there has been no damage to the rain garden. Vic West, on the other hand, has no intentional access points. A trail of river rock that was intended to spread water through the rain garden became an unintentional pathway and the children were later told to stay out of the garden.

The planting design in the rain gardens and natural features in the case studies was approached in a variety of ways, some more successful than others. Having an intentional approach that the school has helped formulate, and a method of organizing and checking ideas for making changes to the garden, are important elements in creating a garden that will function well and provide a usable resource that will be maintained into the future.

The gardens at Vic West are entirely native plant gardens and were designed with little input from the school. The plants are not used specifically for learning, however, the students play in the courtyard, no doubt using the plants for play in a variety of ways. Many large deciduous shrubs were planted and since installation, have taken over, growing upwards of 2m in height, crowding out smaller plants and blocking sightlines so teachers cannot see students. Keeping the shrubs at a reasonable size required a great deal of maintenance and produced a large amount of garden trimmings to be disposed of.

The school does not have clear intentions for the gardens or a champion within the school that guides decision-making. This has meant that plants have been added to the gardens in an unchecked way. Pampas grass (*Cortaderia selloana*) was planted and removed due to the razor sharpness of the leaves; cow parsnip (*Heracleum lanatum*) was planted and removed based on its potential to cause skin damage; peas were planted one year and nothing was planted in their place in years to follow.

On the other end of the spectrum, the rain garden and ethnobotanical garden at Bertschi are tied in with the teaching practices at the school. Consequently any future changes would need to be well researched and have to go through the school board for approval. The current plant palette is tied in with the school's educational approach, providing a variety of teaching resources throughout the seasons. Blue wildrye (*Elymus glaucus* 'Buckley') is used for making rope and baskets and a variety of edible fruit plants such as woodland strawberry (*Fragaria vesca*) and lingonberry (*Vaccinium vitis-idaea*) are used for eating and making jam.

Maintenance

With many schools across North America minimizing features in the schoolyard to avoid maintenance costs, the question about how to maintain these projects is often the first obstacle that comes up. The case studies offered a number of valuable lessons in this area.

- First and foremost, the project needs to be valuable to the school, and potentially to others as well, in order to merit the continued investment. The more valued the space is, the more the school, teachers, students, parents, community groups, school districts and municipalities will support it.
- The garden should be designed with a balance between minimizing maintenance needs and achieving other goals.
- The school should have clear intentions about the space that can help guide decisions for making additions or changes.
- Having a chief steward at the school is helpful, although, this person should not be relied upon to do all the work but rather to coordinate work that needs to be done. Biannual work parties can be organized as community building and celebration days.
- Combining maintenance and education is highly recommended among advocates for green school grounds (Stonehouse, 2010); however, none of the schools were practicing this.

Safety and regulations

While there are differences between the projects at the public and private schools, the application of safety and regulations was not as large a design determinant as I had expected it would be. The main cause of the variation between the two, rather, was the educational philosophy at the school. My original assumption was that private schools would be able to install much more interesting and less risk adverse projects than public schools. Yet the case studies demonstrate that public schools are quite willing and able to implement interesting projects under the right circumstances as was demonstrated at Da Vinci and Vic West. The case studies demonstrate that the application of rules and regulations are not black and white but seem to be applied differently for each situation.

Another concern I expected to run into but did not find is the fear of students interacting with water. In three out of the four case studies students interact directly with rainwater, in two of those cases ponding water is present. As discussed earlier in this section, there are many ways to manage water quality concerns and each circumstance will be different in terms of the potential risk presented by the presence of water on the school ground. Ball et al. (2008) discuss risk management as assessing both the risks and benefits in play provisions. As developing a more connected relationship with rainwater is the main focus of rainwater systems, avoiding touching the water or creating any kind of pond based on the unlikely chance that children will become ill or drown is an unproductive limitation to place on the space.

Creating recognizable risk is key to healthy child development and to maintaining children's attention in play (Ball et al., 2008; White, 2004). The case studies at Oak and Orca and Da Vinci, and to a lesser extent Bertschi, demonstrate this kind of risk-benefit analysis in their decision-making. This kind of flexibility and critical thinking is central to the productive design of nature play spaces and the forward movement of educational landscapes.

5.3 Landscapes that teach

This section revisits the secondary goals that were specific to each school. Each project shone in different ways offering a diverse body of information to draw from. In this section I will look at campuses that teach, project-based learning, greening and diversification, and play.

Campuses that teach: Bertschi's Green Teaching Building

Bertschi School's Living Building Science Wing is an example of a Green Teaching Building (GTB), a campus designed to create a culture of sustainability, connecting users with the building functions, flow of resources and natural processes at play throughout the space (L. B. Cole, 2014; Orr, 2002). It is the school's approach to education and the campus design *together* that creates the GTB; this means engaging users in a variety of ways (including the tour that I was given for this research).

There are a number of limitations to this approach. Firstly, to accomplish it holistically, the building and landscape must be designed with this specific intention, meaning that it is best done in new construction. The school must be adaptable to adjust their teaching practices to embrace the new resources. Within this, the delivery of the curriculum must be flexible and ideally, teachers should be trained in a number of areas including experiential education, architectural systems and sustainability.

The Living Building allowed Bertschi School's already strong environmental ethic and connection to their school ground to blossom further. Cole (2014) argues that TGBs need to communicate in a variety of ways to reach the most learners. Some of the more interesting features that make the building come alive when it rains were developed directly from the children's ideas. This demonstrates the value of involving children in the design of a building that is seeking to draw on and illuminate their experience of the world. Science teacher Julie Blystad described some of the ideas that the children generated:

> …they came up with all kinds of wonderful ideas. The runnel that you saw, they wanted a stream running through the classroom. The runnel is surrounded by the 5 species of salmon, that was from them…
>
> Yes, oh my goodness, they run in from recess when [water runs through the runnel in the classroom], sometimes it splashes up against the glass and they just love that. Did you see the wine bottle [rain chain]? It just pours out of there, and that's just a thrill. You can hear the rain on the skylight, we got a

> lot of rain this morning and the water was running. (J. Blystad, personal communication, February 14, 2014)

This quote illustrates the multi-sensory experience that occurs in the science classroom when it rains. It is not the building features themselves that bring the project to life but the way these features harness the natural systems that flow through them, communicating that flow in a variety of ways. It is the living features that are often malleable and directly engaging, making them an important part of the system and a key element in connecting with young children (Louv, 2008a). Continued engagement with the natural features (like the gardens and the salmon at Bertschi) as they grow and change over time maintains learners' attention and embeds lessons (L. B. Cole, 2014).

As resource use is directly connected to systems in the building, this means that changes in activity in the building will be reflected throughout the system and become apparent in one way or another. Monitoring the energy, rainwater and grey water systems is an important component of the learning at Bertschi.

> One time the first year I was in here we dissected squid, I had three classes that were doing that. Everybody washed their hands and totally flooded the living wall [which is used to filter grey water]… I watch more carefully my water use because it was even kind of sudsy in there. We hadn't anticipated anything like that happening. (J. Blystad, personal communication, February 14, 2014)

This direct connection to resource use is one of the strengths of the TGB approach. Some trial and error is inevitable in this type of new design, a flexible and responsive learning environment is necessary to embrace the opportunities present in these lessons.

Project based learning: Da Vinci's living laboratory

Da Vinci's water garden demonstrates the power of project-based learning and that, under the right circumstances, public schools are capable of doing things that many assume they cannot. The rich engagement that went on in creating the water garden has left the school with a rare resource in their yard that has been used for hands-on and project-based learning for over 10 years. To create a resource that will continue to engage over the years a good amount of time, energy and resources must be put towards creating it. The limitations of this approach are that it requires a high level of commitment from the school, both the teacher and the students, and support from both professionals and funders. The teacher must be capable of undertaking such a project in the context of the rest of their work and the school and school district/board must be supportive.

Three of the five barriers to outdoor learning in public schools that Dyment (2005) outlines in her study are relevant to this discussion:

1. teacher's confidence and expertise;
2. requirements of school curricula; and
3. shortages of time, resources and support.

The project at Da Vinci contradicts the claim that teachers are not well equipped to facilitate outdoor learning. While the interests and abilities of Dan Evans are not the norm among public school teachers, he is by no means unique. This project demonstrates that there are some excellent teachers out there and that with support from the principal, the community and the municipality, motivated public school teachers can achieve great things.

The other two barriers, however, came up when Evans retired and Jason Hieggelke took over as science teacher. Curriculum changes meant that the science class was working more indoors and increased class sizes meant that it was difficult for Hieggelke to manage the students outdoors. The science class' visits to the water garden have been cut back from weekly to once ever two months. While the water garden remains an activated, well-used space, this demonstrates that the public school system does present some barriers to outdoor learning even with a tremendous resource in the schoolyard.

The water garden reaffirms Lieberman and Hoody's (1998) study stating that environment based education programs can enhance the experience of learning for most subjects. When undertaking the project, the water garden was focused on science. The project was approached as a problem to be solved. For one year Evans conducted the project in his science class, and for the subsequent two years students *volunteered* to undertake the project. This in itself demonstrates the potential for project-based learning to draw and maintain students' interest. In the years that followed the water garden became increasingly popular with the arts classes and is currently used mostly for photography, sculpture, art and reading. This supports the notion that using nature for education is not solely a resource for science class but an inspiring place of creativity and relaxation (Kaplan, 1995; Lieberman & Hoody, 1998).

The project at Da Vinci supports the idea that to remain an activated space, greening projects must change with the school (Danks, 2010) and that hands-on, outdoor learning reaches more students (Dyment, 2005). Over the years the school has used the water garden as a living laboratory, experimenting with plants and aquatic life and even running a living machine for six years. Allowing teachers and students to create their own experiences in an existing space builds ownership and allows the space to continue feeding the school from a hands-on learning perspective (Danks, 2010). This type of learning reaches more learners, many students finding more success in this context than in the classroom (Lieberman & Hoody, 1998). Jason Hieggelke commented on this point in his interview:

> Kids really do like getting dirty, they like doing work.... When you see this business, it really is a helpful thing; they love it after they've done it. These are usually the struggling students. These are not the high academic

> students, I think it's really beneficial for students who are struggling to have a moment of success that doesn't have to do with specific academics that gives them a sense of ownership. (J. Hieggelke, personal communication, February 4, 2014)

Greening and diversification: Vic West's green courtyard

The project at Vic West created a green space in a mostly paved schoolyard, adding nature to the school ground and diversifying the learning and play space. The project both demonstrates the value of greening public school grounds and points to key considerations in improving the approach to future greening projects. The limitations to projects like Vic West are that they require an ongoing commitment from the school to maintain them. School districts do not have extra resources to put into these projects and are therefore reluctant to offer support. Public school teachers often feel tied to their curriculum with little flexibility to include outdoor projects and high student to teacher ratios mean that managing students outdoors is a challenge. Fears around liability often place strict limitations on what can be done.

Malone and Tranter (2003) outline three types of schoolyard play: physical, social and cognitive. Vic West already had a physical play space so (without guidance in developing their ideas) the school decided that the space should be designed for quiet play: sitting, reading and having conversations. Malone and Tranter categorize this as social play. While the space *is* used for social play, the school has had to force this use through continuously enforcing rules. The students' natural inclination towards the space is to explore inside the large shrubs, create tunnels and play with the natural materials, which Malone and Tranter would call cognitive play: exploring, building and experimenting. Poor design and strict rules stop children from engaging in important developmental learning activities. Greening projects should focus on creating diversity that will function within the context of the school ground so students can engage in diverse play activities that are manageable for teachers.

Providing nature in the everyday lives of children is critical to healthy child development. Children are drawn to the natural environment and want to explore and experiment within it (Louv, 2008b). The garden at Vic West, while imperfect in design, attracts so many children at recess that they cannot run around, as there are too many of them in the space (this actually helps with management of the space).

Not surprisingly, nature is important for adults as well (Matsuoka & Kaplan, 2008). The garden has become a social space for parents as they wait to pick up their children, creating familiarity and cohesion in the school community. Jana Dick commented on this in her interview:

> It's beautiful, it's really beautiful. A lot of the parents when they're waiting for their kids they're in there. It's calming. They have conversations, there's relationship building. Where as before, it was just a big vacant piece of cement. (J. Dick, personal communication, January 30, 2014)

Nature play: Oak and Orca's nature playground

I save this, the last section of this chapter, for a subject that is close to my heart. To design nature play spaces for children, we must remain connected with the spirit of outdoor play ourselves. The life of a nature playground is much like that of an educational rainwater system: it is not the play features themselves that make the system come alive but the way they harness the life that flows through them. In this case, the way they create a sense of place and inspire and enlighten the children who laugh, play and explore in the playground. To accomplish this well, a balance must be stricken between creating playful design features, embedded learning opportunities, and the pragmatic and educational needs of the school. The school's participation in creating this space is of critical importance.

The limitations of this approach are that it requires flexibility in the school's approach to their yard as it often includes loose, natural materials that are available to students during recess and features that change over time. The school must have clear intentions that direct the decisions made to create the nature play area, how they will use it and manage the children's use of it. Inevitably, the nature play space will require more maintenance than a standard play structure.

Creating a nature playground at a school, and in this case a nature playground with a rainwater system integrated into it, starts with the process of learning how children and/or youth need to play within a certain context and how the school would like them to engage with the outdoor space through play (Ball et al., 2008). Ball et al. (2008) advocate for the development of a clear play policy as it relates to the outdoor play area. This is to help guide decision-making and to outline the intentions behind features that may be identified as creating risk. The school's bioregional teaching practices helped set clear intentions for the space, once again pointing to the importance of the school's educational philosophy in shaping the outdoor environment (Malone & Tranter, 2003). In the workshops with the teachers, the idea of 'emergent learning' was important in the creation of features in the yard. The school defines emergent learning as a diversity of features with embedded meaning and function that allow learning to occur through discovery, experimentation and play rather than through contrived means (K. Woodcock, personal communication, March 15, 2014). While this idea is integrated throughout the entire design, the play-swale is the main element that offers any kind of risk due to the students contact with water. The interactive play opportunities that this feature creates changes the rainwater system from a system to be mostly observed, to one that allows children to get excited, experiment and play.

The nature play space must be considered as a whole, with some features providing direct interaction, while others communicate the function of the system, and yet others create a living context to play within (Moore & Cooper, 2008). A diversity of play opportunities should be available, nature play spaces being particularly good for providing cognitive learning opportunities through the use of loose materials and features that can be manipulated (Malone & Tranter, 2003). The use of natural building materials, natural shapes and forms, loose materials, living things and natural process are central to the design of the nature play space at Oak and Orca.

Kellert (2002) discusses the importance of contact with nature in middle childhood years (around seven until twelve), describing the human affinity to nature as 'biophilia'. My experience with the younger students at the school, who were particularly interested in helping plant the garden and in discussing the plants, reinforces this idea. While biophilia is a quality inherent in every human being, Kellert states that is it greatly shaped by learning, culture and experience (Kellert, 2002). Reflecting back on this, in the future, I would like to include the students more in research and design for the rain garden and ethnobotanical garden to help create a more evolved understanding and relationship with the plants. This could lend itself to a richer overall participation for the students and more direct contributions to the design that the students could take ownership over.

Participation in the design process also helps to enhance the sense of place at the school through the project (Kellert, 2008; Moore & Cooper, 2008). Kellert (2008) describes place as integral to personal and community identity. He states that people who have closer attachments to place are more likely to contribute to, and to assume responsibility for, the care of that place. Place exists in physical form, in the relationships we have with that place, and in our minds (Kellert, 2008). Unlike pre-fabricated play structures, a nature playground that reflects this idea cannot be inserted into the landscape without the participation of the users in its creation. Seeking to create a sense of place through the project brings more depth to nature playgrounds, creating meaningful relationships between the users and the space.

Connecting children with nature in their everyday environments, creating a sense of place, and ensuring that there is a diversity of features that can speak to different children's needs and interests are the main goals of nature playgrounds. When the rainwater project was finished, the students at Oak and Orca made me a thank you card; these are some of their notes to me:

> My favorite thing about the rain garden is the [play] swale. – Austin
>
> Thank you for the rainwater system. I think it's very cool. I like watching the water flow down it. – Jamie
>
> I like the plants in the rain garden. It was fun helping you to plant the plants. Thank you for planting your plants in the rain garden. I like the sword fern. It has a cool name. –Khagan
>
> I love how you made that little creek flow and how you got the monkey bars up and fix. – Ethan
>
> I like how it looks exactly like a rain garden. I like how the water moves around the rocks. I liked planting the rain garden. Thank you for making our yard beautiful! – Sonnet

5.4 Summary

This research is about enabling smoother and more informed application of research and design ideas to school grounds, and in so doing, developing an understanding of the larger scale contributions that schools can make to the development of sustainable urban rainwater management.

Schools have much to contribute to the development of more sustainable urban rainwater management. On a broad scale, community-based, educational schoolyard rainwater systems can contribute to creating change in society through education, knowledge generation, community building and increased awareness. Schools are unique in the urban environment in their ability to bring community members together to learn and invest in shared goals. The case studies demonstrated that a broad spectrum of the community participated in these projects, contributing in a variety of ways and pointing to the potential for schools to act as agents of change in the urban environment.

The school's participation in the design process was central to creating a sense of place at the school and the successful use of the project as a tool for learning, both throughout the project implementation and in its use. To create successful design solutions, the projects must draw out and build upon existing potential from within the school, using the school's educational philosophy as a central figure. The students and educators direct participation in the creation of the rainwater system is how this can be drawn out, creating a deeper understanding of, and connection to, the project. This is of critical importance in designing projects that create educational and/or regenerative relationships between the school and the rainwater system.

Schoolyard rainwater systems hold the potential to manage rainwater onsite in a number of creative ways that offer opportunities for learning, play and connection to nature. The design of the rainwater system will vary from school to school but should include high level thinking that seeks to create connections to the larger watershed, ecological process and the school's educational philosophy. The function of the system should be communicated in a variety of ways, revealing natural process and creating a diversity of features that are engaging for students. This is key to creating lasting learning experiences that can be accessed in a number of ways and built upon and/or changed over the years.

Chapter 6: Conclusion

This research poses two questions: How, through collaboration and thoughtful design practices, can rainwater management systems on school grounds can be developed as resources for learning? And, what can these rainwater systems contribute to the development of more sustainable urban rainwater management? The research was undertaken through a literature review and the analysis of three case studies of rainwater management systems on school grounds that are used for education. This information was used to inform a pilot project at a school in Victoria, BC. The results of the research point to the importance of schools as places where the community can come together to learn as a group and implement change in an environment where it will have an impact. Improving outdoor learning environments is not just about creating nice features; it is about engaging community members, students and educators in a process of learning and growth that seeks to create relationships between people and place.

6.1 Changing urban rainwater systems

For both practical and environmental reasons, urban rainwater systems are in need of change. Cities all over the world are exploring how to improve the way we manage rainwater. From a technical standpoint, the solutions are in a good place. Low-impact development can be used throughout the city to manage water on a site-by-site basis. This approach has proven to be effective in managing rainwater and extracting many pollutants. However, to be effective, this change must be implemented on a watershed scale. In an urban ecosystem, many other complex human systems must shift to accommodate this change. Landscape architecture's role in this change is multi-dimensional and difficult to measure and define. While we can measure water and pollutants in and out of a rainwater facility, we cannot measure the change in perception and understanding that must be present for low-impact development to be successfully implemented and maintained on a watershed scale.

To begin to create this change, we need to create a closer connection between urban inhabitants and the natural systems that flow through the city. Bringing water to the surface and managing it in a natural feature (like a rain garden) is the first step. This is essentially like inserting a biological component into our existing rainwater infrastructure. These systems respond to the urban context, they die if toxic pollutants are poured into them and require ongoing maintenance to keep them working properly. It is this closer relationship with the repercussions of our actions and ongoing management that connects us with natural systems and helps us learn how to manage our relationship with the world around us in a more sustainable way. The more natural systems are a necessary part of the urban landscape, the easier it is to create and maintain the relationships that support them. To facilitate this, people need to understand and value the work that these natural features are doing. However, in the urban environment, simply managing rainwater better is often not enough. On a site-by-site basis, rainwater management systems and rainwater facilities must be multifunctional and contribute to a variety of different human needs.

6.2 The potential for rainwater systems on school grounds

Applying progressive rainwater management strategies to schools requires an assessment of other, complimentary needs that schools have. Connecting children with nature and diversifying educational environments are key partners in creating this change.

Connecting children to nature in the urban environment has become an important issue in recent decades. There are many larger issues at play within this topic such as a culture of paranoia and helicopter parents, and planning and design that does not accommodate children's need for independent mobility and access to nature well. These issues require ongoing work and will not be resolved in the short term. However, schools are places where we can connect children with nature in their daily lives.

How children engage with the natural features is the next question. Part of the problem is that children's lives are increasingly controlled, supervised and preplanned. This research does not offer a solution to that, but at a very small scale, we can provide children with more flexibility in their relationship with the world through giving them more freedom to engage with their environment on their own terms and to have dynamic experiences with nature.

Included in this is having children involved in creating that space. Changing children's environments requires a reframing of our thinking from an overbearing-controlled approach to something looser. We need to let go of our expectation that educational environments need to look a certain way and remain static and predictable. Involving students in this process not only helps to create something different, it engages them in shaping their environment. With some guidance and education, children and youth can be empowered as stewards and critical thinkers. This teaches them about rainwater systems and how they are connected to the landscape and are capable of creating change within their environment.

There are many different ways that rainwater systems can be integrated into school grounds as resources for learning. To be effective, the strategy taken must draw on and enhance the school's educational philosophy and build on existing potential within the school. The design process should seek to draw out and create important relationships between the natural systems on the school ground and the daily workings of the school. Every school functions differently from philosophical and pragmatic standpoints. Creating solutions tailored to the needs of each school can help expand existing potential for outdoor learning, be it through environmental learning, hands-on education or play.

6.3 What rainwater management systems on school grounds can contribute to improving urban rainwater management

This research demonstrates that schools are key places to improve the quality of urban rainwater management for more reasons than we might think. As places that educate our children and future generations, we all have a stake in the quality of schools and the ideas that are planted there. This makes schools unique in the urban environment. Schools are places where exposing young minds to responsible and engaging rainwater management can produce an increased understanding of the issues and a closer connection to natural systems. They are also places where the community can come together to invest in shared goals.

Community involvement in creating schoolyard rainwater systems is central to their success. Schools are not the only beneficiary of this effort; the larger community grows in the process as well. Schools act as a centralizing figure that enables a greater collaboration to occur. A diversity of groups and individuals must come together to create these projects; because of this, knowledge that is generated is far reaching and benefits the development of sustainable urban rainwater systems in a number of ways. The projects contribute to increased awareness in the issues, knowledge generation in professionals and community members, and community building between like-minded people.

Schools are also capable of managing a significant amount of rainwater. With the goal of implementing LID on a watershed scale, a variety of solutions will be required to manage as much of the urban environment through LID as possible. Schools hold large properties and present many opportunities for managing rainwater from significant portions of the school site.

6.4 Directions for future research

This research focuses on how to create rainwater systems on school grounds that can be used for learning. Assessing the impact that these systems have on the educational environment, how schools are using them in connection with the curriculum and how students are responding would be beneficial in moving forward.

The research also highlights the potential for schools to contribute to the development of more sustainable urban rainwater management. The costs of implementation and maintenance and the need for an informed design approach remain a challenge for most schools. However, based on the educational and practical benefits, the potential for municipalities to partner with schools to implement rainwater management solutions should be assessed. As mentioned in the discussion chapter, the City of Portland has pursued this relationship with a number of schools, often with the help of community groups who aid in facilitating the project. This provides a number of case studies that could be considered for developing a model for collaboration in other cities.

6.5 Closing remarks

Many different areas of research were explored in this thesis. As a designer, I am inclined to take a broad approach to the subject matter, bringing a variety of ideas together to create design solutions. Creating an academic thesis out of this approach was challenging, however, as I explored different avenues for focusing my research, I continued to return to the need to include as full a picture as possible to highlight the complexities that go into creating innovative change in places that present such intense challenge and opportunity. School grounds are indeed special places that are formative for students and communities alike.

In implementing the pilot project, it was amazing to me how much appetite there was in the community for this work. Many organizations, including the school I worked with, were quick to support the project but were not in a position to implement the project themselves. Unfortunately school ground design is a very difficult, if not near impossible, place to make a living as a landscape architect due to the lack of funding and need for an involved design process. However, the positive energy that came out of all 4 of the case studies was due to the fact that people were not being paid, they were involved because they care. What this means about implementing these projects on a larger scale was not a focus of this research; however, perhaps it is about acknowledging that we must create change as a larger community and that schools are places where that magic can happen.

Figure 6.1: The wonderful spirit of play

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Appendix A: Case study consent forms

Participant Consent Form

FOR PARTICIPANT GROUP 1: School Board and/or Principal

University of Victoria Department of Environmental Studies PO Box 1700 STN CSC Victoria BC V8W 3R4	Participant Consent Form

Nurturing Landscapes: Bringing together education, ecology and design in the creation of schoolyard stormwater management systems

You are invited to participate in a research project that is being conducted by Catherine Orr, M.A. Candidate.

Catherine Orr is a graduate student in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact her by email at cmorr@uvic.ca or by phone at 778-679-8476. This research is being conducted under the supervision of Dr. Val Schaefer, Professor, in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact him by email at schaefer@uvic.ca or by phone at 250-472-4387.

Research Team and Funding

Main advisor: Dr. Val Schaefer, School of Environmental Studies, University of Victoria
Secondary advisor: Kevin Connery, Blue+Green Design Studio

While Catherine Orr is the main researcher, Dr. Schaefer and Mr. Connery will be supporting this research throughout the entire process.

Industry sponsor: Scott Murdoch, Murdoch de Greef Inc.

To ground the research into a professional context Catherine will be doing an internship with Murdoch de Greef Inc., a landscape architecture firm in Victoria, BC.

Funders: The Real Estate Foundation and Mitacs

This research is supported by a partnership between these 2 generous funders.

Purpose and Objectives

This research looks specifically at the design of stormwater management systems on school grounds. School grounds present a plethora of unique challenges and opportunities, especially as it relates to water and natural features in the schoolyard. While most schools shy away from what can seem like insurmountable challenges such as water quality issues, heavy use patterns and long-term maintenance, an increasing number of schools have met these challenges with creative design solutions, drawing out fruitful learning opportunities and creating healthier environments. My goals in this research are to explore this new approach to education and design and push forward our understanding of the collaboration between education, design and ecology in the design, implementation and use of stormwater management systems on school grounds.

Participants Selection

You are being asked to participate in this study because of the exemplary work that has been done with stormwater management at X School.

What is involved

If you agree to participate in this research, I will seek further consent from a teacher and another professional (likely the landscape architect) who is/was directly involved in the development, implementation and current use of the stormwater management system at X School. With them, I will conduct a 30-45 minute in-person interview relating to their experiences with the design process and the effectiveness of the project for the school. I will also request access to materials used in the design process such as communication materials, construction documents and educational resources directly relating to the use of the stormwater management system. I will assess the current condition of the stormwater management system for design quality, use patterns and ecological health and function. Photographs will be taken of the stormwater management system and complimentary design elements when children are not present. No children will be photographed or interviewed for this research.

Compensation

There will not be any financial compensation for your participation in this study, however, as this research looks to highlight exemplary work it will bring attention to the good work being done at X School.

Risks

There are no known or anticipated risks to you by participating in this research.

Benefits

Participants will have the opportunity to contribute to a growing body of knowledge that looks to connect children with the natural world, create healthier learning environments and improve the quality of urban water systems. A new approach to schoolyard design is emerging and research projects like this one are critical to share and highlight successes, understand shortcomings and push forward progressive ideas.

Voluntary Participation

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. You have an absolute right to: (1) withdraw at any time for any reason; (2) not to provide a reason or rationale for withdrawing. The Real Estate Foundation, Mitacs, Murdoch DeGreeff and Blue+Green Design Studio are not involved in this research study, although they have been consulted and have approved of the research being conducted. -If you wish to withdraw from the research project at any time you may contact the researcher (Catherine Orr) by phone, e-mail or in person.

Anonymity

If you so desire, your name will not be disclosed to anyone at any time. However, due to the nature of this research unless it is requested, your personal information may be used in this study.

Confidentiality

The confidentiality of your data will be protected. Electronic copies of interviews, any photographs and electronic copies of the project documentation will be stored on a password-protected project laptop while data is being collected. The laptop will be kept as secure as possible throughout the research. When the research is complete, the interviews, documentation and photos will be burned onto CDs and stored in a locked filing cabinet at the University of Victoria. The interviews and photos will then be removed from the project laptop. Field notes and consent forms will be kept in a locked case while data is being collected and then transported to a locked cabinet at the University of Victoria.

Dissemination of Results
It is anticipated that the results of this study will be shared with others in the following ways: published articles, reports, theses, presentations at scholarly meetings and conferences, and class workshops. Theses produced with this research will be available online through the University of Victoria's D-space. A summary of the research results will be shared with The Real Estate Foundation, Mitacs, Murdoch Degreef, Blue+Green Design Studio and Evergreen in report form. There is potential that additional materials will be developed for these organizations to allow them to introduce the research results within their professional communities.

Use of Data
Interviews will be audio recorded. A copy of the transcript will be returned to the interviewee for review before being used of as data by researchers if requested, the school board may also request to see the interview transcripts before use. Data from this study, including interview transcripts, may be used by the investigators for future scholarly research building on/expanding on the current project. It will not be used for any other purpose whatsoever. Results from future studies may be shared with others in the following ways: published articles, thesis, reports, presentations at scholarly meetings and conferences, and class workshops. Any future use of data obtained through interviews will be bound by the terms outlined in this form (dissemination, confidentiality, disposal, anonymity).

Photographs will be taken of the stormwater management project at the school only, children will not be photographed.

Disposal of Data
Electronic copies of the interviews, documentation and photos will be kept on a password protected laptop during the data collection process. Once interviews and photographs are complete they will be burned onto CDs and erased from the project laptop. Audio recordings and paper copies of field notes and consent forms will be kept in a locked case with the researcher. These will be stored in the researcher's office in the School of Environmental Studies at the University of Victoria. Following the researcher's term with the University of Victoria, these will be stored in a locked box with the researcher's personal belongings.

Data from this study may be stored until August 2023. After this date, data will be disposed of by shredding all hardcopies of transcripts; electronic copies of the same will be deleted. In addition, audio recordings, documentation and photos will be erased and/or destroyed.

Contacts
Individuals that may be contacted regarding this study include the researcher. Their name and contact info are provided at the top of this form.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please check:

I wish to be provided with a transcript of the recorded interview ☐
I do not wish to be provided with a transcript of my recorded interview ☐

Name of Participant *Signature* *Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Participant Consent Form
FOR PARTICIPANT GROUP 2: Interviewees

University of Victoria Department of Environmental Studies PO Box 1700 STN CSC Victoria BC V8W 3R4	Participant Consent Form - Interviewees

Nurturing Landscapes: Bringing together education, ecology and design in the creation of schoolyard stormwater management systems

You are invited to participate in a research project that is being conducted by Catherine Orr, M.A. Candidate.

Catherine Orr is a graduate student in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact her by email at cmorr@uvic.ca or by phone at 778-679-8476. This research is being conducted under the supervision of Dr. Val Schaefer, Professor, in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact him by email at schaefer@uvic.ca or by phone at 250-472-4387.

Research Team and Funding
Main advisor: Dr. Val Schaefer, School of Environmental Studies, University of Victoria
Secondary advisor: Kevin Connery, Blue+Green Design Studio

While Catherine Orr is the main researcher, Dr. Schaefer and Mr. Connery will be supporting this research throughout the entire process.

Industry sponsor: Scott Murdoch, Murdoch de Greef Inc.

To ground the research into a professional context Catherine will be doing an internship with Murdoch de Greef Inc., a landscape architecture firm in Victoria, BC.

Funders: The Real Estate Foundation and Mitacs

This research is supported by a partnership between these 2 generous funders.

Purpose and Objectives
This research looks specifically at the design of stormwater management systems on school grounds. School grounds present a plethora of unique challenges and opportunities, especially as it relates to water and natural features in the schoolyard. While most schools shy away from what can seem like insurmountable challenges such as water quality issues, heavy use patterns and long-term maintenance, an increasing number of schools have met these challenges with creative design solutions, drawing out fruitful learning opportunities and creating healthier environments. My goals in this research are to explore this new approach to education and design and push forward our understanding of the collaboration between education, design and ecology in the design, implementation and use of stormwater management systems on school grounds.

Participants Selection
You are being asked to participate in this study because of the exemplary work that has been

done with stormwater management at X School and your involvement as an educator in this project.

What is involved
If you agree to participate in this research, I will conduct a 30-45 minute in-person interview relating to your experiences with the collaborative process, design process, implementation, current use, educational value and effectiveness of the stormwater management project. If you so desire, you will have the opportunity to review a transcript of the interview in case you wish to change or remove any responses prior to our analysis of the interview. Where possible, I would also like to review materials that the school provided or produced for the design process such as educational materials for the students and sketches from design charettes in addition to educational materials actively used to engage and teach children with the stormwater management system.

Compensation
There will not be any financial compensation for your participation in this study, however, as this research looks to highlight exemplary work it will bring attention to the good work being done at X School and encourage other educators to use school grounds productively.

Risks
There are no known or anticipated risks to you by participating in this research.

Benefits
Participants will have the opportunity to contribute to a growing body of knowledge that looks to connect children with the natural world, create healthier learning environments and improve the quality of urban water systems. A new approach to schoolyard design is emerging and research projects like this one are critical to share and highlight successes, understand shortcomings and push forward progressive ideas.

Voluntary Participation
Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. You have an absolute right to: (1) withdraw at any time for any reason; (2) not to provide a reason or rationale for withdrawing. The Real Estate Foundation, Mitacs, Murdoch DeGreef and Blue+Green Design Studio are not involved in this research study, although they have been consulted and have approved of the research being conducted. If you wish to withdraw from the research project at any time you may contact the researcher (Catherine Orr) by phone, e-mail or in person.

Confidentiality
The confidentiality of your data will be protected. Electronic copies of interviews, any photographs and electronic copies of the project documentation will be stored on a password-protected project laptop while data is being collected. The laptop will be kept as secure as possible throughout the research. When the research is complete, the interviews, documentation and photos will be burned onto CDs and stored in a locked filing cabinet at the University of Victoria. The interviews and photos will then be removed from the project laptop. Field notes and consent forms will be kept in a locked case while data is being collected and then transported to a locked cabinet at the University of Victoria.

Dissemination of Results
It is anticipated that the results of this study will be shared with others in the following ways: published articles, reports, theses, presentations at scholarly meetings and conferences, and class workshops. Theses produced with this research will be available online through the University of Victoria's D-space. A summary of the research results will be shared with The Real Estate Foundation, Mitacs, Murdoch DeGreef, Blue+Green Design Studio and Evergreen in report form. There is potential that additional materials will be developed for these organizations to allow them to introduce the research results within their professional communities.

Use of Data
Interviews will be audio recorded. A copy of the transcript will be returned to the interviewee for review before being used of as data by researchers if requested. Data from this study, including interview transcripts, may be used by the investigators for future scholarly research building on/expanding on the current project. It will not be used for any other purpose whatsoever. Results from future studies may be shared with others in the following ways: published articles, theses, reports, presentations at scholarly meetings and conferences, and class workshops. Any future use of data obtained through interviews will be bound by the terms outlined in this form (dissemination, confidentiality, disposal, anonymity).

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Individuals that may be contacted regarding this study include the researcher. Their name and contact info are provided at the top of this form.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please check:

I wish for my interview to remain anonymous for this research project ☐

I wish to be provided with a transcript of my recorded interview ☐
I do not wish to be provided with a transcript of my recorded interview ☐

Name of Participant *Signature* *Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix B: Interview questions

Bertschi: Interview with Julie Blystad

1. General
    - How did this project come about from the school's perspective?
2. Key participants and roles
    - What was your role in the project?
    - The Restorative Design Collective was formed for this project, can you talk a little bit about the dynamics of the design team and how the school fit in?
    - How were the students involved in the project?
3. Design process
    - What policies at Bertschi made this project desirable?
    - What were the main educational goals of the project? Who defined these goals?
    - Did the school have any specific goals relating to rainwater?
    - Did the school have any practical concerns about the project?
4. Conceptual design
    - Did you feel like the educational goals of the project were adequately addressed in the design?
5. Implementation
    - Stan told me that the students helped with planting, were you there for that? How did the students respond to that? Did they help with anything else in the installation?
6. Use
    - Can you tell me about the salmon at Bertschi?
    - How much do you use the living building for teaching with your students?
    - How is the outdoor space used?
    - Would you say the building and outdoor space accommodates you and your class well from a practical standpoint?
    - Have any unexpected opportunities and challenges come up?
    - Has this new building changed the way you teach?
    - Has this project pushed forward ideas about education in your mind?
7. Maintenance
    - Do the students help with maintenance?

Da Vinci: Interview with Dan Evans

1. General
    - What is your background and what did you teach at da vinci?
    - How did this project come about?
2. Key participants and roles
    - What was your role in the project?
    - Who else was involved and what were their roles?
    - The students played a central role, how did that unfold?
3. Design process
    - How did you get the school board on board with this project?
    - What steps were taken in the design process? How did you come up with the design that you did?
        - Is there anything that you would have done different?
    - What were the main educational and ecological goals of the project and who defined them?
    - Did the goals change over the course of the project?
    - What concerns, constraints and barriers were presented? Who defined these?
    - What were the underlying challenges of the site?
4. Conceptual design
    - How did the educational and ecological goals translate into design?
    - How were the concerns, constraints and barriers addressed in the design?
    - What influence did the students have on the final design?
5. Implementation
    - I read who your funders were in the project summary, who acquired the funding from them?
    - It's impressive how much the students helped with construction, was this an important part of the educational experience for them? Was this difficult to coordinate? Do you think it was effective?
6. Use
    - How well were the educational and ecological objectives met?
    - What unexpected opportunities and challenges have come up?
    - How frequently did you use the water garden with your class? Can you describe to me how a typical lesson involving the water garden unfolded?
    - Are there any features, seasons or ecological processes in the water garden that become important from an educational perspective?
        - Can you talk a bit about that? Why do the students gravitate towards…
    - In terms of the built and natural systems of the water garden, would you say that the water garden works well and is healthy?
        - Are there any areas where you've had trouble in terms of the functionality of the system?

        - Any areas where you've had no trouble at all?

7. Maintenance
    - Did you have your students helping with the maintenance of the water garden?
    - How much time and money goes into maintenance?
    - What problems have arisen?
8. Overall
    - Lessons learned from an educational perspective?
    - Lessons learned from a site perspective?

Da Vinci: Interview with Jason Hieggelke

Education:

- What is your background and what do you teach at da vinci?
- When you started at da Vinci was the water garden already in place?
- Your name is list online as the teacher in charge of the water garden, what does this role entail and how did you come to have this responsibility?
- What kind of inputs of time and materials does the water garden need to stay healthy and functional and who does this?
    - How much of your time goes into managing the water garden?

Educational approach:

- How frequently do you use the water garden with your class? Can you describe to me how a typical lesson involving the water garden unfolds?
- How would you describe this educational approach and why do you think it's important?
    - Do you find that your students respond differently to this type of learning?
- Are there any features of the water garden that have become important from an educational perspective?
    - Can you talk a bit about that? Why do the students gravitate towards…
    - Are there specific natural features or ecological processes in the water garden that stand out as important learning tools?
- How functional is the water garden for you in terms of hosting and managing your students while they are outside?
    - Do you ever run into problems?
- Are there any elements in the water garden that are important from a practical standpoint, for example, places for students to stand while you instruct?

Physical aspects of education:

- The water garden looks like it has evolved over the years and had some new features added to it, how do these new projects come about?
    - Is the school typically on board with these types of projects? Have you had any trouble convincing the school board to allow you to alter the learning environment?
- In terms of the built and natural systems of the water garden, would you say

that the water garden works well and is healthy?
    - Are there any areas where you’ve had trouble in terms of the function-ality of the system?
    - Any areas where you’ve had no trouble at all?
- Have you had any surprises in terms of life in the water garden?
- What about the water garden excites the students the most?

Design:
- What kind of access do the students have to the water garden? Can they go in whenever they want?
- What’s your favorite part of the water garden?
- Most other schools would claim that this type of feature would be impossible to create and maintain in a schoolyard, what makes da Vinci different?
-

Extra questions:

Are other teachers at the school using it?
What types of activities in the water garden do the students most respond to?
- Are there certain types of lessons that are more conducive to teaching in the water garden than others?
- Does the school support

VIc West Elementary: Jana Dick and Brenda Cook Interview Questions

i. General
   - I know that the project was spear headed by leadership Victoria, did they approach you to do it? How did it come about?
   - Did they manage and guide the whole process? If not, who was responsible for this?

ii. Key participants and roles
   - What roles did you each have in the project?

iii. Design process/Conceptual design
   - What were the main educational goals of the project and who defined them?
   - Did you have any ecological goals aside from managing stormwater?
   - Any other goals?
     - How did these goals translate into design?
   - Seems as though there was quite a bit of engagement that went on with the students in advance of the project, was any of it particularly effective or memorable?
     - I read that the students all did a survey asking them what they'd like to see in the rain garden, how did their ideas materialize in the design?
   - What concerns, constraints and barriers did the school present?
     - How were these addressed in the design?

iv. Implementation
   - Looks like lots of groups pulled together to make this happen, did Leadership Victoria seek out all this community support?
   - In your mind was this an important part of the project?
   - I see that the students helped with planting, was this a good learning experience for them?
   - Was there any other community or student participation in the construction process or was it all done by professionals?
   - Did any issues come up in construction?

v. Use
   - How much is the rain garden used for educational purposes?
   - Can you describe to me how a typical lesson would go down?
   - What issues and opportunities have come up since it's been built?
   - Is there anything that stands out as being a particularly effective learning tool in terms of features, seasons, ecological processes…
   - How does it accommodate you from a functional perspective?
   - What kind of access do the students have to the garden?

vi. Maintenance
   - What dynamics (ie input of time, energy, materials etc) are required to support the system? Who is responsible for this?
     - Is this work currently a part of the educational program?
   - What problems have arisen?

vii. General
   - What constraints do you face in terms of using the garden as an educational tool?

Vic West Elementary: Deborah LeFrank Interview Questions

i. Key participants and roles
   - Leadership Victoria spearheaded the project, can you describe to me role you had in the process? Did you manage the project?

ii. Design process/Conceptual design
   - What were the main educational and ecological goals of the project?
      - Can you talk a bit about how you envisioned the rain garden being used from an educational perspective?
      - Can you just talk a bit about what's important in designing an educational landscape?
   - What other goals or desires were there?
      - How did these goals translate into design?
   - Seems as though there was quite a bit of engagement that went on with the students in advance of the project, were you a part of this?
      - what did you receive from the activities that the students did?
      - How did this material translate into design?
   - What concerns, constraints and barriers did the school environment present and how were these addressed in the design?

iii. Implementation
   - I see that the students helped with planting, how did that go?
   - Were there any issues that came up in the construction process?

iv. Use
   - Have you had any opportunities to revisit the project?
   - In retrospect, what do you think were the really good moves and what do you think could have been done differently?

v. Maintenance
   - How did maintenance play into the design?
   - Did you produce a maintenance plan or did someone else do that?
   - I imagine that the garden was designed to be low maintenance, the school still struggles to keep up with the maintenance. Can you comment on how this might be dealt with? From what I understand native plan gardens are supposed to be reasonably low maintenance once they're established, is it even possible?

Appendix C: Case study analysis questions

- Any programs the project was associated with and what impact they had.
- How does the larger community engage with the project?
- How did the design process serve as an educational tool?
- How did the students inform the design?
- How did the teachers/rest of the school inform the design?
- What does the design communicate about the school/How did the values of the school shape the project?
- How did the school's educational approach shape the design?
- Who else's values shaped the project and how?
- What fears and regulations came up? How were they dealt with?
- How did the project respond to the schoolyard context?/What were the main factors that influenced decision making from a practical standpoint?
- What state is the rainwater system in today?
- How is it maintained?/Who are the stewards?
- How do the students interact with the rainwater system?/How is it used for educational purposes?/What is the main use of the system?
- How is natural process revealed?
- How has it changed over the years?
- How has the RWS contributed to the school ground in both positive and negative ways?
- How is it used by the larger community?
- What enables and disables the school from using the garden?

Appendix D: Pilot project consent forms

Letter of information for parents

University of Victoria Department of Environmental Studies PO Box 1700 STN CSC Victoria BC V8W 3R4	Letter of information

Nurturing Landscapes: Bringing together education, ecology and design in the creation of schoolyard stormwater management systems

University of Victoria
School of Environmental Studies

Project summary:
We will be conducting a design-build project at Oak and Orca in the schoolyard. This will be a participatory design project, meaning, the school community (including students, teachers, the principal and staff) will play a central role in developing the project and will help with the installation. The project is centered around the design of sustainable water systems in the schoolyard and the creation of effective, beautiful and playful outdoor learning environments.

Process:
Your child is invited to participate in 4 design workshops and the planting day for the project installation. Each workshop will be 2.5 hours in length with a 15 minute break mid-way through. The workshops will proceed as follows:

1. Learning about the water cycle and how if affects Oak and Orca's schoolyard
2. Site analysis and map making
3. Game playing to learn about the schoolyard and how we like to use it
4. Idea generation, drawing and model making

Participation in the workshops is optional. At the beginning of each workshop the activities will be described to the students and they will be given the opportunity to participate or they may choose to do other activities prepared by the teachers.

Consent:
In signing the consent form, you are giving consent for your child to participate in the design-build project, they will then be given the opportunity to give consent at each step of the process. If you do not want your child to participate in the project they will automatically do the activities prepared by the teachers and will not be included in the design-build project.

<u>Researcher: Catherine Orr</u>
Background:

- Bachelor of Environmental Design, Faculty of Architecture, University of Manitoba
- 6 years of experience working in landscape architecture in Vancouver, BC
- Currently in year 2 of a Master of Arts degree

<u>Supervisory committee:</u>
Supervisor: Dr. Val Schaefer – Professor, University of Victoria

- Specializes in ecological restoration, environmental education and urban ecology

Advisor: Kevin Connery – Landscape Architect and Park Planner – City of Richmond and Blue+Green Design Studio

- Specializes in ecological design

Industry Partner: Scott Murdoch – Biologist and Landscape Architect – Murdoch DeGreef

- Specializes in sustainable urban water management and natural systems design

Please see consent forms for further information.

Sincerely,

Catherine Orr
MA Candidate
University of Victoria
School of Environmental Studies
PH: 778-679-8476
e-mail: cmorr@uvic.ca

Participant Consent Form

FOR PARTICIPANT GROUP 4: Kara Woodcock, Principal of Oak and Orca School and Teachers

University of Victoria Department of Environmental Studies PO Box 1700 STN CSC Victoria BC V8W 3R4	Participant Consent Form

Nurturing Landscapes: Bringing together education, ecology and design in the creation of schoolyard stormwater management systems

You have been invited to participate in a design-build pilot project that is a part of a larger research project that is being conducted by Catherine Orr, M.A. Candidate.

Catherine Orr is a graduate student in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact her by email at cmorr@uvic.ca or by phone at 778-679-8476. This research is being conducted under the supervision of Dr. Val Schaefer, Professor, in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact him by email at schaefer@uvic.ca or by phone at 250-472-4387.

Research Team and Funding

Main advisor: Dr. Val Schaefer, School of Environmental Studies, University of Victoria
Secondary advisor: Kevin Connery, Blue+Green Design Studio

While Catherine Orr is the main researcher, Dr. Schaefer and Mr. Connery will be supporting this research throughout the entire process.

Industry sponsor: Scott Murdoch, Murdoch de Greef Inc.

To ground the research into a professional context Catherine will be doing an internship with Murdoch de Greef Inc., a landscape architecture firm in Victoria, BC.

Funders: The Real Estate Foundation and Mitacs

This research is supported by a partnership between these 2 generous funders.

Purpose and Objectives

My goals in this research are to push forward our understanding of the collaboration between education, design and ecology in the design, implementation and use of stormwater management systems on school grounds. The purpose is to create healthier, more effective and nurturing learning and play environments in the schoolyard. School grounds present a plethora of unique challenges and opportunities, especially as it relates to water and natural features on the schoolyard. This research began with the analysis of 3 exemplary case studies where sustainable stormwater management has been successfully integrated into a school environment. In this the second portion of the research, I will use the information gained through the case study analysis to guide a design-build pilot project at Oak and Orca.

Participants Selection

You are being asked to participate in this project as a educator and a member of the Oak and Orca School community.

What is involved

If you agree to participate in this design-build pilot project, we will engage in a participatory design process at Oak and Orca with the goal of creating a demonstration scale (meant for educational purposes) stormwater management system in the schoolyard. You will be asked to lend your expertise as an educator in the collaborative effort of creating a meaningful outdoor learning space for you and your students. This could involve small group discussions with other team members, participation in site analysis and design workshops, decision making in regards to the final design, participation in installation and stewardship. While you will play an integral role in the design process, you will not be asked to manage this project. Group discussions will be recorded and you may be quoted in the research. However, comments made are a part of an evolving, iterative process so do not let this impede from expressing your views. If you are to be quoted in the research you may review and edit any comments made to be more reflective of your intentions. The design process and project installation will take place over the course of 3 months. During this time the students and teachers will be asked to participate in 3-4 design and educational workshops that will be 2.5 hours in length. The portion of the project installation that the students and teachers will participate in will take place over a number of hours, students and teachers will aid in digging and spreading soil and planting. Teachers with additional skills that they would like to contribute are welcome.

Compensation

Funding is being raised to improve the schoolyard at Oak and Orca. This funding is being allocated to us specifically for the creation of a rain garden and related elements. If for whatever reason Oak and Orca can no longer be a part of this project the funding will be used to create a rain garden elsewhere or it will be returned to the funders.

Risks

There are no known or anticipated risks to you by participating in this research.

Benefits

The University of Victoria School of Environmental Studies has secured funding to improve the schoolyard at Oak and Orca. As an educator at the school, you are invited to play a central role in shaping the learning environment. Participants will have the opportunity to contribute to a growing body of knowledge that looks to connect children with the natural world, create healthier learning environments and improve the quality of urban water systems. A new approach to schoolyard design is emerging and research projects like this one are critical to share and highlight successes, understand shortcomings and push forward progressive ideas.

Voluntary Participation

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. You have an absolute right to: (1) withdraw at any time for any reason; (2) not to provide a reason or rationale for withdrawing. The Real Estate Foundation, Mitacs, Murdoch DeGreef and Blue+Green Design Studio are not involved in this research study, although they have been consulted and have approved of the research being conducted. ~~Your decision to participate will not in any way affect opportunities or services received from these organizations.~~ If you wish to withdraw from the research project at any time you may contact the researcher

(Catherine Orr) by phone, e-mail or in person.

Anonymity
If you so desire, your name will not be disclosed to anyone at any time. However, unless it is requested, your personal information may be used in this study.

Confidentiality
The confidentiality of your data will be protected. Electronic copies of group discussions, any photographs and electronic copies of the project documentation will be stored on a password-protected project laptop while data is being collected. The laptop will be kept as secure as possible throughout the research. When the research is complete, the group discussions, documentation and photos will be burned onto CDs and stored in a locked filing cabinet at the University of Victoria. The interviews and photos will then be removed from the project laptop. Field notes and consent forms will be kept in a locked case while data is being collected and then transported to a locked cabinet at the University of Victoria.

Dissemination of Results
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Use of Data
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Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please check:

I wish to remain anonymous for this research project ☐

Name of Participant *Signature* *Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Participant Consent Form

FOR PARTICIPANT GROUP 6: Students at Oak and Orca

University of Victoria Department of Environmental Studies PO Box 1700 STN CSC Victoria BC V8W 3R4	Participant Consent Form

Nurturing Landscapes: Bringing together education, ecology and design in the creation of schoolyard stormwater management systems

You have been invited to participate in a design-build pilot project that is a part of a larger research project that is being conducted by Catherine Orr, M.A. Candidate.

Catherine Orr is a graduate student in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact her by email at cmorr@uvic.ca or by phone at 778-679-8476. This research is being conducted under the supervision of Dr. Val Schaefer, Professor, in the School of Environmental Studies at the University of Victoria, British Columbia. You may contact him by email at schaefer@uvic.ca or by phone at 250-472-4387.

Research Team and Funding

Main advisor: Dr. Val Schaefer, School of Environmental Studies, University of Victoria

Secondary advisor: Kevin Connery, Blue+Green Design Studio

While Catherine Orr is the main researcher, Dr. Schaefer and Mr. Connery will be supporting this research throughout the entire process.

Industry sponsor: Scott Murdoch, Murdoch de Greef Inc.

To ground the research into a professional context, Catherine will be doing an internship with Murdoch de Greef Inc., a landscape architecture firm in Victoria, BC.

Funders: The Real Estate Foundation and Mitacs

This research is supported by a partnership between these 2 generous funders.

Purpose and Objectives

My goals in this research are to push forward our understanding of the collaboration between education, design and ecology in the design, implementation and use of stormwater management systems on school grounds. The purpose is to create healthier, more effective and nurturing learning and play environments in the schoolyard. School grounds present a plethora of unique challenges and opportunities, especially as it relates to water and natural features on the schoolyard. This research began with the analysis of 3 exemplary case studies where sustainable stormwater management has been successfully integrated into a school environment. In this the second portion of the research, I will use the information gained through the case study analysis to guide a design-build pilot project at Oak and Orca.

Participants Selection

Your child is being asked to participate in this project as a member of the Oak and Orca School community.

What is involved

If you agree for you child to participate in this design-build pilot project, we will engage in a participatory design process at Oak and Orca with the goal of creating a demonstration scale (meant for educational purposes) stormwater management system in the schoolyard. This may involve: group discussions, learning about the water cycle, watersheds and natural systems, site analysis, producing and sharing design ideas through drawing, discussion, games and/or model making, help with installation of the new features at the school, potential future stewardship responsibilities. While no children will be interviewed individually for this research, the researcher will speak with individual children throughout the process. Children may be quoted in the research and their design drawings may be used as examples. The design and installation process will be photographed, you may request for your child to be censored in these photos. The design process and project installation will take place over the course of 3 months. During this time the students will be asked to participate in 3-4 design and educational workshops that will be 2.5 hours in length. The portion of the project installation that the students will participate in will take place over a number of hours, students will aid in digging and spreading soil and planting.

Compensation
There will not be any financial compensation for your child's participation in this study, however, the opportunity to participate in a design-build project is a unique experience and one that most people enjoy.

Risks
There are no known or anticipated risks to you by participating in this research.

Benefits
The University of Victoria School of Environmental Studies has secured funding to improve the schoolyard at Oak and Orca. As a member of the school community your child is invited to play a role in shaping their schoolyard. Participants will have the opportunity to contribute to a growing body of knowledge that looks to connect children with the natural world, create healthier learning environments and improve the quality of urban water systems. A new approach to schoolyard design is emerging and research projects like this one are critical to share and highlight successes, understand shortcomings and push forward progressive ideas.

Voluntary Participation
Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. You have an absolute right to: (1) withdraw at any time for any reason; (2) not to provide a reason or rationale for withdrawing. The Real Estate Foundation, Mitacs, Murdoch DeGreef and Blue+Green Design Studio are not involved in this research study, although they have been consulted and have approved of the research being conducted. ~~Your decision to participate will not in any way affect opportunities or services received from these organizations.~~ If you wish to withdraw from the research project at any time you may contact the researcher (Catherine Orr) by phone, e-mail or in person.

Anonymity
If you so desire, your name will not be disclosed to anyone at any time. However, unless it is requested, your personal information may be used in this study.

Confidentiality

The confidentiality of your data will be protected. Electronic copies of group discussions, any photographs and electronic copies of the project documentation will be stored on a password-protected project laptop while data is being collected. The laptop will be kept as secure as possible throughout the research. When the research is complete, the group discussions, documentation and photos will be burned onto CDs and stored in a locked filing cabinet at the University of Victoria. The interviews and photos will then be removed from the project laptop. Field notes and consent forms will be kept in a locked case while data is being collected and then transported to a locked cabinet at the University of Victoria.

Dissemination of Results

It is anticipated that the results of this study will be shared with others in the following ways: published articles, reports, theses, presentations at scholarly meetings and conferences, and class workshops. Theses produced with this research will be available online through the University of Victoria's D-space. A summary of the research results will be shared with The Real Estate Foundation, Mitacs, Murdoch DeGreef, Blue+Green Design Studio and Evergreen in report form. There is potential that additional materials will be developed for these organizations to allow them to introduce the research results within their professional communities.

Use of Data

Data from this study may be used by the investigators for future scholarly research building on/expanding on the current project. It will not be used for any other purpose whatsoever. Results from future studies may be shared with others in the following ways: published articles, theses, reports, presentations at scholarly meetings and conferences, and class workshops. Any future use of data obtained through interviews will be bound by the terms outlined in this form (dissemination, confidentiality, disposal, anonymity).

Disposal of Data

Electronic copies of the group discussions, documentation and photos will be kept on a password protected laptop during the data collection process. Once interviews and photographs are complete they will be burned onto CDs and erased from the project laptop. Audio recordings and paper copies of field notes and consent forms will be kept in a locked case with the researcher. These will be stored in the researcher's office in the School of Environmental Studies at the University of Victoria. Following the researcher's term with the University of Victoria, these will be stored in a locked box with the researcher's personal belongings.

Data from this study may be stored until August 2023. After this date, data will be disposed of by shredding all hardcopies of transcripts; electronic copies of the same will be deleted. In addition, audio recordings, documentation and photos will be erased and/or destroyed.

Contacts

Individuals that may be contacted regarding this study include the researcher. Their name and contact info are provided at the top of this form.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Visually Recorded Images/Data
Participant or parent/guardian to provide initials, *only if you consent*:

- Photos may be taken of me [my child] for:_____Analysis _______ Dissemination*________
- Videos may be taken of me [my child] for:_____Analysis _______ Dissemination*________
- Quotes may be taken from me [my child] for:_ Analysis _______ Dissemination*________
- Drawings produced by me [my child] may be used for:__________________________________ ____Analysis _______ Dissemination*________

*Even if no names are used, you [or your child] may be recognizable if visual images are shown in the results.

Name of Child Participant

Name of Parent/Guardian *Signature* *Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher

Appendix E: Design meeting 1 - Mapping exercise material

This handout was given to the participants of design meeting 1 along with a site plan. Using pencil crayons, the participants created maps using this as a key.

Site use diagram - General

- ☐ Formal gathering places (teacher addressing and organizing students)
- ☐ Informal gathering places for teachers
- ☐ Informal gathering places for students
- ☐ Active play areas (please describe in few words on plan)
- ☐ Quiet areas (please describe in few words on plan)
- ☐ Creative play areas (please describe in few words on plan)
- → Circulation – draw arrows on the plan to indicate formal and informal circulation pathways
- ⊗ Temporary storage (day to day use)
- ☒ Permanent storage
- ☐ Which aspects of the grounds do you think are an asset?
- ☐ Can you identify problem areas and explain why they are a problem?
- ☐ Any concerns about supervision on the school grounds?
- ☐ What do you find aesthetically pleasing about the present site?
- ☐ What improvements would you like to see in the future?

Site use diagram - Educational

☐ Site features/areas currently used for teaching.

→ What do you teach here, what time of year and how often?

Which subjects/what kind of learning do you see being reinforced by potential new features on the school ground?

What ideas do you have to accommodate this development?

Do the students currently participate in the maintenance of the site? Explain.

Appendix F: Workshop 1 - Student mapping legend

In workshop 1, the students were asked to map their experience of the yard. This is the legend that they used.

Oak and Orca's Schoolyard

1. Best hiding place
2. Best place to run around
3. Best place to sit with your friends
4. Best place to sit by yourself
5. Best place to build things
6. Coolest thing about Oak and Orca's schoolyard
7. Is there something you don't like about the schoolyard?
8. Favorite tree or plant growing in the schoolyard.
9. Where have you seen animals?
10. Where have you seen bugs?

Appendix G: Pilot project design guidelines

Oak and Orca Bioregional School: Schoolyard design guildelines

Flexibility

- The schoolyard should be built in such as way that it can evolve and change as the school changes.
- All areas should be designed to host a range of uses. Contrived designs that suggest specific, one dimensional uses should be avoided.
- There should be loose parts that students can manipulate.

Bioregionalism

- The schoolyard should reflect the bioregional context through material selection (including plants), expression of seasonal change, revealing of natural process, creation of habitat, connections to ethnoecology and other culturally significant relationships with the landscape.

Emergent learning

- A diversity of features with embedded meaning and function should be available to allow learning to occur through discovery, experimentation and play rather than by contrived means.

Practical elements:

- To improve drainage and erosion.
- To create a place that can stand up to heavy use and still remain natural.
- To improve the functionality of the schoolyard.

Multifunctionality

- Any new addition to the schoolyard should meet a number of goals and not just have one purpose. Ex: A new garden can be designed specifically to accommodate learning, active play, enhance the school identity, create habitat, link to the seasons, spatially improve the function of the schoolyard etc.

Identity

- The schoolyard should express the identity of the school for those attending the school, teachers, staff and visitors alike. In addition to the other objectives listed here, this can be achieved through attention to detail, use of colour, texture, signage, temporary artwork, permanent artwork, outdoor expression of work being done at the school etc.

Diverse play

- The schoolyard should offer a diversity of play opportunities. Opportunities to climb, jump, swing and balance. Ascending challenges for younger children and open space. Creative spaces that are flexible, diverse in spatial arrangement, colour and texture. Social spaces that are intimate for small groups and open for large groups. Spaces where children can comfortably sit alone for quiet time.

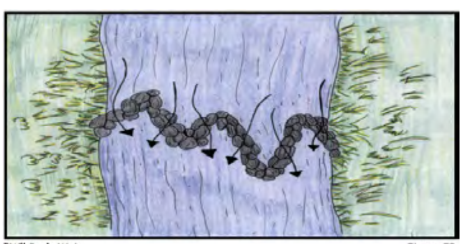
Active teaching

- The schoolyard should host an array of active teaching opportunities that can evolve with evolving priorities within the school. Ex: A dye garden with plants traditionally used in dying fabric (among other things) can be a part of an activated learning environment.

Appendix H: Pilot project master plan

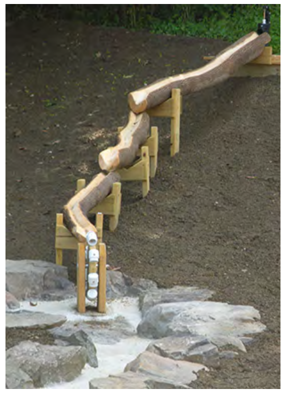
Appendix I: Workshop 2 - Inspirational images

I showed these images to the students when I was explaining what I wanted them to design for the workshop.



"W" Rock Weir Figure 53
adapted from Applied River Morphology

Vortex Rock Weir with Floating Logs Figure 52
adapted from "Applied River Morphology"



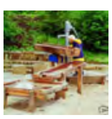

love

Appendix J: Design meeting 3 and Bioregional Fair - Concept plan

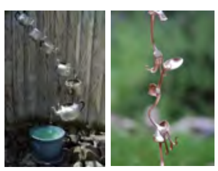
Oak and Orca's
Rainwater System Concept Plan

(1) New gutters and cistern(s)

(2) Lined swale for water play and experimentation



Additional: We could design the upper portion of the channel to accommodate the addition of a circular pumping system.



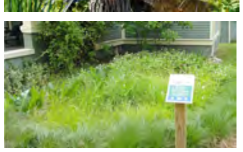
(3) Student made rain chains/rain sculptures

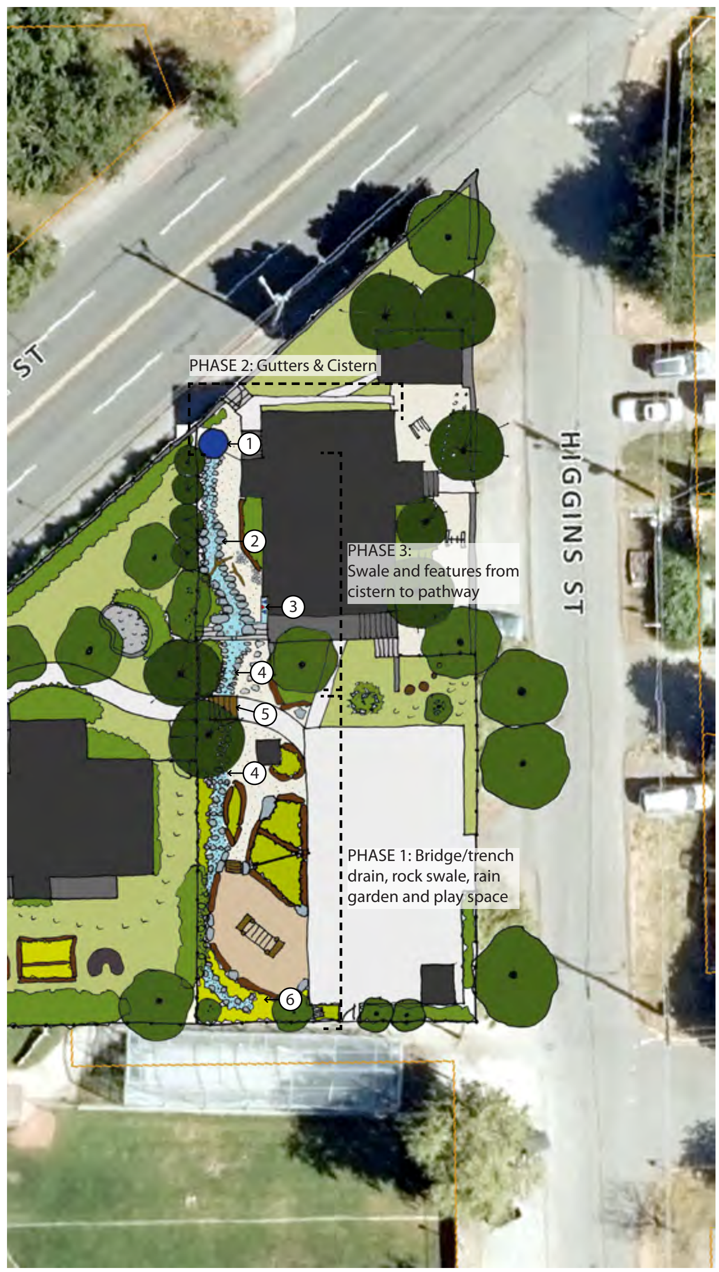
(4) Rock swale with stepping stones

(5)

Trench drain or small wooden bridge

(6) Rain Garden

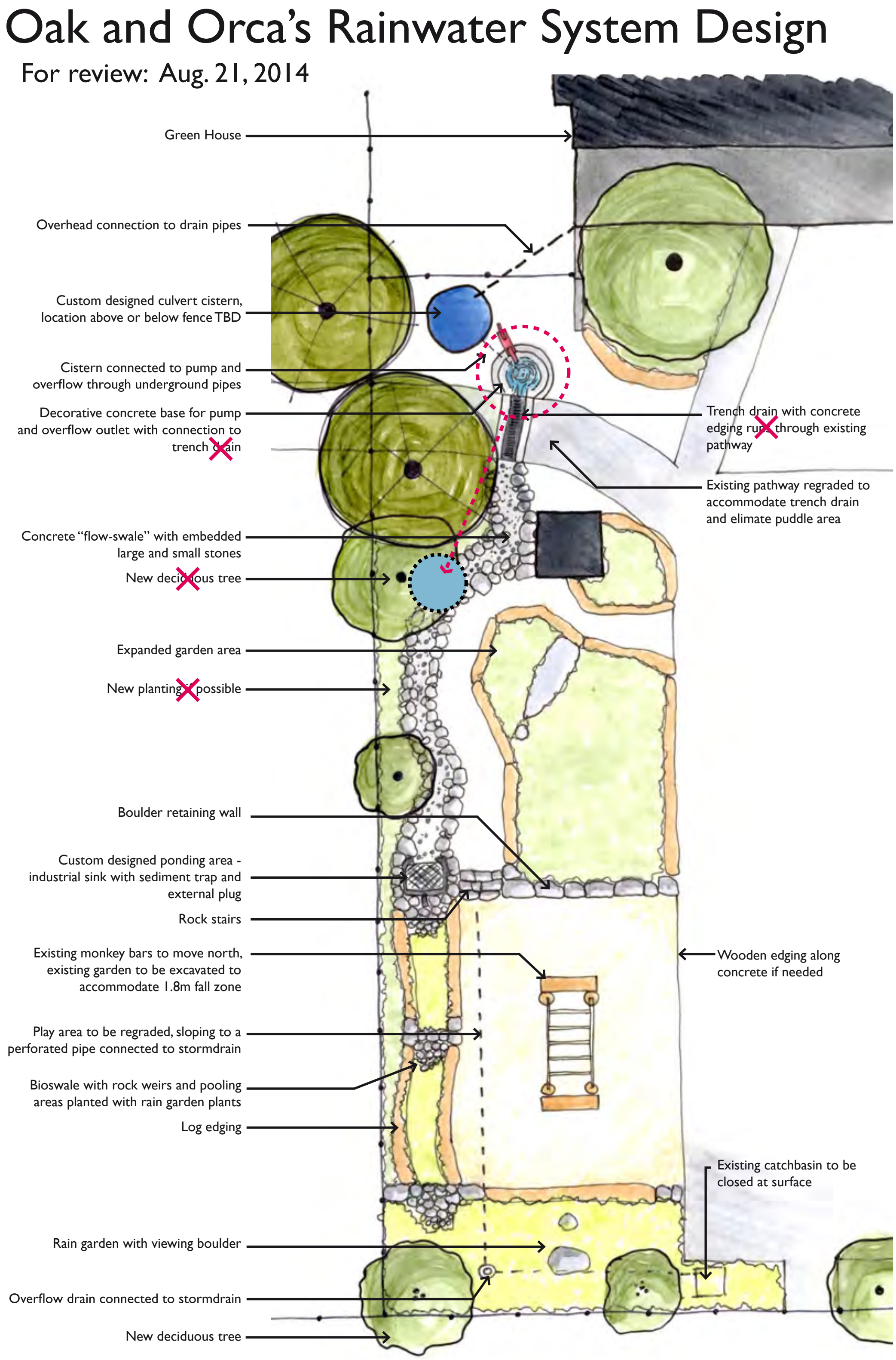




At the Bioregional Fair, I pinned up the material that was produced in the design meetings and workshops and the concept plan. This material was along the fence line where the project was slated to be built.

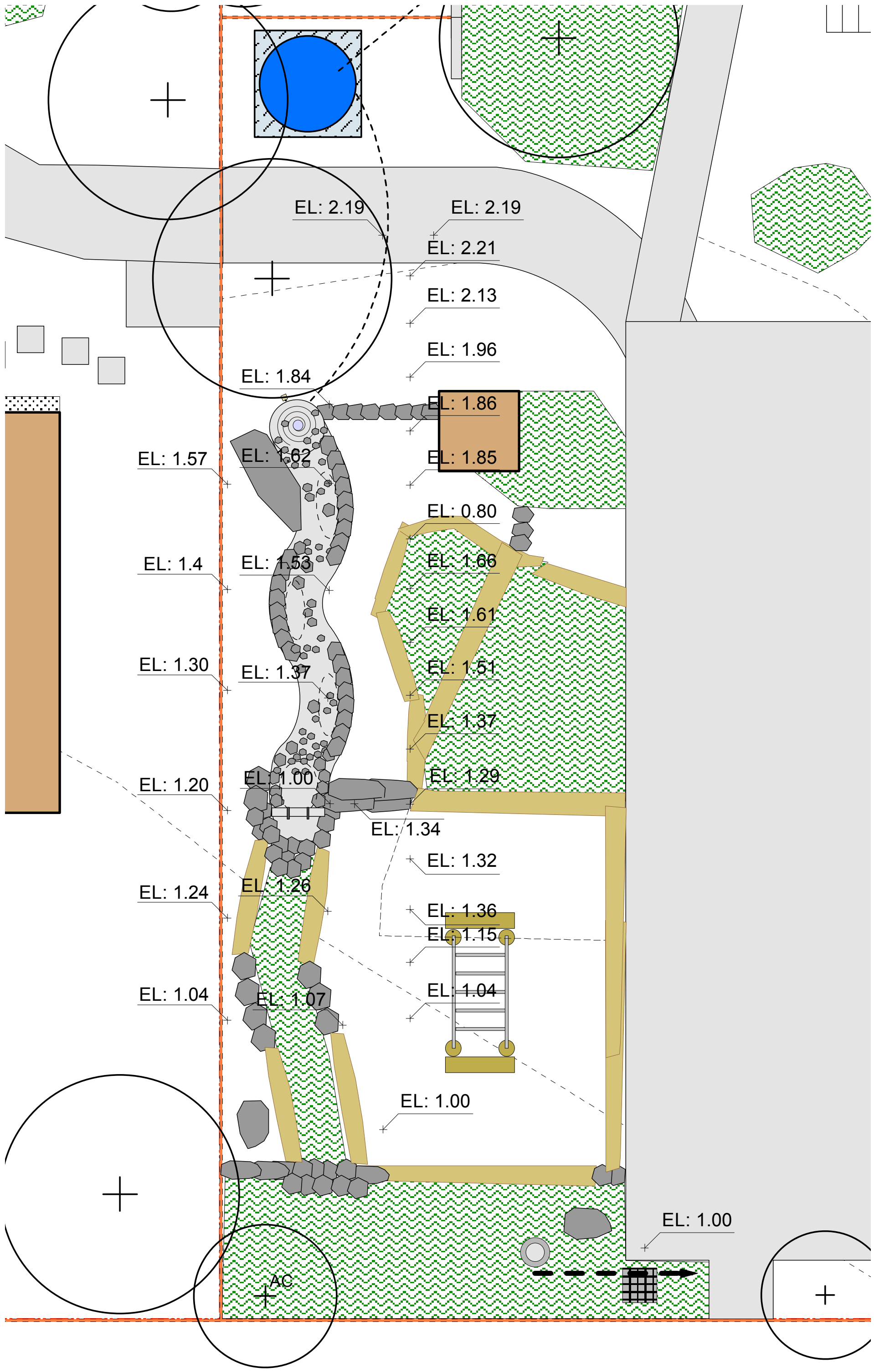
Appendix K: Design evolution

This plan depicts the design once it had moved further south down the site. The red marks indicate the change to send the water into underground pipes.



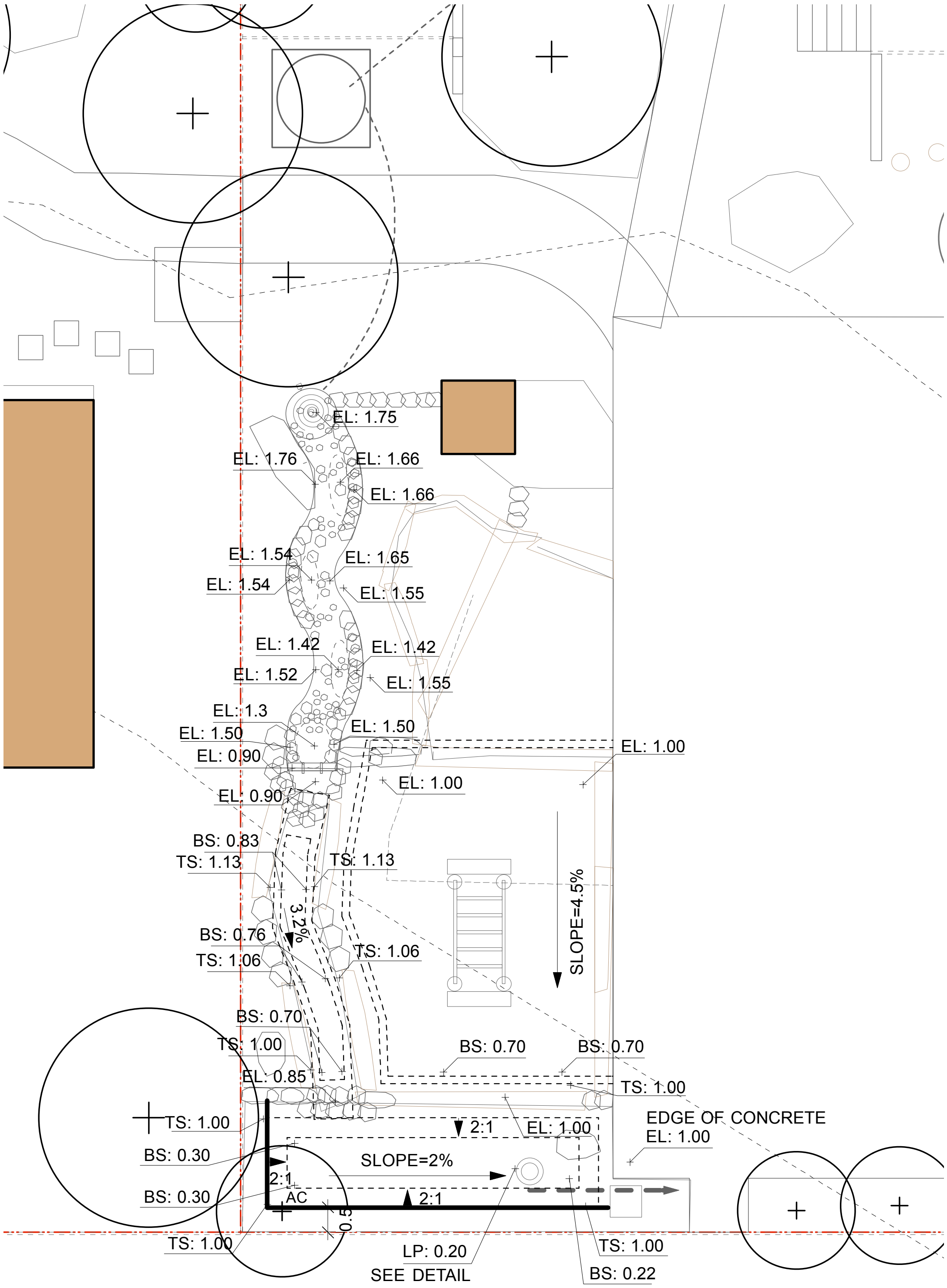
Appendix L: Grading and details

This plan depicts existing grades which were taken with the help of an older Oak and Orca student and a transit level loaned to me from the Geography Dept.



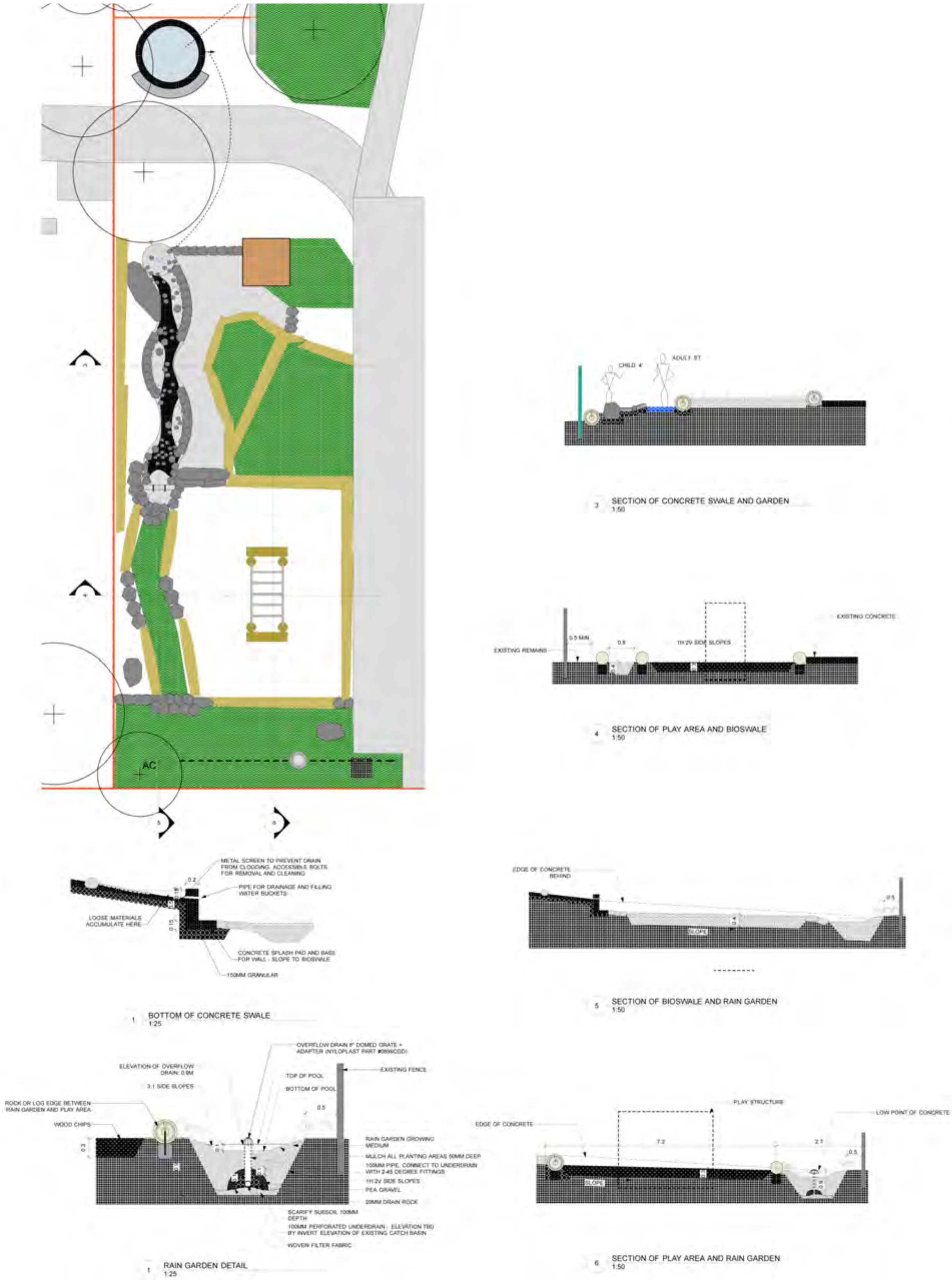
Existing grading

This plan depicts excavation grades and required a detailed understanding of how we would build all of the features to complete.

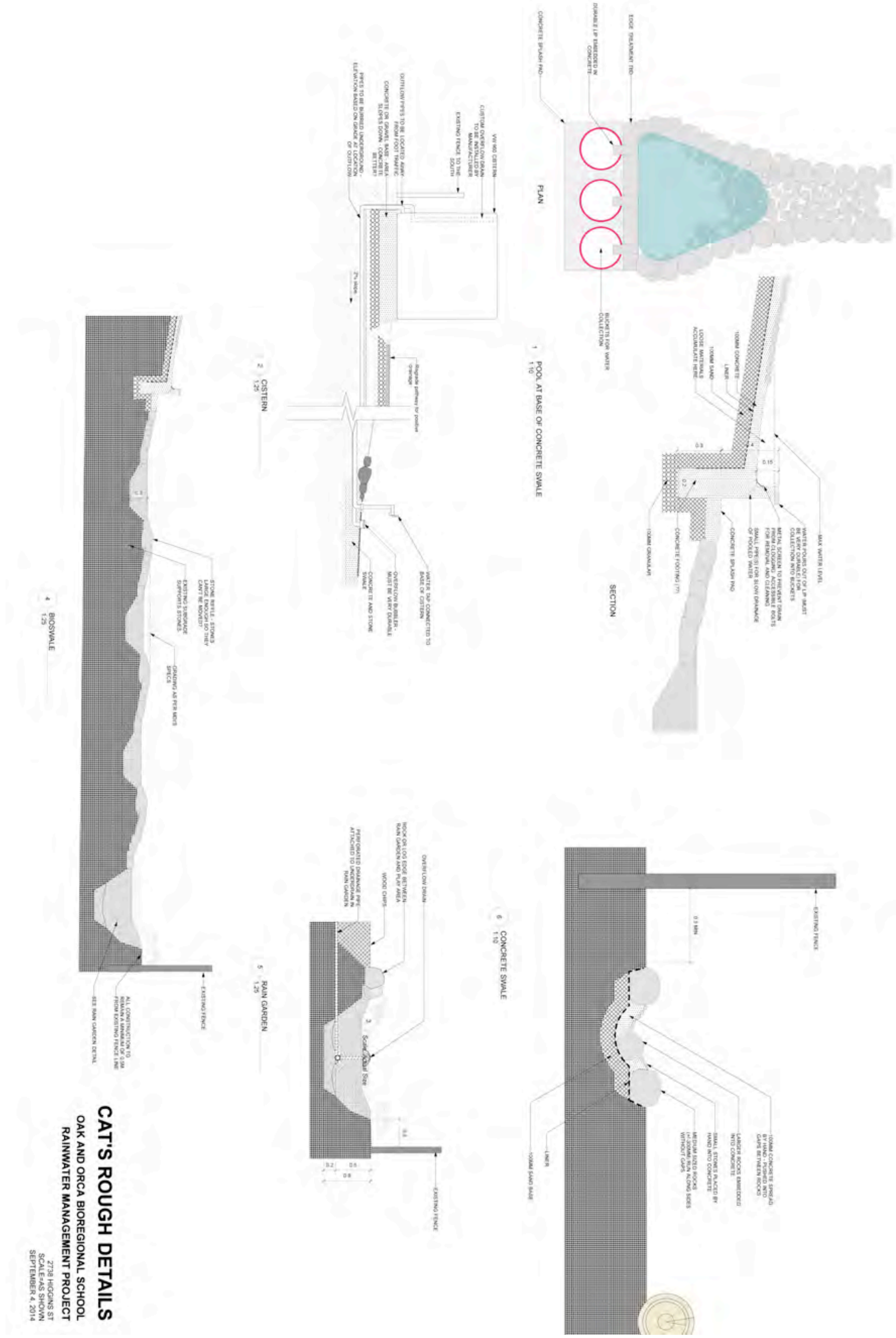


Proposed excavation depths

This plan, sections and detail were drawn for my own use in understanding the site grading and detail design and for communicating the ideas with Kevin Connery, who was reviewing the design.



Design details for Kevin's review.



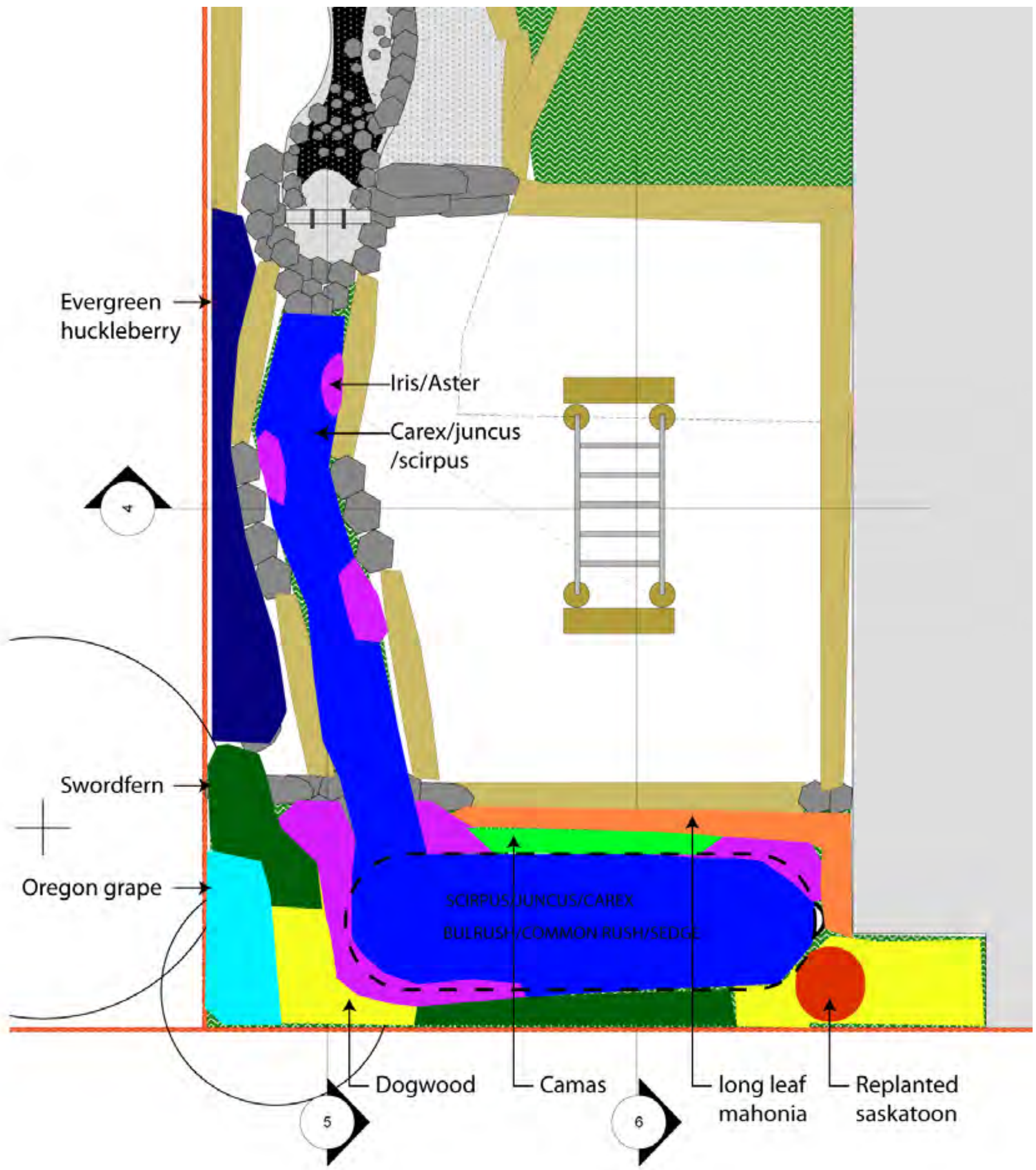
Appendix M: Final presentation board

Appendix N: Construction team photo

Eric Ebarb (left) and I during the construction of the project. Eric was central to the success of building the project, I could not have found a better person to work with.

Appendix O: Planting plan, plant list and descriptions

At this point in the process my computer had crashed and I no longer had access to my drafting program. This was the first planting plan that I drew up which was printed off and worked with by hand to get to the final version which is slightly different from this.



This information about the plants that were planted in the gardens was given to the school in their resource book.

Arctostaphylos uva-ursi
Kinnikinnick, bearberry

Evergreen

Native range: Wide distribution across N. America and the world

Exposure: Full sun to part shade

Mature size:

Height: 10-15cm

Width: 30-60cm

Ethnobotanical: The leaves were used medicinally for kidney and bladder conditions. Kinnikinnick is said to be an Alguonquian term meaning 'smoking mixture'; the leaves were smoked much like tobacco.

Provincial/state distribution:

Oxalis oregana
Redwood sorrel

Evergreen

Native range: Southwest BC to California

Exposure: Part shade to full shade

Mature size:

Height: 10-15cm

Width: 15-30cm

Ethnobotanical: Some groups ate the leaves or redwood sorrel, however, the plant contains axalic acid, which gives the leaves a sour, tangy taste and is potentially harmful.

Provincial/state distribution:

Erigeron glaucus
Beach fleabane daisy

Semi-evergreen

Native range: Coastal California and Oregon

Exposure: Full Sun

Mature size:

Height: 15-20 cm

Width: 25-30 cm

Maintenance: Tidy up plants in early spring before new growth begins. Can be divided in early spring or autumn.

Ethnobotanical: First Nations people used many *Erigon* species in ceremonies.

Why is this plant in the rain garden? At the time of construction, the native plant, Douglas Aster, was exchanged for this plant due to availability. The Beach Fleabane Daisy is an adapted non-native and was recommended by the nursery as a plant that grows well in rain gardens.

Provincial/state distribution:

Camasia quamash
Camas

Perennial

Native range: BC, Alberta and northwest US

Exposure: Full sun

Mature size:

Height: 45-60cm

Width: 15-20cm

Ethnobotanical: An important staple food, bulbs were harvested during or soon after flowering, so as not to confuse them with the death camas. Camas was semi-cultivated on Vancouver Island.

Provincial/state distribution:

Iris douglasiana
Douglas iris

Deciduous Evergreen

Native range: Coastal California and Oregon

Exposure: Full Sun

Mature size:

Height: 30-60 cm

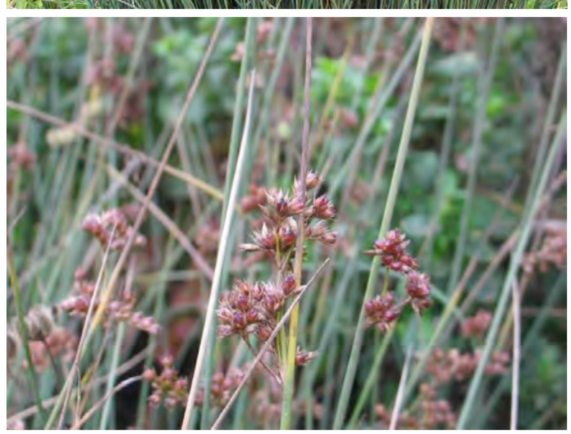
Width: 60-90 cm

Ethnobotanical: Roots and leaves are very strong, used to make cordage, nets for catching deer, fishing nets.

Why is this plant in the rain garden? At the time of construction, the native plant, Pacific Coast Iris, was exchanged for this plant due to availability. The Douglas Iris is an adapted non-native and was recommended by the nursery as a plant that grows well in rain gardens.

Provincial/state distribution:

Juncus patens
California grey rush



Perennial

Native range: Washington to California

Exposure: Full sun to part shade

Mature size:

Height: 30-60cm

Width: 30-60cm

Ethnobotanical: Used for making baskets, paper, thatching, mats and ropes.

Why is this plant in the rain garden? Due to the small scale of the rain garden, juncus patens was chosen over other larger wetland plants. It is an adapted non-native that has proven to work extremely well in rain gardens in Victoria.

Provincial/state distribution:

Carex obnupta
Slough sedge

Evergreen

Native range: Pacific coast from BC to California

Exposure: Full sun to part shade

Mature size:

Height: 60-150cm

Width: 40-70cm

Ethnobotanical: Slough sedge remains a popular basket making material, the inner leaves are split and flattened before being dried. Fine baskets are made from this sedge, often with cedar foundations and intricate designs from dyed strands fo grass or coloured barks.

Provincial/state distribution:

Mahonia nervosa
Longleaf mahonia, dull Oregon grape, cascade barberry

Evergreen

Native range: Southern BC to California

Exposure: Sun to shade

Mature size:

Height: 30-90cm

Width: 30-90cm

Ethnobotanical: Shredded bark was used to make bright yellow dye; bark and berries were used medicinally for liver, gall-bladder and eye problems; berries were mixed with sweeter fruit for eating.

Provincial/state distribution:

Blechnum spicant
Deer fern

Evergreen

Native range: Western coast, Washington and BC.

Exposure: Part shade to shade

Mature size:

Height: 45-60cm

Width: 45-90cm

Maintenance: Trim off dead fronds in early spring.

Ethnobotanical: Leaves were used as a hunger suppressant and medicinally for skin sores (this was learned by watching deer rub their antler stubs on the plant after their antlers had fallen off).

Provincial/state distribution:

Polystichum munitum
Western sword fern

Evergreen

Native range: Western coast from Alaska to California.

Exposure: Part shade to shade

Mature size:

Height: 90-120cm

Width: 60-120cm

Maintenance: Trim off dead fronds in early spring, may be divided in spring.

Ethnobotanical: Leaves used in pit ovens, for food storage and on berry drying racks and for flooring and bedding. Rhizomes were dug in the spring and eaten as a starvation food. Children used the leaves to play a game called "pala-pala" this involved seeing who could pull the most leaflets off in one breath while saying 'pala' with each one.

Provincial/state distribution:

Cornus sericea 'Midwinter fire'
Red twig dogwood

Deciduous

Native range: Low to mid elevations throughout N. America

Exposure: Full sun to part shade

Mature size:

Height: 60-150cm

Width: 40-70cm

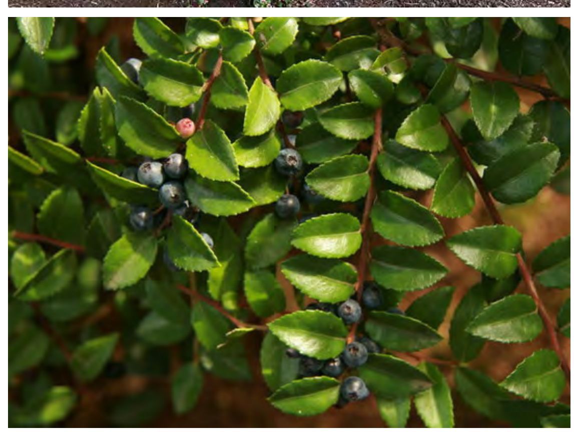
Maintenance: This shrub can be pruned back heavily from

every year to every few years (a few inches from the ground) to encourage the growth of bright twigs. This is recommended if the shrub starts gettting too large for the rain garden.

Ethnobotanical: Branches were used for salmon spreaders and basket rims. The bark and twigs were used for a variety of medicinal preparations and were extremely important winter browse food for moose, deer and elk.

Provincial/state distribution:

Vaccinium ovatum 'Thunderbird'
Thunderbird evergreen huckleberry



Evergreen

Native range: BC to California

Exposure: Sun to shade

Mature size:

Height: 1.3-2.0m

Width: 1.0-1.5m

Maintenance: Can be trimmed back in spring.

Ethnobotanical: Berries were eaten by many groups, in fact people travelled far to get them. Berries ripen in the fall and last until December. They are said to be tastier after the first frost.

Provincial/state distribution:

Mahonia aquifolium
Tall Oregon grape

Evergreen

Native range: Western North America

Exposure: Full sun - part shade

Mature size:

Height: 1.2-1.8 m

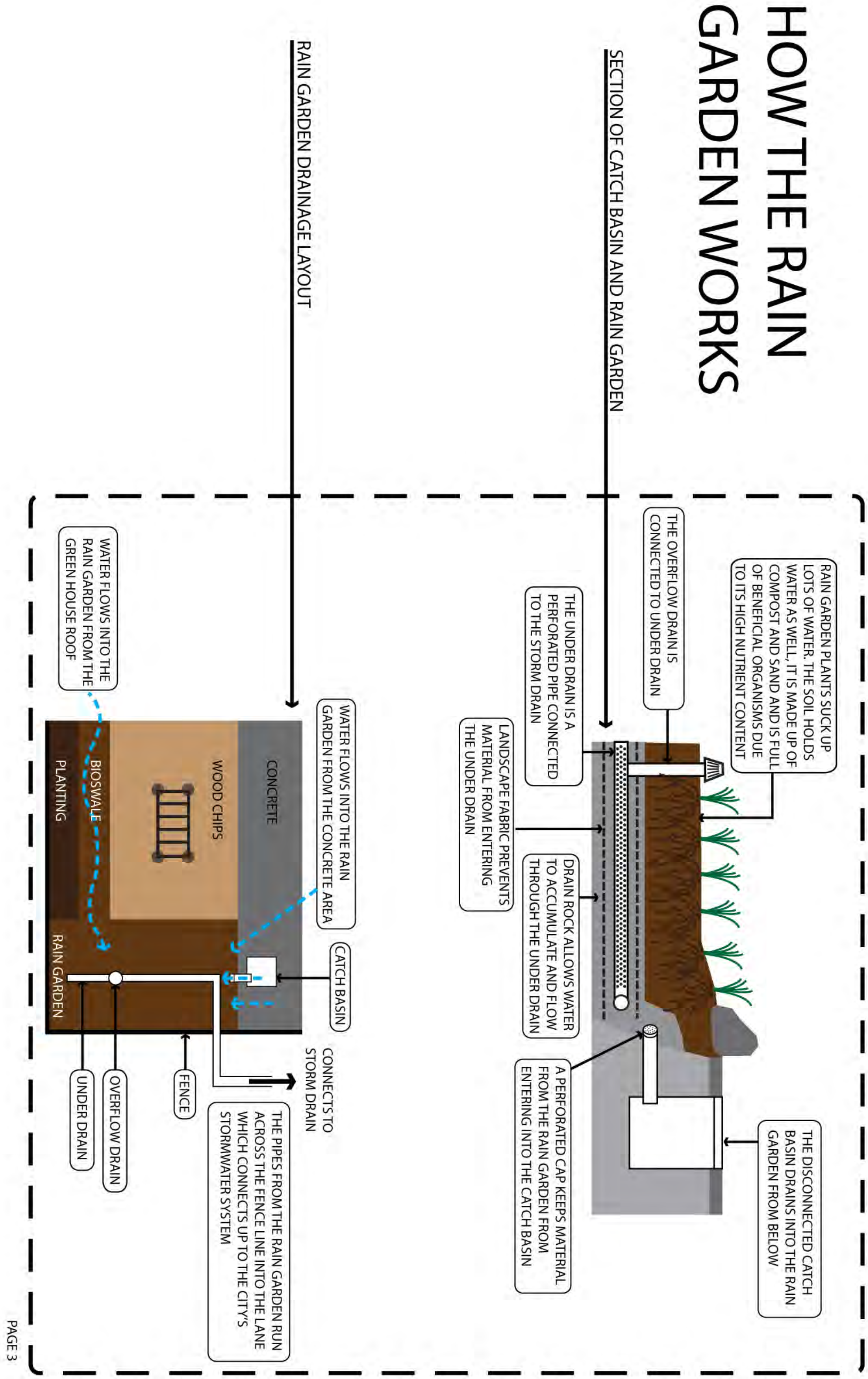
Width: 1.2-1.8 m

Ethnobotanical: Shredded bark was used to make bright yellow dye; bark and berries were used medicinally for liver, gall-bladder and eye problems; berries were mixed with sweeter fruit for eating.

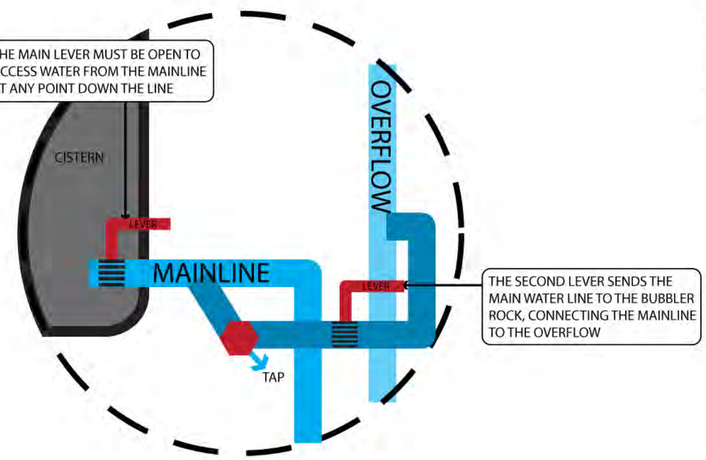
Provincial/state distribution:

Appendix P: Rainwater system diagram

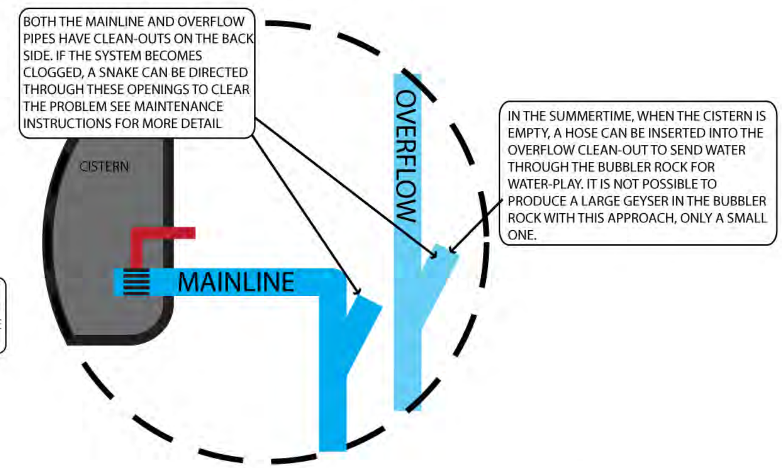
These two diagrams accompanied the diagram in the body of the text to explain how the system works to the school.



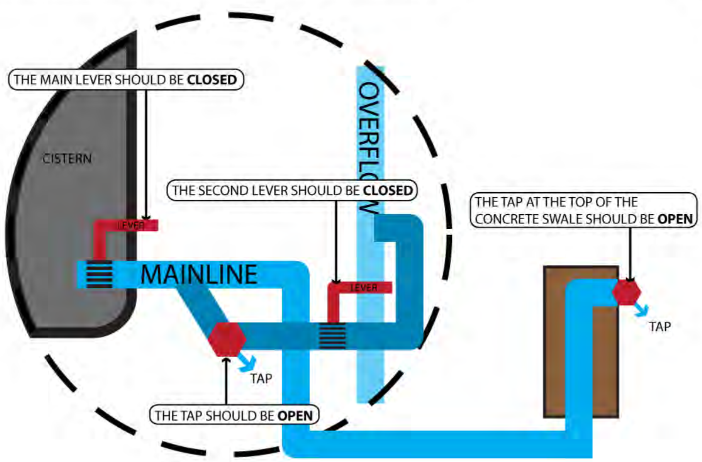
HOW THE CISTERN LEVERS WORK



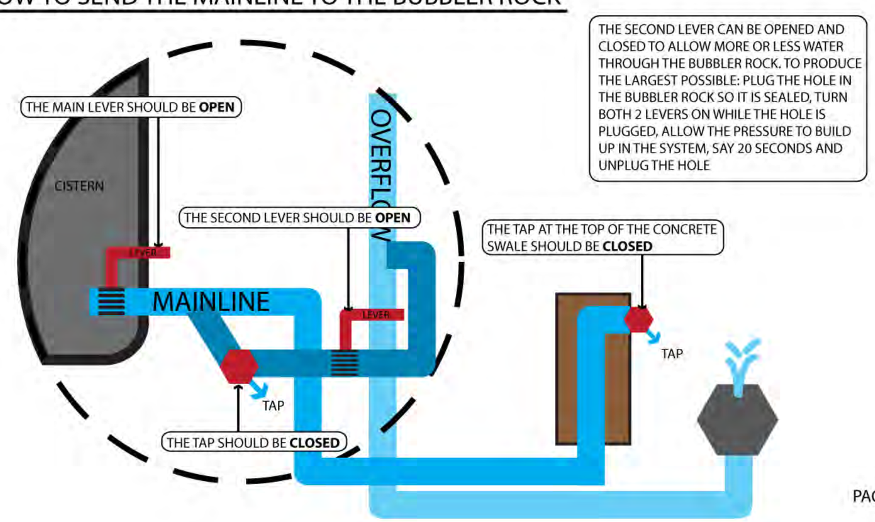
CLEAN-OUT AND SUMMERTIME USE



COLD WEATHER SETTINGS IN CASE OF FREEZE



HOW TO SEND THE MAINLINE TO THE BUBBLER ROCK



Appendix Q: Willow tunnel

The willow tunnel was an idea that was brought forward in the master planning session that the school wanted to implement. We hired Andrew Kent (the Willow Way) who built the willow tunnel as a workshop with the school.

Appendix R: Opening day invitations

The project contributor's invitation:

You are invited to come celebrate the opening of **Oak and Orca's**

Schoolyard Rainwater System

Thanks to our sponsors the project was a huge success! We would like to invite you to our opening day celebration on December 5th from 2:30-3:30 at 2738 Higgins St, Victoria. We have reserved 7 red-twig dogwood shrubs to be planted in the rain garden by the contributors. Please let us know if you can attend by emailing: orr.cat@gmail.com.

The general invitation:

You are invited to come celebrate the opening of **Oak and Orca's**

Schoolyard Rainwater System

After 6 weeks of construction the project is finally complete! We are holding an opening day celebration on Friday, December 5th from 2:30-3:30 at the school, 2738 Higgins St. We hope to see you there!

Appendix S: News articles about the pilot project

TIMES COLONIST

Environmentally focused school a natural home for a rain garden

Jeff Bell / Times Colonist
December 8, 2014 09:56 PM

Students play in the rain garden at Oak and Orca Bioregional School, a joint project with the University of Victoria. Photograph By DARREN STONE, Times Colonist

With its focus on environmental sustainability, Victoria's Oak and Orca Bioregional School is prime territory for a rain garden.

Rain gardens are designed around a low area that gathers stormwater and runoff, using the water rather than dumping it into the stormwater system right away, said Catherine Orr, a landscape architect and University of Victoria environmental-studies student overseeing the project.

That way, when the water does reach storm drains, there is less of it and it's cleaner, Orr said.

"We're trying to improve our stormwater infrastructure by adding a biological component to it."

Orr said the project, which is largely complete, has been embraced by the school community.

The independent alternative school, near the corner of Cook Street and Hillside Avenue, has about 60 students attending multi-age classes up to Grade 12, and another 80 who are doing distance learning.

As a bioregional school, its goal is to connect students with the natural environment as much as possible, Orr said.

The main task left is to connect gutters to a 960-litre cistern, to collect water from the school roof.

Students have been enjoying the new attraction. Teva Vanderheyden, 10, said he was looking forward to learning about the rain garden, but he also has fun standing in the water as it flows through the system.

"It's so awesome," he said.

Oak and Orca teacher Smiler Overton said the rain garden will be a good addition to the school.

"In my experience, there's a lot to be learned from playing. But they can go deeper into it, so we can talk about how the water's going into the cistern and how it's going into the rain garden and how it's getting filtered."

The project is supported by UVic, the City of Victoria, the Capital Regional District, the non-profit group Mitacs, the Real Estate Foundation, Murdoch de Greeff Inc. Landscape Architects, Vancity and the RBC Blue Water Project.

Other examples of rain gardens in Victoria can be seen at Victoria West Elementary School, Fisherman's Wharf Park and on Tyee Road adjacent to Dockside Green.

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NEWS

Rain garden teaches students the value of water

by Andrea Peacock - Victoria News
posted Dec 8, 2014 *at* 4:00 PM

A local school is now the home of a new educational and functional rainwater system.

“It's essentially a garden that has a lot of water storage capacity within it,” said Catherine Orr, University of Victoria environmental studies graduate student and leader of the rainwater system project. “What we're trying to do here is mimic natural systems within how we manage rainwater currently.”

Brooklyn Hall, 9, dumping a bucket of water into the new rainwater system at Oak and Orca Bioregional School. — *Image Credit: Andrea Peacock Photo*

The rainwater system is located at Oak and Orca Bioregional School in Victoria, and runs almost the entire length of the school site. The rainwater is collected from the school's roof into the 960-litre cistern and flows through an educational play feature and into a bioswale, a linear trench with specialized soil and plants, then drains into a native plant rain garden. The majority of the water drains into the rain garden, with very little passing through the stormwater system. During a heavy rainfall, the system will slow the runoff down and improve the water quality before entering the storm drain.

“What we don't realize a lot of the time here in the city . . . is that outlets points are receiving water that is polluted,” said Orr.

Being located at a school, Orr said this rain garden will serve mainly an educational purpose, but will still be functional.

“The kids will be maintaining the rain garden as well as the rest of the system,” said Orr. “So they'll do things like weeding, and . . . sediment does build up in these over time, so maybe twice a year they'll have to get the sediment out of the rain garden."

Smiler Overton, a teacher at Oak and Orca, said the rainwater system will be a good opportunity to incorporate hands-on learning with classroom lessons.

"It gets kids thinking about how we're in an ecosystem, we're not masters of it," said Overton.

The entire system at Oak and Orca cost about $20,000, not including all of the time Orr spent on the project as a graduate student.

"The most expensive part is connecting to the storm drain," said Orr.

The project was funded and supported by Mitacs, the Real Estate Foundation, the City of Victoria, the Capital Regional District, Murdoch de Greeff Inc., Vancity and the RBC Blue Water Project.

"We wanted to support the notion by promoting the educational aspect [of] learn[ing] what rainwater management is all about," said John Sturdy, assistant director of engineering and public works at the City of Victoria.

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Tina Quade

Exciting! This sounds a lot like the Urban Rain Garden project at Vic West Elementary done through Leadership Victoria. http://magazine.good.is/articles/project-012-project-urban-raingarden

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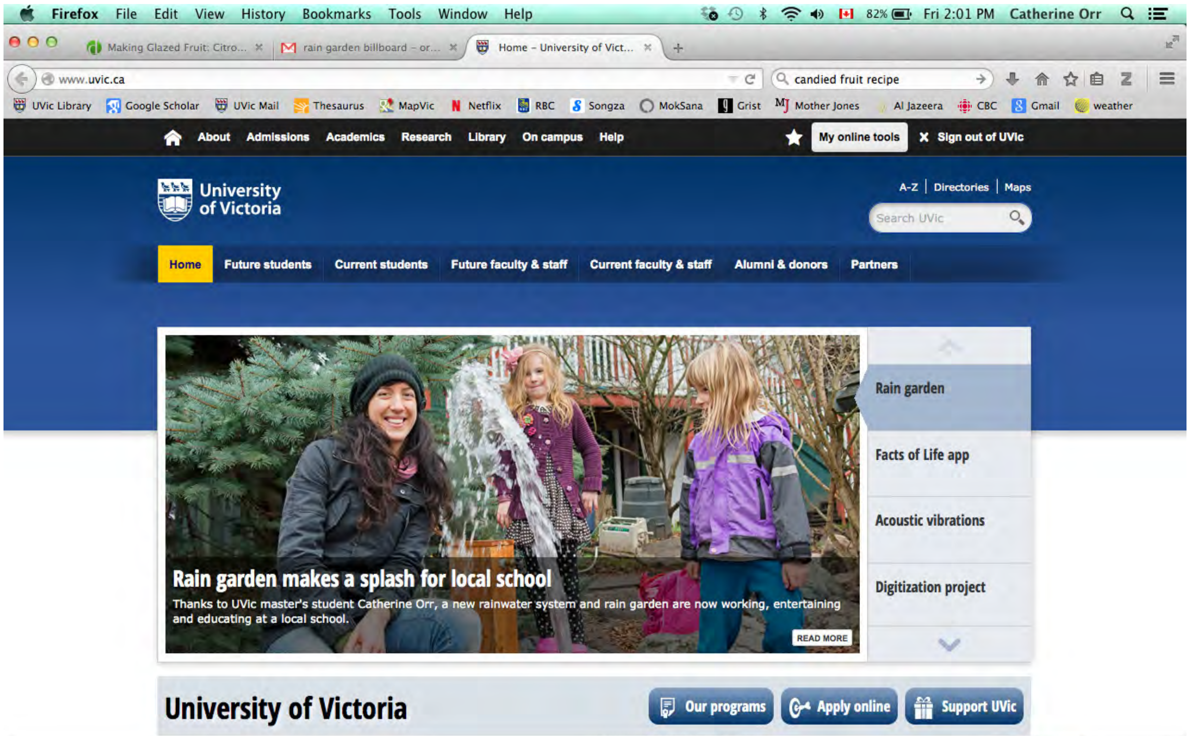

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Rain garden makes a splash for local school

Fri, 2014-12-12 11:56

Landscape architect and environmental studies master's student Catherine Orr saw her graduate project as a way to connect with a local school and a community about water and the importance of rainwater management.

Catherine Orr and Oak and Orca schoolchildren make a splash with rain garden project. Photo: Photo Services.

"I approached Oak and Orca Bioregional School about my idea for a rainwater system," Orr says, because "the school teaches project-based learning and both teachers and students were excited about the design process."

And after a nine-month design and planning process, a new rainwater system and rain garden are now working, entertaining and educating at the school—an accomplishment shared by Orr, the school and community partners including the City of Victoria, UVic, the CRD, Mitacs, Real Estate Foundation, Murdoch de Greef Inc, Vancity and RBC Blue Water Project.

"Our partners were very interested and supportive of this project," says Orr. "Education, collaboration and creativity are key to improving how we manage urban rainwater."

Catherine Orr with environmental studies professor Eric Higgs. Photo: Photo Services.

The rainwater system runs almost the entire length of the school site, starting with water collection from the building's roof into a 960-litre cistern, flowing through an educational play feature, into a bioswale (a linear trench with specialized soil and plants) and ending with a native plant rain garden. The entire system is gravity fed and designed to manage the majority of rain that falls throughout the year. Rainwater collection projects are also a boon for municipal storm sewer systems, as they lessen peak load during periods of heavy rainfall.

"Teaching children the importance of water," explains Orr, "is a step toward better water management in the future."