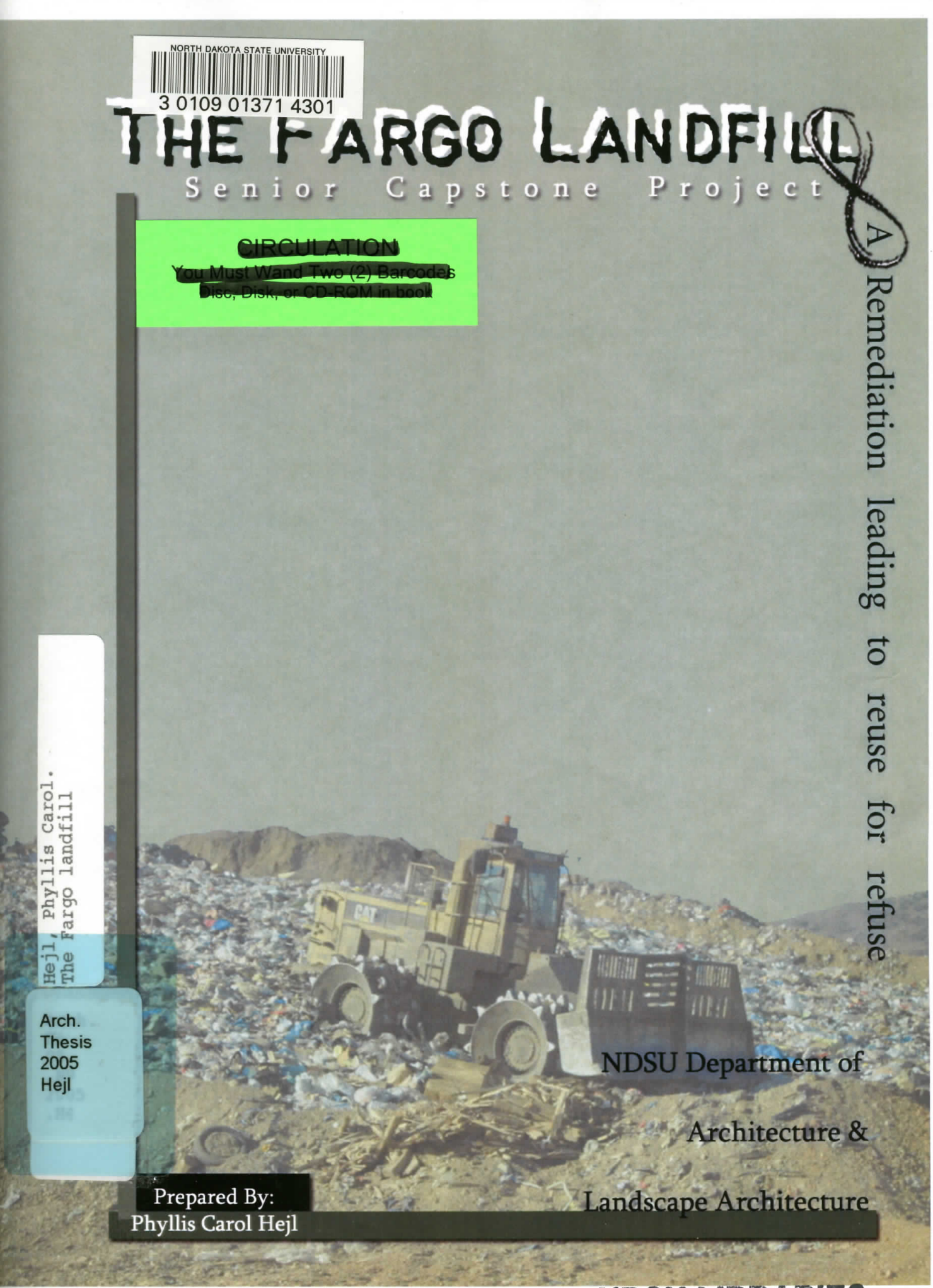
THE FARGO LANDFILL

Senior Capstone Project

A Remediation leading to reuse for refuse



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The Fargo Landfill: A Remediation Leading to Reuse for Refuse

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The Fargo Landfill: A Reclamation Leading to Reuse for Refuse

A design thesis submitted to the department of Architecture and Landscape Architecture of North Dakota State University

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In partial fulfillment of the requirements for the degree of Bachelor of Landscape Architecture

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Table of Contents

Table of Contents

Table of Figures

Table of Figures

Table of Figures

Abstract

The U.S. has approximately 3,091 active landfills which take in about 279 million tons of garbage annually (How Landfill's Work website). Since 1990, more than 11 billion tons of domestic and foreign waste has been disposed of in the United States. This is equivalent to covering every acre in the nation with 4.7 tons of waste. As the population rises, so does the amount of waste generated and the need for somewhere safe to put it. Landfills are usually capped and forgotten about, or not put to an appropriate reuse. They can also pose a very serious threat to the environment and people around them. Most problems occur when landfills close. Current techniques do not remediate the waste; they simply cover it up. The creation of new landfills faces stiff opposition from every angle. No one wants to live or work near a landfill, and they should not be located in the wilderness at the expense of our natural areas. Our country is rapidly entering into a garbage crisis and something needs to be done.

The Fargo area currently has more space to deal with waste so we do not feel the pinch yet. But per capita, people here create just as much waste as the rest of the country. We need to start planning now for better waste disposal and remediation. The Fargo landfill takes up 160 acres or the equivalent of 25 city blocks. According to Duane Haugen, general supervisor at the Fargo Landfill, It currently takes in 150,000 tons of waste and creates 700,000 gallons of leachate water needing treatment annually. The landfill capacity is 8 million tons and is expected to be at this mark sometime in the next 18 years when it will be capped and vegetated for wildlife habitat. The Fargo landfill has already taken some steps toward becoming environmentally conscious by installing 20 methane collection pipes and using bio-diesel in all the trucks and bulldozers. Despite these efforts, the process needs to be refined to make the Fargo site safe for its surrounding environment and provide an adaptive reuse. In doing so, the site will become an asset to the city rather than a liability.

The Fargo landfill is located on 45th St. between 7th Ave and 12th Ave N. This location puts it in a central area of Fargo and its surrounding communities. I propose the implementation of a closed-circuit system for land filling as well as bio and phyto remediation, and a showcase for waste handling and treatment for the city of Fargo. The landfill will become a place for students, civic groups, and others to come and learn what happens to the waste they create, and what affect it has on the environment.

This capstone project research will focus on the studies of waste reduction, soil and water remediation, and different ways to exhibit garbage in a way to teach visitors and residents of Fargo and its surrounding areas about their waste, in order to create a meaningful experience.

Figure 1.1 Garbage Cartoon

(www.jokes.glowport.com)

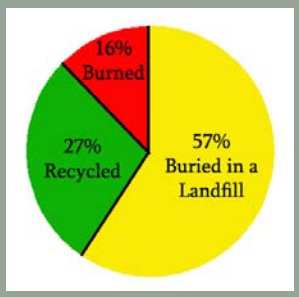

Figure 2.1 Waste Pie Chart

The Creation of Waste

Americans generate approximately four pounds of garbage per person, per day. This means we produce almost 280 million tons of refuse per year (How Landfills Work, website). Of this waste, the U.S. recycles only 27%, burns 16%, and buries the remaining 57% in landfills. In Fargo, ND there are about 100,655 residents who create the same four pounds per day. This averages out to about 73,478.5 tons per year. This may be difficult to envision, so think of it as the residents of Fargo creating 490 blue whales (the largest mammals on earth) per year and placing them at the landfill. Keep in mind this only takes into account the residents of Fargo proper. There are many other towns and cities around the area (from as far as 40 miles away) who contribute additional waste. The residents of Fargo recycle at an astonishingly low rate as well. Of the 73,478.5 tons of waste created each year only 7,000 tons is recycled. Only 9% of the population in Fargo recycles (City of Fargo website). Waste is a terrible thing to waste; so many things can be reused as something else. In other parts of the country, recycling is mandatory. For instance, in New Jersey there are "Garbage Police" who go around making sure people do not have hazardous materials in their household waste. In Florida, there are fines for not recycling. In these parts of the country the government provides separate bins for recyclable materials for the residents. The city of Fargo has both curbside pickup and various drop-off locations. Fargo has curbside recycling but it costs a household $4-$5 per month to supply a bin for separating the recyclables, and for weekly collection. Drop off recycling is a little more popular, since it's free and easy to haul waste to the many collection sites. Still, most residents do not elect to participate. Residents do not perceive a waste production problem yet, and may not until the landfill is at capacity and Fargo needs to build a new one.

Figure 2.2 Blue Whale

(http://images.tvnz.co.nz/film/findingnemo.whale.c.jpg)

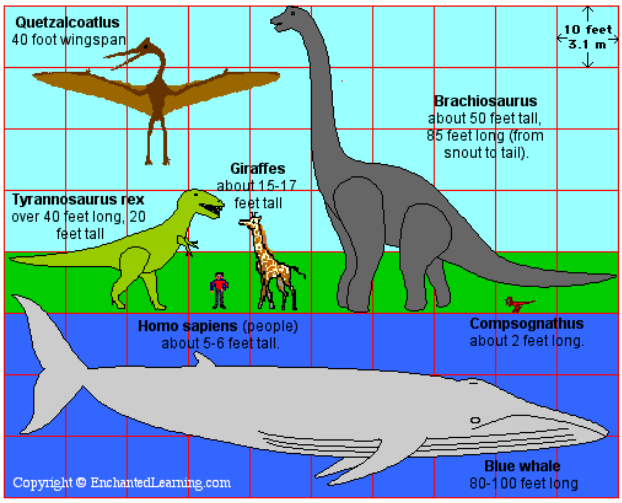

Figure 2.3 Size Comparison Chart

(www.enchantedlearning.com)

Figure 2.4 Landfill Liner

(www.cityoffargo.com)

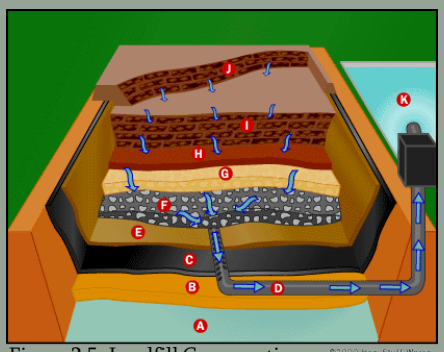

Figure 2.5 Landfill Cross-section

(http://people.howstuffworks.com/landfill

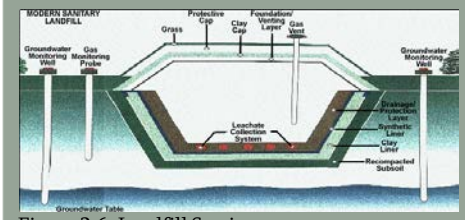

Figure 2.6 Landfill Section

(www.egr.msu.edu/tosc/geneva/images/landfill%20image.jpg)

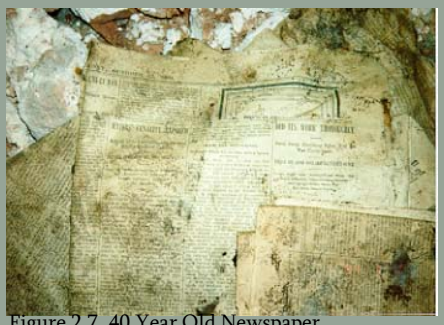

Figure 2.7 40 Year Old Newspaper

(www.homestead.com/thedumpsite/files.jpg

How Landfills Operate

Some people refer to landfills as dumps. A dump is actually defined as an open hole in the ground where unregulated trash is buried and vermin are common. Landfills are carefully designed structures built into or on top of the ground in which trash is isolated from the surrounding environment (How Landfill's Work website). This is accomplished with a bottom liner and daily cover. The purpose of a landfill is to bury trash in such a way that it will be isolated from groundwater, kept dry and have minimal contact with air. In an environment such as this, garbage will decompose very, very slowly.

The way landfills are generally constructed is similar throughout the U.S. A hole is dug 30'-50' below ground level. The subgrade is comprised of clay that has been highly compacted to help prevent seepage of pollutants into groundwater should a leak occur. The hole is covered with a high density polymer liner which is 1/10" thick. The seams of the liner are fused to help prevent leakage. On top of this is a layer of sand 1'-2' thick, added to help prevent garbage from puncturing the liner. On top of the sand is a layer (varying in thickness from 1'-3') of soft waste. This is comprised of household waste or other forms of trash that do not have sharp edges. After these preliminary layers, normal land filling really begins and garbage is dumped until the various cells and rows are filled up. When one row of cells is full, then another hole is dug, lined, and then filled until all the landfill's rows are filled. The landfill is then considered to be at capacity and is capped.

The basic parts of a landfill are: a bottom liner system which separates the trash and leachate from groundwater, cells where trash is stored in the landfill, a stormwater drainage system that collects rainwater that falls on the landfill, a leachate collection system which collects water that has percolated through the landfill and contains contaminating substances, a methane collection system that collects the methane produced from the breakdown of substances, and a covering or cap which is an impermeable layer that seals the top of the landfill so no water can infiltrate it (McBean, et al. 1995)

Waste is brought to landfills mainly by large dump trucks. These trucks are weighed at the scale before and after dumping to determine the tonnage of the waste so an accurate fee can be charged. The dump trucks then follow a designated path to the operating cell. Garbage is dumped into the cell and compacted by large bulldozers and additional garbage throughout the day. At the end of each day the cells are covered with six inches of daily cover. Most landfills use either petroleum polluted soil, bio-solids from a water treatment plant, or they 'borrow' soil from an adjacent site. One new technology in land filling is the use of sprays made of paper or other organic substances. These eliminate the task of removing the daily cover each morning. They are still considered experimental by the Environmental Protection Agency. Every morning on regular landfills, the daily cover is removed and land filling is begun again. Trash put in a landfill stays there almost indefinitely time because of the near lack of oxygen and moisture. For instance, a 40 year old newspaper with easily readable print was found in an excavated landfill. Landfills are not designed to breakdown trash, merely to bury it.

Figure 2.8 Landfill Cover

(http://geosynthetic.co.uk/images/civ2.jpg

How Landfills Generally Close

It costs between $80,000 and $500,000 per acre to cap a landfill (McBean, et al., 1995). These costs are dependant upon local availability of materials. For example, when the Fargo Landfill closes, if it costs $250,000 per acre and there are 155 acres, it will cost $38,750,000 to merely cap the landfill. Landfills must also monitor, inspect, and maintain the landfill and its protective systems for at least 30 years post-closure. (EPA, website). Remediation or repairs that may need to be made during this period add hundreds of thousands of dollars per year to monitoring costs, depending on the scale of the landfill. Since landfills decompose so slowly, pollution will be generated almost indefinitely. This pollution will go unchecked once the landfill is not monitored anymore. Currently people are starting to create new uses for landfills such as wildlife habitat or parkland for cities. This is a good step for a successful reuse, but does not address any reclamation issues or pollution exposure.

The principle cause of pollution associated with landfills is the infiltration of water into the refuse to create leachate. When leachate leaks into the surrounding soil or groundwater is when the pollution occurs. The solution to this pollution so far has been to cap the landfill. This cuts off the infiltration of water into the landfill. Liners similar to the one at the base of the landfill, or 2 ft of highly compacted clay, or both are generally used as a cap for a landfill (McBean, et al., 1995). A layer of topsoil 2-4 ft thick is then layered on top of the liner to be used as a growing medium for vegetation. The vegetation is mainly comprised of grasses or wildflowers so roots will not puncture the liner. Trees and shrubs may be grown, but additional topsoil is required, not to mention closer monitoring to catch gas seepage. These reclamation issues involve a substantial amount of money and are usually not achieved.

Figure 2.9 Landfill Protestors

(www.mtribe.freeserve.co.uk/baystone.htm

Figure 2.10 Backyard Landfill

www.homestead.com/thedumpsite/files.jpg

Figure 2.11 Pollution Cartoon

(www.cartoonstock.com)

The Need for Projects Like This

Landfills all over the country are beginning to close due to more strict government regulations, or because they are simply full. Opposition to the creation of new landfills is fierce. People generally do not want a landfill in their backyard. The amount of waste being buried in landfills will only decline through implementation of the three R's: reduce, reuse, and recycle. Landfills can be a contaminant or a permanent scar on the surrounding environment. That is why I believe this project is important. I will introduce a new 'R'…remediate. The Environmental Protection Agency defines remediation as: 'Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a hazardous waste site.'

Again, 'If you want to preserve something, bury it in a landfill…it will never decompose.' -Duane Haugen, general supervisor of the Fargo Landfill. This thought was disturbing enough to me to justify doing this as my capstone project. It means the garbage we create today will be here indefinitely. Dr. Eakalak Khan, a professor at NDSU who teaches civil engineering courses dealing with hazardous waste management said "We have been to Mars and the Moon, but we still bury our waste." Our landfills are reaching capacity at a pace exceeding the rate of landfills being created. One reason for this is because new landfills face public opposition everywhere. People want a place for their garbage to go but do not want the place to be anywhere close to them. The problem is that landfills will always be near something. The view of landfills is a bad one, and rightly so. In short a landfill is a mound of waste which poses a threat to its surrounding environment. The waste currently in landfills is so compacted that it will never receive the oxygen or moisture required to decompose. We are beginning to reduce, reuse, and recycle, but we also need to think of a way to remediate in order to actually solve the problem. Through remediation, the problems of land filling could be solved along with our garbage crisis.

The Fargo landfill will be at capacity in a mere 18 years. The current plan is to cap the landfill, create a wildlife habitat and begin a new one. The landfill will not make a good habitat for anything due to soil, water, and air contamination, and it's location in an urban setting.

It is a fact that eventually the liners in landfills fail, polluting surrounding water and soil. According to Dr. Wei Lin, a professor at NDSU who teaches civil engineering courses dealing with water pollution, "There isn't a liner that doesn't leak". The landfill will create hazardous methane gas for at least 20+ years after it is closed. The landfill will only be monitored for 20 years after closure but will be toxic long after thereby creating the potential to poison the residents of Fargo Moorhead for years to come. An old Native American proverb says that we do not inherit the earth from our ancestors, but rather borrow it from our children. I think we need to repair the effects our actions have had on the environment, and not leave it for the next generation to deal with.

What This Project Will Accomplish

Theory or Unifying Idea

Landfill remediation will provide a cost effective, aesthetically pleasing, environmentally friendly solution to the garbage crisis we are facing. Rather than burying waste to remain in the land and poison us for decades, remediation will face the problem head on and break it down.

On par with the idea of remediation is the concept of reuse. In fact, the purpose of remediation is to create an area safe for use by humans, plants, and animals.

Combining remediation techniques and developing an end use provides an array of ideas to incorporate into this project. Closed circuit water usage, energy creation, education, display areas, and others yet to be discovered. These and other elements will come together to create treasure from trash.

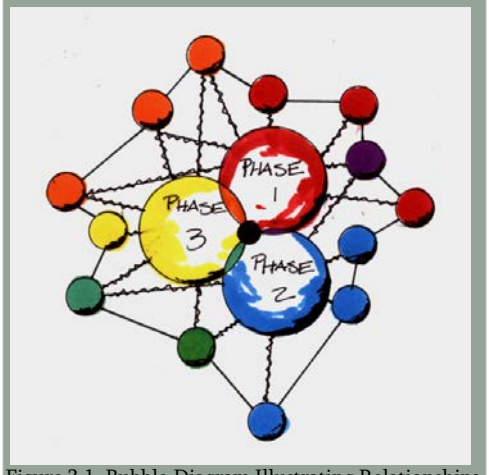

Figure 3.1 Bubble Diagram Illustrating Relationships of Parts of Project Related to One Another

Goals of this project

This project is about reclaiming a landfill and providing a viable reuse for it after closure. I believe part of the problem of land filling is the separation of elements. Each piece of landfills is designed by different organizations, and obligations of the landfill are turned over to different parties as it is in different stages. The consequences of certain actions are often overlooked or combinations of processes are missed because of this. When landfills are designed and operated, all parts need to be managed together in order to achieve the best product.

This project can be split up into three different parts to plan the best reclamation and reuse possible. Because of the size and complexity of this project it is understood that a certain portion of the detailing for project will have to be sacrificed in order to complete the project in the time frame provided.

Phase one will deal with extending the life of the landfill. This will be done by reducing the volume of waste put in the landfill through incineration and increased recycling efforts. Pollution levels need to be kept in check. Reducing the amount of pollution in the landfill should not in turn increase pollution in the air.

Phase two is the remediation of the soil, air, and water associated with the landfill. This will be a large portion of the project due to its combination of many separate techniques. The Fargo landfill needs to become as close to a closed circuit as possible. It will be impossible to contain all air, water, and soil entering or exiting the site, but I will make sure threats to surrounding areas are addressed. Phase two is a critical part of the project because it is a cutting edge effort. Landfills are not closed this way currently and restrictions and codes for closure of landfills are very strict. Even though this will be a test site, it still needs to function in order to be a credible design in the end.

Phase three will be the end use design. This is the final phase prior to completion of the project. It is an opportunity to teach people to think of all areas as assets rather than liabilities. It is also where I will attempt to make something out of nothing; to give the site a legitimate purpose; and thereby have a reason to reclaim the landfill other than environmental concerns.

Landscape Type
This project deals with natural resource development and/or sustainable design. Most of this project is about combining reclamation efforts into a system that will solve a problem and turn the problem into a community asset.

Project Emphasis
The emphasis for this project is remediation and reuse. Essentially, I will be recycling the Fargo landfill into something the residents can use again. Where master planning for remediation and reuse ends, an opportunity to showcase how these elements relate to one another is begun. I will reduce the distance between people and their waste, thus revealing the multiplicity and interconnectedness of the waste systems that support life. Where and how this will happen is yet to be determined in the master planning portion of the project. The ideal second and third phase of this project will demonstrate how people, plants, animals, and their waste will relate to and interact in the site All phases of the project will occur simultaneously and will affect each other throughout implementation.

Personal Goals and Objectives
My personal goals and objectives for this project are as lofty as my project goals and objectives. This project was chosen by the environmentalist in me. I hope this project will be beneficial to future students, not necessarily all in landscape architecture, and beneficial to me in helping to further understand environmental improvement and remediation. Some of my goals include:
-To further understand what combinations of processes work best for remediation
-To practice the commitment necessary to take a project from concept to master plan similar to what would be expected in an office setting.
-To put forth 100% effort from start to finish
-To attain the LHB sustainable design award
-To show off what I have learned in my 5 years of landscape architecture curriculum and what I am capable of to my friends and family

Site Introduction

Site Information

The Fargo landfill is located on the edge of West Fargo and is bordered by 7th Avenue N., 12th Avenue N., and 45th Street. It encompasses 160 total acres; 155 of which will be land filled. The landfill will be at capacity in 18 years and will accommodate over 8 million tons of waste. By comparison to landfills in other parts of the country this one is medium sized. I believe it is important to fix problems at home before going out and trying to solve other's problems. Since Fargo is currently my home, this landfill is perfect.

Because of the location of the landfill (in the Midwest) there is ample space to create new landfills after this one closes. The challenge will be to convince people to adhere to higher standards when it is not perceived as necessary. Another challenge will be the climate of the area. Plants, soil, and water have the tendency to freeze around here, which hampers remediation through biological means. One of the opportunities of the site is its high visibility. Some of the only topography in the area is the landfill, so if it is changed, people will notice. Another opportunity is that a project as comprehensive as this one has not yet been done. When one is, it will be recognized internationally. Fargo could be at the forefront of solving the world garbage crisis. I selected this site because of its proximity, and because of its personal interest to me. It is very innovative in design, and I hope it is still credible and worth further research after its completion.

Figure 3.2 The Fargo Landfill

(www.cityoffargo.com)

Clients/Owners

The City of Fargo currently owns and operates the landfill and will remain as such through the entire project. The clients for this project will be the City of Fargo, as a population and as a government. The residents will no longer be threatened by the landfill, and the government will not have to create another landfill for a long time or worry about liabilities of the landfill.

Users

Users of the site would be the residents of Fargo; more specifically students and civic groups. The hope is that people of all ages will be able to come to the site and learn about nature and the environment, or about more complex issues such as how the site works. An interesting idea would be to combine the education of younger children along with the education of university students. University students could be able to be a part of the monitoring and maintenance of the landfill.

Cost/Budget

The final cost for this project is difficult to determine. Other landfills of similar size cost tens to hundreds of millions of dollars to simply close, another factor is maintaining and monitoring the landfills for 30 years. The landfill will lose its some of its ability to produce methane through the implementation of my design. This will result in a loss of net profits from the landfill since the methane is sold to Cargill at a good price. Cargill burns the methane in order to heat it's boilers and produce it's products. This loss of profit will be offset by the introduction of a new source of income; incineration. The final cost of this project can be expected to be in the ballpark of $100 million. Many people would agree their health is priceless, so I think $100 million is justifiable. Also, the landfill will be operational a lot longer thereby retarding the startup costs of a new landfill. The expenses of this project would be incurred by anyone who brings waste to the landfill. It will be in the form of higher fees at the scale house. The higher prices will hopefully act to passively encourage people to recycle.

Figure 3.3 Recycling Cartoon
(www.cartoonstock.com


Figure 3.4 Fly Ash
(www.avtexfibers.com)


Figure 3.5 Constructed Wetland
(http://sofia.usgs.gov)

Major Project Elements

Project Needs
There are certain elements I have included in hopes of making this project successful. How and where these elements are implemented will be determined in the conceptual and master planning phases of the project. I believe it is important to identify them now in the hopes that they will be applied later.

Waste Reduction
Waste reduction is the first phase of the project and will be accomplished through multiple methods.

Incinerator
The incinerator will reduce the volume of garbage by at least 75% (Incinerators website) and will create electricity for the landfill to collect revenue. Strict regulations and multiple ways of reducing emissions need to be applied for this to not be an environmental threat.

Resource Recovery Facility
Non-combustible materials will be sorted out of ash here and sent to a recycling facility. This will prevent these materials from being added to the waste, and will provide additional revenue for the landfill

Remediation
Remediation is the second phase of the project and will also be accomplished through a variety of methods.

Landfill Cap
The cap of the closed landfill will no longer be impermeable. This will allow water and root systems to infiltrate the waste and to filter out toxins.

Plant Test Plots
These will allow people to learn which species and cultivars work best for phytoremediation. They will be implemented in such a way as to be aesthetically pleasing.

Leachate & Water Filtration
A closed circuit water system for the landfill will reduce the amount of water the city needs to clean, and will prevent some pollution of the Red River by toxins from the landfill. It will do this by collecting and reusing all water that enters the site. The only way water will leave the site will be by evaporation. It will also provide an educational opportunity for students.

Infiltration and Holding Ponds
A separate system will be used to contain and filter extra storm water. Since the water will not infiltrate the landfill, it will not be considered leachate and will not need extensive treatment. It will be treated in a series of ponds which will be functional and aesthetic.

Air Purifying
The landfill will no longer add dust and debris to the air around it due to improved wind buffers during land filling and lush vegetation after closure. Irrigation from the closed circuit water system will also contribute to lower dust amounts.

Environmental Showcase

The end use of the site is the third and final phase of the project prior to completion. It will be a place the people of Fargo and its surrounding areas to be affected by the waste they dispose of.

Classroom/Laboratory

This will be a space for lectures or testing of samples. There will be a built structure on site during and after land filling.

Demonstration Areas

These will be areas outside to demonstrate sustainable design elements and remediation ideas. These will teach students how land filling and remediation applications work, and why.

Sampling areas

People will be able to take soil, water, and vegetation samples on-site and analyze them in the laboratory.

Energy Creation

This will be accomplished through incineration. The landfill will hopefully be able to pay for itself, and be an asset to the community fund pool.

Site History

The first official Fargo Landfill was begun in the 1940's. This first landfill still exists, and is located on the 35 westernmost acres of the present landfill site. The first landfill did not have to follow government regulations on pollution. There is no liner at the bottom of this landfill. By definition the old landfill was actually a dump. The old landfill was closed in 1979, just before Subtitle D regulations of the Resource Conservation and Recovery Act were implemented. The old landfill was capped with a clay liner on top and planted with grasses. The present day landfill was begun in 1980 under the new government regulations. In fact, it was the first landfill in this area to meet government regulations. The landfill has been under successful operation for almost a quarter century. It has also recently begun collecting and selling its methane to Cargill at a substantial profit. The landfill takes in over 150,000 tons of waste every year and is expected to remain open for another 18 years. The landfill has already purchased land adjacent to the site to create a new landfill when this one reaches capacity.

Resource Conservation and Recovery Act

Subtitle C

a) Criteria for sanitary landfills

Not later than one year after October 21, 1976, after consultation with the States, and after notice and public hearings, the Administrator shall promulgate regulations containing criteria for determining which facilities shall be classified as sanitary landfills and which shall be classified as open dumps within the meaning of this chapter. At a minimum, such criteria shall provide that a facility may be classified as a sanitary landfill and not an open dump only if there is no reasonable probability of adverse effects on health or the environment from disposal of solid waste at such facility. Such regulations may provide for the classification of the types of sanitary landfills.

(b) Disposal required to be in sanitary landfills, etc.

For purposes of complying with section 6943 (2) [1] of this title each State plan shall prohibit the establishment of open dumps and contain a requirement that disposal of all solid waste within the State shall be in compliance with such section 6943 (2) [1] of this title.

(c) Effective date

The prohibition contained in subsection (b) of this section shall take effect on the date six months after the date of promulgation of regulations under subsection (a) of this section.

Subtitle D

(a) Closing or upgrading of existing open dumps

Upon promulgation of criteria under section 6907 (a)(3) of this title, any solid waste management practice or disposal of solid waste or hazardous waste which constitutes the open dumping of solid waste or hazardous waste is prohibited, except in the case of any practice or disposal of solid waste under a timetable or schedule for compliance established under this section. The prohibition contained in the preceding sentence shall be enforceable under section 6972 of this title against persons engaged in the act of open dumping. For purposes of complying with section 6943 (a)(2) and 6943 (a)(3) of this title, each State plan shall contain a requirement that all existing disposal facilities or sites for solid waste in such State which are open dumps listed in the inventory under subsection (b) of this section shall comply with such measures as may be promulgated by the Administrator to eliminate health hazards and minimize potential health hazards. Each such plan shall establish, for any entity which demonstrates that it has considered other public or private alternatives for solid waste management to comply with the prohibition on open dumping and is unable to utilize such alternatives to so comply, a timetable or schedule for compliance for such practice or disposal of solid waste which specifies a schedule of remedial measures, including an enforceable sequence of actions or operations, leading to compliance with the prohibition on open dumping of solid waste within a reasonable time (not to exceed 5 years from the date of publication of criteria under section 6907 (a)(3) of this title).

(Subtitle D continued)

(b) Inventory

To assist the States in complying with section 6943 (a)(3) of this title, not later than one year after promulgation of regulations under section 6944 of this title, the Administrator, with the cooperation of the Bureau of the Census shall publish an inventory of all disposal facilities or sites in the United States which are open dumps within the meaning of this chapter.

(c) Control of hazardous disposal

(1)

(A) Not later than 36 months after November 8, 1984, each State shall adopt and implement a permit program or other system of prior approval and conditions to assure that each solid waste management facility within such State which may receive hazardous household waste or hazardous waste due to the provision of section 6921 (d) of this title for small quantity generators (otherwise not subject to the requirement for a permit under section 6925 of this title) will comply with the applicable criteria promulgated under section 6944 (a) and 6907 (a)(3) of this title.

(B) Not later than eighteen months after the promulgation of revised criteria under subsection [1] 6944(a) of this title (as required by section 6949a (c) of this title), each State shall adopt and implement a permit program or other system or [2] prior approval and conditions, to assure that each solid waste management facility within such State which may receive hazardous household waste or hazardous waste due to the provision of section 6921 (d) of this title for small quantity generators (otherwise not subject to the requirement for a permit under section 6925 of this title) will comply with the criteria revised under section 6944 (a) of this title.

(C) The Administrator shall determine whether each State has developed an adequate program under this paragraph. The Administrator may make such a determination in conjunction with approval, disapproval or partial approval of a State plan under section 6947 of this title.

(2)

(A) In any State that the Administrator determines has not adopted an adequate program for such facilities under paragraph (1)(B) by the date provided in such paragraph, the Administrator may use the authorities available under sections 6927 and 6928 of this title to enforce the prohibition contained in subsection (a) of this section with respect to such facilities.

(B) For purposes of this paragraph, the term "requirement of this subchapter" in section 6928 of this title shall be deemed to include criteria promulgated by the Administrator under sections 6907 (a)(3) and 6944 (a) of this title, and the term "hazardous wastes" in section 6927 of this title shall be deemed to include solid waste at facilities that may handle hazardous household wastes or hazardous wastes from small quantity generators. (Environmental Protection Agency, website)

ND Land Filling Requirements/Regulations

'Landfills in the United States are governed by the Environmental Protection Agency. In North Dakota, landfills fall under the jurisdiction of the government health department. In 1991, the EPA imposed new laws governing landfills through the Resource Recovery and Conservation Act (RCRA). These regulations drastically changed the way landfills are operated today. The RCRA has three main goals:

1. To decrease the amount and/or toxicity of waste that must be disposed of by producing less waste to begin with.
2. Increasing recycling of materials such as glass, paper, steel, plastic, and aluminum thus recovering these materials rather than discarding them
3. Providing safer disposal capacity by improving the design and management of incinerators and landfills.

There are quite a few important issues involving the closure of landfills. Groundwater, Gasses; methane and non-methane, leachate collection systems, closure procedures and methods. The EPA has instilled these regulations for the safety of both humans and the environment (Bigger, 1998).

Groundwater

Groundwater pollution is a major concern of landfills because 50% of the United States' drinking water comes from groundwater. Because of the likelihood that many toxins could make their way into the ground water with relative ease, and the difficulties associated with removing these toxins, the EPA has implemented requirements for monitoring procedures. Owners of landfills must install enough wells to accurately assess the quality of the uppermost aquifer - 1). Beneath the landfill before it has passed the landfill and 2). At a relative point of compliance down gradient from the landfill. Sampling and analysis must be analyzed for both constituents detected initially and others, defined by the director of the state.

The owner must build and maintain a control system designed to prevent storm waters from running onto the active portions of the landfill. They must be able to handle at least a 25 year, 24 hour storm. All water workings must be managed according to the Clean Water Act (Bigger, 1998).

Figure 5.1 Drinking Water
(www.dow.com/images/water

Maximum Contaminate Levels

Below is a list of the maximum levels of contaminates allowed to be present in drinking water. Almost all these chemicals are present in much larger quantities of the leachate produced by the landfill. It should also be noted that there are potentially 6,000+ chemicals in leachate and landfills in general…only 200 or so are tested for.

Chemical	mg/L
Arsenic	0.05
Barium	1.0
Benzene	0.005
Cadmium	0.01
Carbon Tetrachloride	0.005
Chromium	0.05
2,4-Dichlorophenoxy acetoc acid	0.1
1,4-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007
Endrin	0.0002
Fluoride	4
Lindane	0.004
Lead	0.05
Mercury	0.002
Methoxychlor	0.1
Nitrate	10
Selenium	0.01
Silver	0.05
Toxaphene	0.005
1,1,1-Trichloromethane	0.2
Trichloroethylene	0.0005
2,4,5-Trichlorophenoxy acetic acid	0.01
Vinyl Chloride	0.002

(Bigger, 1998)

Figure 5.2 Methane Collection Pipe
(www.cityoffargo.com)

Figure 5.3 Methane Collection Building
(www.cityoffargo.com)

Gas Emissions

There are two important forms of gaseous emissions of concern to landfills. The first is methane (CH), the second is other gases. Methane is formed in solid waste establishments through the decomposition of waste. All gases are collected and either sold for fuel or burned on site. Methane is combustible in concentrations of 5-15% by volume in air. In 1991 the EPA ruled that owners and/or operators of all Municipal Solid Waste Landfill units must ensure that:

1. The concentration of methane gas generated by a facility does not exceed 25% of the lower explosive limit for methane in facility structures.
2. The concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary.
3. Owners and/or operators must implement a routine methane monitoring program to ensure the standards of this section are met. The type and frequency of monitoring must be determined on the following factors:
    a. Soil Conditions
    b. Hydrogeologic conditions surrounding the facility
    c. Hydraulic conditions surrounding the facility
    d. Location of facility structures and property boundaries
4. In addition to these rules North Dakota states that "methane and other gases from waste decomposition may not be allowed to migrate laterally from the landfill so as to endanger structures, environmental resources, or adjacent properties. The landfill has installed two probes per hectare of landfill surface area that has retained waste for at least two years. Gases are collected form these probes four times a year. They are measured and analyzed by specialists according to regulatory procedures. The information is then reviewed by authorities as well as owners and/or operators. If gaseous emissions are exceeding limitations, the owner must immediately notify the state and develop a remediation plan within 60 days (Bigger, 1998).

Leachate Collection System

Every landfill must have a working leachate collection system (McBean, et al., 1995).

Closure and Post Closure

The cover of the landfill is the main element in the closure process. It must be composed of an infiltration layer of a minimum 18" earthen material and an additional 6" of earthen material for the purpose of plant growth and erosion control. The cover must have a permeability of no greater than 1 x 10^-5cm/sec. The owner is responsible for the maintenance of the cover, ground water and gas monitoring, and continued leachate management thirty years after the initial closing (Bigger, 1998).

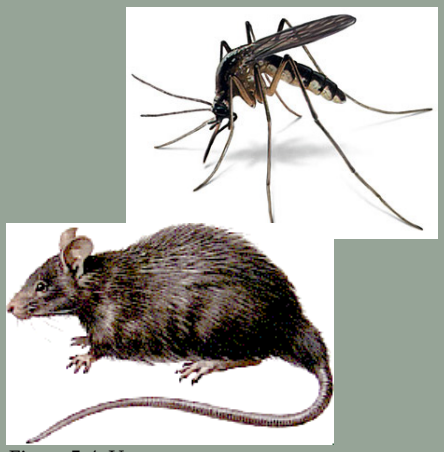

Figure 5.4 Vectors
(http://wichita.edu/mschneegurt/bio103.gif

Figure 5.5 Banned Items
(www.cityoffargo.com)

Additional Issues During the Life of the Landfill

The control of vectors, fires, odors, blowing litter, and scavenging is an additional responsibility of the landfill operator. Vectors include any rodents, flies, mosquitoes, or other animals that could possibly transmit disease to humans. Open burning of waste is not permitted.

The owner must control public access to prevent illegal dumping and public exposure.' (Learning With the Landfill, 1998)

Items Not Allowed At the Landfill:

*Appliances - the landfill will accept them for a fee and transfer them to Hazer's Auto & Truck Salvage. The fee is $20 plus the weight of the appliance.

*Batteries - most stores provide battery recycling free of charge

*Motor Oil - the landfill has a used motor oil tank, it simply can not be allowed in the landfill

*Tires - the landfill will accept them for a fee and then transfer them elsewhere to be recycled

*Yard Waste - this must be taken to a compost/recycling facility. Conveniently there is one located adjacent to the landfill. It is owned and operated by the City of Fargo as well. (City of Fargo, website).

Figure 6.1 Map of United States

(www.rootsweb.com)

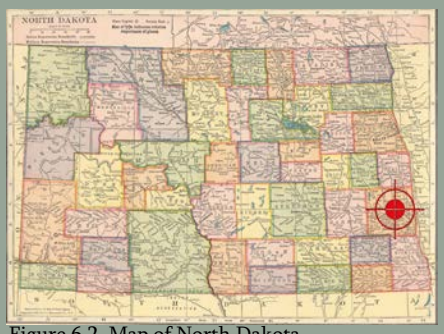

Figure 6.2 Map of North Dakota

(www.rootsweb.com)

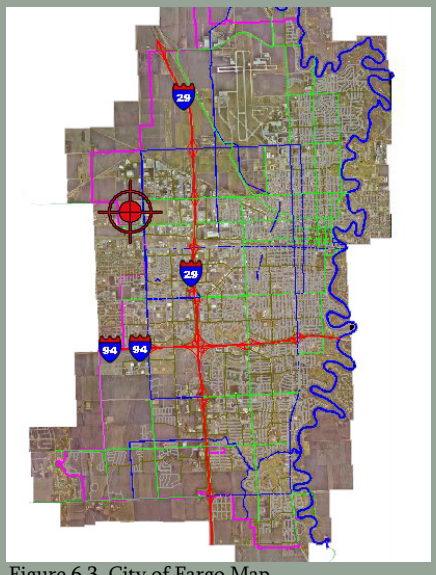

Figure 6.3 City of Fargo Map

(www.cityoffargo.com)

Specific Location

The Fargo landfill is located on the border of Fargo and West Fargo in the state of North Dakota. It is bordered to the north by 12th avenue north; to the east by 45th street; and to the south by 7th avenue north. The site is located in an area zoned for heavy industrial, industrial, and agricultural uses but is relatively close to residential areas, schools, and retail areas. The location of the landfill adjacent to the industrial park prevents the viability of turning the landfill into a successful park or wildlife habitat. This lead to the idea of creating a showcase for waste. The site is easily accessed, which will accommodate large volumes of visitors.

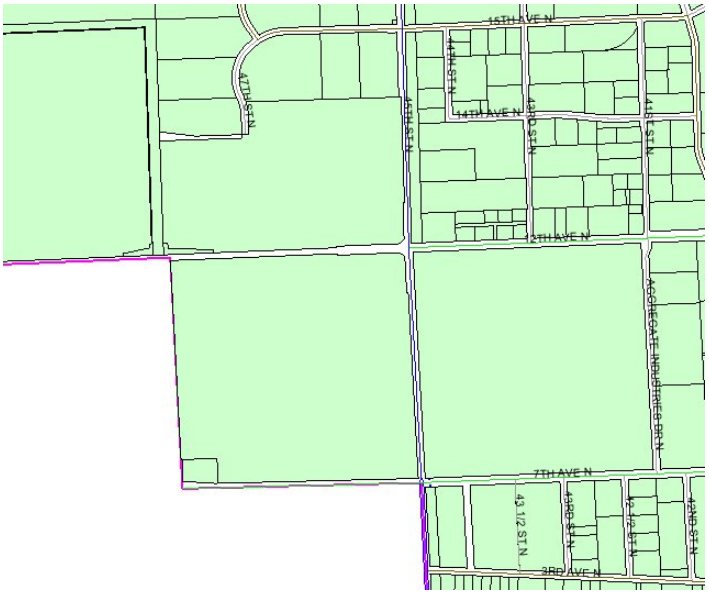

Figure 6.5 Fargo Industrial Park Map

Figure 6.4 Landfill Aerial Photo

(www.cityoffargo.com)

Site Survey/Land Use Diagram

On the map below: The blue area has been dubbed the 'Old Landfill'. This area is unlined and poses a very serious threat to the environment. This area needs to be addressed first in the remediation plan. The red area refers to the currently active land filling area. The northernmost portion of this is full and has been capped and revegetated. Part of the waste in this area should be reclaimed in order to prolong the life of the landfill, but part should be left as a reminder to people of their actions. The green area illustrates the portion dedicated to polluted soil and chipping wood. The contaminated soil is cultivated and re-cultivated to aerate it and remove pollutants. This soil is then used as daily cover for the landfill. The wood that is chipped is sold as a fuel source to companies in the southern part of the state. The yellow area is the part of the site to be filled after the red area is full. It also includes the entire green portion of the site as well. The sections of the landfill will be at capacity in 18 years A new row of cells is currently being lined for use. The yellow and green areas will take a lot longer to fill due to incineration. The pink area is the site entrance. This is where trucks are weighed and charged. It is also the area not to be filled with waste. This area would make a good entrance to the site during and after remediation.

Figure 6.6 Land-Use Diagram
(www.cityoffargo.com)

Figure 6.7 Combine

(www.gis.usu.edu/ArcWebpage/combine.jpg

Economic Base

North Dakota as a whole is an agriculturally based state. People in this area have made their living from the land for centuries. This is not necessarily the case in Fargo. The Fargo-Moorhead area has a more diverse economic base ranging from research & technology to retail to food service. The Fargo area has a very good job market, with only a 2.2% unemployment rate. The average annual salary of a resident of Fargo is $31,320 (Fargo Demographics, website). These statistics contribute to the impending success of a project like this. There is a sufficient economic base to fund it, as well as enough people to be interested in having a space such as this. Fargo is the largest city in North Dakota and is the commercial, financial, cultural, and medical center of the area. Fargo is unique in that it requires no more than a 20 minute drive from the heart of the city to reach the open fields common to the rest of North Dakota.

Demographics

The population of Fargo is close to 100,655 people. This number of people is added to significantly when West Fargo Harwood and Horace North Dakota, along with Moorhead and Dilworth Minnesota are taken into account; not to mention the students of North Dakota State University, Minnesota State University Moorhead, and Concordia College who are not considered residents here. The population of Fargo is steadily increasing at 22.2% every 10 years. The population is 50/50 male to female with the largest age group being 25-34 years old at 16.7%. The 20-24 years old age group is a close second at 14.9%. Caucasians are the predominate race of the area at 95%, followed by 1.7% Asian, 1.3% Hispanic, 1.3% American Indian, and 1% Black. There are about 39,268 households in the area, 52.8 of which are family households. Of the households, 10,751 of these have children under the age of 18. The average size of families in the area is 2.91 (Fargo Demographics, website). The diversity of Fargo is what will help make this a successful project. People here want cultural and educational places to visit. The people of Fargo have been trying to make it a more attractive city to tourists and residents for quite some time. The remediation of the landfill will provide another opportunity for this.

Figure 6.8 Waste Pile at Fargo Landfill

Figure 6.9 Leachate Leakage

(www.homestead.com/thedumpsite/files.jpg)

Figure 6.10 Football Field/1 Acre

(www.vmedia.rivals.com/uploads/935/128504.jpg)

Environmental Issues

Ah, environmental issues at a landfill, where to begin. The most important environmental issue of a landfill is a failed liner. When the liners fail, surrounding groundwater and soils are severely polluted. A way to prevent this would be to remediate the waste rather than leave it to slowly decompose naturally. Another concern would be erosion. Landfills have very steep sloped sides. It is imperative to prevent erosion so the cap is not carried away by the wind or rainfall. Yet another issue is the leachate water produced after precipitation. This water is the primary contaminate associated with landfills. The leachate needs to be treated before it can be released into the surrounding water table. One more concern would be the waste itself. Some items are banned from a sanitary landfill, for safe disposal elsewhere. Items like batteries, paint, or other household hazardous waste can cause an increased likelihood of liner failure or more sever pollution. Some people throw these items in their regular garbage anyway, without thinking of the consequences. It must be planned for some hazardous waste to be included in the landfill in order to prevent dire consequences later on. Landfills today also try to prevent roots of cover vegetation from protruding through the cap into the waste. Such intrusions allow for water to permeate the landfill which creates more leachate and methane production. Methane production is the final environmental issue to be discussed. Methane production lasts for at least 30 years after a landfill is closed. It can prevent vegetation from growing, increase offending odors, or worse, cause an explosion if it is not properly monitored and released. At minimum, landfills need to collect the methane and either burn it themselves, or sell it to be used to create electricity. The environmental issues of the landfill should be the focus of this project. They will provide considerable opportunities and constraints like preventing pollution or contamination, recovering materials, developing new techniques for capping and treatment, showing people the consequences of the waste they create, and many others to be discovered during design development.

Site Area

The overall area encompassed by the Fargo landfill is 160 acres. This is equivalent to 160 football fields. 155 of those acres will eventually be filled with garbage. The area of the old landfill is the west 35 acres of the site. The landfill will reach 30' down into the earth and 70' upward to create a 100' mountain of trash. The landfill will contain over 8 million tons of waste when it reaches capacity. The shear size and volume of the site provide plenty of area for the many elements needed to make this site work. The surface area of the landfill will need to be increased in order to remediate the waste mountain successfully.

Major Landmarks

The landfill is definitely the major landmark of the area. Bordering the landfill is Cargill to the west (coincidentally this is where the collected methane is shipped), the Fargo Industrial Park to the north, northeast, and east, the Fargo Compost site to the southeast, and a construction recycling facility to the south. The area surrounding the landfill has nothing to draw people to the area unless they work near it. The remediation of the landfill will draw people to the area and possibly increase business for the adjacent companies. The surrounding areas also seem to advocate recycling and reuse. This only adds to the notion that the landfill should be reused as something positive.

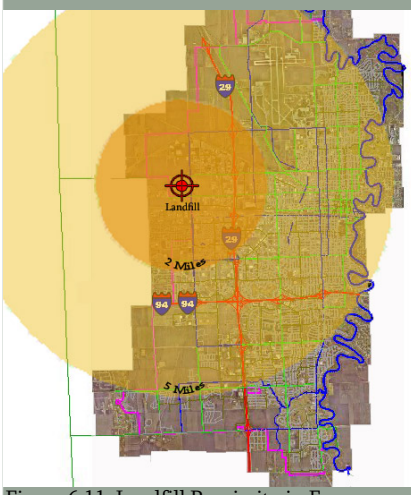

Figure 6.11 Landfill Proximity in Fargo

(www.cityoffargo.com)

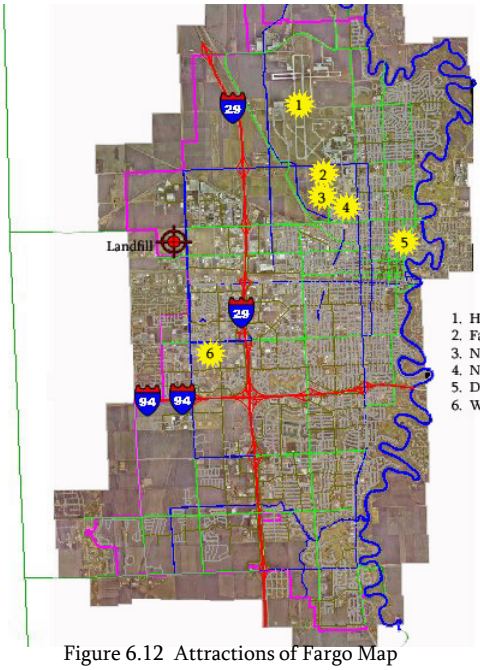

Figure 6.12 Attractions of Fargo Map

(www.cityoffargo.com)

Figure 6.13 Downtown Fargo

(www.members.cox.net/audobon5425/fm/fm.htm

Figure 6.14 FargoDome

www.nlfan.com/Fargo/photos/fargodome.jpg

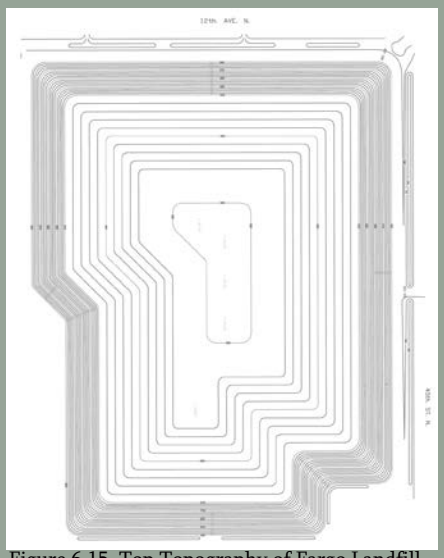

Figure 6.15 Top Topography of Fargo Landfill (www.cityoffargo.com)

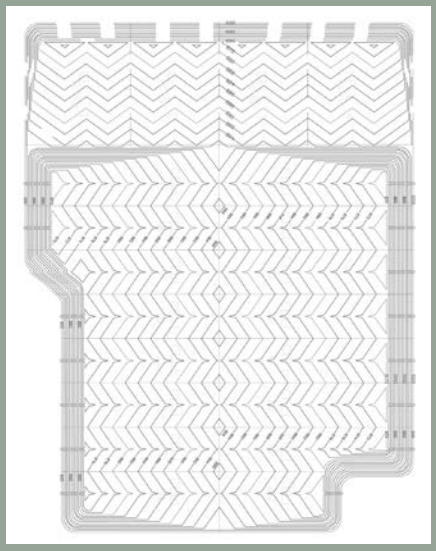

Figure 6.16 Bottom Topography of Fargo Landfill (www.cityoffargo.com)

Site Topography

The topography of the landfill actually begins 30' underground. The cells were excavated to this depth to allow for a liner, sand layer, and leachate collection system, and the additional waste contained in these cells. The landfill is graded so there is a 3.5% slope to the outside and northern boundaries at the base of the landfill to allow for collection of leachate. The sides of the bottom of the landfill are at a 26.6% slope until the landfill reaches the road grade, or 900' above sea level. The landfill then will extend to 70' above the beginning grade of 900'. The sides of the visible portion of the landfill also have a slope of 26.6% for the first 45' with a much less severe slope of 2.8% for the next 22 feet. The last two vertical feet of the landfill will have a slope of just 1% to allow for stormwater drainage off the landfill. All water that enters the site is collected and piped to the City's Wastewater Treatment Center The 70' elevation change severely contrasts with the surrounding flatness of the outlying area. This allows the landfill to be visible for miles. The topography can be manipulated as long as a minimum 1% slope is maintained for proper site drainage. It should also be noted that 70' is the maximum height the landfill can reach to meet government regulations. The topography of the landfill should be altered to not only provide more aesthetic interest, but to also increase the surface area to aid in remediation. This can be done in such a way as to provide the same amount of land filling space.

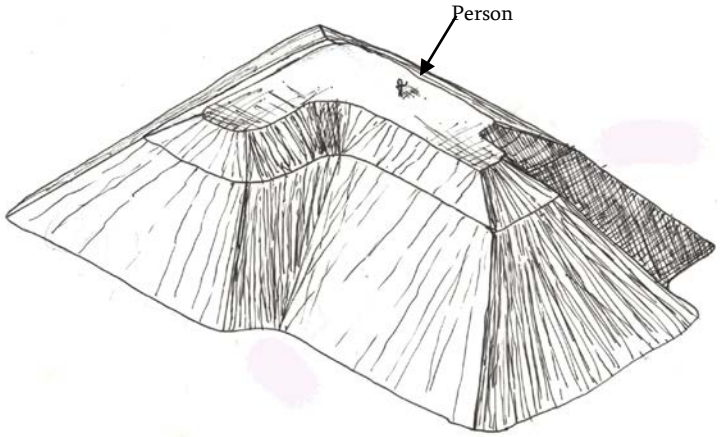

Figure 6.17 Aerial View of Fargo Landfill


Figure 6.18 Vegetated Part of Fargo Landfill


Figure 6.19 Vegetative Buffer of Fargo Landfill


Figure 6.20 Gulls at Fargo Landfill

Vegetation

The vegetation of the landfill is comprised of buffer trees and shrubs along the south and east borders of the landfill and cover plants on the north side of the landfill. The buffer to the east is comprised of Ponderosa Pine, Redosier Dogwood, and Korean Lilac along with miscellaneous ditch vegetation. The buffer is starting to thrive and is almost tall enough to mask direct views of the landfill. Next to the scale house is a planting of several Sugar Maples. The southern border of the landfill is comprised of Poplars and Ash trees. These trees are well established and serve as a good screen of the landfill. The north side of the landfill has been capped and covered. The cover vegetation is comprised of Kentucky Bluegrass, Fine Fescue, and Perennial Rye. Additional vegetation has begun to grow due to the spread of seed by wildlife, and wind mechanisms. The existing vegetation of the landfill is extremely limited. This is due in part to the cost of plant variety, the limited growing medium (2' of soil), and the climate extremes of North Dakota. The types of vegetation should be expanded to create visual interest in the site as well as for remediation purposes and pollution reduction.

Wildlife

There is limited wildlife at the Fargo landfill. The most noticeable would be gulls and black birds that have made the landfill their main food source. These birds constantly circle the landfill or perch on the adjacent power lines. The birds do not harm the land filling process in any way, but ingest harmful wastes and possibly transport these wastes off site. The other wildlife of the landfill would be a variety of vermin such as mice, rats, and rabbits. These animals also do not affect the land filling process, but could transport harmful material off site. The animal population will need to be controlled in some way as to keep landfill material on site.

Figure 6.21 North American Geology

(www.blackboard.ndsu.nodak.edu/bin/common/course_id=_2931)

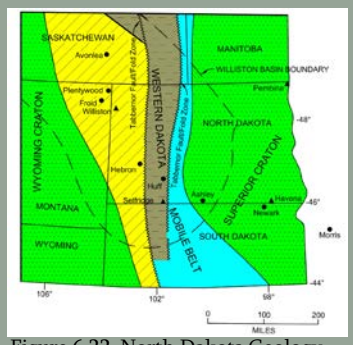

Figure 6.22 North Dakota Geology

(www.blackboard.ndsu.nodak.edu/bin/common/course_id=_2931)

Figure 6.23 Fargo Landfill Hydrology

(www.cityoffargo.com)

Geology

Fargo is located in the Red River Valley in the remnants of glacial Lake Agassiz. The area is comprised of glacial deposits or a loose mixture of pebbles, sand and silty clay. Glacial lake remnants are the outwash areas, beach, and shore deposits of loose sand and gravel (Bigger, 1998). The geology has affected the site by providing minimal drainage, and poor building conditions. It is also what has made the Fargo area so flat.

Soils

The landfill is located on Fargo and Ryan clays. These soils are typically deep level, poorly drained, fine textured soils formed in the glacial lacustrine areas. Sediments are found in the flats and slight depressions of glacial Lake Agassiz. The Fargo and Ryan clays provide a deep and level surface, but a concern is its shrink swell factor which occurs during the winter freeze and summer thaws (Bigger, 1998). The shrinking and swelling of the earth create an area where the soil is constantly moving, therefore building structures becomes difficult. At the landfill the shrink swell is not a factor underneath the main part of the landfill, since it is 30' below road level. Where it would be a factor would be the edges of the landfill, and any part of the landfill not used to store waste.

Site Hydrology

Any water that enters the landfill is either directed off the landfill by the cap or filters through the landfill to create leachate. All the water on the site is collected and pumped to the Wastewater Treatment Facility located on 32nd avenue north in Fargo. The wastewater is treated and discharged into the Red River. I would like to create a closed water system at the landfill to reduce the amount of water discharged into the river. A closed system would also be a great learning opportunity for visitors to the site. The site drainage would be altered with the manipulation of the site's topography.

Figure 6.24 Major Roadways of Fargo
(www.cityoffargo.com)

Figure 6.25 School Districts of Fargo
(www.cityoffargo.com)

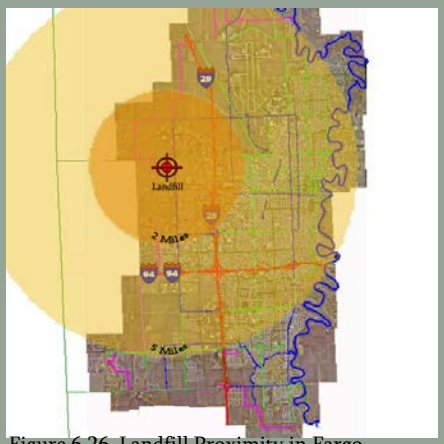

Figure 6.26 Landfill Proximity in Fargo
(www.cityoffargo.com)

Transportation Linkages

The Fargo Landfill is extremely easy to access. To the north the site is bordered by 12th avenue which is considered a minor artery by the city of Fargo. To the east is 45th street, which is considered a major artery. To the south is 7th avenue which is considered a minor artery as well. This allows for easy access for visitors to the site. It will also minimize confusion about directions to the site.

Proximity to Schools

Since the landfill is located on the west-central side of Fargo, this places it in a relatively central location for access by schools. There are over 30 schools located within seven miles of the landfill in Fargo and West Fargo. The landfill would be a great place for field trips for students and residents of Fargo to learn about their environment and their waste.

Views

Views from the landfill are extensive. Since there is limited topography, one can see for miles without interruption. The views off and on site are impressive, but not necessarily good. This is due to its location in an industrial park, and trash that flies about on windy days. Views of the landfill are also extensive since it is the major topographic feature of the area. These views are also impressive but not good. The landfill is literally a giant pile of trash, until it is covered. Then it is a pile of trash masked by grasses and perennials. The extensive views give the area high visibility which can be taken advantage of to promote the area.

Figure 6.27 Views at and of the Fargo Landfill

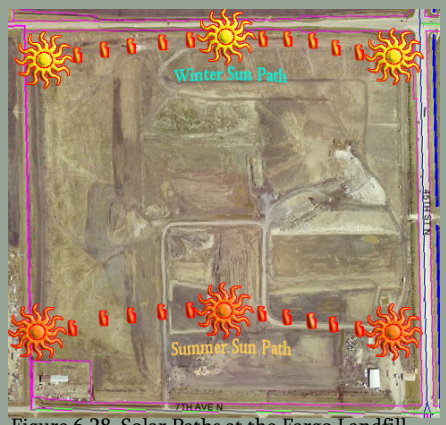

Figure 6.28 Solar Paths at the Fargo Landfill

(www.cityoffargo.com)

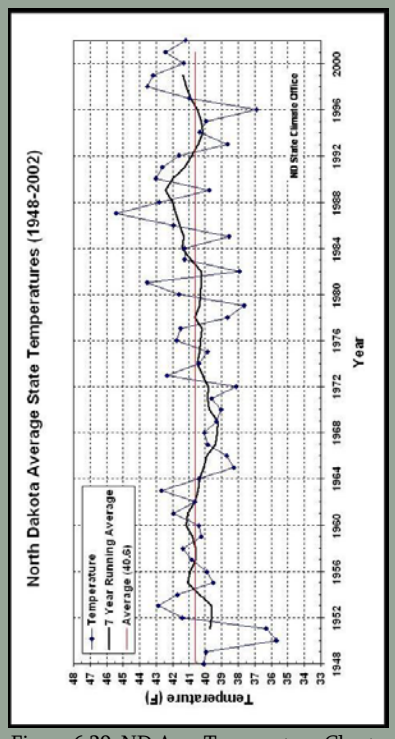

Figure 6.29 ND Avg. Temperature Chart

(www.soilsci.ndsu.nodak.edu/Enz/enz/StateAvg.htm)

Solar Orientation

Day length and solar zenith angle are important factors affecting North Dakota climate and microclimate. Day length ranges from less than nine hours in December to more than 16 hours in June. Noon sun angles are much higher in summer than in winter. The combination of these factors at North Dakota's location produces much more radiational energy at the earth's surface in summer than in winter, which contributes to the large seasonal temperature changes and the general north-south temperature gradient across the state. The different sides of the landfill receive differing amounts of sunlight daily and seasonally. This will affect moisture and temperature levels of the sides. These elements dictate what type of vegetation will work best on each respective side. It will also affect placement and orientation of any built structures to be added.

Annual Precipitation

The Fargo area is a fairly arid region. The area receives between 12 and 23 inches of precipitation per year. It seems the number would be greater considering the area receives over 20 inches of snowfall per year, but snowfall has less water content by volume than rain. Precipitation rates are greatest during the spring and autumn months of the year. Summer and winter are comparatively dry periods. This affects the types of vegetation to be grown drastically. The plants will need to be able to handle periods of wet and dry. The implementation of irrigation as a part of the closed-circuit water system will help alleviate effects of the dry periods. The water treatment system needs to be able to handle seasonal influxes of runoff and leachate in the spring and fall months, the wettest periods of the year.

Annual Temperatures

The temperatures in Fargo fluctuate drastically from season to season. Throughout the year temperatures can range from -25° Fahrenheit to over 100° Fahrenheit. This creates a harsh environment for plant growth. Plants in the area need to be extremely hardy in order to survive. The area needs to be designed to minimize the effects of temperature on plant and animal life.

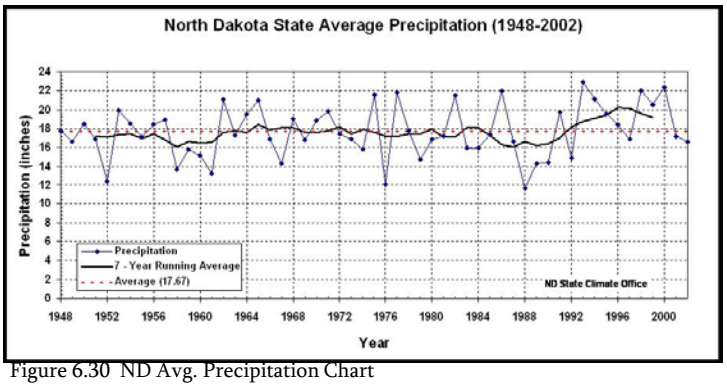

Figure 6.30 ND Avg. Precipitation Chart

(www.soilsci.ndsu.nodak.edu/Enz/enz/StateAvg.htm)

Figure 6.31 Wind Patterns at Fargo Landfill (www.cityoffargo.com)

Figure 6.32 Built Structure at Fargo Landfill

Figure 6.33 Dump Truck at Fargo Landfill (www.cityoffargo.com)

Prevailing Winds

The average wind speed is at its greatest in ND in late winter and early spring. The wind is at its lowest speed during summer months. The winds in the Red River Valley happen to be 10-20% higher than the rest of the state. This is due to the flatness of the area On an annual basis, the prevailing wind flow at Fargo shows strong incoming north and north-northwest flow and a strong south and south-southeast return flow. The wind on site needs to be minimized to alleviate the wind-chill effect in summer, and the blowing waste year round.

Existing Structures

There are minimal built structures at the landfill to accommodate the highest volume of waste. The landfill will not be able to accommodate built structures on top of the waste pile for at least 30 years after closure to allow for settling time. The current structures include: a scale house to weigh trucks and charge fees for dumping, an office to house documents of the landfill and provide a break-room for employees, an equipment quonset that houses the landfill's bulldozers and trucks, a methane collection building that collects and ships the methane to Cargill, there is also a flare built into the methane collection building to prevent excessive buildup of methane or explosions, and leachate collection pumps located at the base of the landfill on top of the liner, these pumps transfer the wastewater to be treated off site. All the existing structures on site will either remain in place or be reused in a way to keep with the theme of recycling on site.

Acoustic Environment

The landfill is an extremely noisy place. This is because of the constant stream of trucks coming to unload waste, and the bulldozers that move back and forth to compact the waste. The methane collection system and flare add noise as well, which is not noticed on top of or to the south end of the site due to the high volume of noise created by the trucks and bulldozers. If a learning center is to be operational during active land filling, it will need to be soundproofed to allow for classes or demonstrations to be held.

Opportunities and Constraints

Opportunities

-The landfill is seen as an eyesore in the community, almost any design solution will be seen as an improvement.
-The landfill is full of excess nutrients for plant material.
-The landfill is highly visible.
-Is the perfect location to show people the implications of their waste.
-Will be able to manipulate topography into an interesting landform.
-Will be able to showcase different elements of landfills all at once
-The landfill is not closed yet, so remediation can begin at an earlier stage than usual.

Constraints

-The limited annual precipitation might inhibit plant growth
-The variations in temperature through seasons will have a detrimental effect on plant material.
-The design solution must not allow pollution of surrounding areas to occur.
-People have a bad perception of the landfill, and may not want to spend the money required to remediate it fully.

Figure 7.1 Fresh Kills Landfill Images
(www.nyc.gov.html/dcp/html/fkl)

Figure 7.2 Fresh Kills Landfill Site Plan
(www.nyc.gov.html/dcp/html/fkl)

Figure 7.3 Fresh Kills Landfill Aerial
(www.nyc.gov.html/dcp/html/fkl

Fresh Kills Landfill
Staten Island, NY

Site History
Before Fresh Kills was a land filling site, it was a low-lying marsh filled with creeks and an excellent habitat for various birds and fish. Part of the site remains this way, and has been designated a significant fish and wildlife habitat by the New York Department of Environmental conservation.
Fresh Kills has been in operation since 1958 and encompasses 2,200 acres. By 1997 three of the landfill's six cells containing waste had been capped. The rest are expected to be capped by 2011. The landfill was closed in 2001, but was re-opened to accommodate debris from the World Trade Center attack of that year.

Site Elements
The park plan for the redevelopment of Fresh Kills will be implemented in 2007. It is considered to be one of the most ambitious public works projects in the world and will be a model for sustainable regeneration and nature led development. Some of the main elements are: *Recreational fields, Biking /Hiking trails, Event arena, Golf Course, Marsh/Tidal wetland preserve, Green House Clusters, World Trade Center Memorial site, Boardwalk, and a link to adjacent LaTourette Park.*

Applications
The redesign of Fresh Kills landfill sheds a new light on the reclamation of landfills. The project was an international competition and opened the door for new and innovative design solutions for the future. Truth be told, it was this project that led to my interest in the subject of landfill reclamation leading to my capstone project. It provides a setting for humans, wildlife, birds, and plants all in one. It is also a new form of public ecological landscape that considers human and environmental needs. I would like to incorporate these ideas into my project.
The design for Fresh Kills is an innovative solution, but is superimposed on conventional ideas. The landfill will be capped in the standard way of a liner, impermeable clay, and minimal soil as a growing medium for vegetation. The design will definitely mask the landfill underneath, but it will do nothing to remediate the toxins or speed up the break down of materials. The citizens of New York will always have a park sitting on a pile of waste. I will be rethinking these solutions for my project.

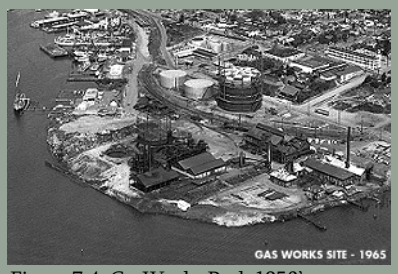

Figure 7.4 GasWorks Park 1950's

(www.cityofseattle.net/parks/GASWORKS.htm)


Figure 7.5 GasWorks Park Plan

(www.cityofseattle.net/parks/GASWORKS.htm)


Figure 7.6 Pollution Sign at GasWorks Park

(www.cityofseattle.net/parks/GASWORKS.htm)


Figure 7.7 GasWorks Park

(www.cityofseattle.net/parks/GASWORKS.htm)

Gasworks Park
Seattle WA

Site History
On the North side of Lake Union in Washington State, was a beautiful lakeshore perfect for birds, wildlife, and fish. In 1906 an industrial plant was constructed here to manufacture gas from coal. The plant operated until the 1950's when the import of oil made the plant obsolete. In 1962 the abandoned and contaminated area was acquired by the city of Seattle for a park. By 1975 the park was open to the public.

Site Elements
Gas Works Park occupies 19.1 acres on the north shore of Lake Union and has an excellent view of Seattle. It was initially said that nothing would grow on this site due to contaminants of hydrocarbons, soot, and petrochemical waste polluting the soil. Looking at some of the pictures I would say they were right. Topsoil has been added to parts of the site to allow for moderate plant growth. Despite the remaining toxic pollution, the park remains a favorite of Seattle residents. As many as 50,000 people congregate there for the Fourth of July. People use the site for: Frisbee, Sunbathing, Kite flying, Kayak launching, picnicking, and viewing their city. The main elements of the site are: *Old machinery painted for a play barn for children, a manmade hill constructed for kite flying, a sundial at the top of the hill, and various paths to accommodate users.*

Applications
The creation of Gas Works Park on a polluted site opened the door for engineers and landscape architects to work together to crate a place for the public to enjoy. During the 13 years the land was acquired but not yet opened, the site went through some remediation procedures. The site had to be tested to make sure it was safe enough for people to go there. People have really come to enjoy the park (for its open waterfront with great views), but concern has been raised about people ignoring warning signs posted for their protection.
Gas Works Park was indeed remediated a bit in the sixties and seventies, but was mainly covered with some topsoil and turfgrass. The toxins still remain in the ground and water, with little between them and visitors to the site. The visitors are in danger when they are exposed to these pathogens, and so is any wildlife that may come into contact with them as well. Eventually these toxins will not pollute the site anymore, but that will be due to them leaching off the site into adjacent soils or the groundwater. The Fargo landfill needs a solution that will treat the site so it will not endanger anyone.

Figure 7.8 Ground Water Extraction Pump

Figure 7.10 Filtration Pond Construction

Figure 7.9 Water Aerator & Filtration Pond

Becker County Landfill

Detroit Lakes, MN

Site History

The area of the Becker County Landfill used to be just like all the other land around it. It was semi-hilly and used for agricultural purposes. The Landfill began land filling operations in 1972. The landfill operated until 1990. It is 33 acres and contains 1,372,000 cubic yards of waste. In 1992, the Minnesota Pollution Control Agency indicated the landfill required immediate action to protect the public health and environment. In 1996 it was discovered that half of the landfill was only covered with 6"-1' of cover, rather than the 3'-4' required by Minnesota law. A groundwater extraction and treatment system needed to be installed to treat water polluted from the landfill.

Site Elements

The landfill is now covered with an impermeable synthetic membrane with 2.5' of soil on top of it. Landfill gas is extracted and burned through a piping system. No energy is created from this process and the system only operates at 54% during winter months due to freezing. Landfill gas has seeped through the 'impermeable' membrane and is preventing vegetation from growing near well-heads. Waste was removed from 15 acres of the site in order to create a stormwater management system, which also creates a buffer between the landfill and its property boundary. The environmental impact of the landfill is monitored by many wells in and around the landfill. Water wells around the landfill are contaminated with numerous volatile organic compounds, but levels are now stabilized and systems have been put in place to treat contaminates. In 2003 a groundwater remediation system was constructed. The costs of these remediations have been steep. The total for one year was $180,143.27, this is a few years after the landfill went through it closure procedures. The landfill will have to spend at least this much money in following years in order to prevent further pollution and to treat what they have.

Applications

This case study illustrates exactly what I would like to prevent from happening at the Fargo Landfill. Conventional techniques for landfill closer combined with questionable remediation spell disaster for the environment and people near landfills. The Becker County Landfill has taken the right steps to correct the problem it has created. I would like to prevent the problem before it starts. Landfills across the country are closed this way all the time. It costs less initially, until pollution occurs and remediation is required. Not to mention the priceless costs to people's health and the environment. A better solution would be to spend more money initially to prevent problems later.

Taos Living Lab
Taos, NM

Site History
In 2003 the New Mexico State Legislature allocated funds to build the Living Lab. The construction of the lab began in the fall of 2004. The lab is located adjacent to the Taos middle school.

Site Elements
The Living Lab is a center to promote ecological literacy for students throughout Taos County. It provides education in ecology, agriculture, aquaculture, engineering, and environmental restoration. The learning space is engineered to demonstrate the most innovative concepts in sustainable buildings, ecological design, and environmental stewardship. The building is self sustaining. It generates power from the sun, collects rainwater for irrigation, and reclaims wastewater through a Living Machine® system. The Living Machine® uses communities of microorganisms and plants to digest organic compounds in wastewater. Everything on site has a multiple use and nothing is wasted; just put to a new use. Through the Living Lab, kids learn that natural systems can transform waste into valuable resources.

Figure 7.11 Bamboo at Taos Living Lab

(www.dharmalivingsystems.com/living machines

Applications
The Living Lab is teaching children and young adults about the importance of ecology, and recycling. Wastewater is filtered and used for irrigation, the solids are used as food for mushrooms and then as fish food. It is an excellent example of sustainability. I would like to incorporate something like this at the Fargo Landfill, only with a much larger scope. People of all ages need to be educated about the ease and feasibility of re-using materials, and keeping the environment healthy. What better location to do this than a landfill. Numerous new techniques and ideas for land filling could be created and implemented here.

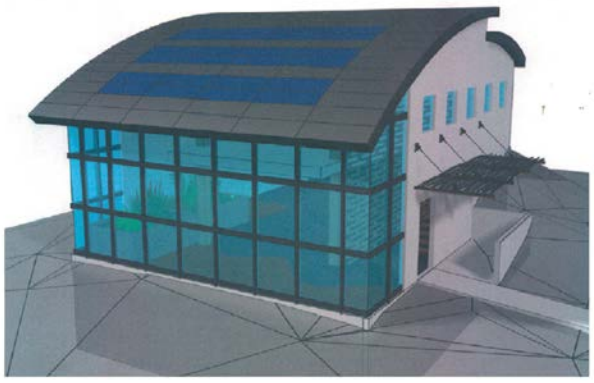

Figure 7.12 Taos Living Lab Model

(www.dharmalivingsystems.com/livingmachines

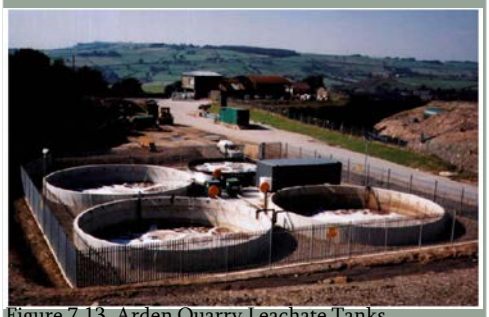

Figure 7.13 Arden Quarry Leachate Tanks
(www.drydenaqua.com)

Figure 7.14 AFM Filter
(www.drydenaqua.com)

Arden Quarry Landfill Leachate Treatment System
Edinburgh, UK

Site History
Midway through the year 2000, the Arden Quarry Landfill implemented a new leachate treatment system. The system has since been working at 100% compliance with discharge consent.

Site Elements
The leachate treatment system here operates on the principle that landfill leachate needs to be treated efficiently, reliably, and as simple as possible; many systems are over engineered and don't take into account the biology of the process. Bacteria, protozoa, algae, and multi-cellular organisms develop in the treatment system. Their activity treats the leachate; it is actually their life support system. This system uses air diffusers to incorporate oxygen into the tanks because of its high level of transfer, and gentleness with the bacteria floc. The system also uses open air lagoons. I know how it sounds, but as long as oxygen levels are maintained above a certain point there is no release of odors. It also creates an environment for photosynthetic algae, which further increase the oxygen levels and scavenges ammonia, phenols, and some heavy metals.
There are essentially five steps in the treatment process. 1. Raw leachate is first treated by anaerobic bacteria in tank one; oxygen is later incorporated to facilitate aerobic bacteria. When they are done feeding on their toxins and their food source is depleted, the bacteria will feed on themselves. This prevents the buildup of sludge; some systems have been in place for over ten years without needing sludge removal. 2. In tank two and three nitrifying bacteria oxidize ammonia into nitrate. Separate tanks for autotrophic and heterotrophic bacteria provide for more stable treatment. 3. The leachate is filtered to remove bacteria and other organisms which are then put back in their respective tanks to retain their treatment capabilities. 4. The leachate in now put though an Aqua Filter Media®. The AFM is made of recycled green and brown glasses which have been processed to create a media resistant to biofouling. This filtration method will replaced standard sand filters due to its treatment capabilities and its low cost. 5. The leachate is now free of most hazardous or toxic substances and is now pumped into the sanitary sewer system. Concentrations of most harmful substances are below detection at this point. This leachate treatment system treats 250 cubic meters of water every day. This is with only one AFM in place. More water could be treated using multiple filters in parallel.

Figure 7.15 Leachate Samples During Filtering
(www.drydenaqua.com)

(Arden Quarry continued)
Applications

Land filling and treatment of its by products is very advanced in European countries. This is due to the lack of open spaces left to just dump garbage. This landfill treatment system treats leachate better than most current systems, and it does so almost completely biologically. The system still pipes the water into the sewer system though, which is something I would like to avoid. In a closed circuit system the water could remain on site for irrigation purposes or to be used in secondary water uses, such as toilets. The leachate would need to be first treated further through the use of plant material and additional filters. This would be a great addition to an ecological learning laboratory.

Figure 7.16 Leachate Pond Comparison After Filtration
(www.drydenaqua.com)

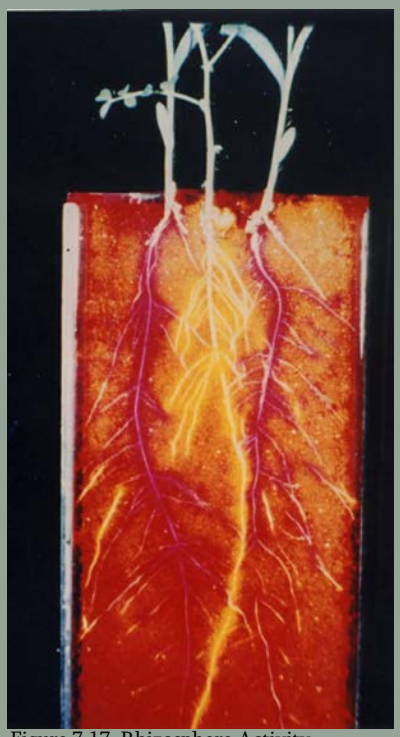

Figure 7.17 Rhizosphere Activity

(www.can.edu.cn/lpn/chapter1/rhizosphere.jpg)

Phyto and Bio remediation

To the modern student of ecology, and the environment, it is instructive that all artificial pollution events, both regional and global, find their origin in MAN and his activities and, at the same time, the major modes of natural cleansing are accomplished by MICROBES through their activities; on one hand, God's highest achievement in Creation is found doing the most destruction, while the lowliest life-form crafted by His hand does the janitor's duty - the former by disobedience and the latter by design.

-(Terry, Banuelos, 2000)

Phytoremediation

Phytoremediation is the use of vegetation to contain, sequester, remove, or degrade inorganic and organic contaminants in soil, sediments, surface waters, and groundwater. The specific phytotechnology mechanism employed in the final design of the system depends on the type of constituents that need to be addressed and the specific clean-up objectives of the site. Phytotechnology addresses chemical environmental threats such as: heavy metals, metalloids, radio nuclides, salts, agrochemicals, hydrocarbons, chlorinated compounds, and nitro-aromatics.

To remove toxins from soil, the plants either trap contaminants in the rhizosphere to be utilized by bacteria, uptake contaminates (they remain inside the plant), breakdown or degrade the contaminant into a lesser, more stable form, utilize contaminates for energy, or release it as harmless gases during respiration. To achieve the best possible results, oxygen limitations need to be reduced.

The mechanisms that form the basis for phytotechnologies focus primarily on the processes within the rhizosphere. The rhizosphere is the root-soil interface which is highly bioactive and involves the interaction of plants and microbes.

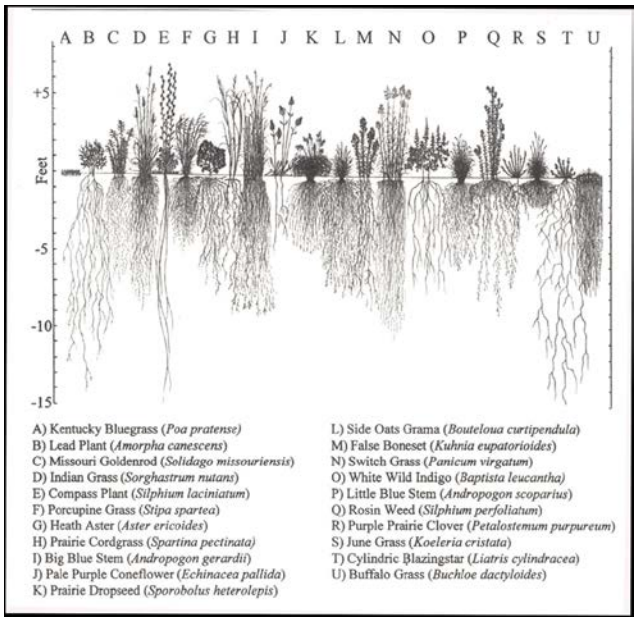

Figure 7.18 Root Depth Chart

(Scheper, Tsao, 2003)

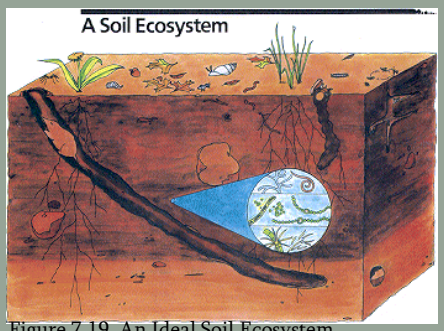

Figure 7.19 An Ideal Soil Ecosystem
(www.ic.ucsc.edu/-wxcheng/wewu/links.html

Bioremediation

Environmental bioremediation is a treatability technology that uses biological activity to reduce the concentration or toxicity of a pollutant. It commonly uses processes by which microorganisms transform or degrade chemicals in the environment. In one square meter of soil there can be upwards of 10,000 different species of bacteria and fungi. It is enhanced biological treatment of environments contaminated with a variety of organic and inorganic compounds. It is also a new application of a very old technology used for wastewater treatments. The Romans used it as early as 600 B.C. in their sewer systems. Bioremediation occurs naturally in all soil and water especially in the rhizosphere and warm oxygen rich water. To be effective, sites need to be evaluated by nature, location, and concentrations of site contaminants to determine the type of bioremediation to use. There are three basic types of bioremediation employed.

1. Biostimulation - A process is designed to enhance the site environment to enable existing microbes to perform at their best. This is done by increasing the oxygen, temperature, or moisture of a site. It is also the most successful form of bioremediation.
2. Bioaugmentation - Species of microbes non-native to the site are introduced to treat certain contaminates specifically. This has only met limited success. There is an initial jump in treatment, but the introduced microbe levels fall after only days or weeks.
3. Intrinsic Treatment - This is used when testing has shown that contaminates will degrade naturally over time. The site is regularly monitored, but nothing else is actively done. This is the most cost effective form of bioremediation.

Figure 7.20 Incinerator Smoke Stack
(www.incineration.com)

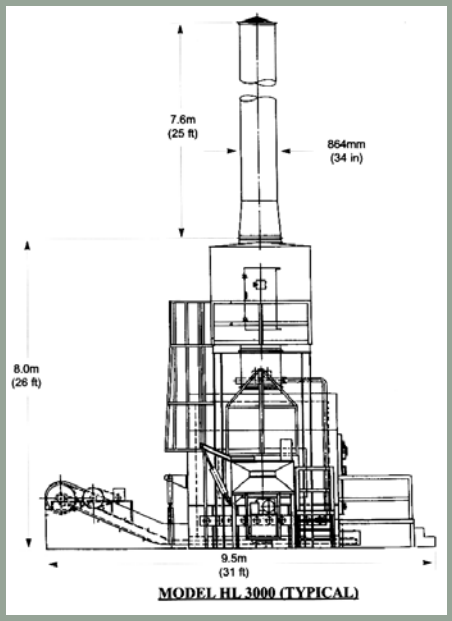

Figure 7.21 Incinerator Blueprint
(www.enviroliteracy.org/article.php/60.html)

Incineration

Solid waste management inevitably deals with the options of landfills, incineration, and recycling. Ultimately landfills have been shown to be the least effective method of management due to available space. Recycling is probably the best way to go about management, but has met limited success due to it being optional. Incineration reduces the volume of combustible trash by about 70% and the weight by 90%. Incineration has met opposition publicly due to the cost and pollutants that arise and are emitted in the combustion process. These pollutants are the same as the pollutants that could infiltrate the groundwater and should be prevented from entering the air. In order to prevent toxic emissions, systems are equipped with pollution control devices such as: scrubbers, fabric filters, electromagnetic precipitators, afterburners, and the addition of certain minerals. The Environmental Protection Agency imposes an 18 month moratorium on licensing for all new facilities while it reviews the employed safety standards.

Most incineration operations today are waste-to-energy facilities. They use the combustion process to generate steam and electricity. One of the most effective plants is the Commerce Refuse to Energy Facility located in Los Angeles (Part of the South Coast Air Basin). Environmental requirements here are the toughest in the world. The facility uses a state of the art combination of pollution control devices. It injects limestone and ammonia into the furnace, followed by a dry scrubber, and finishes with a filter fabric or baghouse. It is able to burn 360 tons of trash a day and generate ten megawatts of electricity (enough for 20,000 homes). After combustion metals are able to be removed and recycled. This is one of the cleanest plants in the world.

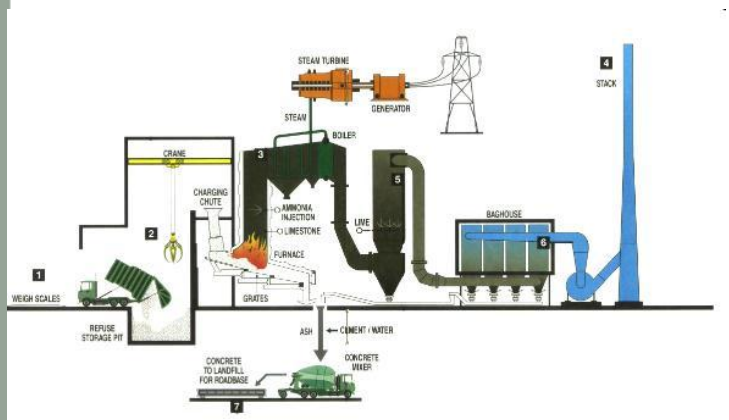

Figure 7.22 Incineration Process
(www.epa.gov/reg3artd/images/Incinerator.jpg)

Figure 7.23 Fargo Waste Water Treatment Center (www.cityoffargo.com)

Wastewater Treatment in Fargo

The Wastewater Treatment Plant is located on 32nd Avenue north and Broadway. It is designed to be able to treat 15 million gallons per day. The average daily flow is more along the lines of 12 million gallons per day. Of the wastewater that enters the plant, 97% is from residential uses, and 3% is from industrial (landfill) uses. The wastewater is 99.9% water.

The plant uses both mechanical and biological treatments to remove organic and inorganic suspended and settleable solids. Chemicals are used for disinfection, chlorine reduction, odor control, and the biosolid de-watering process. Biological processes include aerobic and anaerobic bacteria in a septic tank environment which break down suspended material in the wastewater.

Water enters the treatment plant through bar racks which remove solids larger than one inch that are disposed at the landfill. The water continues on to seven primary clarifiers where solids are settled and deposited onto a hopper which moves them to anaerobic digesters. The water then flows from the clarifiers to three rotating distributor Biochemical Oxygen Demand (BOD) trickling filters. These filters treat the water biologically by spraying it onto synthetic media stacked to 15 feet in tanks. Aerobic bacteria grow and produce a slime called zoogleal film. Organisms in the film feed on suspended material in the wastewater and break it down. Airways under the synthetic media provide the oxygen required by the bacteria. The wastewater is now sent to two nitrification filters that operate similarly to the BOD filters, but remove ammonia and organic nitrogen. The wastewater now moves into a mixing chamber where chlorine is added for disinfection. After this, the chlorine is removed by the addition of sulfur dioxide. The wastewater is now done being treated and is discharged as effluent into the Red River. When the river is flooded, a lift station pumps the effluent into six waste stabilization ponds. They are located along Highway 10 in West Fargo. They are also used to provide tertiary treatment to wastewater when necessary for state discharge limits.

Biochemical Oxygen Demand (BOD) is the rate at which microorganisms use the oxygen in water or wastewater while stabilizing it under aerobic conditions. It is a very good measure of the quality of wastewater. A lower number means a higher quality of water. The BOD level of wastewater entering the treatment plant is normally between 200-250 mg/L. Water discharged form the ponds are between 10-15 mg/L. The permitted level for the city of Fargo 25 mg/L. Dried biosolids from the plant are removed and hauled to the Fargo Landfill and used for daily cover purposes.

I plan to stop the transfer of leachate to the Wastewater Treatment Plant, but rather treat it on site at the landfill and reuse it for irrigation purposes, thereby reducing the amount of discharge into the Red River.

Spatial Allocations for Program Elements

Parking Lot - 4,800' sq. total

12 Parking Spaces - 9' x 20'
- 4 impermeable spaces
- 4 semi-permeable spaces
- 4 permeable spaces

3 Runoff Collection Ponds - 5' deep
- *accommodates and measures runoff from various paving materials

Laboratory and Greenhouses - 35,000' sq. total

3 classrooms - roughly 50' x 20'
3 laboratories - roughly 50' x 50'
2 greenhouses - roughly 120' x 50'
- *will provide secondary treatment for wastewater

4 bathrooms
- 2 men's bathrooms - 3 stalls each
- 2 women's bathrooms - 3 stalls each

Detention Ponds - 30 acres total

3 connected ponds - 10'-15' deep
- * will provide tertiary treatment for wastewater

Incinerator - 40,000' sq total
- *located on city owned land for future land filling
- *will process 600 tons of waste per day
- *will adhere to the most strict pollution guidelines

Primary Leachate Treatment Tanks - 7,000' cu. total

1 anaerobic tank - holds 600 gallons of leachate
2 aerobic tanks - each hold 300 gallons of leachate
2 Aqua Filter Media® - each treats 250 cubic meters per day

Waste Showcase - 1 acre total
- *will serve to display wastefulness vs. conservation to site visitors
- *will provide alternative action examples to visitors

Waste Remediation - 155 acres total

Woodland - 20 acres
Savannah - 70 acres
Grassland - 65 acres
- *will study which type of remediation works best

Paths - 40,000' sq total
- *will be interconnected
- *will be 7' wide
- *will be made of recycled, permeable material

Usage

Parts of the site will be used all year round and others will be mainly used spring through fall.

The classroom/laboratory/greenhouses will be used all year by research technicians and visitors to the site to learn about waste and its implications. The greenhouses will also serve to treat the effluent produced by the building and landfill year round. The detention ponds/wetlands will be used year round to treat water as wetlands never completely freeze. The waste showcase will be able to be in use, but may not be visited as frequently during winter months due to cold weather. The areas to test remediation techniques between woodland, savannah, and grassland will only be able to treat the site during spring through summer months.

Although parts of the site will not be operational during winter months, the overall site will still function and serve to sustain itself and take in waste.

Final Expenses

As mentioned previously, the final budget for a project such as this is difficult to determine. The goal of a capstone project is to design at the landscape architecture as art level and to not worry about a budget. It should be noted that the elements of the design will be implemented in stages, therefore spreading out costs over the years. Once again, many believe the worth of their health is priceless, so I believe no amount of money would be out of the question.

To make sure I fully understand the different methods and implications of land filling, and the subsequent methods for remediation I have researched a variety of topics.

I have studied landfill governmental regulations, landfill closure procedures throughout the country, water treatment systems, plant remediation techniques, waste reduction, and appropriate end uses for contaminated sites. These separate elements have taught me about the remediation of landfills and other sited as well as influenced some innovative design ideas.

I have also researched the different phases in the life cycle of a landfill. I feel it is important to understand how a landfill begins, operates, and closes in order to design an appropriate end use for one. I have visited the Fargo landfill many times during work and again several times to study it and interview the workers. My visits to the landfill have made me appreciate what we have and take for granted as well as a desire to make something wonderful out of a place previously considered awful.

I have acquired my information through books, magazines, journals, websites, and interviews with landfill personnel and civil engineers.

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Fargo Landfill
A remediation leading to re-use for refuse
Fargo, ND

The U.S. has approximately 3,091 active landfills which take in about 279 million tons of garbage annually. Since 1990, more than 11 billion tons of domestic and foreign waste has been disposed of in the United States. This is equivalent to covering every acre in the nation with 4.7 tons of waste. As the population rises, so does the amount of waste generated and the need for somewhere safe to put it. Landfills are usually capped and forgotten about, or not put to an appropriate reuse. They can also pose a very serious threat to the environment and people around them. Most problems occur when landfills close. Current techniques do not remediate the waste; they simply cover it up. The creation of new landfills faces stiff opposition from every angle. No one wants to live or work near a landfill, and they should not be located at the expense of our natural areas. Our country is entering into a garbage crisis.

The Fargo area currently has more space to deal with waste so we do not feel the pinch yet. But per capita, people here create just as much waste as the rest of the country. We need to start planning now for better waste disposal and remediation. The Fargo landfill takes up 160 acres or the equivalent of 25 city blocks. It currently takes in 150,000 tons of waste and creates 700,000 gallons of leachate water needing treatment annually. The landfill capacity is 8 million tons and is expected to be at this mark sometime in the next 18 years when it will be capped and vegetated for wildlife habitat. The Fargo landfill has already taken some steps toward becoming environmentally conscious by installing 20 methane collection pipes and using bio-diesel in all the trucks and bulldozers. Despite these efforts, the process needs to be refined to make the Fargo site safe for its surrounding environment and provide an adaptive reuse. In doing so, the site will become an asset to the city rather than a liability.

The Fargo landfill is located on 45th St. between 7th Ave and 12th Ave N. This location puts it in a central area of Fargo and it's surrounding communities. I propose the implementation of a closed-circuit system for land filling as well as bio and phyto remediation, and a showcase for waste handling and treatment for the city of Fargo. The landfill will become a place for students, civic groups, and regular people to come and learn what happens to the waste they create, and what affect it has on the environment.

This capstone project research will focus on the study waste reduction, soil and water remediation, and different ways to exhibit waste to visitors and residents of Fargo and its surrounding areas.

Title

The Fargo Landfill: A rehabilitation leading to reuse for refuse

Landscape Type

This project will be about the reclamation of the Fargo landfill and incorporating a research facility to study the stages of reclamation. My project will most closely resemble projects that deal with reclamation of severely contaminated areas such as: Gasworks Park and Fresh Kills landfill in New York. The design will borrow ideas for reclamation from places such as the Minnesota Landscape Arboretum, and a Ford manufacturing plant. It will use an incinerator to reduce the volume of waste and examine new ways of naturally filtering and removing toxins from water and soil. This will extend the life of the landfill and rehabilitate the area. These processes will be monitored from an observational learning center on site during and after landfill operation by University professors and students. This will be a functional end use for the landfill.

Conceptual basis or unifying idea

Landfills all over the country are beginning to close due to rising amounts of garbage. The amounts of waste are not going to decline any time other than with aggressive implementation of recycling; which would be a whole other project in itself. Landfills are a contaminant which will be a permanent scar on the surrounding environment. The solution to this problem is to devise a plan of better operation and to come up with a plan for reclamation and reuse.

This project will emphasize reclamation through phytoremediation and bioremediation. This is the use of vegetation to contain, sequester, remove, or degrade inorganic and organic contaminants in soils, sediments, surface waters, and ground water. The plants will provide a cost effective and educational solution to the problems of landfills.

I will combine several different proven methodologies to remediate the soil and leachate water of the landfill. The landfill will not be monitored professionally after a period of time, and will pose no threat to citizens of the Fargo-Moorhead area. It will also be able to remain open for a much longer period of time, thereby reducing the expenses of creating a new landfill.

Project Justification

'If you want to preserve something, bury it in a landfill…it will never decompose.' -Duane Haugen of the Fargo Landfill. This is disturbing enough to justify a reclamation plan. It means the garbage we create today will be here indefinitely. We keep creating waste, so we need to think of a way to remediate it so we do not run out of room to store it. The waste currently in the landfill is so compacted that it will never receive the oxygen required to decompose.

Another reason is the Fargo landfill will be at capacity in a mere 18 years. The current plan is to cap the landfill, create a wildlife habitat and begin a new one. The landfill will not make a good habitat for anything due to poor soil quality, contamination of water, soil, and air, and since the landfill is located in an urban setting. The landfill will create hazardous methane gas for at least 20+ years after it is closed.

Lastly, it is a fact that eventually the liners in landfills fail, polluting surrounding water and soil. The landfill will be monitored for 20 years after closure but will be toxic long after thereby poisoning the residents of Fargo Moorhead.

User/Client Definition

The Fargo sanitary landfill will be designed to benefit the residents of Fargo-Moorhead and to ultimately serve the civil engineering, landscape architecture, and natural resource management students of North Dakota State University. The landfill will be owned and operated by the city of Fargo until it reaches capacity and it will be monitored annually after it closes for 20 years. Any monetary resources (methane production) produced by the landfill will be put into the cities budget as prior to modification.

The personnel of the landfill during operation will be the same personnel as prior to improvement. After the landfill reaches capacity there will be one person to monitor ground, water, and soil pollution once a year for 20 years. There will also be NDSU faculty on site to monitor filtration tanks, and teach their respective classes. A maintenance engineer will be needed to clean and maintain the classrooms and greenhouses. Peak usage will be during the time when the landfill is in operation and a classroom is in place. After the landfill hits capacity it will only be occupied by students and faculty. A small parking lot for student drop off and 10 cars for staff will be provided. These parking spaces will also be a demonstration of pervious versus impervious surfaces.

Major Project Elements

Waste incinerator
Research labs
- water filtration rates
- soil rehabilitation rates
- plant toxicity levels
- soil toxicity levels
- green roof technology
- observation classroom

Green houses
water filtration tanks
- water filtration ponds
- Parking lot
- pervious surfaces
- semi-impervious surfaces
- impervious surfaces
- detention ponds

Plant test plots
Vegetative buffer
Fence improvements

Site Information

The Fargo sanitary landfill is located along 45th Street between 7th avenue North and 12th avenue North. It lies adjacent to the Fargo industrial park. It consumes 160 acres total and will hold 8 million tons of waste when it reaches capacity. It was constructed about 35 years ago and was the first landfill in the immediate area to meet Environmental Protection Agency standards. The landfill has a high density polymer liner with one foot of sand on top located beneath the waste. 120 feet of brown clay is beneath that. The compacted waste begins 35 feet underground and reaches 70 feet above ground level with a 4:1 slope.

The landfill more than adequately provides for its own operation and puts the surplus of funds in the city pool of money.

Some environmental issues of the site are the contaminated leachate, which cannot be leaked out, and air pollution of gases and debris. The other obvious pollutant is the soil and waste beneath it. The vegetation on site includes a buffer of dogwood shrubs and ponderosa pines on the East side, and a double row of ash trees on the South side. The North side of the landfill has already reached capacity and has been covered with four feet of cover and planted with native prairie grasses. The cover comprised of compacted clay and will not allow for much water or air to permeate and decompose the waste. All the water that enters the site is collected and sent by pipe to a treatment plant for chemical treatment and disposal in the Red River.

The Fargo landfill is accessed by 7th Avenue North, 12th Avenue North, and 45th Street. There are no bike paths or sidewalks near the landfill. The roads inside the landfill change every few days to accommodate for new cells to be filled. Views to the landfill are extensive. It is the major topographic feature of this area of Fargo and can be seen for a few miles. Driving either way on 45th Street the plant screen is beginning to be effective. Only the very top of the landfill can be seen. Views from the top of the landfill are extensive. For several miles the only changes in topography are overpasses or shelterbelts. Prevailing winds come from the Northwest in the winter and from the Southwest in the summer. Wind affects the site a lot. The operators of the landfill put down a four inch layer of soil as daily cover at the end of each workday. This prevents wind from blowing the waste around when there are no bulldozers to compact it. During the day temporary fence structures do not prevent the wind from blowing the refuse around, but they keep it from blowing onto the roads, or into the fence.

The existing structures at the Fargo landfill are a weigh scale and house to measure tonnage of incoming waste, a quonset to house the bulldozers, 20 methane extraction pipes, one methane collection house, a pipe to Cargill to transport methane, five leachate pumps, a pipe from the landfill to the water treatment plant, and an oil disposal barrel. The whole site is currently surrounded by a seven foot high fence topped with barb-wire to keep people and animals out. There is a substantial amount of noise at the landfill. Trucks and bulldozers are constantly coming to and leaving the landfill. All the trucks have backup alarms as well, which does not help control the noise level.

Project Emphasis

Extending the life of the landfill

The implementation of an incinerator adjacent to the landfill will extend the life of the landfill while allowing for an easier environmental rehabilitation. The city of Fargo is already looking into incinerator technologies, and most major cities across the US have already implemented them since they cut waste volume down by at least 70 percent.

Adaptive reuse of the landfill

Turning the landfill into a classroom/observation lab for NDSU students is a more plausible design solution than having wildlife habitat in the midst of an industrial park. The classroom/observation lab will benefit the NDSU students as well. They will no longer need to learn only from books. They will be able to see design solutions first hand. They will also be able to see the cutting edge land filling and natural resource rehabilitation as it takes place.

Environmental rehabilitation

The landfill will use a process called phytoremediation in the rehabilitation process. It will be revegetated with plants that will uptake toxins and excessive nutrients. The leachate will also be treated on site by the same phytoremediation processes. This will make the landfill less of an environmental threat if the liner should fail.

Plan for proceeding

Research will include the study of phytoremediation, green roof technology, past landfill closure procedures and several case studies of different typologies. The process for phytoremediation will include journal articles, and engineering manuals as well as some interviews. Green roof technologies will include case studies as well as plant selection books. Landfill closure procedures will be through manuals and case studies. The case studies will focus on the previously mentioned topics and some open spaces designed on polluted areas. Documentation of this research will be recorded into separate binders labeled by topic. Documentation will be in chronological order by date and scope of design. Sketching will be in a sketchbook and additional materials outside of the sketchbook will be added based on which part of the design it relates to.

Schedule of work
Fall semester 2004

Week #1 (Oct 4-8)

07 Oct Thesis Proposal due: to AR/LA 561 Instructor (2 copies)
07 Oct Student critic preference slips & faculty preference slips available
Research

Week #2 (Oct 11-15)

14 Oct Students and Faculty return preference slips to main office
Research

Week #3 (Oct 18-22)

21 Oct Primary and Secondary Critics announced
Research

Week #4 (Oct 25-29)

28 Oct Last day of AR/LA 561 Class
Research
Define the Program

Week #5 (Nov 1-5)

Research
Further work on Program

Week #6 (Nov 8-12)

11 Nov Veterans' Day Holiday
Organize Site Information
Work on Draft of Program

Week#7 (Nov 15-19)

15-19 Nov Final week of AR/LA 571 Design Studio / presentations
Work on Draft of Program

Week #8 (Nov 22-26)

24 Nov Draft Thesis Program due to Primary Critic (1 copy)
25-26 Nov Thanksgiving Holiday
Further Site Analysis and Documentation

Week #9 (Nov 29-Dec 2)

Organize Rest of Site Information and Documentation

Week #10 (Dec 6-10)

09 Dec Final Thesis Program due to Primary Critic (1 copy)
10 Dec Last day of classes
Review of Program with Thesis Critic
Work on Final Program Draft

Week #11 (Dec 13-17)

16 Dec Program grade due to AR/LA 561 course instructor
13-17 Dec Final Examinations

Week #12 (Dec 20-24)

Week #13 (Dec 27-31)

Week #14 (Jan 3-7)

Research

Spring semester

Week #15	(Jan 10-14)	
	11 Jan	Classes begin
	Conceptual and Schematic Design Work	
Week #16	(Jan 17-21)	
	17 Jan	Martin Luther King, Jr. Holiday
	Conceptual and Schematic Design Work	
Week #17	(Jan 24-28)	
	Conceptual and Schematic Design Work	
Week #18	(Jan 31-Feb 4)	
	Conceptual and Schematic Design Work	
Week#19	(Feb 7-11)	
	Design Development	
Week #20	(Feb 14-18)	
	Design Development	
Week #21	(Feb 21-25)	
	21 Feb	President's Day Holiday
	Design Development	
Week #22	(Feb 28-Mar 4)	
	Design Development	
Week #23	(Mar 7-11)	
	07-11 Mar	Mid-semester Thesis Reviews
	Presentation Drawings	
Week #24	(Mar 14-18)	
	14-18 Mar	Spring Break
	Presentation Drawings	
Week #25	(Mar 21-25)	
	23 Mar	4th year Statements of Intent due in AR/LA 472
	25-28 Mar	Easter Holiday
	Presentation Drawings	
Week #26	(Mar 28-Apr1)	
	Presentation Drawings	
Week #27	(Apr 4-8)	
	Presentation Drawings	
Week #28	(Apr 11-15)	
	Board Layout	
Week #29	(Apr 18-22)	
	Board Layout	
Week #30	(Apr 25-29)	
	25 Apr	Thesis Projects due at 4:30pm in the Memorial Union Ballroom
	26-27 Apr	Annual Thesis Exhibit in the Memorial Union Ballroom
	28 Apr-05 May	Final Thesis Reviews
	29 Apr	Draft of Thesis document Due to Primary Critics
Week # 31	(May 2-6)	

Previous studio work

	Fall	Spring
2nd Yr	*Tim Kennedy*	*Dennis Colliton*
	*Six Pack Design	*NDSU Fountain Plaza
	*Ideal Landscape	*Devils Lake Open Space
	*Plains Art Café Muse	*Design Scenarios
		*Camp Wilderness Ampitheatre
3rd Yr	*Joshua Walter*	*Tim Kennedy*
	*Car Park Design	*Pool Area Perspective
	*Sheyenne National Grasslands Campground	*Camp Cormorant Graphics
		*Upper Landing Housing Development
		*Masonry Competition
4th Yr	*Joshua Walter, Mark Barnhouse*	*Angela Hansen*
	Cindy Urness	*Broadway Square
	*Fargo Downtown Revitalization	*Edgeley Design Charette
		*Fort Totten Historic Preservation
		*Stone Competition

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THE FARGO LANDFILL:

What is a Landfill?

Dump - an open hole in the ground where trash is buried and that has various animals (rats, mice, birds) swarming around.

Landfill - carefully designed structure built into or on top of the ground in which trash is 'isolated' from the surrounding environment (groundwater, air, rain). This isolation is accomplished with a bottom liner and daily covering of soil.

The purpose of a landfill is to bury the trash in such a way that it will be isolated from groundwater, will be kept dry and will not be in contact with air. Under these conditions, trash will not decompose much. A landfill is not like a *compost pile*, where the purpose is to bury trash in such a way that it will decompose quickly.

Proposing the Landfill

For a landfill to be built, the operators have to make sure that they follow certain steps. The Environmental Protection Agency regulates where a landfill can be placed and how it can operate. The whole process begins with someone proposing the landfill. Taking care of trash and building landfills are local government responsibilities. Before a city or other authority can build a landfill, an environmental impact study must be done on the proposed site to determine:

- the area of land necessary for the landfill
- the composition of the underlying soil and bedrock
- the flow of surface water over the site
- the impact of the proposed landfill on the local environment and wildlife
- the historical or archaeological value of the proposed site

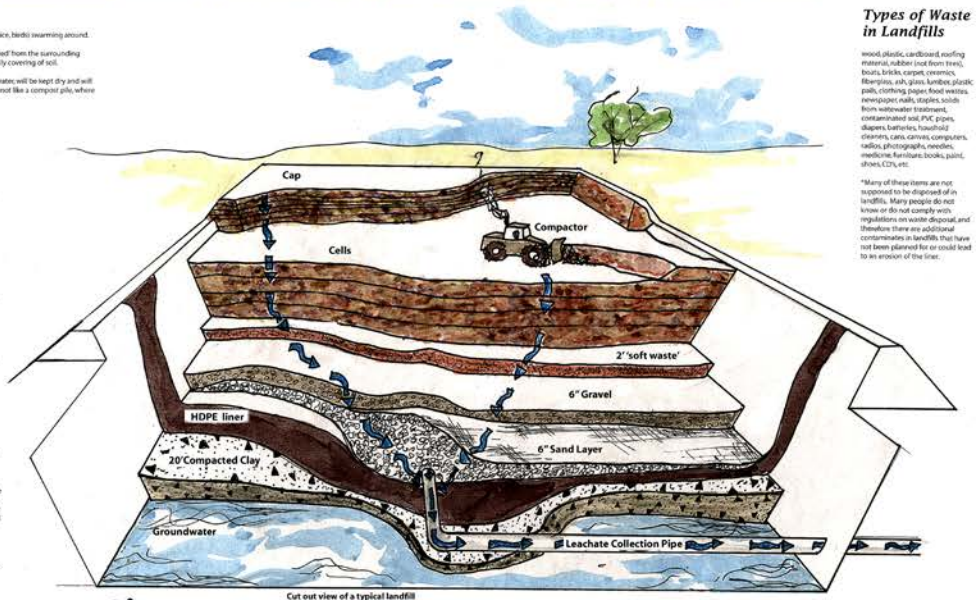
Once the environmental impact study has been completed, permits must be obtained from the local, state and federal governments. In addition, money will have to be raised from taxes or municipal bonds to build and operate the landfill. Because funding usually comes from some public source, public approval must be obtained through local governments or a referendum.

Once the environmental impact study is complete, the permits are granted and the money has been raised, construction begins.

First, access roads to the landfill site must be built if they do not already exist. These roads will be used by construction equipment, sanitation services and the general public. After roads have been built, then the landfill can be excavated.

Bottom Liner System

A landfill's major purpose and one of its biggest challenges is to contain the trash so that the trash doesn't cause problems in the environment. The bottom liner prevents the trash from coming in contact with the outside soil, particularly the groundwater. In MSW landfills, the liner is usually some type of durable, puncture-resistant synthetic plastic (polyethylene, high-density polyethylene, polyvinyl chloride). It is usually 30-100 mils thick. The plastic liner may be also be combined with compacted clay soils as an additional liner. The plastic liner may also be surrounded on either side by a fabric mat (geotextile mat) that will help to keep the plastic liner from tearing or puncturing from the nearby rock and gravel layers. Trash put in a landfill will stay there for a very long time. Inside a landfill, there is little oxygen and little moisture. Under these conditions, trash does not break down very rapidly. In fact, when old landfills have been excavated or sampled, 40-year-old newspapers have been found with easily readable print. Landfills are not designed to break down trash, merely to bury it. When a landfill closes, the site, especially the groundwater, must be monitored and maintained for up to 30 years.



Cut out view of a typical landfill

Types of Waste in Landfills

wood, plastic, cardboard, roofing material, rubber (not from tires), boats, bricks, carpet, ceramics, fiberglass, ash, glass, lumber, plastic pails, clothing, paper, food wastes, newspaper, nails, staples, solids from wastewater treatment, contaminated soil, PVC pipes, diapers, batteries, household cleaners, cans, canvas, computers, radios, photographs, needles, medicine, furniture, books, paint, shoes, CD's, etc.

*Many of these items are not supposed to be disposed of in landfills. Many people do not know or do not comply with regulations on waste disposal, and therefore there are additional contaminates in landfills that have not been planned for or could lead to its erosion of the liner.

Cells

One of the most precious commodities and overriding problems of a landfill is air space. The amount of space is directly related to the capacity and usable life of the landfill. If you can increase the air space, then you can extend the usable life of the landfill. To do this, trash is compacted into areas, called cells, that contain only one day's trash. A cell is approximately 50 feet long by 50 feet wide by 14 feet high (15.25m x 15.25m x 4.26m). The amount of trash within the cell is 2,500 tons and is compressed at 1, 500 pounds per cubic yard. This compression is done by heavy equipment (tractors, bulldozers, rollers and graders) that go over the mound of trash several times). Once the cell is made, it is covered with soil and compacted further. Cells are arranged in rows and layers of adjoining cells.


Compactor

Leachate Collection System

No system to exclude water from the landfill is perfect and water does get into the landfill. The water percolates through the cells and soil in the landfill much as water percolates through ground coffee in a drip coffee maker. As the water percolates through the trash, it picks up contaminants (organic and inorganic chemicals, metals, biological waste products of decomposition) just as water picks up coffee in the coffee maker. This water with the dissolved contaminants is called leachate and it typically acidic. To collect leachate, perforated pipes run through out the landfill. These pipes then drain into a leachate pipe, which carries leachate off site to a water treatment facility.

Common Chemicals in Landfill Gas and Soil

Methane	Trichloroethylene
Dichloromethane	Benzene
Trichloroethane	Carbon Dioxide
Tetrachloroethylene	Mercury
Vinyl Chloride	Lead
Dichloroethane	Arsenic
Dibromoethane	*Various other heavy metals and Volatile Organic Compounds-VOC's
Trichloromethane	
Tetrachloromethane	**When these materials are burned they are known to give off dioxins, which are endocrine disruptors and carcinogens

**There are 60,000 chemicals used in everyday commerce in the U.S., fewer than 200 of them are analyzed for potential groundwater

Methane Collection System

Bacteria in the landfill break down the trash in the absence of oxygen. A byproduct of this anaerobic breakdown is landfill gas, which contains approximately 50 percent methane and 50 percent carbon dioxide with small amounts of nitrogen and oxygen. This presents a hazard because the methane can explode and/or burn. So, the landfill gas must be removed. To do this, a series of pipes are embedded within the landfill to collect the gas. In some landfills, this gas is vented or burned.

More recently, it has been recognized that this landfill gas represents a usable energy source. The methane can be extracted from the gas and used as fuel. The landfill will increase its gas production over time (from 300 cubic feet per minute to 1,250 cubic feet per minute). The excess gas will have to be burned. It is not cost-effective to compress the excess gas to liquid and sell it.

Groundwater Monitoring

Surrounding the landfill are groundwater monitoring stations. These are pipes that are sunk into the groundwater so water can be sampled and tested for the presence of leachate chemicals. The temperature of the groundwater is measured. Because the temperature rises when solid waste decomposes, an increase in groundwater temperature could indicate that leachate is seeping into the groundwater. Also, if the pH of the groundwater becomes acidic, that could indicate seeping leachate.

The groundwater monitoring stations are placed around the landfill to detect the seepage of leachate. However, leachate water does not spread outward from a leak in a circular fashion. The leachate will find the path of least resistance and snake along it until it reaches an outlet. The probabilities of groundwater monitors catching a leak before a major problem is remote.

Dry Tomb Landfilling vs Wet Landfilling

The most common type of landfilling is the dry tomb method. In this method the idea is to keep air, light, and water from entering the cells of waste. The reasoning for this is to minimize methane production, which could cause an explosion. Also, if no water enters the landfill, then no leachate will need to be treated.

There are several problems with this method. First of all, in this kind of environment, nothing will breakdown. We would be stuck with a mountain of waste forever. Secondly, it is impossible to keep all outside elements out of a landfill. Eventually caps and liners fail, which leads to infiltration of the waste.

A new type of landfilling is the wet cell approach. Water is cycled through the waste prior to capping in an attempt to leach all the toxins out of the landfill before capping and to make the waste produce all the methane possible right away, rather than continuous production.

This technique is undoubtedly better than the dry tomb approach, but still has flaws. For instance, more leachate water is produced which will need to be treated. Also, nothing is done to remediate the waste, so in the end there is still a mountain of waste.

Dry tomb landfilling is one of the older types f landfilling and is seen by many as unsustainable and outdated.

Cap

When a section of the landfill is finished, it is covered permanently with a polyethylene cap (40 mil). The cap is then covered with a 2-foot layer of compacted soil. The soil is then planted with vegetation to prevent erosion of the soil by rainfall and wind. No trees, shrubs or plants with deep penetrating roots are used so that the plant roots do not contact the underlying trash and allow leachate out of the landfill.

Occasionally, leachate may seep through weak point in the covering and come out on to the surface. It appears black and bubbly. Later, it will stain the ground red. Leachate seepages are promptly repaired by excavating the area around the seepage and filling it with well-compacted soil to divert the flow of leachate back into the landfill.

Section of a Cap


How a landfill is designed to leak


Typical Groundwater Monitor

How a landfill actually leaks

How a Landfill Closes

It can cost anywhere from $80,000 to $200,000 per acre to close a landfill. Most of this comes is due to the capping procedure. It is very expensive to haul in 3 feet of clay and 1-2 feet of topsoil to prevent leakage and grow vegetation.

Most landfills are designated for 'wildlife habitat' after closure. Th eonly wildlife a capped landfill attracts are ground nesting birds and vectors. A closed landfill is not suitable habitat for anything, due to high levels of contaminates and lack of shelter.

Some closed landfills are being designed for reuse as parkland and open space for cities. This seems like a good solution to a problem, until you consider that the waste is not addressed at all. The problem is simply covered up even more; literally by topsoil and larger vegetation, and figuratively by putting a fancy facade on top of a pile of waste.

When a landfill leaks it adds millions of additional dollars to the closing cost due to expensive remediation efforts. A scary thought is that a landfill only needs to be monitored for 30 years post operation. It will have the potential to contaminate forever, but we will have no way of knowing if it is.

Common Chemicals in Leachate

Iron	Chloride
Manganese	Sulphate
Hydrogen Sulfide	Chromium
Heavy Metals	Cadmium
Vinyl Chloride	Phenoxypropionic acid
Calcium	Trichloroethylene
Magnesium	Mercury
Sodium	*Any chemical in landfill soil and gas can be presumed to also be in the leachate


Digital representation of the redesign for FreshKills. - obtained from the City of New York website

Case Study 1- FreshKills Landfill

FreshKills landfill is located on Staten Island, New York. Before it was a landfilling site, it was a low-lying marsh filled with creeks and an excellent habitat for various birds and fishes. Part of the site remains this way, and has been designated an important habitat by the New York Department of Environmental Conservation. Fresh Kills has been in operation since 1958 and encompasses 2,200 acres. By 1997, three of the landfill's six sectors were full and had been capped. The rest will be capped by 2011. The landfill was closed in 2001 but was reopened to accomodate 9/11 debris.

The park plan for the redevelopment of FreshKills will be implemented in 2007. It is considered to be one of the most ambitious public works projects in the world. Some of the main elements are: recreational fields, biking, hiking, arenas, marsh/tidal wetland preserves, golf course, memorials, and links to other parks.

The re-design of freshKills landfill sheds a new light on the reclamation of landfills. This project was an international competition, thus opening the door for new ideas about what do do with closed landfills. This project is an innovative solution, but is superimposed on conventional ideas. The landfill is essentially a dry tomb, and does nothing to remediate the waste. This design still only masks the underlying waste and risks of pollution and contamination. The citizens of New York will always have a park sitting atop a mountain of trash.


Site Plan of FreshKills landfill. - obtained from the City of New York website


Old machinery at gasworks park. - obtained from the City of Seattle website

Case Study 2- Gas Works Park

Gas Works Park is located on the north side of Lake Union, in Seattle, Washington. It was a beautiful lakeshore perfect for birds, wildlife, and fish. In 1906 an industrial plant was constructed there to manufacture gas from coal. The plant operated until to 1950's when the import of oil made the coal production obsolete. In 1962 the abandoned, contaminated area was aquired by the City of Seattle for a park. By 1975 the park was open to the public.

Gas Works Park occupies 19.1 acres and has an excellent view of Seattle. It was initially said nothing would grow on this site due to contaminates like hydrocarbons, soot, and petrochemicals polluting the soil and water. Looking at some pictures, that is a correct statement. Topsoil has been added to some parts of the park to allow for moderate plant growth. Despite the remaining toxic pollution, the park is a favorite of Seattle residents and visitors. As many as 50,000 people gather here for the Fourth of July celebration. People use the site for: frisbee, sunbathing, kayaking, and picknicing. The main elements on site are: old machinery painted vibrant colors and used as a play structure, a manmade hill for kite flying, a sundial at the top of the hill, and various paths.

The creation of Gas Works Park on a polluted site opened the door for engineers and landscape architects to work together and create a place for the public to enjoy. During the 13 years the land was aquired but not opened to the public, the site went through some very basic remediation procedures. The site had to be tested to make sure it was safe for people to go there. There are still warning signs about polluted water and soil, but people give them no heed anymore. Even though the site went through some remediation proceedures, it was mainly just covered with topsoil. The toxins still remain in the original soil and water. Eventually the toxins will be gone, but this will be due to them leaching off site and migrating elsewhere. It is a good park design, but does almost nothing to remediate, or protect people from pollution.


Sundial at Gas Works Park. - obtained from the City of Seattle website

Case Study 3- Becker County Landfill

The Becker County landfill in located on the outskirts of Detroit Lakes, Mn.. The area of the landfill used to be semi hilly and used for agricultural purposes. The landfill began operation in 1972, and operated until 1990 when it was capped and closed. It is 33 acres square, and holds 1,372,000 cubic yards of waste. In 1992, the Minnesota Pollution Control Agency indicated the landfill required immediate action to protect the public health and environment from further pollution. In 1996 it was discovered that half the landfill was covered with 6' or less of topsoil, rather than 3'-4' as previously thought. The bottom liner also had leaks, which required the installation of pumps to extract the groundwater for treatment. It should be noted that the leaks cannot be fixed which means the groundwater pumps will have to run indefinately.

The landfill is now covered with an 'impermeable' synthetic membrane with 2.5' of topsoil as cover. Landfill gas is extracted and burned through a piping system, not sold to create energy. Landfill gas has already begun to seep out of the membrane and is killing vegetation at the seepage points. Waste was excavated from 13 acres of the site in order to create a stormwater and leachate management system. Water wells around the landfill are contaminated with numerous volatile organic compounds, levels of which are just beginning to stabilize due to groundwater extraction. The price tag for all these remediations has been steep. The total for just one year of bare-bones remediations was over $180,000. At least this amount will need to be spent for many years to come to prevent further pollution and to treat what they already have.

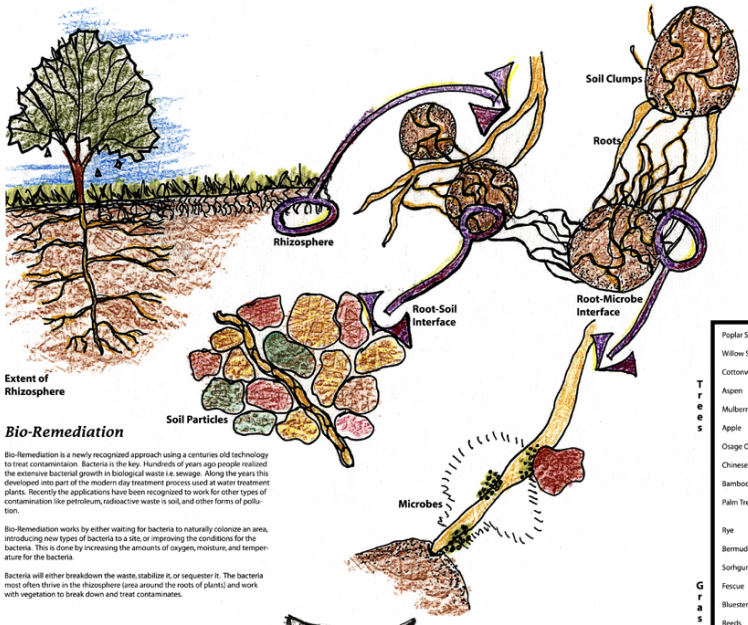

Groundwater and Stormwater treatment pond at the Becker County Landfill. - obtained on site

How Landfills Operate and Close

Board 2 of 10

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:



Bio-Remediation

Bio-Remediation is a newly recognized approach using a centuries old technology to treat contaminaton. Bacteria is the key. Hundreds of years ago people realized the extensive bacterial growth in biological waste i.e. sewage. Along the years this developed into part of the modern day treatment process used at water treatment plants. Recently the applications have been recognized to work for other types of contamination like petroleum, radioactive waste is soil, and other forms of pollution.

Bio-Remediation works by either waiting for bacteria to naturally colonize an area, introducing new types of bacteria to a site, or improving the conditions for the bacteria. This is done by increasing the amounts of oxygen, moisture, and temperature for the bacteria.

Bacteria will either breakdown the waste, stabilize it, or sequester it. The bacteria most often thrive in the rhizosphere (area around the roots of plants) and work with vegetation to break down and treat contaminates.

Phytoremediation

Phytoremediation is the use of plant material to treat, stabilize, and sequester contaminated soil, air, and water. It works is several ways:

Phytovolatilization - Plants take up water & contaminates through the roots, transport them to the leaves, and release the contaminates as detoxified vapor into the atmosphere.

Microorganism Stimulation - Plants secrete enzymes through their roots that stimulate the growth of fungi and bacteria which metabolize the contaminates.

Phytostabilization - Plants prevent contaminates from migrating by reducing runoff, erosion, and groundwater flow rates.

Phytoaccumulation/Extraction - Plant roots remove metals and transport them to leaves and stems where they can be harvested and recovered.

Phytodegradation - Contaminates are absorbed inside the plant and broken down to non-toxic molecules by natural chemical processes within the plant.

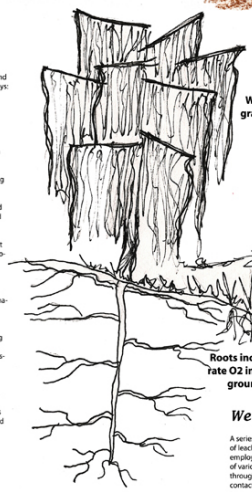
There are many advantages to phytoremediation. It is easy to implement and maintain, low cost, environmentally friendly, aesthetically pleasing, and can be used to treat a variety of contamination at once.

As with anything there are negative aspects as well. Phytoremediation may take several years to complete depending on contamination levels, is dependanto on climatic conditions, is only effective on areas within the root zone of the plants, and possible negative effects on the food chain if contaminated plant materials are consumed.

As many technologies will be used simultaneously at the landfill, phytoremediation will play an integral part of a larger whole. Contaminated plant material will be harvested the first two years and incinerated. After this is when animals will be introduced and in no danger of being poisoned.

Grinder Operation

The grinder is where all the non-recyclable biodegradable refuse will go. It will take in waste such as newspaper, cardboard, branches, etc. The grinder functions as a paper shredder or meat grinder only on a much larger scale. The grinder will speed up the process of biodegration by increasing the surface area exposed to the elements. It will also allow the material to be more readily digestible by worms and bacteria. The grinder will be able to process in excess of 1,500 tons per day during excavation of the landfill and will more than adequately handle the lower amounts of refuse post landfill excavation.



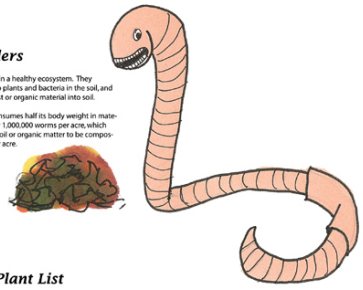
Wetland Systems

A series of wetland systems will be used to treat leachate water. An abundance of leachate water will be created due to the wet cell landfilling technique employed. Wetland systems have proven themselves successful in the treatment of various types of wastewater, including leachate. It works by filtering the water through soil, over rocks, and into plant material and resulting bacteria. The more contact time the water has with the wetland, the cleaner it gets. Curves and topography changes allow for more contact time. A flood-pulse approach is also the best approach. Wetlands wil be flooded, allowed to sit for 2 weeks, and then drained to remain dry to moist for 1-2 weeks. This allows the plant material and soil to have time to use up nutrients and become hungry for more.

Nature's Tillers

Earthworms are a vital part in a healthy ecosystem. They increase oxygen available to plants and bacteria in the soil, and help to break down compost or organic material into soil.

Every day an earthworm consumes half its body weight in material. Good soil contains over 1,000,000 worms per acre, which translated to 31,000 lbs. of soil or organic matter to be composted and aerated per day, per acre.



Phytoremediation Plant List

	Plant Type		Chemicals Treated
Trees	Poplar Ssp.	Perennials & Annuals	Sunflower
	Willow Ssp.		Clover
	Cottonwood		Alfalfa
	Aspen		Cowpeas
	Mulberry		Draecena
	Apple		English Ivy
	Osage Orange		Chrysanthemum
	Chinese Evergreens		Spider Plants
	Bamboo Palm		Snake Plants
	Palm Trees		Aloe Vera
Grasses	Rye		Ficus
	Bermuda		Gerbera Daisy
	Sorhgum		Ribbon plant
	Fescue		Peace Lily
	Bluestem	Aquatic	Iris Ssp.
	Reeds		Water Lily
	Wild Rice		Lemna
	Cattails		Algae
	Barely		Seaweed
	Hops		Fern Ssp
	Hemp		Moss
	Nettles		Lichen

Atrazine (Herbicide)
Alachlor (Herbicide)
Chlorinated aliphatics TCE
Aromatics BTEX
Excess Nutrients
Ammunition Wastes (TNT, RDX)
Pesticides
Polynuclear aromatic hydrocarbons
Pb
Cd
Zn
As
Cu
Se
U
Hydrophobic Organics (PAH, PCB, DDT, dieldrin)
Benzene
Mercury
Formaldehyde
Trichloroethylene
Radionucleides
Trichlorophenols

This list of plant and chemicals was obtained through various sources, including phytoremediation guidebooks, the Environmental Protection Agency, and the work of Bill Wolverton, a scientist for NASA who has spent the better part of his career studying the filtration abilities of plants.

It should e noted that neither the plant list nor the chemical list are complete. They are both just a small portion of a vast spectrum of possibilities. Phytoremediation is a relatively new technology and the treatment capabilities of all plants are not yet known.

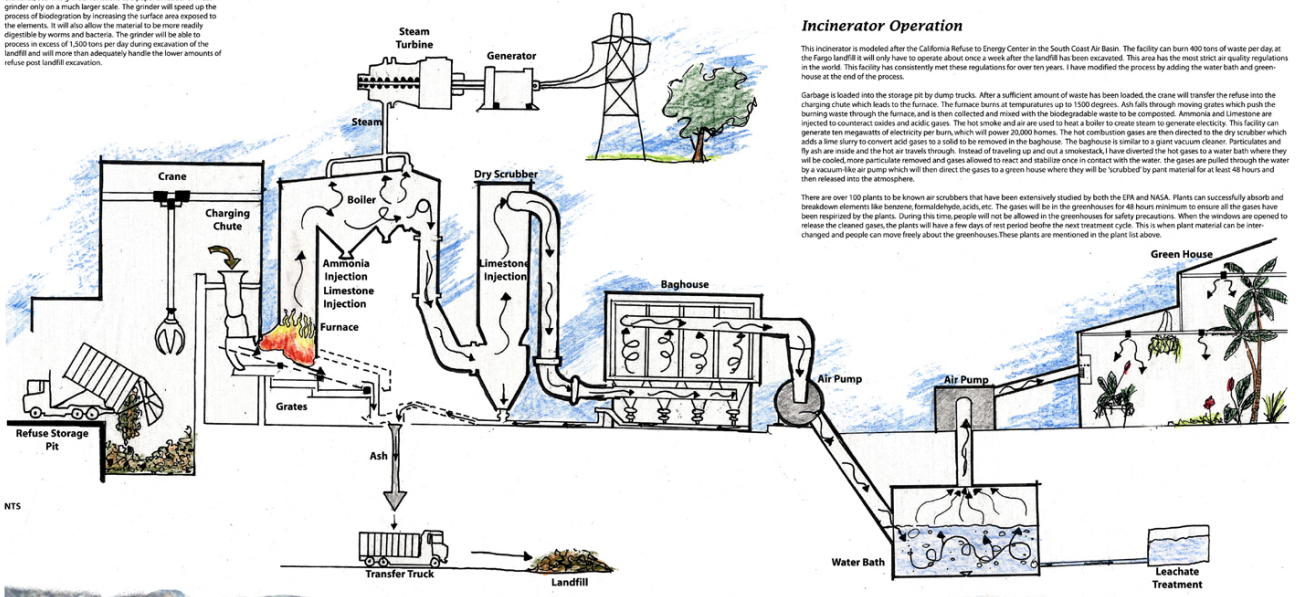
A particularly good aspect of plants thought of as super-remediators, is that they are native species. If a plant has a large, fibrous root system it is a good choice. As well as plants with a large appetite for water. Air Scrubbing plants generally are water loving and have broad leave or are fast growing.

Incinerator Operation

This incinerator is modeled after the California Refuse to Energy Center in the South Coast Air Basin. The facility can burn 400 tons of waste per day, at the Fargo landfill it will only have to operate about once a week after the landfill has been excavated. This area has the most strict air quality regulations in the world. This facility has consistently met these regulations for over ten years. I have modified the process by adding the water bath and greenhouse at the end of the process.

Garbage is loaded into the storage pit by dump trucks. After a sufficient amount of waste has been loaded, the crane will transfer the refuse into the charging chute which leads to the furnace. The furnace burns at temparatures up to 1500 degrees. Ash falls through moving grates which push the burning waste through the furnace, and is then collected and mixed with the biodegradable waste to be composted. Ammonia and Limestone are injected to counteract oxides and acidic gases. The hot smoke and air are used to heat a boiler to create steam to generate electicity. This facility can generate ten megawatts of electricity per burn, which will power 20,000 homes. The hot combustion gases are then directed to the dry scrubber which adds a lime slurry to convert acid gases to a solid to be removed in the baghouse. The baghouse is similar to a giant vacuum cleaner. Particulates and fly ash are inside and the hot air travels through. Instead of traveling up and out a smokestack, I have diverted the hot gases to a water bath where they will be cooled, more particulate removed and gases allowed to react and stabilize once in contact with the water. the gases are pulled through the water by a vacuum-like air pump which will then direct the gases to a green house where they will be 'scrubbed' by pant material for at least 48 hours and then released into the atmosphere.

There are over 100 plants to be known air scrubbers that have been extensively studied by both the EPA and NASA. Plants can successfully absorb and breakdown elements like benzene, formaldehyde, acids, etc. The gases will be in the greenhouses for 48 hours minimum to ensure all the gases have been respirized by the plants. During this time, people will not be allowed in the greenhouses for safety precautions. When the windows are opened to release the cleaned gases, the plants will have a few days of rest period beofre the next treatmeet cycle. This is when plant material can be interchanged and people can move freely about the greenhouses.These plants are mentioned in the plant list above.



Remediation Board 3 of 10 Technologies

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:

Location

The Fargo landfill is located immediatley West of 45th St, between 7 Ave N. and 12th Ave N. The landfill is no more than 10 miles away from any point in the city, and is located in a relatively central point when West Fargo and Moorhead are considered.

NTS

Demographics

The population of Fargo is close to 100,655 people. This number of people is added to significantly when West Fargo Harwood and Horace North Dakota, along with Moorhead and Dilworth Minnesota are taken into account, not to mention the students of North Dakota State, Minnesota State Moorhead, and Concordia College who are not considered residents here. The population of Fargo is steadily increasing at 22.2% every 10 years. The population is 50/50 male to female with the largest age group being 25-34 years old at 16.7%. The 20-24 years old age group is a close second at 14.9%. Caucasians are the predominate race of the area at 91%, followed by 1.7% Asian, 1.3% Hispanic, 1.3% American Indian, and 1% Black. There are about 39,268 households in the area, 52.8 of which are family households. Of the households, 10,751 of these have children under the age of 18. The average size of families in the area is 2.91. The Fargo area has a very good job market, with only a 2.2% unemployment rate. The average annual salary of a resident of Fargo is $31,320.

NTS

Area

The overall area encompassed by the Fargo landfill is 160 acres. 155 of those acres will eventually be filled with garbage. The area of the old landfill is the west 35 acres of the site. The landfill will reach 30' down into the earth and 70' upward to create a 100' mountain of trash. The landfill will contain over 8million tons of waste when it reaches capacity.

Prairie Potholes

Prairie potholes (sloughs) are water-holding depressions of glacial origin in the prairies of the Northern United States and southern Canada. Water is supplied to the potholes by precipitation on the water surface, basin runoff, and seepage inflow of ground water. Depletion of pothole water results from evapotranspiration, overflow, and seepage outflow. Since potholes generally do not overflow, seepage outflow is the principal way in which dissolved salts can be removed. Salinity of pothole water is therefore a good indication of the seepage balance. Net seepage outflow results in fresh to brackish waters that constitute ephemeral to semipermanent ponds, whereas net seepage inflow results in brackish to saline waters that constitute semipermanent to permanent ponds.

NTS

Prairie potholes, or sloughs, are water-holding depressions of glacial origin that occur in 300,000 square miles of prairies in north central United States and south-central Canada. These potholes provide the most productive wetland habitat for waterfowl in North America. Although comprising only 10 percent of the continental waterfowl-breeding, the pothole region produces about 50 percent of the duck crop in an average year and much more in bumper years. Potholes also furnish water for other wildlife and livestock.

Geology

Fargo is located in the Red River Valley in the remnants of glacial Lake Agassiz. The area is comprised of glacial deposits or a loose mixture of pebbles, sand and silty clay. Glacial lake remnants are the outwash areas, beach, and shore deposits of loose sand and gravel. Map created by John F Bluemle.

Wildlife

There is limited wildlife at the Fargo landfill. The most noticeable would be gulls and black birds that have made the landfill their main food source. These birds constantly circle the landfill or perch on the adjacent power lines. The birds do not harm the land filling process in any way, but ingest harmful wastes and possibly transport these wastes off site. The other wildlife of the landfill would be a variety of vermin such as mice, rats, and rabbits. These animals also do not affect the land filling process, but could transport harmful material off site. The animal population will need to be controlled in some way as to keep landfill material on site.

Vegetation

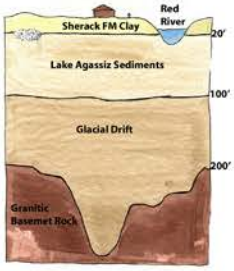
The vegetation of the landfill is comprised of buffer trees and shrubs along the south and east borders of the landfill and cover plants on the north side of the landfill. The buffer to the east is comprised of Ponderosa Pine, Redosier Dogwood, and Korean Lilac along with miscellaneous ditch vegetation. Next to the scale house is a planting of several Sugar Maples. The southern border of the landfill is comprised of Poplars and Ash trees. These trees are well established and serve as a good screen of the landfill. The north side of the landfill has been capped and covered. The cover vegetation is comprised of Kentucky Bluegrass Fine Fescue, and Perennial Rye. Additional vegetation has begun to grow due to the spread of seed by wildlife, and wind mechanisms. The existing vegetation of the landfill is extremely limited. This is due in part to the cost of plant variety, the limited growing medium (2' of soil), and the climate extremes of North Dakota. The types of vegetation should be expanded to create visual interest in the site as well as for remediation purposes.

Existing Structures

There are minimal built structures at the landfill to accommodate the highest volume of waste. The landfill will not be able to accommodate built structures on top of the waste pile for at least 30 years after closure to allow for settling time. The current structures include a scale house to weigh trucks and charge fees for dumping, an office to house documents of the landfill and provide a break-room for employees, an equipment quonset that houses the landfill's bulldozers and trucks, a methane collection building that collects and ships the methane to Cargill, there is also a flare built into the methane collection building to prevent excessive buildup of methane or explosions, and leachate collection pumps located at the base of the landfill on top of the lines these pumps transfer the wastewater to be treated off site.

Soils

The landfill is located on Fargo and Ryan clays. These soils are typically deep level, poorly drained, fine textured soils formed in the glacial lacustrine areas. Sediments are found in the flats and slight depressions of glacial Lake Agassiz. The Fargo and Ryan clays provide a deep and level surface, but a concern is its shrink swell factor which occurs during the winter freeze and summer thaws. The shrinking and swelling of the earth create an area where the soil is constantly moving, therefore building structures becomes difficult. At the landfill the shrink swell is not a factor underneath the main part of the landfill, since it is 30' below road level. Where it would be a factor would be the edges of the landfill, and any part of the landfill not used to store waste.



Views

Views from the landfill are extensive. Since there is limited topography, one can see for miles without interruption. The views off and on site are impressive, but not necessarily good. This is due to its location in an industrial park, and trash that flies about on windy days. Views of the landfill are also extensive since it is the major topographic feature of the area. These views are also impressive but not good. The landfill is literally a giant pile of trash, until it is covered. Then it is a pile of trash masked by grasses and perennials.

Acoustic Environment

The landfill is an extremely noisy place. This is because of the constant stream of trucks coming to unload waste, and the bulldozers that move back and forth to compact the waste. The methane collection system and flare add noise as well, which is not noticed on top of or to the south end of the site due to the high volume of noise created by the trucks and bulldozers. If a learning center is to be operational during active land filling, it will need to be soundproofed to allow for classes to be held.

Site Hydrology

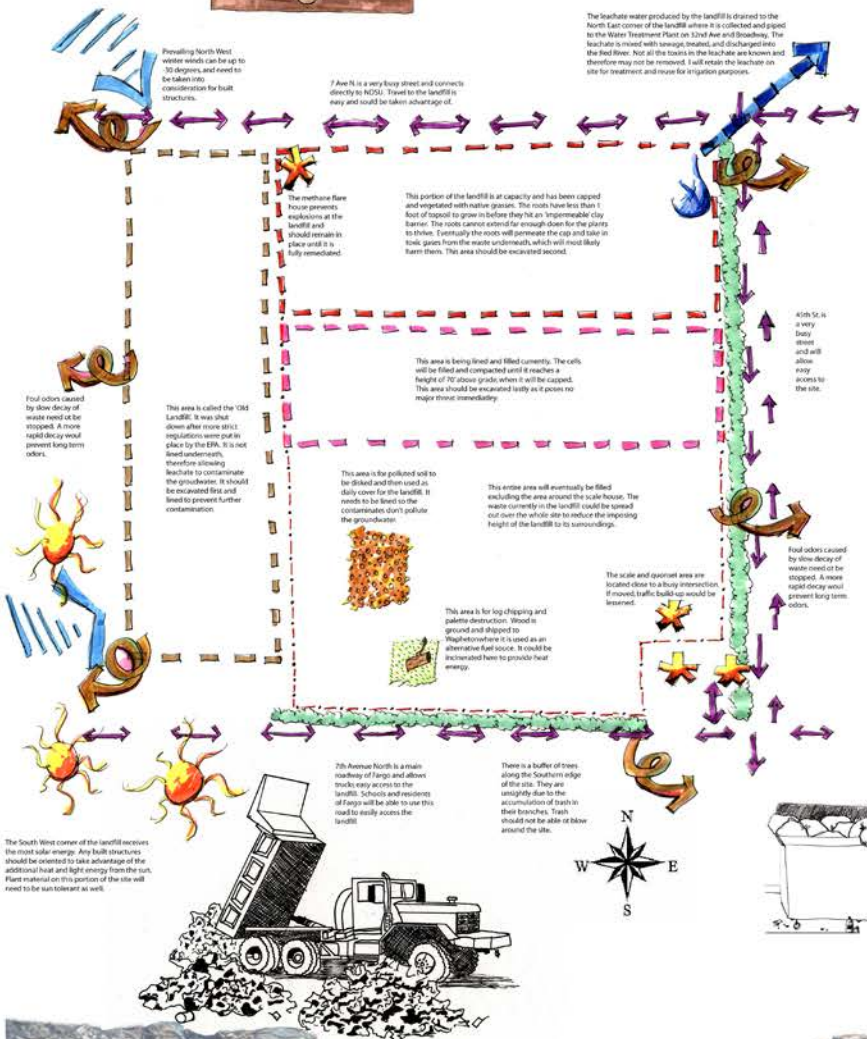
Any water that enters the landfill is either directed off the landfill by the cap or filters through the landfill to create leachate. All the water on the site is collected and pumped to the Wastewater Treatment Facility located on 32nd avenue north in Fargo. The wastewater is treated and discharged into the Red River. I would like to create a closed water system at the landfill to reduce the amount of water discharged into the river. A closed system would also be a great learning opportunity for visitors to the site.

Transportation Linkages

The Fargo Landfill is extremely easy to access. To the north the site is bordered by 12th avenue which is considered a minor artery by the city of Fargo. To the east is 45th street, which is considered a major artery. To the south is 7th avenue which is considered a minor artery as well.
Proximity to Schools
Since the landfill is located on the west central side of Fargo, this places it in a relatively central location for access by schools. There are over 30 schools located within seven miles of the landfill in Fargo and West Fargo. The landfill would be a great place for field trips for students to learn about their environment.

Solar Orientation

Day length and solar zenith angle are also important factors affecting North Dakota climate. Day length ranges from less than nine hours in December to more than 16 hours in June. Noon sun angles are much higher in summer than in winter. The combination of these factors at North Dakota's location produces much more radiational energy at the earth's surface in summer than in winter, which contributes to the large seasonal temperature changes and the general north-south temperature gradient across the state.



Annual Precipitation

The Fargo area is a fairly arid region. The area receives between 17 and 23 inches of precipitation per year. It seems the number would be greater considering the area receives over 20 inches of snowfall per year, but snowfall has less water content by volume than rain. Precipitation rates are greatest during the spring and autumn months of the year. Summer and winter are comparatively dry periods.
Annual Temperatures
The temperatures in Fargo fluctuate drastically from season to season. Throughout the year temperatures can range from -25° Fahrenheit to over 100° Fahrenheit. This creates a harsh environment for plant growth. Plants in the area need to be extremely hardy in order to survive.
Prevailing Winds
The average wind speed is at its greatest in ND in late winter and early spring. The wind is at its lowest speed during summer months. The winds in the Red River Valley happen to be 10-20% higher than the rest of the state. On an annual basis, the prevailing wind flow at Fargo shows strong incoming north and north-northwest flow and a strong south and south-southeast return flow.

Environmental Issues

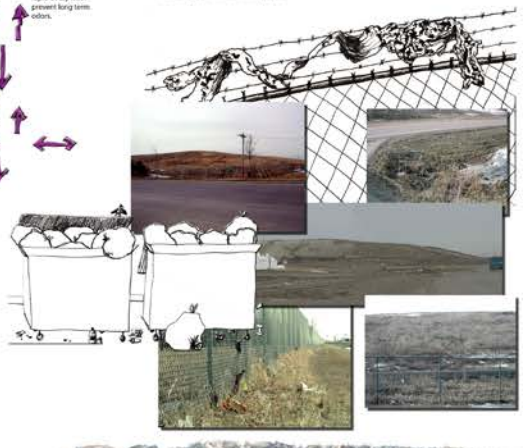
Ah, environmental issues at a landfill, where to begin. The most important environmental issue of a landfill is a failed liner. When the liners fail, surrounding groundwater and soils are severely polluted. A way to prevent this would be to remediate the waste rather than leave it to slowly decompose naturally. Another concern would be erosion. Landfills have very steep sloped sides. It is imperative to prevent erosion so the cap is not carried away by the wind or rainfall. Yet another issue is the leachate water produced after precipitation. This water is the primary contaminate associated with landfills. The leachate needs to be treated before it can be released into the surrounding water table. One more concern would be the waste itself. Some items are banned from a sanitary landfill, for safe disposal elsewhere. Items like batteries, paint, or other household hazardous waste can cause an increased likelihood of liner failure or more sever pollution. Some people throw these items in their regular garbage anyway, without thinking of the consequences. It must be planned for some hazardous waste to be included in the landfill in order to prevent dire consequences later on. Landfills today also try to prevent roots of cover vegetation from protruding through the cap into the waste. Such intrusions allow for water to permeate the landfill which creates more leachate and methane production. Methane production is the final environmental issue to be discussed. Methane production lasts for at least 30 years after a landfill is closed. It can prevent vegetation from growing, increase offending odors, or worse, cause an explosion if it is not properly monitored and released. At minimum, landfills need to collect the methane and either burn it themselves, or sell it to be used to create electricity.

Initial Impressions

The people of Fargo do not seem overly concerned with their environment or recycling. The garbage crisis is still perceived as nothing to worry about. This landfill is set to close in the next 15 years, the debate about where to expand has already begun. Are people concerned? Nope. "They" will figure out a good solution by that time. What residents of this area have not realized is that landfills in general simply aren't a good solution, and something better needs to be created.

The first thing I noticed about the Fargo landfill was the odor. You can smell the landfill long before you can actually see it. The breezy weather of the Fargo area does not help to abate this problem at all. Another thing the wind contributes to is scattered refuse all around the perimeter of the landfill. There are papers and plastic bags caught in everything. This does nothing to improve people's opinions of the landfill. Occasionally some of the refuse escapes the fencing and blows about on surrounding roads and clogs ditches.

Observing the landfill is one thing, but being on top of it is quite another. The drive up the access roads to the dumping area is exciting. It can reach near 40 degrees slope, which becomes even more interesting after a rain. The dumping area is by far more busy, noisy, smelly, and squishy than any other part of the landfill. The compactors whizz by at fast paces, not too far from where trucks are dumping. It is a good idea to stay out of their way. The way down the side of the landfill is just as adrenaline-filled as the ride up. Hopefully the brakes in your vehicle are in top shape.



Site Inventory and Analysis

Board 4 of 10

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:

Project Overview

The world is facing a garbage crisis. People keep creating waste, but we are rapidly running out of space to put it. In the U. S. in 1980 there were over 6,000 landfills. Today there are barely 2,000. As Americans, we generate 4 lbs of garbage per person, per day. In Fargo alone we generate over 73,000 tons annually. As our country has become more populous and developed, we have begun to ship the waste to areas less populated and more rural. The raw technology exists to solve the problem, we simply need to put it together.

Project Statement

Landfill remediations need to provide a cost effective, aesthetically pleasing, environmentally friendly solution to the garbage crisis. Rather than bury the waste to remain in the land to poison us for decades, remediation will face the problem head on and break it down. However, eliminating toxic contamination in the landfill should not create pollution in the air and water. On par with the idea of remediation is the concept of reuse. In fact, the purpose of remediation is to create an area safe for use by humans, plants, and animals. The combination of several remediation techniques is key to the success of this effort.

Design Process

I began the design process with a clear idea of the end product I would like to achieve. The goal of this project is to inform and get professionals and citizens talking and working together. This idea is meant to be adaptable, and with cooperation, even better solutions can be designed in the future. This project will simply start the process. My design for the Fargo landfill will solve the garbage crisis as far as I am able to take it with the allotted time and knowledge. I will create a space that is functional, safe re-usable, and beautiful. It will also respond to the area in which it is located, and provide actual habitats and ecosystems for people and wildlife. To get started, I made a list of elements to include in the project and then explored the relationships between them.

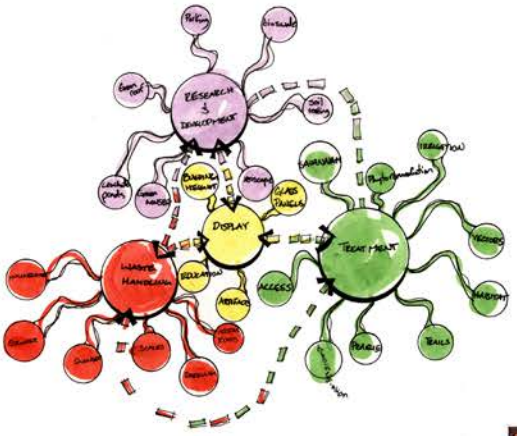
List of Elements

Waste Handling
Grinder
Wet Cell Landfilling
Incinerator
Scales
Support Buildings
Parking

Display Areas
Education
Artifacts
Confrontation
Habitats

Treatment
Native Vegetation
Bioremediation
Phytoremediation
Prairie
Wetlands
Savannah
Wildlife
Trails
Vectors

Research and Development
Green Roof Technology
Bionwales
Leachate treatment
Soil testing
Plant harvesting
Biopolymers
Biodiesel
Hydrogen Power
Wind Energy



Waste Equals Food

In the book *Cradle to Cradle* the authors have a passage where they describe the excess in nature and how nutrients are reused. I am including it in its entirety as it influenced my project greatly.

'Nature operates according to a system of nutrients and metabolisms in which there is no such thing as waste. A cherry tree makes many blossoms and fruit so (perhaps) germinate and grow. That is why the tree blooms. But the extra blossoms are far from useless. They fall to the ground, decompose, feed various organisms and microorganisms, and enrich the soil. Around the world, animals and humans exhale carbon dioxide, which plants take in and use for their own growth. Nitrogen from the wastes is transformed into protein by microorganisms, animals, and plants. Horses eat grass and produce dung, which provides both nest and nourishment for the larvae of flies. The Earth's major nutrients-carbon, hydrogen, oxygen, nitrogen-are cycled and recycled. Waste equals food.'

It is completely possible for people to handle their excess in the same manner as a cherry tree. A large portion of waste is biodegradable, therefore useful. As for non-biodegradable refuse...help is on the way. With the advent of biosolids, ethanol, and other environmentally friendly products, there will be a day when there will be no such thing as waste. Fargo could be at the forefront of solving the garbage crisis if more research and development was done with these technologies.


Cherry Tree Illustrating the Project's Concept

New Recycling Program

Currently, the City of Fargo has both curbside pick up, and drop off recycling at various locations. Recycling in Fargo is not as successful as it could be. It costs $4-$5 per month to supply a bin for pick up and for the collection of recyclables from homes. It costs extra for extra bins. Also, while there are many collection bins throughout the city for free drop off, it is still a hassle for people to save their garbage and then haul it ot ne collected.
A new recycling program for the city of Fargo is essential for the success of this project. It is estimated that close to 50% of waste is recycleable, the city of Fargo currently recycles at a rate of 9%. I am proposing mandatory recyling city wide. Bins will be provided for free, and picked up at no extra charge. The catch is that if people do not recycle, they will be charged a fine. This system works well worldwide, and is easily applyable for cities. The need for additional trucks will not be a financial problem, because not as many trucks will be needed to pick up other garbage. Items that will be recycled include but are not limited to: aluminum, plastic, glass, cardboard, and newspaper. Food waste will be picked up seperately and hauled to the compost pile, which will no doubt need to be expanded.

Typical recycling truck and bin

Garbage Composting

Any and all garbage that is biodegradeable will be composted, including waste already in the landfill. This will reduce the volume of the waste and also allow the waste to be remediated. The garbage will first be pu through a grinder, which operates much like a paper shredder on a way larger scale. The ground garbage will be mixed with the ash from the incinerator, and then piled in the open, excavated areas. The garbage will then be wet landfilled in a new way. The garbage will be irrigated twice a week to both speed break down, and to leach out chemicals. The garbage will be overturned two to three times by a dozer between irrigations. This will also speed breakdown. After one month composting time, the garbage will be planted and seeded. Both medium and small size trees will be planted along with native grasses and flower plugs as well as hydroseeding a native grass mix. This should ensure coverage and success of the plants. After planting and seeding, the landfill will need to be irrigated at least one more month to ensure plant growth. The leachate treatment system will be in place right away as to allow for treated leachate water to be used for irrigation purposes. The wetland system will be the first area to take in garbage for composting and planting as to further treat the leachate water. The entire landfill should be excavated, composted and treated within five years. The end result will be the site plan that follows.


During Composting


Immediately After Planting


During Remediation

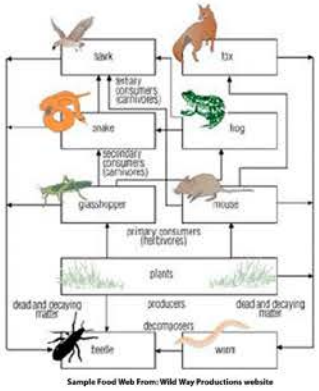

Muskrat lodge

Partial Food Web Illustration

One of the inspirations for this entire project was my knowledge that the Fargo landfill is to become designated for wildlife habitat after closure. A landfill closed under current practises and standards is no place for wildlife to be. As the landfill is not planned to be remediated or designed for habitat in any way, diverse wildlife will not populate it anyway.

If animal habitat is considered in the design phase, it is extremly easy to incorporate into the project. Not only that, but it will improve the site's sustainability and self preservation. For instance, worms, and bacteria will decompose the waste at the landfill turning it into useable soil by the plant material. the plant material will be eaten or used for housing by other animals, which will be eaten by other animals and so on. The grasses and animals that are eaten will become excrement and return to the worms and bacteria to become soil again. In this way, everything has a purpose and nothing will become overabundant. It will also provide a learning tool for designers, residents, and students.

The example food web provided is just a small portion of the web that will be created at the landfill post remediation. The bigger and more diverse the web, the better it will work. The Fargo landfill will be able to be designated for wildlife habitat, and actually mean it.



Sample Food Web From: Wild Way Productions website

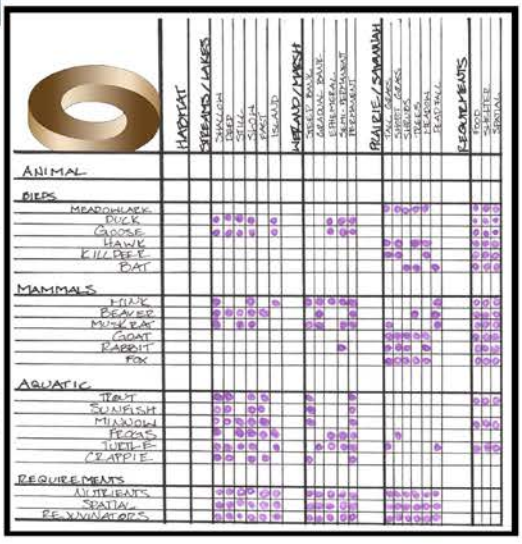
Animal Habitat Matrix

This is the matrix I used to help in the design of the habitat system for the landfill. It only represents a part of the wildlife that will inhabit the landfill. It would be nearly impossible to represent all of the possible animals that could survive there. The animals I chose to represent are native to eastern North Dakota, and coexist naturally in the wild. Others reasons for selection of certain animals would be their specific diet. For example, bats and sparrows eat almost twice their weight per day in mosquitoes; which I would like to keep in check naturally. Another example is the trout. This fish is very sensitive to pollution, so its inclusion towards the end of the water treatment system will be a natural monitor of any problem within the system.

Some of the animals in this list require deadfall, or larger trees for shelter. This material will need to be placed in areas as needed. This will not be a problem to attain because currently at the landfill, branches and stumps are brought in to be ground and burned. Some of this material can easily be diverted to become housing for animals. Some larger trees will also need to be brought in via spade, to speed up the time for trees to become large enough to be used as shelter. Most of the trees used selectively for their remediation qualities are fast growers anyway, so this should not be too much of a problem.

Other than the birds and insects, the rest of the animals to be included at the landfill will need to be brought in. There is simply no way a turtle can get in otherwise. I realize this will not allow the process to be totally natural, but given that the habitat is to be a remediated landfill in the heart of an industrial park, it is impossible for it to be a natural process anyway.

The beauty of this matrix and the food web, is that everything is dependent upon everything else for survival. The wetlands need inhabitants, the birds need the fishes and mammals. Everything is connected. Including humans. We need a place for our excess to go and be used by something to produce something else. We also need a place to remind ourselves that we are a part of a bigger whole. The Fargo landfill will give us that.



Waste Showcase/Confrontation

Framed Garbage

During the research portion of this project, I studied many remediation projects, many of them being closed landfills. The projects all provided a re use for the areas, and the public recieved them well. Not only did almost none of these do anything to remediate the waste, they did not attack the problem at the core. In these projects, waste was actually glorified. For example, in New Jersey old pipe pipe was used to create viewers. Another example was the classic tires painted with vibrant colors to become planters. These do nothing to remediate the waste; they just delay the inevitable discarding of the product. A true remediation of a landfill needs to address the garbage handling in that area, and let people know how much waste they create. Most people do not know they create 1 ton of refuse per year all by themselves, and when they find out are much more willing to try and reduce their waste.

This task will be accomplished at the landfill with etched glass panels strategically places along the pathways at important vistas. The panels will be etched with images of garbage, putrid leachate ponds, rats, and other images of typical landfills. The glass will allow people to see through this waste into a meadow, wetland, or prairie. They will serve as an important reminder of what the Fargo landfill will look like if no remediation effort is done. Another effort will be inside the research and development building. Waste excavated from teh landfill will be framed and hang on the walls to remind empleyees and visitors what was at the landfill. The waste will be from at least 15 years ago but will not be decomposed.

Layout Scheme 1

This layout includes most of the elements listed above. The blue area represents the area to be taken up by leachate filtration, in the form of a wetland. It is located where the old landfill was. As that will be the first part to be remediated, and as the landfill will need a leachate system right away, it makes sense to locate it here. The part that doesn't quite work is that it seems seperated from the rest of the site. The same goes for all the elements, they seem isolated. The incinerator and grinder have been located in near proximity to the scales, which is convenient for truck access. The location of the scales doesn't work because the impending incresse in traffic to the landfill. The research and development building is not only by itself, it is too far away from the incinerator and grinder to successfully monitor them both.

Layout Scheme 2

This layout incorporates all the elements from the list, while creating a more dynamic flow through the site. The water filtration still begins at the old landfill, but extends further into the site. It still seems like a separate entity rather than part of a whole. The research and development building as well as the incinerator, grinder, and greenhouses have been located on the southern side of the site to take advantage of sun angles and wind directions. Theses buildings are too far from the scales to minimize truck traffic on site. They are also too close to the edge of the landfill to allow for much elevation change between the road and the buildings. A few display areas have been noted, but more display would be better, to confront people about wastefulness and its repercussions.

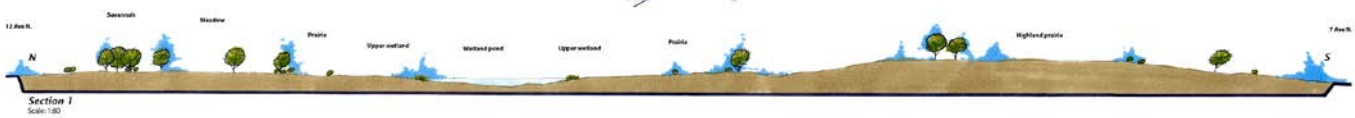
Layout Scheme 3

This design is by far the best. The wetland system has been further spread out throughout the site, and is divided in two separate entities, to allow for flood pulse flow. There are more areas suitable for display, since throughout the site environments change so often. The built structures have all been located near one another to allow for ease of access and monitoring. The drawback to this is that it will be expensive to relocate the scales, but as cost is not an issue with this project it is not too big a problem. The many environments and ecosystems will lend better to wildlife habitat creation as well.

Design Board 5 of 10 Development

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:



Section 1
Scale: 1:80

Section 2
Scale: 1:80

Section 3
Scale: 1:80

Site Plan and Sections
Board 6 of 10

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:

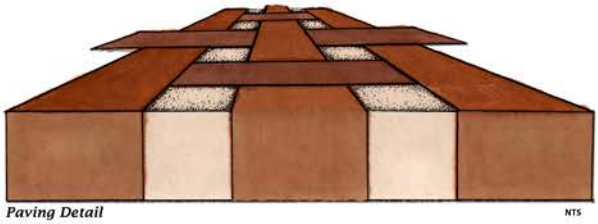
Perspective 1

The parking lot at the Fargo landfill will serve dual purposes, to provide a place to park, and to illustrate runoff differences between paving types. Half the parking lot will be paved with completely impervious concrete, while the other half will have a semi pervious brick/gravel pattern. Runoff will be directed into catch basins for people to observe and measure the difference in amounts. The semi pervious side will have significantly less runoff. After measurement or in the event of large rainfall, the basins will be drained into a bioswale for filtration and evaporation. Excess runoff will drain to the surrounding ditches and drained.

Green Roof Detail

The Research and Development building will have a roof that is 70% green, the rest of the roof will be for skylighting. The green roof will be vegetated with sedum and sedges. These plants can take the most harsh climates while requiring a minicule amount of growing medium. The green roof will provide habita for many types of ground nesting birds, as well as significantly reduce the amount of runoff created by the building roof.

NTS



Paving Detail

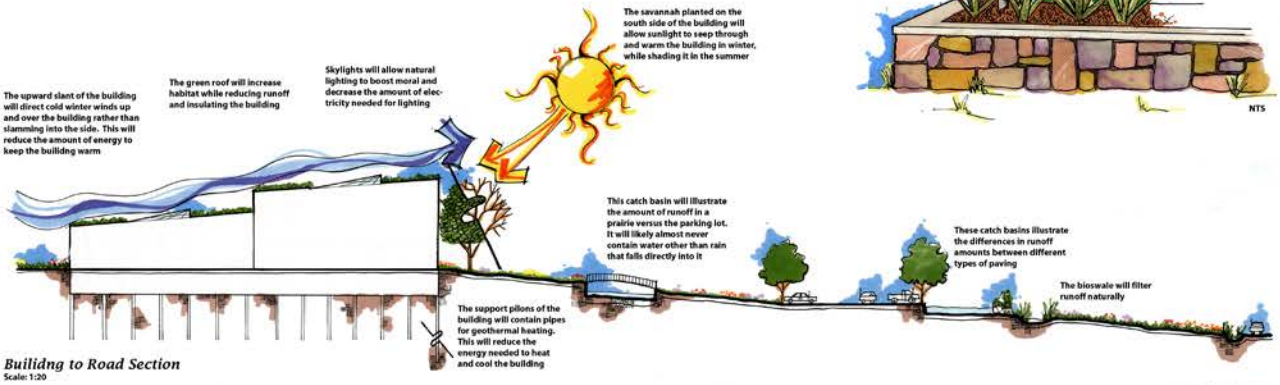
NTS

The paving for the semi-pervious sidde of the parking lot will be a combination brick/gravel. The brick will be laid in a loose basket weave pattern with gravel in between bricks. The gravel allows for the infiltration of water down to the soil. Larger grade gravel will be used underneath the paving as a base to allow further runoff.

Fence detail

The fence around the landfill will have a low-lying planter around the base filled with vines to grow through the chain link, and yucca to discourage riffraff. The existing chain link will remain as it can be removed easily and cost effectively after remediation is complete, and further development of the landfill continues. The barbwire at the top of the fence will be removed, as it does nothing for the appearance and does not effectively keep people out.

NTS



Buildng to Road Section

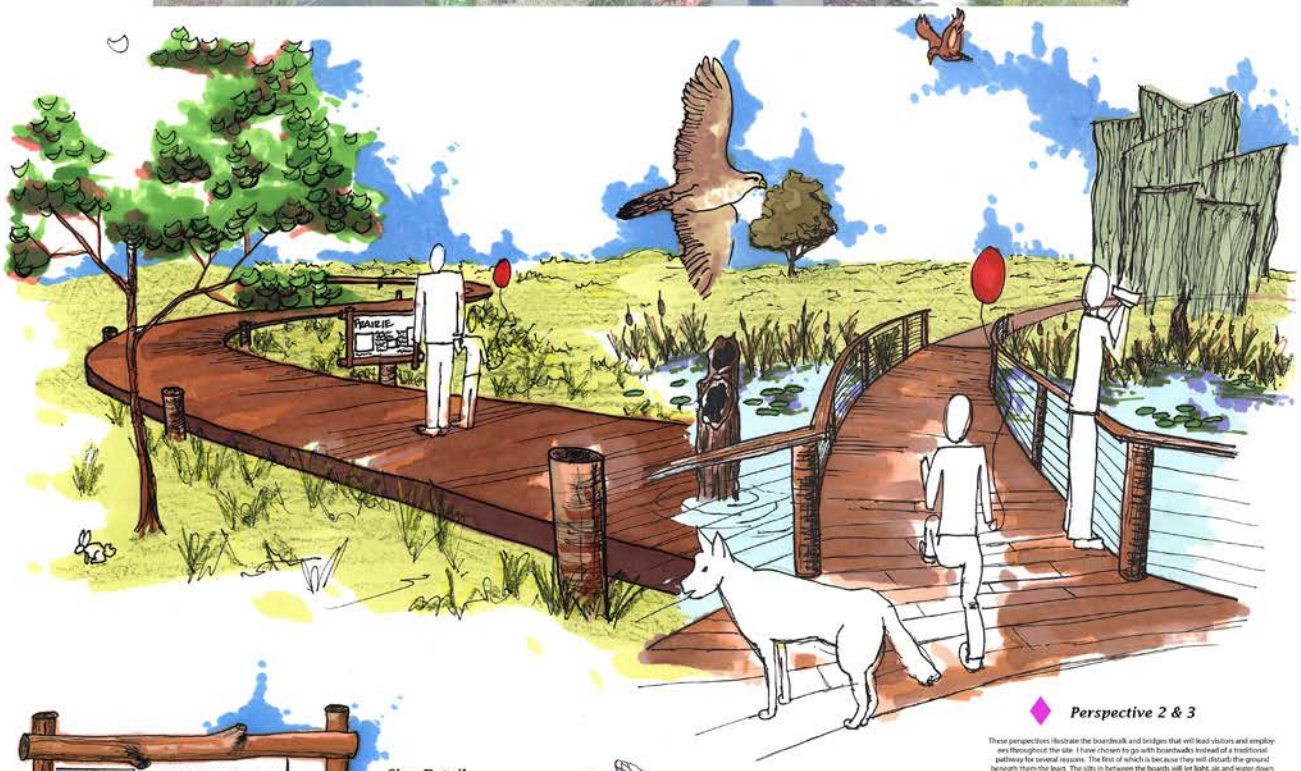
Scale: 1:20

Perspectives and Sections

Board 7 of 10

Waste is a Terrible Thing to Waste

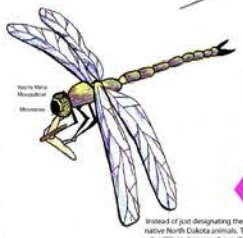
THE FARGO LANDFILL:



NTS

Sign Detail

Information signage will be constructed from logs and branches previously brought to the landfill for grinding and shipping. The information will be printed on recycled plastic and protected with glass on either side. Material represented will be anything from an animal and its habitat to what kind of garbage or contaminate a plant helps to remediate.



Perspective 2 & 3

These perspectives illustrate the boardwalk and bridges that will lead visitors and employees throughout the site. I have chosen to go with boardwalks instead of a traditional pathway for several reasons. The first of which is because they will disturb the ground beneath them the least. The slits in between the boards will let light, air, and water down through the boards while allowing plant material to grow up between them. The underside of the boardwalk can also become home to small mammals or bats. The boards for the boardwalks will be pressure treated to help against rot without using chemicals. When a board eventually rots, it can be easily replaced, without ripping out the whole structure. Rotted boards can be ground up and used as mulch elsewhere on the site. All along the path will be informational signs so visitors can learn about the flora and fauna they are amongst, and how they work together to survive.

Perspective 4

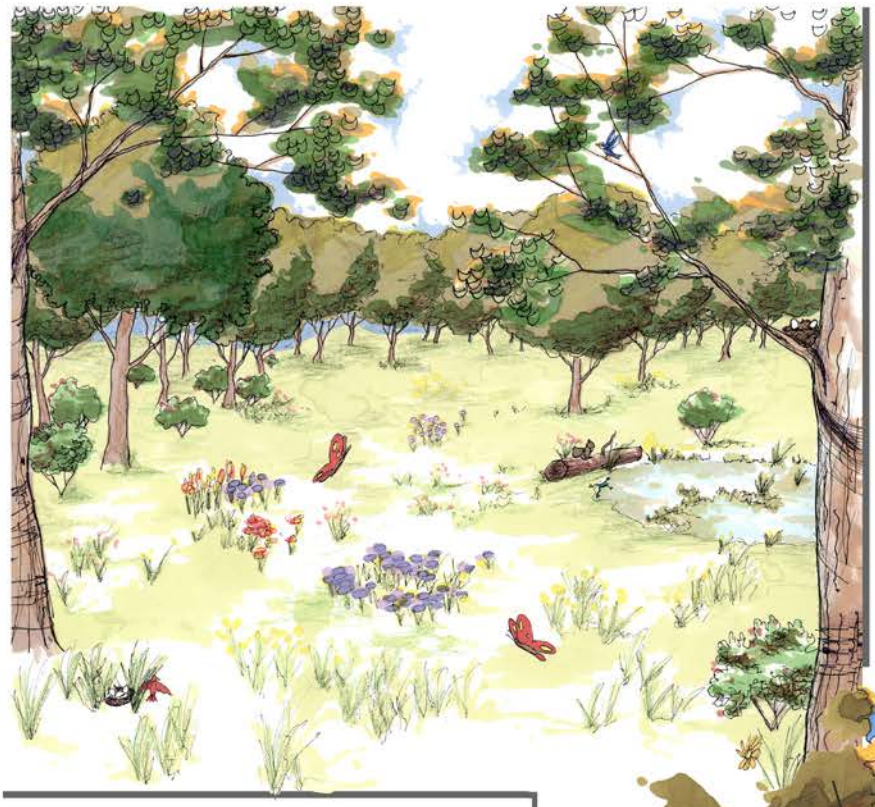
Instead of just designating the landfill to become 'wildlife habitat' I have chosen to create habitats for native North Dakota animals. The animals will live off the vegetation or other animals or insects at the landfill. In doing so, they will help to keep the system a self-sustaining one. For instance, muskrats need aquatic vegetation to build their nests and for part of their food supply. Mink need muskrats for food and to use their lodging as their own. Hawks eat mink and also use vegetation to build homes. So on and so on. After the Fargo landfill is remediated and possibly developed further, part of the wildlife habitat can remain. The wetland system can become a fully functioning stormwater system and with some planning, most of the animals will be able to remain on site.

Perspectives and Details

Board 8 of 10

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:



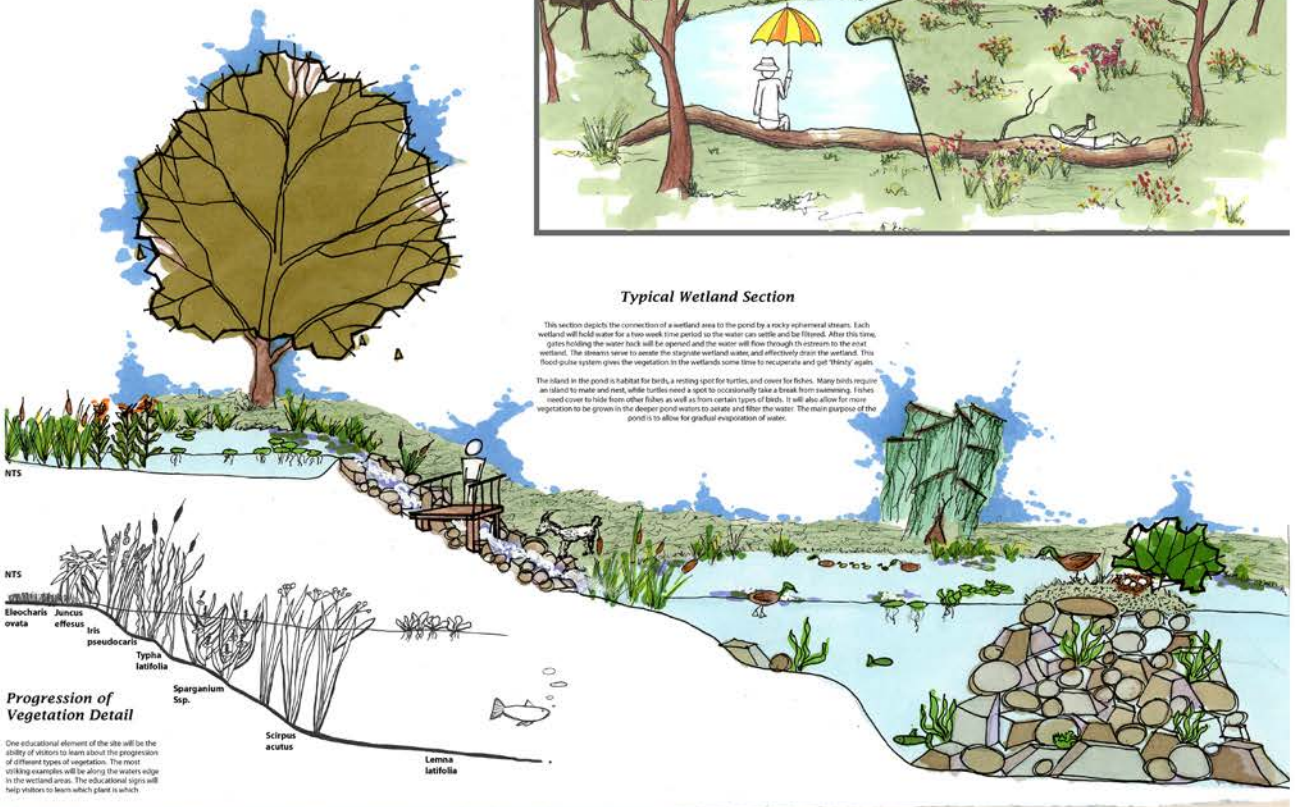
Meadow Perspective

There are two meadow areas in the site plan. They are filled with a wildflower mix native to North Dakota and have bloom times varied throughout the year. The idea is to have visitors walk through the prairie and wetland areas which will be varying shades of green with few splashes of color, and then through a break in the savannah to an area bursting with vibrant color and fragrance. The flowers will also attract many butterflies, bees, and certain birds. The feeling inside the meadow is more protected, and seperate contrasting with the vast openess of the prairie and wetland areas.

Monarch on Clover
NTS

Vernal Pool Perspective

A vernal pool is basically a shallow depression in the ground that fills occasionally with water for a week or two after a large rain or snowmelt. Vernal pools are very important in a healthy wetland ecosystem. A vernall pool can act as a device to control and filter stormwater, not to mention provide mating grounds for several types of mammals, and many insects. Mosquitoes will not be able to reproduce in them as the larvae takes longer to develop than the pool will have water in it. There are several vernal pools throughout the site providing habitat for a variety of organisms.



Typical Wetland Section

This section depicts the connection of a wetland area to the pond by a rocky ephemeral stream. Each wetland will hold water for a two-week time period so the water can settle and be filtered. After this time, gates holding the water back will be opened and the water will flow through th estream to the next wetland. The streams serve to aerate the stagnate wetland water, and effectively drain the wetland. This flood-pulse system gives the vegetation in the wetlands some time to recuperate and get "thirsty" again.

The island in the pond is habitat for birds, a resting spot for turtles, and cover for fishes. Many birds require an island to mate and nest, while turtles need a spot to occasionally take a break from swimming. Fishes need cover to hide from other fishes as well as from certain types of birds. It will also allow for more vegetation to be grown in the deeper pond waters to aerate and filter the water. The main purpose of the pond is to allow for gradual evaporation of water.

NTS

NTS

Eleocharis ovata
Juncus effesus
Iris pseudocaris
Typha latifolia
Sparganium Ssp.
Scirpus acutus
Lemna latifolia

Progression of Vegetation Detail

One educational element of the site will be the ability of visitors to learn about the progression of different types of vegetation. The most striking examples will be along the waters edge in the wetland areas. The educational signs will help visitors to learn which plant is which.

Perspectives and Details

Board 9 of 10

Waste is a Terrible Thing to Waste

THE FARGO LANDFILL:

Compost Spreader for Natural Agricultural Fertilization
Image obtained from Internet

Expenses for fertilizer, lime, and soil conditioners as a percent of total farm production expenses
Image obtained from USDA website

How This Project is Financially Feasible

Cost Associated with Traditional Landfill Closure

It costs between $80,000 and $200,000 per acre to close and cap a landfill in the traditional manner. At $140,000 (the median price) the Fargo landfill which is 160 acres will cost upwards of $22,400,000 to merely cap and close the landfill.

The 'Old Landfill' is currently designated an EPA superfund site requiring cleanup. This will tack on at least an additional $10,000,000.

The Fargo landfill will inevitably leak. It is a fact that all liners eventually fail. Using the Becker County landfill as precedent, it will cost at least $500,000 to remediate any and all groundwater pollution...as well as any gas leaks and soil problems.

Revenue Associated with Traditional Landfill Closure

The Fargo landfill currently earns between $2-7 million dollars annually by selling the methane produced to Cargill. Thirty-years or so post closure, the landfill will no longer be monitored for methane and will stop selling it, since it should no longer be produced by then.

Cost Associated with the Implementation of This Project

It would be impossible to calculate exactly the cost of this remediation strategy. An educated guess estimates around $100 million dollars. This price tag would include the excavation of the entire landfill, the construction of a grinder and incinerator, greenhouses,the construction of a research and development building, the wetland constructions, the vegetative materials, the millions of earthworms and other animals to be introduced, and the trail system.

It should be noted the City of Fargo is planning on the construction of an incinerator anyway, so this would eliminate the neccessity of including it in the price tag.

Another important point would be the leakage factor. By the time the landfill would begin to leak, the remediaiton process would be long complete. Therefore, if it leaked, it would just be a natural part of the Fargo groundwater flow and would pose no threat of pollution

Revenue Associated with the Implementation of This Project

While this project will require an enormous amount of money to complete, it will be able to more than make up for itself.

The incinerator on site will be able to power 20,000 homes daily. The sale of electricity will more than make up for the loss of revenue from selling methane.

The new recycling program will divert all yard and food wastes to the Fargo Composting Site. The size of the composting operation will increase tenfold, producing the most reusable natural fertilizer in the area. This compost can be sold to local farmers to use in place of chemical fertilizer and will replace lost or depleted topsoil.

The landfill will no longer be a landfill. It will become re-usable and adaptable to change. It could become anything. The city will be able to sell the land to developers and tax it for years to come. This will add tens of millions of dollars to the city's bank account.

Finally, the landfill will pose no risk to the residents of Fargo. There will be no contamination of soil, air, or water created by the landfill. No one can put a price tage on their health.

What Could the Remediated Fargo Landfill Become?

A cranberry bog

Two states in the U.S. produce the entire cranberry crop: Wisconsin and Massachusetts. We even import cranberries from other countries to fill the demand. Cranberries will grow in the North Dakota climate as long as they are seasonally flooded. The landfill will have a wetland system in place already, so it could easily be converted into a cranberry bog. This idea is a little far out there, but it is to illustrate the vast scope of possibilities available to the landfill post remediation.

Cranberry Bog Harvests
Images obtained from the Internet

Expansion of the Industrial Park

One of the most likely scenarios for the landfill post remediation would be to develop it as more industrial park. What will be different about this addition to the industrial park is that it will have a stormwater system in place at the time of construction. Employees will be able to stroll about the grounds on breaks, and the city will not have yet another rectangular detention pond lined with turfgrass. The industrial park addition could be developed in such a way as to still maintain habitat for most species on site. It would be a model for sustainable development. My vision for the types of businesses to locate here would be biopolymer manufacturing, ethanol manufacturing, and other businesses making products created in the research and development building located in my plan.

Industrial Park Creates Jobs
Images obtained from the Internet

A Wind Field

Due to the topography created at the old landfill, it would lend well to becoming a wind field. The 160 acres the landfill comprises could be filled with enough windmills to power the entire city of Fargo-Moorhead, and West Fargo. In fact, we would have ample electricity to sell to other areas and increase revenue further. The wind field idea could be used in conjuction with any development idea, as they don't take up much space horizontally. Fargo is one of the windiest places in the area, due to the areas flatness. We could take advantage of that and create clean energy that is renewable.

Windmills Creating Electricity
Images obtained from the Internet

Leave the landfill as Habitat/Parkland

Another idea would be to leave the landfill as a new gem in the system of Fargo Parks. The area is currently devoid of parks; the nearest one is a few miles away. A lot of land in this area is used by humans for development or for agriculture. A 160 acre wildlife preserve/park in the city could benefit the residents and city not in monetary value, but in educational opportunities, and in providing more space for people to be outside amongst nature. The pond could easily be expanded into more of a lake, for residents to fish in, or the annual influx of butterflies could become a new city holiday.

Cities Can Support Ecosystems
Image obtained from the Internet

A Snowmobile Track

The people of this area are accustomed to long winters. One of the activities that is very popular amongst all ages is snowmobiling. The topography at the landfill will create amazing jumps for riders to attempt. The landfill is large enough to provide interesting snowmobiling for many riders at once. The idea could even be expanded to include snowmobile races and trick shows. The people of Fargo currently have to travel long distances in search of good sites to ride, so this would allow the residents of Fargo to remain here, rather than leaving for vacations.

Topography Spurns Good Snowmobiling
Images obtained from the Internet

A Housing Development

A housing development on an old landfill in an industrial park would have seemed like a stretch prior to remediation. However, with the remediation comes amenities. The site will have a large pond with streams, mature vegetation, and topography...something very valued in this area. The site is also close to three main thoroughfares: I-2 Ave, 42 St., and 7 Ave. Access to and from the site would be very convenient. A housing development here would be perfect for people who worked in and around the industrial park, as well as college students due to its proximity to North Dakota State University. The development would also increase the property taxes available for the development, providing more funds for the city.

Housing Developments Increase Property Value
Images obtained from the Internet

Various Outdoor Activities

People in the northern midwest are notorious for appreciating the different seasons provided by our climate. This is why an area such as the landfill could be designed as an outdoor adventure park of sorts. Everything from mountain biking, to frisbee golf, to paintball could all be included on one site. A family, or group of friends, or even co-workers could all go together and participate in whichever activity suits their fancy. This option could provide substantial revenue with tournaments for each sport, and even through renting equipment. This idea would also allow a good majority of wildlife to stay at the landfill as well.

Residents of Fargo Getting Exercise Outside
Images obtained from the Internet

Where Do We Go From Here?

Board 10 of 10

Waste is a Terrible Thing to Waste

Why hello. My name is Carol Hejl, and man am I glad to be done with school. I hope if you've read through this program it's been helpful to whatever project you're doing. I grew up in the area and am now off to Chicago, where I will be working with the department of the environment. Anyway, good luck with the rest of school to you; and maybe we'll cross paths someday!