Sustainable Stormwater Feasibility Report for the Ford Plant Site

St. Paul, Minnesota

Prepared for
City of St. Paul

August 2009

BARR

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

Sustainable Stormwater Feasibility Report
For the Ford Plant Site
Table of Contents

List of Figures

List of Appendices

Acknowledgements

Barr Engineering Co. would like to thank the following companies and agencies for the invaluable and enthusiastic assistance they provided in developing and refining this report, including the Ford Motor Company, ARCADIS, City of St. Paul, Ramsey County, Minnesota Pollution Control Agency (MPCA), and the Ford Site Sustainable Redevelopment Team.

Funding for this report was commissioned by the City of St. Paul through a grant provided by the MPCA.

Minnesota Pollution Control Agency

City of St. Paul

Barr Engineering Co.

1.0 Executive Summary

Under the direction of Mayor Chris Coleman and under a grant provided by the Minnesota Pollution Control Agency (MPCA), the City of St. Paul commissioned this report to investigate the feasibility of low-impact stormwater management at the Ford Plant site, in anticipation of the closing of the plant and redevelopment of the site. At this time, the planned use or re-use of the site is not known. This report sets forth general recommendations that can be used during decision-making processes for potential redevelopment. In the event that the plant remains open, the guidance provided by this report may assist Ford in retrofitting the plant to be more environmentally sensitive.

Several local, state and federal entities have jurisdiction over the site. The most pertinent regulations with regards to stormwater management at the Ford Plant site are the City of St. Paul's ordinances and Capitol Region Watershed District's (CRWD) regulations. The most stringent of these regulations come from CRWD upon redevelopment, which requires that the runoff volume from the first inch of rainfall from impervious surfaces remain on site if feasible given site constraints, and 90 percent of total suspended solids must be removed during a 2.5-inch rain event.

The Ford Plant and the nearby railroad parcels have 85 percent impervious cover. The stormwater runoff from the site is collected in a stormwater system and discharged to the Mississippi River through a culvert by Hidden Falls. As in most areas of St. Paul, stormwater runoff from the site is untreated,carrying sediment and possible pollutants from streets and parking lot surfaces into the Mississippi River. This report will discuss strategies and stormwater Best Management Practices (BMPs) that could be installed during redevelopment of the site to reduce the volume and improve the quality of stormwater discharged from the site.

Ford Motor Company has hired a consultant, ARCADIS, to perform site investigations with soil borings and groundwater monitoring wells for Phase I/II Environmental Assessments. The assessments prepared by ARCADIS and the data contained in those assessments were analyzed as to the feasibility of managing stormwater by infiltration at the Ford Plant site.

While the Environmental Assessment process is not complete, locations of some impacts have been identified. These impacted areas need to be considered when planning for stormwater infiltration, and in some cases remediation and soil correction (removing the impacted soil and replacing with clean backfill) may need to be considered.

Stormwater infiltration is restricted by the ability of the receiving soil to infiltrate. Permeable soils are necessary to treat runoff; and sandy soils are more receptive to infiltration than silty or clayey soils. The soil borings conducted by ARCADIS were analyzed to determine the predominant soil type at each location. The soils at the Ford Plant contain gravel, sand, silt, clay and organic material. There are some areas in the middle of the site that have moderately permeable soils; however, much of the site contains clay. Soil correction is a possible course of action to promote infiltration. Many locations across the site have not been sampled, so the possibility of infiltration in those areas is unknown. Further soil borings in more locations around the site will assist in building a complete soils map for the entire Ford Plant site.

The ARCADIS soil borings also documented the presence of bedrock and groundwater. Groundwater is present in two locations in the bedrock: in the Platteville Limestone unit approximately 20 feet below the ground and in the St. Peter Sandstone approximately 100 feet below the ground surface. The uppermost surface of bedrock is generally 6 to 15 feet below the ground surface on the site. The bedrock is deep enough to provide sufficient soil cover for infiltration, and shallow enough to make soil correction down to bedrock a feasible option if impacted or impermeable soils need to be removed. The presence of the low-permeable Hidden Falls Member in the Platteville Limestone unit likely prevents much if any infiltrated water from reaching the St. Peter Sandstone near the site. The presence of groundwater seeps at the bluff line near the Ford Plant site indicates that infiltrated water at this location likely flows horizontally through the Platteville Limestone and then down to the river. The close proximity of the site to the bluff line and the presence of a low-permeable layer under the limestone make it unlikely that much water infiltrates into the sandstone layer. In this location, the elevation of the groundwater in the St. Peter Sandstone is controlled by the water surface elevation of the Mississippi River.

Given these site constraints, a key goal of this report is to target locations where potential regional stormwater features could be cost-effectively implemented. All available data from the Environmental Assessment process and multiple public sources relevant to stormwater management was compiled in a database and used in the analysis for this report. Factors that place limits on infiltration (shallow bedrock and groundwater, impermeable soils, impacted soils and groundwater, utility conflicts, high slopes) were screened together in an overlay process to determine which areas were most and least challenging for promoting infiltration. While there is still more soils data that needs to be collected, the results of that analysis indicate that there are areas where infiltration would be challenging. If possible, stormwater management BMPs should avoid those difficult locations. However there appear to be areas where infiltration may be feasible (see Figure 15).

Redevelopment of the Ford Plant site, or retrofitting it for continued manufacturing, should involve a comprehensive and integrated analysis of all elements of design, including stormwater. The social and ecological implications of each component of the development can be enhanced by integrating stormwater management and site design into the initial design process. One outcome of an integrated design approach could be the creation of stormwater management corridors that also provide recreational and ecological corridors for pedestrians and wildlife habitat alike. Stormwater management can enhance the aesthetics of a development, improve development potential, provide educational opportunities, and result in cost reductions, such as reduced stormwater infrastructure costs and reduced irrigation requirements. A conceptual example of how the site could be developed in such a way is included in this report (Figure 20).

Ultimately, the prospect may not prove feasible, but it is worth a thorough study to evaluate as the City of Saint Paul looks for opportunities to meet its mandate to reduce stormwater runoff volume and provide water quality treatment. This report details several low-impact stormwater BMPs, including rainwater gardens and regional infiltration basins. While the goal of this project is infiltration to reduce stormwater runoff volume, if site conditions cannot be remediated due to cost and other considerations, filtration basins are also a way to treat and remove the pollutants contained in stormwater runoff. Additional BMPs discussed include impervious surface reduction, porous pavement, on-site storage and reuse, and green roofs, all of which can have either an infiltration or a filtration component.

Additional investigations will be required to develop a full implementation strategy. Monitoring the existing runoff from the site will enable stormwater modeling to predict the specific volume and pollutant reduction benefits that could be anticipated with installation of stormwater BMPs. Monitoring should continue through all phases of the redevelopment to assess the success of the BMPs.

As part of this analysis, a geospatial information systems (GIS) database was developed by Barr to assist in the clear presentation of all available data, and to provide a tool for planners and decision-makers in developing stormwater master plans. The figures at the end of this report were developed using this database. The database and associated mapping documents are included on a DVD in Appendix C.

2.0 Site Description

This report presents the findings of a sustainable stormwater feasibility analysis for the proposed Ford Plant redevelopment in St. Paul, Minnesota. The conclusions are based on analysis of public sources of data, including investigations performed by Ford Motor Company's consultant ARCADIS. The analysis involved compiling geospatial data sources relevant to stormwater into a geospatial database and using that data to assess the Ford Plant for sustainable stormwater solutions, particularly stormwater infiltration practices. The database compilation and feasibility report were prepared by Barr Engineering Co. (Barr) to support future redevelopment of the Ford Plant site, including the option of retrofitting the existing site for other manufacturing operations. This document is intended to be used as a tool by the City of St. Paul and current and future stakeholders in redevelopment of this site. This work was performed by Barr on behalf of the City of St. Paul, and made possible by a grant from the Minnesota Pollution Control Agency (MPCA).

2.1 Historical Use

The Ford Motor Company's Twin Cities Assembly Plant (TCAP) (see Figures 1 and 2) began production at its Highland Park location in 1924 (Ford Website, 2009). The site is located at 966 South Mississippi River Boulevard in the City of St. Paul, Ramsey County, Minnesota. Prior to Ford's acquisition of the site, the property was reportedly undeveloped (ARCADIS, 2007a). The site facilities have changed substantially over the years as Ford built and dismantled a racetrack, expanded production facilities and removed structures to support continuous improvement and modernization. The plant has produced millions of vehicles in the years since operation began. The plant also mined sand to manufacture vehicle windows for the vehicles manufactured at the site for many years, resulting in a network of subsurface tunnels in the St. Peter Sandstone bedrock unit. The plant is currently scheduled to cease automobile production sometime in 2011, although previous closing announcements have been delayed. (Giles, 2008)

The City of St. Paul is looking at a number of reuse options for the Ford Plant site in the event that Ford shuts down its operations. Those options include: reusing at least some of the existing buildings and infrastructure for manufacturing, or redeveloping the site completely into some combination of industrial, commercial, residential and open space.

2.2 Environmental Assessments

In preparation for TCAP shut-down and site redevelopment, Ford enrolled the site in the Minnesota Pollution Control Agency's Voluntary Investigation and Cleanup Program (MPCA VIC) (#VP23530) and the MPCA Petroleum Brownfield Program (MPCA PBP). Ford also hired ARCADIS to conduct environmental assessments at the site to investigate the potential presence of impacts on site and the potential need for remediation. ARCADIS completed a Phase I Environmental Site Assessment (PHASE I) in June 2007 and follow-up investigation work during the summer and fall (ARCADIS, 2007a). Results of the investigation were published in a report titled "Phase II Exterior Investigation Report" in October 2007 (ARCADIS, 2007b). ARCADIS identified limited locations with soil and/or groundwater impact present above MPCA and Minnesota Department of Health (MDH) risk-based criteria (see Figure 3) and recommended follow-up investigation to define and delineate the extent of impacts, conduct additional groundwater monitoring, and complete a receptor survey. The proposed environmental investigation work is currently on hold due to the extension of Ford's operations until 2011. Any remediation options will be based on the future redevelopment plan and will require MPCA approval.

Multiple investigations into potential environmental impacts present at various locations around the Ford Plant site have been conducted since at least 1987. These are detailed in the Phase I Environmental Site Assessment prepared by ARCADIS (PHASE I). These investigations should be considered in further assessment of the site for stormwater management.

2.3 Impact

The ARCADIS PHASE I identified areas of interest where possible impact could have occurred (ARCADIS, 2007a). Many of these locations were investigated during the initial Phase II Investigation conducted by ARCADIS. Additional information and copies of the PHASE I and PHASE II reports can be found on the City's Ford Plant website: http://www.stpaul.gov/index.asp?NID=1207.

While much of the site has been investigated to date by ARCADIS, there are several areas of the Ford Plant site that have not yet been investigated. Additional investigation work is currently on hold due to Ford Motor Company's decision to extend plant operations until at least 2011. The "Supplemental Phase II – Exterior Investigation Work Plan" details additional soil borings and groundwater monitoring wells that will be drilled to conduct further investigations into potential soil and groundwater impact (ARCADIS, 2008). Additionally, ARCADIS has identified additional soil boring locations in the north parking lot that will be investigated as part of the Supplemental Phase II investigations (see Appendix B). These additional borings and wells will enhance the understanding of the site conditions and will guide selection of remediation techniques, if necessary. After completion of the proposed ARCADIS supplemental investigations following plant closure, locations underneath the footprint of the active production facility, paint building, and various other structures at the Ford Plant site will be investigated.

The completed environmental investigation results for soil samples were primarily compared to the MPCA's Tier 2 Industrial SRVs, which is an appropriate criterion to assess direct contact concerns for the current land use. If the site land use is changed in the future, the soil data may require screening against Tier 2 Residential or Recreational SRVs. In the context of stormwater infiltration, the MPCA often requires comparison of soil concentrations to their Tier 1 Soil Leaching Values (SLVs). SLVs serve as a preliminary and conservative screening tool to assess the potential for soil impacts to leach via precipitation or surface water infiltration and impact groundwater. Ford Motor Company, the City and any potential developer will work closely with the MPCA to determine the best course of action following plant closure.

2.4 Soils Investigation for Infiltration and Volume Reduction

The most important factor in planning and designing low-impact stormwater best management practices (BMPs) that utilize infiltration is the permeability (or infiltration capacity) of the soil. The infiltration capacity is determined by the grain size of the soil particles. Larger grains, such as gravel and sand, allow water to easily infiltrate and are ideal for infiltration. Finer grain soils, such as silts, clays and organic materials, do not allow water to infiltrate as easily and present challenges for stormwater BMPs that utilize infiltration.

The Natural Resources Conservation Service (NRCS) hydrologic soil types are classified from A to D, with A having the highest capacity for infiltration (sands and gravel) and D having the lowest (clays). NRCS's soil database contains only limited data for the Ford Plant site; only the eastern portion in the location of the baseball fields is classified by soil type in NRCS's database. That area is listed as a B/D soil, meaning that when wet, the soil acts like a low-infiltrating D soil (see Figure 5). This area would not likely be ideal for infiltration practices, but it may pose possibilities for rate control and water quality treatment through infiltration.

ARCADIS placed over 100 soil borings (some shallow and some deep) during their environmental investigation and classified the soil layers at most locations (ARCADIS, 2007b). The boring logs indicate the presence of multiple layers of fill including gravel, sand, silt and clay soil types. Wherever a clay layer is present, it presents challenges for infiltration without soil correction. A few of the ARCADIS boring logs indicate the predominance of sand; however, these borings are surrounded by other borings that indicate the presence of clay, sandy clay, or clayey sand. Several soil borings to the east of the main assembly building indicate that sandy silt or silty sand layers are most prevalent, however, some clay layers are present in this area as well (see Figure 6).

It is possible that sandy soils exist under the buildings, but it is probable that soil correction may be necessary at most locations outside the building footprints to promote infiltration at the Ford Plant site. Soil correction is discussed in Section 6.2.

2.5 Bedrock

The bedrock profile at the Ford Plant site was determined by ARCADIS based on deep soil borings installed in 2007 (see Appendix A; ARCADIS, 2007a). Generally, the top layer of bedrock was encountered 6 to 15 feet below grade (see Figure 7). The top layer of bedrock in a few locations on the east side of the site is highly fractured Decorah Shale, varying in thickness from zero to 25 feet. In most portions of the site the uppermost bedrock unit is a 20- to 25-foot thick layer of fractured Platteville Limestone. Below the limestone is a thinner layer of Glenwood Shale, approximately 5 to 15 feet thick. These units all rest on the St. Peter Sandstone deposit, a thick layer that extends down below the Mississippi River. The sandstone layer begins approximately 50 feet below the ground surface of the Ford Plant site.

ARCADIS delineated the general locations of several subsurface tunnels located below TCAP. Many of these tunnels were used to mine sand for glass-making operations at the plant. These tunnels are located in the St. Peter Sandstone bedrock unit.

2.6 Groundwater

ARCADIS encountered groundwater in three separate horizons:

- Perched groundwater was encountered in some locations in the soil layer above the bedrock, likely due to the presence of clay.

- Perched groundwater was also present in the Platteville Limestone at an elevation of 774 to 795 feet NAVD88. The groundwater in the limestone generally flows to the west and south toward the Mississippi River, although some isolated groundwater mounding was observed near the southwest corner of the Ford Plant, which indicates that some of the perched groundwater could take a more circuitous route to the river (see Figure 8).

- Groundwater was encountered in the St. Peter Sandstone at an elevation of 690 to 710 feet MSL at the approximate Mississippi River surface elevation. Groundwater in the St. Peter Sandstone flows toward the river, to the west and south (see Figure 9).

2.7 Impervious Surfaces

The Ford site is a 121.5-acre parcel that includes manufacturing facilities and three baseball diamonds (see Figure 4). Two adjacent parcels totaling 13.0 acres are presently owned by Canadian Pacific Railway, and will likely be sold if TCAP ceases operation. Of the total 134.5 acres for the three parcels, impervious surfaces such as buildings, parking lots and walkways comprise 114.6 acres, or 85.2 percent of the site. The impervious surface on Ford's site alone is 103.4 acres, or 85.1 percent of the entire 121.5-acre parcel.

2.8 Known Utilities

In the design of stormwater management systems, it is important to be aware of any potential underground conflicts from other utilities. Relocating utilities for stormwater systems is always an option, but that can add time and expense to any project. It is important to know about potential underground conflicts in the feasibility stage of a design for stormwater conveyance or infiltration.

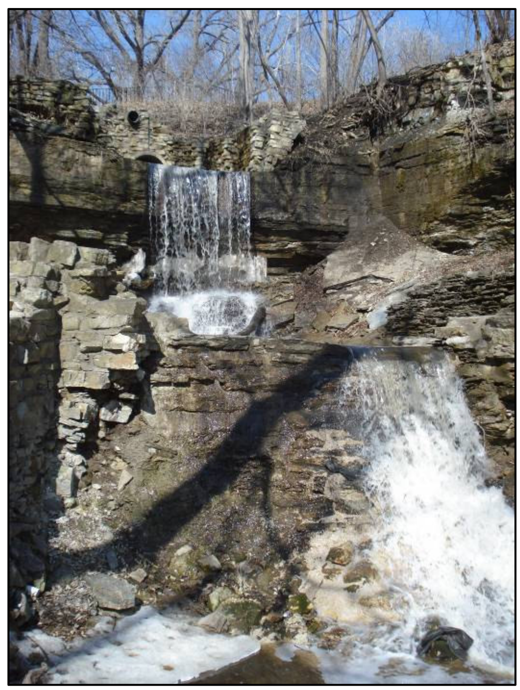
Utility information for the site was provided by the City of St. Paul (see Figure 10). Gas, electric, sanitary and storm sewer GIS data was overlayed with the Ford Plant site. The utilities that are located within the project site generally service the TCAP alone; however, data for cable and telecomm utilities were not available for review. It is unlikely that a main fiber-optic line was placed through the Ford Plant site, since the facility has been operational for more than 80 years.

There is an underground electrical line in the northwest parking lot that connects the hydroelectric dam to the electrical grid along Ford Parkway. The depth of the underground line is not known given the available public data provided by the City; however Ford or Xcel Energy may have data on this line.

There is a strong possibility that the existing Ford Plant stormsewer system may collect runoff from the Lunds shopping plaza and the apartment complex located on the east side of the plant. These properties were historically part of the Ford Plant and there is no GIS data on the presence of stormsewers in either the shopping center or the apartment complex. Runoff from the Ford Plant stormwater system leaves the site by a 48-inch pipe. This pipe connects to the City stormsewer that drains the neighborhood to the south of the plant and discharges under Mississippi River Boulevard into Hidden Falls Regional Park where the water then flows overland into the Mississippi River.

2.9 Hidden Falls Regional Park

Hidden Falls Regional Park is part of the St. Paul park system and was created in 1887 (City Website). It lies largely in the floodplain of the Mississippi River at the base of the river bluffs and features hiking and biking trails, picnic shelters, views of Historic Fort Snelling, access to the Mississippi River, connection to the St. Paul regional trail system, and most prominently, Hidden Falls. Hidden Falls is a natural, spring-fed waterfall. The flow at Hidden Falls is augmented by storm runoff from the Ford Plant and surrounding neighborhoods by the 48-inch pipe that discharges just uphill of the Falls. Hidden Falls Park is an important natural and historic amenity for the community. Preserving and enhancing the falls is a priority for the City. Therefore, the future stormwater management plan for the site should be designed to ensure that adequate water flow to the Hidden Falls outlet is maintained.



Hidden Falls provides a dramatic scene in spring. Photo Credit: N. Campeau

2.10 FEMA Floodplain

The Ford Plant sits on a bluff overlooking the Missisippi River gorge and floodplain. Any proposed development activity near a floodplain should weigh the risks presented by potential flooding. The Federal Emergency Management Agency (FEMA) publishes studies that state the risk of flooding potential for areas adjacent to studied water bodies. On the west side of TCAP, the Mississippi River flows generally north to south. In this location, the Mississippi River is contained in the river gorge, over 100 feet below the elevation at the Ford Plant site. A review of the FEMA floodplain shows that the Ford Plant is located outside of the FEMA one-percent-annual-chance floodplain (also known as 100-year floodplain). The 0.2-percent-annual-chance floodplain (or 500-year floodplain) comes closest to the site, with floodwater still many feet below Mississippi River Boulevard near the access road to the hydroelectric dam (see Figure 11).

3.0 Pertinent Stormwater Regulations

3.1 City of St. Paul

The City of St. Paul has jurisdiction over the entire Ford Plant site. The city's regulations incorporate stormwater requirements imposed by EPA, MPCA and DNR. Other entities also have jurisdiction over the site as discussed in subsequent sections of this report.

3.1.1 Stormwater Regulatory Framework from City Code

The City of St. Paul has an established a regulatory framework that will guide future development of the Ford site. Key elements of this framework include the City's stormwater and zoning regulations.

3.1.1.1 Stormwater Regulations

Section 52 of the city's Code of Ordinances (City Code) sets forth the requirements for the Storm Water Pollution Prevention Plan (SWPPP), as part of the federal EPA's National Pollutant Discharge Elimination System (NPDES). This ordinance covers all construction activity that disturbs more than one (1) acre, and requires that erosion control BMPs be enacted during construction.

The SWPPP also requires rate control be considered (Section 52.04.d). For all sites larger than 0.25 acres, the peak discharge rate into public stormsewers from the site during a 100-year storm event cannot be larger than Q = 1.64 x A, where Q is the peak discharge in cubic feet per second and A is the area of the site in acres.

Section 52.04.f of the Code covers requirements for permanent stormwater pollution controls. When any project replaces pervious area with impervious surface, a water quality volume equal to one-half inch of runoff from the new impervious surfaces must be created. Due to the high percentage of impervious surfaces currently at the Ford Plant site, it is unlikely that this requirement will affect any future development at the site. It is more likely that any development plan would require the reduction of total impervious area and/or require greater infiltration to implement the City's volume reduction goals.

3.1.1.2 Zoning and Land Use Regulations

Section 66 of the Code covers zoning requirements for the different land uses permitted in the City. If any redevelopment of this site would be rezoned Traditional Neighborhood 3

(TN3), then at least 20 percent of the project area must be open space. That open space requirement can be partially satisfied by stormwater basins and/or treatment facilities. The adoption of thoughtful stormwater BMPs can help a developer satisfy open space requirements.

Section 63.319 of the Code sets forth the same maximum peak discharge for parking structures as Section 52.04.d, listed above.

In 1976, the governor of Minnesota designated the Mississippi River and its corridor as a critical area in order to protect the biological and cultural functions of the river. The City of St. Paul administers this through the River Corridor Overlay District (Section 68 of the Code). Portions of the Ford Plant site fall within this district. This district governs what development is permissible along the river and specifies development criteria that address water quality:

1. The phases of development shall be planned so that only areas which are actively being developed are exposed. Other areas shall have cover of vegetation or mulch.

2. Natural vegetation in shoreland and bluff areas shall be preserved to retard surface runoff and soil erosion and to utilize excess nutrients.

3. Sediment shall be retained within the development site area either by filtering runoff as it flows through the development area or by detaining sediment-laden runoff in a sediment basin so that the soil particles settle out.

4. Water released to a drainage system shall be directed in such a manner as to travel over natural areas rather than across established surfaces.

5. Stormwater runoff may be directed to wetlands only when free of silt, debris and chemical pollutants and only at rates which will not disturb vegetation or increase turbidity.

6. Development which takes place near slopes greater than twelve (12) percent shall not result in increased runoff onto those slopes sufficient to damage vegetation or structures thereon.

7. Plans shall be submitted to the Planning Commission for any development placed landward from dikes, floodwalls or levees which is below the flood protection elevation of the dikes, floodwalls or levees. The plans must provide measures to ensure that floodwaters do not back up onto the development from stormwater drainage systems.

The St. Paul Code of Ordinances can be found on the city's website at www.stpaul.gov by selecting "City Charter and Code."

3.1.2 Draft Saint Paul Comprehensive Plan 2020

The Water Resources Management Plan, part of the City's new Comprehensive Plan includes as a key strategy reducing pollution in Saint Paul water bodies. The plan presents several methods for accomplishing this goal through the implementation of public education programs and by promoting more effective BMPs to reduce impervious cover, treat stormwater increase native plantings, and reduce soil erosion.

3.1.3 Sustainable St. Paul

An important City initiative and a top priority of Mayor Chris Coleman of St. Paul is the Sustainable St. Paul plan. The 2008 Sustainable St. Paul Annual Report sets forth priorities for green development in the city. The City requires sustainable development for all municipal buildings and encourages low-impact design for all new developments and retrofits in the city. All buildings are encouraged to follow U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) and the State of Minnesota Buildings, Benchmarks and Beyond (B3) Sustainable Building Guidelines. Both sets of guidelines have strong emphases in sustainable stormwater management. The proposed Version 2.1 B3 guidelines for stormwater are:

- Control quantity of runoff from the site to pre-settlement conditions for the 100-year, 24-hour precipitation event.
- No discharge from a 1.25-inch rainfall based on Rational Method.
- Create micro-catchments of less than one acre and treat for a 2-year, 1-hour precipitation event.
- Remove 80 percent of total suspended solids (TSS) for a 2-year, 24-hour rainfall event.
- Remove 60 percent of Total Phosphorus (TP) for a 2-year, 24-hour rainfall event.

- For Type D (clay) soils, store the 1.25-inch rainfall for irrigation, non potable purposes, and/or transpiration using proposed vegetation.

- All BMPs must have an Operations and Maintenance plan.

- Maintain or improve infiltration rates.

- Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90 percent of average annual rainfall using acceptable BMPs.

The State of Minnesota Sustainable Building Guidelines can be found at

www.msbg.umn.edu.

Additionally, the City of St. Paul is currently reviewing its own stormwater guidelines and is looking to pursue green initiatives that promote sustainable stormwater design.

3.2 Capitol Region Watershed District

The Ford Plant is located within the Capitol Region Watershed District (CRWD). The CRWD has implemented progressive stormwater requirements for development within its jurisdiction. Pertinent stormwater regulations are as follows:

- Runoff rates for proposed development cannot exceed the existing runoff rates for the 2-year, 10-year and 100-year precipitation events.

- Stormwater volume retention must be provided for the equivalent runoff from 1 inch of rainfall over the impervious surfaces of the development.

  – Required Volume (ft^3) = Impervious surfaces (ft^2) x 1.0 (in) x 0.9 coefficient x 1/12 (ft/in)

- Acceptable design infiltration rates are as follows:

Soil Group	Rate (inches/hour)
A (Sand)	0.80 – 1.63
B (Loam)	0.30 – 0.60
C (Sandy clay loam)	0.20
D (Clay)	0.00

- Infiltration BMPs must be capable of infiltrating the required volume with 48 hours.

- Stormwater must be pretreated prior to infiltration to remove solids.

- BMPs must be enacted to achieve 90 percent removal of TSS during a 2.5 inch, NURP water quality storm.

There are also cases under which infiltration is not possible or desirable:

- Potential impact
- Low permeability (D soils)
- Groundwater within three (3) feet of bottom of infiltration area
- Bedrock within three (3) feet of bottom of infiltration area
- Karst areas
- Utility locations
- Nearby wells

If any of these challenges listed above ultimately are found to apply to the site and cannot be remediated, then three "Alterative Compliance Sequencing" steps must be followed for redevelopment:

1. The development must comply with the volume reduction requirements by other BMPs besides infiltration to the greatest extent possible.
2. The remaining volume from Step 1 must be offset by credits from stormwater volume reduction at other locations.
3. A stormwater fee will be imposed on any volume that cannot be reduced or offset so that the watershed district can enact volume reduction BMPs elsewhere in the watershed.

Additionally, excess infiltration above the guidelines up to an inch of rainfall above the one-inch requirement, can be banked for use on future developments.

Further guidance is available at the Capitol Region Watershed District's webpage at www.capitolregionwd.org.

3.3 State of Minnesota

Various departments and agencies have regulations that impact stormwater management on the site including the Department of Natural Resources (MnDNR), Pollution Control Agency (MPCA) and Department of Health (MDH). Most of the responsibilities for administering the state rules and regulations are handled by the city, county and watershed district, and are described in detail above.

MnDNR protects the water quality and ecological function of the Mississippi River through the Mississippi River Critical Area Program, which delineates the Mississippi River Critical

Area Corridor. This program works in conjunction with the Mississippi National River and Recreation Area Program as administered by the National Park Service. The City of St. Paul administers this program on a local level through Section 68 of the City ordinances, as described above.

MPCA sets regulations to reduce pollution from stormwater runoff to protect the health of the state's waterbodies. These rules are administered locally by the City and the Capitol Region Watershed District. Those regulations are described above. MPCA also provides guidance for proper handling of stormwater and selection of stormwater BMPs through its "Minnesota Stormwater Manual" (MPCA, 2005). The Metropolitan Council has also published a useful manual on stormwater BMPs, "Minnesota Urban Small Sites BMP Manual" (Barr, 2001).

MPCA also administers the Industrial Stormwater Program, which regulates stormwater discharges from industrial sites to surface and groundwater. It is likely that the Ford Plant currently operates under such a permit. If the Ford Plant remains open, or another industrial use for the site is selected, any site modifications and stormwater practices will need to be confirmed with MPCA's Industrial Stormwater Program.

MDH governs the protection of groundwater by promoting wellhead protection plans and setting limits on the levels of impacts that are allowed to reach groundwater within those protected wellhead areas. These plans area generally administered by the county, in this case Ramsey County. A review of the County Well Index indicates that the nearest wells, a well owned by Highland Village Apartments and a well located at 2078 Ford Parkway, are located over 500 feet east of the Ford plant site, and likely out of the one-year wellhead protection zone. The nearest municipal wells are located at the intersection of Ford Parkway and Snelling Avenue, over one mile from the Ford Plant site.

4.0 Stormwater Management Goals

4.1 Volume Reduction

The City of St. Paul has set a goal of reducing stormwater runoff at the Ford Plant site. The Ford Plant site is currently over 80 percent impervious, so there are many opportunities on the site to reduce runoff. The City of St. Paul has initially discussed a general approach to their volume reduction goal:

- If feasible given site conditions, achieve volume reduction of runoff generated by one-inch rain event, or related water quality protection standard.

- Incorporate Low Impact Development (LID)/Green Infrastructure that combines landscaping and aesthetic amenities with sustainable stormwater management

The MPCA Minnesota Stormwater Manual states that on an average year, 90 percent of all rain events were 1.09 inches or less (MPCA, 2005).

4.2 Water Quality Improvement

The stated water quality goals for the Ford Plant are to remove total suspended solids (TSS), chloride, phosphorus, nitrogen, heavy metals and biota, consistent with the treatment systems to manage the runoff to required levels.

5.0 GIS Analysis

5.1 Description of Data Sources

GIS is a powerful tool that facilitates easy layering of multiple data types to build spatial relationships that assist in decision-making. Many data sources were compiled for the Ford plant site for this study.

5.1.1 City of St. Paul/Ramsey County Data

The City of St. Paul and Ramsey County share GIS data storage responsibilities. Their data is considered public, but can only be used with proper permissions from Ramsey County. The City and county shared the relevant data for the Ford Plant site. This data includes:

- Utilities
  - Storm sewer
  - Sanitary sewer
  - Electrical features
  - Gas lines
- Topographic Information
  - One-foot contours
  - Lidar data
- Natural Features
  - Bedrock classifications
  - Surficial classifications
  - Water features
- Transportation Features
  - Streets
  - Railroads
  - Curb and sidewalk
- Building Footprints
- Parcel Data
- River Corridor Overlay District (digitized by Barr from a hard-copy map)

5.1.2 ARCADIS/Ford

ARCADIS, with the permission of Ford Motor Company, contributed many sources of data, in addition to reports prepared by ARCADIS that were downloaded from St. Paul's Ford Plant website (http://www.stpaul.gov/index.asp?NID=1207):

- Boring Locations
    - Locations of detected Tier 2 Industrial SRV exceedances
    - Groundwater monitoring data
    - Boring logs
- Groundwater Contours for St. Peter Sandstone and Platteville Limestone
- Cross section locations for soil and bedrock profiles (digitized by Barr from a hard-copy map)

5.1.3 USGS Aerial Imagery

One-foot pixel resolution, color imagery from 2004 and 2008 is free and available from USGS. Both sets of imagery were used due to the higher quality of the 2004 data and the more recent capture date of the 2008 imagery.

5.1.4 Other Public Data Sources

Several other public sources of data were used for this analysis and are included in the database:

- Minnesota Department of Natural Resources
    - Water features
    - National Wetland Inventory (NWI)
    - Digital Flood Insurance Rate Map (DFIRM) floodplain layers from FEMA
- Natural Resources Conservation Service - USDA
    - Soils database
- Metropolitan Council
    - Landuse data
- Minnesota Geological Service
    - County Well Index
- MetroGIS
    - Sewersheds (large areas)
    - Watersheds (large areas)

5.2 Data Generated by Barr Engineering Co.

Barr performed additional analysis on many layers to provide additional value to the report and assist in determining the feasibility of various stormwater BMPs.

- Topographic Data
  - One-foot contours: Barr converted the city's Lidar data from the St. Paul Vertical Datum to the NAVD88 vertical datum and created new one-foot contours that reflect whole-foot elevation values for NAVD88 (see Figure 13).
  - Slope grid: Using the elevation data provided by the City and county, Barr created a slope grid to assist in determining which areas have slopes that are likely too steep for development and stormwater BMPs, other than creating terraced slopes.

- Bedrock
  - Depth to Bedrock: Using the data in the soil boring logs provided by ARCADIS, depth to bedrock was calculated across the site, and contours were created (see Figure 7).
  - Bedrock Elevation: Using the depth to bedrock information and the elevation information, the elevation of the highest bedrock layer was determined and contours were created.

- Soils Data: Using the soil boring logs from ARCADIS, the predominant soil was mapped for each soil boring location (see Figure 6). The predominant soil was determined to be the soil that was observed between 5 and 10 feet below the ground surface. These depths were considered most relevant, since construction of stormwater basins generally results in the top 3-5 feet of soil being removed, so the top layer has less importance than the soil horizon below five feet in depth as an infiltration unit. Additionally, soil boring data was hyperlinked to the original soil boring log provided by ARCADIS.

- Impacted Soils: The locations of the impacted soils identified by ARCADIS based on their comparison of soil data to Tier 2 Industrial SRVs were mapped by spatially joining the data from multiple ARCADIS tables and data sources.

- Storm Sewersheds: Using the storm sewer GIS data and the one-foot contours from the city and county, the tributary storm sewersheds were digitized for the Hidden Falls outfall (including the bulk of the Ford Plant site) and for two areas adjacent to the Ford Plant site that could potentially be redirected to the Ford Plant site for water quality treatment purposes (see Figure 14), if carefully planned in conjunction with site redevelopment and in cooperation with property owners.

- Impervious Cover: This layer was digitized for the Ford Plant and adjacent Canadian Pacific parcels using building footprints and aerial photography (see Figure 4).

5.3 Database Compilation

The data described in Sections 5.1 and 5.2 were combined into a single ESRI file geodatabase. An ESRI map file was created with all the above layers for analysis purposes and burned to a DVD that is included with this report. A PDF file that displays all the layers is also included so that users who do not have ESRI's ArcMap program may still view the data.

5.4 Stormwater Overlay Analysis

GIS analysis was performed to identify areas of the Ford Plant site where infiltration stormwater BMPs may be successful, as well as to identify areas where infiltration would not likely be feasible. An overlay technique was used to view multiple features on the map at the same time and then see which areas of the site are potentially better suited for various BMPs. This technique is demonstrated on Figure 15.

The principal features analyzed for this analysis are soils data, locations of potential impact hot spots, depth to bedrock, and topographic data. The overlay analysis is not exhaustive due to the many areas of the site that do not have soil borings as previously described. Future environmental assessment activities by Ford and their consultant should provide valuable soils data for the north side of the facility. The overlay showed that the best soils for infiltration are located in the middle of the site between the main production facility and the paint building, however, there are some known impacts in that area as well. The depth to bedrock is generally in the six (6) to ten (10) foot range, which is acceptable for stormwater infiltration. Some locations on the site show a depth to bedrock of five (5) feet or less, which would provide too little separation from the bedrock for stormwater infiltration to adequately clean the runoff before it enters the fractured bedrock and ultimately reaches the groundwater. However, even though bedrock is shallow, the lateral movement of infiltrated water through the soils overlaying the bedrock could realize added water quality treatment benefits for pollutants such as TSS and TP. In-depth discussion of these challenges is provided in Section 6 of this report.

6.0 Stormwater Recommendations

6.1 Discussion of Challenges at Ford Plant

As discussed in Section 3.2 of this report, the Capitol Region Watershed District has identified some of the possible challenges that can be encountered in providing infiltration of stormwater at a site. Many of these challenges exist at the Ford Plant site. Encountering these challenges does not eliminate the possibility of infiltrating stormwater, but these challenges will increase the need for further investigations into existing conditions, and will increase design and construction costs to enable infiltration to occur.

6.1.1 Potential Impact

Infiltration in, or groundwater flow through, potential impacted areas is an aspect that should be considered when evaluating stormwater management at the Ford plant site. Currently, ARCADIS has identified eight (8) locations that exceed Tier 2 Industrial SRV levels for certain impacts. Any location that is found to be impacted and would accept infiltrated stormwater under a redevelopment plan would likely have to be fully remediated to acceptable levels for infiltration so that the water does not become impacted, and thus potentially spread impact into groundwater or the Mississippi River. The ARCADIS soil sample results were primarily compared to the MPCA's Tier 2 Industrial SRVs, which may not be the appropriate screening criteria to assess the potential for soil impacts to leach and impact groundwater in a redevelopment scenario. If the future development plan is for any use other than industrial, other criteria may be applicable. The MPCA's voluntary programs will be involved in decisions regarding infiltration in potentially impacted areas.

6.1.2 Low Permeable Soils

The hydrologic characteristics of a soil determine its ability to infiltrate water. These hydrologic categories are set by the NRCS and labeled A, B, C, and D. A soils have the highest capacity to infiltrate (sand) and D soils have the lowest (or no) ability to infiltrate stormwater (clay). The presence of D soils in any soil layer can act like a liner, preventing the infiltration of stormwater through the soil. There is quite a bit of clay present at the Ford Plant site, as discovered by ARCADIS during the soil boring investigation (see Figure 6). If infiltration is desired in locations where clay soils are present it is likely the clay soils would need to be removed and replaced with clean sand fill possibly hauled from offsite. The quantity of soil that would need to be removed and replaced by clean sand is dependent on a full analysis and testing of the soils where infiltration would be promoted. A more complete understanding of the extent of the impacted soils at the Ford Plant site will assist in this analysis.

Several soil borings did not encounter any clayey soils, and in several more borings the clay layers were rather thin. So, soil correction may be feasibly employed to either remove the clay layer and replace it with clean sand, or blend the multiple layers of sand, silt and clay throughout the entire soil profile, provided the resulting blended mixture is able to infiltrate stormwater.

The relatively shallow bedrock depths of 6 to 10 feet mean that it could be feasible to remove the soil down to bedrock in the specific locations designated for infiltration and backfill those areas with clean sand. This would ensure that stormwater could infiltrate all the way through the soil to bedrock, where it could then be transported to the groundwater in the bedrock through fractures or allowed to flow laterally through the soil overlaying the bedrock where few fractures are present.

6.1.3 High Groundwater

High or mounded groundwater can present hurdles for infiltration as well. Although three levels of groundwater were discovered during soil borings, the highest one was only found perched in locations with clay layers. Soil correction could remove this layer or strategically placed dewatering trenches could capture and direct mounded water away to assist in managing the flow of water through the soils on the site. The other two layers, perched groundwater in the limestone layer and the groundwater deep in the sandstone, are well below the three-foot threshold for infiltration, provided infiltrated water does not pass through impacted soils (see Figures 8 and 9).

The depth to the groundwater in the Platteville Limestone unit is around 20 feet. From the approximate groundwater contours provided by ARCADIS, there appears to be groundwater mounding in a few locations across the site. Further investigation would be required to ensure that additional water from infiltration would not cause the groundwater to perch so high that damage to structures would occur.

6.1.4 Shallow Bedrock

The bedrock is deep enough in most locations for infiltration through at least four (4) feet of soil. The bedrock is generally 10 feet below the ground surface, and since an infiltration basin would likely be no deeper than three (3) feet, even after excavation there should still be sufficient cover over the bedrock for proper infiltration in compliance with St. Paul and CRWD requirements. However, in some locations the bedrock is shallower, so careful investigation during stormwater system design will be necessary.

An additional concern with the bedrock at the Ford Plant site is proximity of the site to the bluff of the Mississippi River. Any infiltrated water would likely reach the Platteville Limestone layer through fractures, but would likely not penetrate deeper into the St. Peter Sandstone due to the presence of a layer of low permeability in the limestone called the Hidden Falls Member. Groundwater at this interface with the Hidden Falls Member flows toward the bluff where it seeps out as natural springs before it cascades down the bluff to the river. Increased infiltration could cause more water to surface along the bluff and to weather the bluff through freeze-thaw cycles, conceivably causing the bluff line to accelerate its migration toward Mississippi River Boulevard and the Ford Plant site. The extent of this possible increased erosion at the bluff line due to increased infiltration is unknown. Additional monitoring of groundwater flow to determine the current groundwater flow in the Platteville Limestone and an analysis of the anticipated increase in groundwater flow due to infiltration is needed in order to more fully assess the potential for increased erosion.

Evidence of this natural erosive action at the interface of the Hidden Falls Member is visible along the bluff on both sides of the Mississippi River. To mitigate this erosion, the groundwater flow from infiltration could be captured and concentrated by use of a groundwater collection trench just uphill of the bluff line and discharged in a managed zone such as Hidden Falls. This trench could be excavated through the soil to the bottom of the limestone layer in order to capture the water flowing through the soil or limestone before it surfaced along the bluff line. This trench could be backfilled with clean sand with a drain tile at the base of the trench to direct captured groundwater to specific outfall locations where increased seepage flows could be managed to prevent erosion (see Figure 16). Further investigations on the groundwater movement along the Hidden Falls Member interface at the bluff line would be necessary to determine the placement and extent of any trenches. However, natural ice formations resulting from groundwater surfacing along the bluff line during the winter are often considered part of nature's beauty and as such, a diversion trench may elicit negative reactions by some. Stakeholder involvement to discuss the advantages and disadvantages of such facilities is recommended.

The subsurface tunnels will need to be investigated to ensure that stability at the ground surface is not a concern. Since the tunnels were mined for sand, it is likely that the tunnels are in the St. Peter Sandstone unit below the Platteville Limestone, which is the unit likely to receive most of any infiltrated stormwater. Most of the infiltrated runoff will likely remain in the Platteville Limestone due to the confining Hidden Falls member below the limestone. If additional investigations of the tunnel systems determine that certain sections are weak, it may be desirable to direct infiltration away from these areas to ensure the stability of the ground surface. If any tunnels penetrate the Platteville Limestone layer, infiltration at the edge of these tunnels will need to be carefully considered to determine what affect increased infiltration would have on the stability of the limestone in these areas.

6.1.5 Karst Areas

The top layer of bedrock in most locations is limestone, which can produce karst features such as sinkholes or caves due to its solubility. While no known karst features are located on the Ford Plant site, caves are quite common in this area, so a careful investigation for karst features is essential.

6.1.6 Utility Conflicts

Utilities are not a major concern at the Ford Plant site as most of the utilities on the site serve the Ford Plant and would likely be removed under any redevelopment scenario (see Figure 10). A possible exception is the potential existence of storm sewer from the Lunds Plaza and apartment complex to the east of the Ford Plant site. An additional potential conflict is the presence of underground electrical lines in the northwest parking lot that connect the hydroelectric dam to the electrical grid along Ford Parkway.

The nearest well is over 500 feet away, and is likely upgradient from the Ford Plant, thereby preventing any infiltrated water from reaching a well location.

6.2 Remediation of Impacted Sites

If possible, stormwater Best Management Practices (BMPs) should be placed away from any known impacted locations. If that is not possible, then these locations should be remediated to prevent infiltrated runoff from coming into contact with impacted soils and then entering the groundwater.

Soil correction is one option that involves removing the impacted soil entirely and backfilling with clean soil, preferably clean sand, to promote infiltration. If BMPs are designed to promote infiltration, then the soil must be overexcavated around the perimeter of the infiltration basin, as the infiltrated runoff will travel horizontally as it infiltrates through the soil. If infiltration is not desired and/or possible, a liner system could possibly be installed underneath a filtration basin equipped with a flow-capturing drain tile placed at the bottom of the filtration basin, or other stormwater BMP. The liner (poly or clay) would prevent the stormwater runoff from coming into contact with the remaining impacted soil. Due to the relatively shallow bedrock (approximately 10-feet below the ground surface), excavation of impacted material may likely be less expensive than installation of a liner.

6.3 Integrated Treatment System

The goal of any stormwater master plan for the Ford Plant site (whether it remains as an operational assembly plant or is redeveloped) will be to combine multiple stormwater treatment BMPs to provide significant runoff volume reduction and improved water quality.

It will be essential to consider low-impact stormwater solutions at each phase of the design process. If properly designed and installed, stormwater treatment BMPs should not only provide the desired volume, rate and water quality controls but also provide secondary amenities such as an aesthetically-pleasing sense of place, wildlife habitat, recreational, and educational opportunities. It is important to consider the social and ecological impacts of a stormwater treatment system. An integrated stormwater system can provide corridors through any future development to promote pedestrian and bicycle traffic to housing and businesses within and adjacent to the development (see Figure 17). BMPs that have successfully provided such ancillary benefits include linear rainwater gardens, chambering devices for promoting urban tree watering and growth, porous pavers, turfed parking areas and green roofs, to name a few.

Low-Impact Stormwater as an Amenity – Headwaters at Tryon Creek, Portland, OR by Portland Bureau of Envionmental Services. Photo Credit: M. Metzger

6.3.1 Green Infrastructure as Structural Framework for Transportation

The Ford Plant site is situated between Mississippi River Boulevard and the Highland Village neighborhood, effectively blocking direct access from this vibrant and walkable neighborhood to the river. Providing new linkages between the neighborhood and the river would be an important asset for the community. Linear stormwater treatment systems, or green infrastructure, can provide that linkage.

Green infrastructure can also promote pedestrian and bicycle traffic within the development itself. The entire development could be structurally organized around the green infrastructure and provide opportunities for future parcel development. A pedestrian and bicycle-focused development would provide a safer environment by moving cars away from parks and trails.

6.3.2 Ecological Corridor

A stormwater corridor can also provide an ecological corridor for various species of animals. By connecting the neighborhood to the Mississippi River, movement of species between the neighborhood and the parkland along the river could be promoted. Aside from the obvious dangers of introducing deer onto urban landscapes with vehicular traffic, promoting the movement of wildlife (birds, butterflies, small animals, etc.) could provide an enhancing experience for those who live and work in this community. The storage and use of stormwater for irrigation of trees could serve a vital and cost-effective role in establishing an urban forest on portions of the site.

6.4 Possible Treatment of Surrounding Neighborhoods

Potential redevelopment of the Ford Plant site may also provide the opportunity to enhance the water quality of runoff from nearby neighborhoods (see Figure 14). Currently, it appears that most of the runoff from these neighborhoods collects in the storm sewers and discharges directly into the Mississippi River untreated. Redevelopment could provide an opportunity to explore treating at least some of the first flush of runoff from a storm.

Most of the pollutants delivered by runoff into receiving water bodies are from the first part of a storm as the rain washes accumulated nutrients, pollutants, and sediment into the storm sewer system. By treating this first flush, significant improvements in water quality can be made. Generally, if the first inch of precipitation during a storm is treated, the majority of total suspended solids (TSS) and nutrients that are carried in runoff can be captured before they discharge to the receiving water body.

The Ford Plant stormwater runoff discharges by a pipe to Hidden Falls Regional Park. The tributary storm sewershed to this location (which includes all of the Ford Plant with the exception of the northwest corner of the parking lot) is 163 acres. There is another storm sewer pipe, or trunk, that collects stormwater from the neighborhoods surrounding the Ford Parkway and discharges to the Mississippi River near the Ford Bridge. The tributary area of that storm sewershed to the intersection of Cretin Avenue and Ford Parkway is 157 acres. Another storm sewer system collects runoff from the neighborhood to the southeast of the Ford Plant site. That stormwater collects in a trunk along St. Paul Avenue and discharges to the southeast. The tributary storm sewershed to the intersection of St. Paul Avenue and Prior Avenue is 148 acres.

It is important to note that high flows from these other two neighborhoods would likely need to continue to discharge in the existing storm sewer system. The solution to a water quality problem for this neighborhood should not be allowed to create a flooding problem for the Ford Plant site that would adversely impact residents, workers, and lower property values. The City must consider many factors in evaluating this neighborhood treatment opportunity, including costs, compatibility with site redevelopment, impacts on current infrastructure, maintenance requirements and the interests of affected property owners.

The City must consider many factors in evaluating this broader treatment opportunity. Based on the challenges for infiltration of stormwater as defined previously, introducing additional stormwater into the site from surrounding neighborhoods may create additional technical, financial, or legal complexities that would need to be carefully analyzed.

6.5 Appropriate Stormwater BMPs

A more complete analysis of design considerations for specific Best Management Practices (BMPs) can be found in the Metropolitan Council's Minnesota Urban Small Sites BMP Manual (prepared by Barr Engineering Co.) (Barr, 2001) or in MPCA's Minnesota Stormwater Manual (MPCA, 2005). The following is a brief summary of specific stormwater treatment BMPs that should be considered in redevelopment of the Ford Plant site.

6.5.1 Impervious Surface Reduction

The first consideration in stormwater management is to design the development to produce the least amount of stormwater as possible. By keeping impervious surface area to a minimum, runoff can be dramatically reduced, particularly for the more common, small precipitation events in which shallow infiltration and evapotranspiration are highly effective. Evapotranspiration consists of a combination of evaporation from land and plant surfaces as well as water utilized and transpired by plants.

Porous pavement used in parking bumpouts to treat stormwater in Minneapolis. Project by Barr. Photo Credit: E. Holt

6.5.1.1 Site Design

The first step is careful site design. A low impact development design approach including transportation elements can significantly reduce impervious surfaces, which results in less stormwater runoff. By reducing building setbacks and reconsidering parking requirements, driveways and sidewalks can be shortened and parking areas reduced. Another strategy is to "disconnect" roads and structures from the structural stormwater system by directing runoff from impervious surfaces to vegetated areas, which would allow the water to infiltrate and be removed by evapotranspiration. Barr's report for MPCA, "A Holistic Approach to Residential Development for Hanover, Minnesota" (MPCA, 2007), provides further guidance on the additional, non-stormwater benefits of conservation design processes.

6.5.1.2 Street Design

Porous Pavement at Ramsey Washington Metro Watershed District's new offices. Project by Barr.

Streets can be designed in a way to allow further reductions in impervious surface area. Street widths can be reduced to minimize impervious area. Parking bumpouts can be used with narrower lanes between the bumpouts, or streets can be designed as narrow one-way streets, with or without parking bumpouts. Additionally, pervious surfaces can be employed in the street design, such as permeable pavers or porous pavement. Barr designed a stretch of road in Minneapolis along 54th Street that used a pervious surface in the parking lanes in between bumpouts to treat stormwater runoff from the road.

6.5.1.3 Parking Lot Design

Parking lots present many opportunities for impervious surface reduction. The availability of transit and bicycling opportunities should be considered in the demand for parking spaces. Many parking lots have far more parking spaces than are necessary. Parking lot design also presents significant opportunities for impervious surface reduction. The size of each space and drive aisles should be reconsidered, especially in light of consumer trends for smaller vehicles. The inclusion of some smaller parking spaces, at least for compact cars, should be considered as a starting point.

Rainwater gardens in Minnetonka City Hall's parking lots treat stormwater. Project by Barr.

The surface of the parking lot itself can be made pervious, as discussed under Street Design above. The surface can be constructed of pervious pavers or porous pavement to allow the precipitation that falls directly on it to infiltrate into the soil below. Careful soil preparation and soil correction is often necessary to ensure that the pavement functions and removes stormwater runoff. Designed overflow systems are essential so that the pervious parking surfaces do not overflow and create hazards during large precipitation events. This BMP works well for new construction as well as retrofits of existing facilities. Ford's Rouge Complex in Dearborn, Michigan, effectively employed porous pavement as well as rainwater gardens to reduce impervious surfaces and treat stormwater.

Parking lot surface area can also be reduced and stormwater can be treated through use of parking lot island rainwater gardens. These infiltration (or filtration) basins inside the parking lots collect runoff from small catchments of the impervious parking lot and treat the first flush of a rain event, described in Section 6.4.

6.5.1.4 Meadow Plantings

The Ford Plant site is over 80 percent impervious, and the remaining pervious cover likely consists of compacted soils that do not allow shallow infiltration. Mowed turf grass can only support a shallow root structure that does not allow infiltration. Runoff from these compacted turf areas can be quite significant as compared to a native prairie. Root systems of typical urban vegetation (trees, turf grass) typically have root systems of only 2 to 3 feet in depth. The root structure of native plantings and grasses typically grow as deep as 5 to 10 feet. These root structures break the soil and create additional capacity for stormwater runoff to infiltrate into the soil. The pore spaces provided by the root structure can dramatically improve the capacity of the soil to retain water that can then be released to the atmosphere by evapotranspiration (Barr, 2001). All proposed open spaces should be evaluated for native plantings and grasses instead of turf grass whenever possible to reduce runoff.

Native plantings like this in Burnsville can be contained to a rainwater garden or planted over a much larger area to provide stormwater treatment. Project by Barr.

6.5.1.5 Green Roofs

Ford's Rouge Plant in Dearborn, Michigan has the world's largest green roof. Photo from www.greenroofs.org

Green roofs are becoming more common, particularly in dense urban areas where little room for stormwater management is available on site. Green roofs can capture small rainfalls and release the water to the atmosphere by evapotranspiration. Green roofs can be expensive due to the heavy weight of the soil, which requires the entire structure to be built to withstand greater dead load. Green roofs are especially problematic in building retrofit situations where the weight of the soil was not part of the original design of the roof support system, however, depending on site constraints of dense areas with mostly impervious cover, green roofs can be a favorable option for increasing pervious cover and treating stormwater, while delaying the peak of storm . The initial expense of green roofs may pay back over time, since green roofs provide cooling, which reduces energy costs for the building and reduces urban heat island effects in the area. Green roofs also have a longer life span, reducing roof replacement costs over time. Finally, green roofs can provide aesthetically-pleasing places for people to enjoy as well as wildlife habitat.

6.5.2 Pretreatment

Pretreatment of runoff is essential for extending the life of infiltration and filtration BMPs. It is important to remove as much of the heavier sediments (sand, gravel) that come in the first flush of a precipitation event to prevent the need for repeated cleaning and excavation of larger BMPs. It is typically easier and cheaper to remove sediment from pretreatment BMPs than to excavate accumulated sediment in a rainwater garden and its revegetation.

Many non-structural pretreatment BMPs also promote infiltration by slowing down the stormwater runoff over vegetated areas. Common vegetated pretreatment BMPs include vegetated swales and buffer/filter strips. Structural pretreatment BMPs can include manhole sumps, oil and grit separators, and sedimentation basins.

6.5.3 Infiltration

The goal of this report is to assess the feasibility of stormwater infiltration. As stated in this report, there are many challenges to infiltration on this site fromimpacted soils, impermeable soils, and shallow bedrock. In spite of these challenges, infiltration may be possible at the Ford Plant site.

Rainwater gardens can be fit into small and irregular shapes, such as this Habitat for Humanity development. Project by Barr.

6.5.3.1 Rainwater Gardens

Rainwater gardens are vegetated basins that collect and infiltrate the first flush of stormwater runoff. Rainwater gardens are typically designed to accommodate the runoff from no more than half an acre of impervious surface, and should hold standing water for no longer than 48 hours to protect the plantings in the basin, although a 24-hour detention time is preferred. The basins are usually constructed 6 to 18 inches in depth. Hydrologic A soils (sand) are preferred for their capacity to infiltrate water quickly. B soils can also infiltrate stormwater effectively, however, a basin with B soils could not be constructed as deep as a basin with A soils to allow stormwater to infiltrate within a 48-hour period (Barr, 2001).

Rainwater gardens in Burnsville reduced volume by over 90 percent. Project by Barr.

Rainwater gardens should be installed higher in the watershed to capture rainfall where it lands. Monitoring of rainwater gardens designed by Barr in Burnville, Minnesota, demonstrated a 93 percent reduction in annual runoff volume from installation of rainwater gardens in the right-of-way.

6.5.3.2 Infiltration Basins and Trenches

Regional infiltration basins can be designed to accommodate runoff from much larger areas than rainwater gardens, serving up to 50 acres of impervious area (MPCA, 2005). However, extensive pretreatment is required. Depending on the infiltration capacity of the soil, basins may be up to 12 feet deep. At the Ford Plant site, even with extensive soil correction, the maximum depth would be 6 feet, but a 3-foot depth is more appropriate to ensure that basins drain within 48 hours and do not create a safety hazard.

Infiltration trenches can treat less area than a regional infiltration basin, typically about two (2) acres of impervious surface.

These infiltration methods are generally designed to be off-line systems that receive the first flush of a rain event while allowing the larger flows from a major storm to pass by through a structural stormwater system.

A concern with these large-scale infiltration methods that is applicable to the Ford Plant site is the possibility of causing groundwater mounding. Large amounts of infiltrated water could cause the perched groundwater in the Platteville Limestone to mound up and cause structural damage to buildings near the infiltration basins. For further consideration of this BMP, additional groundwater investigations would be necessary to determine the direction of groundwater flow in the Platteville Limestone, and what effect infiltration of stormwater would have on the existing groundwater elevation.

6.5.3.3 Underground Infiltration

In sites where space is limited, infiltration can be placed underground in large pipes or storage vaults. Stormwater is collected by catchbasins, typically with a sump for pretreatment, and is then routed into underground chambers where the stormwater can infiltrate underground. This BMP can be very effective for retrofit situations, and was installed at the Ford Rouge Plant in Dearborn, Michigan.

6.5.4 Filtration

In locations where infiltration is not possible for any of the reasons discussed in this report, filtration could be used to remove sediment and pollutants from stormwater runoff. Filtration would employ the same techniques described above to filter the water, however, the impacted soil would be replaced with a clean, well-graded sand medium with an underdrain or drain tile at the bottom of the infiltration device to collect the stormwater after it has filtered through the media. The stormwater collected in the drain tile would then return to a piped stormwater system and eventually discharge to another stormwater BMP or receiving water body, or could reenter the site to create a surface water feature. A liner may be required under the filtration basin, depending on the level of impact remaining.

While filtration can be nearly as effective as infiltration in removing sediment and can remove some nutrients from stormwater, there would be little volume reduction. The process of filtering the stormwater would reduce the stormwater peak discharge and would allow the stormwater more time to evapotranspirate; however, most of the runoff would still discharge from the site.

6.5.5 Other Treatment BMPs

6.5.5.1 Stormwater Ponds and Wetlands

Stormwater ponds are online, end-of-line systems designed to treat runoff from large areas by removing sediments through extended detention. Stormwater ponds can be used to treat areas up to one square mile (Barr, 2001). Stormwater ponds provide little volume reduction benefit, and often must be lined to prevent the surrounding groundwater from rising to the permanent pool of the pond, or groundwater mounding.

Stormwater wetlands are generally end-of-line treatment systems designed to remove sediment and nutrients by microbial breakdown of pollutants, plant uptake and sedimentation. Stormwater wetlands function similarly to stormwater ponds by promoting sedimentation during detention. These wetlands can be designed to treat large areas, and can reduce stormwater volume somewhat through evapotranspiration. The use of stormwater wetlands as part of a treatment system can add a visual amenity to the community, as well as providing habitat for many species of animals and plants.

While providing natural treatment for stormwater, there are several limitations in the use of wetlands. Stormwater wetlands, if not lined, will raise the groundwater elevation and could cause unacceptable groundwater mounding. The wetlands are expensive to build and maintain, and until the plantings fully establish, will not have the desired pollutant removal rates.

6.5.5.2 Stormwater Reuse

Stormwater reuse can take several forms, but all stormwater reuse methods have the common characteristic of utilizing something undesirable (excess stormwater) for a beneficial purpose. Underground cisterns or surface ponds could be used to store runoff for reuse by providing irrigation water for turf grass, urban street trees, meadows or gardens.

BMPs utilizing modular chambers to capture runoff and provide water for trees could be used if the site remains highly impervious, either as a manufacturing facility or a dense urban village. These chambers can be placed in sidewalks or in parking lots and the chambers have the structural integrity to carry heavy surface loads while providing a space for loose soils and extensive root growth. These chambers can be used to promote infiltration through deep roots of urban trees, as well as filtration by use of a drain tile at the base of the chamber in situations where infiltration is not possible. An example of this modular system is the Silva Cell manufactured by Deep Root Partners.

More extensive and complex reuse can be employed as well. Stormwater can be retained in aboveground or underground tanks and used to assist in cooling systems for manufacturing processes. Such a system was recently designed for a metal recycling facility in Minneapolis by Barr Engineering Co. Stormwater reuse can be used under any use of the Ford Plant site, from industrial to residential.

6.6 Feasibility of Stormwater Goals

The goals for redevelopment of the Ford Plant site are very ambitious; however they are attainable with further investigation to more clearly understand the groundwater movement through the bedrock and to document the full extent of the impact. There are significant challenges to promoting infiltration at this site as discussed above. Those challenges will increase the amount of investigation required and the cost to implement the infiltration BMPs.

Underground storage can be used for infiltration or storage for potential stormwater reuse, as was done by American Iron in their metal scrapping processes. Project by Barr.

6.6.1 Volume Reduction

6.6.1.1 Infiltration BMPs

If infiltration practices are employed at this site in a dispersed manner throughout the watershed, meeting the City's stormwater volume reduction goal may be possible. Meeting that goal will require soil investigation at each proposed infiltration location to check for the permeability of the soils and the presence of potential impact. If either of these conditions exists, remediation and soil correction, as discussed in this report, would be necessary.

Meeting a volume reduction goal beyond the one-inch storm would be possible, but much more difficult, and probably not cost-effective. Since the soils at the Ford Plant site generally have low permeability, soil correction will have to be implemented in many locations. To increase the size of the infiltration basins to handle a 1.5-inch storm would require an additional 50 percent storage capacity, yet would only capture five (5) percent more stormwater on an annual basis (see Section 4.1).

6.6.1.2 Filtration BMPs

If further cost-benefit analyses, or the ongoing environmental assessments, conclude that infiltration is not possible, legal or desirable, then filtration BMPs will have to be installed, as discussed in the report. While impervious surface reduction and BMPs would slow stormwater runoff and promote evapotranspiration resulting in a marked decrease in runoff volume discharge. Depending on the ultimate development plan and impervious cover for a redeveloped Ford Plant site, volume reductions on an annual basis using infiltration alone would be closer to 25 to 50 percent (Barr, 2001).

6.6.2 Water Quality Improvement

The goal of reducing pollutant loading is not dependant on whether filtration or infiltration methods are used, although filtration will require additional BMPs to meet stated goals. With an appropriate combination of impervious surface reduction, rainwater gardens for micro-catchments, infiltration or filtration basins to treat the first flush, and end-of-line stormwater ponds or wetlands to treat runoff from the site, the water quality goals should be met. Achieving the required 90 percent removal of TSS will require stormwater management to be considered from the beginning of the design process for the entire development. Figure 18 shows an example of a possible scenario to manage stormwater at the Ford Plant site after redevelopment. Actual configuration of such a system will depend on site reuse and need to be designed in coordination with all stages of site planning.

6.7 Monitoring Strategy

Developing a monitoring strategy for the stormwater volume and water quality will be essential to determine the effectiveness of the BMPs selected. Effective monitoring will provide a unique case study on the benefits of applying low-impact stormwater practices to brownsfield sites.

6.7.1 Modeling

Hydrologic, hydraulic and water quality modeling should be done of existing conditions and during each phase of the redevelopment. The monitoring data acquired for the existing conditions can be used to calibrate the models for the redevelopment phases to more accurately predict the ultimate improvements in volume reduction and pollutant removal.

6.7.2 Monitoring Existing Conditions

The first step in a monitoring program for the redevelopment of the site is to determine stormwater flows under existing conditions. Monitoring equipment should be installed inside stormsewers to capture the flow rate and runoff volume (at a minimum) and TSS. TSS is more difficult to sample and can be generalized from the total volume of runoff measured. Flow monitoring equipment should be installed in locations that will help isolate the contribution of stormwater from the Ford Plant site. The following conceptual monitoring station locations could provide the necessary data for evaluation of the effectiveness of the BMPs. These locations are subject to owner approval and final design (see Figure 19).

- In the main trunk upstream of Mississippi River Boulevard and upstream of the junction with the stormwater flows from the neighborhood directly south of the Ford Plant.
- In any storm sewer that may exist in the northwest parking lot of the Ford Plant.
- In storm sewer that may exist that enters the site from the Lunds shopping plaza or the apartments east of the Ford Plant.
- Flow monitors distributed in the existing stormsewers on the Ford Plant site. The phasing and redevelopment of this site is unknown, so if development happens in phases, it will be instructive to learn how each BMP installation affects runoff.

If it is determined that the northwest parking lot sheet flows off the site onto Ford Parkway and into the storm sewer located along Ford Parkway, a berm could be constructed to redirect stormwater from the entire parking lot to a single location where monitoring would be possible.

A rain gage should be installed on site to capture rainfall events in real-time. Although a rain gage exists at the nearby Minneapolis-St. Paul Airport, rainfall can vary widely over just a few miles, and site-specific data is vital for calibration of any hydrologic and hydraulic model.

Stormwater monitoring equipment should be installed and monitored for at least one year of rainfall data. Installation and monitoring can be conducted by the City, the Capitol Region Watershed District, the MPCA, a potential developer, or through a joint effort by all interested organizations. The data from this unique project could be used to help guide future decisions about stormwater management in the City and could provide valuable information for municipalities facing the increasing challenges of treating stormwater from brownsfield sites.

6.7.3 Monitoring During and After Installation of BMPs

The flow monitors installed to monitor the pre-redevelopment conditions should remain in place throughout construction and for several years following to allow time for vegetation to fully establish. Rainwater gardens can see improved effectiveness over time as the root structures of the plantings break up soils and provide natural conduits for infiltration. Tracking changes in runoff as the stormwater BMPs age would provide valuable data in the life-span of various BMPs and would indicate when maintenance was necessary.

6.8 Implementation Strategies

6.8.1 Additional Investigations

Before the feasibility of all stormwater treatment options can be fully considered, more data must be collected from the Ford Plant site.

The additional data from proposed soil borings and monitoring wells from the Supplemental Phase II Environmental Assessment will assist in building a fuller picture of the soils, bedrock and groundwater throughout the site. There will still be locations without data, such as all locations under the existing buildings. Soils, bedrock and groundwater data under existing building locations can be inferred from the soil borings that surround the buildings, but all locations of impact will not be known until investigations are completed at those locations.

The nature and movement of the groundwater in the Platteville Limestone is critical to understanding how infiltrated stormwater would impact groundwater, existing and proposed structures, and the bluffline of the Mississippi River. Further groundwater monitoring at more locations will create a clearer understanding of where infiltration of stormwater should be focused.

Any additional investigations will assist in the design of a site and stormwater treatment system that takes advantage of permeable soils and locations without impact.

6.8.2 Modeling and Monitoring

As discussed above, modeling the site and implementing stormwater monitoring is important to fully understand the volume reduction and pollutant removal levels that are attainable. Groundwater modeling to determine the feasibility of infiltration BMPs is also essential to this process.

Existing conditions models (groundwater, hydrology, hydraulics and water quality) should be completed and stormwater monitoring equipment should be installed no less than one year before any changes to the site occur.

6.8.3 Stormwater Design and Installation

Stormwater design must be fully integrated with the design process for the entire Ford Plant site to maximize the water quality benefits, as well as utilizing the stormwater BMPs as amenities to the community and the development. As part of the design process, modeling groundwater, hydrology, hydraulics and water quality of proposed conditions during each phase of the development should be completed for comparison to existing conditions.

6.8.3.1 Phasing of Stormwater BMPs

Phasing of stormwater BMPs will likely be driven by the design and implementation of different phases of the Ford site redevelopment (see Figure 20). Ideally, the phasing would be such that BMPs in the upstream reaches of the watershed (areas to the north and east) would be installed first, and BMPs downstream would be installed last. This would allow the BMPs to only receive stormwater in post-construction conditions. Construction runoff can be very destructive to infiltration BMPs and should be handled by appropriate construction stormwater management BMPs, as required by the SWPPP.

If the phasing of the project generally starts upstream and works downstream, the existing stormsewer at the Ford Plant site should be left in place and removed as the redevelopment continues further south.

If the phasing happens such that downstream BMPs are constructed first, then those BMPs should be left off-line until such time in the project phasing when they would no longer receive construction runoff.

6.8.4 Operations and Maintenance

Operations and maintenance (O&M) of low-impact stormwater BMPs is an important consideration that must be incorporated into the design of an overall stormwater management plan. It is critical to communicate the level of O&M required for each proposed BMP so that the expectations are clear on what maintenance is required to sustain the effectiveness of the BMPs. Low-impact BMPs that are discussed in this report, while becoming more widespread, are not as commonly used as traditional stormwater solutions, therefore it is important to develop site-specific O&M recommendations to extend the life of the system. A schedule for inspections and maintenance, such as replacing the soil in rainwater gardens, should be developed for each BMP. A BMP O&M manual for each type of BMP should also be developed to assist the City of St. Paul and the landowner with how to appropriately care for the plantings in the basins and what signs to look for to know when an infiltration or filtration basin is no longer functioning. Guidance for specific BMPs can be found in MPCA's Minnesota Stormwater Manual and in the Metropolitan Council's Minnesota Urban Small Sites BMP Manual, prepared by Barr and included in Appendix D.

6.8.5 Implementation Cost Discussion

Price and cost-effectiveness is an important part of any feasibility study for future development. At this time, given the limited information that is known about the existing conditions of the Ford Plant site and the uncertainties about future development, it is not possible to make any estimations of cost that would provide any value in the decision-making process.

The anticipated Supplemental Phase II investigation, as well as further investigations suggested in this report, will provide necessary information on impacted soils that may exist on site. Without information on the extent of the impact, it is not possible to give a meaningful estimate of the level of effort necessary to remediate the property for stormwater infiltration.

The future development plan for the Ford Site is also critical in developing an estimate of the cost of providing sustainable stormwater management. A park-like setting with nearly 100 percent pervious cover would require many fewer stormwater infiltration BMPs than a dense urban village with 50 percent or more impervious cover.

As the overall Ford Plant redevelopment planning process progresses and the level of effort to remediate the site and design a stormwater management system that is fully integrated with the proposed redevelopment of the Ford Plant site becomes clearer, this report will be a useful tool to further develop implementation strategies and then evaluate the cost of implementing those strategies.

7.0 References

City of St. Paul Website. "About Hidden Falls." Viewed March 1, 2009. http://www.stpaul.gov/facilities.asp?page=detail&RID=42

Ford Motor Company Website. "Ford Motor Company's History in Twin Cities." Viewed March 1, 2009. http://media.ford.com/article_display.cfm?article_id=8241

Ford Motor Company. June 2007. Phase I Environmental Site Assessment for Twin Cities Assembly Plant. Prepared by ARCADIS. (ARCADIS, 2007a)

Ford Motor Company. October 29, 2007. Initial Phase II – Exterior Investigation Report for Twin Cities Assembly Plant. Prepared by ARCADIS. (ARCADIS, 2007b)

Ford Motor Company. December 19, 2007. Additional Soil Investigation and Surface Soil Risk Assessment Report – Baseball Fields – Feature 139. Prepared by ARCADIS. (ARCADIS, 2007c)

Ford Motor Company. May 13, 2008. Supplemental Phase II – Exterior Investigation Work Plan for Twin Cities Assembly Plant. Prepared by ARCADIS. (ARCADIS, 2008)

Giles, Kevin. July 24, 2008. "Two-Year Reprieve Provides Redevelopment Breathing Room." Star Tribune. http://www.startribune.com/business/25880099.html

Metropolitan Council (Met Council). July 2001. Minnesota Urban Small Sites BMP Manual. St. Paul. Prepared by Barr Engineering Co. (Barr, 2001)

Minnesota Pollution Control Agency (MPCA). November 2005. The Minnesota Stormwater Manual. St. Paul. Prepared by Emmons & Olivier Resources, Inc.

Minnesota Pollution Control Agency (MPCA). September 2007. A Holistic Approach to Residential Development for Hanover, Minnesota. St. Paul. Prepared by Barr Engineering Co.

Figures

Appendices

Appendix A

Soil and Bedrock Cross Sections by ARCADIS

Appendix B

Proposed Supplemental Phase II Soil Borings and Monitoring Wells by ARCADIS

Appendix C

Ford Plant Sustainable Stormwater GIS and Planning Database by Barr (on DVD)

Appendix D

Metropolitan Council Minnesota Urban Small Sites BMP Manual by Barr (on CD)