Implementing a Sustainable Design for the Wilson Hall West Parking Lot

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August 13, 2021

Introduction

My 2021 SIST Internship exposed me to the world of sustainable design, civil engineering, and the basic principles of architecture. This summer, I was given the task of redesigning Wilson Hall's West parking lot to become more sustainable and environmentally conscious.

Abstract

Uncertain rainfall, overbearing floods, and prolonged droughts have led to the need for a redesign of Fermilab's Wilson Hall West parking lot. The inefficiency of the current parking lot has led to runoff pollution in the laboratory's ecosystem. Among the concepts brainstormed to combat this issue were the implementation of rain gardens, elevated landscape islands, more frequently installed catch basins and permeable soils.

Issue

Runoff is stormwater that flows on the ground in whichever direction gravity takes it. The water can be evaporated by sunlight or absorbed by soil in most cases. However, in settings such as parking lots; intense runoff is known to accumulate intensely as a result of concrete and other water-resistant materials being used to pave said lots. Runoff could therefore potentially be led into nearby ecosystems, which could potentially harm the health of nearby wildlife and human communities. Runoff can often contain pollutants such as grease, gasoline, metals (from car batteries and airborne fumes), sediment (found in parking lots that are broken down by weather and erosion), fertilizers, pesticides, and other trash.

Solution

Multiple solutions have been considered in the implementation of a sustainable redesign for the Wilson Hall parking lot. Among the proposed options were the following:

- ➔ Use permeable/absorbent paving materials; this will reduce the volume of runoff by entrapping the precipitation into the ground. Examples include brick, gravel, mulch
- ➔ Plant trees/plants; the soil filters pollutants and runoff water from one another. Plant roots help absorb runoff.
- ➔ Add curbing to prevent water from flowing into the lot from surrounding areas
- ➔ Add a slope toward water drain to push runoff to a common endpoint
- ➔ Underdrains: direct water runoff below the subgrade and into a lower gradient. This diverts water from paved surfaces and back into the natural water table.

❖ Visuals

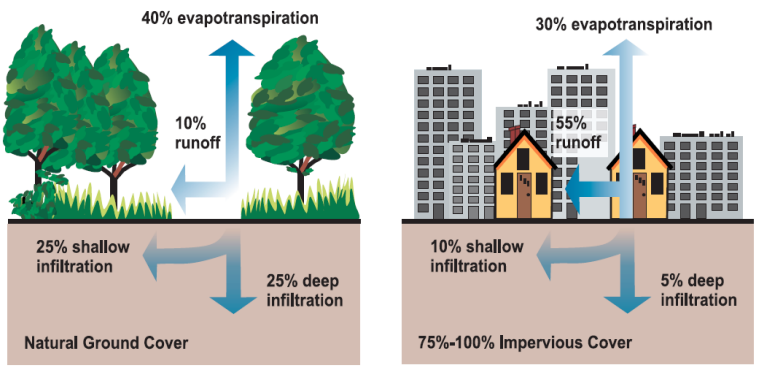


Figure 1 showcases the impact of stormwater in rural (left) and urban (right) areas. For example, for the rural area, 40% of rainfall may undergo evapotranspiration, a process that transfers water to the atmosphere through evaporation.

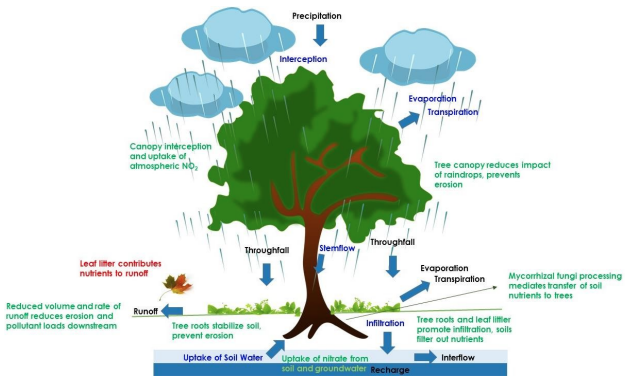


Figure 2 displays the relationship between rainfall, trees, and runoff. As portrayed in the graphic, trees can intercept rainfall with their leaves, therefore reducing the impact and volume of stormwater. Surrounding soil and grass will also entrap much of the stormwater for nutrients and eventual evaporation. All in all, the overall runoff produced by rainfall will be dramatically reduced as a result of trees being planted.

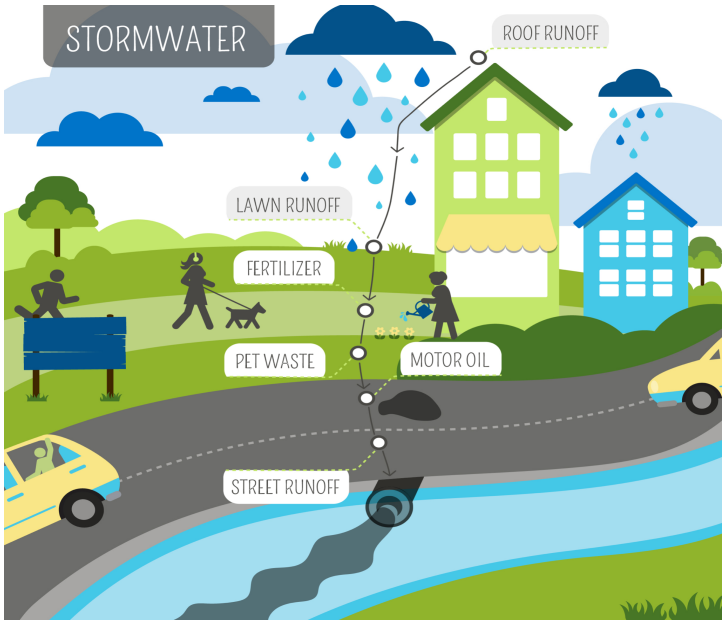
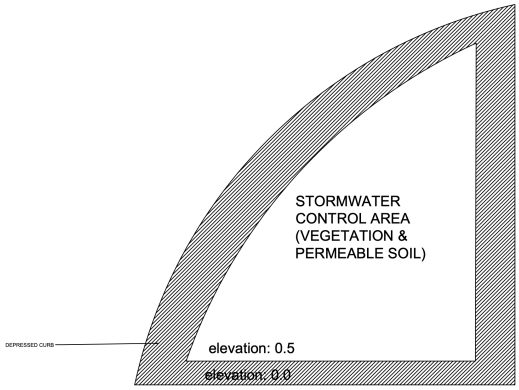


Figure 3 visually displays the potential contents of runoff. Before rainwater hits the ground, it interacts with many barriers that can contaminate the water. Examples include roof runoff, fertilizer, and motor oil.

❖ Proposed Design

The following image showcases a small sample of the parking lot before the redesign.

The overall area of this subsection is .391 Acres, which translates to around 17032 feet. For our stormwater control measure, the size must be about 1/10th of the overall size of the lot sub section.



In the proposed design of the landscape island, there exists permeable soil and vegetation to permeate runoff and filter any contaminants within the water. There is also a depression on the curb of the island to avoid overflooding and provide ample water for any surrounding islands and catch basins.

❖ Vegetation

As a result of the immense heat caused by parking lot pavement and little moisture caused by Illinois frequent droughts, the use of native plants would be the best option to plant in our landscape islands. Examples of Illinois native plants include:

Butterfly Weed

Notes:

- Grows in clay soils
- Need bright sunlight
- Produces blooms every 2-3 years

Culver's-root (Veronicastrum virginicum)

Notes:

- Full Sun, Partial Sun, or Shade
- Needs clay or loam soil
- Blooms in the late summer
- Grows to 3'-6'

Great Blue Lobelia (Lobelia siphilitica)

Notes:

- Full Sun or Partial Sun
- Grows in the late summer
- Grows to 1’-4’
- Needs wet soil

New England aster (Symphyotrichum novae-angliae)

Notes:

- Grows in clay or loam soil
- Blooms early fall
- Grows 3’-6’
- Needs full sun or partial sun

❖ Soil

Permeable soil will have to be used for the landscape island in order for rainwater and runoff to filter and nutritionize the plants. Examples of permeable soils that can be utilized are:

Gravel

Advantages:
- No Decomposition
- Absorbs Heat
- Doesn't Attract Pests

Disadvantages:
- Possibility of Gravel Sinking in Soil

Loam

Advantages:
- Drought Resistant (holds water for long periods)
- Faster to Warm under Heat
- Very fertile

Disadvantages:
- May Contain Unwanted Components i.e. rocks

❖ Guidelines

Fermilab's overall campus is enclosed between Kane County & Dupage County. The laboratory must comply with both county's individual environmental rules and regulations, specifically named National Pollutant Discharge Elimination System (NPDES). The following information will list the requirements for Kane County & Dupage County NPDES permits.

➢ **Kane County**

1. Managing and mitigating the effects of urbanization on stormwater drainage throughout Kane County through planning, appropriate engineering practices and proper maintenance;
2. Protecting the public health and safety and reducing the potential for loss of human life and property from Flood damage
3. Protecting the public from the degradation of water quality on a Watershed basis;
4. Preserving and enhancing the natural hydrologic and hydraulic functions and natural characteristics of watercourses and Floodplains to protect water quality, aquatic habitats, reduce Flood damage, reduce soil Erosion, provide recreational and aesthetic benefits and enhance community and economic development;
5. Controlling Sedimentation and Erosion in and from stormwater facilities, Developments, agricultural fields, and construction sites and reducing and repairing stream bank Erosion

➢ **Dupage County**

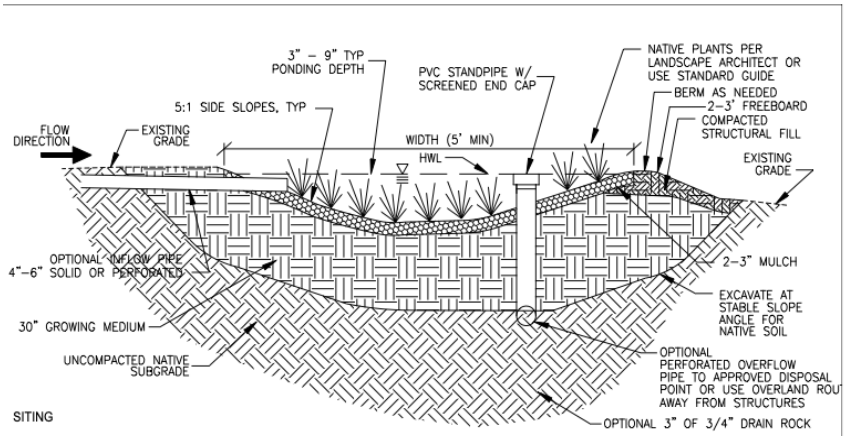
1. An ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance, to the extent allowable under state or local law;
2. Requirements for construction site operators to implement appropriate erosion and sediment control best management practices, including green infrastructure storm water management techniques where appropriate and practicable;
3. Requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality;
4. Require all regulated construction sites to have a storm water pollution prevention plan that meets the requirements of Part IV of NPDES Permit No. ILR10 including management practices, controls, and other previsions at least as protective as the requirements contained in the Illinois Urban Manual, 2002, or as amended including green infrastructure techniques where appropriate and practicable;
5. Procedures for site plan review which incorporate consideration of potential water quality impacts and review of individual pre-construction site plans to ensure consistency with local sediment and erosion control requirements;
6. Procedures for receipt and consideration of information submitted by the public; and
7. Procedures for site inspections and enforcement of control measures.

❖ Design

The following section will showcase various design options for this specific project. With every example, a short explanation and a design visual will be given.

➢ RAIN GARDEN

Rain gardens are small, shallow, flat bottomed depressions constructed to temporarily hold and infiltrate stormwater allowing stormwater to soak into the ground onsite rather than leaving a property as runoff. Rain gardens are constructed to retain stormwater runoff and facilitate infiltration and remove other pollutants through plants, microbes and soils.



SITING

- > 10' from, and downstream of building foundations
- pre-construction slopes < 8%
- > 2' from bottom of garden to seasonal high ground water
- conveyance from upstream impervious areas
- 10' from property line
- distance from septic and well _____ft
- site in appropriate soils for infiltration

DESIGN

- ponding depth 3-9"
- 5:1 side slopes, minimum
- determine soils type, moisture availability, sun exposure
- 30" adequate growing medium, specified soil mixes or natural top soil
- consider amended soil 50% sand, 30% compost and 20% topsoil, 30" deep
- see local ordinance for sizing
- compacted structural fill prevents erosion at overflow
- direct overflow away from structures
- choose appropriate plants, especially deep-rooted native vegetation. see standard planting guides
- use plug or container grown plant material spaced 1' on center
- shredded hardwood mulch or comparable non-floatable mulch

CONSTRUCTION

- sediment control of excavation required
- perimeter control required to prevent compaction, including foot traffic
- be prepared to water new plants if needed

MAINTENANCE

- periodic inspection and weeding needed
- may take up to 3 years to establish native vegetation
- provide maintenance and operations plan
- easement, title and performance bond required

SMALL RAIN GARDEN

DUPAGE COUNTY EXAMPLE DETAIL FOR RAIN GARDEN

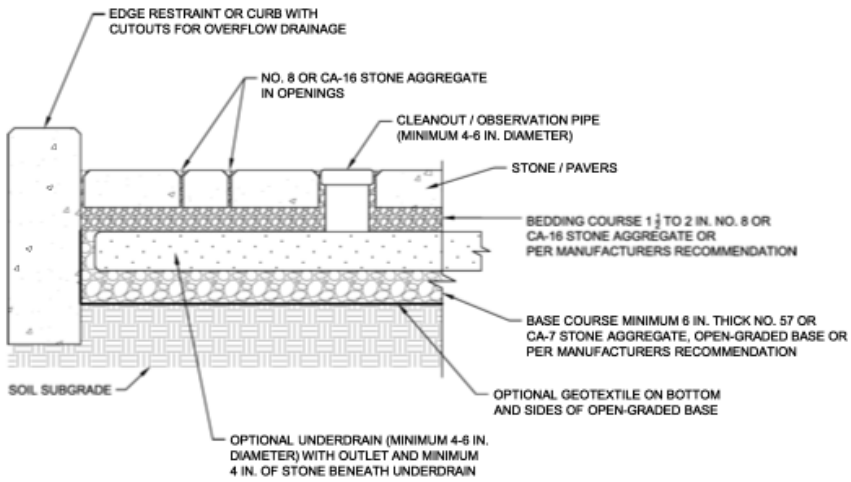
DATE: jUNE, 2017

➢ **PERVIOUS and POROUS PAVEMENT**

Alternate pavement systems are designed to allow water to pass through the surface into the subsurface for storage and infiltration and to also reduce peak runoff rates and volumes.

PERMEABLE STONE / PAVER SURFACE

FOR THE CONSTRUCTION OF A SMALL PERVIOUS SURFACE, SUCH AS A PATIO OR WALKWAY ACHIEVED WITH STONE OR CONCRETE PAVERS. PROJECTS WITH VEHICULAR TRAFFIC, STORMWATER STORAGE REQUIRED BY ORDINANCE, SLOPES GREATER THAN 5%, OR OTHER CHALLENGES, AS DETERMINED BY THE DIRECTOR OR ADMINISTRATOR IN A WAIVER COMMUNITY, WILL REQUIRE A DETAILED SITE-SPECIFIC DESIGN.



DESIGN

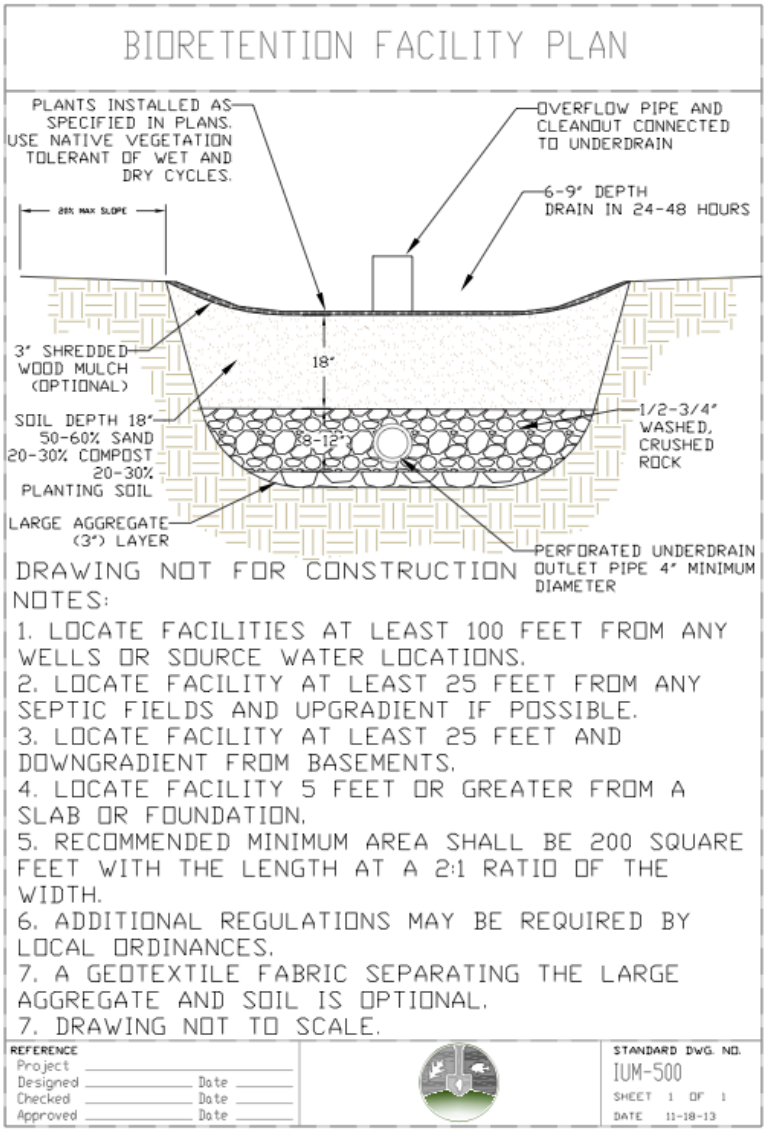
- **SURFACE SLOPE:** 5 % MAXIMUM
- **SUBGRADE SLOPE:** 0-1% OR USE BAFFLES / CHECK DAMS
- **FOUNDATION SEEPAGE PROTECTION:** PAVEMENT SEPARATION OF LESS THAN 5 FEET, USE AN IMPERMEABLE MEMBRANE

- ALL AGGREGATE MATERIAL SHALL BE WASHED, CRUSHED, ANGULAR STONE THAT IS FREE OF FINES
- ROUTE SUMP PUMP AND GUTTER DISCHARGES AWAY FROM PAVEMENT TO AVOID REDUCED PERMEABILITY FROM SATURATION OR CLOGGING
- AN UNDERDRAIN IS RECOMMENDED IN SOILS WITH LOW PERMEABILITY (LESS THAN 0.5 IN/HR)

March 2, 2021

➢ **BIORETENTION FACILITY**

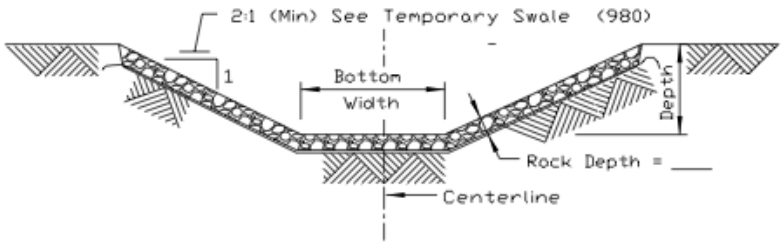
Facility that utilizes a soil media, mulch, and vegetation to treat stormwater runoff through filtration in clay soils areas and through infiltration in areas with porous soils. Similar to rain gardens where it is constructed to temporarily hold and infiltrate stormwater allowing stormwater to soak into the ground onsite rather than leaving a property as runoff.



➢ **TEMPORARY SWALE**

The purposes of this practice are to prevent runoff from entering disturbed areas by intercepting and diverting it to a stabilized outlet and to intercept sediment-laden water in disturbed areas and divert it to a sediment-trapping device.

TEMPORARY ROCK SWALE PLAN



Reach No.			
From Station			
To Station			
Grade, %			
Drainage Area, Ac			
Construction Layout Data			
Top Width, Ft.			
Bottom Width			
Side Slope			
Depth, Ft.			
Stabilization Material			

NOTES:

1. All trees, stumps, brush and debris shall be removed from the construction area and disposed of properly.
2. Riprap shall meet IDOT gradation RR-3 Quality Designation A or B. Aggregate shall meet IDOT coarse aggregate gradations CA-2 or CA-3. Rock shall be placed according to construction specification 25 ROCKFILL using placement Method 1 and Class III compaction.
3. Filter fabric shall meet the requirements of material specification 592 592 GEOTEXTILE, Table 1 or 2, Class I, II, or IV and shall placed over the area prior to the placing of rock.
4. Spoil material from construction will be deposited in low areas or otherwise spread so as not to interfere with flow of water into the swale. Any earth fill shall be compacted to prevent differential settlement in the completed swale. The swale will be constructed to the specified grade, width and depth.

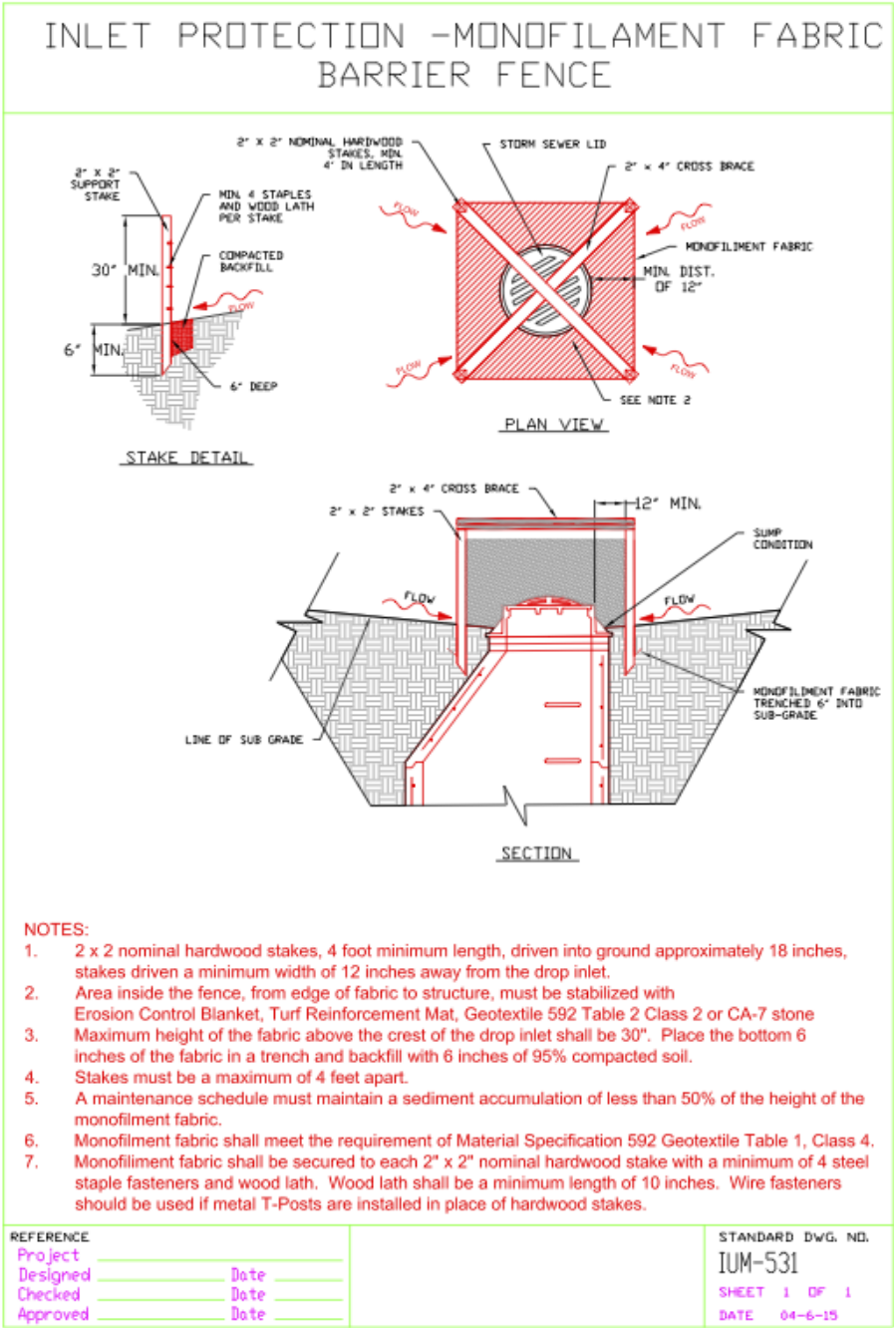
REFERENCE
Project _____
Designed _____ Date _____
Checked _____ Date _____
Approved _____ Date _____

NRCS
Natural Resources Conservation Service

STANDARD DWG. NO.
IL-680R
SHEET 1 OF 1
DATE 11-21-01

➢ **<u>INLET PROTECTION – Monofilament Fabric Barrier Fence</u>**

The purpose of this practice is to help prevent sediment from entering storm drains during construction operations. This practice allows early use of the storm drainage system.



NOTES:

1. 2 x 2 nominal hardwood stakes, 4 foot minimum length, driven into ground approximately 18 inches, stakes driven a minimum width of 12 inches away from the drop inlet.
2. Area inside the fence, from edge of fabric to structure, must be stabilized with Erosion Control Blanket, Turf Reinforcement Mat, Geotextile 592 Table 2 Class 2 or CA-7 stone
3. Maximum height of the fabric above the crest of the drop inlet shall be 30". Place the bottom 6 inches of the fabric in a trench and backfill with 6 inches of 95% compacted soil.
4. Stakes must be a maximum of 4 feet apart.
5. A maintenance schedule must maintain a sediment accumulation of less than 50% of the height of the monofilment fabric.
6. Monofilment fabric shall meet the requirement of Material Specification 592 Geotextile Table 1, Class 4.
7. Monofiliment fabric shall be secured to each 2" x 2" nominal hardwood stake with a minimum of 4 steel staple fasteners and wood lath. Wood lath shall be a minimum length of 10 inches. Wire fasteners should be used if metal T-Posts are installed in place of hardwood stakes.

Conclusion

Fermilab's Wilson Hall West parking lot must undergo renovations to combat the increasing rainfall volume in Illinois. With the rise in rainfall comes a rise in runoff, which can in turn harm the surrounding ecosystems and erode the lot's fixtures. With the use of permeable surfaces, landscape islands, and underdrains, the issue could subside dramatically. The implementation of this plan would ultimately serve to favor not only the Fermilab community, but also the surrounding Dupage and Kane counties.

Acknowledgements

I would like to thank my supervisor John Wills for his guidance throughout my internship. My thanks also extends out to the staff of Fermilab's Diversity and Inclusion division for providing another chance to develop my career in STEM. I am immensely grateful for the support this laboratory has given me throughout my high school and early college years.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.

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