MSE Berm: Overcome Site Constraints and Maximize Air Space

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Agenda

1. **Regulatory Framework**
   NCDEQ Coal Ash Management Act, Federal CCR Rule, and Mountain Energy Act driving the project.

2. **Site Constraints**
   Active facility, topographic changes, jurisdictional wetlands made landfill siting a challenge.

3. **Design and Construction**
   MSE Berm is welded wire baskets backed by geogrid, backfilled, & vegetated that are installed working from one end (i.e., STA 0+00) to the other.

4. **MSE Berm Considerations**
   Attention to detail, safety when working at heights, labor intensity of construction, tie-in to landfill are unique to incorporation of MSE Berm.

5. **Unexpected Site Conditions**
   Bedrock in MSE Berm footprint forced a redesign with installation splitting berm in three sections.

6. **Benefits and Additional Challenges**
   Improved efficiency and added safety.

Regulatory Framework

Timeline of Regulation

1964
Ash Basin constructed to receive sluiced fly ash & bottom ash from plant's original coal-fired unit

1971
Ash Basin underwent expansion by raising & expanding the dikes

1982
Ash Basin taken out of service as it reached its capacity & impounded water was allowed to drain naturally

December 2008
Release due to dike failure at another site started push for regulation

August 2014
Coal Ash Management Act adopted in North Carolina

December 2014
USEPA Administrator signed Final Rule: Disposal of Coal Combustion Residuals (CCR) for Electric Utilities

June 2015
Mountain Energy Act signed by the Governor

2016
Excavation of Ash Basin began with transport to an off-site landfill

2020
Construction of on-site CCR landfill began

Coal Ash Management Act

North Carolina General Assembly adopted legislation that provided a broad program to address existing and future CCR management. The Coal Ash Management Act required:

- NCDEQ to establish schedule & process for closure and remediation of all CCR surface impoundments.
- Closure and remediation of certain CCR surface impoundments no later than August 1, 2019
- Assessment of risks to public health, safety, & welfare, the environment, and natural resources of CCR impoundments located beneath CCR landfills to determine advisability of continued operation
- Assessment of groundwater
- Survey of drinking water supply wells & replacement of contaminated water supplies
- All electric generating facilities to convert to generation of dry fly ash, along with prohibiting disposal of stormwater to CCR surface impoundments
- Department of Transportation to develop technical specifications for use of CCR

Federal CCR Rule

In response to releases, USEPA finalized national regulations for disposal of CCR. Comprehensive regulations aimed at preventing leaking of contaminants into groundwater, blowing of contaminants into air as dust, & catastrophic failure of impoundments.

Design of CCR landfills need to consider the following in determining on-site location:

- **Seismic Zones** – Areas with 2% or greater probability that maximum expected horizontal acceleration will exceed 0.10 in 50 years must obtain certification from Professional Engineer
- **Aquifer** - Must be constructed with base no less than 5' above upper limit of uppermost aquifer or demonstrate no hydraulic connection with seasonal high water table
- **Wetlands** - New CCR landfills located in wetlands must rebut the presumption that a reasonable alternative non-wetland site exists, show the unit will not contribute to any water quality violation, will not degrade wetlands and will achieve no net loss of wetlands
- **Unstable Areas** - CCR landfills must be engineered to avoid unstable areas

Mountain Energy Act

An act to direct the North Carolina Utilities Commission to render an expedited decision on applications to convert to natural gas

As part of the natural gas conversion, the coal combustion residuals surface impoundments at this site were designated high-priority with the need to close as soon as possible, but no later than August 1, 2022.

Site Constraints

Active Facility

- Bound on all sides with no opportunity for expansion

- Unavailable landfill site occupied by coal fired plant in the process of being demolished

- Unavailable landfill site occupied by an active combined cycle plant

- Unavailable landfill site occupied by Ash Basin in need of closure

Available Location

Met regulatory requirements but posed landfill design challenges

After years of transporting CCR off-site for disposal, the decision was made to construct an on-site landfill. The only viable location was a small parcel previously used as a laydown area for the combined cycle construction project. It had significant changes in topography as well as adjacent wetlands along the northwestern side.

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Disposal Volume vs. Airspace

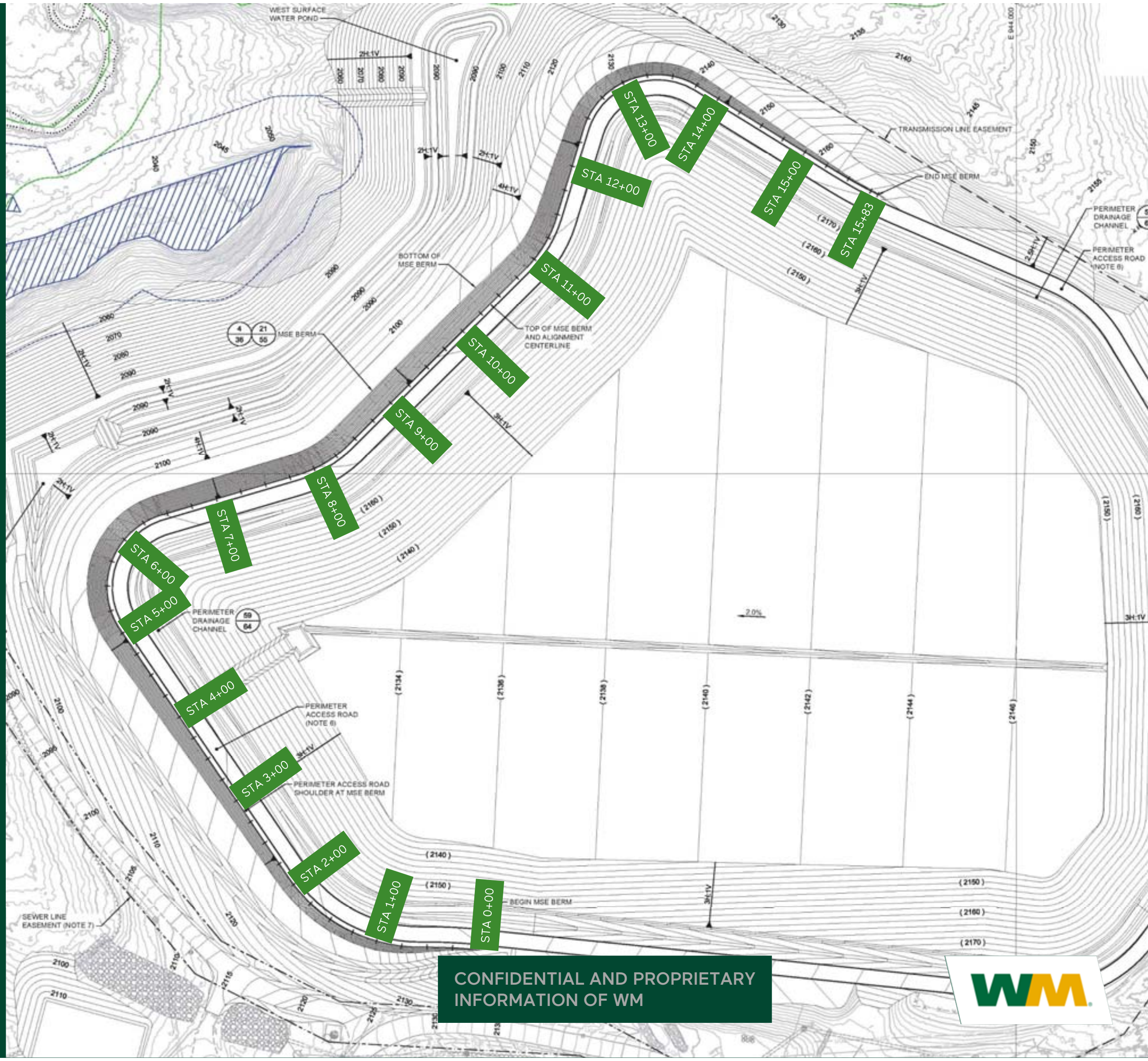
- Ash Basin
  - 46.4-acre former disposal area for CCR
  - Approximately 2,000,000 yd^3 had already been disposed of off-site
  - Remaining 998,000 yd^3 to be disposed of in the on-site landfill following construction
- Landfill Location
  - Limited to approximately 10-acre level area for traditional landfill geometry
  - Airspace would be similarly limited to approximately 480,000 yd^3 considering a height of 30’
- Maximizing Airspace
  - Utilize natural topographic change to extend landfill footprint to approximately 12.5 acres
  - Incorporate a Mechanically Stabilized Earth (MSE) Berm to retain CCR on the sloped side
  - Increases airspace to approximately 1,100,000 yd^3

Design and Construction

NW side of landfill contained by MSE Berm

First such application of MSE Berm for a landfill permitted in the state

Given the relatively small footprint for the landfill and the remaining volume of ash in the larger ash basin being closed, the Engineer of Record incorporated a MSE Berm into the traditional landfill design. The 1,583 foot long and approximately 75-foot tall MSE Berm runs along the northwest side, up the existing slope, and effectively separates the CCR Landfill from the adjacent wetlands while increasing airspace in the landfill.



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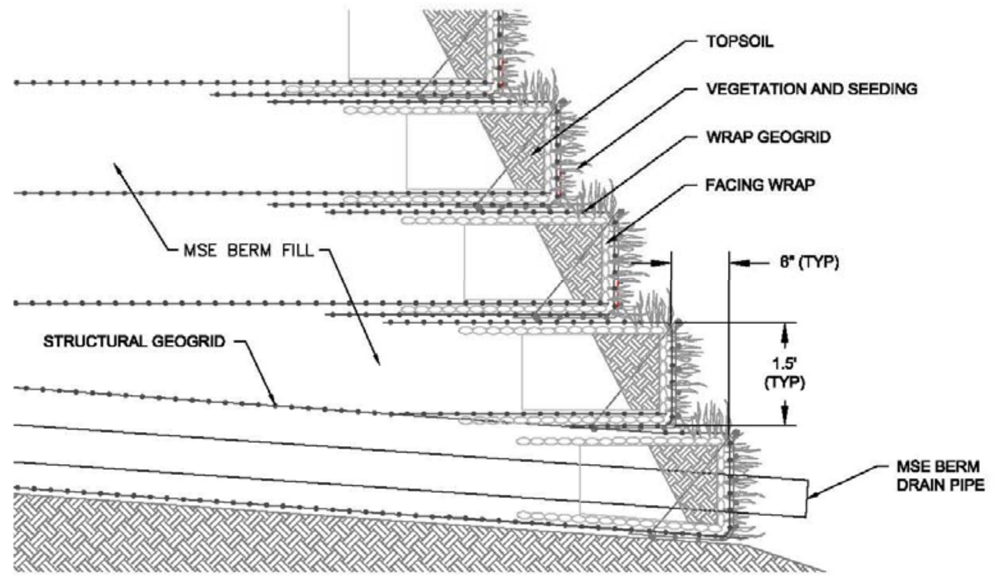
47 courses to reach final MSE Berm height

Each course is 1.5′ high welded wire basket, placed on a 6″ batter

Structural geogrid started each course with a welded wire basket face, wrapped in geogrid & erosion control blanket. A combination of fill materials was to be used (i.e., MSE Berm Fill, Topsoil, and General Fill) behind the face. A back drain was included in the design to allow for stormwater drainage.



Structural geogrid varied by course

Type I

Used for Courses 33 through 47, between STA 0+00 and 15+83 (20' lengths).

- 301,026.91 ft^2 required
- 3,425 lbs./ft Ultimate Tensile
- 2,090 lbs./ft Long-Term Tensile

Type II

Used for Courses 16 through 32, between STA 0+00 and 10+50 (30-40' lengths) as well as between STA 10+50 and 15+83 (70-80' lengths).

- 944,783.60 ft^2 required
- 9,500 lbs./ft Ultimate Tensile
- 5,672 lbs./ft Long-Term Tensile

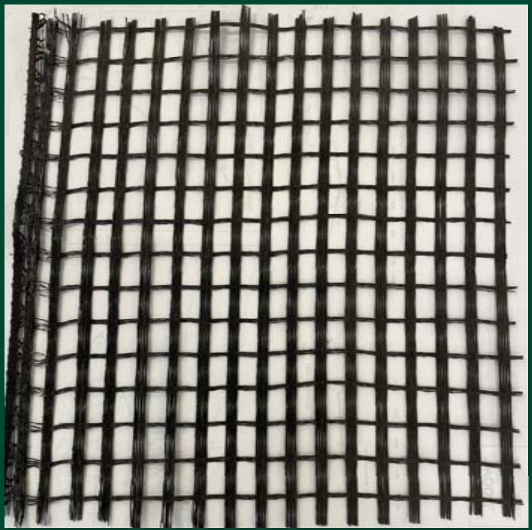
Type III

Used for Courses 1 through 15 , between STA 0+00 and 10+50 (50-70' lengths) as well as between STA 10+50 and 15+83 (90' lengths).

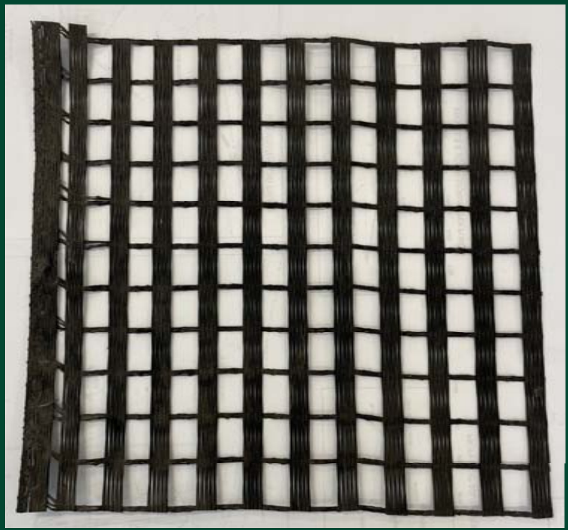
- 747,432.18 ft^2 required
- 27,400 lbs./ft Ultimate Tensile
- 16,370 lbs./ft Long-Term Tensile

Structural geogrid varied by course

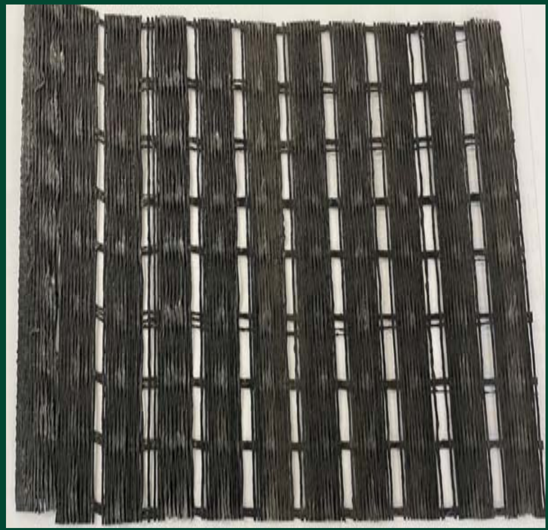
Type I



Type II



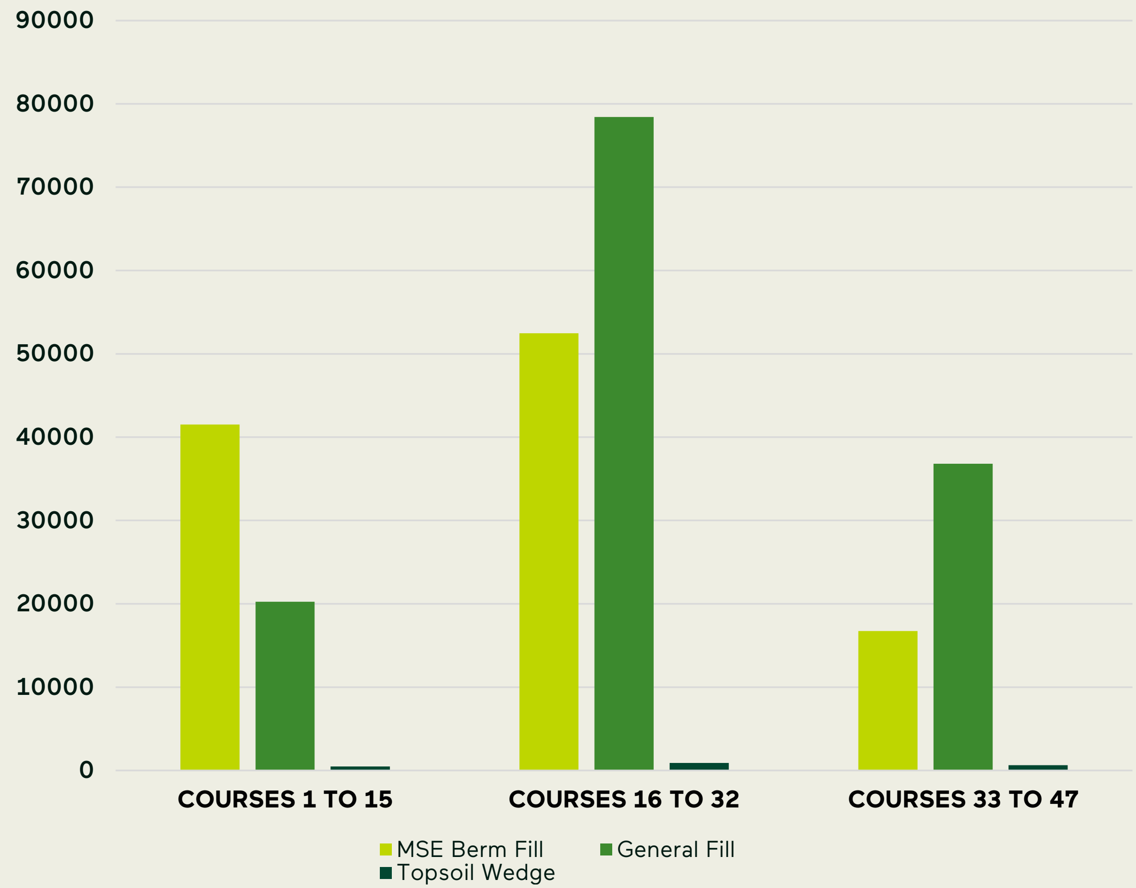
Type III



Fill for the MSE Berm varied as well

Majority was General Fill outside the geogrid & MSE Berm Fill within the geogrid

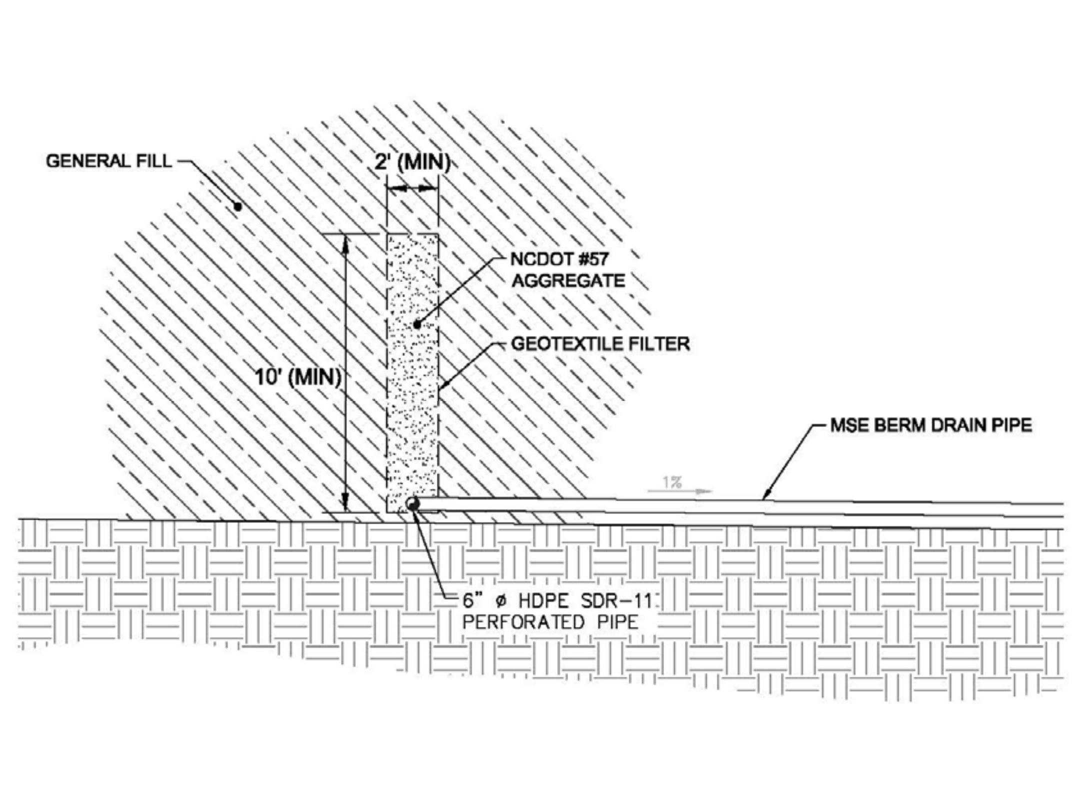
MSE Berm Fill was to be placed in 9" lifts and compacted to 95%. This material was classified as SW, SP, SW-SM, or SWSC, fines content less than 40%, and hydraulic conductivity greater than 1 x 10^{-4} cm/sec. Along the facing of the MSE Berm, topsoil was to be placed to the depth of each basket and compacted using hand operated equipment. General Fill was used to backfill outside the limits of the geogrid.

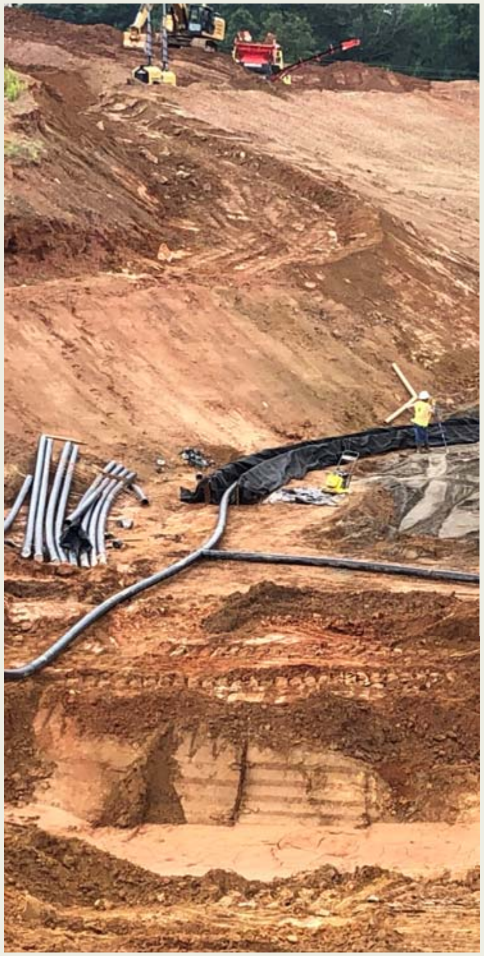


Back drain for stormwater drainage

Required every 200′ along face of MSE Berm

Back drains were to be placed within the MSE Berm Fill and consist of 6″ diameter perforated pipe. A 2′ wide by 10′ tall area of #57 stone wrapped in geotextile was to surround the perforated pipe. Each back drain was to be connected to a 6″ diameter solid pipe that daylights out the face of the MSE Berm.





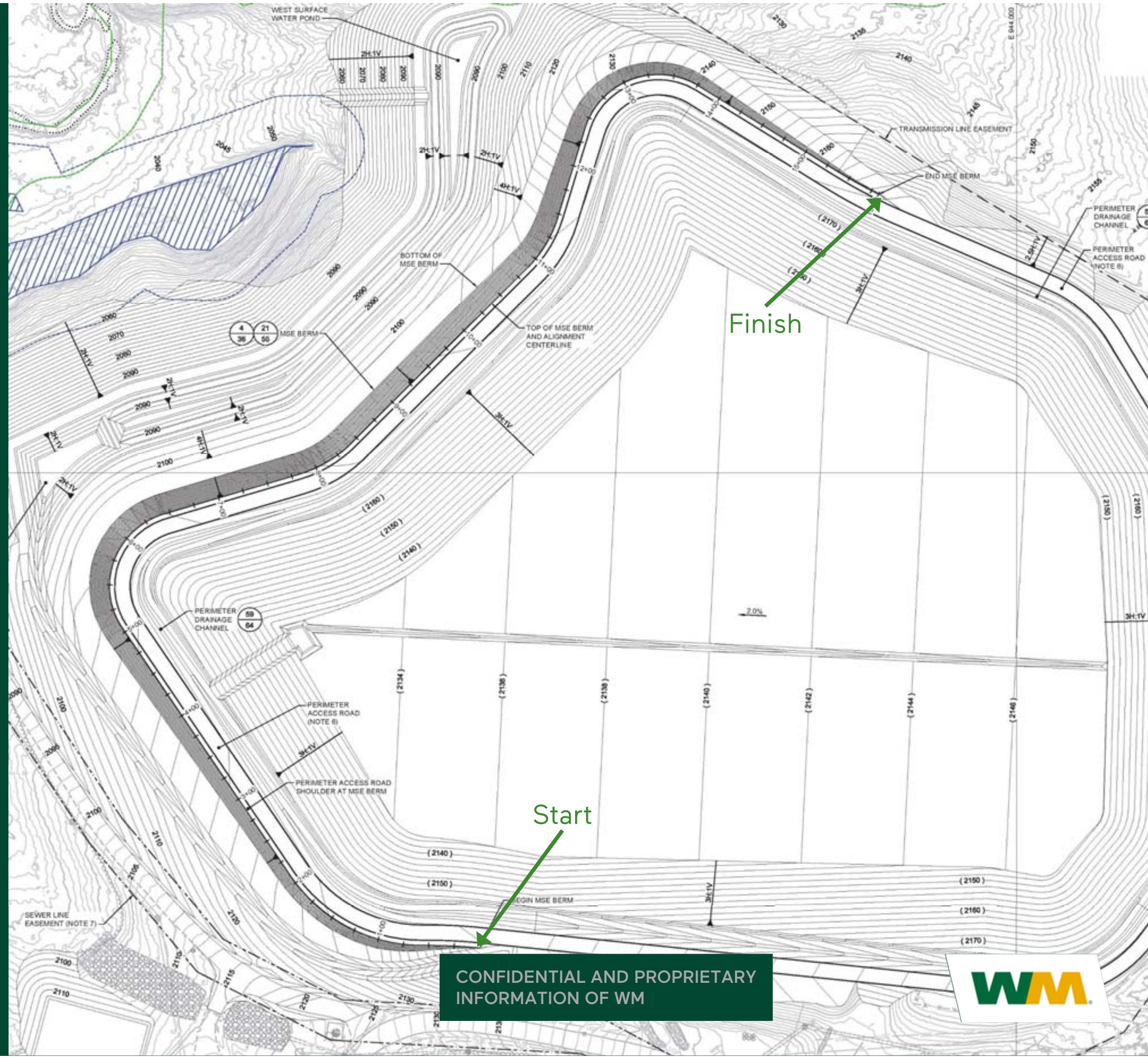

CAT

Typically begin at one end and work clockwise

Construct courses bottom (i.e., 1) to top (i.e., 47)

Attention to detail is required where:

- Tying into existing slopes at ends since leveling course is required
- Constructing interior corners due to the overlap in geogrid and fill placement
- Setting the batter off the prior course as verification survey must be completed first



Each course is constructed in similar fashion

- Welded wire basket is placed at the front of the MSE Berm to start the course
- Diagonal braces are placed every 2' along the front

- Geogrid & erosion control blanket are wrapped at the front of the MSE Berm
- A section is left at the front to overlap the backfill after placement

- Structural geogrid is placed behind the basket face of the MSE Berm
- Material properties and length varies by course

- MSE Berm Fill & General Fill are used as backfill between geogrid layers
- Each are compacted as per specifications

Each course is finished the same

New tasks in each course lag behind the prior and follow until course is complete.

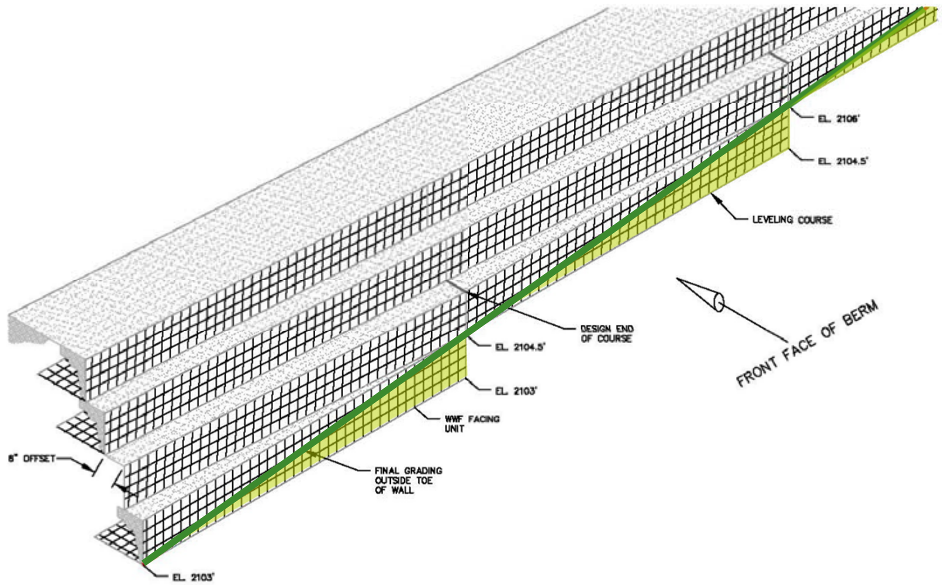
- Back drains are constructed with each course until the final back drain elevation is met
- Topsoil is placed at face of MSE Berm for each lift of fill material
- Compaction is by hand equipment to avoid damage to the welded wire basket
- The face of MSE Berm is vegetated at completion

MSE Berm Considerations

Attention to Detail

Leveling course required to tie into existing slopes

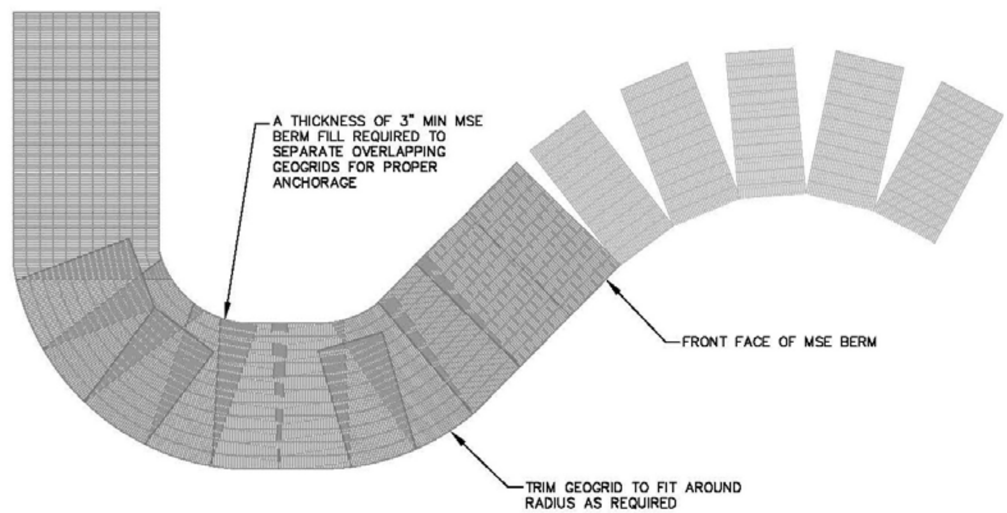
Since baskets can't be placed at angles, level areas need to be created to allow baskets to be placed squarely where tying into existing slopes. These are starting points for each course.



Attention to Detail

Interior corners are complicated by geogrid overlaps

Construction of interior corners take longer as geogrid placement begins to overlap in these tight spaces. In addition, MSE Berm Fill is required to be placed between overlapping geogrid layers.



Attention to Detail

Starting the next course must be precise

Each course has a 6" batter from the prior course. The survey crew must verify the wall edge to establish the baseline for setting the following course.

Safety when working at heights

- OSHA requires fall protection at heights of 6′ which for this site was courses 4 through 47

- Signage with visual barriers were used to warn of fall hazard and to restrict personnel access

- Concrete blocks were placed along the length of MSE Berm as anchor points for tie off lines

- Safety for wildlife also became a concern as height of MSE Berm increased

Labor intensity of construction

Most work was done manually

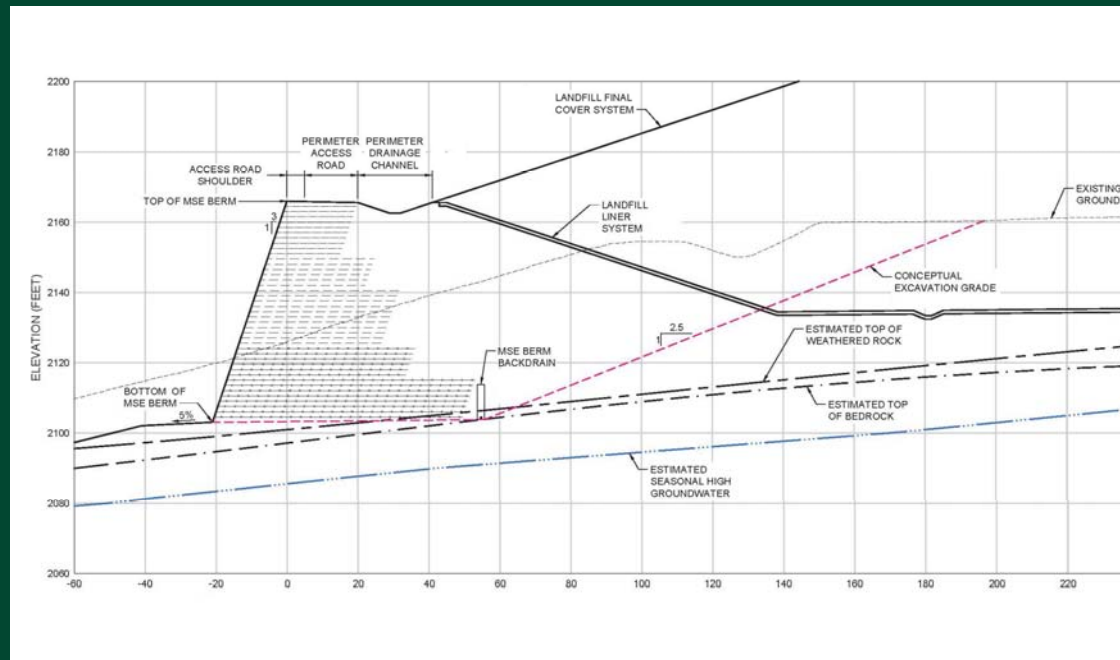
Wire welded baskets and wrapping were all placed by hand. To prevent bulging at the front of the wall, compaction was via hand tools instead of heavy equipment. Installation was scheduled for 80 working days

Large crew working in tight space

Subcontractor crew size of approximately 10-12 dedicated to MSE Berm construction. WM had an additional 7 personnel supporting with backfill and geogrid placement that tied into the overall landfill construction

Tie-in to landfill

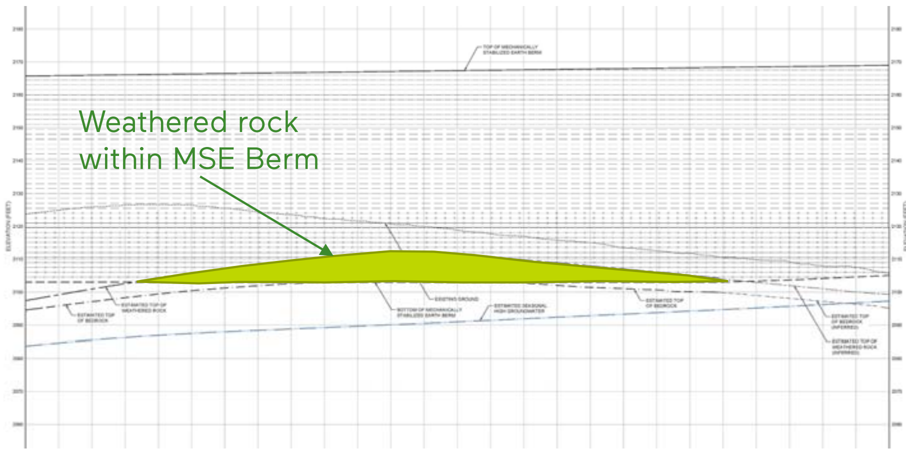
STA 8+00 which is typical



Required excavation at a 2:5:1 slope from the back of the MSE Berm into the landfill, which was a considerable amount of over excavation compared to typical landfill installation. Layers of structural geogrid extended back as far as 90' from the MSE Berm towards the landfill. MSE Berm installation needed to be complete through Course 47 before the landfill subgrade and liner installation could begin.

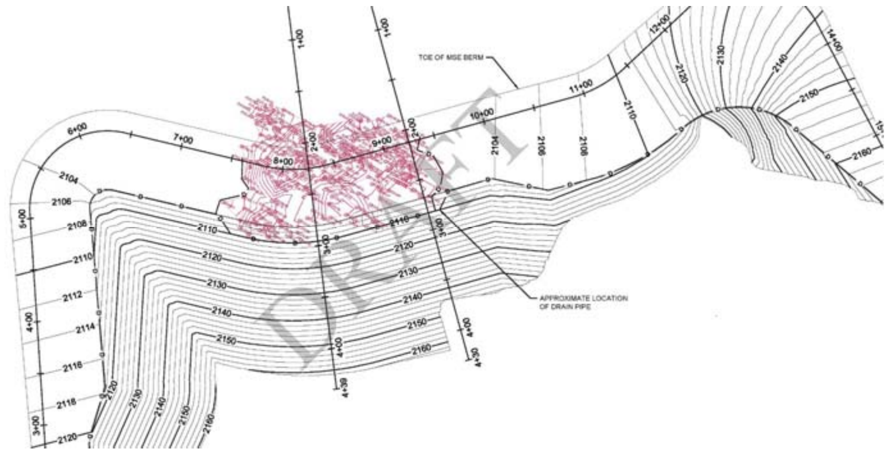
Unexpected Site Conditions

Bedrock in MSE Berm footprint



Anticipated Conditions

Bedrock (i.e., unrippable rock) would not be encountered within the MSE Berm footprint. Rock was to be limited to weathered rock between STA 8+00 and STA 10+00.



Actual Conditions

Bedrock, not weathered rock, was encountered within the MSE Berm footprint between STA 4+00 and STA 4+60 and again between STA 7+60 and STA 9+40.

Bedrock in MSE Berm footprint

Bedrock was initially encountered on May 11th and design resolution was achieved on July 24th.

- WM notified client upon discovery and worked with client and their Engineer of Record in determining a resolution
- Concurrent with the redesign effort, WM explored various options to remove bedrock
  - D9 Dozer – limited success
  - Excavator with hammer – limited success
  - Drilling – not used
  - Blasting – not used
  - Chemical splitting – not used
- Ultimately decision was to stop chasing the edges of bedrock

Bedrock in MSE Berm footprint

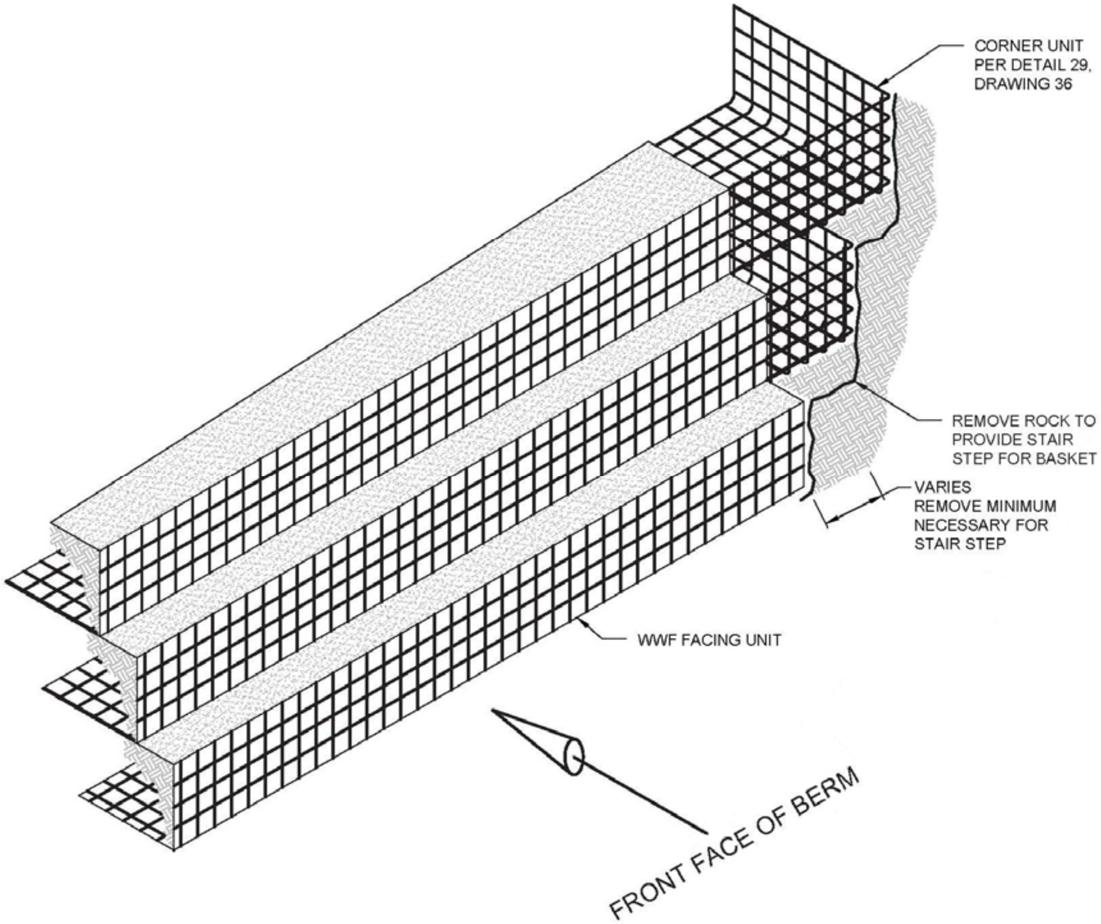
Design Resolution

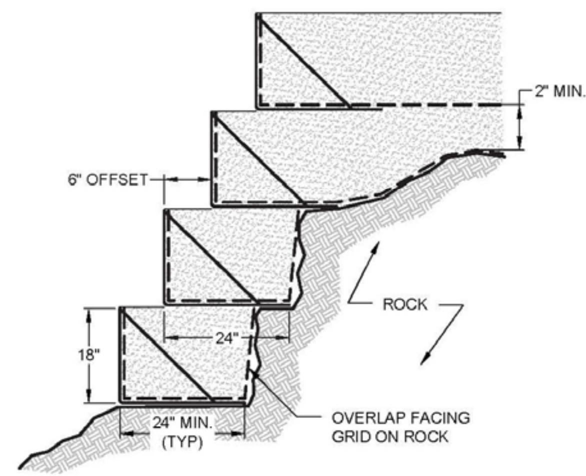
STA 4+00 to STA 4+60

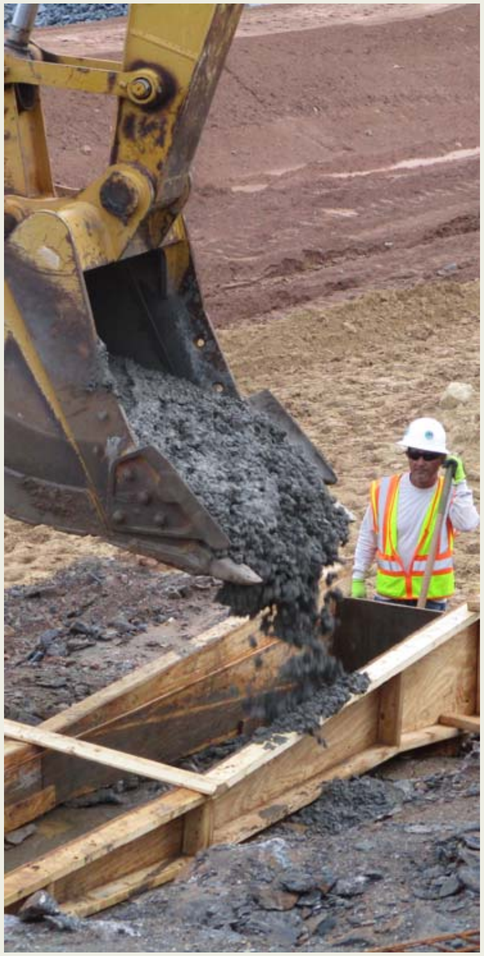
- Rock to be removed
- MSE Berm to be constructed as per original design with no modifications

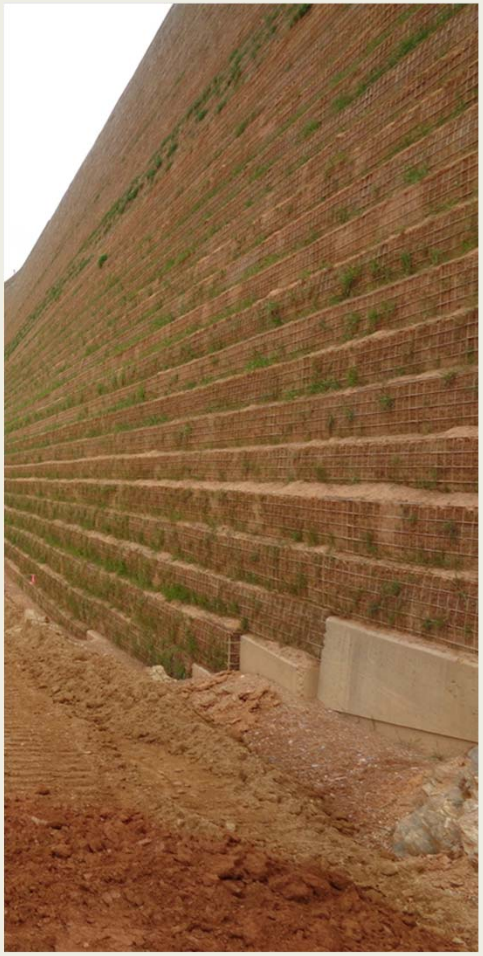
STA 7+60 to STA 9+40

- Rock to remain in place
- MSE Berm to be redesigned around exposed bedrock
- New configuration included adjustment to geogrid requirements and additional drain pipe installation
- Slope stability analysis conducted on new MSE Berm configuration under long-term static and seismic loading conditions


CORNER UNIT
PER DETAIL 29,
DRAWING 36
REMOVE ROCK TO
PROVIDE STAIR
STEP FOR BASKET
VARIES
REMOVE MINIMUM
NECESSARY FOR
STAIR STEP
WWF FACING UNIT
FRONT FACE OF BERM


2" MIN.
6" OFFSET
ROCK
24"
18"
24" MIN.
(TYP)
OVERLAP FACING
GRID ON ROCK



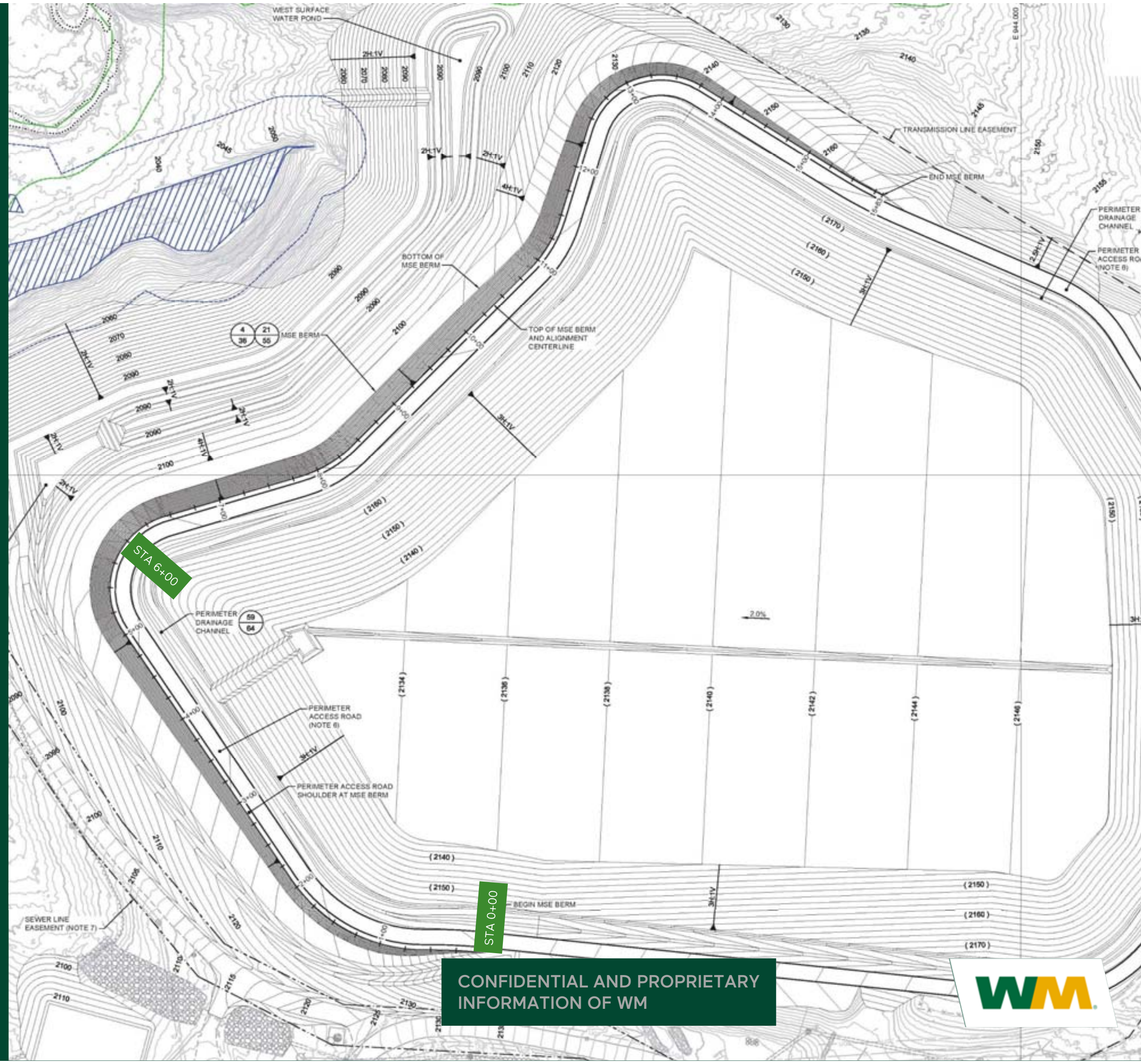

NIGHT-LITE
SHO-HD
1250-WATT
8kW

Installation split into three working sections

South wall section

This section included the following attention to detail areas:

- Interior corner at STA 6+00
- Leveling courses from STA 5+00 to STA 0+00



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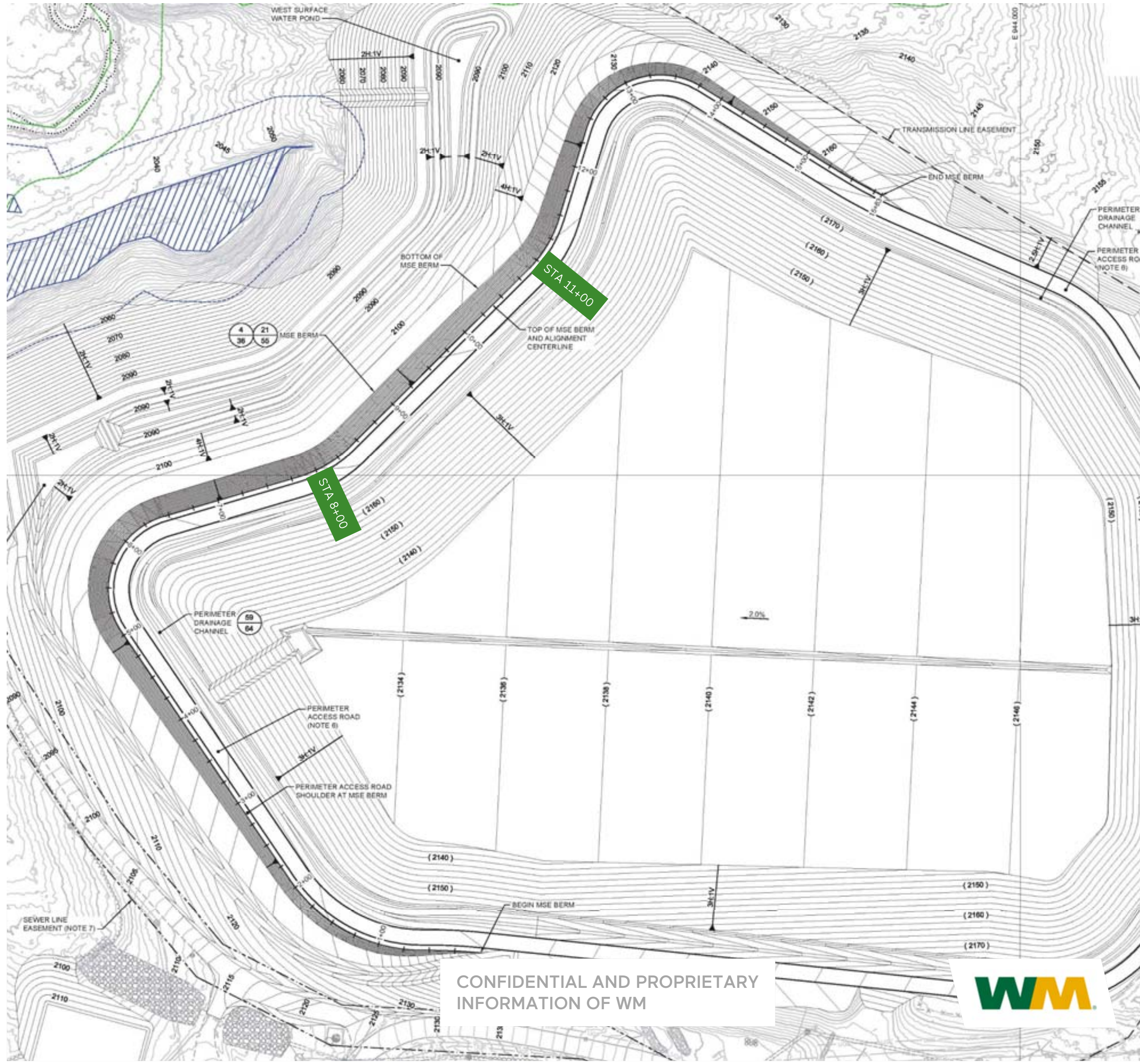
Installation split into three working sections

Center wall section

This section included the following attention to detail areas:

- Exterior corner at STA 8+00
- Exterior corner at STA 11+00
- Transition of geogrid around bedrock at STA 7+60 to STA 9+40
- Change in geogrid length at STA 10+50

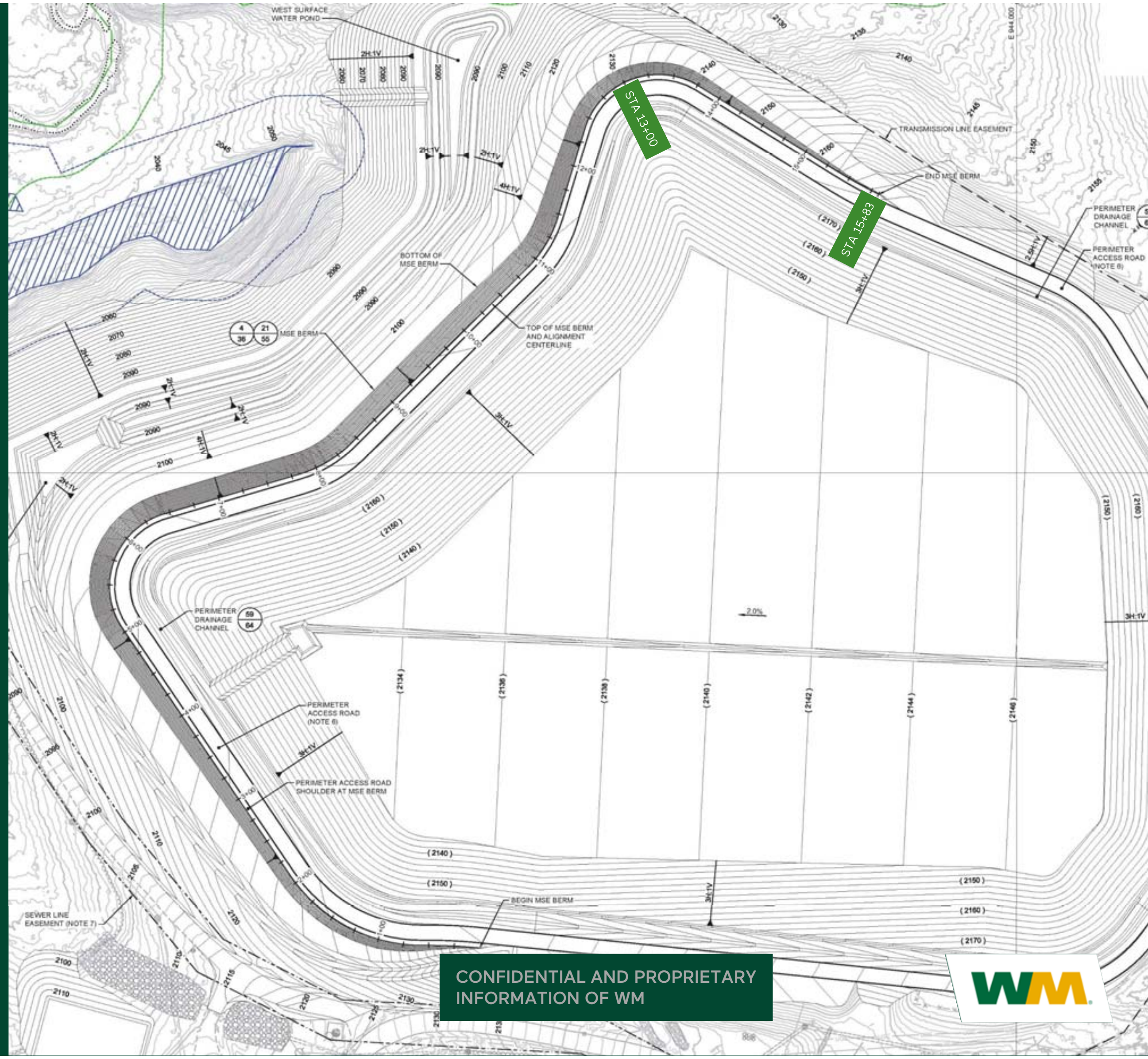


Installation split into three working sections

North wall section

This section included the following attention to detail areas:

- Interior corner at STA 13+00
- Leveling course from STA 12+50 to STA 15+83




SOUTH
WALL
CENTER
WALL
NORTH
WALL
STA. 10+50




Benefits and Additional Challenges

Improved efficiency and safety for all crews involved

Typical installation (i.e., working from one end to the other) would have created downtimes for WM and our subcontractor.

WM was responsible for the subgrade preparation, including rock removal. Our subcontractor was responsible for basket and geogrid placement. WM completed the backfill of each course.

Improvements to efficiency

Equipment

Working the MSE Berm in sections provided more efficient equipment flow, allowing:

- Multiple travel paths for access to/from the MSE Berm during fill placement and staging of wall components
- Separation of equipment, reducing the downtime due to equipment interferences

Crews

Working the MSE Berm in sections created the potential to avoid bottlenecks such as:

- Inside corners being slower to construct, the new sequence allowed crews to construct around them
- Created large working areas for placing fill over the geogrid vs. potential to catch up to geogrid placement and waiting for geogrid
- Started MSE Berm where leveling pad wasn't needed, allowing pad to be constructed before wall reached that location. Also allowed subsequent course to start while crew completed leveling pad

Improvements to safety

Buffer zone between equipment and personnel

By working the MSE Berm in three sections, WM's approach provided more separation of ground crews from fill placement equipment, eliminating potential safety hazards.

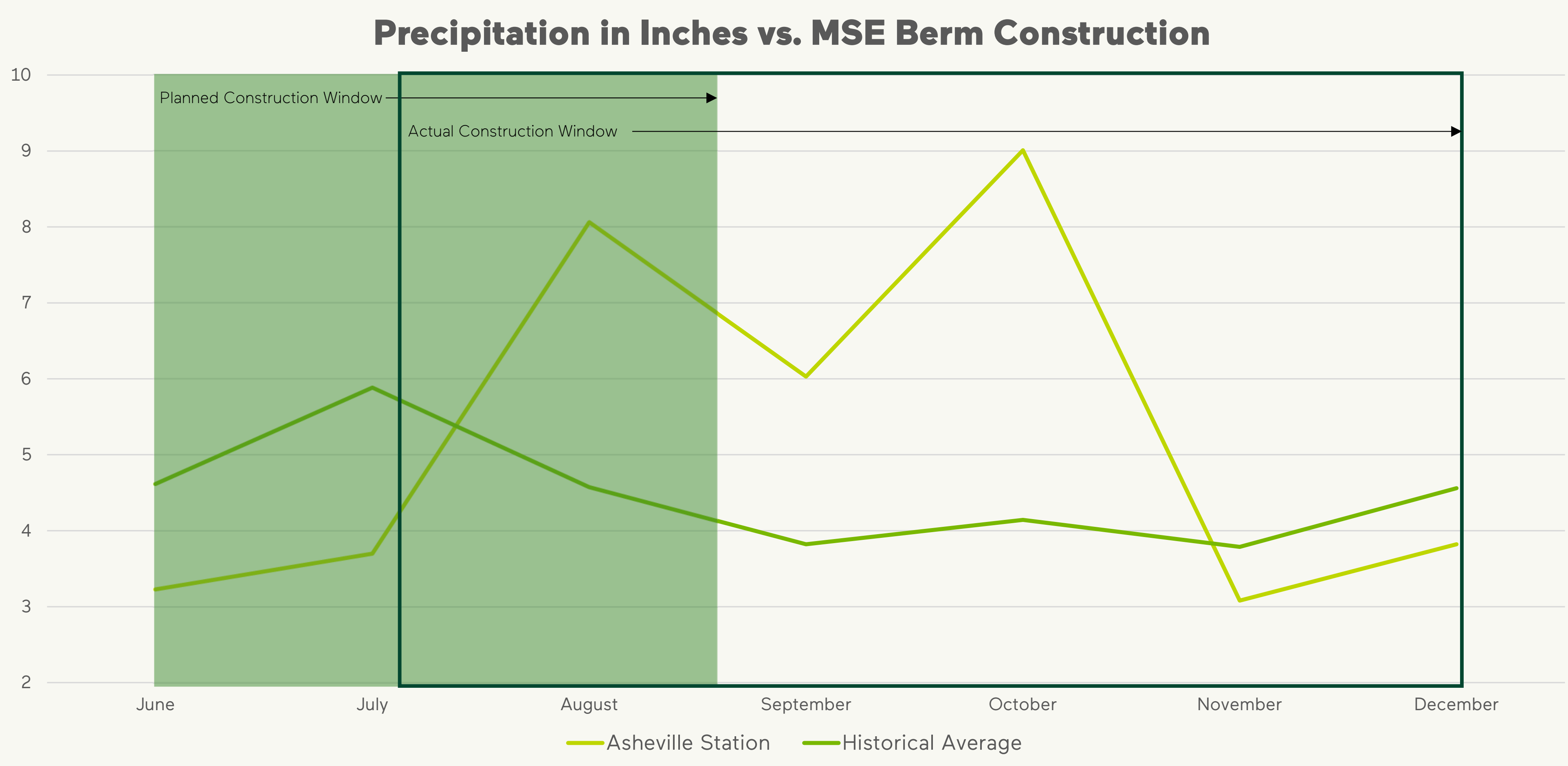
Tight landfill construction schedule

Landfill footprint in 2019

The project was awarded in December 2019 with a proposed landfill completion date in October 2020. The MSE Berm was originally scheduled to start in June.

Landfill footprint in 2021

Permit delays pushed the start of landfill construction approximately one month. As a result of that delay and the issues with unexpected bedrock, the MSE Berm start was pushed into August.

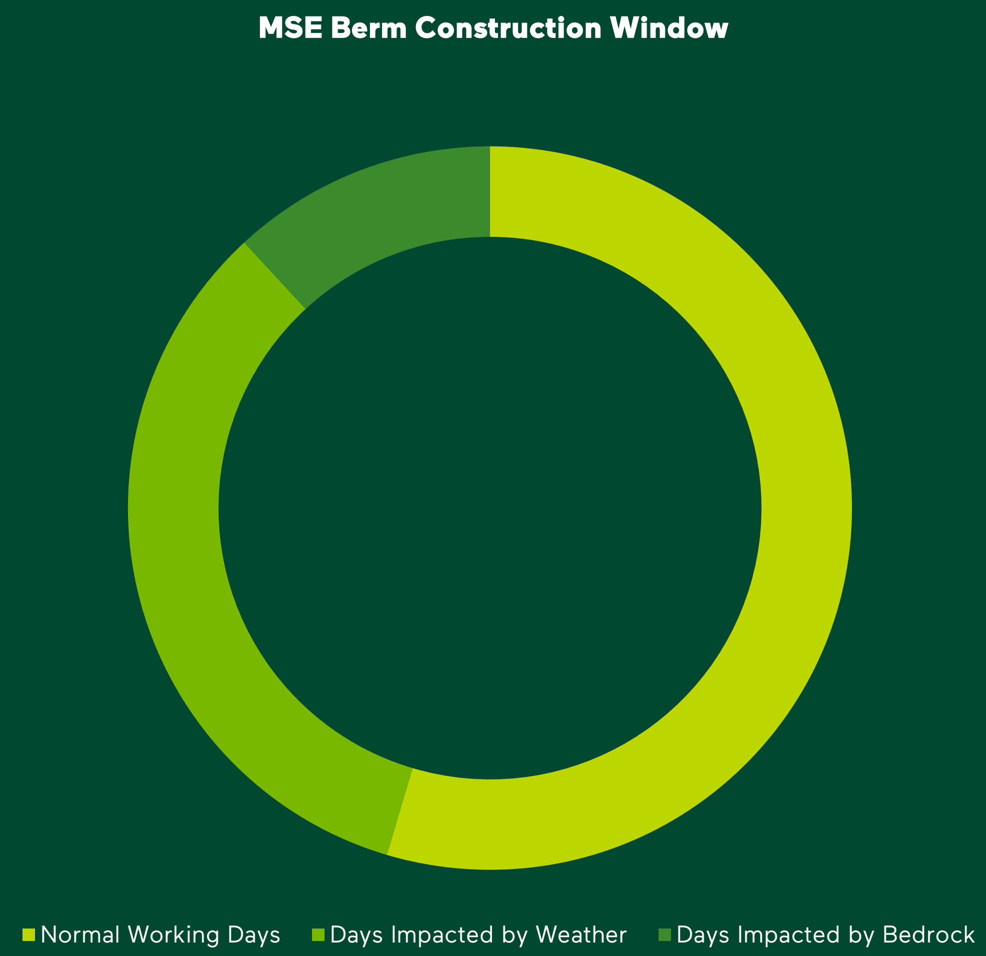

Precipitation in Inches vs. MSE Berm Construction
10
9
8
7
6
5
4
3
2
Planned Construction Window
Actual Construction Window
June
July
August
September
October
November
December
Asheville Station
Historical Average




MSE Berm a critical piece of tight schedule

Improved efficiency helped overcome impacts.

WM's approach to MSE Berm construction, which allowed for working the berm in multiple sections, helped improve efficiency enough to counteract the negative potential of bedrock and weather impacts. When accounting for the 14 days of bedrock impact and 40+ days of weather impact, the MSE Berm was constructed within the proposed schedule.



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