NATHANIEL J. HOLT, PE

dan@holtengineering.net

July 5, 2022

Town of North Castle
Planning Board
17 Bedford Road
Armonk, NY 10504

Attn: Christopher Carthy, Chairman

RE: Hugh Harris
9 Sterling Road North
Application for Site Plan and Wetland Permit Approval

Dear Chairman Carthy and Members of the Planning Board:

We last appeared before your Board on October 22, 2021 during which time the Property Owner was requesting that the Planning Board designate itself as the Approving Authority and consider Mr. Harris' request for approval to construct a swimming pool and related improvements. The Board may recall that the application for a wetland permit was initiated at the Conservation Board and after several attempts the Board voted to deny the permit. Unfortunately, Mr. Harris had retained the services of Mary Jaehnig a Certified Soil Scientist to conduct a Wetland Functional Assessment of the property. The Board may recall that during the October meeting Mr. Krupa, the co-chairman of the Conservation Board indicated that had the assessment been submitted prior to the vote, the outcome may have been different.

As indicated in Ms. Jaehnig's analysis, the wetland is not of high quality. The report noted that the vegetation in the wetland and wetland buffer consisted of mostly invasive species; interestingly, a significant component of the Harris mitigation plan was the removal of those invasives and the "hand planting" of native wetland vegetation. (This concept was supported by John Fava a previous Chairman of the Conservation Board.)

Another However, at the time that the vote was taken Mr. Harris had retained the services of Mary Jaehnig, a ——to prepare a Wetland Functional Analysis. Ms. Jaehnig's report, which was dated September 28, 201 which concluded that while there was a wetland on the property it (the wetlands) were <u>not</u> of high quality and provided little of the benefits typically attributed to a healthy wetland. Unfortunately, Ms. Jaehnig's report was not completed before the Conservation Board voted on the application. (You may also recall that Mr. John Krupa; Co-Chair of the Conservation Board said that had the analysis been provided before the vote, the outcome may have been different.)

It is based upon Mr. Krupa's comment regarding the Jaehnig report that the Planning Board reconsider this application as the approving authority.

There were also several outstanding comments derived from a previously issued Building Permit that need to be addressed at this time, which are restated below:

- A modular block retaining wall which was not on the previously RPRC approved plans, exceeded four feet in height and required a certification by a Licensed Engineer

Attached is a Certification Letter from Michael Risbergs, PE attesting to the construction of the modular block wall. Also note that the installation of the permeable pavement driveway was completed and in compliance with the manufacturer's specifications

- The work completed under the permit exceeded the maximum Gross Land Coverage depicted on the RPRC plans

This application includes the increase in gross land coverage for the previous application and the current application.

- The relocation of two driveway entry piers within the Seymour Place right of way

The current plans reflect the required relocation of the entry piers on Seymour Place (the piers on Sterling Road were previously relocated and are reflected on the current site plans.

Review Comments from the Town Engineer and Town Planner relative to the current application include:

- An expanded Variance from the Zoning Board of Appeals to allow for the construction of the pool and patio

It would be the applicant's request that the matter be referred to the Zoning Board of Appeals at the earliest opportunity.

- Soil Testing for the proposed stormwater mitigation requirements.

This office has recently been advised that under the previous application (prepared by others) required that five (5) Cultec Model #360 XLHD be installed. The applicant advises that the units are on the north side of the house and in close proximity to the proposed pool site. As shown on the attached site plans, one additional unit is shown to be attached to the existing units. The combined volume is sufficient for winterization (and pool backwash activities). The applicant will defer to the Town Engineer if this alternative meets the intent of the Town Code.

- Verification that the Westchester County Department of Health issued a wetland permit for the new septic system.

A permit was issued by the Westchester County Department of Health in 2021 and has expired. The permit is considered a "Remediation Permit". As the septic system lies between the access into the property and the proposed pool, the replacement of the septic system will follow or take place in conjunction with the construction of the proposed swimming pool. It is also acknowledged that the WCDH has recently issued updated its "Rules and Regulations" for the construction of septics and wells. However, in this office's opinion those regulations have no effect on obtaining a renewed permit.

Based upon the above, it is requested that the Planning Board schedule a public hearing on the proposed wetland permit application at this time, or if appropriate, refer the matter to the Zoning Board of Appeals for consideration.

Very truly yours,

Nathaniel J. Holt, PE

encl

VICINITY MAP
1" = 2,000'±

PROPERTY DATA

1. PROPERTY OWNER: HUGH HARRIS
9 STERLING ROAD N
ARMONK, NEW YORK 10504

2. TAX MAP DESIGNATION: 108.02-1-58

3. ZONING DISTRICT R-2A SINGLE FAMILY RESIDENTIAL 2 ACRE

GENERAL NOTES

1. SITE TOPOGRAPHY FROM A SURVEY PREPARED BY STEPHEN HOPPE, LS DATED FEBRUARY 28, 2018. SURVEY UPDATED BY TC MERRITTS ENTITLED "TOPOGRAPHIC SURVEY PREPARED FOR HUGH AND VIOLETTA HARRIS" DATED AUGUST 20, 2019.
2. EROSION CONTROLS MUST BE PROPERLY INSTALLED, MAINTAINED AND INSPECTED AROUND THE WORK SITE.
4. CONSTRUCTION ENTRANCES MUST BE PROPERLY MAINTAINED SO THAT NO DEBRIS OR DIRT IS DEPOSITED ON THE STREET.
5. EXPOSED AREAS MUST BE STABILIZED AS SOON AS LAND ALTERATIONS ARE COMPLETED.
6. ANY UNDERGROUND PIPING OR STRUCTURES MUST BE INSPECTED PRIOR TO BACKFILLING
7. 24 HOUR NOTICE IS REQUIRED FOR ANY INSPECTION.
8. PRIOR TO THE START OF ANY EXCAVATION OPERATIONS THE CONTRACTOR SHALL CALL "DIG SAFELY NEW YORK" AT 1-800-962-7962 OR 811.9. WETLANDS ASSOCIATED WITH PARCEL 108.02-1-57 FROM TC MERRITTS RECORD SURVEY.
10. ADDITIONAL WETLAND INFORMATION BASED UPON A SKETCH PREPARED BY EVANS ASSOCIATES.
11. PRIOR TO THE START OF CONSTRUCTION, THE LIMIT OF DISTURBANCE LINE SHALL BE FIELD STAKED AND REVIEWED/APPROVED BY THE TOWN CONSULTING ENGINEERS.

490 x — EXISTING SPOT GRADE
PROPERTY LINE
TP 1 — DEEP TEST PIT
TREE TO BE REMOVED
490 — EXIST CONTOUR
PROP CONTOUR

GRAPHIC SCALE
20 0 10 20 40 80
(IN FEET)
1 inch = 20 ft.

SHEET: 1 of 5

5- Rev's Revision to Planning Bd	
4- October 10, 2021	2021
Resubmission to Planning Bd	
3- July 26, 2021	
2- Clarified Pool Wall	
1- May 29, 2020	2020
Misc	
Original Date: March 13, 2020	
Project Number: HAR-4	

Nathaniel J. Holt, P.E.
NATHANIEL J. HOLT 049142 LICENSED PROFESSIONAL ENGINEER
Date:

NATHANIEL J. HOLT, P.E.
592 ROUTE 22
PAWLING, NEW YORK 12564
(914) 760-1800

EXISTING CONDITIONS PLAN

PROPOSED IN-GROUND POOL
for
HARRIS
9 STERLING ROAD NORTH, ARMONK, NY

C:\Data\HEC- Projects_Cad\HARRIS-ARMONK\HARRIS Pool 2022.07\07.dwg, 7/11/2022 5:50:49 PM

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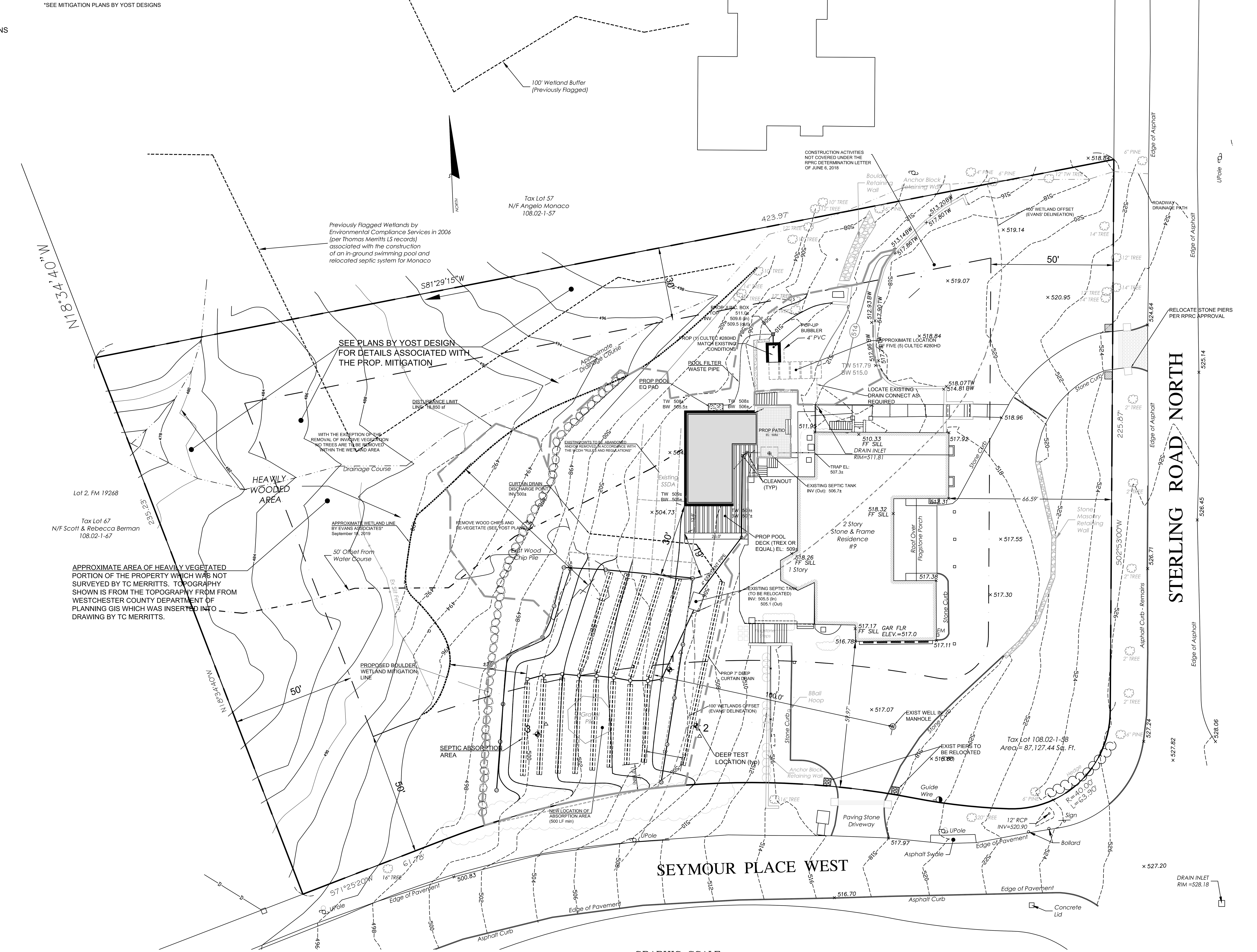
10. ADDITIONAL WETLAND INFORMATION BASED UPON A SITE WALK AND SKETCH PREPARED BY EVANS ASSOCIATES

WETLAND DISTURBANCE MITIGATION*

WETLAND/WETLAND BUFFER DISTURBANCE	REMOVAL of INVASIVES	WETLAND PLANTINGS	REQUIRED (2:1) MITIGATION	PROPOSED MITIGATION
15,193 sf	26,409 sf	6,970 sf	**30,386 sf**	**33,379 sf**

*SEE MITIGATION PLANS BY YOST DESIGNS



LEGEND

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SITE PLAN W/ APPROVED SSDS

PROPOSED IN-GROUND POOL for HARRIS

9 STERLING ROAD NORTH, ARMONK, NY

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1- April 6, 2020 Misc.

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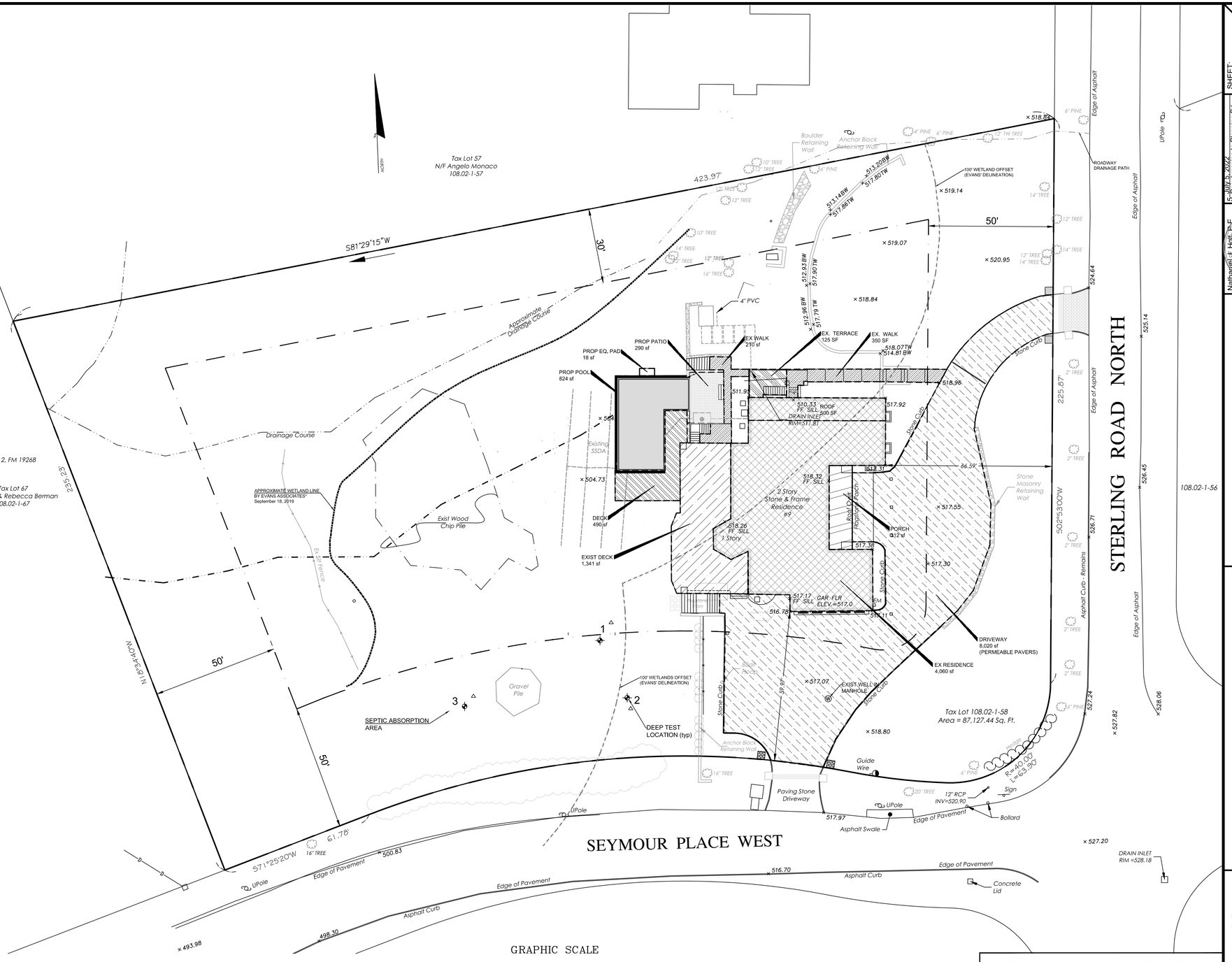
SHEET: 2 of 5

GROSS LAND COVERAGE CALCULATIONS WORKSHEET

APPLICATION NAME: HUGH HARRIS
TAX MAP DESIGNATION: 108.02-1-58

GROSS LOT COVERAGE	APPROVED	EXISTING	PROPOSED
1. TOTAL LOT AREA	87,120 sf		
2. MAXIMUM PERMITTED GROSS LAND COVERAGE	13,270 sf		
3. BONUS MAXIMUM GROSS LAND COVER Distance principal home is beyond minimum front yard setback 16.5 ft x 10 =	165 sf		
4. TOTAL MAXIMUM PERMITTED GROSS LAND COVERAGE	13,435 sf		
5. AMOUNT OF LOT AREA COVERED BY PRINCIPAL BUILDING 4,090 sf (EXISTING) + 0 sf (PROPOSED)	4,060 sf	4,060 sf	4,060 sf
6. AMOUNT OF LOT AREA COVERED BY ACCESSORY BLDGS 0 sf (EXISTING) + 0 sf (PROPOSED)	0 sf	0 sf	0 sf
7. AMOUNT OF LOT AREA COVERED BY DECKS 1,340 sf (EXISTING) + 490 SF (PROPOSED)	1,041 sf	1,340 sf	1,830 sf
8. AMOUNT OF LOT AREA COVERED BY PORCHES 300 sf (EXISTING) + 0 (PROPOSED)	312 sf	312 sf	312 sf
9. AMOUNT OF LOT AREA COVERED BY DRIVEWAY, PARKING AREAS AND WALKWAYS 8,545 sf (EXISTING) + 0 (PROPOSED)	7,113 sf	8,580 sf	8,580 sf
10. AMOUNT OF LOT AREA COVERED BY TERRACES/PATIOS 125 sf (EXISTING) + 290 SF (PROPOSED)	278 sf	125 sf	415 sf
11. AMOUNT OF LOT AREA COVERED BY TENNIS COURT, POOL & MECHANICAL EQUIP 0 sf (EXISTING) + 798 SF (PROPOSED)	0 sf	0 sf	784 sf
12. AMOUNT OF LOT AREA COVERED BY ALL OTHER STRUC. 0 sf (ORIGINAL) + 0 SF (PROPOSED)	0 sf	0 sf	0 sf
13. PROPOSED GROSS LAND COVERAGE:Total of Lines 5-12:	12,804 sf	14,417 sf[1]	15,981 sf[2]

[1]VARIANCE OF 982 sf REQUIRED FOR EXISTING CONDITIONS
[2]VARIANCE OF 3,177 sf REQUIRED FOR EXISTING CONDITIONS



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APPROVED BY THE TOWN OF NORTH CASTLE PLANNING BOARD
RESOLUTION DATED: _____

CHRISTOPHER CARTHY, CHAIRMAN
TOWN OF NORTH CASTLE PLANNING BOARD

_____ DATE: _____

ENGINEERING PLANS REVIEWED FOR CONFORMANCE TO THE RESOLUTION:

_____ DATE:_____
JOSEPH M. CERMELE, PE
KELLARD SESSIONS, CONSULTING
CONSULTING TOWN ENGINEERS

SHEET: 3 of 5

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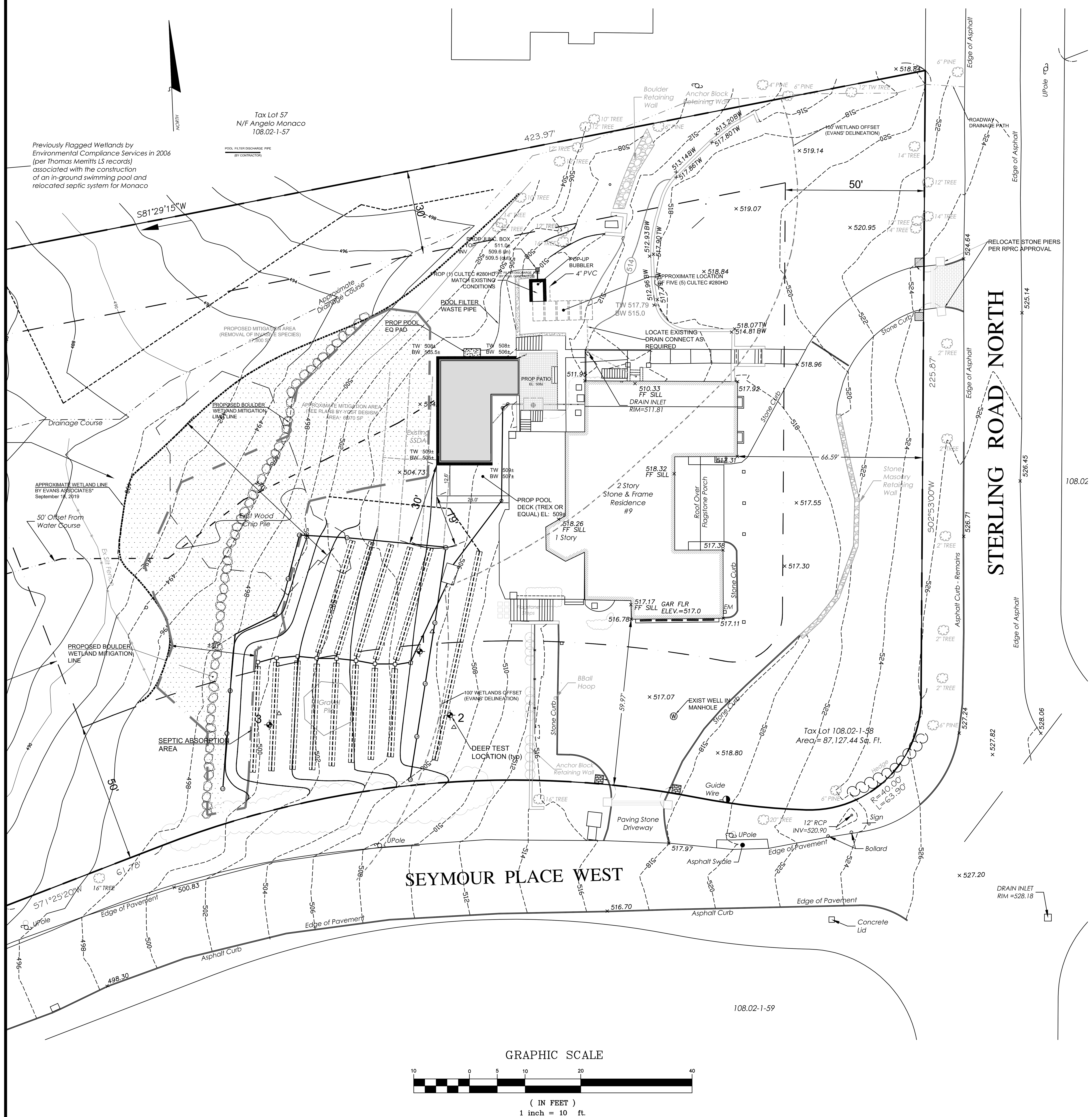
PROPOSED COVERAGE PLAN

PROPOSED IN-GROUND POOL
for
HARRIS
9 STERLING ROAD NORTH, ARMONK, NY



STORMWATER ANALYSIS

REQUIRED: CAPTURE 25 YR STORM EVENT (6")
OVER INCREASE IN IMPERVIOUS AREA

EXISTING CONDITIONS

PROPERTY AREA: 87,120 SF

SOIL TYPE: WdB -WOODBRIDGE

PERVIOUS AREAS (HSG = C/D)

LAWN-POOR (RCN 73) 4,585 sf = 0.11 ac

PROPOSED CONDITIONS

DECK (TREX) (60% IMP)	500 sf = 0.011 ac (0.007 ac Net)
POOL (NOT INCLUDED IN RUNOFF)	765 sf = 0.018 ac
POOL PATIO (PERVIOUS PAVERS)	290 sf = 0.007 ac
LAWN (RCN 75)	3,520 sf = 0.081 ac
TOTAL	4,785 sf = 0.110 ac

RUNOFF CURVE NUMBER

DECK	0.007 ac x 98 = 0.686	
LAWN	0.081 ac x 75 = 6.075	
PATIO	0.007 ac x 75 = 0.525	
	0.095	7.29 = 76.8, **SAY 76.7 say 77**

RUNOFF VOLUME

THE INCREASE IN RUNOFF VOLUME DUE TO THE INCREASE IN IMPERVIOUS AREA IS:

(3.67" - 3.3") / 12 x 4,585 sf = **141 cf**

WINTERIZATION DRAWDOWN

POOL VOLUME: 765 sf x 0.5ft = 382.5 cf

POOL DRAWDOWN VOLUME CONTROLS

THERE ARE 5 CULTEC MODEL #280 HD INSTALLED UNDER THE PREVIOUS SITE PLAN APPROVED BY THE RPRC. TO ADDRESS THE POOL WINTERIZATION, AN ADDITIONAL CULTEC 280 HD IS PROPOSED.

PROPOSED MITIGATION

ONE CULTEC UNIT (MODEL 330XLHD) HAS THE CAPACITY OF 11.32 cf/ft. THEREFORE:

382.5 cf /11.32 cf/lf = 33.8 lf = 5 Units;

VOLUME PROVIDED: 440 cf

**NO ALLOWANCE TAKEN FOR PERCOLATION, UPON TESTING, THE DESIGN WILL BE MODIFIED AS MAY BE NECESSARY

AS NOTED ABOVE, THE TREX DECK AND POOL PATIO WILL RESULT IN AN INCREASE IN IMPERVIOUS AREA THAT REQUIRES MITIGATION. HOWEVER, TOPOGRAPHICALLY, IT IS NOT POSSIBLE TO PROVIDE GRAVITY FLOW FROM THE PATIO AREA TO THE INFILTRATION SYSTEM.

ALTERNATIVE CONSIDERATION

APPARENTLY, SOME FORM OF MITIGATION WAS PROVIDED FOR THE RECENTLY COMPLETED RENOVATIONS TO THE RESIDENCE. AS REPORTED BY THE APPLICANT/OWNER, APPROXIMATELY 8,000 SF OF THE EXISTING ASPHALTIC DRIVEWAY WAS REMOVED AND REPLACED BY PERMEABLE PAVERS.

FOR THE PURPOSE OF THIS ANALYSIS A CONSERVATIVE RCN VALUE OF 88 HAS BEEN ASSIGNED TO THE PERMEABLE PAVERS VARIES. THE RESULTING REDUCTION IN RUNOFF ASSOCIATED WITH THE 25 YEAR STORM EVENT IS ILLUSTRATED BELOW:

ASPHALT (CN 98): 6.2" (4133 CF OF RUNOFF DURING THE 25 YEAR EVENT)

PERMEABLE PAVER (88): 5.1" (3,400 CF OF RUNOFF DURING THE 25 YEAR EVENT)

RUNOFF VOLUME REDUCTION: 733 CF

BY COMPARISON: THE PROPOSED POOL AND PATIO AREAS "CREATE" 141 CF OF ADDITIONAL RUNOFF. THEREFORE BY REPLACING THE EXISTING PAVED DRIVEWAY PROVIDED 5 TIMES THE REQUIRED AMOUNT OF MITIGATION

APPROVED BY THE TOWN OF NORTH CASTLE PLANNING BOARD
RESOLUTION DATED: ____________________

CHRISTOPHER CARTHY, CHAIRMAN
TOWN OF NORTH CASTLE PLANNING BOARD

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STATE OF NEW YORK · NATHANIEL HOLT · 074128 · LICENSED PROFESSIONAL ENGINEER
Date: ______

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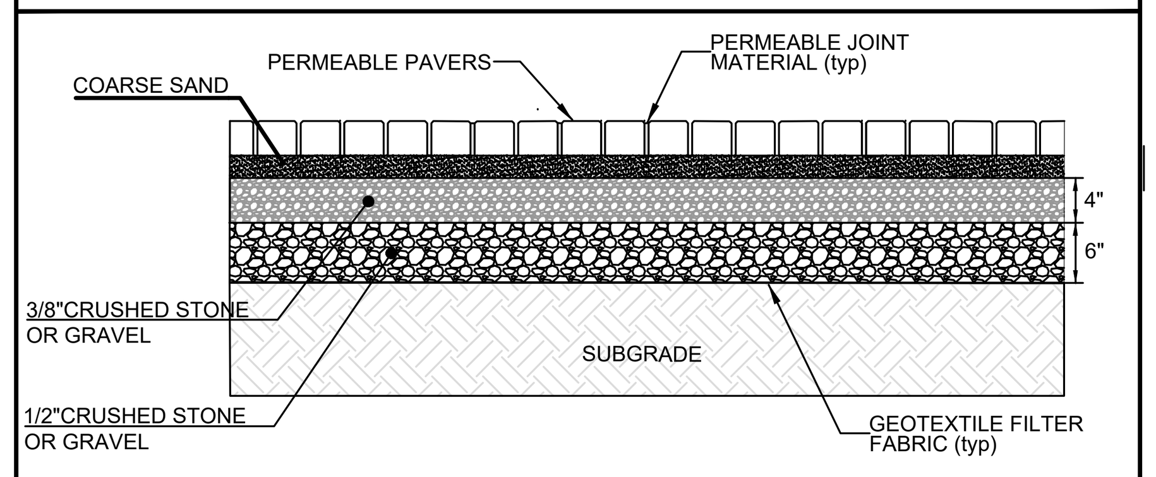
STORMWATER MITIGATION PLAN

PROPOSED IN-GROUND POOL for HARRIS
9 STERLING ROAD NORTH, ARMONK, NY

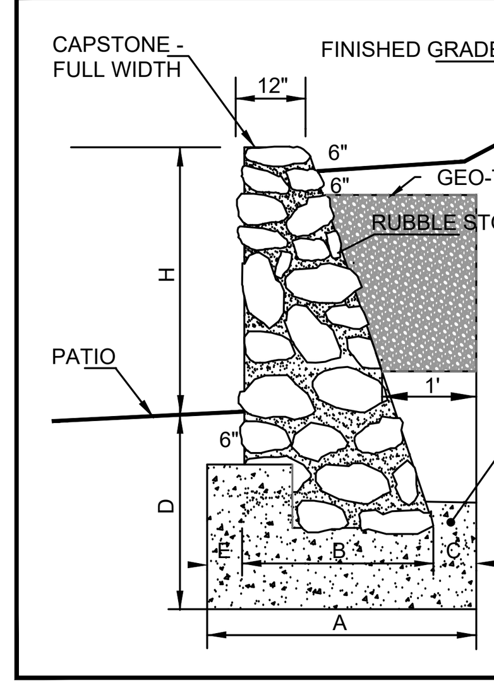
PERMEABLE PAVERS
N.T.S.



NOTES:

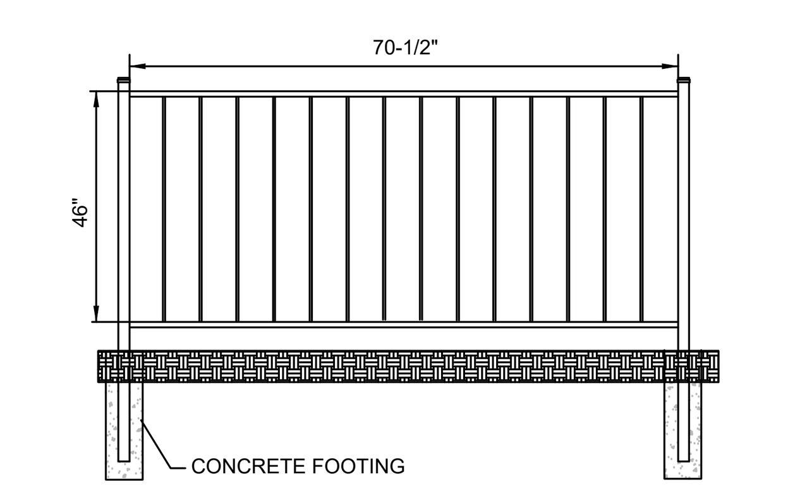
1. PERMEABLE PAVERS TO BE BELGARD OR APPROVED EQUAL.
2. INSTALLATION OF PAVERS TO BE IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS.

RUBBLE STONE WALL DETAIL
N.T.S.



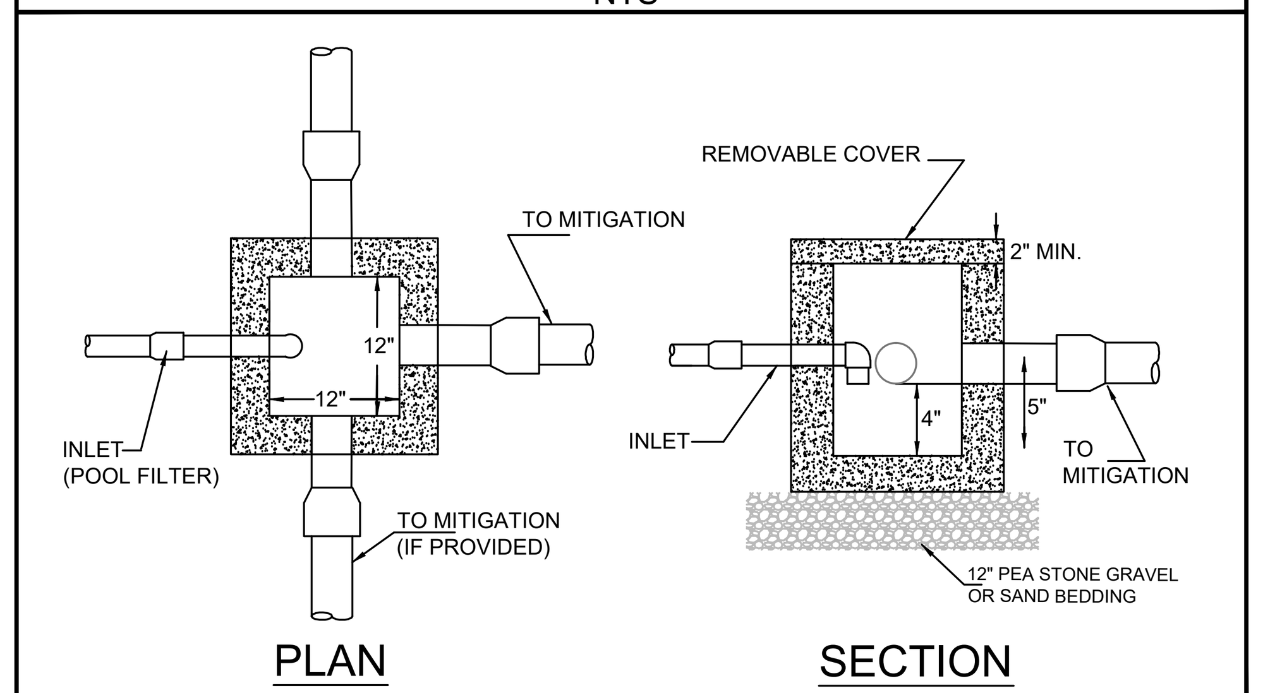
H(ft)	A	B	C	D	E
1	1'-0"	1'-5"	4"	2'-0"	3"
2	2'-3"	1'-8"	4"	2'-0"	3"
3	2'-8"	1'-10"	7"	3'-0"	3"
4	3'-0"	2'-2"	7"	3'-0"	3"

ALUMINIUM POOL FENCE (ALTERNATE)
NTS

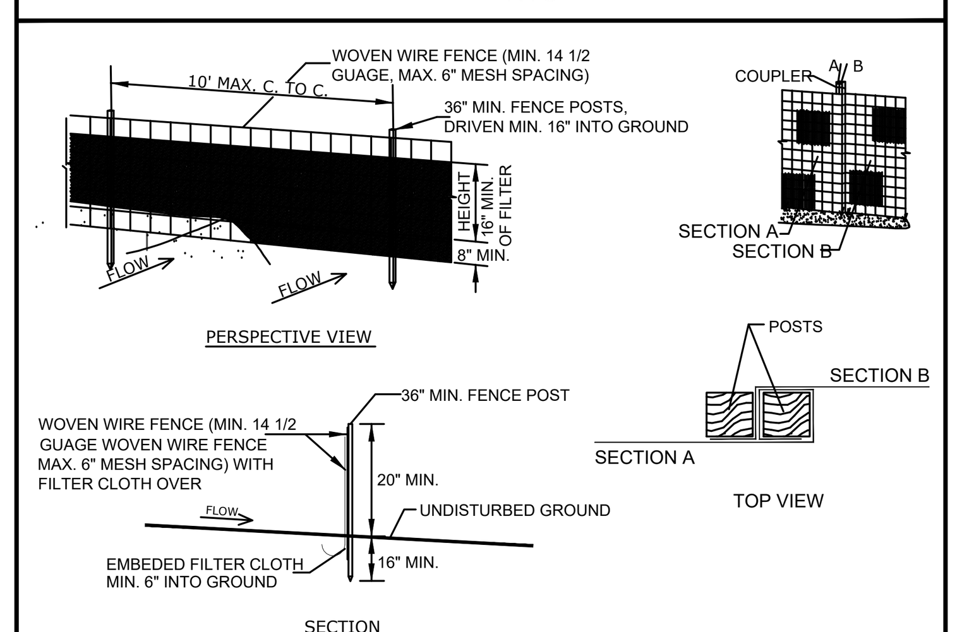


1. FENCE TO BE OVATION MODEL AS MANUFACTURED BY JERITH MANUFACTURING, CO OR EQUAL
2. COLOR TO BE BLACK
3. DEPTH OF FOOTING TO BE AT FROST LINE
4. FENCE AND GATE(S) SHALL COMPLY WITH ALL APPLICABLE NYS BUILDING CODE REQUIREMENTS

JUNCTION BOX DETAIL
NTS



SILT FENCE DETAIL
NTS



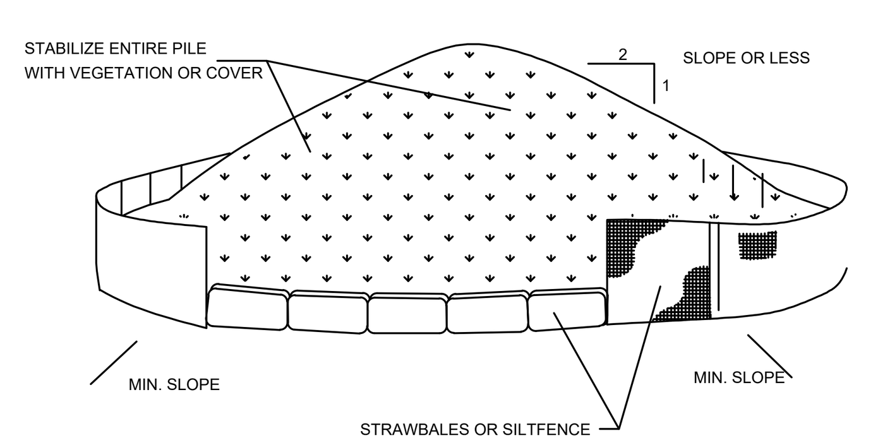
CONSTRUCTION NOTES FOR FABRICATED SILT FENCE

1. WOVEN WIRE FENCE TO BE SECURELY FASTENED TO FENCE POSTS WITH WIRE TIES OR STAPLES.
2. FILTER CLOTH TO BE SECURELY FASTENED TO WOVEN WIRE FENCE WITH TIES SPACES EVERY 24" AT TOP OF MID SECTION
3. WHEN TWO SECTIONS OF FILTER CLOTH JOIN EACH OTHER THEY SHALL BE OVERLAPPED BY SIX INCHES AND FOLDED UNDER.
4. MAINTENANCE SHALL BE PERFORMED AS NEEDED AND ACCUMULATED DEBRIS REMOVED WHEN "BULGES" DEVELOP IN THE FENCE

JOINING SECTIONS OF FENCING

POSTS: STEEL EITHER "T" OR "U" TYPE OR 2" HARDWOOD
FENCE: WOVEN WIRE, 14 1/2 GA. 6" MAX. MESH OPENING
FILTER CLOTH: FILTER X, MARAFI 100X, STABILINKA T140N OR APPROVED EQUAL.
PREFABRICATED UNIT: GEOFAB, ENVIROFENCE, OR APPROVED EQUAL.

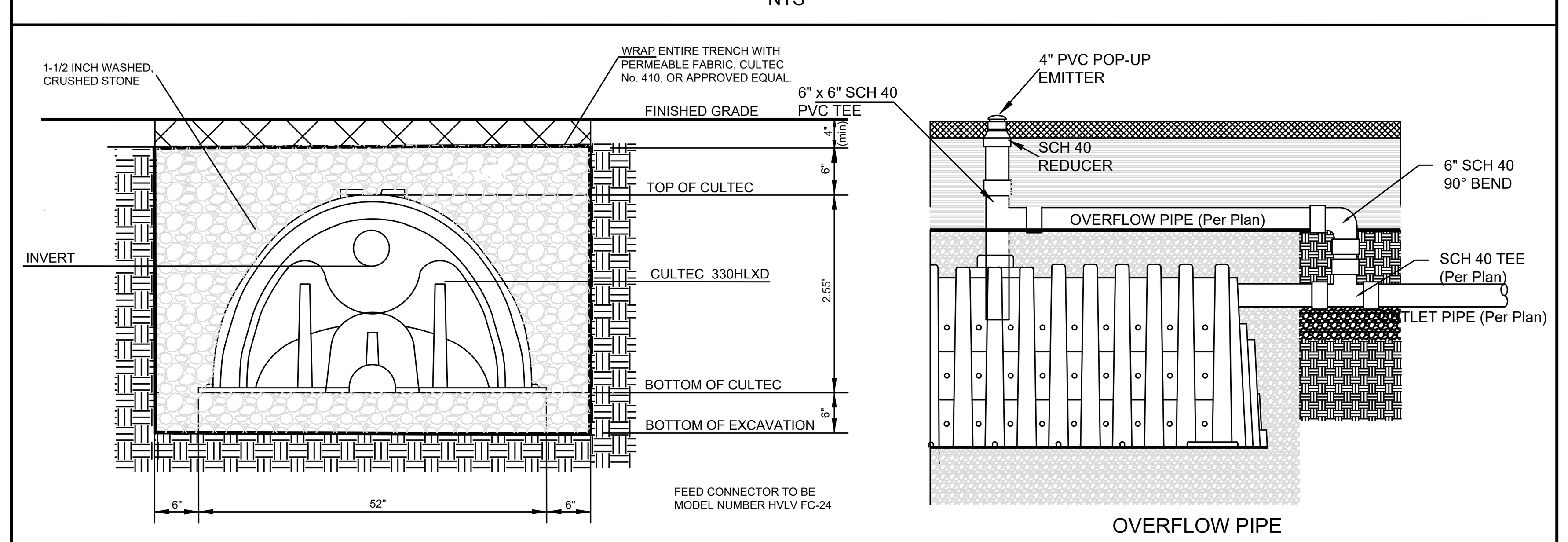
SOIL STOCKPILING DETAIL
NTS

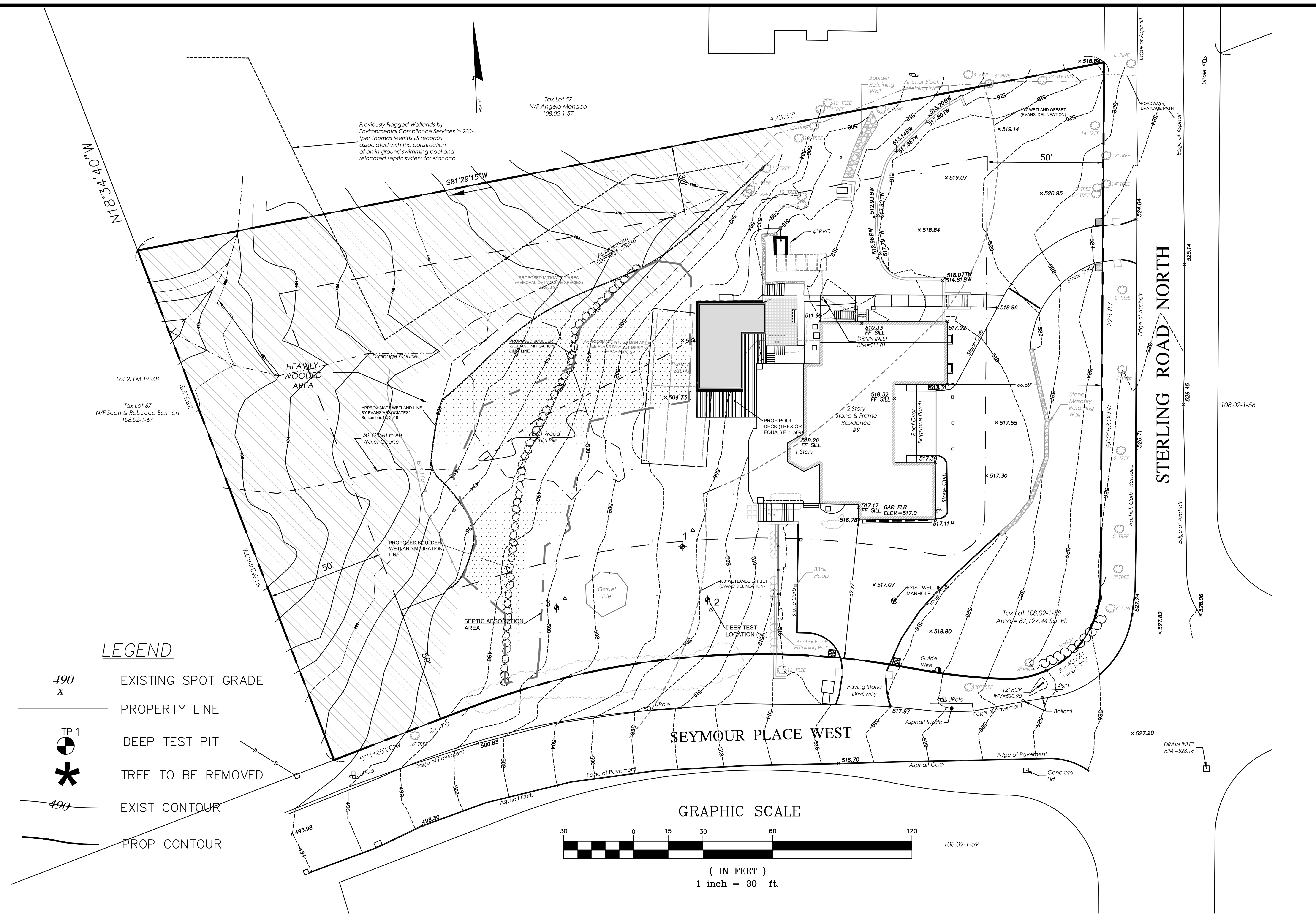


NOTES

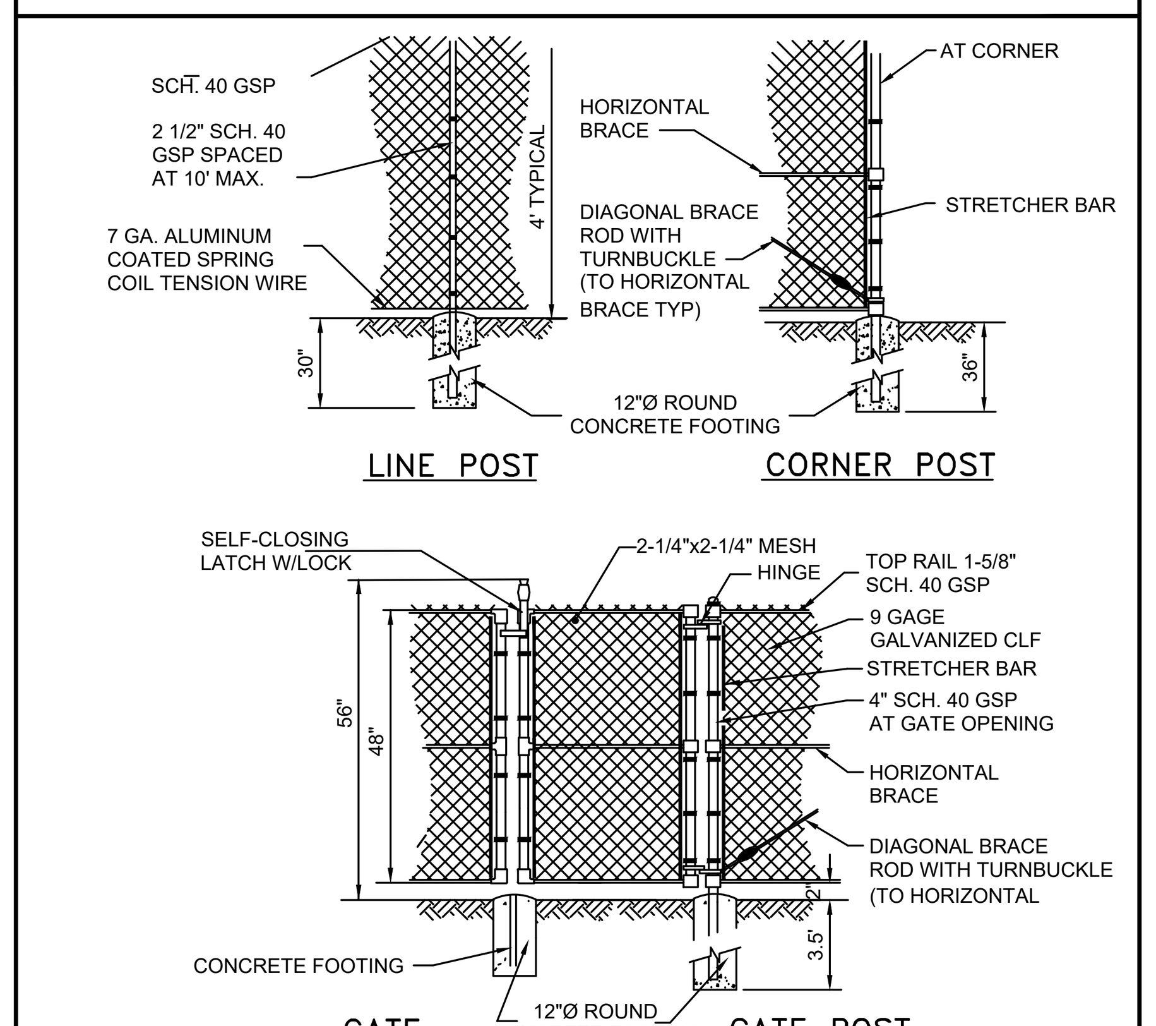
1. AREA CHOSEN FOR STOCKPILING OPERATIONS SHALL BE DRY AND STABLE.
2. MAXIMUM SLOPE OF STOCKPILE SHALL BE 1:2.
3. UPON COMPLETION OF SOIL STOCKPILING, EACH PILE SHALL BE SURROUNDED WITH EITHER SILT FENCING OR STRAWBALES, THEN STABILIZED WITH VEGETATION OR COVERED.
4. SOIL STOCKPILES SHALL BE LOCATED A MINIMUM OF 100' FROM WETLANDS AND WATERCOURSES.

INFILTRATION UNIT
NTS





CHAIN LINK FENCE DETAIL



NOTES:

1. GALVANIZED STEEL WOVEN WIRE FABRIC SHALL BE STRETCHED TAUT WITH STRETCHER BARS AND STRAPS. FASTENED TOP & BOTTOM AT LINE POSTS WITH GALVANIZED PIG RING TIES.
2. FENCE TO BE MINIMUM HEIGHT OF 48".
2. THE GATE(S) SHALL BE SELF CLOSING.
3. ALL MATERIAL SHALL BE BLACK IN COLOR.
4. FENCE AND GATE SHALL COMPLY WITH ALL APPLICABLE NYS BUILDING CODE REQUIREMENTS AND SPECIFICALLY SECTION R326.4.2 OF THE 2020 RESIDENTIAL CODE OF NEW YORK STATE

APPROVED BY THE TOWN OF NORTH CASTLE PLANNING BOARD
RESOLUTION DATED: ____________________

CHRISTOPHER CARTHY, CHAIRMAN
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WETLAND/WETLAND MITIGATION PLAN

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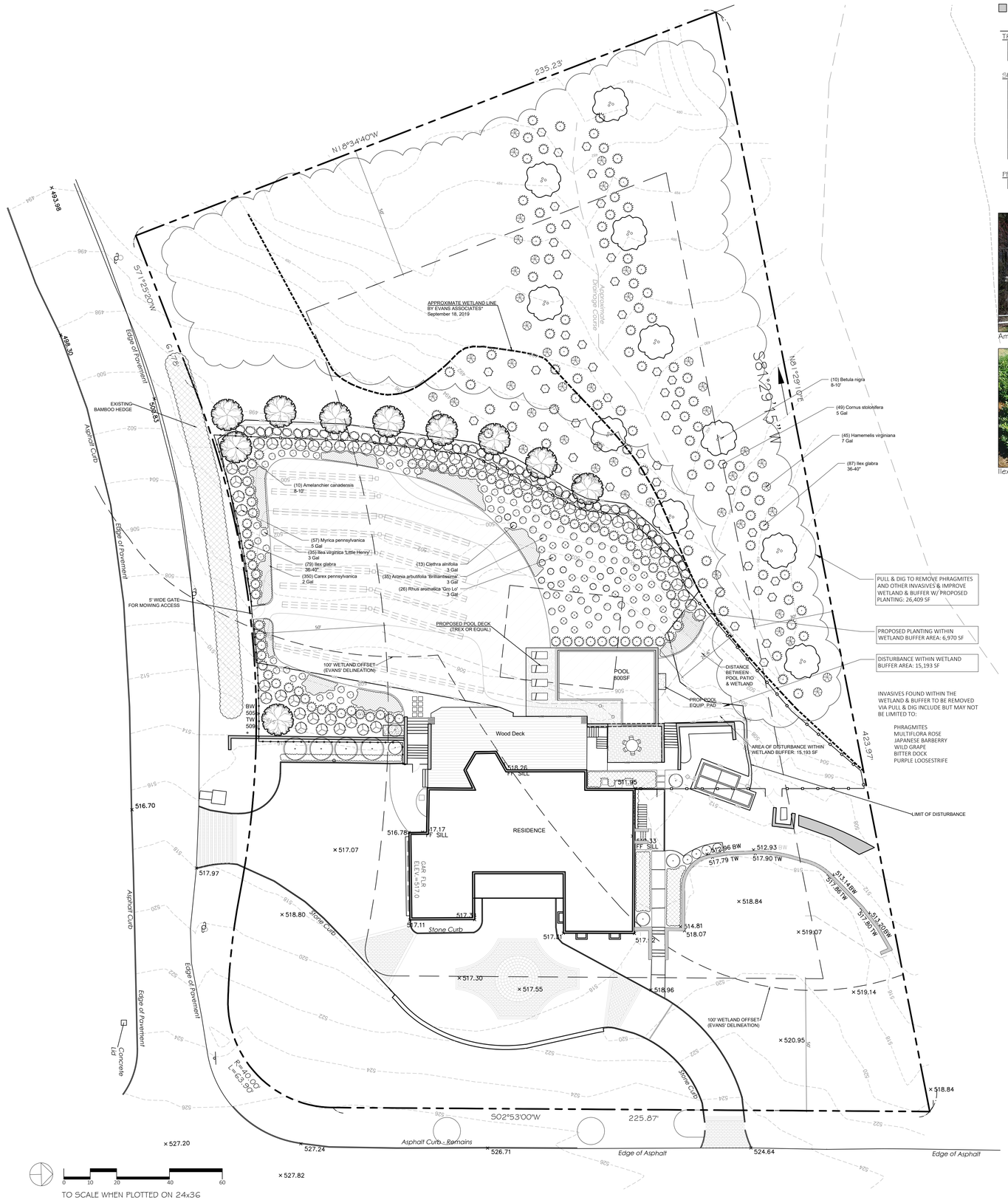


TO SCALE WHEN PLOTTED ON 24x36

PROGRESS SET NOT FOR CONSTRUCTION

PLANTING SCHEDULE

QTY	BOTANICAL NAME	COMMON NAME	SIZE	COMMENTS
TREES				
13	Amelanchier canadensis	Serviceberry	8-10'	
10	Betula nigra	River Birch	8-10'	Container Root
SHRUBS				
35	Aronia arbutifolia 'Brilliantissima'	Red Chokeberry	3 Gallon	
13	Clethra alnifolia	Sweet Pepperbush	3 Gallon	
49	Cornus stolonifera	Red Osier Dogwood	5 Gallon	
45	Hamemelis virginiana	Witch-Hazel	7 Gallon	
166	Ilex glabra	Inkberry	36-40"	
35	Itea virginica 'Little Henry'	Virginia Sweetspire	3 Gallon	
57	Myrica pennsylvanica	Northern Bayberry	5 Gallon	
26	Rhus aromatica 'Gro Lo'	Fragrant Sumac	1 Gallon	
PERENNIALS				
350	Carex pennsylvanica	Pennsylvania Sedge	2 Gallon	18" o.c.

PROPOSED PLANTING IMAGES


Hamemelis virginiana


Itea virginica 'Little Henry'


Amelanchier canadensis


Betula nigra


Rhus armoatica 'Gro Low'


Aronia arbutifolia 'Brilliantissima'


Clethra alnifolia


Ilex glabra


Hamemelis virginiana


Myrica pennsylvanica


Carex pennsylvanica

PLANTING NOTES

1. PLANT MATERIAL SHALL BE FURNISHED AND INSTALLED AS INDICATED; INCLUDING ALL LABOR, MATERIALS, PLANTS, EQUIPMENT, INCIDENTALS, AND CLEAN-UP.

2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PLANTING AT CORRECT GRADES AND ALIGNMENT. LAYOUT TO BE APPROVED BY LA PRIOR TO INSTALLATION.

3. PLANTS SHALL BE TYPICAL OF THEIR SPECIES AND VARIETY; HAVE NORMAL GROWTH HABITS; WELL DEVELOPED BRANCHES, DENSELY FOLIATED, VIGOROUS ROOT SYSTEMS AND BE FREE FROM DEFECTS AND INJURIES.

4. CONTRACTOR SHALL REPORT ANY SOIL OR DRAINAGE CONDITIONS CONSIDERED DETRIMENTAL TO THE GROWTH OF PLANT MATERIAL.

5. ALL PLANT MATERIAL SHALL BE GUARANTEED BY THE CONTRACTOR TO BE IN VIGOROUS GROWING CONDITION. PROVISIONS SHALL BE MADE FOR A GROWTH GUARANTEE OF AT LEAST ONE YEAR FROM THE DATE OF ACCEPTANCE FOR TREES AND SHRUBS. REPLACEMENTS SHALL BE MADE AT THE BEGINNING OF THE FIRST SUCCEEDING PLANTING SEASON. ALL REPLACEMENTS SHALL HAVE A GUARANTEE EQUAL TO THAT STATED ABOVE.

6. INSOFAR AS IT IS PRACTICABLE, PLANT MATERIAL SHALL BE PLANTED ON THE DAY OF DELIVERY. IN THE EVENT THIS IS NOT POSSIBLE, THE CONTRACTOR SHALL PROTECT, IRRIGATE & CARE FOR STOCK NOT PLANTED.

7. QUALITY AND SIZE OF PLANTS, SPREAD OF ROOTS, AND SIZE OF BALLS SHALL BE IN ACCORDANCE WITH ANSI 260 (REV. 1980) "AMERICAN STANDARD FOR NURSERY STOCK" AS PUBLISHED BY THE AMERICAN ASSOCIATION OF NURSERYMEN, INC.

8. ALL PLANTS SHALL BE PLANTED IN AMENDED TOP SOIL THAT IS THOROUGHLY WATERED AND TAMPED AS BACK FILLING PROGRESSES. PLANTING MIX TO BE AS SHOWN ON PLANTING DETAILS. LARGE PLANTING AREAS TO INCORPORATE FERTILIZER AND SOIL CONDITIONERS AS STATED IN PLANTING SPECIFICATIONS.

9. PLANTS SHALL NOT BE BOUND WITH WIRE OR ROPE AT ANY TIME SO AS TO DAMAGE THE BARK OR BREAK BRANCHES. PLANTS SHALL BE HANDLED FROM THE BOTTOM OF THE BALL ONLY.

10. PLANTING OPERATIONS SHALL BE PERFORMED DURING PERIODS WITHIN THE PLANTING SEASON WHEN WEATHER AND SOIL CONDITIONS ARE SUITABLE AND IN ACCORDANCE WITH ACCEPTED LOCAL PRACTICE. PLANTS SHALL NOT BE INSTALLED IN TOPSOIL THAT IS IN A MUDDY OR FROZEN CONDITION.

11. NO PLANT, EXCEPT GROUND COVERS, SHALL BE PLANTED LESS THAN TWO FEET FROM EXISTING STRUCTURES AND SIDEWALKS.

12. SET ALL PLANTS PLUMB AND STRAIGHT. SET AT SUCH LEVEL THAT A NORMAL OR NATURAL RELATIONSHIP TO THE CROWN OF THE PLANT WITH THE GROUND SURFACE WILL BE ESTABLISHED. LOCATE PLANT IN THE CENTER OF THE PIT.

13. ALL INJURED ROOTS SHALL BE PRUNED UTILIZING CLEAN, SHARP TOOLS TO MAKE CLEAN ENDS BEFORE PLANTING.

14. EACH TREE AND SHRUB SHALL BE PRUNED IN ACCORDANCE WITH STANDARD HORTICULTURAL PRACTICE TO PRESERVE NATURAL CHARACTER OF PLANT. PRUNING SHALL BE DONE WITH CLEAN, SHARP TOOLS.

16. ALL PLANTING BEDS SHALL BE MULCHED WITH 2" LAYER OF DOUBLE SHREDDED HARDWOOD BARK MULCH.

17. ALL DISTURBED AREAS AND NEW PLANTING BEDS TO BE TREATED WITH 4" TOP SOIL & SEEDED IN ACCORDANCE WITH PERMANENT STABILIZATION METHODS.

18. NO HERBICIDES SHALL BE USED WITHIN THE WETLAND BUFFER.

19. ALL PLANTS PLANTED WITHIN WETLAND BUFFER ARE TO BE INSTALLED BY HAND.

WETLAND BUFFER DISTURBANCE & IMPROVEMENTS

WETLAND	WETLAND BUFFER AREA ON PROPERTY	LIMIT OF DISTURBANCE AREA	IMPROVEMENTS WITHIN BUFFER
STREAM	**60,371 SF**	LIMIT OF DISTURBANCE WITHIN WETLAND BUFFER: **15,193 SF**	PROPOSED PLANTING WITHIN WETLAND BUFFER AREA: **6,970 SF** PULL & DIG TO REMOVE PHRAGAMITES AND OTHER INVASIVES & IMPROVE WETLAND & WETLAND BUFFER W/ PROPOSED PLANTING: **26,409 SF**
		TOTAL AREA OF IMPROVEMENT REQUIRED FOR 2:1 MITIGATION WITHIN WETLAND BUFFER: **30,386**	TOTAL AREA OF IMPROVEMENT WITHIN WETLAND BUFFER: **33,379 SF**

INVASIVE PLANTS WITHIN WETLAND BUFFER TO BE REMOVED


Phragmites


Japanese Barberry


Multiflora Rose


Wild Grape


Bitter Dock


Purple Loosestrife

YOST DESIGN
LANDSCAPE ARCHITECTURE
178 elizabeth st
pearl river, ny 10965
p 845.365.4595 | f 914.361.4473
yostdesign.com

SURVEYOR:

HARRIS RESIDENCE

9 STERLING ROAD NORTH
ARMONK, NY 10504

DATE: NOVEMBER 4, 2020
DRAWN BY: AVM
JOB NO: 040518
SCALE: 1" =20'
FILENAME: 2022_0706 Harris

REVISIONS:
1 2/22/2020
4/1 2/202 1
5/05/202 1
1 1/1 0/202 1
07/06/2022

REGISTERED LANDSCAPE ARCHITECT
BLYTHE YOST
002369
STATE OF NEW YORK

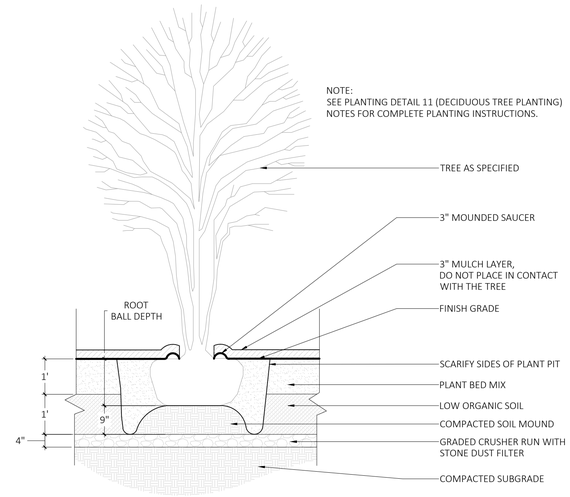
Blythe M Yost ASLA | Registered Landscape Architect
NYS # 002369

MITIGATION/ PLANTING PLAN

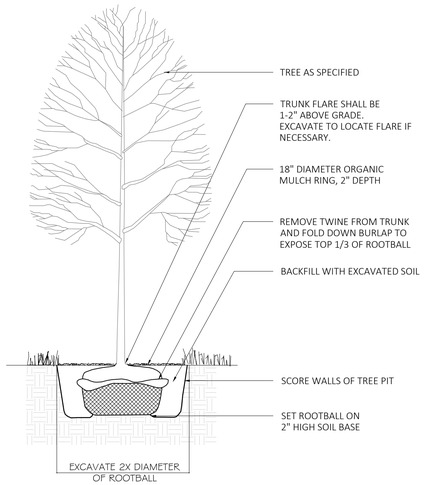
SHEET NO.

L-701

SHEET: 1 of 2



1 L-801 MULTISTEM TREE PLANTING
SCALE: 1/2"=1'



2 L-801 DECIDUOUS TREE PLANTING
SCALE: 1/4"=1'

NOTES:

1. SET TREE PLUMB.

2. DO NOT STAKE UNLESS DIRECTED TO DO SO BY LANDSCAPE ARCHITECT

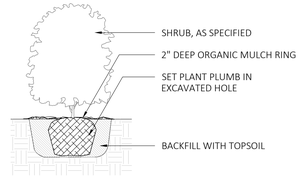
3. REMOVE COMPLETELY ANY NON-BIODEGRADABLE MATERIALS BINDING THE ROOTBALL.

4. REMOVE WIRE BASKET COMPLETELY IF ROOTBALL WILL BARE. OTHERWISE, CLIP AND PEEL BACK WIRE BASKET AT LEAST ONE THIRD OF THE WAY FROM THE TOP OF THE ROOTBALL.

5. SATURATE SOIL WITHIN SIX (6) HOURS OF PLANTING AND WATER AS NECESSARY UNTIL IRRIGATION IS INSTALLED.

6. DO NOT ADD ANY SOIL AMENDMENTS OTHER THAN COMPOST UNLESS DIRECTED TO BY LANDSCAPE ARCHITECT.

7. DO NOT ADD ANY SOIL OR MULCH AGAINST TRUNK OF TREE. IF ROOT FLARE IS NOT EXPOSED, REMOVE SOIL AND EXPOSE.



3 L-801 SHRUB PLANTING
SCALE: 1/2"=1'

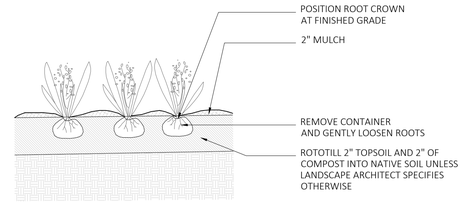
NOTES:

1. FOR B & B PLANT MATERIAL, REMOVE ALL TWINE AND ROLL BACK BURLAP FROM TOP 1/2 OF BALL. IF ANY MATERIALS USED TO BIND THE ROOTBALL ARE NON-BIODEGRADEABLE, REMOVE COMPLETELY INCLUDING WIRE BASKET.

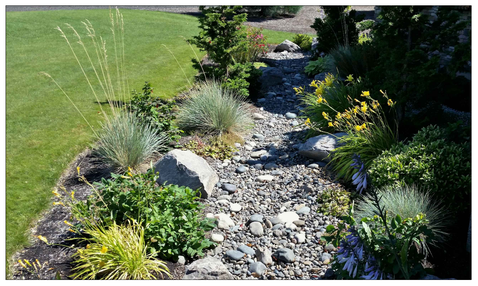
2. FOR CONTAINER GROWN PLANT MATERIAL, REMOVE CONTAINER. TO HELP PREVEN LOOSENING OF SOIL AND SCARIFY BALL TO HELP PREVENT GIRDLING ROOTS.

3. SATURATE SOIL WITHIN SIX (6) HOURS OF PLANTING, AND WATER AS NECESSARY UNTIL IRRIGATION INSTALLED.

4. NO MULCH OR SOIL SHOULD BE PLACED AGAINST THE PLANT'S TRUNK.



4 L-801 GROUNDCOVER PLANTING
SCALE:1/2"=1'



5 L-801 DRY RIVER BED IMAGES
SCALE:

YOST DESIGN
LANDSCAPE ARCHITECTURE
178 elizabeth st
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yostdesign.com
Blythe M Yost ASLA | Registered Landscape Architect

SURVEYOR:

HARRIS RESIDENCE

9 STERLING ROAD NORTH
ARMONK, NY 10504

DATE: NOVEMBER 4, 2020
DRAWN BY: AVM
JOB NO: 040518
SCALE: VARIES
FILENAME: 2022_0706 Harris

REVISIONS:
04/12/2021

Blythe M Yost ASLA | Registered Landscape Architect

DETAILS SHEET

SHEET NO.

L-801

PFIZER – JÄHNIG
ENVIRONMENTAL CONSULTING

September 28, 2021
Wetland Functional Assessment
9 Sterling Road North
Armonk, New York

Setting:
The northwestern portion of the property located at 9 Sterling Road North is a locally regulated wetland as shown by the flagging of Evans Associates on September 18, 2019. The wetland is located on a hillside and is a headwater to a tributary to the Byram River. An intermittent watercourse is contained within the wetland and originates just northwest of the existing dwelling.

The watercourse and wetland is located on the lower flank of a slope that starts near Route 22, approximately 2000 feet to the east and ends 1000 feet to the west as the flow enters the Byram River tributary. The hillside wetland is fed by both subsoil seepage and stormwater runoff from Sterling Road North.

Wetland Description:
The wetland is scrub/shrub (open with a shrub and diverse groundcover) and becomes forested in the southwestern corner and along the northern property line. Minor rills are located on the hillside. The forested wetland supports red maple, ash spp., birch spp., with spicebush, arrowwood vibernum and winterberry in the shrub story. The scrub/shrub portion supports silky dogwood, highbush blueberry, shrub willow, sensitive fern, lurid sedge, foxtail sedge, asters, jewelweed, brambles, blue vervain, and rush spp., and dead trees. Invasive species such as phragmites, multiflora rose, Japanese barberry, wild grape, bitter dock, and purple loosestrife have taken hold on the edges and within the wetland.

17 FAIRVIEW AVE. **RIDGEFIELD, CT 06877** **TEL. (203) 431-8113**
MaryJaehnigSoils@gmail.com

The wetland soil is relatively thin sandy loam and developed in glacial till over bedrock. The moderate slopes result in active changes to surface flow and rill development.

Wetland Buffer Description:
The wetland buffer has been disturbed during earlier site development. Soils have been regraded with areas of compacted fill. The vegetation present is a mix of early colonizer and mostly invasive species as groundcover. The invasive vegetation noted on the disturbed soils include bitter dock, purple loosestrife, goldenrod spp., creeping thistle, wild grape, multiflora rose, and phragmites. The buffer area is open and vulnerable to the spread of the invasive species.

Wetland Functions and Values:
The functional assessment uses 'A Rapid Procedure for Assessing Wetland Functional Capacity' by Dennis W. Magee and Garrett G. Hollands', 1998, based on Hydrogeomorphic (HGM) Classification.

The class for this wetland is a small slope wetland connected downstream to other systems. Features were noted and inventoried in the wetland to determine the value of each function.

1) Modification of Groundwater Discharge.
High Value, due to observed outlet, intersection of water table with topography despite component of stormwater road runoff.

2)Modification of Groundwater Recharge.
Low to no value, lacks capacity for long term storage of water necessary for significant recharge, fast transit time, no underlying glacial stratified drift deposits.

3)Storm and Flood Storage.
Low, Vegetation provides roughness which slows down runoff but water passes relatively quickly through the slope to downstream receiving waters.

4)Modification of Streamflow.
Moderate, the wetland is a source of groundwater discharge as well as surface runoff to downstream systems and helps provide stable base flow during dry times.

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5)Modification of Water Quality.
Low, residence time is low, long term storage is low, modification to water by physical and chemical treatment of solids is therefore low.

6)Export of Detritus.
Moderate, the wetland flushes detritus due to short residence time. This function is modified lower due to small size and moderate vegetation density.

7)Contribution to Abundance and Diversity of Wetland Vegetation.
Low, due to unpredictable hydrology, small size, introduction of invasives.

8)Contribution to Abundance and Diversity of Wetland Fauna.
Low, lack of open water, disturbed buffer plant community, lack of predictable hydrology.

Conclusions:
The highest values of the wetland involve discharge of groundwater to the surface and regulation of the base line flow of downstream watercourses. Export of detritus is also high and the detritus produced and carried downstream provides nutrients to benthic communities off site.

The degradation of the buffer and resulting invasive species with lack of shrub and tree layers is hurting the values for wetland flora and fauna. The compacted buffer fill also adds additional runoff to the wetland. Untreated road runoff enters the wetland during storm events.

A comprehensive planting plan to introduce native species in tree, shrub and ground layers would enhance the wildlife potential of both buffer and wetland, slow velocity of surface runoff to lessen erosion in the wetland and buffer. A restoration planting plan should include removal of some invasives, particularly the phragmites, in the buffer and wetland.

Submitted by,

Mary Jaehnig

soil scientist

17 FAIRVIEW AVE. **RIDGEFIELD, CT 06877** **TEL. (203) 431-8113**
MaryJaehnigSoils@gmail.com

Project Information

Harris Residence
9 Sterling Rd N
Armonk, NY 10504

CLIENT INFORMATION

Hugh Harris
Homeowner
9 Sterling Rd N
Armonk, NY 10504
(347) 621-2627

CONSULTANT INFORMATION

Michael Risbergs
Director of Inspections

OFFICE: 212–519–7521
DIRECT: 718-790-9089

EMAIL:
MRISBERGS@METROSPECNYC.COM

STATE OF LISCENSURE

- **NEW YORK (NY)**
- NEW JERSEY (NJ)
- CONNECTICUT (CT)

METROSPEC ARCHITECTURE & ENGINEERING

Michael Risbergs, PE
Technical Director of Engineering & Inspections

May 25, 2022

Issued to:

Town of North Castle Buildings Department, New York State

Issued on behalf of:

Mr. Hugh Harris
Homeowner
9 Sterling Rd N
Armonk, NY 10504

RE: Paver Specifications and Retaining Wall Installation

To whom it may concern,

I, Michael Risbergs, certify that to the best of my knowledge and professional judgment all work pertaining to a) permeability specifications of the Cambridge Paving Stone system and b) the construction of the curved retaining wall adjacent to the driveway, substantially conforms to approved construction documents and is in accordance with applicable provisions of the New York State Construction Codes and provisions of such codes adopted by the Town of North Castle.

Attachments:
Cambridge Paving Stone System.
ICPI Technical Specifications.
Progress inspection photo of the retaining wall.

We trust the above meets with your approval. If you have any questions, or need additional information, please do not hesitate to call us.

Respectfully Yours,

Michael Risbergs, PE
Technical Director of Engineering & Inspections
METROSPEC SPECIAL INSPECTION AGENCY
16 WEST 56TH STREET – 5TH FLOOR
NEW YORK, NY 10019

PROJECT: Harris Residence
LOCATION: 9 Sterling Rd N, Armonk NY
CLIENT: Hugh Harris

Tech Spec 9

icpi
Interlocking Concrete Pavement Institute

Guide Specification for the Construction of Interlocking Concrete Pavement

SECTION 32 14 13.13
INTERLOCKING CONCRETE PAVERS

Note: This guide specification for manually installed concrete paver applications in the U.S. and Canada. Contact ICPI for current information and guide specifications for mechanical installation. This document should be edited to fit project conditions and location. Brackets [ ] indicate text for editing. Notes are provided on the use of a compacted aggregate base under the bedding sand and pavers. Other bases can be used such as cement or asphalt-treated aggregate, concrete or asphalt, as well as other setting materials. The user should refer to Interlocking Concrete Pavement Institute (ICPI) Details & Specifications for Interlocking Concrete Pavement at www.icpi.org for various guide specifications and detail drawings. This Section includes the term "Architect." Edit this term as necessary to identify the design professional in the General Conditions of the Contract. Coordinate all Sections with the General Conditions as well.

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Interlocking Concrete Paver Units (manually installed).
   2. Bedding and Joint Sand.
   3. Edge Restraints.

B. Related Sections:
   1. Section: [ ]-Curbs and Drains.
   2. Section: [ ]-Aggregate Base.
   3. Section: [ ]-Cement Treated Base.
   4. Section: [ ]-Asphalt Treated Base.
   5. Section: [ ]-Pavements, Asphalt and Concrete.
   6. Section: [ ]-Roofing Materials.
   7. Section: [ ]-Geotextiles.

Note: Pavements subject to vehicles should be designed in consultation with a qualified civil engineer, in accordance with ASCE 58-10 *Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways*, ICPI Interlocking Concrete Pavement Structural Design Program software, and in accordance with the ICPI Tech Spec technical bulletins. Use the current year reference. Edit ASTM and CSA references below and throughout this Section according to project location.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. ASTM C 33, Standard Specification for Concrete Aggregates.
   2. ASTM C 136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   3. ASTM C 140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   4. ASTM C 144, Standard Specification for Aggregate for Masonry Mortar.
   5. ASTM C 936, Standard Specification for Solid Concrete Interlocking Paving Units.
   6. ASTM C 979, Pigments for Integrally Colored Concrete.
   7. ASTM D 698, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,000 ft-lbf/ft^3 (600 kN-m/m ^{3})).
   8. ASTM D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   9. ASTM D 2940, Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.

B. Canadian Standards Association (CSA):
   1. A231.2, Precast Concrete Pavers.
   2. A23.2A, Sieve Analysis of Fine and Coarse Aggregates.
   3. A23.1-FA1, Concrete Materials and Methods of Concrete Construction.
   4. A179, Mortar and Grout for Unit Masonry.

C. Interlocking Concrete Pavement Institute (ICPI):
   1. ICPI *Tech Spec* technical bulletins.

D. American Society of Civil Engineers (ASCE)
   1. 58-10 Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways

1.03 SUBMITTALS

A. In accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.

B. Manufacturer's drawings and details: Indicate perimeter conditions, relationship to adjoining materials and assemblies, [expansion and control joints,] concrete paver [layout,] [patterns,] [color arrangement,] installation [and setting] details.

C. Sieve analysis per [ASTM C 136][CSA A23.2A] for grading of bedding and joint sand.

D. Concrete pavers:
   1. [Four] representative full-size samples of each paver type, thickness, color, finish that indicate the range of color variation and texture expected in the finished installation. Color(s) selected by [Architect] [Engineer] [Landscape Architect] [Owner] from manufacturer's available colors.
   2. Accepted samples become the standard of acceptance for the work.
   3. Test results from an independent testing laboratory for compliance of paving unit requirements to [ASTM C 936][CSA A231.2].
   4. Manufacturer's catalog product data, installation instructions, and material safety data sheets for the safe handling of the specified materials and products.

E. Paver Installation Subcontractor:
   1. A copy of Subcontractor's current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.

Note: ICPI certifies that installers have passed an exam on installation knowledge and does not certify or guarantee the quality of installation. Job references should be carefully reviewed and verified to assist in identifying competent contractors.

   2. Job references from projects of a similar size and complexity. Provide Owner/Client/General Contractor names and phone numbers.

1.04 QUALITY ASSURANCE

A. Paving Subcontractor Qualifications:
   1. Utilize an installer having successfully completed concrete paver installation similar in design, material, and extent indicated on this project.

2. Utilize an installer holding a current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.

B. Regulatory Requirements and Approvals: [Specify applicable licensing, bonding or other requirements of regulatory agencies.].

C. Mock-Ups:

Note: A site visit and approval by the owner's representative during the first day of paving may substitute for a mock-up.

1. Install a 7 ft x 7 ft (2 x 2 m) paver area.
2. Use this area to determine surcharge of the bedding sand layer, joint sizes, lines, laying pattern(s), color(s) and texture of the job.
3. Evaluate the need for protective pads when compacting paving units with architectural finishes.
4. This area will be used as the standard by which the work will be judged.
5. Subject to acceptance by owner, mock-up may be retained as part of finished work.
6. If mock-up is not retained, remove and properly dispose of mock-up.

1.05 DELIVERY, STORAGE & HANDLING

A. General: Comply with Division 1 Product Requirement Section.

B. Refer to manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

C. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers packaging with identification labels intact.
1. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.
2. Deliver concrete pavers to the site in steel banded, plastic banded or plastic wrapped packaging capable of transfer by fork lift or clamp lift.
3. Unload pavers at job site in such a manner that no damage occurs to the product.

D. Storage and Protection: Store materials protected such that they are kept free from mud, dirt, and other foreign materials. [Store concrete paver cleaners and sealers per manufacturer's instructions.]

1.06 PROJECT/SITE CONDITIONS

A. Environmental Requirements:
1. Do not install sand or pavers during heavy rain or snowfall.
2. Do not install sand and pavers over frozen base materials.
3. Do not install frozen sand or saturated sand.
4. Do not install concrete pavers on frozen or saturated sand.

1.07 MAINTENANCE

A. Extra Materials: Provide [Specify area] [Specify percentage] additional material for use by owner for maintenance and repair.

PART 2 PRODUCTS

2.01 INTERLOCKING CONCRETE PAVERS

Note: In addition to ASTM or CSA conformance, ASCE 58-10 recommends a maximum 3:1 aspect ratio (length ÷ thickness) and a minimum $3^1/_8$ in. (80 mm) thickness for vehicular applications. Residential driveways should use a minimum $2^3/_8$ in. (60 mm) thick units with a maximum 4:1 aspect ratio.

A. Manufacturer: [Specify ICPI member manufacturer name.].
1. Contact: [Specify ICPI member manufacturer contact information.].

B. Interlocking Concrete Paver Units, including the following:
1. Paver Type: [Specify name of product group, family, series, etc.].
a. Material Standard: Comply with material standards set forth in [ASTM C 936][CSA A231.2].
b. Color [and finish]: [Specify color.] [Specify finish].
c. Color Pigment Material Standard: Comply with ASTM C 979.

Note: Concrete pavers may have spacer bars on each unit. Spacer bars are recommended for mechanically installed pavers and for those in heavy vehicular traffic. Manually installed pavers may be installed with or without spacer bars. Verify with manufacturers that overall dimensions do not include spacer bars.

d. Size: [Specify.] inches [({Specify.}mm)] x [Specify.] inches [({Specify}mm)] x [Specify.] inches [({Specify.} mm)] thick.

Note: For ASTM C 936 use the following material characteristics:

e. Average Compressive Strength: 8,000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa).
f. Average Water Absorption (ASTM C 140): 5% with no unit greater than 7%.
g. Freeze/Thaw Resistance (ASTM C 1645): Resistant to 50 freeze-thaw cycles while immersed in water or a 3% saline solution (depending on conditions during service life) with no greater mass lost than 225 g/m^2 of surface area after 28 cycles, or 500 g/m2 after 49 cycles. Freeze-thaw testing requirements shall be waived for applications not exposed to freezing conditions.

Note: For CSA A231.2 use the following material characteristics:

h. Minimum average cube compressive strength of 7,250 psi (50 MPa) for laboratory cured specimens or 5,800 psi (40 MPa) for unconditioned field samples.
i. Resistance to 28 freeze-thaw cycles while immersed in a 3% saline solution with no greater mass lost than 225 g/m^2 of surface area after 28 years, or 500 g/m^2 after 49 cycles.

2.02 PRODUCT SUBSTITUTIONS

A. Interlocking concrete pavers: as specified or approved equal.

2.03 BEDDING AND JOINT SAND

A. Provide bedding and joint sand as follows:
1. Clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.
2. Do not use stone dust.
3. Do not use limestone screenings or sand for the bedding that does not conform to the grading requirements of [ASTM C 33][CSA A23.1-FA1].
4. Do not use mason sand, or sand conforming to [ASTM C 144][CSA A179] for the bedding sand.

Note: If the pavement will be exposed to heavy traffic with trucks, i.e., a major thoroughfare with greater than 1.5 million 18-Kip (80 kN) equivalent single axle loads, see *ICPI Tech Spec 17–Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications* for test methods and criteria for assessing bedding sand durability. Limestone screenings will typically not meet the durability requirements outlined in *Tech Spec 17*. However, there are some granite materials that can meet these requirements. *Tech Spec 17* recommends using concrete sand as a first preference.

4. Where concrete pavers are subject to vehicular traffic, utilize sands that are as hard as practically available.

Table 1. Grading Requirements for Bedding Sand

Gradation for Bedding Sand			
ASTM C33		CSA A23.1 FA1	
Sieve Size	Percent Passing	Sieve Size	Percent Passing
3/8 in.(9.5 mm)	100	10.0 mm	100
No. 4 (4.75 mm)	95 to 100	5.0 mm	95 to 100
No. 8 (2.36 mm)	80 to 100	2.5 mm	80 to 100
No. 16 (1.18 mm)	50 to 85	1.25 mm	50 to 90
No. 30 (0.6 mm)	25 to 60	630 µm	25 to 65
No. 50 (0.3 mm)	5 to 30	315 µm	10 to 35
No. 100 (0.15 mm)	0 to 10	160 µm	2 to 10
No. 200 (0.075 mm)	0 to 1	80 µm	0 to 1

Note: Bedding sands should conform to ASTM C33 or CSA A23.1 FA1 gradations for concrete sand. For ASTM C33, ICPI recommends the additional limitations on the No. 200 (0.075 mm) sieve as shown. For CSA A23.1 FA1, ICPI recommends reducing the maximum passing the 80 µm sieve from 3% to 1%.

Table 2. Grading Requirements for Joint Sand

Gradation for Joint Sand			
ASTM C144		CSA A179	
Sieve Size	Percent Passing	Sieve Size	Percent Passing
No. 4 (4.75 mm)	100	5.0 mm	100
No. 8 (2.36 mm)	95 to 100	2.5 mm	90 to 100
No. 16 (1.18 mm)	70 to 100	1.25 mm	85 to 100
No. 30 (0.6 mm)	40 to 75	630 µm	65 to 95
No. 50 (0.3 mm)	10 to 35	315 µm	15 to 80
No. 100 (0.15 mm)	2 to 15	160 µm	0 to 35
No. 200 (0.075 mm)	0 to 5	80 µm	0 to 10

5. Sieve according to [ASTM C 136][CSA A23.2A].
6. Bedding Sand Material Requirements: Conform to the grading requirements of [ASTM C 33][CSA A23.1-FA1] with modifications as shown in Table 1.

Note: Coarser sand than that specified in Table 2 above may be used for joint sand including C 33 or A23.1 material as shown in Table 1. Use material where the largest sieve size easily enters the smallest joints. For example, if the smallest paver joints are 2 mm wide, use sand 2 mm and smaller in particle size. If C 33 or A23.1 sand is used for joint sand, extra effort may be required in sweeping material and compacting the pavers in order to completely fill the joints.

7. Joint Sand Material Requirements: Conform to the grading requirements of [ASTM C 144][CSA-A179] as shown with modifications in Table 2 or meet the requirements for bedding sand in Table 1.

Note: Specify specific components of a system, manufactured unit or type of equipment. See *ICPI Tech Spec 3–Edge Restraints for Interlocking Concrete Pavements* for guidance on selection and design of edge restraints.

2.04 EDGE RESTRAINTS

A. Where not otherwise retained, provide edge restraints installed around the perimeter of all interlocking concrete paving unit areas as follows:
   1. Manufacturer: [Specify manufacturer.].
   2. Material: [Plastic] [Concrete] [Aluminum] [Steel] [Pre-cast concrete] [Cut stone] [Concrete].
   3. Material Standard: [Specify material standard.].

2.05 ACCESSORIES

A. Provide accessory materials as follows:

Note: Delete article below if geotextile is not used.

1. Geotextile:
   a. Material Type and Description: [Specify material type and description.].
   b. Material Standard: [Specify material standard.].
   c. Manufacturer: [Acceptable to interlocking concrete paver manufacturer] [Specify manufacturer.].

Note: Delete article below if cleaners, sealers, and/or joint sand stabilizers are not specified.

2. [Cleaners] [Sealers] [Joint sand stabilizers]

a. Material Type and Description: [Specify material type and description.].
b. Material Standard: [Specify material standard.].
c. Manufacturer: [Specify manufacturer.].

PART 3 EXECUTION

3.01 ACCEPTABLE INSTALLERS

A. [Specify acceptable paving subcontractors.].

3.02 EXAMINATION

A. Acceptance of Site Verification of Conditions:
   1. General Contractor shall inspect, accept and certify in writing to the paver installation subcontractor that site conditions meet specifications for the following items prior to installation of interlocking concrete pavers.

Note: Compaction of the soil subgrade is recommended to at least 98% standard Proctor density per ASTM D 698 for pedestrian areas and residential driveways. Compaction to at least 98% modified Proctor density per ASTM D 1557 is recommended for areas subject to heavy vehicular traffic. Stabilization of the subgrade and/or base material may be necessary with weak or saturated subgrade soils.

   a. Verify that subgrade preparation, compacted density and elevations conform to specified requirements.
   b. Verify that geotextiles, if applicable, have been placed according to drawings and specifications.

Note: Local aggregate base materials typical to those used for highway flexible pavements are recommended, or those conforming to ASTM D 2940. Compaction of aggregate is recommended to not less than 98% Proctor density in accordance with ASTM D 698 is recommended for pedestrian areas and residential driveways. Minimum 98% modified Proctor density according to ASTM D 1557 is recommended for vehicular areas. Mechanical tampers are recommended for compaction of soil subgrade and aggregate base in areas not accessible to large compaction equipment. Such areas can include that around lamp standards, utility structures, building edges, curbs, tree wells and other protrusions.

Note: Prior to screeding the bedding sand, the recommended base surface tolerance should be ± $^{3}/_{8}$ in. (10 mm) over a 10 ft. (3 m) straight edge. See *ICPI Tech Spec 2–Construction of Interlocking Concrete Pavements* for further guidance on construction practices.

Note: The elevations and surface tolerance of the base determine the final surface elevations of concrete pavers. The paver installation contractor cannot correct deficiencies in the base surface with additional bedding sand or by other means. Therefore, the surface elevations of the base should be checked and accepted by the General Contractor or designated party, with written certification to the paving subcontractor, prior to placing bedding sand and concrete pavers.

   c. Verify that [Aggregate] [Cement-treated] [Asphalt-treated] [Concrete] [Asphalt] base materials, thickness, [compacted density], surface tolerances and elevations conform to specified requirements.
   d. Provide written density test results for soil subgrade, [aggregate] [cement-treated][asphalt-treated][asphalt] base materials to the Owner, General Contractor and paver installation subcontractor.
   e. Verify location, type, and elevations of edge restraints, [concrete collars around] utility structures, and drainage inlets.
   2. Do not proceed with installation of bedding sand and interlocking concrete pavers until [subgrade soil and] base conditions are corrected by the General Contractor or designated subcontractor.

3.03 PREPARATION

A. Verify base is dry, certified by General Contractor as meeting material, installation and grade specifications.
B. Verify that base [and geotextile] is ready to support sand, [edge restraints,] and, pavers and imposed loads.
C. Edge Restraint Preparation:
   1. Install edge restraints per the drawings [and manufacturer's recommendations] [at the indicated elevations].

Note: Retain the following two subparagraphs if specifying edge restraints that are staked into the base with spikes.

2. Mount directly to finished base. Do not install on bedding sand.
3. The minimum distance from the outside edge of the base to the spikes shall be equal to the thickness of the base.

3.04 INSTALLATION

A. Spread bedding sand evenly over the base course and screed to a nominal 1 in. (25 mm) thickness. Spread bedding sand evenly over the base course and screed rails, using the rails and/or edge restraints to produce a nominal 1 in. (25 mm) thickness, allowing for specified variation in the base surface.
   1. Do not disturb screeded sand.
   2. Screeded area shall not substantially exceed that which is covered by pavers in one day.
   3. Do not use bedding sand to fill depressions in the base surface.

Note: When initially placed on the bedding sand, manually installed pavers often touch each other, or their spacer bars if present. Joint widths and lines (bond lines) are straightened and aligned to specifications with pry bars as paving proceeds.

B. Lay pavers in pattern(s) shown on drawings. Make horizontal adjustments to laid pavers as required.

Note: Contact manufacturer of interlocking concrete paver units for recommended joint widths.

C. Provide joints between pavers between [1/16 in. and 3/16 in. (2 and 5 mm)] wide. No more than 5% of the joints shall exceed 1/4 in. (6 mm) wide to achieve straight bond lines.

D. Joint (bond) lines shall not deviate more than ± 1/2 in. (15 mm) over 50 ft. (15 m) from string lines.

E. Fill gaps at the edges of the paved area with cut pavers or edge units.

F. Cut pavers to be placed along the edge with a [double blade paver splitter or] masonry saw.

Note. Specify requirements for edge treatment in paragraph below.

G. [Adjust bond pattern at pavement edges such that cutting of edge pavers is minimized. All cut pavers exposed to vehicular tires shall be no smaller than one-third of a whole paver.] [Cut pavers at edges as indicated on the drawings.]

H. Keep skid steer and forklift equipment off newly laid pavers that have not received initial compaction and joint sand.

I. Use a low-amplitude plate compactor capable of at least minimum of 5,000 lbf (22 kN) at a frequency of 75 to 100 Hhz to vibrate the pavers into the sand. Remove any cracked or damaged pavers and replace with new units.

J. Simultaneously spread, sweep and compact dry joint sand into joints continuously until full. This will require at least 4 passes with a plate compactor. Do not compact within 6 ft (2 m) of unrestrained edges of paving units.

K. All work within 6 ft. (2 m) of the laying face must be left fully compacted with sand-filled joints at the end of each day or compacted upon acceptance of the work. Cover the laying face or any incomplete areas with plastic sheets overnight if not closed with cut and compacted pavers with joint sand to prevent exposed bedding sand from becoming saturated from rainfall.

L. Remove excess sand from surface when installation is complete.

Note: Excess joint sand can remain on surface of pavers to aid in protecting their surface especially when additional construction occurs after their installation. If this is the case, delete the article above and use the article below. Designate person responsible for directing timing of removal of excess joint sand.

M. Allow excess joint sand to remain on surface to protect pavers from damage from other trades. Remove excess sand when directed by [Architect].

N. Surface shall be broom clean after removal of excess joint sand.

3.05 FIELD QUALITY CONTROL

A. The final surface tolerance from grade elevations shall not deviate more than ± 3/8 in. (10 mm) over 10 ft (3 m). Use a straightedge, flexible straightedge or transit depending on surface slope and contours.

B. Check final surface elevations for conformance to drawings.

Note: For installations on a compacted aggregate base and soil subgrade, the top surface of the pavers may be 1/8 to 1/4 in. (3 to 6 mm) above the final elevations after compaction. This helps compensate for possible minor settling normal to pavements.

C. The surface elevation of pavers shall be 1/8 in. to 3/8 in. (3 to 10 mm) above adjacent drainage inlets, concrete collars or channels.

Note: For pedestrian access routes maximum elevation should not exceed 1/4 in. (6 mm).

D. Lippage: No greater than 1/8 in. (3 mm) difference in height between adjacent pavers.

Note: Cleaning and sealing may be required for some applications. See *ICPI Tech Spec 5–Cleaning and Sealing Interlocking Concrete Pavements* for guidance on when to clean and seal the paver surface, and when to stabilize joint sand. Delete article below if cleaners, sealers and or joint sand stabilizers are not applied.

3.06 [CLEANING] [SEALING] [JOINT SAND STABILIZATION]

A. [Clean] [Seal] [Apply joint sand stabilization materials to concrete pavers in accordance with the manufacturer's written recommendations.]

3.07 PROTECTION

A. After work in this section is complete, the General Contractor shall be responsible for protecting work from damage due to subsequent construction activity on the site.

END OF SECTION

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Maytrx

VERTICAL OR SETBACK

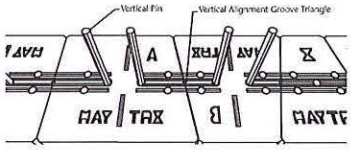
Installation Instructions:

MaytRx 3-Inch, 6-Inch & Stretcher Vertical and Setback Wall Pin Placement

There are three types of walls that can be built with pins: vertical freestanding double sided walls with zero batter, vertical retaining walls with almost zero batter, and setback retaining walls with a 7-degree batter. MaytRx 6 and MaytRx 3 use the following procedures when building a retaining wall. Pins, geogrid and engineering all are important parts of the wall.

MaytRx 6 and Stretcher Retaining Wall

Figure 1



MaytRx 6 Pin Placement Vertical Retaining Wall:

Place 6 ½"-long MaytRx Pins through the vertical (center) hole into the center groove of the wallstone below. When the pin is centered in the hole, push the wallstone "back" towards the bank. This creates almost a zero batter. See Figure 1.

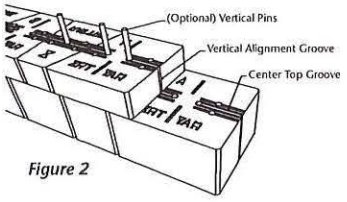


Figure 2

MaytRx 3 and 6 Pin Placement in Vertical Freestanding Walls:

MaytRx wallstones include a pin hole for vertical alignment and securing geogrid. Although optional in the double-sided configuration, they may be used for additional interlock. Place the 6 ½"-long or 3 ¼" MaytRx Pins (depending on the wallstone being used) through the vertical (center) hole. Let them drop into the center groove of the wallstone below. When the pin is centered in the hole, check the visual side groove to confirm your wall is centered on the middle groove of the layer below. This creates a zero batter. See Figure 2.

MaytRx 6 Pin Placement Setback Retaining Wall:

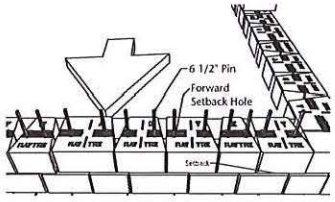


Figure 3

Place 6 ½"-long MaytRx Pins through the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole pull the wallstone "forward" towards the front of the wall. This creates a 7-degree batter. See Figure 3.

MaytRx 3 Retaining Wall

MaytRx 3 Pin Placement Vertical Retaining Wall:

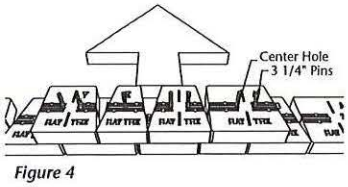
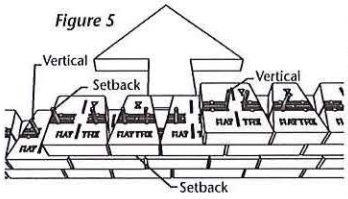


Figure 4

Place 3 1/4"-long MaytRx Pins through the vertical (center) hole into the center groove of the wallstone below. When the pin is centered in the hole push the wallstone "back" towards the bank. See Figure 4.

MaytRx 3 Pin Placement Setback Retaining Wall:

Figure 5



Note: The MaytRx 3 wallstone setback hole is normally used for the 6 and 3 combined wall. To build a wall based on the setback charts of MaytRx 6-inch with all 3-inch high wallstones, use a combination of this vertical and setback pin position to create a 3-inch setback row with a 3-inch vertical row above it. For the setback row, place the 3 1/4" long MaytRx Pins into the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole pull the wallstone "forward" towards the front of the wall. Then place a vertical row above it. This creates a 7-degree batter when used together. See Figure 5.

MaytRx 3 & 6 Combined Retaining Walls

MaytRx 3 and 6 Vertical Combined Pins:

MaytRx 3 and 6 combined designs use both size pins in the wall. When pinning the 6" high wallstone to the wall, use 6 ½" pins, when pinning the 3-inch high wallstone, use the 3 1/4" pins. Follow the instructions for each size wallstones vertical alignment formula. See Figure 6.

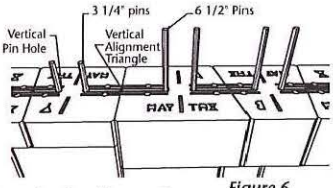
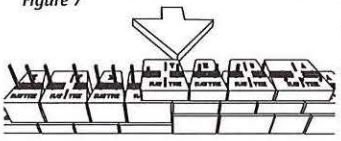


Figure 6

MaytRx 3 and 6 in Combined Setback Retaining Walls:

Place 6 ½" long MaytRx Pins through the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole, pull the wallstone "forward" towards the front of the wall. With the 3-inch high MaytRx wallstone, place the 3 1/4" long MaytRx Pins through the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole, pull the wallstone "forward" towards the front of the wall. See Figure 7.

Figure 7



MaytRx 3 and 6 Combined Geogrid Wall

For informational details of general applications, vertical geogrid charts are available on the Cambridge website. Check municipal codes for your location and for all walls over 36 inches you should consult a licensed design professional. Please refer to the engineering page in this book for details and links. Vertical 6-inch and 3-inch retaining walls use the 6-inch vertical or setback geogrid charts and add two layers of 3-inch wallstone for one layer of 6-inch wallstone shown in the illustration, pinning or gluing every wallstone. The 6 and 3 designs are random. In an engineered wall, you have to use geogrid under all conditions and that must not be compromised by the random design layers without the direction of your design professional. He may suggest extra layers or special retained soils behind the wall.

The base is an important part of any retaining wall. The wall shown in these diagrams should be considered a landscape or freestanding wall. Check with your local building department for the regulations that cover the wall you will be building. Refer to the "Basic Retaining Wall" area of this book for design criteria. We normally set the wall first row (course) 1" below the surface for every foot of height that will be exposed above the grade, on top of a 6" crushed stone leveling pad base that is compacted every 3" during installation. Drainage is very important and is discussed in the "Basic Retaining Wall" area of this book as well.

Tech Spec Guide

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Your requested ICPI Tech Spec 23 follows this page.

Design and Installation Professionals frequently turn to interlocking concrete pavements and permeable interlocking concrete pavements because they offer lower initial and life cycle costs and provide environmentally sustainable solutions.

ICPI provides resources for ICP and PICP design, construction, and maintenance. These include: Tech Specs, Guide Specs, Detail Drawings, Construction Tolerance Guides, Fact Sheets, Design Manuals and design software. ICPI also offers several relevant continuing education courses at icpi.org and aecdaily.com

Find the right guide for your location.

Many ICPI members subscribe by state or province to this Tech Spec service to support the development and revision of these technical documents. The ICPI website Technical Center offers the opportunity to select Tech Specs by state or province.

ICPI Tech Spec Library

- Tech Spec 1: Glossary of Terms for Segmental Concrete Pavement
- Tech Spec 2: Construction of Interlocking Concrete Pavements
- Tech Spec 3: Edge Restraints for Interlocking Concrete Pavements
- Tech Spec 4: Structural Design of Interlocking Concrete Pavement for Roads and Parking Lots
- Tech Spec 5: Cleaning, Sealing and Joint Sand Stabilization of Interlocking Concrete Pavement
- Tech Spec 6: Reinstatement of Interlocking Concrete Pavements
- Tech Spec 7: Repair of Utility Cuts Using Interlocking Concrete Pavements
- Tech Spec 8: Concrete Grid Pavements
- Tech Spec 9: Guide Specification for the Construction of Interlocking Concrete Pavement
- Tech Spec 10: Application Guide for Interlocking Concrete Pavements
- Tech Spec 11: Mechanical Installation of Interlocking Concrete Pavements
- Tech Spec 12: Snow Melting Systems for Interlocking Concrete Pavements
- Tech Spec 13: Slip and Skid Resistance of Interlocking Concrete Pavements
- Tech Spec 14: Concrete Paving Units
- Tech Spec 15: A Guide for the Construction of Mechanically Installed Interlocking Concrete Pavements
- Tech Spec 16: Achieving LEED Credits with Segmental Concrete Pavement
- Tech Spec 17: Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications
- Tech Spec 18: Construction of Permeable Interlocking Concrete Pavement Systems
- Tech Spec 19: Design, Construction and Maintenance of Interlocking Concrete Pavement Crosswalks
- Tech Spec 20: Construction of Bituminous- Sand Set Interlocking Concrete Pavement
- Tech Spec 21: Capping and Compression Strength Testing Procedures for Concrete Pavers
- Tech Spec 22: Geosynthetics for Segmental Concrete Pavements
- Tech Spec 23: Maintenance Guide for Permeable Interlocking Concrete Pavements
- Tech Spec 25: Construction Guidelines for Segmental Concrete Paving Slabs and Planks in Non-Vehicular Residential Applications

Tech Spec 23

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Maintenance Guide for Permeable Interlocking Concrete Pavements

Introduction

Permeable interlocking concrete pavements (PICP) are a proven method for reducing stormwater runoff and pollutants while supporting pedestrian and vehicular traffic. Many laboratory and in-situ research projects over the past two decades by universities, government stormwater agencies, and industry have demonstrated significant runoff and pollutant reductions with cost-saving benefits. The U.S. Federal Highway Administration **www.fhwa.dot.gov/pavement/concrete/pubs/hif19021.pdf** has published information supporting PICP use in walkways, plazas, driveways, parking lots, alleys and streets.

Like all stormwater control measures, PICP requires maintenance as it traps sediment on its surface not unlike an air conditioning filter. Larger particles are initially trapped while allowing water to pass. Some enter the jointing stone and are trapped there. The jointing stone with larger particles eventually captures smaller particles and this decreases the infiltration rate over time. While still infiltrating water, many smaller particles are trapped within the surface and interior joints. Smaller particles are trapped and eventually decrease infiltration which results in surface ponding.

Every PICP site varies in sediment deposition onto its surface, particle size distribution, and the resulting cleaning frequency. For example, beach sand (a coarse particle size distribution) on the surface will not clog as quickly and require less effort removing than fine clay sediment. Besides the particle size distribution, the rate of surface infiltration decline also depends on the traffic, size, and slope of a contributing impervious area, adjacent vegetation and eroding soil, paver joint widths and jointing stone sizes. ICPI offers a PICP site selection

Figure 1. PICP is seeing increased use in municipal streets to reduce stormwater runoff, local flooding, storm pipe upsizing, and combined sewer overflows. These streets are in Atlanta, GA.

Figure 2. Sand-filled joints and bedding common to interlocking concrete pavement **are not used** *in PICP.*

tool on **www.icpi.org/software** to help identify favorable sites and avoid one that may incur additional maintenance.

While routine maintenance assures long-term infiltration, surface infiltration can be restored from neglected maintenance. A significant advantage of PICP is its ability to remove settled or wheel-packed sediment in the joints. This Tech Spec provides guidance on routine and restorative maintenance practices that support surface infiltration. This bulletin also provides guidance on maintaining the surface as an acceptable pedestrian and vehicular surface.

Practices Supporting Surface Infiltration

PICP design and construction that complies with ICPI guidelines are fundamental to long-term surface infiltration. Guidelines are found in ASCE 68-18 standard on PICP, the ICPI manual, *Permeable Interlocking Concrete Pavements* and in *ICPI Tech Spec 18–Construction of Permeable Interlocking Concrete Pavements* available on **www.icpi.org**. Some essential characteristics described below support continued infiltration.

PICP doesn't use sand. Unlike interlocking concrete pavements, sand jointing or bedding materials to support paving units and dense-graded aggregate bases are not used in PICP. Sand joints and bedding allow very little water to enter and often eventually clog for traffic borne detritus and sediment.

Construction E & S control is essential. Erosion and sediment control during construction is covered in the previously mentioned documents, and is customized to each project via the Stormwater Pollution Prevention Plan or SWPPP. An inspection checklist is provided at the end of this bulletin that includes sediment control. If the PICP is built first and construction traffic must use it, then it will very likely require vacuum cleaning upon construction completion. The ideal situation is PICP constructed late in the project such that it will not receive much construction traffic and sediment. This may require using temporary construction roads.

If PICP receives run-on from upslope pervious or impervious areas, inspect these areas for erosion and sediment, yard waste, materials storage, etc. Sweep or vacuum the contributing drainage area clean and free of any dirt, leaves and mulch as they are a major source of PICP clogging. Lawn and planting beds should be sloped away from PICP areas.

Maintain filled joints with stones. The jointing stones capture sediment at the surface so it can easily be removed. If sediment is allowed to settle and consolidate, then cleaning becomes more difficult since the sediment is inside the joint rather than on the surface. Settlement of jointing stones in the first few months is normal to PICP as open-graded aggregates for jointing and bedding choke into the larger base aggregates beneath and stabilize. This settlement often requires the joints to be refilled with aggregates three to six months after their initial installation. If possible, this should be included in the initial construction contract specifications. Aggregate-filled joints facilitate sediment removal at the surface and provide interlock for pavement structural stability.

Keeping the joints filled during the PICP service life is essential to trapping sediment and facilitating its removal at the surface and ensuring long term performance. Permeable segmental paving systems that do not use jointing aggregates may incur higher maintenance time and costs to extract accumulated sediment from deep within the joints and bedding, or eventually move through the base/subbase aggregates onto the subgrade and reduce its infiltration.

Filled paver joints means filled to the bottom of the paver chamfers with jointing stone. If the pavers have very

Figure 3. Whether eroded onto or dumped on PICP, erosion and sediment control are essential during construction.

Figure 4. Keeping PICP joints filled with permeable aggregate facilitates removal of accumulated sediment.

small or no chamfers, then they should be filled within ¼ in. (6 mm) of the paver surface. Should the top of jointing stone settle below ¼ in. (6 mm), vacuum equipment can be less effective in removing sediment and cleaning becomes potentially more expensive.

Manage mulch, topsoil and winter sand. Finally, stockpiling mulch or topsoil on tarps or on other surfaces during site maintenance activities rather than directly on the PICP surface helps maintain infiltration. Figure 5 illustrates an example of correct management of landscaping material on PICP, as well as the need to exposed soil slopes.

Sand used in the winter for traction is not recommended. Figure 6 illustrates the consequence to PICP joints when subjected to winter sand for traction. If used, sand should be removed with vacuuming in the spring to prevent a substantial decrease in surface infiltration. Using jointing aggregate is recommended as a better alternative to using sand for winter traction. In addition, the aggregate can provide some refilling of the joints.

Surface Infiltration Inspection & Testing

Visual Inspection—Effective ways to assess PICP surface infiltration is by conducting visual inspections or tests on the surface before, during and immediately after rainfall.

Inspect Before a Rainfall—Sediment crusted in the joints when dry is the most opportune time to remove it. During dry periods, the sediment layer in each joint can sometimes dry out and curl upward. This layer can be easily loosened by vacuum equipment.

Additionally, deciduous leaves and pine needles eventually get crushed by traffic, degrade, and work their way into the joints, thereby reducing infiltration. See Figures 7 and 8. The site should be inspected for sediments from adjacent eroding areas and those areas stabilized immediately.

Weeds growing from within joints indicate accumulated sediment in the joints and neglected maintenance. See Figure 9. Weeds will not germinate unless there is accu-

Figure 5. Mulch placed on tarps prevents more expensive cleaning of PICP.

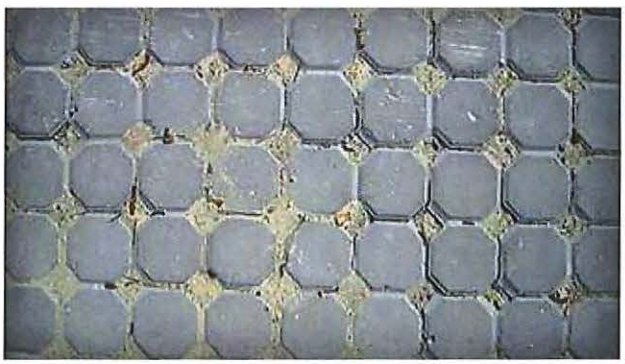

Figure 6. Sand from winter maintenance must be removed the following spring.

Figures 7 and 8. Pine needles and leaves eventually will degrade and get compacted into the joints from traffic. They should be removed by sweeping or vacuuming before that happens.

mulated sediment. Weeds should be removed by hand. Herbicide may kill weeds, but dead vegetation and roots will remain. They typically reduce infiltration and should eventually be removed.

Inspect During and Just After a Rainstorm— The extent of puddles and bird baths observed during and especially after rainstorm indicate a need for surface cleaning.

Table 1. ASTM C1781 test results: relationship between time required to infiltrate and calculated surface infiltration rate

Time to infiltrate water		Approximate surface infiltration rate inches/hr (mm/hr)	
Minutes	Seconds	8 lbs. (3.6 kg) water	40 lbs. (18 kg) water
0.5	30	235 (5,913)	1,175 (29,564)
1	60	117 (2,956)	587 (14,782)
2	120	59 (1,478)	294 (7,391)
4	240	29 (739)	147 (3,696)
6	360	20 (493)	98 (2,464)
8	480	15 (370)	73 (1,848)
15	900	8 (197)	39 (985)
30	1800	4 (99)	20 (493)
60	3600	2 (49)	10 (246)

Note: $I = (K \bullet M)/(D^2 \bullet t)$, where
I = Surface infiltration rate, in./hr (mm/hr)
K = 126,870 for US customary units (4,583,666,000 for metric)
M = water mass, lbs (kg)
D = ring diameter (12 in. or 305 mm)
t = time for water to infiltrate in seconds

- Acceptable performance > 100 in./hr (2,500 mm/h)
- Plan to clean soon
- Clean immediately < 20 in./hr (500 mm/hr)

A minor amount of ponding is likely to occur particularly at transitions from impervious pavement surfaces to PICP. This often occurs first as sediment is transported by runoff and vehicles. See Figures 10 and 11. Should ponding areas occupy more than 20% of the entire PICP surface, then surface cleaning should be conducted. While a rainstorm's exact conclusion is difficult to predict, standing water on PICP for more than 15 minutes during or after a rainstorm likely indicates a location approaching clogging.

Test Surface Infiltration—A quick and subjective test for the amount of surface infiltration is pouring water on PICP. If the water spreads rather than infiltrates, the extent of spreading suggests an area that may be clogging. Should more than approximately 20% of the surface area see ponding during or immediately after a rainstorm, a more objective measure of surface infiltration of these areas can be accomplished using ASTM C1781 *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems.* Figure 12 illustrates the test set up using a 12 in. (300 mm) diameter ring set on plumber's putty. (The ring can be metal or plastic.) Figure 13 illustrates the test apparatus in

Figure 9. Weeds indicate sediment accumulation and lack of surface cleaning to remove it.

Figure 10. Erosion of adjacent asphalt and sediment deposition on PICP.

Figure 11. Ponding on PICP typically first occurs at the junction with impermeable pavement.

Figure 12. Steps in setting up test equipment for measuring surface infiltration using ASTM C1781.

place with water poured into it.

ASTM C1781 test method begins with "pre-wetting" an area inside the ring to ensure the surface and materials beneath are wet. This is done by slowing pouring 8 lbs (3.6 kg) of water while not allowing the head of water on the paver surface to exceed 3/8 in. (10 mm) depth. If the time to infiltrate 8 lbs of water is less than 30 seconds (using a stopwatch typically on a cell phone), the subsequent test is done using 40 lbs (18 kg) of water. If more than 30 seconds, then 8 lbs of water is used in the subsequent tests. Again, a 3/8 in. (10 mm) head is maintained during the pour while being timed with a stopwatch. The surface infiltration rate is calculated using formulas in the test method.

If infiltration measurements on ponded areas consistently result in rates below 20 in./hour (508 mm/hr), they require immediate surface cleaning. PICP surfaces sloped over 2% with less than 40 in./hr infiltrate rate require immediate surface cleaning. An infiltration rate of 20 in./hr equates to 30 minutes' infiltration time and 40 in./hr results in 15 minutes. Table 1 further illustrates the relationship between time

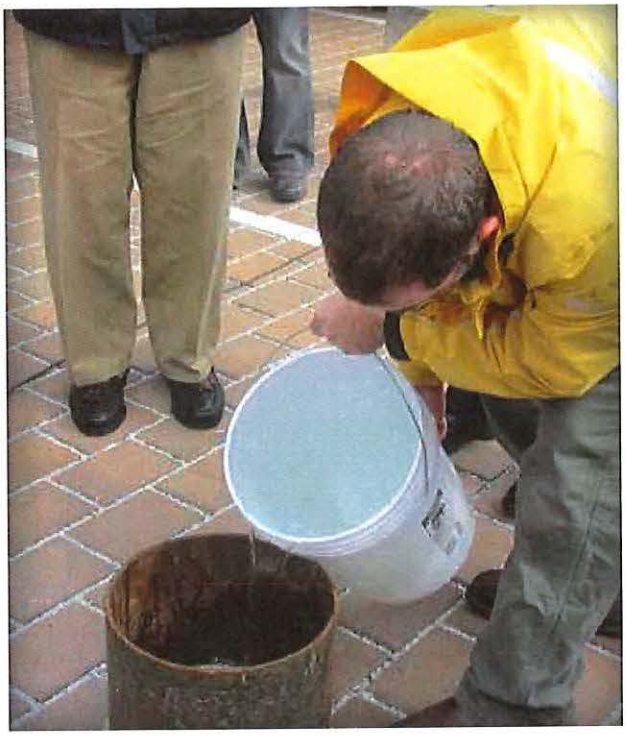

Figure 13. ASTM C1781: pouring the wanter into a 12 in. (300 mm) inside diameter ring set on plumber's putty.

for 40 lbs (18 kg) of water to infiltrate and the calculated infiltration rate. ICPI offers a downloadable calculator for converting time of infiltration to infiltration rates when using C1781. See **www.icpi.org/software.**

Surface Infiltration Maintenance Types

Routine and Restorative Maintenance—There are two approaches or service types for maintaining PICP surface infiltration: routine and restorative. Routine maintenance is done regularly to maintain infiltration. It removes most loose sediment and debris from the surface before being trapped and stuck in the jointing aggregates thereby causing clogging. Routine maintenance may require reinstatement of a small amount of jointing stones or none at all.

Routine Maintenance Equipment Options for Maintaining Various Sized PICP Applications

Cleaning Small Pedestrian Areas and Driveways

Theas are typically under 2,000 sf or 200 m^2 and include patios, plazas, sidewalks, and driveways. Equipment options follow:

Hand-held Bristle Broom— Sweep as needed to clear the surface clear of loose debris. See Figure 14.

Leaf Blower (electric or gas powered)—A minimum air speed of 120 mph (190 kph) is recommended. Jointing aggregates remain in place while removing loose debris such as leaves from the surface. See Figure 15.

Rotary Brush with Plastic Bristles—These are often used to spread jointing stone during construction. Same equipment can be used to clean surface to top of joints. Bristles can flip debris out of joints (depends on bristle reach into the joints). A small amount of aggregate may need to be replaced in the joints after using. See Figure 16.

Wet/Dry Shop Vacuum or Walk-behind Vacuum—Use equipment with a minimum 4 (peak) HP motor with minimum 130 cubic feet (3.7 m^3) per minute suction. These machines can remove some jointing aggregates so they may require replenishment. See Figures 17 and 18.

Power Washer—This equipment should be capable of 1,400 to 1,800 psi (9.6 to 12.4 MPa) pressure. Apply the spray at a 30° angle approximately 18 to 24 in. (45 to 60 cm) from the surface and adjust as needed. This equipment will evacuate jointing aggregate and replenishment will be required. Power washing alone generally is not an optimal cleaning approach because there is almost no opportunity on most sites to remove the water-suspended sediment before the water is absorbed back into the pavement. See Figure 19.

Cleaning Large PICP Areas

These are typically over 2,000 sf or 200 m^2 such as large plazas, long sidewalks and driveways, parking lots, alleys and streets. Equipment options follow:

Street Sweepers—These typically have rotating plastic bristle brushes positioned near the curb side and center pickup into a hopper at the rear. Do not use water as it slows removal of loose dirt into the machine. This machine does provide a small vacuum force to manage dust, but the cleaning action is provided by the mechanical sweeping, so it is moderately effective among large machines for removing sediment in the joints. Bristles from the the main broom can reach into joints parallel to the direction of the broom rotation, but have little effect on the joints not aligned with the broom rotation. See Figure 20.

Regenerative Air Sweepers—Includes a box positioned under the truck and on the pavement through which air is blown and recirculated (hence the term regenerative air). The pavement must have no convex (or reverse) crown in order to create an adequate seal for suction in the box. Air pressure flowing through it picks up loose debris and sediment. Rotating brushes can be used to direct dirt and debris toward the box. See Figure 21.

Figure 14. Bristle broom for removing loose debris

Figure 15. Blowing debris to curbs or gutters for removal and disposal.

Figure 16. Rotary brushes increase cleaning efficiencies.

Restorative Infiltration Maintenance for Large Clogged Surfaces

Restorative maintenance is conducted when sediment has lodged in the jointing stones from traffic and weather. The condition indicates that the PICP surfaces have not been regularly cleaned. Restorative maintenance requires some or complete removal of the jointing aggregates to increase infiltration. The depth of jointing stone removed depends on the penetration depth of the sediment into the joints. This can be determined on a sample of a few clogged joints (typically where ponding occurred) by prying out stones and sediment with a flat head screwdriver until little or no accumulated sediment appears.

True Vacuum Sweepers—These can withdraw jointing material and even the concrete pavers. Therefore, the vacuum engine revolutions must be adjusted by the machine operator during a few test runs to find the setting that withdraws the needed depth of sediment and jointing aggregate. After withdrawal, jointing aggregates will require replenishment. The suction orifice is typically about a yard (meter) wide and positioned on the curb side of the truck. Extremely clogged surfaces will require two or more passes. Figure 22 shows this machine. It is often used by municipalities to clean out storm drain catch basins and may require a separate vacuum attachment to clean pavements.

High-power Washing and Vacuum Equipment—Figure 23 shows the equipment for restorative cleaning where water is applied to help loosen sediment and stones in the joints. Figure 23 shows a vacuum that withdraws sediment and stones immediately after applying water. The water and debris are drawn into a vac truck.

Figure 17. Wet/dry shop vacuum cleans loose sediment from a PICP residential driveway

Figure 18. Walk-behind vacuum cleans a small parking area.

Figure 19. Power washing requires a little practice to minimize jointing stone removal.

High Pressure Air/Vacuum—High pressure air is blasted into the joints and has been shown to be very effective at dislodging sediment and debris. A second step is then required to vacuum up the debris that is dislodged. In Figure 24, the machine in the foreground blows debris completely out of the joints and the second machine takes up the debris into a vac truck similar to that used to clean catch basins. See Figure 24. As with all restorative cleaning methods, clean jointing stone is spread and the empty joints are filled. After removing excess stones from the surface, the pavers with filled joints are compacted with a minimum 5,000 lbf (22 kN) vibratory plate compactor operating at 75-90 Hz. See Figure 25. This helps settle the stones into the joints. Any joints were stones have settled should be filled with more stones within a ¼ inch (5 mm) of the paver surfaces.

Maintenance Equipment Performance

In 2020, the University of Toronto completed a two year research project, Maintenance Equipment Testing on Accelerated Clogged Permeable Interlocking Concrete Pavements. This study evaluated maintenance equipment for restoration of infiltration rates of PICP systems when joints become severely clogged. The research was conducted at the Toronto & Region Conservation Authority's Kortright Centre in Vaughn, Ontario. The research scope of work included the construction of seven 10 ft. by 10 ft. PICP partial infiltration test pads. The cells were carefully clogged to a surface infiltration rate of ≤ 10 in/hr. The sediment infill used to clog the system was regional street cleaning sediments with a known particle size distribution. Five different technologies were investigated: full vacuum sweeper, regenerative air sweeper, dry mechanical sweeper, water pressure washing, and a hybrid high pressure air/vac system specifically designed for permeable pavement. The objective of the study was to evaluate the effectiveness of each method at restoring surface infiltration rates. The impact of cohesive soil sediment was also evaluated as part of the study. All cleaning technologies significantly improve surface infiltration rates. However, the high pressure air-vac hybrid had the best and least variable results, and was the only technique able to fully restore surface infiltration rates. Joint penetration depth was generally a good indicator of restoration effectiveness, except if sediment gradation varies. A complete copy of the report can be found at **https://tinyurl.com/y67zhydz**.

Figure 20. This type of mechanical sweeper removes sediment from joints parallel to the direction of the broom rotation.

Also in 2020 the United States Geological Survey Madison, WI office published results of a four year investigation on cleaning PICP, Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement. Since 2014, this research site has collected water quality, temperature, infiltration rates, and surface flow data with three types of permeable pavement sections (pervious asphalt, porous

Figure 21. A regenerative air machine does routine cleaning in a PICP parking lot.

Figure 22. A true vacuum machine cleaning neglected PICP.

concrete, and permeable interlocking concrete pavement). Contributory drainage from an adjacent parking lot provided an opportunity for accelerate clogging and collect data for 9:1 and 5:1 drainage ratios. The following six pavement cleaning methods were evaluated over a 4-year period: manual cleaning with a masonry trowel; Leaf blower and broom; true vacuum; water-enhanced vacuum; high pressure air system; and pressure washer with soil vacuum. An evaluation of the efficiency of each method was based on comparing surface infiltration rates, pre and post cleaning. Surface variability was high due to surface flow patterns across the permeable surfaces. All cleaning methods improved surface infiltration rates. PICP showed the greatest recovery compared to pervious concrete or pervious asphalt. These systems were more difficult to maintain due to sedimentation penetrating into the solid matrix related to the twisting of interconnected pores created during placement. Different cleaning methods produce different results however, in all instances, when the same method was applied, PICP showed the greatest recovery in infiltration capacity. At this particular site the majority of clogging occurred within the top 1 inch. A complete copy of the report can be found at **https://tinyurl.com/yy9nhou8**.

Inspection Intervals and Procedures for Maintaining Surface Infiltration

Routine maintenance provides the best infiltration performance by implementing the following procedures:

1. **Weekly**—Prevent contamination from routine landscape maintenance such as grass clippings from mowing, hedge trimming, mulching plant beds, etc. by:
   - Broom sweep debris from the paver surface, or
   - Blow debris from the paver surface with a powered leaf blower onto other surfaces that will not retransmit it to the PICP surface.
   - Mechanically sweep paver surface.
   - Remove loose debris, leaves, needles, sediment, topsoil, mulch, etc. after severe rain storms using the above procedures.
   - Collect and dispose of debris.
2. **Semi-annually**—Remove loose surface debris from the pavers and jointing stones (1) when trees have defoliated in the fall and (2) at the end of winter snowfall.
   - Use a wet/dry vacuum for small areas and a regenerative air machine for larger areas.

Figure 23. This equipment provides combined washing and vacuum of unmaintained PICP.

Figure 24. This equipment blows sediment and soiled aggregate from the joints and uses vacuum equipment to remove them.

Figure 25. No matter the equipment used, after removing sediment soiled aggregate, clean aggregate is placed in the joints, the surfaced cleaned and compacted.

- Replenish jointing stone as needed to the bottom of the paver chamfers.
- Check any observation wells and outlet pipes from underdrains to confirm drain down and water outflows.

3. **As needed**—Based on observation and during rainstorms and subsequent surface infiltration tests, remove and replenish the jointing stones and sediment using restorative cleaning equipment and procedures.

Note: *Various factors will affect each project's routine maintenance schedule and each must be reviewed individually.*

Winter Maintenance

Snow Removal—Unlike other permeable pavement surfaces, PICP demonstrates durability in the winter. PICP can be plowed with steel or hard rubber blades. Steel blades typically scratch all pavement surfaces. When using commercial snow removal companies, confirm in writing they provide protective edges on the snowplow equipment to avoid scratching the surface. Most pavers have chamfers on their surface edges which can help protect the edges from chipping by snow plows. For smaller areas, use a plastic snow shovel and fit snow blowers with plastic on the scoops and on the gliders. When possible deposit plowed snow onto grassy areas and not on the PICP when the plowed snow is dirty. Such dirt will remain and likely help clog the PICP surface after the snow melts.

Deicers—When used sparingly, deicers should not damage PICP surfaces as the brine typically forms on the surface to lower the freezing temperature of water and eventually moves into the joints with melting ice or snow. Some deicers will accelerate surface wear on some styles of pavers with blasted or hammered surfaces.

A 2020 University of Toronto study on pavement deicing operations quantified some significant winter safety benefits when using PICP. Besides confirming that the use of permeable pavers can eliminate the occurrence of snow melt refreezing and forming black ice, snow and ice can also melt and dry quicker when deicers are used on PICP. More importantly, the research confirmed that a much lower deicing salt application rate is required on PICP compared to impervious asphalt, while still maintaining a high level

Figure 26. This is an example of snow that should have been deposited on a grassy area. If such areas are not available, then vacuum clean the PICP in the early spring.

Table 2. Maintenance guidelines for all PICP distresses

Distress	Activity	Frequency
Clogging	Schedule appropriate routine cleaning method based on site conditions. Utilize restoration cleaning methods as needed when surface infiltration rates decrease below project threshold. Hot spot cleaning may be appropriate.	1 to 2 times annually; adjust frequency based on sediment loading
Clogged/Damaged Secondary Features	Clean out or repair secondary drainage features.	Annually, after major rain event
Depressions	Repair all paver surface depressions, exceeding 0.5 in. (13 mm)	Annually, repair as needed
Rutting	Repair all paver surface rutting, exceeding 0.6 in. (15 mm)	Annually, repair as needed
Faulting	Repair all paver surface faulting, exceeding 0.25 in. (6 mm)	Annually, repair as needed
Damage Paver Units	Replace medium to high severity cracked, spalled or chipped paver units.	Annually, repair as needed
Edge Restraint Damage	Repair pavers offset by more than 0.25 in. (6 mm) from adjacent units or curbs, inlets, etc.	Annually, repair as needed
Excessive Joint Width	Repair pavers exhibiting joint widths exceeding 0.5 in. (13 mm)	Annually, repair as needed
Joint Filler Loss	Replenish aggregate in joints.	As needed
Horizontal Creep	Repair areas exhibiting horizontal creep exceeding 0.4 in. (10 mm)	Annually, repair as needed
Excessive Settlement	For settlements greater than 1 in. consult a pavement engineer versed in OGA design and construction to determine cause and correction.	As needed.
Additional Distresses	Missing pavers shall be replaced. A geotechnical investigation is recommended for pavement heaves.	Annually, repair as needed

of slip and skid resistance. The study also demonstrated that PICP systems can attenuate and buffer the release of salt back into the environment, an important finding since there is concern about snowmelt and stormwater runoff environmentally damaging lakes and rivers.

Deicer types acceptable for use in on PICP surfaces include sodium chloride, calcium chloride and potassium chloride. Do not use magnesium chloride as it will eventu-

ally destroy all concrete materials. Anti-icing agents that contain ammonium nitrate and ammonium sulfate should not be used since they can also erode concrete. Always read and follow the manufacturer's recommendations for use and heed all warnings and cautions.

Maintenance for Other Distresses

Over time and traffic, PICP can exhibit other distresses besides surface ponding from clogged joints. These are outlined in Table 2 and remedies are provided.

Utility Restoration Guidelines

1. Remove and store pavers for reuse. Secure undisturbed pavers in opening with wood or metal frame.
2. Remove and dispose of all jointing and bedding aggregate as they typically cannot be re-used.
3. Remove the aggregate base and subbase material. Incidental mixing of base and subbase aggregates is acceptable, but make every effort to separate them. Store in on impermeable pavement or a geotextile to prevent contamination. Do not reuse contaminated aggregate.
4. Re-compact subgrade material as required for stability during utility repairs.
5. Repair or install utility as required.
6. If below the bottom of the subbase, place and compact dense-graded road base in lifts not exceeding 6 in. (150 mm) and compact to 100 percent of standard Proctor maximum dry density. The top of the dense-graded aggregate should be at the same elevation as the bottom of the open-graded subbase aggregate. Alternately flowable fill could be used to reestablish the subgrade surface.
7. Reinstate and compact the subbase aggregate in minimum 6 in. (150 mm) lifts. Use a minimum 13,500 (65 kN) plate compactor with a compaction indicator. Add new subbase aggregate if needed.
8. Reinstate and compact the base aggregate as one 4 in. (100 mm) lift. Use a minimum 13,500 lbf (65 kN) plate compactor with a compaction indicator. A lightweight deflectomer (LWD) can be used to ensure that deflections of the compacted base aggregate are below an average of 0.5 mm (assuming a minimum 12 in. (300 mm)) compacted aggregate subbase. An LWD should be used according to ASTM E2835.
9. Place and screed new bedding aggregate in a consistent thickness layer between 1.5 and 2 in. (38 and 50 mm).
10. Reinstate pavers with at surface at least 1 in. (25 mm) higher than the final elevation. Compact the pavers in two perpendicular directions with a minimum 5,000 lbf (22 kN) plate compactor. Fill joints with aggregate, sweep away excess, and compact the pavers in two perpendicular directions again. Compact pavers so they are level with surrounding pavers.
11. Sweep surface clean and remove any excess aggregate and debris.

Other recommendations include keeping all removed materials clean and free of sediment and debris. Minimize excess debris from construction activities and equipment entering the permeable surface. Store all materials away from the permeable surface, otherwise separate materials from the permeable surface with geotextile. Pavement cuts located parallel and close to the wheel path should be extended to include the wheel path. Cuts located within 3 ft (1 m) of a curb or construction joint should include the removal of the adjacent base and subbase to the edge of the curb or construction joint.

References

Drake, et al. (2020), "De-icing Operations for Permeable Interlocking Concrete Pavements", University of Toronto, Dept. of Civil and Mineral Engineering

Danz, et al. (2020), "Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement", U.S. Geological Survey, Middleton, WI

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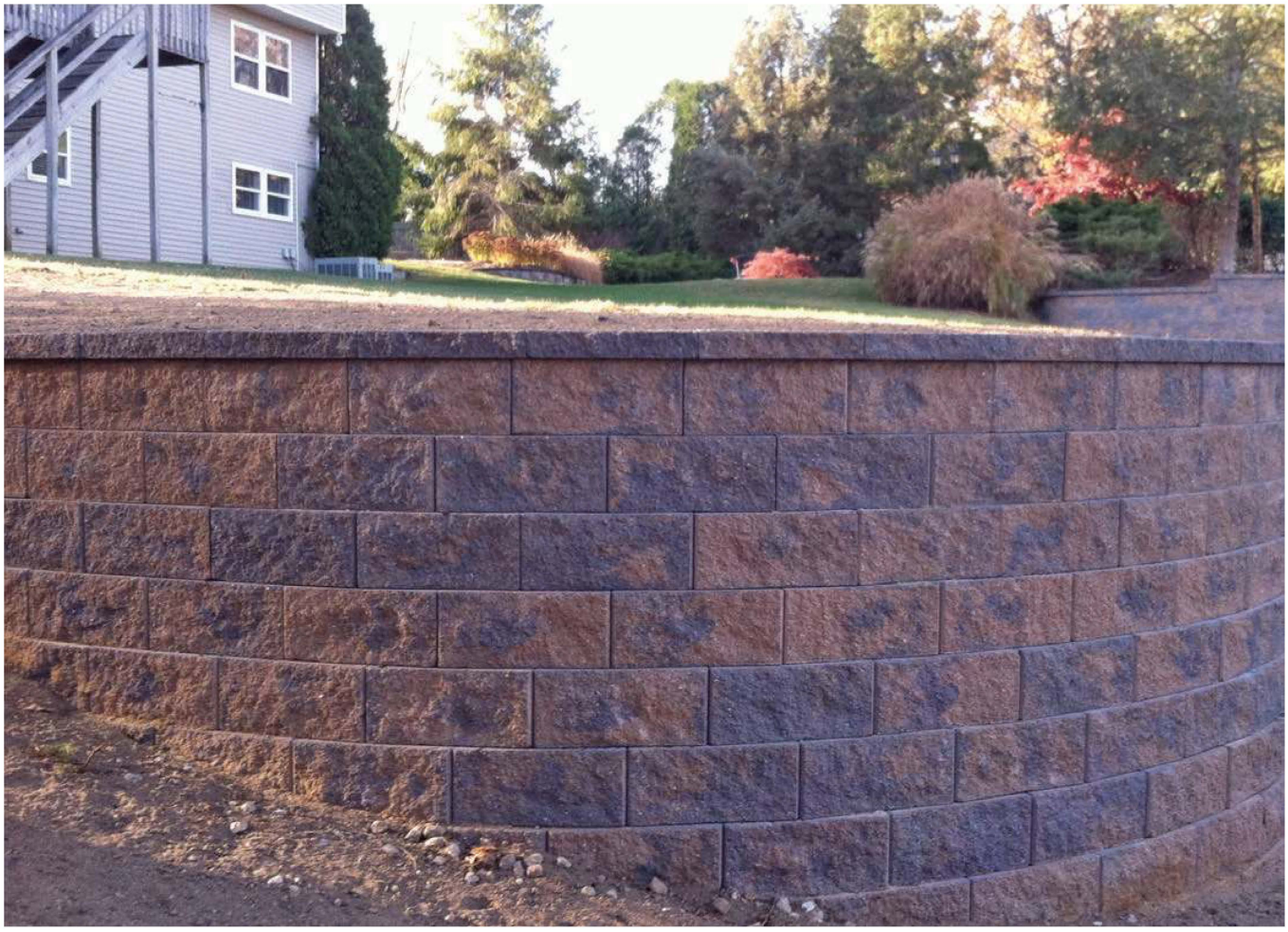
SIGMA MAYTRX OLLDE ENGLISH

GETTING STARTED GUIDE

RETAINING WALL

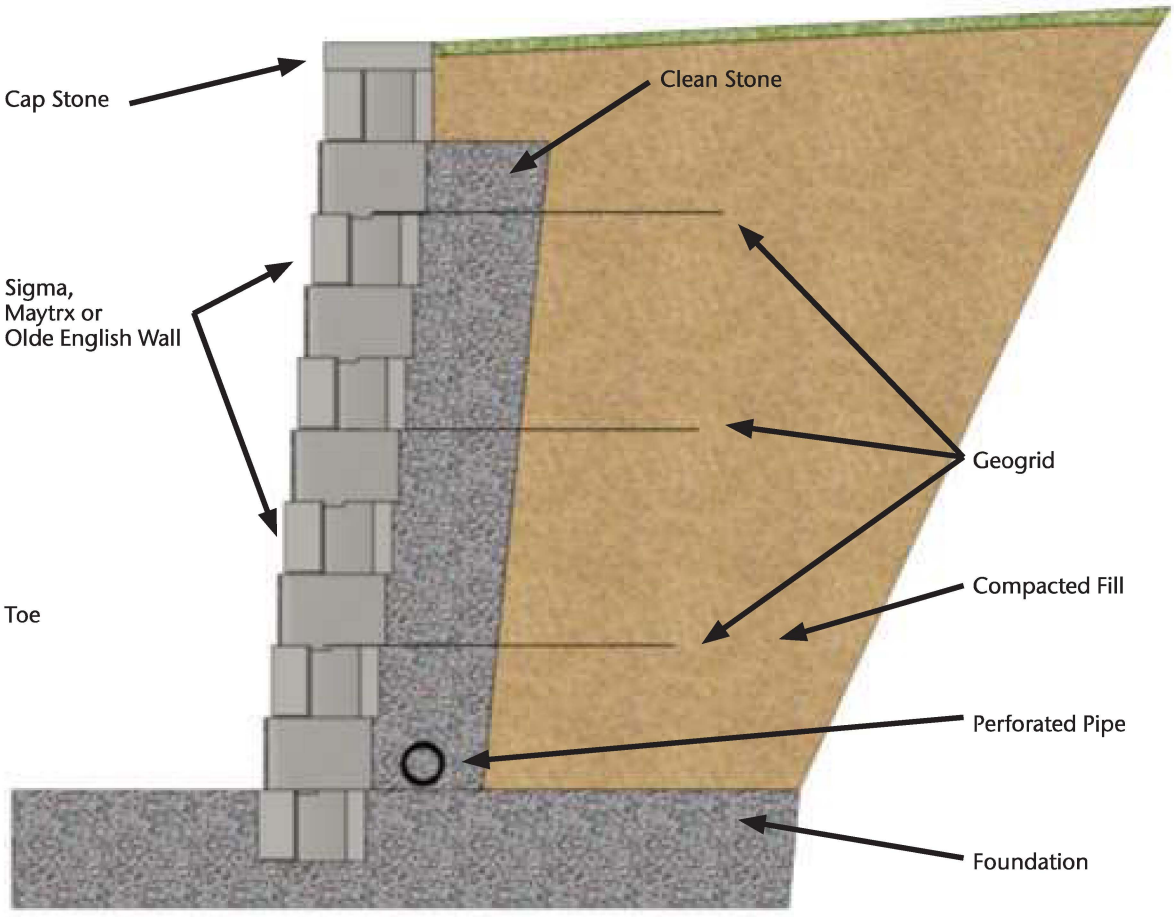
SIGMA-MAYTRX OLDE ENGLISH



BUILDING A WALL

SIGMA-MAYTRX OLDE ENGLISH

This is a starting guide to the Cambridge Retaining Wall Systems including Maytrx, Sigma and Olde English Walls. In this book we cover the general points that are important in building a retaining wall. For any wall over 36" you should also consult our "Sigma or Maytrx Pro-Guide" that is available to download or view at cambridgewallsupport.com or cambridgepavers.com. This will guide you through the factors that influence the strength of the finished wall including load, slope, soil condition, water runoff, geogrid layers, etc. Many municipalities require all retaining walls over a certain height to have a stamp made by a state approved engineer or similar professional that will specify how your wall is built. You will find information on the Cambridge program that allows you to get a free wall design or to receive low cost "stamped" specifications in your state on page 28 of this book. The Sigma stone face and accessories are similar in texture and color to the Cambridge Maytrx line of wall and Outdoor Living Kits. So if you require a tall wall in the rear of your property as well as a double sided wall in your garden and maybe in the future a fire pit or an outdoor fireplace, the finishes will all match.

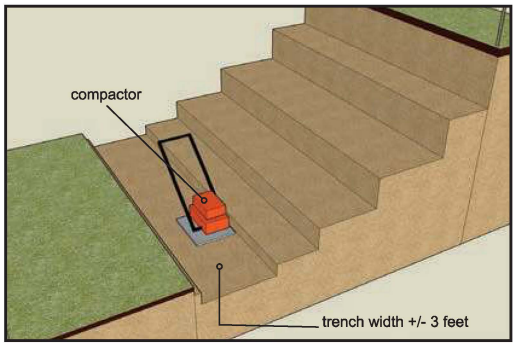


Retaining Walls are made up of more than the Wall Stones. Any wall over 36" consists of the pieces in the illustration above. Foundation, drain pipe, drainage stone, geogrid reinforcement, Wall Stones, Cambridge Cap Stones and select fill are all engineered and installed depending on the site conditions. View Page XX of this book for further information.

SIGMA-MAYTRX OLDE ENGLISH

Protection of soils

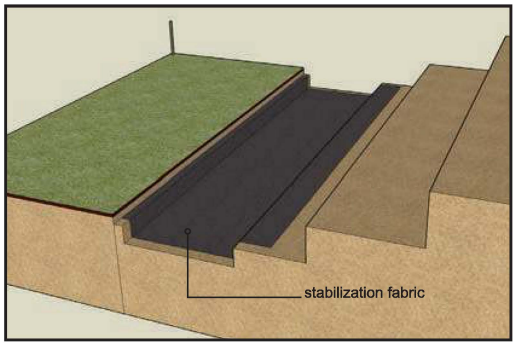
A proper moisture content is required to achieve proper compaction. Foundation soils and all fill soils should be protected from rain and freezing during construction. Frozen soils must NOT be used in retaining wall construction.



Compact sub base

- Compact the soils under the leveling pad to 95% "Standard Proctor Density" or greater.
- If organic soils are encountered they must be removed and replaced with acceptable soils.

TIP:This may, be the proper time to install the drain pipe see the drain pipe guidelines on page XX)



Base stabilization

- The purpose of the leveling pad is to provide a level surface to place the first course of units on. More importantly, the leveling pad spreads out the load of the retaining wall units over a larger area. The strength and quality of your retaining wall depends greatly on the strength and quality of your leveling pad materials.
- Over time the sub-base material can migrate into the leveling pad, thus contaminating it and diminishing its structural integrity. Base stabilization fabric (SRW SS5) separates the leveling pad materials from the sub-base materials so that its strength will not be compromised.

Sigma 6 wall has 4 knobs, install for 6 degree setback, or break off front knobs for near vertical (right)

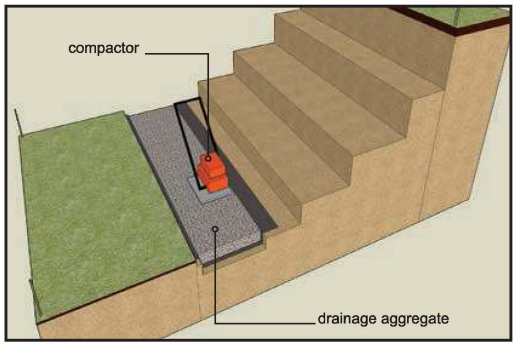
Maytrx Walls come in 6" or 3" height may be used as single sided (Retaining Wall or double sided Freestanding Wall

Olde English Wall may be setback 3/8" to build a wall that can be combined with engineering to serve as a retaining wall

SIGMA-MAYTRX OLDE ENGLISH

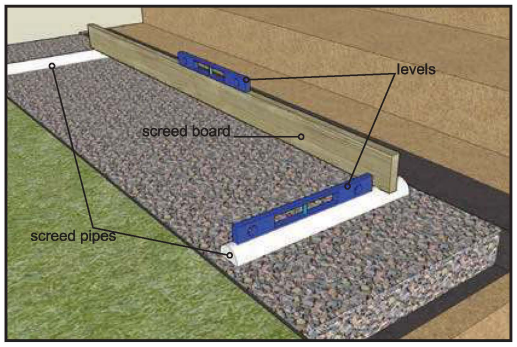
Leveling pad

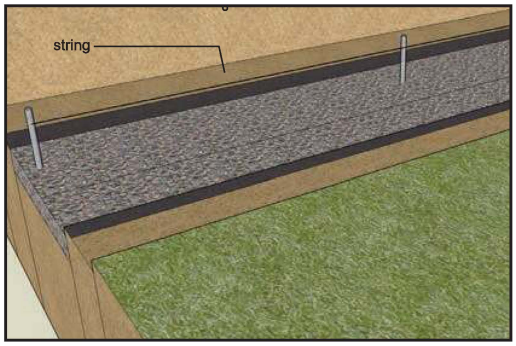
- If possible, start the leveling pad at the lowest elevation of the wall. It is easier to step up than to step down.
- Place well graded gravel or drainage aggregate in the leveling pad trench (see "Excavation" section for minimum leveling pad depths).
- Compact leveling pad to 95% Standard Proctor Density or greater.

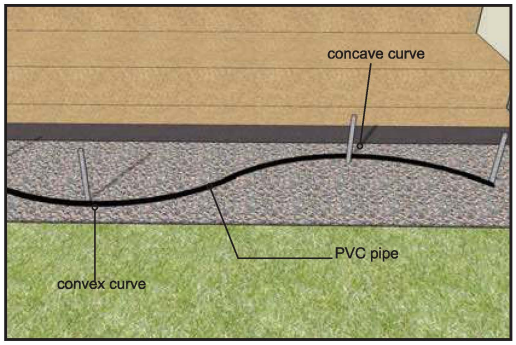


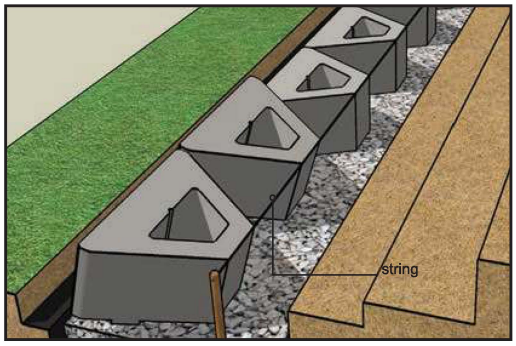
Screeding the leveling pad

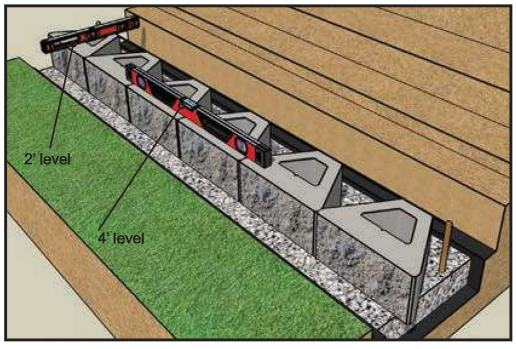
- Place screed pipes across the compacted leveling pad (see illustration).
- If a 10 foot screed is used, an 8 - 9 foot separation of screed pipes works well on straight walls. Screed pipes may need to be closer on curves or corners.
- Make sure the top of the screed pipes are at the correct bottom of the proposed block elevation and are level.
- Place the finish leveling pad material. (If more than 1 ½" is required, do the compaction again.)
- Screed the leveling pad material smooth, being careful that the screed pipes stay level and at the correct elevation.
- Repeat the screeding operation for the length of the leveling pad or if the wall steps up, to the 1st step of the leveling pad.
- Do not walk on or otherwise disturb the leveling pad prior to laying the first course of retaining wall units.





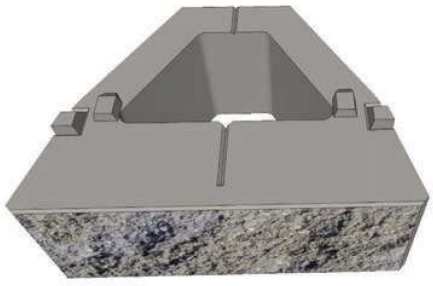






Laying first course: SIGMA

- Use steel stakes and a string line to lay out straight sections of the retaining wall.
- String lines should be placed so that they go along the BACK of the block in order to ensure a straight line. As opposed to the rock face surface on many retaining wall units.
- If the string line is placed at the correct elevation it can be used to check elevation and side to side levelness of the retaining wall unit.
- For laying out a retaining wall that curves, flexible 3/4" PVC pipe works well (see illustration for staking) (see curve and corner guidelines beginning on page 14).
- It is very important that the 1st course of block is laid correctly because it will determine the alignment of the rest of the retaining wall. Any deviations will be magnified as the height of the wall increases.
- It is usually best to start at the lowest elevation of the retaining wall. Again, it is easier to step up than to step down.
- If the bottom of the retaining wall unit has lugs, lips, or any other protrusions, use a hammer and chisel to break them off.
- Carefully place the unit on the screeded leveling pad, using the string line (for straight walls) or the flexible PVC pipe (for curved walls) as alignment guides.
- NEVER let the unit touch the string, because if each unit touches the string it will gradually push it out of alignment, which will result in a crooked wall. A good distance from the string is 1/16 - 1/8 inch away.
- For outside or convex curves, if the retaining wall unit has wings at the back of the unit they may be broken off to facilitate tighter curves.
- Always check the level of the retaining wall units, front to back, side to side, and the elevation in relation to the adjacent units.



Laying first course: Maytrx

- Use steel stakes and a string line to lay out straight sections of the retaining wall.
- String lines should be placed so that they go along the BACK of the block in order to ensure a straight line. As opposed to the rock face surface on many retaining wall units.
- If the string line is placed at the correct elevation it can be used to check elevation and side to side levelness of the retaining wall unit.
- For laying out a retaining wall that curves, flexible 3/4" PVC pipe works well (see illustration for staking) (see curve and corner guidelines beginning on page 14).
- It is very important that the 1st course of block is laid correctly because it will determine the alignment of the rest of the retaining wall. Any deviations will be magnified as the height of the wall increases.
- It is usually best to start at the lowest elevation of the retaining wall. Again, it is easier to step up than to step down.
- If the bottom of the retaining wall unit has lugs, lips, or any other protrusions, use a hammer and chisel to break them off.
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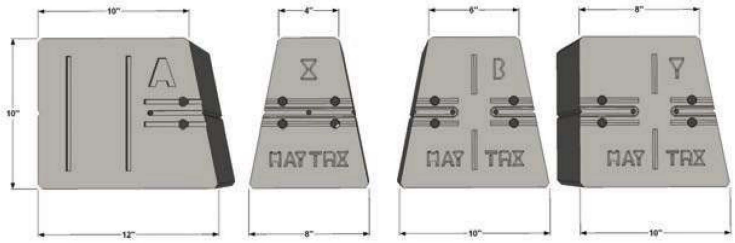

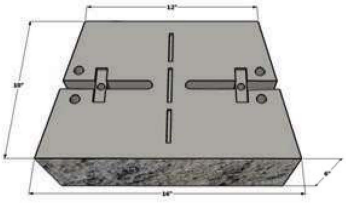

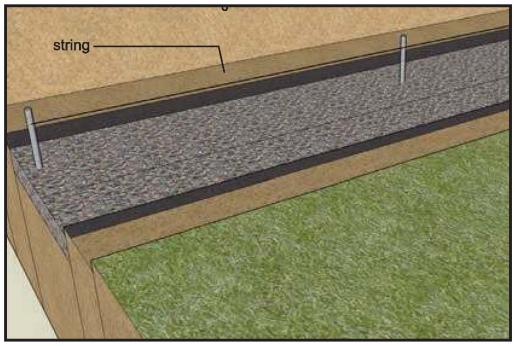

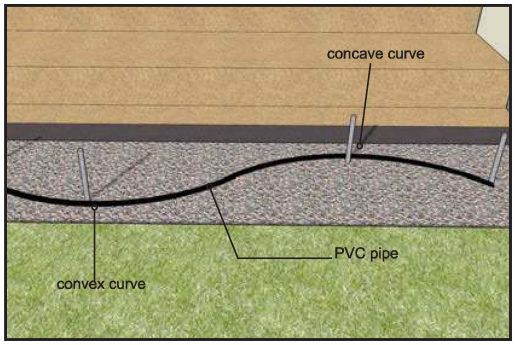

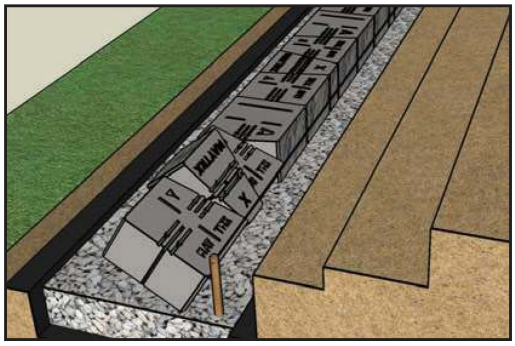

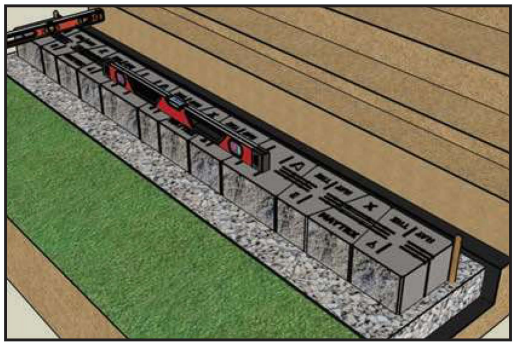

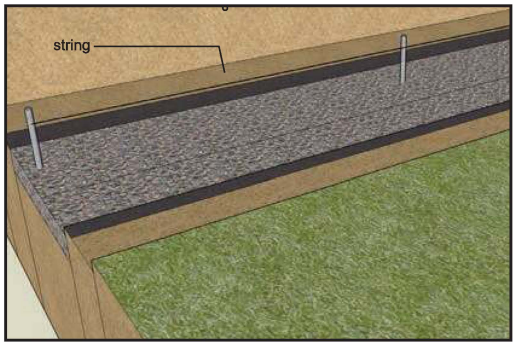

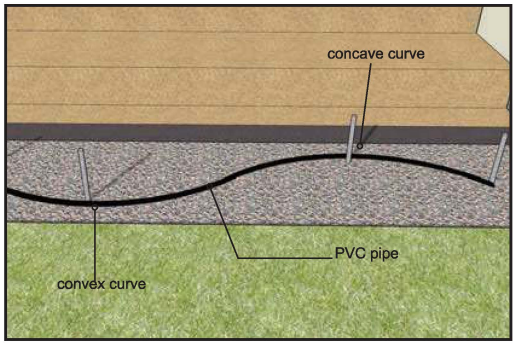

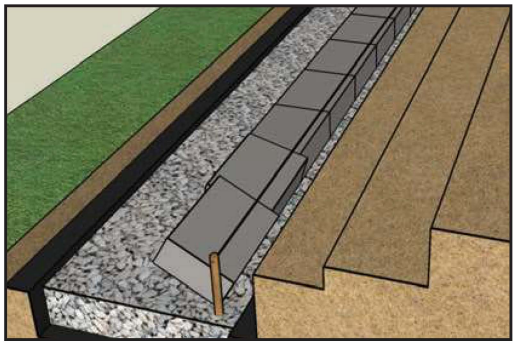

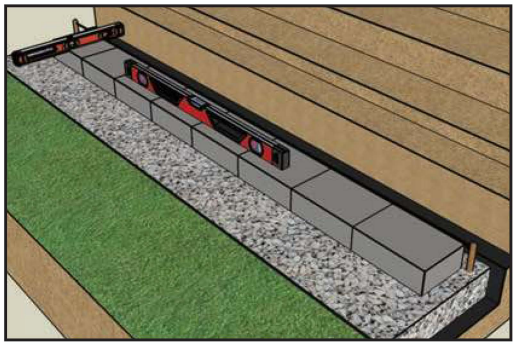

laying first course: Olde English

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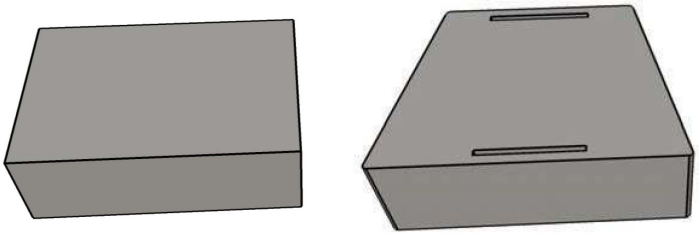

BACKFILL & COMPACTING

SIGMA

Backfill and compacting

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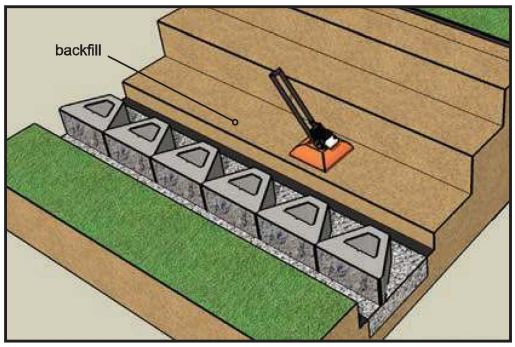
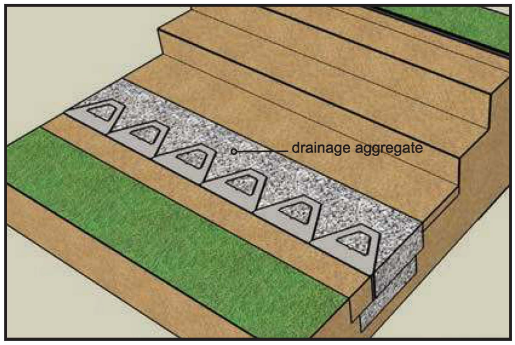
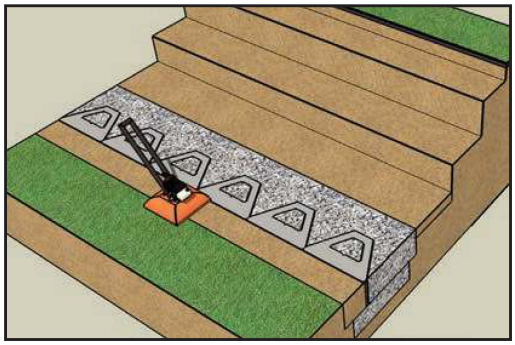
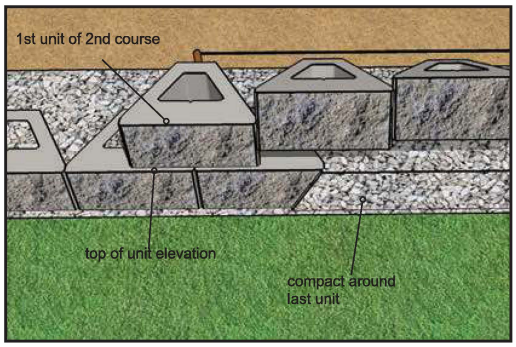


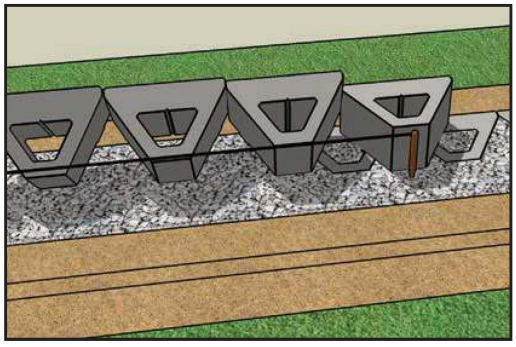


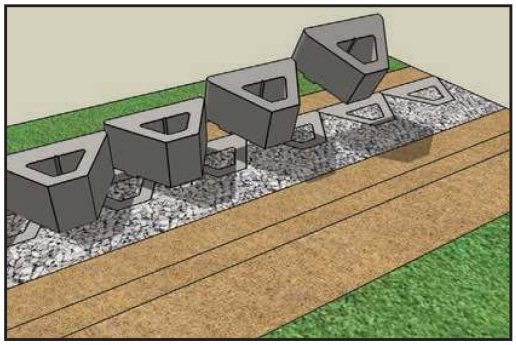


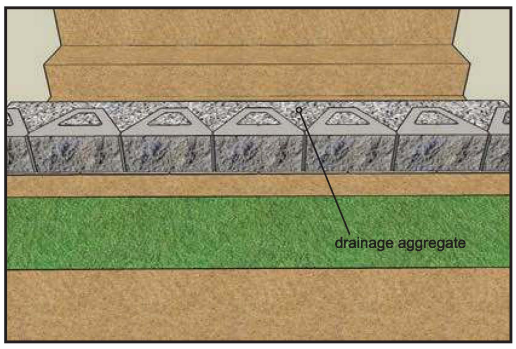
SIGMA

ELEVATION CHANGES & ADDITIONAL COURSES









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Additional courses

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BACKFILL & COMPACTING

OLDE ENGLISH

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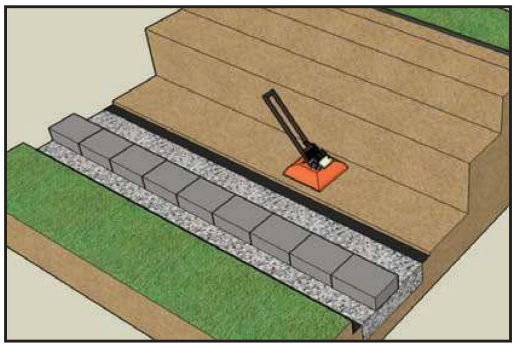
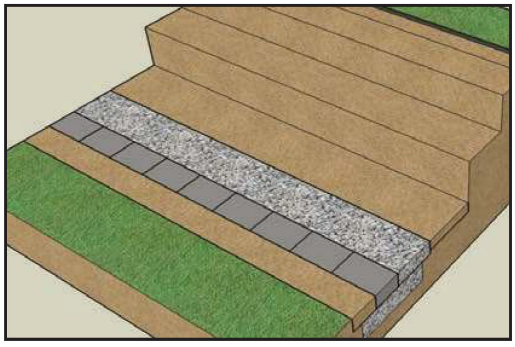
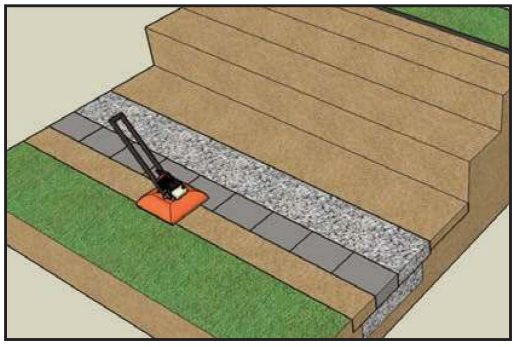
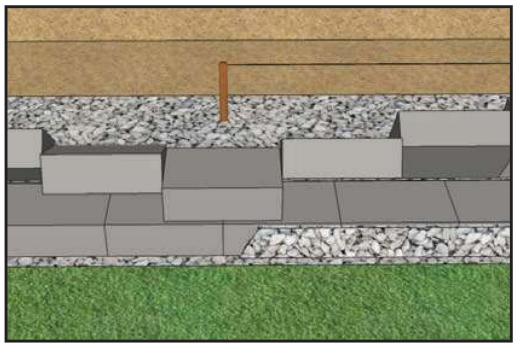


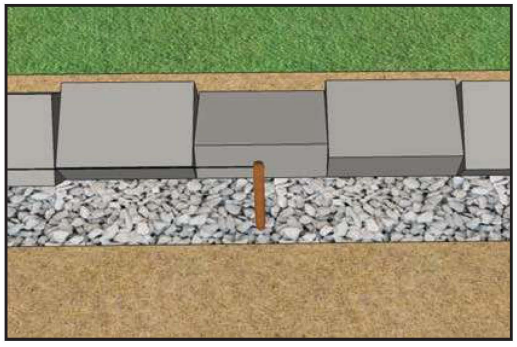


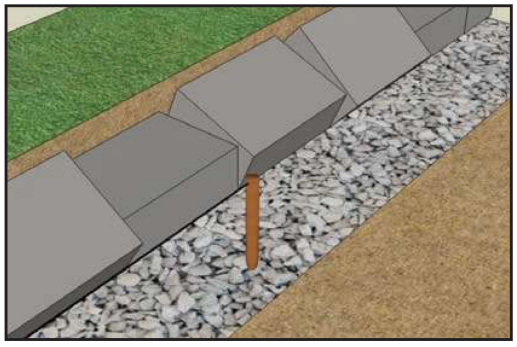


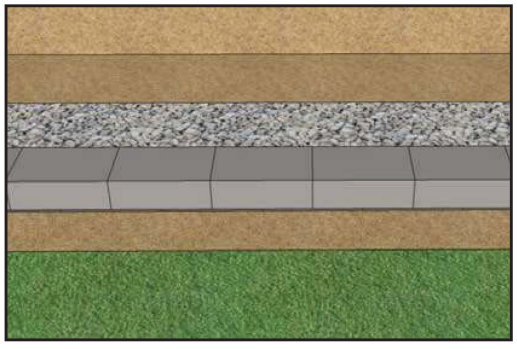
OLDE ENGLISH

ELEVATION CHANGES & ADDITIONAL COURSES









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MAYTRX

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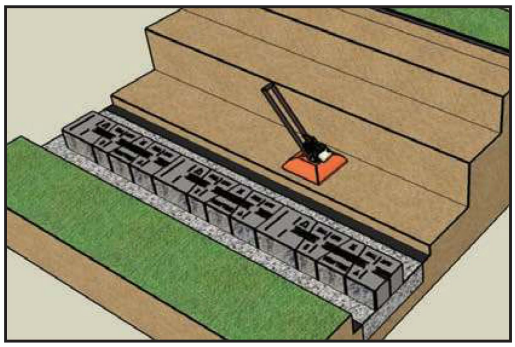
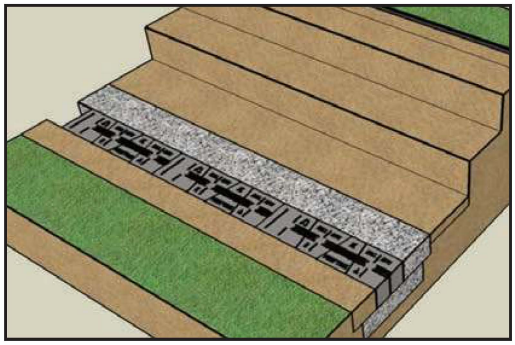
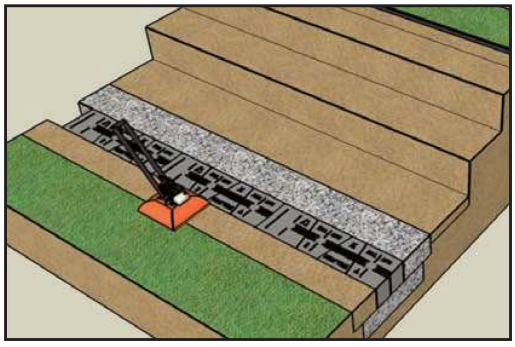
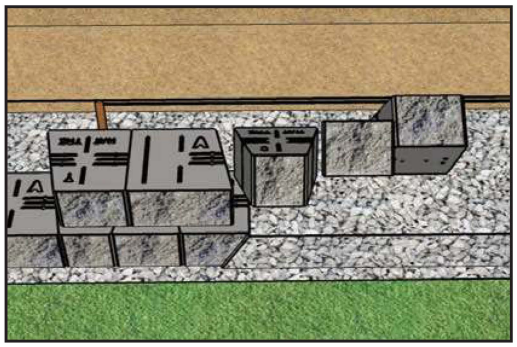


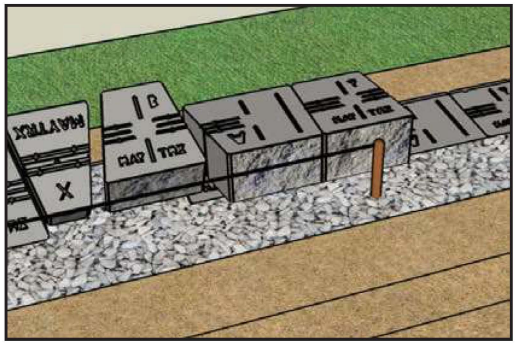


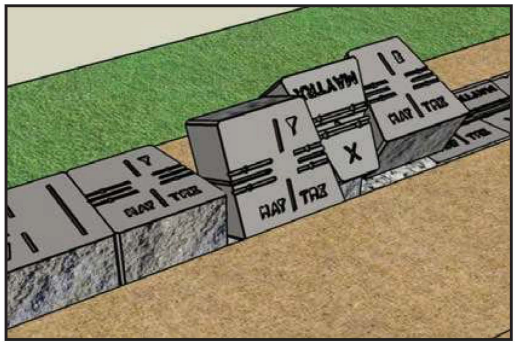


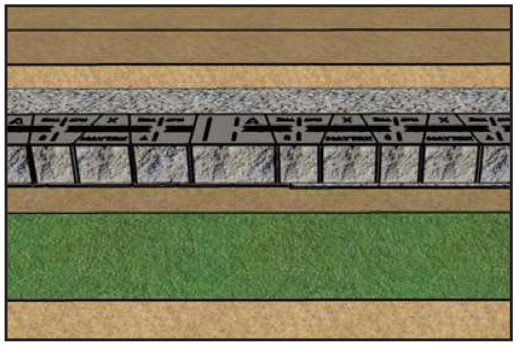
MAYTRX

ELEVATION CHANGES & ADDITIONAL COURSES









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INSTALLATION

SIGMA-MAYTRX OLDE ENGLISH

Capping

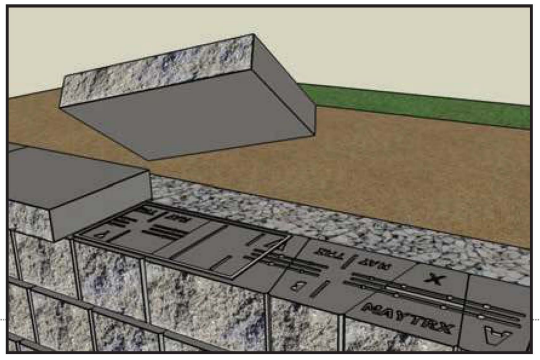
- Clean the top of the retaining wall units of all rock, dirt, and dust.
- Place a bead of retaining wall adhesive around the top of the last retaining wall unit.
- Place the cap on the retaining wall units. Note: A string line can be used to help line up the caps and straighten any waves that may have developed in the retaining wall.
- If a special cap unit is not used, bond the top course to the course just below.

filter fabric

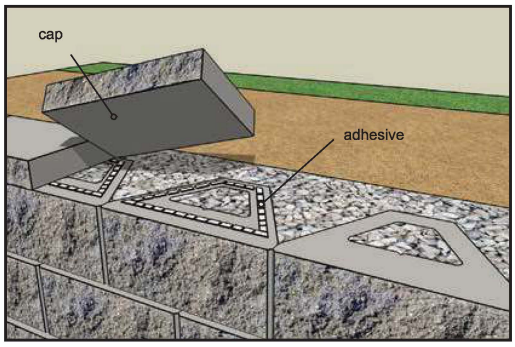
- Place filter fabric on top of the backfill, over the drainage aggregate, and up against the top units or caps before placing the top/planting soils.
- It is recommended that the top/planting soils should be an 8 inch layer of impermeable soils.
- The filter fabric will help prohibit the migration of the fines from the planting soil down into the drainage aggregate and out the face of the retaining wall, thus preventing the plugging of the drainage aggregate and staining of the wall face.

final steps of building the wall

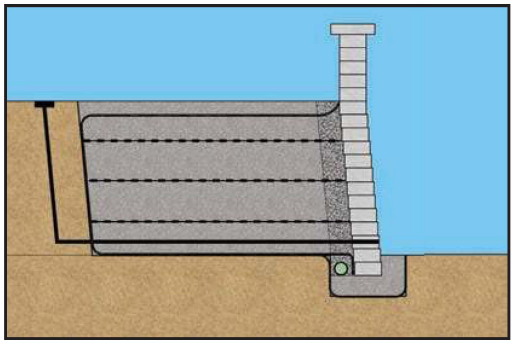
- When finishing the project make sure that the final grade, both the top and bottom of the wall, are shaped so as to divert any water runoff away from the retaining wall. Protect the planting soil from erosion during heavy rains.

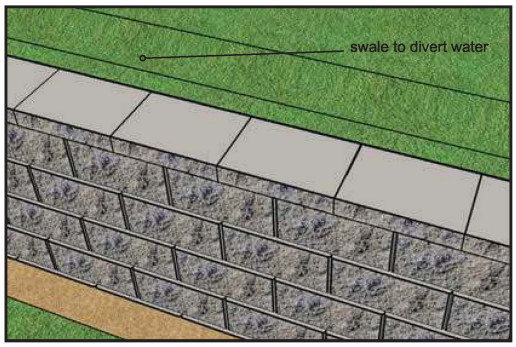


Applies to all the Wall Systems, 13" Caps and Large Caps are used on Maytrx and Sigma, Olde English uses the stone turned to make a cap

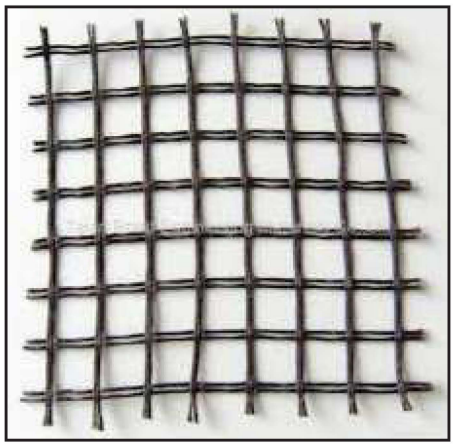


Bring the fabric under the Cap



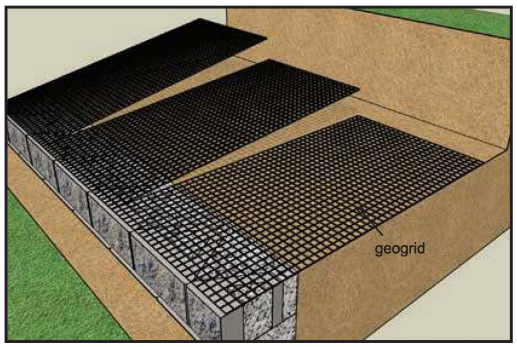


SIGMA-MAYTRX OLDE ENGLISH



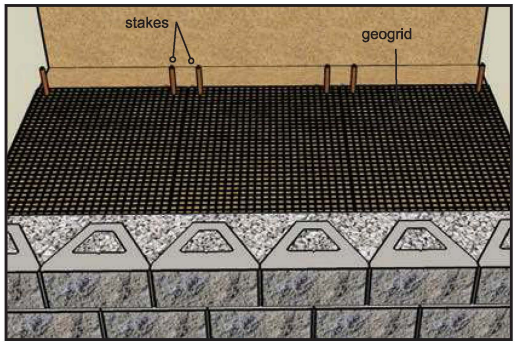
» Geogrid

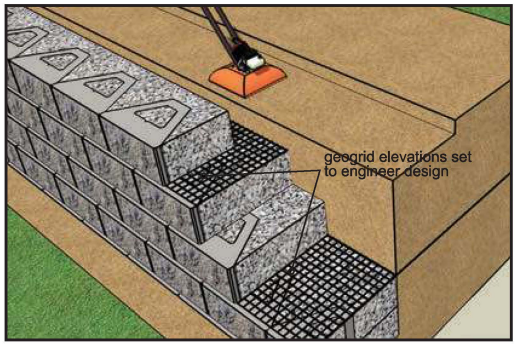
All installation instructions are the same as for gravity retaining walls EXCEPT for the addition of geogrid. Geogrid reinforces the soil, thus allowing taller walls to be constructed. Bi-directional/bi-axial geogrids, means the geogrid is the same strength in both directions. Because of that, this geogrid can be either rolled out parallel to the retaining wall or perpendicular to the retaining wall. If the geogrid depths are the same as the roll width, it may be more efficient to roll out the geogrid parallel to the retaining wall. If the geogrid depths called for are different than the roll width or if the wall curves, it is best to roll out the geogrid perpendicular to the retaining wall. (Not all geogrids are bi-axial, stronger geogrids must be rolled out perpendicular to the retaining wall.)



Using geogrid

- Geogrid depth is measured from the face of the retaining wall unit, to the back of the reinforced soil.
- Geogrid coverage should be 100%. However, the edges of the geogrid, should NEVER overlap. (See page 14 for curve and corner geogrid installation procedures.)
- Use your design table(s), found in page 26 of this guide to determine which course(s) of block to install the geogrid on and how deep it extends into the reinforced soil.
- Place the geogrid as far forward on the retaining wall unit as possible without it showing through the front/face of the retaining wall. Make sure that any connecting devices are engaged by the geogrid.
- Lay the geogrid flat from the wall units to the tail of the geogrid. The backfill, drainage aggregate, and core fill should be level with the top of the retaining wall unit and the geogrid should be as smooth as possible, with no pockets that would create voids under the geogrid.
- Place the next course of block on top of the geogrid and fill the cores with drainage aggregate, if applicable.
- Pull the geogrid taught, being careful not to pull the units back away from the connecting device or disturb the alignment of the units. Use landscape staples or stakes to hold the geogrid in place.



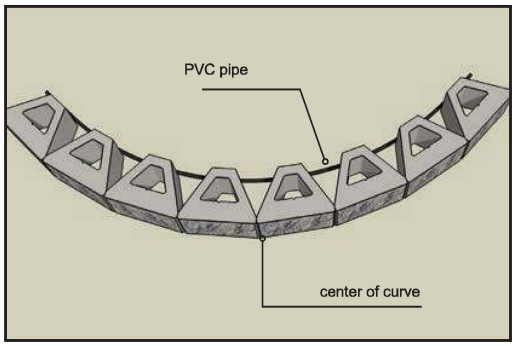


Using geogrid (continued)

- Do not drive or compact directly on the geogrid. A minimum of 6 inches of soil is recommended to cushion the geogrid.
- When backfilling over the geogrid, work the soil from near the retaining wall units toward the tail of the geogrid. When compacting over the geogrid, work from near the retaining wall units toward the tail of the geogrid. This procedure helps keep the geogrid taught.
- See the curve and corner instructions starting below, for geogrid placement.
- continue building wall
- Continue building the retaining wall by returning to “additional courses” on page 11.

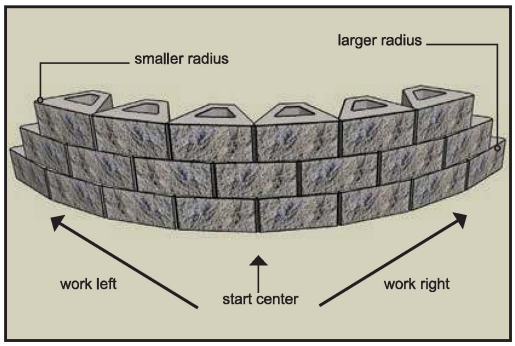
Convex • Outside • Curves

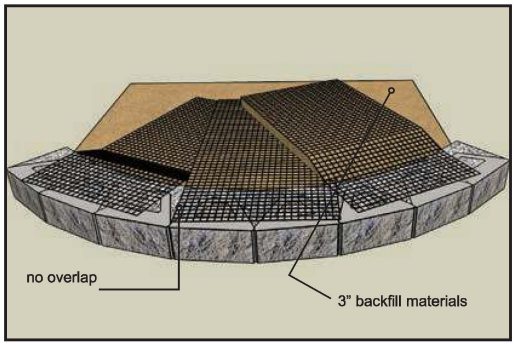
- To achieve desired curve alignment, use 3/4” flexible PVC pipe to outline the back of your retaining wall unit location. This will give you a guideline to help achieve smooth and accurate curves.
- If possible, it is best to start building a curve from the center of the curve and work outward in both directions.
- Start at the same location for all additional courses of retaining wall units.
- If the unit has wings at the back of the block, one or both may be broken off to achieve a tighter radius.
- Because of the batter (unit setback), the bottom course radius will be larger than the radius of the top course. The taller the wall the larger the bottom course radius needs to be in relation to the top course radius.



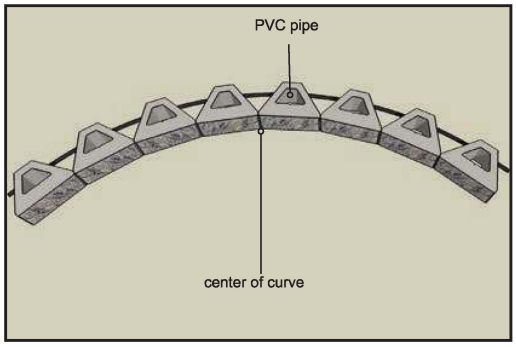
Convex curve geogrid placement

- Geogrid coverage should be 100% butted together, but NOT overlapped on the retaining wall units.
- The geogrid tail, starting just behind the unit will be overlapped. A minimum of 3 inches of soil must be placed between these overlapping geogrid layers.



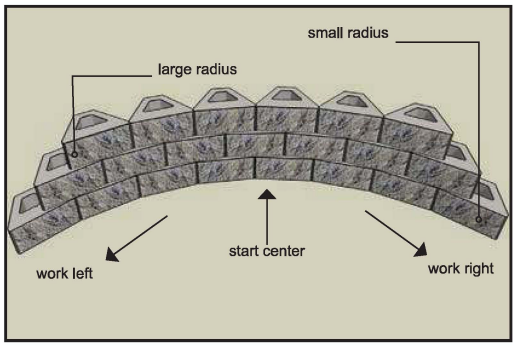


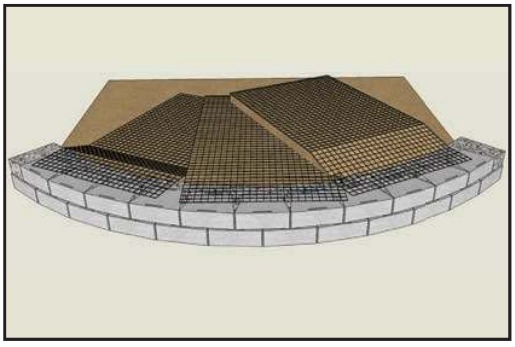
SIGMA-MAYTRX OLDE ENGLISH

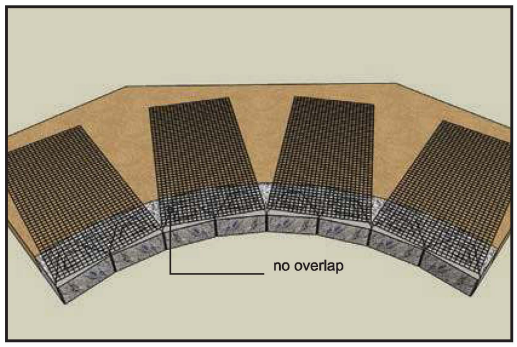


Concave • inside • curves

- To achieve desired curve alignment, use 3/4" flexible PVC pipe to outline the back of your retaining wall unit location. This will give you a guideline to help achieve smooth and accurate curves.
- If possible, it is best to start building a curve from the center of the curve and work outward in both directions.
- Start at the same location for all additional courses of units.
- Because of the batter (unit setback) the bottom course radius will be smaller than the radius of the top course. The taller the wall the smaller the bottom course radius will be in relation to the top course radius.

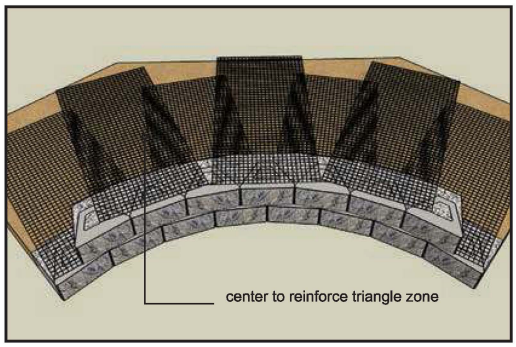


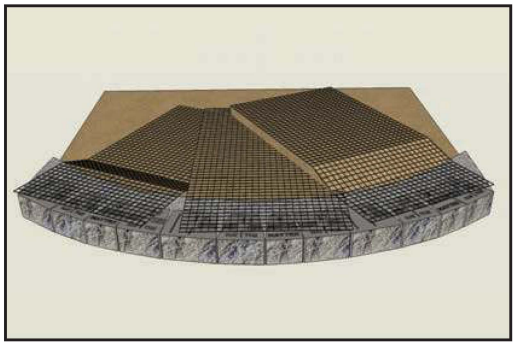




Concave curve

- geogrid placement
- Geogrid coverage should be 100% butted together, but NOT overlapped on the retaining wall units.
- There will be a V or pie shaped wedge of soil starting just behind the units which will not be reinforced. To compensate for the unreinforced section, on the next course of retaining wall units, geogrid is placed by centering over the pie shaped wedge of unreinforced soil below.



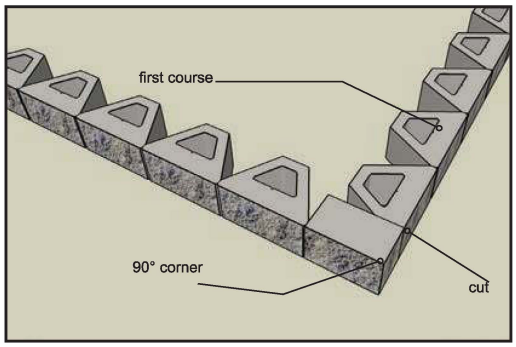


INSTALLATION

SIGMA

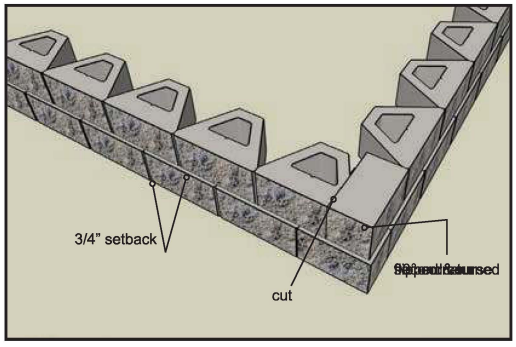
Outside 90° corner

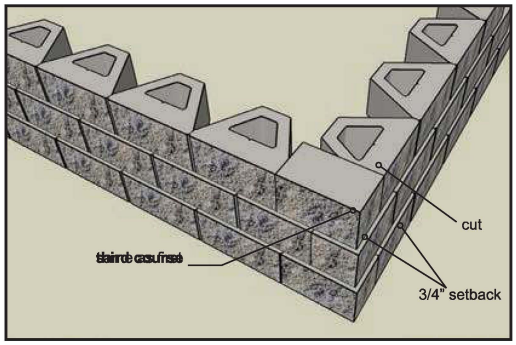
- Lay the corner according to the retaining wall system instructions. Some systems will have special corner units, some will have hand splitting lines, and others will require cutting.
- Each course is usually laid opposite of the course below.
- Where connecting devices cannot be used on corner blocks be sure to keep the same batter (setback) as the rest of the retaining wall.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.

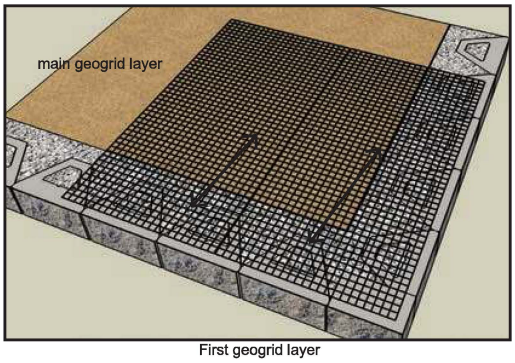


Outside corner

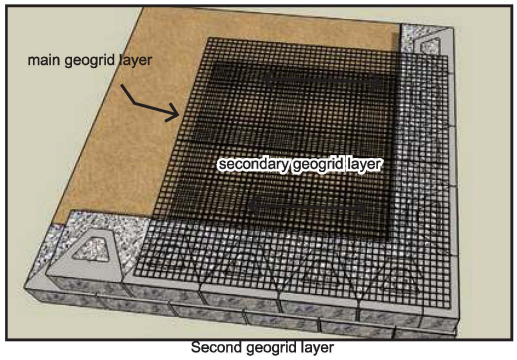
- geogrid placement
- On the 1st course, place the corner wallstone as shown in the top image.
- Then place a full wallstone next to the long face of the Sigma 8 Corner wallstone.
- Cut the wallstone that is placed next to the small face of the corner wallstone to 15 3/4”.
- On the 2nd course the corner wallstone is placed in the opposite direction with a 3/4” setback from the bottom course in both directions.
- Again, place a full wallstone next to the long face of the corner wallstone.
- Then, leaving a space for the wallstone to be cut next to the small face of the corner wallstone, place a full wallstone over two wallstones of the lower course in a half bond fashion. Line up the knobs of the wallstone you are placing with the cores of the wallstones in the lower course.
- Measure between the corner wallstone and the full wallstone. Then cut a full wallstone to that dimension and place in the space that was left for it.
- Continue this process for each additional course.
- Fuller corner instructions are available in an additional sheet from your Sigma supplier.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.



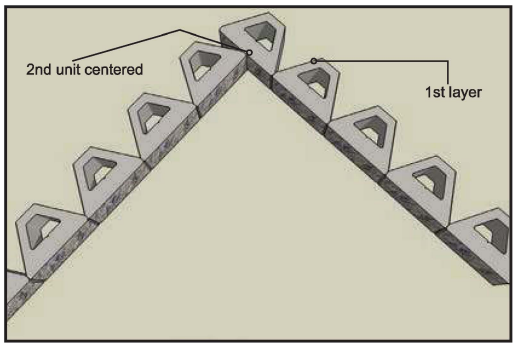




First geogrid layer

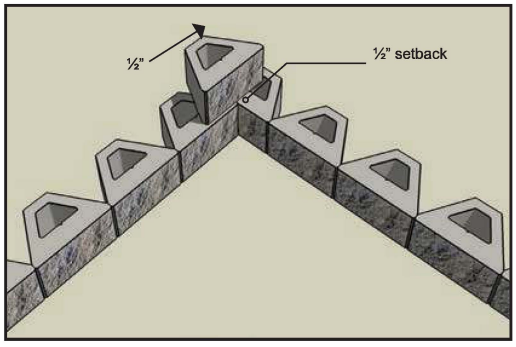


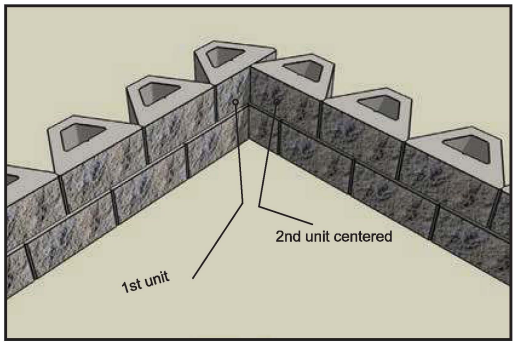
Second geogrid layer



Inside 90° corner

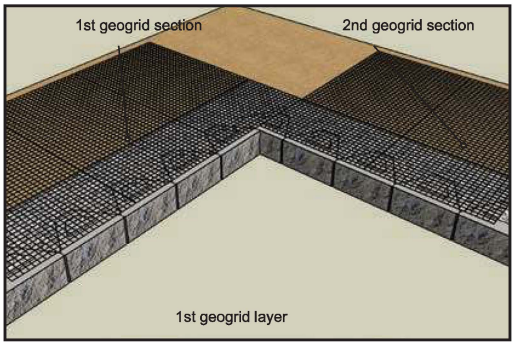
- On the first course, place the face of the first unit of the 90 degree corner at the center of and against the last unit of the wall that the corner is turning from (see illustration).
- On the second course, start the corner in the opposite manner with the first unit being laid straddling the 90 degree corner.
- That unit must be set with the same amount of batter (set back) and slid into the corner the same distance as the batter (set back) for each course.
- The 90 degree unit must be placed against the face of the corner unit.
- Repeat the above steps, alternating the corner units so that they are woven together, forming the 90 degree corner.

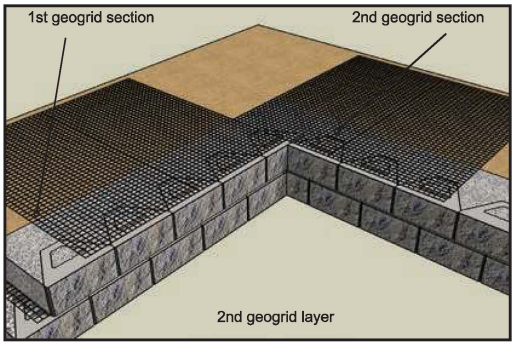




Inside curve geogrid placement

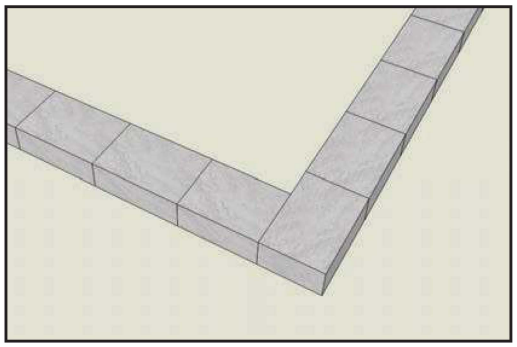
- The first layer of geogrid should extend past the corner a distance which equals the height of the retaining wall divided by 4 (Height of Wall ÷ 4).
- The second layer of geogrid is laid, butting to the 1st layer.
- Per your design table, when the next layer of geogrid is required, that layer of geogrid, on the other leg of the corner, should extend past the corner a distance which equals the height of the retaining wall divided by 4. (Height of wall ÷ 4)
- Continue to alternate the geogrid extending past the corner on every other layer.





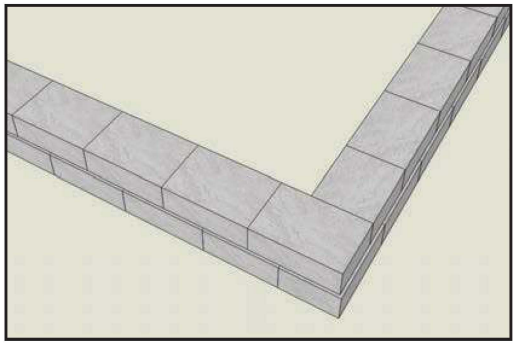
Outside 90° corner

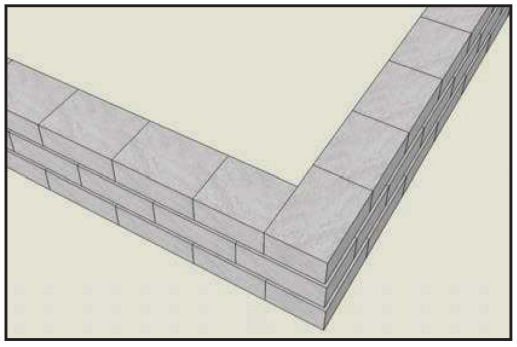
- Lay the corner according to the retaining wall system instructions. Some systems will have special corner units, some will have hand splitting lines, and others will require cutting.
- Each course is usually laid opposite of the course below.
- Where connecting devices cannot be used on corner blocks be sure to keep the same batter (setback) as the rest of the retaining wall.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.

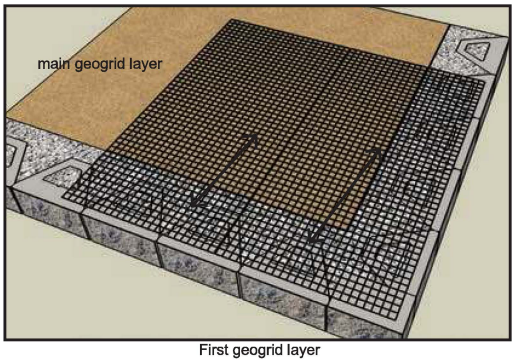


Outside corner

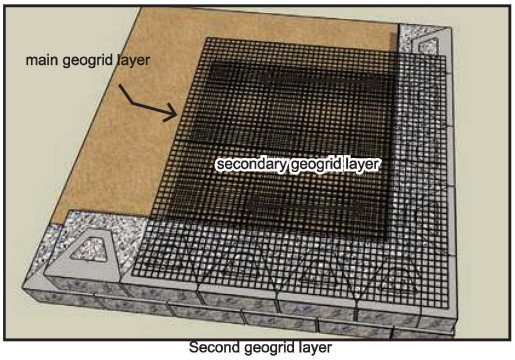
- geogrid placement
- On the 1st course, place the corner wallstone as shown in the top image.
- Then place a full wallstone next to the long face of the Sigma 8 Corner wallstone.
- Cut the wallstone that is placed next to the small face of the corner wallstone to 15 3/4".
- On the 2nd course the corner wallstone is placed in the opposite direction with a 3/4" setback from the bottom course in both directions.
- Again, place a full wallstone next to the long face of the corner wallstone.
- Then, leaving a space for the wallstone to be cut next to the small face of the corner wallstone, place a full wallstone over two wallstones of the lower course in a half bond fashion. Line up the knobs of the wallstone you are placing with the cores of the wallstones in the lower course.
- Measure between the corner wallstone and the full wallstone. Then cut a full wallstone to that dimension and place in the space that was left for it.
- Continue this process for each additional course.
- Fuller corner instructions are available in an additional sheet from your Sigma supplier.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.



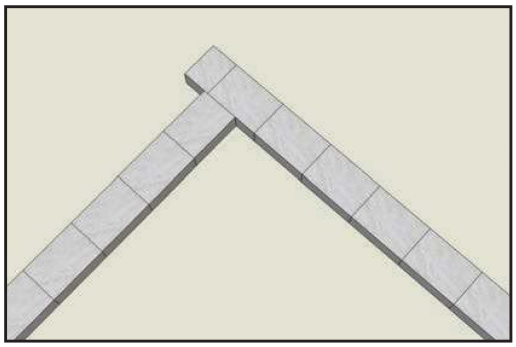




First geogrid layer

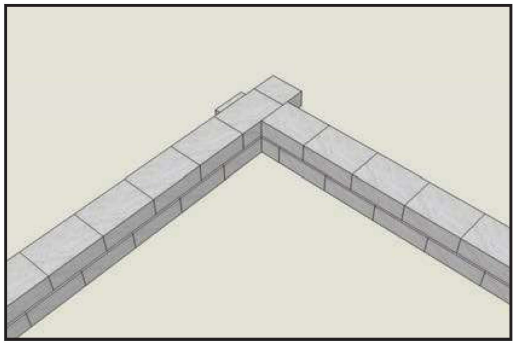


Second geogrid layer



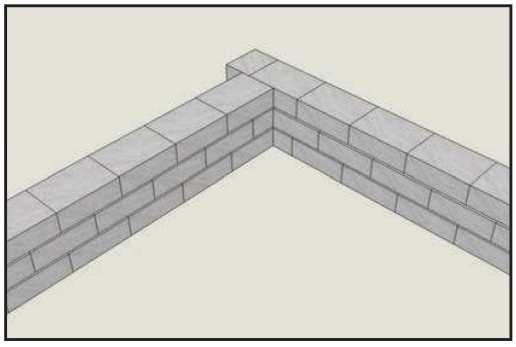
Inside 90° corner

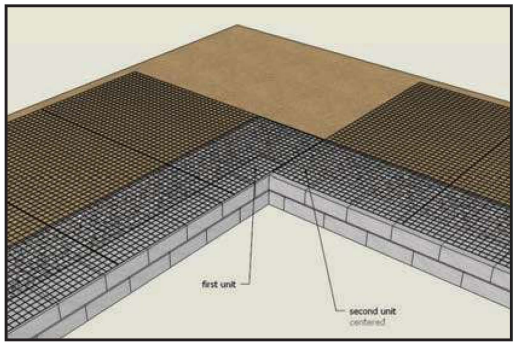
- On the first course, place the face of the first unit of the 90 degree corner at the center of and against the last unit of the wall that the corner is turning from (see illustration).
- On the second course, start the corner in the opposite manner with the first unit being laid straddling the 90 degree corner.
- That unit must be set with the same amount of batter (set back) and slid into the corner the same distance as the batter (set back) for each course.
- The 90 degree unit must be placed against the face of the corner unit.
- Repeat the above steps, alternating the corner units so that they are woven together, forming the 90 degree corner.

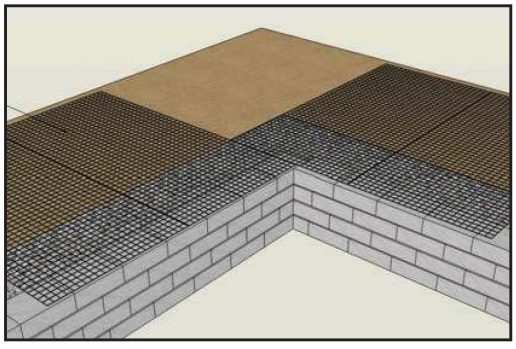


Inside curve geogrid placement

- The first layer of geogrid should extend past the corner a distance which equals the height of the retaining wall divided by 4 (Height of Wall ÷ 4).
- The second layer of geogrid is laid, butting to the 1st layer.
- Per your design table, when the next layer of geogrid is required, that layer of geogrid, on the other leg of the corner, should extend past the corner a distance which equals the height of the retaining wall divided by 4. (Height of wall ÷ 4)
- Continue to alternate the geogrid extending past the corner on every other layer.

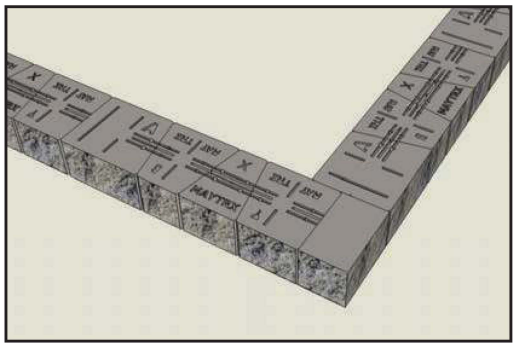






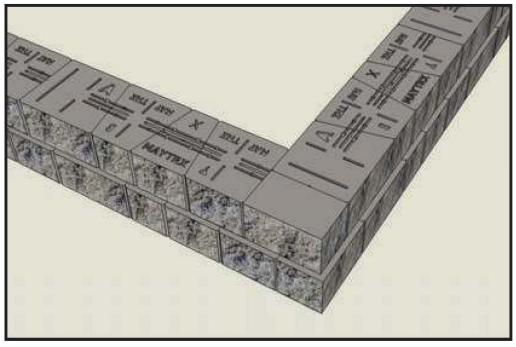
Outside 90° corner

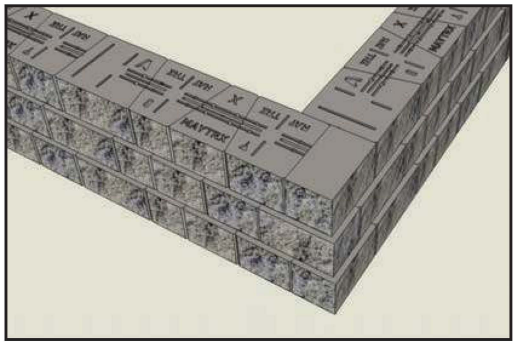
- Lay the corner according to the retaining wall system instructions. Some systems will have special corner units, some will have hand splitting lines, and others will require cutting.
- Each course is usually laid opposite of the course below.
- Where connecting devices cannot be used on corner blocks be sure to keep the same batter (setback) as the rest of the retaining wall.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.

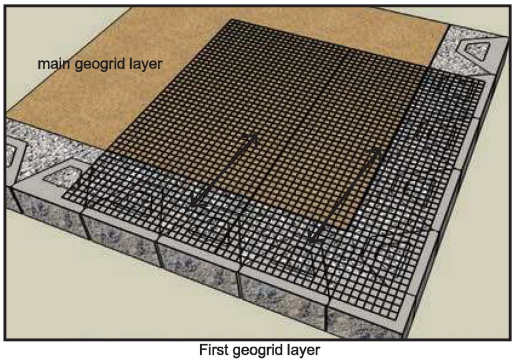


Outside corner

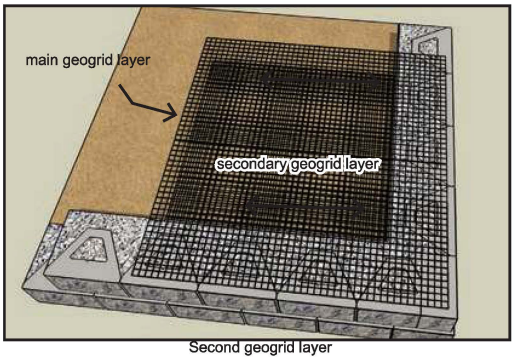
- geogrid placement
- On the 1st course, place the corner wallstone as shown in the top image.
- Then place a full wallstone next to the long face of the Sigma 8 Corner wallstone.
- Cut the wallstone that is placed next to the small face of the corner wallstone to 15 3/4".
- On the 2nd course the corner wallstone is placed in the opposite direction with a 3/4" setback from the bottom course in both directions.
- Again, place a full wallstone next to the long face of the corner wallstone.
- Then, leaving a space for the wallstone to be cut next to the small face of the corner wallstone, place a full wallstone over two wallstones of the lower course in a half bond fashion. Line up the knobs of the wallstone you are placing with the cores of the wallstones in the lower course.
- Measure between the corner wallstone and the full wallstone. Then cut a full wallstone to that dimension and place in the space that was left for it.
- Continue this process for each additional course.
- Fuller corner instructions are available in an additional sheet from your Sigma supplier.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.



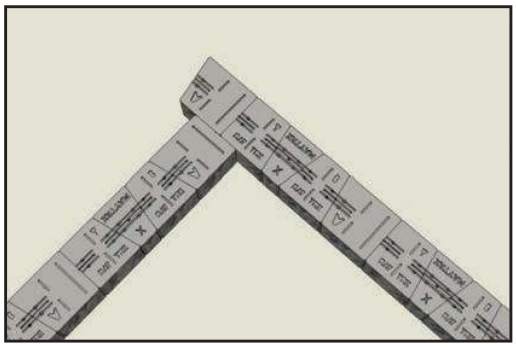


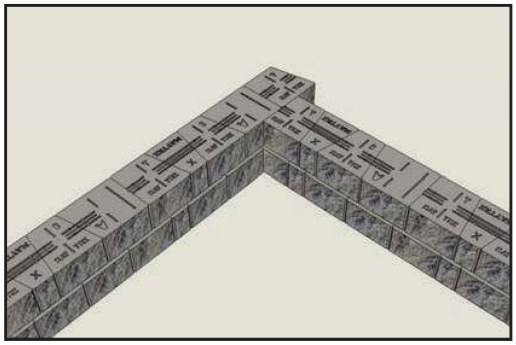


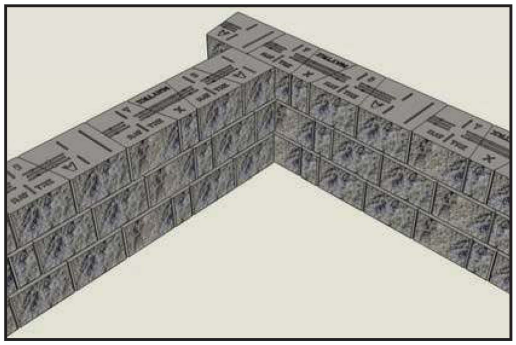
First geogrid layer



Second geogrid layer





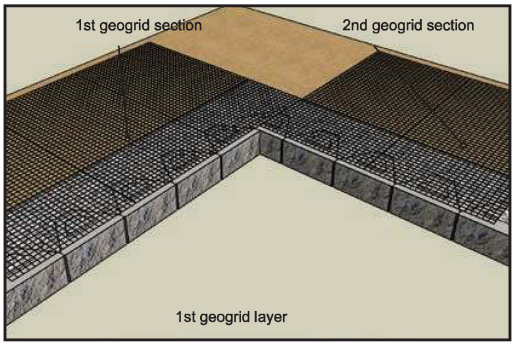


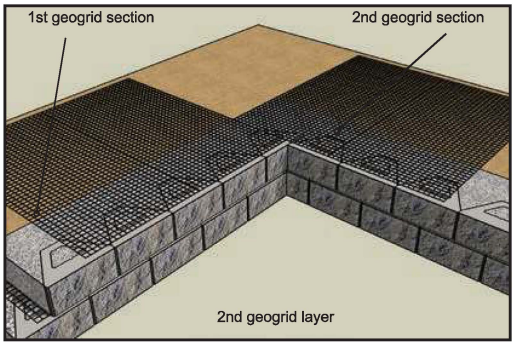
Inside 90° corner

- On the first course, place the face of the first unit of the 90 degree corner at the center of and against the last unit of the wall that the corner is turning from (see illustration).
- On the second course, start the corner in the opposite manner with the first unit being laid straddling the 90 degree corner.
- That unit must be set with the same amount of batter (set back) and slid into the corner the same distance as the batter (set back) for each course.
- The 90 degree unit must be placed against the face of the corner unit.
- Repeat the above steps, alternating the corner units so that they are woven together, forming the 90 degree corner.

Inside curve geogrid placement

- The first layer of geogrid should extend past the corner a distance which equals the height of the retaining wall divided by 4 (Height of Wall ÷ 4).
- The second layer of geogrid is laid, butting to the 1st layer.
- Per your design table, when the next layer of geogrid is required, that layer of geogrid, on the other leg of the corner, should extend past the corner a distance which equals the height of the retaining wall divided by 4. (Height of wall ÷ 4)
- Continue to alternate the geogrid extending past the corner on every other layer.





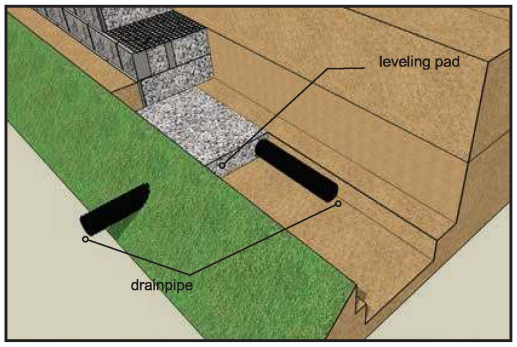
SIGMA-MAYTRX OLDE ENGLISH

» Drainage pipe specifications

- The drain pipe should a minimum diameter of 4 inches.
- Drain pipe outlets can be under the wall units, through the wall units or out the end of the retaining wall. An outlet must be placed at the lowest point of the retaining wall and a minimum of every 50 feet. The drain pipe must be sloped so water can gravitate out of the pipe.

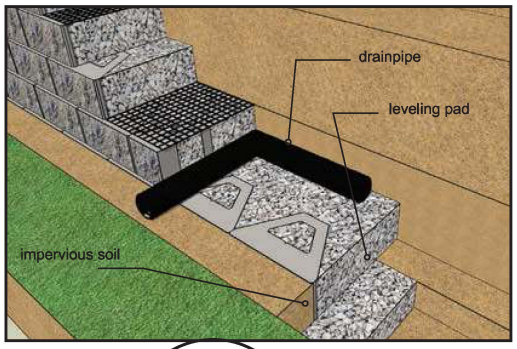
Drain pipe outlet (under/out end)

- Drainage aggregate is used for the leveling pad.
- The drainage aggregate chimney extends down to the leveling pad.
- The drain pipe is placed in the leveling pad directly under the drainage aggregate chimney.
- The outlets are either T'd out under the retaining wall units and daylight out of the slope in front of the retaining wall and/or the drain pipe daylights out of the end of the wall.



Drain pipe outlet

- (thru face of wall/out end)
- The leveling pad material can either be well graded gravel or drainage aggregate.
- Impervious soil (soil that water will not pass through) is placed over the leveling pad and extends to the back of the excavation, between the units, in the unit cores (if applicable), and in front of the retaining wall units, up to the finish grade elevation at the bottom (front) of the retaining wall.
- The drain pipe is placed at the bottom of the drainage aggregate chimney. The drain outlets are T'd out the face or out the end of the retaining wall.
- A notch will need to be cut in the bottom of the retaining wall unit for the outlet to exit through.



additional information

- The material quantities are not represented to be exact, but should be close if the finished retaining wall ends up as originally planned.
- When you first start to use this material estimation method, it would be wise to check the quantities against your usual method of estimating materials to check the accuracy of this method.
- There has been no provision for waste, breakage, or other contingencies that would change material quantities in this material estimating procedure.
- Hardscape Technical Services assumes no responsibility for the accuracy of the material quantities resulting from the use of this estimation method. The responsibility for accuracy of quantities is the user's sole responsibility.

HOW TO CALCULATE THE COST OF YOUR RETAINING WALL

MATERIAL ESTIMATING

step 1 » square feet of wall facing

a. Determine the total height of each end of the wall section using the accompanying design tables. The wall heights are shown directly under the design. Choose the design by picking the exposed wall height that is the same as the height of your proposed retaining wall or, if there is not an exact match choose the next taller design. Then for estimating purposes choose the total height of the design that is indicated below the design. In most cases there will be at least one block buried. Don't forget to include that in your height determination. Again, the total height without the cap is located below the wall in the design tables.

b. Add the total heights (1•a above) of the two ends of the wall section together and divide by 2 to determine the average height of the wall section.

_____ + _____ = _____ ÷ 2 = _____
beginning total hgt | end total hgt | average wall hgt

c. Multiply the average height (1•b above) by the lineal footage of the wall section to determine the number of square feet of wall facing.

_____ x _____ = _____
average hgt | lineal footage | sq. ft. wall face

d. If the wall section steps at either the top of wall or bottom of wall, add 1/2 course of block. Do this by dividing the length of the wall section by 2. **Multiply that result by the Sq ft of Wall System(*see note).** Then add that result to the square feet (1•c above) of wall facing.

_____ ÷ 2 _____ x .(*see note) = _____
wall length | additional sq. ft.

NOTE: TO CALCULATE SQ FT (Per Unit) USE THESE NUMBERS
- For Sigma 6" use .6667, For Sigma 8" use 1.00 (Sq Ft)
- Maytrx use 1 (sq ft)
- Olde English use .333 (sq ft)

_____ + _____ = _____
sq. ft wall face | additional sq. ft. | total sq. ft.

GEOGRID

SIGMA-MAYTRX OLDE ENGLISH

Design tables

Table use guidelines

without or before requesting engineering

For determining Geogrid type, Soil Type, and Case for estimating costs before requesting stamped engineering or for walls that are low enough in height that they do not require a permit or stamped engineering, the procedure is as follows:

Geogrid type

a. For walls up to 6' exposed height either SRW Universal or SRW 3 Series geogrid may be used. The type used may be determined by which type is most economical or which type your dealer has in stock.
b. For walls that are over 6' exposed height and up to 8' exposed height, only SRW 3 Series geogrid may be used.

Soil type

Use the soil classification and approximate friction angle information below.
a. Chart A shows the symbols for the different soil types.
b. Use the Unified Soil Classification System table (Chart B) to determine your soil type.

Chart A: USCS Symbol Definitions

1st and/or 2nd Letters	Definition	2nd Letter	Definition
GG	ravelP		Poorly Graded (uniform particle sizes)
S	SandW		Well Graded (diversified particle sizes)
MS	iltH		High Plasticity
CC	layL		Low Plasticity
OO	rganic		

Chart B: Unified Soil Classification System

Major Divisions			USCS Symbol	Typical Descriptions
COURSE GRAINED SOILS More than 50% of the material is larger than the #200 (.075 mm) sieve	GRAVELS More than 50% of the course fraction is larger than the #4 (4.75 mm) sieve	CLEAN GRAVELS	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS with over 12% fines	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS More than 50% of the coarse fraction is smaller than the #4 sieve	CLEAN SANDS	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS with over 12% fines	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS More than 50% of the material is smaller than the #200 sieve	SILTS AND CLAYS Liquid limit less than 50		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS, ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS Liquid limit greater than 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILSP			T	PEAT, HUMUS, SWAMP SOILS WITH LIGHT ORGANIC CONTENTS

c. Chart C shows particle sizes for different soil types. National Concrete Masonry Association guidelines indicate that rocks/stones over 4" in diameter should not be used in the retaining wall backfill. Bigger diameter pieces in the backfill make compaction problems.

d. Choose the Friction Angle of the soil from Chart D. Be conservative. Choose the friction angle at the bottom of the range, i.e. 26° instead of 28°. If there is any question about soil type, it is wise to choose the 26° soils. It is best not to under-estimate the cost of the retaining wall. Also, the cost difference on retaining walls of these heights is not great enough to risk an under-designed retaining wall.

Chart C: USCS Particle Sizes

Inches	US Standard Sieve #	Particle Size
Over 8"		Boulder
8" to 3"C		obble
3" to 3/4"G		ravel (course)
3/4" minus	4	Gravel (fine)
-4	to 10	Sand (course)
-	10 to 40	Sand (medium)
-	40 to 200	Sand (fine)
-	200 & over	Silt or Clay
1 micron = .001"		

Chart D: Approximate Friction Angle of Soil Types

Soil Description	USCS Classification	Wall Backfill Use Range	Friction Angle Range
Sand, Gravel, Stone	GW, GP, GM, GC, SW, SP	Good	30° - 34°
Silty Sands, Clayey Sands	SM, SC	Moderate	28° - 30°
Silts, Low Plasticity Clays	ML, CL, OL	Difficult	26° - 28°
High Plasticity Silts & Clays, Organics	CH, MH, OH, PT	Bad	0° - 26°

Helpful hints

» Choosing the correct design table

Using your plans or the sketches made by following the Sketching Instructions, choose the Case(s) that is/are applicable to the proposed retaining wall. If the retaining wall configuration does not exactly match one of the cases use the next higher case. For example, if the grade is not flat at the top of wall but there will be less slope than a 4/1 slope, choose the 4/1 slope design. Always choose the more conservative option.

» Choosing the correct height

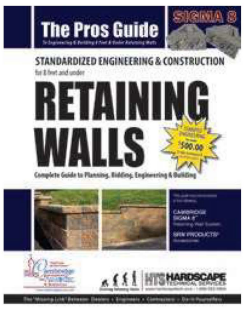
Choose the correct exposed height design. The designs will show how many layers of geogrid are required, the length that each layer is embedded into the soil, and the course of block that the geogrid is placed on top of. Below each design are numbers that will be needed in the material estimation process.

» Multi-height retaining walls

If the wall section has a different height on each end, when estimating and constructing your retaining wall it may make sense to skip some designs. For example, if a wall section begins with an exposed height of 2' and ends with an exposed height of 8', it may make sense to use only the 4', 6', and 8' exposed height designs to simplify the geogrid placement during construction. In that case, the 4' design would be used from the 2' height to the 4' height, the 6' design would be used between the 4' and 6' heights, and the 8' design would be used between the 6' and 8' heights. Also in that case, if the wall steps up at the bottom of wall, the bottom layer of geogrid should be moved up to the next course of block and not eliminated until the 2nd from the bottom layer of geogrid is encountered.

GEOGRID

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



SIGMA 8

These pages reference the Sigma 8 "Pro Guide" available for free download at: cambridgewallsupport.com

B-5

26 DEGREE SOIL for walls up to 8'

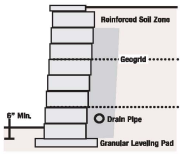
Sigma 8 • SRW Accessories

If used without the stamped engineering, the final determination of the suitability of the contemplated use, and its manner of use, are the sole responsibility of the user, and the user expressly releases HTS, SRW, and retaining wall unit supplier of any and all liability that might arise as a result. These designs have been performed with National Concrete Masonry Association (NCMA) software and have been analyzed for the appropriate factors of safety. © 2013 Hardscape Technical Services. Sigma 8™ is a trademark of Cambridge Wall Systems.

Geogrid: SRW Universal 635 LTDS or SRW 3 Series 1093 LTDS • Block Dimensions: 8"(H) x 18" (W) x 12"(D)

CASE A

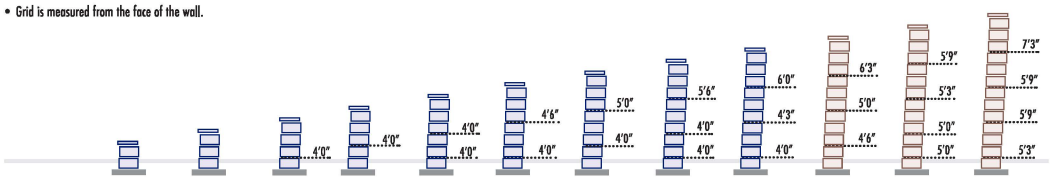
"CASE A" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- No Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.

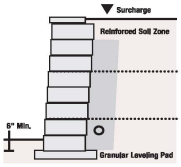


Geogrid Type	SRW Universal - or - SRW 3 Series Grid									SRW 3 Series Grid ONLY		
Exposed Hgt wo/cap	0'8"	1'4"	2'0"	2'8"	3'4"	4'0"	4'8"	5'4"	6'0"	6'8"	7'4"	8'0"
Amount Buried	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"
Total Hgt wo/cap	1.33'	2.00'	2.67'	3.33'	4.00'	4.67'	5.33'	6.00'	6.67'	7.33'	8.00'	8.67'
Grid Sq Yd per Ln Ft	0.000	0.000	0.444	0.444	0.889	0.944	1.000	1.500	1.583	1.750	2.333	2.667
Grid total depth	0.00	0.00	4.00	4.00	8.00	8.50	9.00	13.50	14.25	15.75	21.00	24.00
# Block per Ln Ft	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67
# Cap per Ln Ft"	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667

- See "Material Estimating" for Adhesive estimate.

CASE B

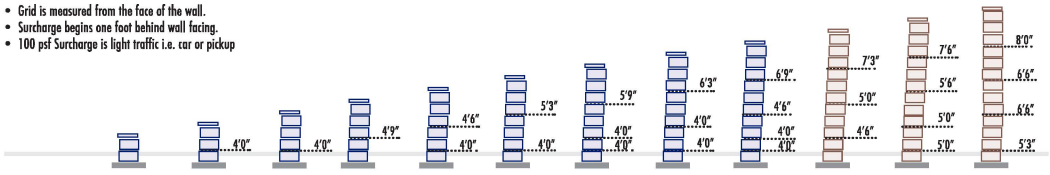
"CASE B" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 100 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins one foot behind wall facing.
- 100 psf Surcharge is light traffic i.e. car or pickup

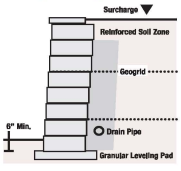


Geogrid Type	SRW Universal - or - SRW 3 Series Grid									SRW 3 Series Grid ONLY		
Exposed Hgt wo/cap	0'8"	1'4"	2'0"	2'8"	3'4"	4'0"	4'8"	5'4"	6'0"	6'8"	7'4"	8'0"
Amount Buried	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"
Total Hgt wo/cap	1.33'	2.00'	2.67'	3.33'	4.00'	4.67'	5.33'	6.00'	6.67'	7.33'	8.00'	8.67'
Grid Sq Yd per Ln Ft	0.000	0.444	0.444	0.528	0.994	1.028	1.528	1.583	2.139	1.861	2.556	2.917
Grid total depth	0.00	4.00	4.00	4.75	8.50	9.25	13.75	14.25	19.25	16.75	23.00	26.25
# Block per Ln Ft	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67
# Cap per Ln Ft"	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667

- See "Material Estimating" for Adhesive estimate.

CASE C

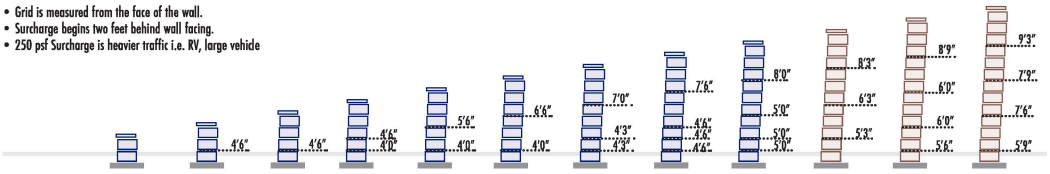
"CASE C" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 250 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins two feet behind wall facing.
- 250 psf Surcharge is heavier traffic i.e. RV, large vehicle

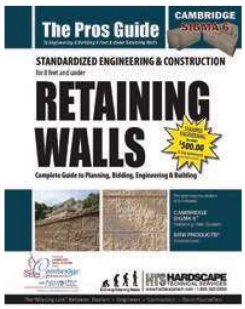


Geogrid Type	SRW Universal - or - SRW 3 Series Grid									SRW 3 Series Grid ONLY		
Exposed Hgt wo/cap	0'8"	1'4"	2'0"	2'8"	3'4"	4'0"	4'8"	5'4"	6'0"	6'8"	7'4"	8'0"
Amount Buried	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"
Total Hgt wo/cap	1.33'	2.00'	2.67'	3.33'	4.00'	4.67'	5.33'	6.00'	6.67'	7.33'	8.00'	8.67'
Grid Sq Yd per Ln Ft	0.000	0.500	0.500	0.944	1.056	1.167	1.722	2.333	2.556	2.194	2.917	3.361
Grid total depth	0.00	4.50	4.50	8.50	9.50	10.50	15.50	21.00	23.00	19.75	26.25	30.25
# Block per Ln Ft	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67
# Cap per Ln Ft"	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667

- See "Material Estimating" for Adhesive estimate.

SIGMA 6

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



GEOGRID

These pages reference the Sigma 6 "Pro Guide" available for free download at: cambridgewallsupport.com

B-5

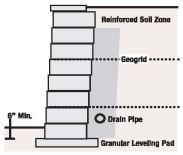
26 DEGREE SOIL for walls up to 8'

Cambridge Sigma 6 • SRW Accessories

Geogrid: SRW Universal 635 LTDS or SRW 3 Series 1093 LTDS • Block Dimensions: 6"(H) x 16" (W) x 12"(D)

CASE A

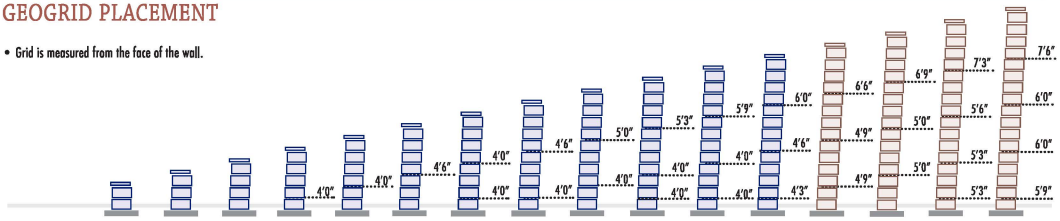
"CASE A" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- No Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.

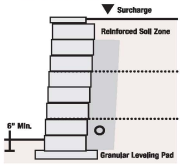


Geogrid Type	SRW Universal - or - SRW 3 Series Grid												SRW 3 Series Grid ONLY			
Exposed Hgt wo/cap	0'6"	1'0"	1'6"	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
Amount Buried	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
Total Hgt wo/cap	1.0'	1.5'	2'	2.5'	3'	3.5'	4'	4.5'	5'	5.5'	6'	6.5'	7'	7.5'	8'	8.5'
Grid Sq Yd per Ln Ft	0.000	0.000	0.000	0.444	0.444	0.500	0.889	0.944	1.000	1.472	1.528	1.639	1.778	1.861	2.583	2.806
Grid total depth	-	-	-	4.00	4.00	4.50	8.00	8.50	9.00	13.25	13.75	14.75	16.00	16.75	23.25	25.25
# Block per Ln Ft	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75
# Cap per Ln Ft*	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67

*Caps come in multiple sizes. Check with your local retailer for what size is available in your area. • See "Material Estimating" for Adhesive estimate.

CASE B

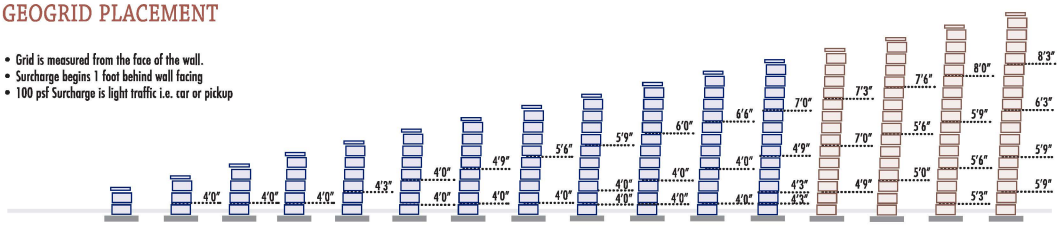
"CASE B" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 100 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins 1 foot behind wall facing
- 100 psf Surcharge is light traffic i.e. car or pickup

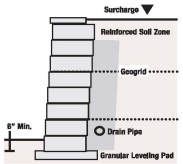


Geogrid Type	SRW Universal - or - SRW 3 Series Grid												SRW 3 Series Grid ONLY			
Exposed Hgt wo/cap	0'6"	1'0"	1'6"	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
Amount Buried	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
Total Hgt wo/cap	1.0'	1.5'	2'	2.5'	3'	3.5'	4'	4.5'	5'	5.5'	6'	6.5'	7'	7.5'	8'	8.5'
Grid Sq Yd per Ln Ft	0.000	0.444	0.444	0.444	0.472	0.889	0.972	1.056	1.528	1.556	1.611	2.250	2.111	2.000	2.722	2.889
Grid total depth	-	4.00	4.00	4.00	4.25	8.00	8.75	9.50	13.75	14.00	14.50	20.25	19.00	18.00	24.50	26.00
# Block per Ln Ft	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75
# Cap per Ln Ft*	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67

*Caps come in multiple sizes. Check with your local retailer for what size is available in your area. • See "Material Estimating" for Adhesive estimate.

CASE C

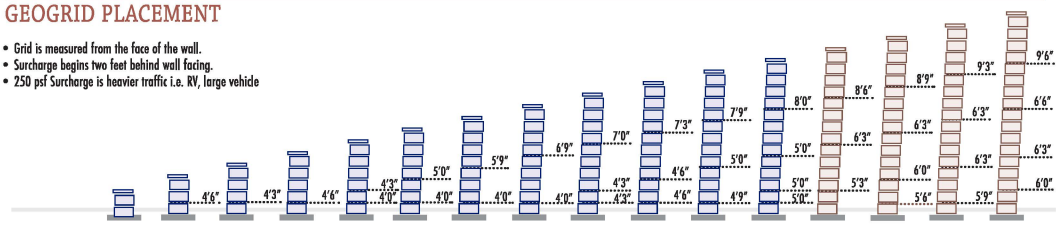
"CASE C" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 250 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins two feet behind wall facing.
- 250 psf Surcharge is heavier traffic i.e. RV, large vehicle

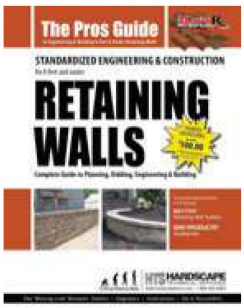


Geogrid Type	SRW Universal - or - SRW 3 Series Grid												SRW 3 Series Grid ONLY			
Exposed Hgt wo/cap	0'6"	1'0"	1'6"	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
Amount Buried	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
Total Hgt wo/cap	1.0'	1.5'	2'	2.5'	3'	3.5'	4'	4.5'	5'	5.5'	6'	6.5'	7'	7.5'	8'	8.5'
Grid Sq Yd per Ln Ft	0.000	0.500	0.472	0.500	0.917	1.00	1.083	1.194	1.722	1.806	1.944	2.556	2.222	2.944	3.056	3.139
Grid total depth	-	4.50	4.25	4.50	8.25	9.00	9.75	10.75	15.50	16.25	17.50	23.00	20.00	26.50	27.50	28.25
# Block per Ln Ft	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75
# Cap per Ln Ft*	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67

*Caps come in multiple sizes. Check with your local retailer for what size is available in your area. • See "Material Estimating" for Adhesive estimate.

GEOGRID

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



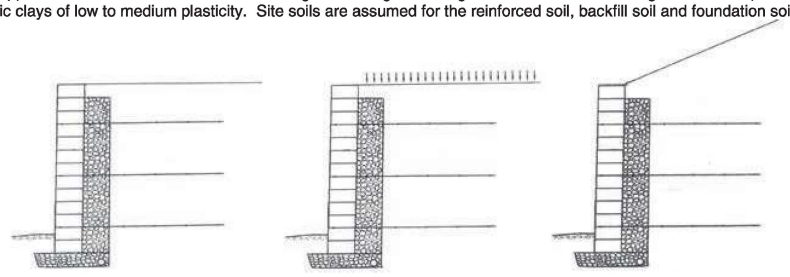
MAYTRX

These pages reference the Maytrx "Pro Guide" available for free download at: cambridgewallsupport.com

Maytrx Wall System & SRW3 Geogrid Placement Tables

Sample designs, **27 degree** friction angle soil

These charts are applicable for site soils when the friction angle is 27 degrees or higher and the moist unit weight is 120 lbs. per cubic foot. That is typical for inorganic clays of low to medium plasticity. Site soils are assumed for the reinforced soil, backfill soil and foundation soil.



Site Configuration: Flat at top and bottom of wall, no surcharge											
Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	5th/4.0'						
6.0'	6.5'	13	3	2nd/4.25'	5th/4.25'	9th/5.25'					
8.0'	9.0'	18	5	1st/6.0'	3rd/6.0'	6th/6.0'	10th/6.0'	14th/6.75'			
10.0'	11.0'	22	6	1st/7.25'	4th/7.25'	7th/7.25'	10th/7.25'	14th/7.25'	18th/8.25'		

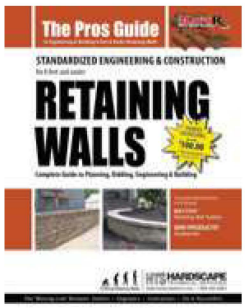
Site Configuration: Flat at top and bottom of wall, 100 PSF surcharge (Light Traffic)											
Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	3	1st/4.0'	3rd/4.0'	7th/5.25'					
6.0'	6.5'	13	4	1st/4.25'	3rd/4.25'	7th/4.75'	11th/6.5'				
8.0'	9.0'	18	6	1st/6.0'	2nd/6.0'	5th/6.0'	8th/6.0'	12th/6.5'	16th/8.25'		
10.0'	11.0'	22	7	1st/7.25'	3rd/7.25'	6th/7.25'	9th/7.25'	12th/7.25'	16th/7.75'	20th/9.5'	

Site Configuration: Flat at bottom of wall, 3 horizontal to 1 vertical slope at top of wall											
Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	6th/4.75'						
6.0'	6.5'	13	4	1st/5.25'	2nd/5.25'	6th/5.25'	10th/6.5'				
8.0'	9.0'	18	6	1st/8.0'	3rd/8.0'	5th/8.0'	7th/8.0'	11th/8.0'	15th/8.75'		
10.0'	11.0'	22	8	1st/10.25'	2nd/10.25'	4th/10.25'	6th/10.25'	9th/10.25'	11th/10.25'	15th/10.25'	19th/10.5'

1) Sample designs are to be used for preliminary design only when actual soil, site geometry and surcharge conditions are conservatively represented by the assumptions of the tables in all situations. A qualified engineer using actual design conditions for the proposed site should perform the final as-built design.
2) Sample designs have been prepared exclusively for the use of SRW™ 3 series geogrid.
3) MINIMUM FACTORS OF SAFETY: 1.5 for internal reinforcement pullout and tensile overstress, 1.5 for external sliding, 2.0 for external overturning and bearing capacity. NO provision or analysis included for global stability.
4) Sample designs require adequate drainage provisions for both the reinforced wall fill and retained backfill.
5) Geogrid must be one continuous piece from the face of the retaining wall block to the back of the reinforced soil mass. No splicing of geogrid. Geogrid must butt together at edges but must not be overlapped. Geogrid must be pulled tight before backfill is placed.
6) Follow the installation instructions that are supplied with the retaining wall system that you are purchasing. (Which should include foundation preparation, block alignment, core filling of block, drainage rock placement, backfill placement, and compaction.)
7) See your local building department for permitting requirements.
8) Each design is to be used up to the indicated height only. When the retaining wall exceeds that height a higher design shall be used.
9) When the retaining wall steps up at the bottom of the wall, bottom geogrid layers should be moved up with the steps and not dropped off until the next layer of geogrid is encountered.
10) Light Traffic is auto or empty pickup truck loading. Any vehicle traffic or parking loads exceeding Light Traffic vehicle weights at the top of the retaining wall shall require a special site specific preliminary design.
11) If there is a slope at the bottom of the wall, additional embedment depth of the bottom courses may be required.
12) If your site does not fit the above site configurations, call SRW Products at (800) 752-9326 for a free site-specific preliminary design.

MAYTRX

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



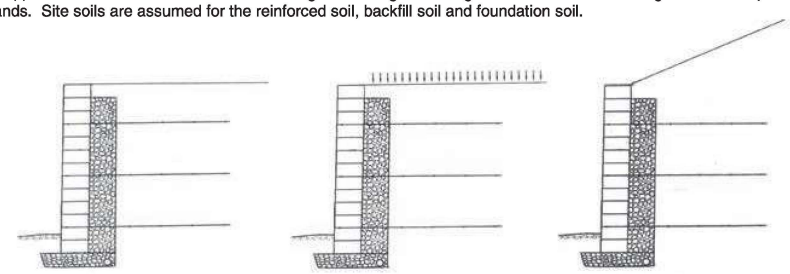
GEOGRID

These pages reference the Maytrx "Pro Guide" available for free download at: cambridgewallsupport.com

Maytrx Wall System & SRW3 Geogrid Placement Tables

Sample designs, **30 degree** friction angle soil

These charts are applicable for site soils when the friction angle is 30 degrees or higher and the moist unit weight is 125 lbs. per cubic foot. That is typical for silty sands. Site soils are assumed for the reinforced soil, backfill soil and foundation soil.



Site Configuration: Flat at top and bottom of wall, no surcharge

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	5th/4.0'						
6.0'	6.5'	13	3	2nd/4.25'	5th/4.25'	9th/4.75'					
8.0'	9.0'	18	5	1st/6.0'	3rd/6.0'	6th/6.0'	10th/6.0'	14th/6.25'			
10.0'	11.0'	22	6	1st/7.25'	3rd/7.25'	6th/7.25'	10th/7.25'	14th/7.25'	18th/7.5'		

Site Configuration: Flat at top and bottom of wall, 100 PSF surcharge (Light Traffic)

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	3rd/4.0'	7th/4.75'						
6.0'	6.5'	13	4	1st/4.25'	3rd/4.25'	7th/4.25'	11th/5.75'				
8.0'	9.0'	18	5	1st/6.0'	4th/6.0'	8th/6.0'	12th/6.0'	16th/7.5'			
10.0'	11.0'	22	7	1st/7.25'	3rd/7.25'	5th/7.25'	8th/7.25'	12th/7.25'	16th/7.25'	20th/8.75'	

Site Configuration: Flat at bottom of wall, 2 1/2 horizontal to 1 vertical slope at top of wall

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	5th/4.0'						
6.0'	6.5'	13	3	1st/4.25'	5th/4.25'	9th/5.75'					
8.0'	9.0'	18	5	1st/6.25'	4th/6.25'	6th/6.25'	10th/6.25'	14th/7.75'			
10.0'	11.0'	22	7	1st/8.25'	3rd/8.25'	5th/8.25'	8th/8.25'	10th/8.25'	14th/8.25'	18th/9.5'	

1) Sample designs are to be used for preliminary design only when actual soil, site geometry and surcharge conditions are conservatively represented by the assumption table in all situations. A qualified engineer using actual design conditions for the proposed site should perform the final as-built design.
2) Sample designs have been prepared exclusively for the use of SRW™ 3 series geogrid.
3) MINIMUM FACTORS OF SAFETY: 1.5 for internal reinforcement pullout and tensile overstress, 1.5 for external sliding, 2.0 for external overturning and bearing capacity. NO provision or analysis included for global stability.
4) Sample designs require adequate drainage provisions for both the reinforced wall fill and retained backfill.
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6) Follow the installation instructions that are supplied with the retaining wall system that you are purchasing. (Which should include foundation preparation, block alignment, core filling of block, drainage rock placement, backfill placement, and compaction.)
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11) If there is a slope at the bottom of the wall, additional embedment depth of the bottom courses may be required.
12) If your site does not fit the above site configurations, call SRW Products at (800) 752-9326 for a free site-specific preliminary design.

GEOGRID

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.

OLDE ENGLISH

These pages are available for free download at:
cambridgewallsupport.com

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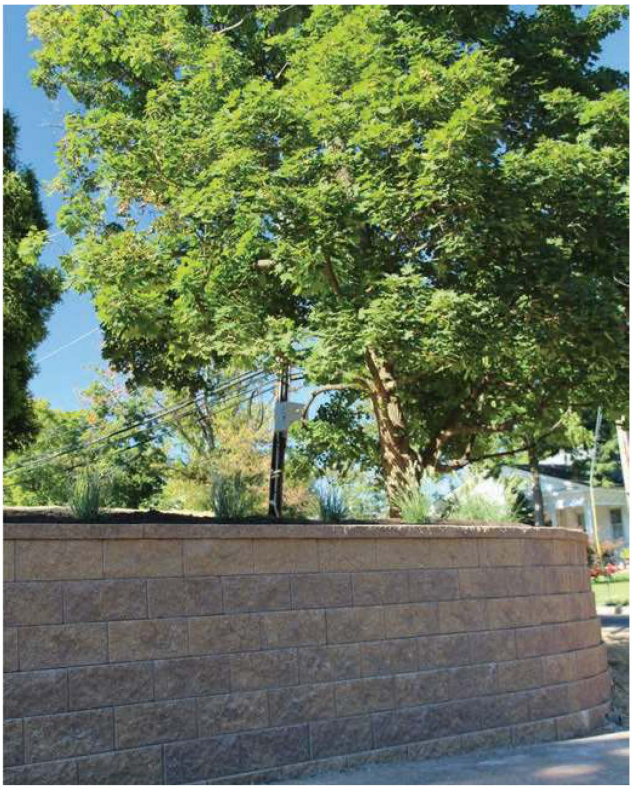
GEOGRID

These pages are available for free download at:
cambridgewallsupport.com

SIGMA-MAYTRX OLDE ENGLISH

How To Build An Engineered Retaining Wall And Obtain A Stamped Drawing For Submittal To A Local Municipality.



The best place to source design information or necessary drawings for MaytRx and Sigma Wall Systems is cambridgepavers.com. HTS (Hardscape Technical Services) has created a manual, "Complete Guide to Planning, Bidding, Engineering, and Building the MaytRx Wall", which is an excellent primer for building an engineered wall as well as a stamped drawing program that costs less than $500 in most cases. Their affiliate company SRW offers free takeoffs and geogrid layouts.

SRW/HTS has an arrangement with Cambridge Pavers to provide MaytRx and Sigma engineered wall designs if the geogrid needed for the project is purchased from Cambridge. Cambridge suggests that you consult an engineer, design professional or HTS for MaytRx and Sigma Walls higher than 36 inches or that involve loads, poor soil or other design factors such as water runoff. See program information below.

SRW Free Design Request Program

Fill out the design request form on cambridgepavers.com. Within 3 days of receiving your information SRW will provide:

- Geogrid layer drawing
- Wall Takeoff (Sq. Ft., Caps, Pins)
- Adhesive needed

Note: *This is not a "Stamped" drawing; it is a calculation based on your information using NCMA design software.*

HTS Stamped Drawing Program

Typically, when a homeowner or contractor discovers that their retaining wall project needs a permit by the local building department, it is also learned that to obtain a permit they must provide engineering stamped by an engineer registered in the state of the project. The stamped engineering requirement will vary, from locality to locality. The determining factor for requiring stamped engineering is usually the exposed height of the retaining wall. Some local building departments require stamped engineering on retaining walls as short as 2' in exposed height. Fill out the design request form and prepare a soil sample.

What To Expect

When stamped engineering services are requested, HTS:

- Insures that the project fits the 8' and under program,
- Verifies that all the required information is supplied, and forwards the package to the independently licensed engineer.

The engineer reviews the request and the customer receives:

- A cover letter from Hardscape Technical Services (HTS).
- A stamped cover letter from the engineer indicating the proper design table to use for construction.
- The proper design table stamped on the site configuration (case) to be used.
- Upon receipt of the stamped engineering document, you may proceed in obtaining the building permit from the local building department.

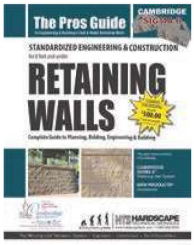
Find all forms requested on this page of the handbook along with processing instructions, and also information on Geogrid in the Professional Contractors Section of the Cambridge website (www.cambridgepavers.com).

SIGMA-MAYTRX OLDE ENGLISH

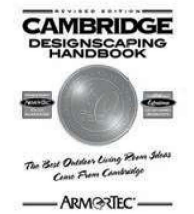
STAMPED DRAWINGS

LINKS

SIGMA-MAYTRX OLDE ENGLISH

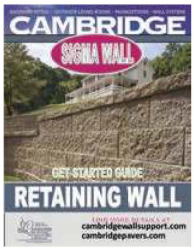


Separate Sigma 6 & Sigma 8 "Pro Guides" are available for free download at:
cambridgewallsupport.com

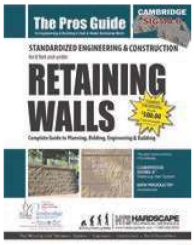


Cambridge Designscape Book is available for free download at:
cambridgewallsupport.com

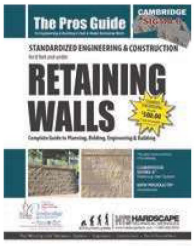
These pages reference the Cambridge Product Line Spec available for free download at:
cambridgewallsupport.com



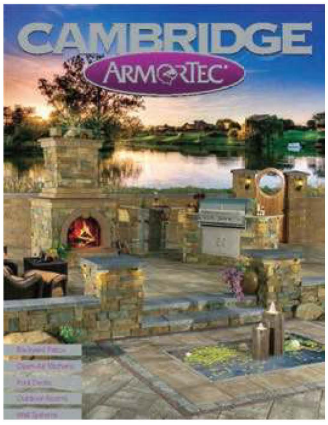
Sigma "Getting Started" Guide is available online for Tablet, Smartphone or PC access at:
cambridgewallsupport.com



Maytrx Wall "Pro Guide" is available for free download at:
cambridgewallsupport.com



Ideal guide for Retaining Walls. Sigma and Maytrx Wall preloaded for NCMA Software is available at:
cambridgewallsupport.com



Many of these pages reference the Cambridge Outdoor Living Brochure 2014. This is an invaluable tool in viewing color and textures as well as the full line of outdoor living products available from Cambridge.
available for free download at:
cambridgewallsupport.com
or Viewable at
cambridgepavers.com

YouTube

Cambridge Pavers
Cambridge Walls
Sigma Walls

SketchUp

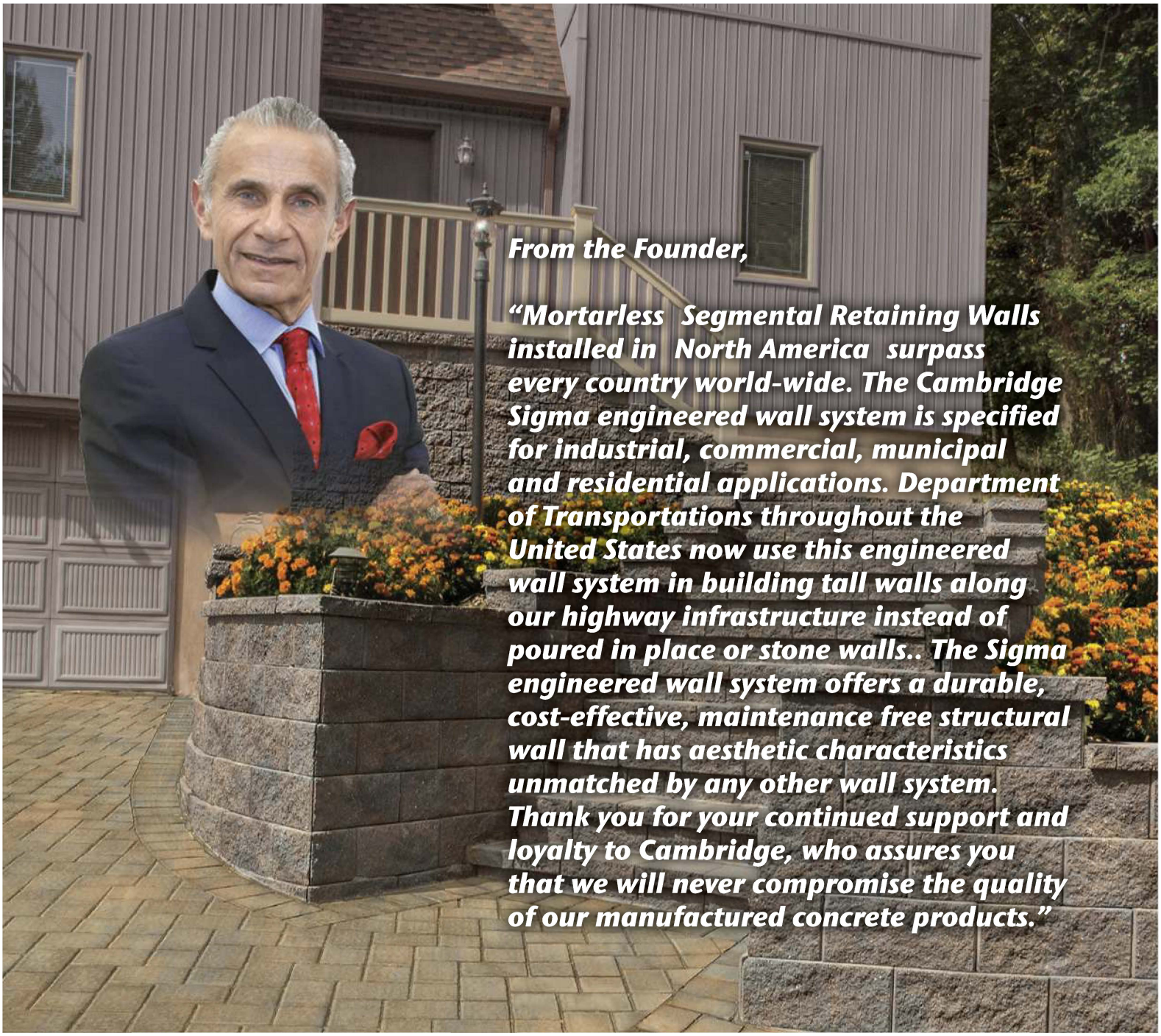
Cambridge Pavers
Cambridge Walls

"They'll Look Like New Forever."
Cambridge Pavingstones
With ARMORTEC
www.cambridgepavers.com

Cambridge Website is available at:
cambridgepavers.com

CAMBRIDGE WALL SYSTEMS SUPPORT

Cambridge Wall Support Website is available at:
cambridgewallsupport.com



Premium Quality Pavingstones, Wall Systems & Outdoor Living Room Components

Cambridge Pavers Inc.
P.O. Box 157
Lyndhurst, NJ 07071-0157

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FAX: 201.993.5532

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Tech Spec 9

icpi
Interlocking Concrete Pavement Institute

Guide Specification for the Construction of Interlocking Concrete Pavement

SECTION 32 14 13.13
INTERLOCKING CONCRETE PAVERS

Note: This guide specification for manually installed concrete paver applications in the U.S. and Canada. Contact ICPI for current information and guide specifications for mechanical installation. This document should be edited to fit project conditions and location. Brackets [ ] indicate text for editing. Notes are provided on the use of a compacted aggregate base under the bedding sand and pavers. Other bases can be used such as cement or asphalt-treated aggregate, concrete or asphalt, as well as other setting materials. The user should refer to Interlocking Concrete Pavement Institute (ICPI) Details & Specifications for Interlocking Concrete Pavement at www.icpi.org for various guide specifications and detail drawings. This Section includes the term "Architect." Edit this term as necessary to identify the design professional in the General Conditions of the Contract. Coordinate all Sections with the General Conditions as well.

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Interlocking Concrete Paver Units (manually installed).
   2. Bedding and Joint Sand.
   3. Edge Restraints.

B. Related Sections:
   1. Section: [ ]-Curbs and Drains.
   2. Section: [ ]-Aggregate Base.
   3. Section: [ ]-Cement Treated Base.
   4. Section: [ ]-Asphalt Treated Base.
   5. Section: [ ]-Pavements, Asphalt and Concrete.
   6. Section: [ ]-Roofing Materials.
   7. Section: [ ]-Geotextiles.

Note: Pavements subject to vehicles should be designed in consultation with a qualified civil engineer, in accordance with ASCE 58-10 *Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways*, ICPI Interlocking Concrete Pavement Structural Design Program software, and in accordance with the ICPI Tech Spec technical bulletins. Use the current year reference. Edit ASTM and CSA references below and throughout this Section according to project location.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. ASTM C 33, Standard Specification for Concrete Aggregates.
   2. ASTM C 136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   3. ASTM C 140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   4. ASTM C 144, Standard Specification for Aggregate for Masonry Mortar.
   5. ASTM C 936, Standard Specification for Solid Concrete Interlocking Paving Units.
   6. ASTM C 979, Pigments for Integrally Colored Concrete.
   7. ASTM D 698, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,000 ft-lbf/ft^3 (600 kN-m/m ^{3})).
   8. ASTM D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   9. ASTM D 2940, Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.

B. Canadian Standards Association (CSA):
   1. A231.2, Precast Concrete Pavers.
   2. A23.2A, Sieve Analysis of Fine and Coarse Aggregates.
   3. A23.1-FA1, Concrete Materials and Methods of Concrete Construction.
   4. A179, Mortar and Grout for Unit Masonry.

C. Interlocking Concrete Pavement Institute (ICPI):
   1. ICPI *Tech Spec* technical bulletins.

D. American Society of Civil Engineers (ASCE)
   1. 58-10 Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways

1.03 SUBMITTALS

A. In accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.

B. Manufacturer's drawings and details: Indicate perimeter conditions, relationship to adjoining materials and assemblies, [expansion and control joints,] concrete paver [layout,] [patterns,] [color arrangement,] installation [and setting] details.

C. Sieve analysis per [ASTM C 136][CSA A23.2A] for grading of bedding and joint sand.

D. Concrete pavers:
   1. [Four] representative full-size samples of each paver type, thickness, color, finish that indicate the range of color variation and texture expected in the finished installation. Color(s) selected by [Architect] [Engineer] [Landscape Architect] [Owner] from manufacturer's available colors.
   2. Accepted samples become the standard of acceptance for the work.
   3. Test results from an independent testing laboratory for compliance of paving unit requirements to [ASTM C 936][CSA A231.2].
   4. Manufacturer's catalog product data, installation instructions, and material safety data sheets for the safe handling of the specified materials and products.

E. Paver Installation Subcontractor:
   1. A copy of Subcontractor's current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.

Note: ICPI certifies that installers have passed an exam on installation knowledge and does not certify or guarantee the quality of installation. Job references should be carefully reviewed and verified to assist in identifying competent contractors.

   2. Job references from projects of a similar size and complexity. Provide Owner/Client/General Contractor names and phone numbers.

1.04 QUALITY ASSURANCE

A. Paving Subcontractor Qualifications:
   1. Utilize an installer having successfully completed concrete paver installation similar in design, material, and extent indicated on this project.

2. Utilize an installer holding a current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.

B. Regulatory Requirements and Approvals: [Specify applicable licensing, bonding or other requirements of regulatory agencies.].

C. Mock-Ups:

Note: A site visit and approval by the owner's representative during the first day of paving may substitute for a mock-up.

1. Install a 7 ft x 7 ft (2 x 2 m) paver area.
2. Use this area to determine surcharge of the bedding sand layer, joint sizes, lines, laying pattern(s), color(s) and texture of the job.
3. Evaluate the need for protective pads when compacting paving units with architectural finishes.
4. This area will be used as the standard by which the work will be judged.
5. Subject to acceptance by owner, mock-up may be retained as part of finished work.
6. If mock-up is not retained, remove and properly dispose of mock-up.

1.05 DELIVERY, STORAGE & HANDLING

A. General: Comply with Division 1 Product Requirement Section.

B. Refer to manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

C. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers packaging with identification labels intact.
1. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.
2. Deliver concrete pavers to the site in steel banded, plastic banded or plastic wrapped packaging capable of transfer by fork lift or clamp lift.
3. Unload pavers at job site in such a manner that no damage occurs to the product.

D. Storage and Protection: Store materials protected such that they are kept free from mud, dirt, and other foreign materials. [Store concrete paver cleaners and sealers per manufacturer's instructions.]

1.06 PROJECT/SITE CONDITIONS

A. Environmental Requirements:
1. Do not install sand or pavers during heavy rain or snowfall.
2. Do not install sand and pavers over frozen base materials.
3. Do not install frozen sand or saturated sand.
4. Do not install concrete pavers on frozen or saturated sand.

1.07 MAINTENANCE

A. Extra Materials: Provide [Specify area] [Specify percentage] additional material for use by owner for maintenance and repair.

PART 2 PRODUCTS

2.01 INTERLOCKING CONCRETE PAVERS

Note: In addition to ASTM or CSA conformance, ASCE 58-10 recommends a maximum 3:1 aspect ratio (length ÷ thickness) and a minimum $3^1/_8$ in. (80 mm) thickness for vehicular applications. Residential driveways should use a minimum $2^3/_8$ in. (60 mm) thick units with a maximum 4:1 aspect ratio.

A. Manufacturer: [Specify ICPI member manufacturer name.].
1. Contact: [Specify ICPI member manufacturer contact information.].

B. Interlocking Concrete Paver Units, including the following:
1. Paver Type: [Specify name of product group, family, series, etc.].
a. Material Standard: Comply with material standards set forth in [ASTM C 936][CSA A231.2].
b. Color [and finish]: [Specify color.] [Specify finish].
c. Color Pigment Material Standard: Comply with ASTM C 979.

Note: Concrete pavers may have spacer bars on each unit. Spacer bars are recommended for mechanically installed pavers and for those in heavy vehicular traffic. Manually installed pavers may be installed with or without spacer bars. Verify with manufacturers that overall dimensions do not include spacer bars.

d. Size: [Specify.] inches [({Specify.}mm)] x [Specify.] inches [({Specify}mm)] x [Specify.] inches [({Specify.} mm)] thick.

Note: For ASTM C 936 use the following material characteristics:

e. Average Compressive Strength: 8,000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa).
f. Average Water Absorption (ASTM C 140): 5% with no unit greater than 7%.
g. Freeze/Thaw Resistance (ASTM C 1645): Resistant to 50 freeze-thaw cycles while immersed in water or a 3% saline solution (depending on conditions during service life) with no greater mass lost than 225 g/m^2 of surface area after 28 cycles, or 500 g/m2 after 49 cycles. Freeze-thaw testing requirements shall be waived for applications not exposed to freezing conditions.

Note: For CSA A231.2 use the following material characteristics:

h. Minimum average cube compressive strength of 7,250 psi (50 MPa) for laboratory cured specimens or 5,800 psi (40 MPa) for unconditioned field samples.
i. Resistance to 28 freeze-thaw cycles while immersed in a 3% saline solution with no greater mass lost than 225 g/m^2 of surface area after 28 years, or 500 g/m^2 after 49 cycles.

2.02 PRODUCT SUBSTITUTIONS

A. Interlocking concrete pavers: as specified or approved equal.

2.03 BEDDING AND JOINT SAND

A. Provide bedding and joint sand as follows:
1. Clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.
2. Do not use stone dust.
3. Do not use limestone screenings or sand for the bedding that does not conform to the grading requirements of [ASTM C 33][CSA A23.1-FA1].
4. Do not use mason sand, or sand conforming to [ASTM C 144][CSA A179] for the bedding sand.

Note: If the pavement will be exposed to heavy traffic with trucks, i.e., a major thoroughfare with greater than 1.5 million 18-Kip (80 kN) equivalent single axle loads, see *ICPI Tech Spec 17–Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications* for test methods and criteria for assessing bedding sand durability. Limestone screenings will typically not meet the durability requirements outlined in *Tech Spec 17*. However, there are some granite materials that can meet these requirements. *Tech Spec 17* recommends using concrete sand as a first preference.

4. Where concrete pavers are subject to vehicular traffic, utilize sands that are as hard as practically available.

Table 1. Grading Requirements for Bedding Sand

Gradation for Bedding Sand			
ASTM C33		CSA A23.1 FA1	
Sieve Size	Percent Passing	Sieve Size	Percent Passing
3/8 in.(9.5 mm)	100	10.0 mm	100
No. 4 (4.75 mm)	95 to 100	5.0 mm	95 to 100
No. 8 (2.36 mm)	80 to 100	2.5 mm	80 to 100
No. 16 (1.18 mm)	50 to 85	1.25 mm	50 to 90
No. 30 (0.6 mm)	25 to 60	630 µm	25 to 65
No. 50 (0.3 mm)	5 to 30	315 µm	10 to 35
No. 100 (0.15 mm)	0 to 10	160 µm	2 to 10
No. 200 (0.075 mm)	0 to 1	80 µm	0 to 1

Note: Bedding sands should conform to ASTM C33 or CSA A23.1 FA1 gradations for concrete sand. For ASTM C33, ICPI recommends the additional limitations on the No. 200 (0.075 mm) sieve as shown. For CSA A23.1 FA1, ICPI recommends reducing the maximum passing the 80 µm sieve from 3% to 1%.

Table 2. Grading Requirements for Joint Sand

Gradation for Joint Sand			
ASTM C144		CSA A179	
Sieve Size	Percent Passing	Sieve Size	Percent Passing
No. 4 (4.75 mm)	100	5.0 mm	100
No. 8 (2.36 mm)	95 to 100	2.5 mm	90 to 100
No. 16 (1.18 mm)	70 to 100	1.25 mm	85 to 100
No. 30 (0.6 mm)	40 to 75	630 µm	65 to 95
No. 50 (0.3 mm)	10 to 35	315 µm	15 to 80
No. 100 (0.15 mm)	2 to 15	160 µm	0 to 35
No. 200 (0.075 mm)	0 to 5	80 µm	0 to 10

5. Sieve according to [ASTM C 136][CSA A23.2A].
6. Bedding Sand Material Requirements: Conform to the grading requirements of [ASTM C 33][CSA A23.1-FA1] with modifications as shown in Table 1.

Note: Coarser sand than that specified in Table 2 above may be used for joint sand including C 33 or A23.1 material as shown in Table 1. Use material where the largest sieve size easily enters the smallest joints. For example, if the smallest paver joints are 2 mm wide, use sand 2 mm and smaller in particle size. If C 33 or A23.1 sand is used for joint sand, extra effort may be required in sweeping material and compacting the pavers in order to completely fill the joints.

7. Joint Sand Material Requirements: Conform to the grading requirements of [ASTM C 144][CSA-A179] as shown with modifications in Table 2 or meet the requirements for bedding sand in Table 1.

Note: Specify specific components of a system, manufactured unit or type of equipment. See *ICPI Tech Spec 3–Edge Restraints for Interlocking Concrete Pavements* for guidance on selection and design of edge restraints.

2.04 EDGE RESTRAINTS

A. Where not otherwise retained, provide edge restraints installed around the perimeter of all interlocking concrete paving unit areas as follows:
   1. Manufacturer: [Specify manufacturer.].
   2. Material: [Plastic] [Concrete] [Aluminum] [Steel] [Pre-cast concrete] [Cut stone] [Concrete].
   3. Material Standard: [Specify material standard.].

2.05 ACCESSORIES

A. Provide accessory materials as follows:

Note: Delete article below if geotextile is not used.

1. Geotextile:
   a. Material Type and Description: [Specify material type and description.].
   b. Material Standard: [Specify material standard.].
   c. Manufacturer: [Acceptable to interlocking concrete paver manufacturer] [Specify manufacturer.].

Note: Delete article below if cleaners, sealers, and/or joint sand stabilizers are not specified.

2. [Cleaners] [Sealers] [Joint sand stabilizers]

a. Material Type and Description: [Specify material type and description.].
b. Material Standard: [Specify material standard.].
c. Manufacturer: [Specify manufacturer.].

PART 3 EXECUTION

3.01 ACCEPTABLE INSTALLERS

A. [Specify acceptable paving subcontractors.].

3.02 EXAMINATION

A. Acceptance of Site Verification of Conditions:
   1. General Contractor shall inspect, accept and certify in writing to the paver installation subcontractor that site conditions meet specifications for the following items prior to installation of interlocking concrete pavers.

Note: Compaction of the soil subgrade is recommended to at least 98% standard Proctor density per ASTM D 698 for pedestrian areas and residential driveways. Compaction to at least 98% modified Proctor density per ASTM D 1557 is recommended for areas subject to heavy vehicular traffic. Stabilization of the subgrade and/or base material may be necessary with weak or saturated subgrade soils.

   a. Verify that subgrade preparation, compacted density and elevations conform to specified requirements.
   b. Verify that geotextiles, if applicable, have been placed according to drawings and specifications.

Note: Local aggregate base materials typical to those used for highway flexible pavements are recommended, or those conforming to ASTM D 2940. Compaction of aggregate is recommended to not less than 98% Proctor density in accordance with ASTM D 698 is recommended for pedestrian areas and residential driveways. Minimum 98% modified Proctor density according to ASTM D 1557 is recommended for vehicular areas. Mechanical tampers are recommended for compaction of soil subgrade and aggregate base in areas not accessible to large compaction equipment. Such areas can include that around lamp standards, utility structures, building edges, curbs, tree wells and other protrusions.

Note: Prior to screeding the bedding sand, the recommended base surface tolerance should be ± $^{3}/_{8}$ in. (10 mm) over a 10 ft. (3 m) straight edge. See *ICPI Tech Spec 2–Construction of Interlocking Concrete Pavements* for further guidance on construction practices.

Note: The elevations and surface tolerance of the base determine the final surface elevations of concrete pavers. The paver installation contractor cannot correct deficiencies in the base surface with additional bedding sand or by other means. Therefore, the surface elevations of the base should be checked and accepted by the General Contractor or designated party, with written certification to the paving subcontractor, prior to placing bedding sand and concrete pavers.

   c. Verify that [Aggregate] [Cement-treated] [Asphalt-treated] [Concrete] [Asphalt] base materials, thickness, [compacted density], surface tolerances and elevations conform to specified requirements.
   d. Provide written density test results for soil subgrade, [aggregate] [cement-treated][asphalt-treated][asphalt] base materials to the Owner, General Contractor and paver installation subcontractor.
   e. Verify location, type, and elevations of edge restraints, [concrete collars around] utility structures, and drainage inlets.
   2. Do not proceed with installation of bedding sand and interlocking concrete pavers until [subgrade soil and] base conditions are corrected by the General Contractor or designated subcontractor.

3.03 PREPARATION

A. Verify base is dry, certified by General Contractor as meeting material, installation and grade specifications.
B. Verify that base [and geotextile] is ready to support sand, [edge restraints,] and, pavers and imposed loads.
C. Edge Restraint Preparation:
   1. Install edge restraints per the drawings [and manufacturer's recommendations] [at the indicated elevations].

Note: Retain the following two subparagraphs if specifying edge restraints that are staked into the base with spikes.

2. Mount directly to finished base. Do not install on bedding sand.
3. The minimum distance from the outside edge of the base to the spikes shall be equal to the thickness of the base.

3.04 INSTALLATION

A. Spread bedding sand evenly over the base course and screed to a nominal 1 in. (25 mm) thickness. Spread bedding sand evenly over the base course and screed rails, using the rails and/or edge restraints to produce a nominal 1 in. (25 mm) thickness, allowing for specified variation in the base surface.
   1. Do not disturb screeded sand.
   2. Screeded area shall not substantially exceed that which is covered by pavers in one day.
   3. Do not use bedding sand to fill depressions in the base surface.

Note: When initially placed on the bedding sand, manually installed pavers often touch each other, or their spacer bars if present. Joint widths and lines (bond lines) are straightened and aligned to specifications with pry bars as paving proceeds.

B. Lay pavers in pattern(s) shown on drawings. Make horizontal adjustments to laid pavers as required.

Note: Contact manufacturer of interlocking concrete paver units for recommended joint widths.

C. Provide joints between pavers between [1/16 in. and 3/16 in. (2 and 5 mm)] wide. No more than 5% of the joints shall exceed 1/4 in. (6 mm) wide to achieve straight bond lines.

D. Joint (bond) lines shall not deviate more than ± 1/2 in. (15 mm) over 50 ft. (15 m) from string lines.

E. Fill gaps at the edges of the paved area with cut pavers or edge units.

F. Cut pavers to be placed along the edge with a [double blade paver splitter or] masonry saw.

Note. Specify requirements for edge treatment in paragraph below.

G. [Adjust bond pattern at pavement edges such that cutting of edge pavers is minimized. All cut pavers exposed to vehicular tires shall be no smaller than one-third of a whole paver.] [Cut pavers at edges as indicated on the drawings.]

H. Keep skid steer and forklift equipment off newly laid pavers that have not received initial compaction and joint sand.

I. Use a low-amplitude plate compactor capable of at least minimum of 5,000 lbf (22 kN) at a frequency of 75 to 100 Hhz to vibrate the pavers into the sand. Remove any cracked or damaged pavers and replace with new units.

J. Simultaneously spread, sweep and compact dry joint sand into joints continuously until full. This will require at least 4 passes with a plate compactor. Do not compact within 6 ft (2 m) of unrestrained edges of paving units.

K. All work within 6 ft. (2 m) of the laying face must be left fully compacted with sand-filled joints at the end of each day or compacted upon acceptance of the work. Cover the laying face or any incomplete areas with plastic sheets overnight if not closed with cut and compacted pavers with joint sand to prevent exposed bedding sand from becoming saturated from rainfall.

L. Remove excess sand from surface when installation is complete.

Note: Excess joint sand can remain on surface of pavers to aid in protecting their surface especially when additional construction occurs after their installation. If this is the case, delete the article above and use the article below. Designate person responsible for directing timing of removal of excess joint sand.

M. Allow excess joint sand to remain on surface to protect pavers from damage from other trades. Remove excess sand when directed by [Architect].

N. Surface shall be broom clean after removal of excess joint sand.

3.05 FIELD QUALITY CONTROL

A. The final surface tolerance from grade elevations shall not deviate more than ± 3/8 in. (10 mm) over 10 ft (3 m). Use a straightedge, flexible straightedge or transit depending on surface slope and contours.

B. Check final surface elevations for conformance to drawings.

Note: For installations on a compacted aggregate base and soil subgrade, the top surface of the pavers may be 1/8 to 1/4 in. (3 to 6 mm) above the final elevations after compaction. This helps compensate for possible minor settling normal to pavements.

C. The surface elevation of pavers shall be 1/8 in. to 3/8 in. (3 to 10 mm) above adjacent drainage inlets, concrete collars or channels.

Note: For pedestrian access routes maximum elevation should not exceed 1/4 in. (6 mm).

D. Lippage: No greater than 1/8 in. (3 mm) difference in height between adjacent pavers.

Note: Cleaning and sealing may be required for some applications. See *ICPI Tech Spec 5–Cleaning and Sealing Interlocking Concrete Pavements* for guidance on when to clean and seal the paver surface, and when to stabilize joint sand. Delete article below if cleaners, sealers and or joint sand stabilizers are not applied.

3.06 [CLEANING] [SEALING] [JOINT SAND STABILIZATION]

A. [Clean] [Seal] [Apply joint sand stabilization materials to concrete pavers in accordance with the manufacturer's written recommendations.]

3.07 PROTECTION

A. After work in this section is complete, the General Contractor shall be responsible for protecting work from damage due to subsequent construction activity on the site.

END OF SECTION

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Maytrx

VERTICAL OR SETBACK

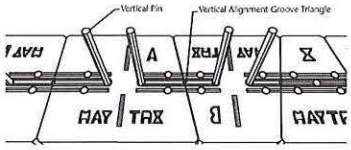
Installation Instructions:

MaytRx 3-Inch, 6-Inch & Stretcher Vertical and Setback Wall Pin Placement

There are three types of walls that can be built with pins: vertical freestanding double sided walls with zero batter, vertical retaining walls with almost zero batter, and setback retaining walls with a 7-degree batter. MaytRx 6 and MaytRx 3 use the following procedures when building a retaining wall. Pins, geogrid and engineering all are important parts of the wall.

MaytRx 6 and Stretcher Retaining Wall

Figure 1



MaytRx 6 Pin Placement Vertical Retaining Wall:

Place 6 ½"-long MaytRx Pins through the vertical (center) hole into the center groove of the wallstone below. When the pin is centered in the hole, push the wallstone "back" towards the bank. This creates almost a zero batter. See Figure 1.

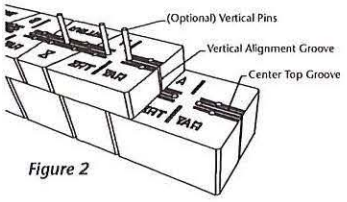


Figure 2

MaytRx 3 and 6 Pin Placement in Vertical Freestanding Walls:

MaytRx wallstones include a pin hole for vertical alignment and securing geogrid. Although optional in the double-sided configuration, they may be used for additional interlock. Place the 6 ½"-long or 3 ¼" MaytRx Pins (depending on the wallstone being used) through the vertical (center) hole. Let them drop into the center groove of the wallstone below. When the pin is centered in the hole, check the visual side groove to confirm your wall is centered on the middle groove of the layer below. This creates a zero batter. See Figure 2.

MaytRx 6 Pin Placement Setback Retaining Wall:

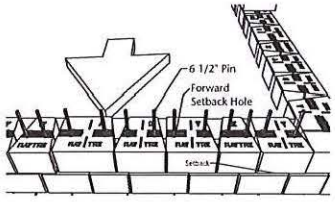


Figure 3

Place 6 ½"-long MaytRx Pins through the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole pull the wallstone "forward" towards the front of the wall. This creates a 7-degree batter. See Figure 3.

MaytRx 3 Retaining Wall

MaytRx 3 Pin Placement Vertical Retaining Wall:

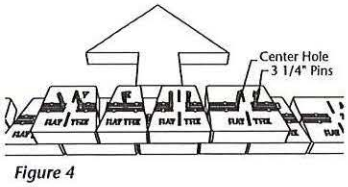
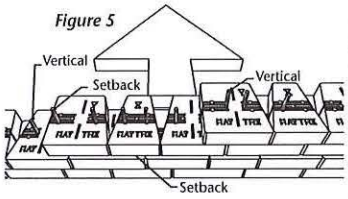


Figure 4

Place 3 1/4"-long MaytRx Pins through the vertical (center) hole into the center groove of the wallstone below. When the pin is centered in the hole push the wallstone "back" towards the bank. See Figure 4.

MaytRx 3 Pin Placement Setback Retaining Wall:

Figure 5



Note: The MaytRx 3 wallstone setback hole is normally used for the 6 and 3 combined wall. To build a wall based on the setback charts of MaytRx 6-inch with all 3-inch high wallstones, use a combination of this vertical and setback pin position to create a 3-inch setback row with a 3-inch vertical row above it. For the setback row, place the 3 1/4" long MaytRx Pins into the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole pull the wallstone "forward" towards the front of the wall. Then place a vertical row above it. This creates a 7-degree batter when used together. See Figure 5.

MaytRx 3 & 6 Combined Retaining Walls

MaytRx 3 and 6 Vertical Combined Pins:

MaytRx 3 and 6 combined designs use both size pins in the wall. When pinning the 6" high wallstone to the wall, use 6 ½" pins, when pinning the 3-inch high wallstone, use the 3 1/4" pins. Follow the instructions for each size wallstones vertical alignment formula. See Figure 6.

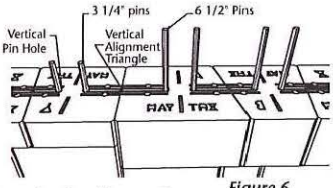
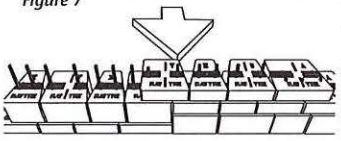


Figure 6

MaytRx 3 and 6 in Combined Setback Retaining Walls:

Place 6 ½" long MaytRx Pins through the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole, pull the wallstone "forward" towards the front of the wall. With the 3-inch high MaytRx wallstone, place the 3 1/4" long MaytRx Pins through the front setback hole into the center groove of the wallstone below. When the pin is centered in the hole, pull the wallstone "forward" towards the front of the wall. See Figure 7.

Figure 7



MaytRx 3 and 6 Combined Geogrid Wall

For informational details of general applications, vertical geogrid charts are available on the Cambridge website. Check municipal codes for your location and for all walls over 36 inches you should consult a licensed design professional. Please refer to the engineering page in this book for details and links. Vertical 6-inch and 3-inch retaining walls use the 6-inch vertical or setback geogrid charts and add two layers of 3-inch wallstone for one layer of 6-inch wallstone shown in the illustration, pinning or gluing every wallstone. The 6 and 3 designs are random. In an engineered wall, you have to use geogrid under all conditions and that must not be compromised by the random design layers without the direction of your design professional. He may suggest extra layers or special retained soils behind the wall.

The base is an important part of any retaining wall. The wall shown in these diagrams should be considered a landscape or freestanding wall. Check with your local building department for the regulations that cover the wall you will be building. Refer to the "Basic Retaining Wall" area of this book for design criteria. We normally set the wall first row (course) 1" below the surface for every foot of height that will be exposed above the grade, on top of a 6" crushed stone leveling pad base that is compacted every 3" during installation. Drainage is very important and is discussed in the "Basic Retaining Wall" area of this book as well.

Tech Spec Guide

icpi
Interlocking Concrete Pavement Institute®

Your requested ICPI Tech Spec 23 follows this page.

Design and Installation Professionals frequently turn to interlocking concrete pavements and permeable interlocking concrete pavements because they offer lower initial and life cycle costs and provide environmentally sustainable solutions.

ICPI provides resources for ICP and PICP design, construction, and maintenance. These include: Tech Specs, Guide Specs, Detail Drawings, Construction Tolerance Guides, Fact Sheets, Design Manuals and design software. ICPI also offers several relevant continuing education courses at icpi.org and aecdaily.com

Find the right guide for your location.

Many ICPI members subscribe by state or province to this Tech Spec service to support the development and revision of these technical documents. The ICPI website Technical Center offers the opportunity to select Tech Specs by state or province.

ICPI Tech Spec Library

- Tech Spec 1: Glossary of Terms for Segmental Concrete Pavement
- Tech Spec 2: Construction of Interlocking Concrete Pavements
- Tech Spec 3: Edge Restraints for Interlocking Concrete Pavements
- Tech Spec 4: Structural Design of Interlocking Concrete Pavement for Roads and Parking Lots
- Tech Spec 5: Cleaning, Sealing and Joint Sand Stabilization of Interlocking Concrete Pavement
- Tech Spec 6: Reinstatement of Interlocking Concrete Pavements
- Tech Spec 7: Repair of Utility Cuts Using Interlocking Concrete Pavements
- Tech Spec 8: Concrete Grid Pavements
- Tech Spec 9: Guide Specification for the Construction of Interlocking Concrete Pavement
- Tech Spec 10: Application Guide for Interlocking Concrete Pavements
- Tech Spec 11: Mechanical Installation of Interlocking Concrete Pavements
- Tech Spec 12: Snow Melting Systems for Interlocking Concrete Pavements
- Tech Spec 13: Slip and Skid Resistance of Interlocking Concrete Pavements
- Tech Spec 14: Concrete Paving Units
- Tech Spec 15: A Guide for the Construction of Mechanically Installed Interlocking Concrete Pavements
- Tech Spec 16: Achieving LEED Credits with Segmental Concrete Pavement
- Tech Spec 17: Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications
- Tech Spec 18: Construction of Permeable Interlocking Concrete Pavement Systems
- Tech Spec 19: Design, Construction and Maintenance of Interlocking Concrete Pavement Crosswalks
- Tech Spec 20: Construction of Bituminous- Sand Set Interlocking Concrete Pavement
- Tech Spec 21: Capping and Compression Strength Testing Procedures for Concrete Pavers
- Tech Spec 22: Geosynthetics for Segmental Concrete Pavements
- Tech Spec 23: Maintenance Guide for Permeable Interlocking Concrete Pavements
- Tech Spec 25: Construction Guidelines for Segmental Concrete Paving Slabs and Planks in Non-Vehicular Residential Applications

Tech Spec 23

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Maintenance Guide for Permeable Interlocking Concrete Pavements

Introduction

Permeable interlocking concrete pavements (PICP) are a proven method for reducing stormwater runoff and pollutants while supporting pedestrian and vehicular traffic. Many laboratory and in-situ research projects over the past two decades by universities, government stormwater agencies, and industry have demonstrated significant runoff and pollutant reductions with cost-saving benefits. The U.S. Federal Highway Administration **www.fhwa.dot.gov/pavement/concrete/pubs/hif19021.pdf** has published information supporting PICP use in walkways, plazas, driveways, parking lots, alleys and streets.

Like all stormwater control measures, PICP requires maintenance as it traps sediment on its surface not unlike an air conditioning filter. Larger particles are initially trapped while allowing water to pass. Some enter the jointing stone and are trapped there. The jointing stone with larger particles eventually captures smaller particles and this decreases the infiltration rate over time. While still infiltrating water, many smaller particles are trapped within the surface and interior joints. Smaller particles are trapped and eventually decrease infiltration which results in surface ponding.

Every PICP site varies in sediment deposition onto its surface, particle size distribution, and the resulting cleaning frequency. For example, beach sand (a coarse particle size distribution) on the surface will not clog as quickly and require less effort removing than fine clay sediment. Besides the particle size distribution, the rate of surface infiltration decline also depends on the traffic, size, and slope of a contributing impervious area, adjacent vegetation and eroding soil, paver joint widths and jointing stone sizes. ICPI offers a PICP site selection

Figure 1. PICP is seeing increased use in municipal streets to reduce stormwater runoff, local flooding, storm pipe upsizing, and combined sewer overflows. These streets are in Atlanta, GA.

Figure 2. Sand-filled joints and bedding common to interlocking concrete pavement **are not used** *in PICP.*

tool on **www.icpi.org/software** to help identify favorable sites and avoid one that may incur additional maintenance.

While routine maintenance assures long-term infiltration, surface infiltration can be restored from neglected maintenance. A significant advantage of PICP is its ability to remove settled or wheel-packed sediment in the joints. This Tech Spec provides guidance on routine and restorative maintenance practices that support surface infiltration. This bulletin also provides guidance on maintaining the surface as an acceptable pedestrian and vehicular surface.

Practices Supporting Surface Infiltration

PICP design and construction that complies with ICPI guidelines are fundamental to long-term surface infiltration. Guidelines are found in ASCE 68-18 standard on PICP, the ICPI manual, *Permeable Interlocking Concrete Pavements* and in *ICPI Tech Spec 18–Construction of Permeable Interlocking Concrete Pavements* available on **www.icpi.org**. Some essential characteristics described below support continued infiltration.

PICP doesn't use sand. Unlike interlocking concrete pavements, sand jointing or bedding materials to support paving units and dense-graded aggregate bases are not used in PICP. Sand joints and bedding allow very little water to enter and often eventually clog for traffic borne detritus and sediment.

Construction E & S control is essential. Erosion and sediment control during construction is covered in the previously mentioned documents, and is customized to each project via the Stormwater Pollution Prevention Plan or SWPPP. An inspection checklist is provided at the end of this bulletin that includes sediment control. If the PICP is built first and construction traffic must use it, then it will very likely require vacuum cleaning upon construction completion. The ideal situation is PICP constructed late in the project such that it will not receive much construction traffic and sediment. This may require using temporary construction roads.

If PICP receives run-on from upslope pervious or impervious areas, inspect these areas for erosion and sediment, yard waste, materials storage, etc. Sweep or vacuum the contributing drainage area clean and free of any dirt, leaves and mulch as they are a major source of PICP clogging. Lawn and planting beds should be sloped away from PICP areas.

Maintain filled joints with stones. The jointing stones capture sediment at the surface so it can easily be removed. If sediment is allowed to settle and consolidate, then cleaning becomes more difficult since the sediment is inside the joint rather than on the surface. Settlement of jointing stones in the first few months is normal to PICP as open-graded aggregates for jointing and bedding choke into the larger base aggregates beneath and stabilize. This settlement often requires the joints to be refilled with aggregates three to six months after their initial installation. If possible, this should be included in the initial construction contract specifications. Aggregate-filled joints facilitate sediment removal at the surface and provide interlock for pavement structural stability.

Keeping the joints filled during the PICP service life is essential to trapping sediment and facilitating its removal at the surface and ensuring long term performance. Permeable segmental paving systems that do not use jointing aggregates may incur higher maintenance time and costs to extract accumulated sediment from deep within the joints and bedding, or eventually move through the base/subbase aggregates onto the subgrade and reduce its infiltration.

Filled paver joints means filled to the bottom of the paver chamfers with jointing stone. If the pavers have very

Figure 3. Whether eroded onto or dumped on PICP, erosion and sediment control are essential during construction.

Figure 4. Keeping PICP joints filled with permeable aggregate facilitates removal of accumulated sediment.

small or no chamfers, then they should be filled within ¼ in. (6 mm) of the paver surface. Should the top of jointing stone settle below ¼ in. (6 mm), vacuum equipment can be less effective in removing sediment and cleaning becomes potentially more expensive.

Manage mulch, topsoil and winter sand. Finally, stockpiling mulch or topsoil on tarps or on other surfaces during site maintenance activities rather than directly on the PICP surface helps maintain infiltration. Figure 5 illustrates an example of correct management of landscaping material on PICP, as well as the need to exposed soil slopes.

Sand used in the winter for traction is not recommended. Figure 6 illustrates the consequence to PICP joints when subjected to winter sand for traction. If used, sand should be removed with vacuuming in the spring to prevent a substantial decrease in surface infiltration. Using jointing aggregate is recommended as a better alternative to using sand for winter traction. In addition, the aggregate can provide some refilling of the joints.

Surface Infiltration Inspection & Testing

Visual Inspection—Effective ways to assess PICP surface infiltration is by conducting visual inspections or tests on the surface before, during and immediately after rainfall.

Inspect Before a Rainfall—Sediment crusted in the joints when dry is the most opportune time to remove it. During dry periods, the sediment layer in each joint can sometimes dry out and curl upward. This layer can be easily loosened by vacuum equipment.

Additionally, deciduous leaves and pine needles eventually get crushed by traffic, degrade, and work their way into the joints, thereby reducing infiltration. See Figures 7 and 8. The site should be inspected for sediments from adjacent eroding areas and those areas stabilized immediately.

Weeds growing from within joints indicate accumulated sediment in the joints and neglected maintenance. See Figure 9. Weeds will not germinate unless there is accu-

Figure 5. Mulch placed on tarps prevents more expensive cleaning of PICP.

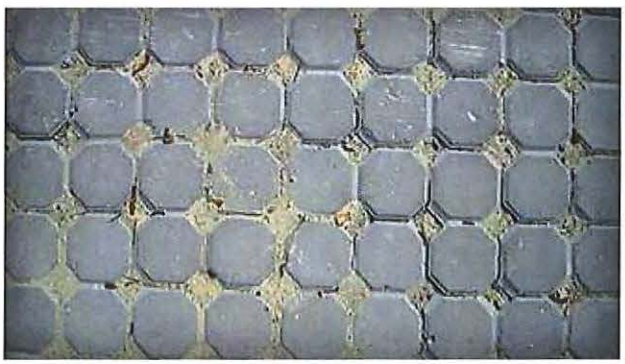

Figure 6. Sand from winter maintenance must be removed the following spring.

Figures 7 and 8. Pine needles and leaves eventually will degrade and get compacted into the joints from traffic. They should be removed by sweeping or vacuuming before that happens.

mulated sediment. Weeds should be removed by hand. Herbicide may kill weeds, but dead vegetation and roots will remain. They typically reduce infiltration and should eventually be removed.

Inspect During and Just After a Rainstorm— The extent of puddles and bird baths observed during and especially after rainstorm indicate a need for surface cleaning.

Table 1. ASTM C1781 test results: relationship between time required to infiltrate and calculated surface infiltration rate

Time to infiltrate water		Approximate surface infiltration rate inches/hr (mm/hr)	
Minutes	Seconds	8 lbs. (3.6 kg) water	40 lbs. (18 kg) water
0.5	30	235 (5,913)	1,175 (29,564)
1	60	117 (2,956)	587 (14,782)
2	120	59 (1,478)	294 (7,391)
4	240	29 (739)	147 (3,696)
6	360	20 (493)	98 (2,464)
8	480	15 (370)	73 (1,848)
15	900	8 (197)	39 (985)
30	1800	4 (99)	20 (493)
60	3600	2 (49)	10 (246)

Note: $I = (K \bullet M)/(D^2 \bullet t)$, where
I = Surface infiltration rate, in./hr (mm/hr)
K = 126,870 for US customary units (4,583,666,000 for metric)
M = water mass, lbs (kg)
D = ring diameter (12 in. or 305 mm)
t = time for water to infiltrate in seconds

- Acceptable performance > 100 in./hr (2,500 mm/h)
- Plan to clean soon
- Clean immediately < 20 in./hr (500 mm/hr)

A minor amount of ponding is likely to occur particularly at transitions from impervious pavement surfaces to PICP. This often occurs first as sediment is transported by runoff and vehicles. See Figures 10 and 11. Should ponding areas occupy more than 20% of the entire PICP surface, then surface cleaning should be conducted. While a rainstorm's exact conclusion is difficult to predict, standing water on PICP for more than 15 minutes during or after a rainstorm likely indicates a location approaching clogging.

Test Surface Infiltration—A quick and subjective test for the amount of surface infiltration is pouring water on PICP. If the water spreads rather than infiltrates, the extent of spreading suggests an area that may be clogging. Should more than approximately 20% of the surface area see ponding during or immediately after a rainstorm, a more objective measure of surface infiltration of these areas can be accomplished using ASTM C1781 *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems.* Figure 12 illustrates the test set up using a 12 in. (300 mm) diameter ring set on plumber's putty. (The ring can be metal or plastic.) Figure 13 illustrates the test apparatus in

Figure 9. Weeds indicate sediment accumulation and lack of surface cleaning to remove it.

Figure 10. Erosion of adjacent asphalt and sediment deposition on PICP.

Figure 11. Ponding on PICP typically first occurs at the junction with impermeable pavement.

Figure 12. Steps in setting up test equipment for measuring surface infiltration using ASTM C1781.

place with water poured into it.

ASTM C1781 test method begins with "pre-wetting" an area inside the ring to ensure the surface and materials beneath are wet. This is done by slowing pouring 8 lbs (3.6 kg) of water while not allowing the head of water on the paver surface to exceed 3/8 in. (10 mm) depth. If the time to infiltrate 8 lbs of water is less than 30 seconds (using a stopwatch typically on a cell phone), the subsequent test is done using 40 lbs (18 kg) of water. If more than 30 seconds, then 8 lbs of water is used in the subsequent tests. Again, a 3/8 in. (10 mm) head is maintained during the pour while being timed with a stopwatch. The surface infiltration rate is calculated using formulas in the test method.

If infiltration measurements on ponded areas consistently result in rates below 20 in./hour (508 mm/hr), they require immediate surface cleaning. PICP surfaces sloped over 2% with less than 40 in./hr infiltrate rate require immediate surface cleaning. An infiltration rate of 20 in./hr equates to 30 minutes' infiltration time and 40 in./hr results in 15 minutes. Table 1 further illustrates the relationship between time

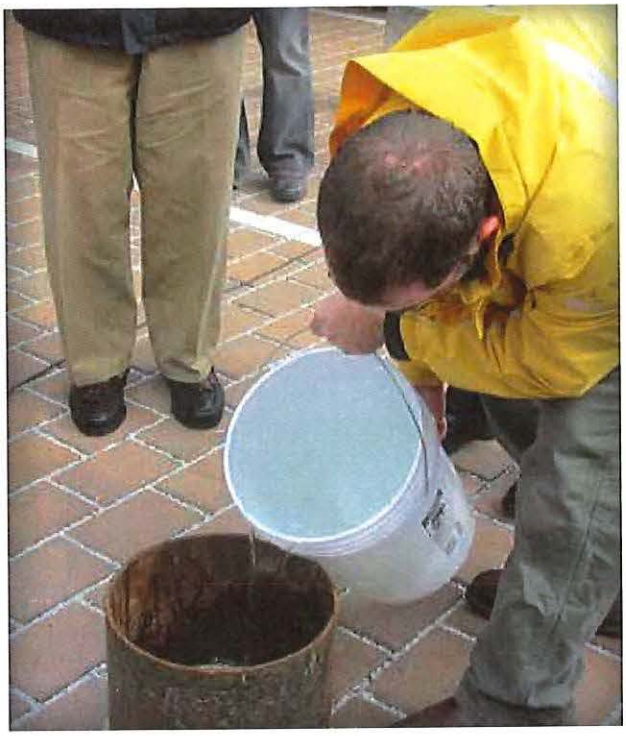

Figure 13. ASTM C1781: pouring the wanter into a 12 in. (300 mm) inside diameter ring set on plumber's putty.

for 40 lbs (18 kg) of water to infiltrate and the calculated infiltration rate. ICPI offers a downloadable calculator for converting time of infiltration to infiltration rates when using C1781. See **www.icpi.org/software.**

Surface Infiltration Maintenance Types

Routine and Restorative Maintenance—There are two approaches or service types for maintaining PICP surface infiltration: routine and restorative. Routine maintenance is done regularly to maintain infiltration. It removes most loose sediment and debris from the surface before being trapped and stuck in the jointing aggregates thereby causing clogging. Routine maintenance may require reinstatement of a small amount of jointing stones or none at all.

Routine Maintenance Equipment Options for Maintaining Various Sized PICP Applications

Cleaning Small Pedestrian Areas and Driveways

Theas are typically under 2,000 sf or 200 m^2 and include patios, plazas, sidewalks, and driveways. Equipment options follow:

Hand-held Bristle Broom— Sweep as needed to clear the surface clear of loose debris. See Figure 14.

Leaf Blower (electric or gas powered)—A minimum air speed of 120 mph (190 kph) is recommended. Jointing aggregates remain in place while removing loose debris such as leaves from the surface. See Figure 15.

Rotary Brush with Plastic Bristles—These are often used to spread jointing stone during construction. Same equipment can be used to clean surface to top of joints. Bristles can flip debris out of joints (depends on bristle reach into the joints). A small amount of aggregate may need to be replaced in the joints after using. See Figure 16.

Wet/Dry Shop Vacuum or Walk-behind Vacuum—Use equipment with a minimum 4 (peak) HP motor with minimum 130 cubic feet (3.7 m^3) per minute suction. These machines can remove some jointing aggregates so they may require replenishment. See Figures 17 and 18.

Power Washer—This equipment should be capable of 1,400 to 1,800 psi (9.6 to 12.4 MPa) pressure. Apply the spray at a 30° angle approximately 18 to 24 in. (45 to 60 cm) from the surface and adjust as needed. This equipment will evacuate jointing aggregate and replenishment will be required. Power washing alone generally is not an optimal cleaning approach because there is almost no opportunity on most sites to remove the water-suspended sediment before the water is absorbed back into the pavement. See Figure 19.

Cleaning Large PICP Areas

These are typically over 2,000 sf or 200 m^2 such as large plazas, long sidewalks and driveways, parking lots, alleys and streets. Equipment options follow:

Street Sweepers—These typically have rotating plastic bristle brushes positioned near the curb side and center pickup into a hopper at the rear. Do not use water as it slows removal of loose dirt into the machine. This machine does provide a small vacuum force to manage dust, but the cleaning action is provided by the mechanical sweeping, so it is moderately effective among large machines for removing sediment in the joints. Bristles from the the main broom can reach into joints parallel to the direction of the broom rotation, but have little effect on the joints not aligned with the broom rotation. See Figure 20.

Regenerative Air Sweepers—Includes a box positioned under the truck and on the pavement through which air is blown and recirculated (hence the term regenerative air). The pavement must have no convex (or reverse) crown in order to create an adequate seal for suction in the box. Air pressure flowing through it picks up loose debris and sediment. Rotating brushes can be used to direct dirt and debris toward the box. See Figure 21.

Figure 14. Bristle broom for removing loose debris

Figure 15. Blowing debris to curbs or gutters for removal and disposal.

Figure 16. Rotary brushes increase cleaning efficiencies.

Restorative Infiltration Maintenance for Large Clogged Surfaces

Restorative maintenance is conducted when sediment has lodged in the jointing stones from traffic and weather. The condition indicates that the PICP surfaces have not been regularly cleaned. Restorative maintenance requires some or complete removal of the jointing aggregates to increase infiltration. The depth of jointing stone removed depends on the penetration depth of the sediment into the joints. This can be determined on a sample of a few clogged joints (typically where ponding occurred) by prying out stones and sediment with a flat head screwdriver until little or no accumulated sediment appears.

True Vacuum Sweepers—These can withdraw jointing material and even the concrete pavers. Therefore, the vacuum engine revolutions must be adjusted by the machine operator during a few test runs to find the setting that withdraws the needed depth of sediment and jointing aggregate. After withdrawal, jointing aggregates will require replenishment. The suction orifice is typically about a yard (meter) wide and positioned on the curb side of the truck. Extremely clogged surfaces will require two or more passes. Figure 22 shows this machine. It is often used by municipalities to clean out storm drain catch basins and may require a separate vacuum attachment to clean pavements.

High-power Washing and Vacuum Equipment—Figure 23 shows the equipment for restorative cleaning where water is applied to help loosen sediment and stones in the joints. Figure 23 shows a vacuum that withdraws sediment and stones immediately after applying water. The water and debris are drawn into a vac truck.

Figure 17. Wet/dry shop vacuum cleans loose sediment from a PICP residential driveway

Figure 18. Walk-behind vacuum cleans a small parking area.

Figure 19. Power washing requires a little practice to minimize jointing stone removal.

High Pressure Air/Vacuum—High pressure air is blasted into the joints and has been shown to be very effective at dislodging sediment and debris. A second step is then required to vacuum up the debris that is dislodged. In Figure 24, the machine in the foreground blows debris completely out of the joints and the second machine takes up the debris into a vac truck similar to that used to clean catch basins. See Figure 24. As with all restorative cleaning methods, clean jointing stone is spread and the empty joints are filled. After removing excess stones from the surface, the pavers with filled joints are compacted with a minimum 5,000 lbf (22 kN) vibratory plate compactor operating at 75-90 Hz. See Figure 25. This helps settle the stones into the joints. Any joints were stones have settled should be filled with more stones within a ¼ inch (5 mm) of the paver surfaces.

Maintenance Equipment Performance

In 2020, the University of Toronto completed a two year research project, Maintenance Equipment Testing on Accelerated Clogged Permeable Interlocking Concrete Pavements. This study evaluated maintenance equipment for restoration of infiltration rates of PICP systems when joints become severely clogged. The research was conducted at the Toronto & Region Conservation Authority's Kortright Centre in Vaughn, Ontario. The research scope of work included the construction of seven 10 ft. by 10 ft. PICP partial infiltration test pads. The cells were carefully clogged to a surface infiltration rate of ≤ 10 in/hr. The sediment infill used to clog the system was regional street cleaning sediments with a known particle size distribution. Five different technologies were investigated: full vacuum sweeper, regenerative air sweeper, dry mechanical sweeper, water pressure washing, and a hybrid high pressure air/vac system specifically designed for permeable pavement. The objective of the study was to evaluate the effectiveness of each method at restoring surface infiltration rates. The impact of cohesive soil sediment was also evaluated as part of the study. All cleaning technologies significantly improve surface infiltration rates. However, the high pressure air-vac hybrid had the best and least variable results, and was the only technique able to fully restore surface infiltration rates. Joint penetration depth was generally a good indicator of restoration effectiveness, except if sediment gradation varies. A complete copy of the report can be found at **https://tinyurl.com/y67zhydz**.

Figure 20. This type of mechanical sweeper removes sediment from joints parallel to the direction of the broom rotation.

Also in 2020 the United States Geological Survey Madison, WI office published results of a four year investigation on cleaning PICP, Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement. Since 2014, this research site has collected water quality, temperature, infiltration rates, and surface flow data with three types of permeable pavement sections (pervious asphalt, porous

Figure 21. A regenerative air machine does routine cleaning in a PICP parking lot.

Figure 22. A true vacuum machine cleaning neglected PICP.

concrete, and permeable interlocking concrete pavement). Contributory drainage from an adjacent parking lot provided an opportunity for accelerate clogging and collect data for 9:1 and 5:1 drainage ratios. The following six pavement cleaning methods were evaluated over a 4-year period: manual cleaning with a masonry trowel; Leaf blower and broom; true vacuum; water-enhanced vacuum; high pressure air system; and pressure washer with soil vacuum. An evaluation of the efficiency of each method was based on comparing surface infiltration rates, pre and post cleaning. Surface variability was high due to surface flow patterns across the permeable surfaces. All cleaning methods improved surface infiltration rates. PICP showed the greatest recovery compared to pervious concrete or pervious asphalt. These systems were more difficult to maintain due to sedimentation penetrating into the solid matrix related to the twisting of interconnected pores created during placement. Different cleaning methods produce different results however, in all instances, when the same method was applied, PICP showed the greatest recovery in infiltration capacity. At this particular site the majority of clogging occurred within the top 1 inch. A complete copy of the report can be found at **https://tinyurl.com/yy9nhou8**.

Inspection Intervals and Procedures for Maintaining Surface Infiltration

Routine maintenance provides the best infiltration performance by implementing the following procedures:

1. **Weekly**—Prevent contamination from routine landscape maintenance such as grass clippings from mowing, hedge trimming, mulching plant beds, etc. by:
   - Broom sweep debris from the paver surface, or
   - Blow debris from the paver surface with a powered leaf blower onto other surfaces that will not retransmit it to the PICP surface.
   - Mechanically sweep paver surface.
   - Remove loose debris, leaves, needles, sediment, topsoil, mulch, etc. after severe rain storms using the above procedures.
   - Collect and dispose of debris.
2. **Semi-annually**—Remove loose surface debris from the pavers and jointing stones (1) when trees have defoliated in the fall and (2) at the end of winter snowfall.
   - Use a wet/dry vacuum for small areas and a regenerative air machine for larger areas.

Figure 23. This equipment provides combined washing and vacuum of unmaintained PICP.

Figure 24. This equipment blows sediment and soiled aggregate from the joints and uses vacuum equipment to remove them.

Figure 25. No matter the equipment used, after removing sediment soiled aggregate, clean aggregate is placed in the joints, the surfaced cleaned and compacted.

- Replenish jointing stone as needed to the bottom of the paver chamfers.
- Check any observation wells and outlet pipes from underdrains to confirm drain down and water outflows.

3. **As needed**—Based on observation and during rainstorms and subsequent surface infiltration tests, remove and replenish the jointing stones and sediment using restorative cleaning equipment and procedures.

Note: *Various factors will affect each project's routine maintenance schedule and each must be reviewed individually.*

Winter Maintenance

Snow Removal—Unlike other permeable pavement surfaces, PICP demonstrates durability in the winter. PICP can be plowed with steel or hard rubber blades. Steel blades typically scratch all pavement surfaces. When using commercial snow removal companies, confirm in writing they provide protective edges on the snowplow equipment to avoid scratching the surface. Most pavers have chamfers on their surface edges which can help protect the edges from chipping by snow plows. For smaller areas, use a plastic snow shovel and fit snow blowers with plastic on the scoops and on the gliders. When possible deposit plowed snow onto grassy areas and not on the PICP when the plowed snow is dirty. Such dirt will remain and likely help clog the PICP surface after the snow melts.

Deicers—When used sparingly, deicers should not damage PICP surfaces as the brine typically forms on the surface to lower the freezing temperature of water and eventually moves into the joints with melting ice or snow. Some deicers will accelerate surface wear on some styles of pavers with blasted or hammered surfaces.

A 2020 University of Toronto study on pavement deicing operations quantified some significant winter safety benefits when using PICP. Besides confirming that the use of permeable pavers can eliminate the occurrence of snow melt refreezing and forming black ice, snow and ice can also melt and dry quicker when deicers are used on PICP. More importantly, the research confirmed that a much lower deicing salt application rate is required on PICP compared to impervious asphalt, while still maintaining a high level

Figure 26. This is an example of snow that should have been deposited on a grassy area. If such areas are not available, then vacuum clean the PICP in the early spring.

Table 2. Maintenance guidelines for all PICP distresses

Distress	Activity	Frequency
Clogging	Schedule appropriate routine cleaning method based on site conditions. Utilize restoration cleaning methods as needed when surface infiltration rates decrease below project threshold. Hot spot cleaning may be appropriate.	1 to 2 times annually; adjust frequency based on sediment loading
Clogged/Damaged Secondary Features	Clean out or repair secondary drainage features.	Annually, after major rain event
Depressions	Repair all paver surface depressions, exceeding 0.5 in. (13 mm)	Annually, repair as needed
Rutting	Repair all paver surface rutting, exceeding 0.6 in. (15 mm)	Annually, repair as needed
Faulting	Repair all paver surface faulting, exceeding 0.25 in. (6 mm)	Annually, repair as needed
Damage Paver Units	Replace medium to high severity cracked, spalled or chipped paver units.	Annually, repair as needed
Edge Restraint Damage	Repair pavers offset by more than 0.25 in. (6 mm) from adjacent units or curbs, inlets, etc.	Annually, repair as needed
Excessive Joint Width	Repair pavers exhibiting joint widths exceeding 0.5 in. (13 mm)	Annually, repair as needed
Joint Filler Loss	Replenish aggregate in joints.	As needed
Horizontal Creep	Repair areas exhibiting horizontal creep exceeding 0.4 in. (10 mm)	Annually, repair as needed
Excessive Settlement	For settlements greater than 1 in. consult a pavement engineer versed in OGA design and construction to determine cause and correction.	As needed.
Additional Distresses	Missing pavers shall be replaced. A geotechnical investigation is recommended for pavement heaves.	Annually, repair as needed

of slip and skid resistance. The study also demonstrated that PICP systems can attenuate and buffer the release of salt back into the environment, an important finding since there is concern about snowmelt and stormwater runoff environmentally damaging lakes and rivers.

Deicer types acceptable for use in on PICP surfaces include sodium chloride, calcium chloride and potassium chloride. Do not use magnesium chloride as it will eventu-

ally destroy all concrete materials. Anti-icing agents that contain ammonium nitrate and ammonium sulfate should not be used since they can also erode concrete. Always read and follow the manufacturer's recommendations for use and heed all warnings and cautions.

Maintenance for Other Distresses

Over time and traffic, PICP can exhibit other distresses besides surface ponding from clogged joints. These are outlined in Table 2 and remedies are provided.

Utility Restoration Guidelines

1. Remove and store pavers for reuse. Secure undisturbed pavers in opening with wood or metal frame.
2. Remove and dispose of all jointing and bedding aggregate as they typically cannot be re-used.
3. Remove the aggregate base and subbase material. Incidental mixing of base and subbase aggregates is acceptable, but make every effort to separate them. Store in on impermeable pavement or a geotextile to prevent contamination. Do not reuse contaminated aggregate.
4. Re-compact subgrade material as required for stability during utility repairs.
5. Repair or install utility as required.
6. If below the bottom of the subbase, place and compact dense-graded road base in lifts not exceeding 6 in. (150 mm) and compact to 100 percent of standard Proctor maximum dry density. The top of the dense-graded aggregate should be at the same elevation as the bottom of the open-graded subbase aggregate. Alternately flowable fill could be used to reestablish the subgrade surface.
7. Reinstate and compact the subbase aggregate in minimum 6 in. (150 mm) lifts. Use a minimum 13,500 (65 kN) plate compactor with a compaction indicator. Add new subbase aggregate if needed.
8. Reinstate and compact the base aggregate as one 4 in. (100 mm) lift. Use a minimum 13,500 lbf (65 kN) plate compactor with a compaction indicator. A lightweight deflectomer (LWD) can be used to ensure that deflections of the compacted base aggregate are below an average of 0.5 mm (assuming a minimum 12 in. (300 mm)) compacted aggregate subbase. An LWD should be used according to ASTM E2835.
9. Place and screed new bedding aggregate in a consistent thickness layer between 1.5 and 2 in. (38 and 50 mm).
10. Reinstate pavers with at surface at least 1 in. (25 mm) higher than the final elevation. Compact the pavers in two perpendicular directions with a minimum 5,000 lbf (22 kN) plate compactor. Fill joints with aggregate, sweep away excess, and compact the pavers in two perpendicular directions again. Compact pavers so they are level with surrounding pavers.
11. Sweep surface clean and remove any excess aggregate and debris.

Other recommendations include keeping all removed materials clean and free of sediment and debris. Minimize excess debris from construction activities and equipment entering the permeable surface. Store all materials away from the permeable surface, otherwise separate materials from the permeable surface with geotextile. Pavement cuts located parallel and close to the wheel path should be extended to include the wheel path. Cuts located within 3 ft (1 m) of a curb or construction joint should include the removal of the adjacent base and subbase to the edge of the curb or construction joint.

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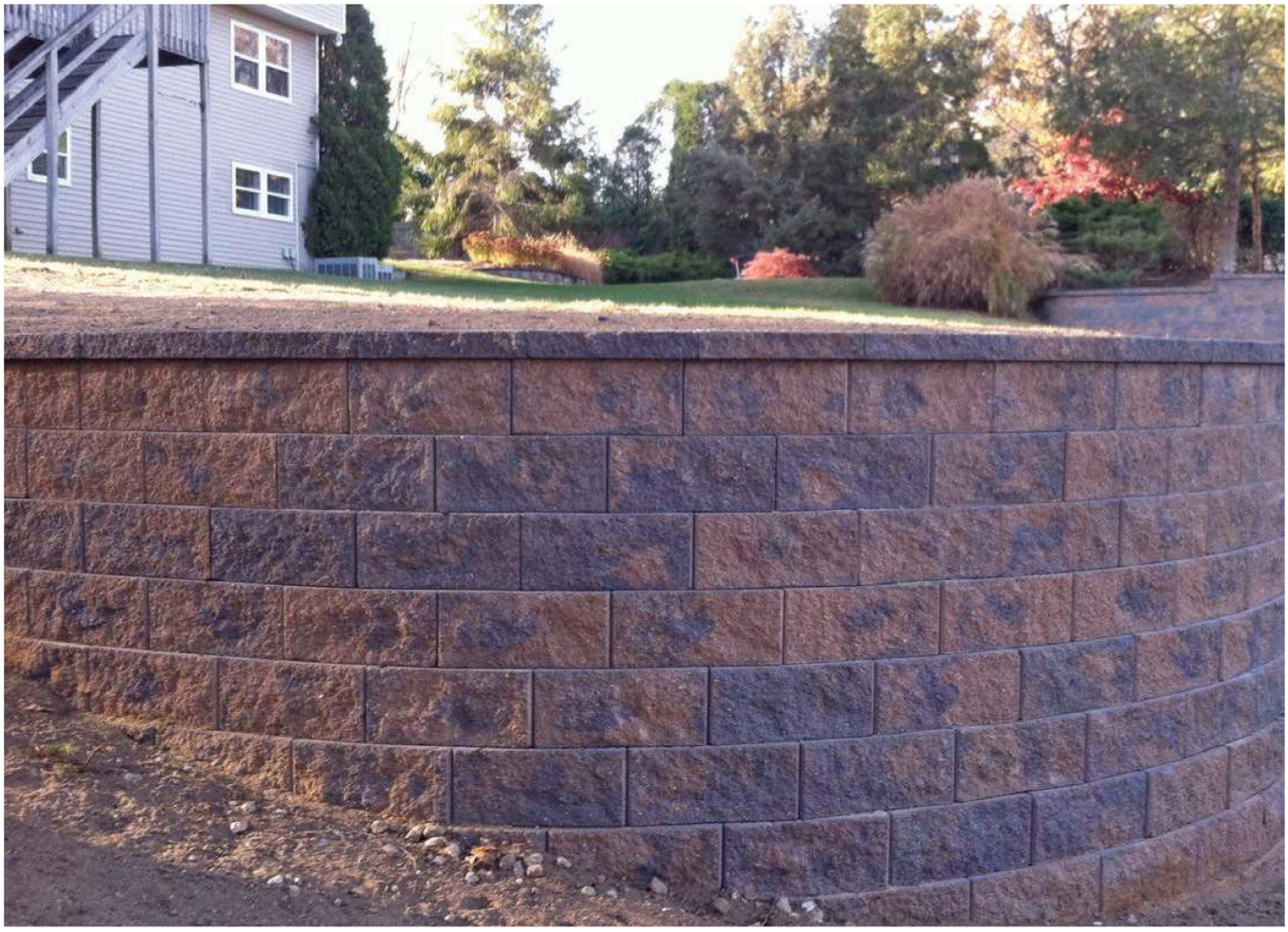
SIGMA MAYTRX OLLDE ENGLISH

GETTING STARTED GUIDE

RETAINING WALL

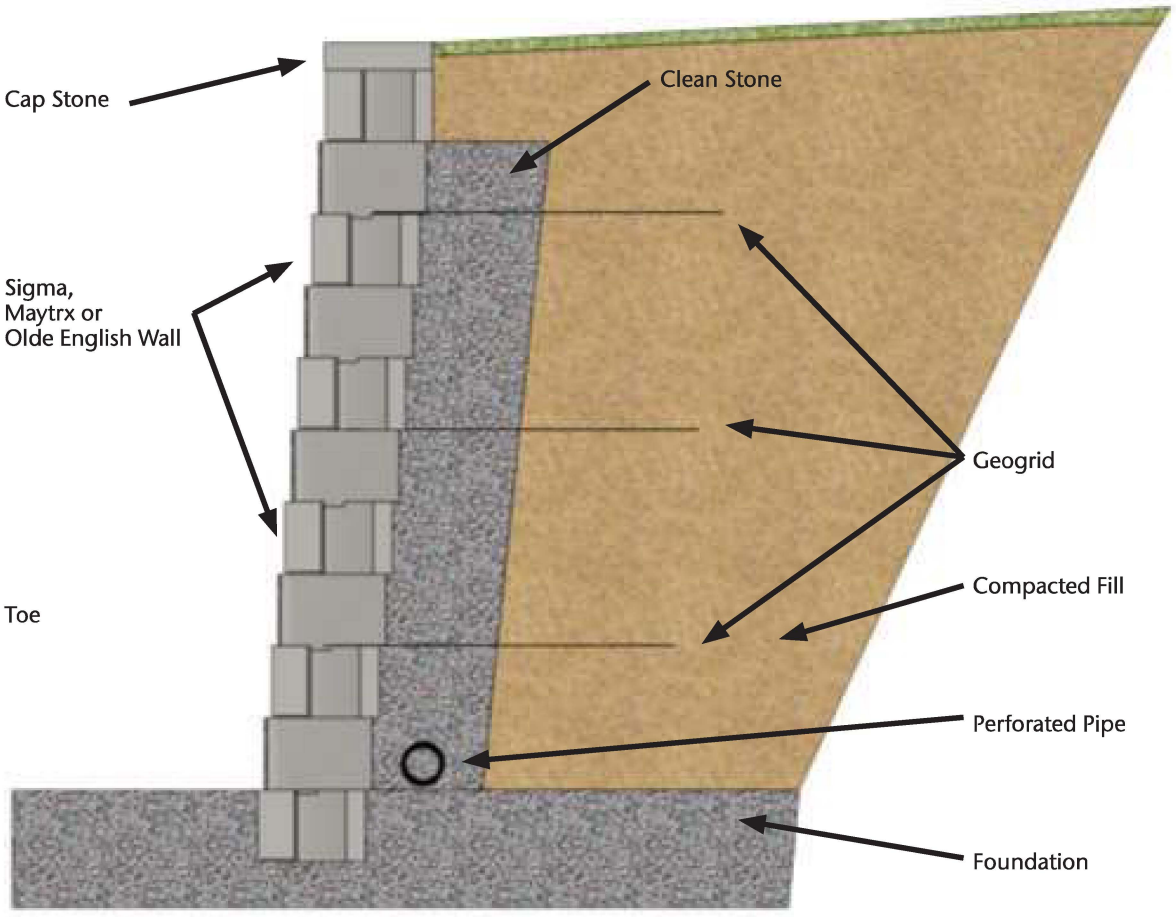
SIGMA-MAYTRX OLDE ENGLISH



BUILDING A WALL

SIGMA-MAYTRX OLDE ENGLISH

This is a starting guide to the Cambridge Retaining Wall Systems including Maytrx, Sigma and Olde English Walls. In this book we cover the general points that are important in building a retaining wall. For any wall over 36" you should also consult our "Sigma or Maytrx Pro-Guide" that is available to download or view at cambridgewallsupport.com or cambridgepavers.com. This will guide you through the factors that influence the strength of the finished wall including load, slope, soil condition, water runoff, geogrid layers, etc. Many municipalities require all retaining walls over a certain height to have a stamp made by a state approved engineer or similar professional that will specify how your wall is built. You will find information on the Cambridge program that allows you to get a free wall design or to receive low cost "stamped" specifications in your state on page 28 of this book. The Sigma stone face and accessories are similar in texture and color to the Cambridge Maytrx line of wall and Outdoor Living Kits. So if you require a tall wall in the rear of your property as well as a double sided wall in your garden and maybe in the future a fire pit or an outdoor fireplace, the finishes will all match.

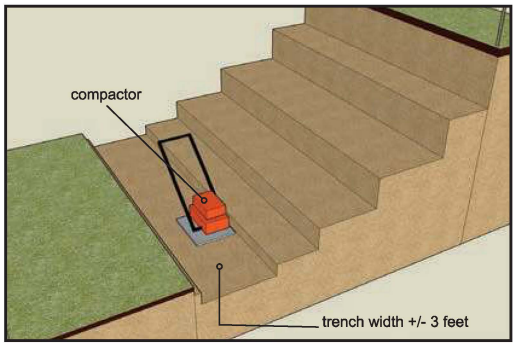


Retaining Walls are made up of more than the Wall Stones. Any wall over 36" consists of the pieces in the illustration above. Foundation, drain pipe, drainage stone, geogrid reinforcement, Wall Stones, Cambridge Cap Stones and select fill are all engineered and installed depending on the site conditions. View Page XX of this book for further information.

SIGMA-MAYTRX OLDE ENGLISH

Protection of soils

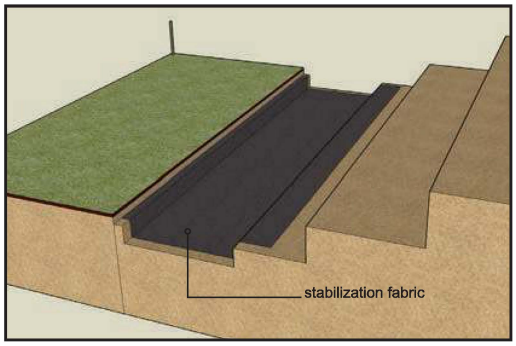
A proper moisture content is required to achieve proper compaction. Foundation soils and all fill soils should be protected from rain and freezing during construction. Frozen soils must NOT be used in retaining wall construction.



Compact sub base

- Compact the soils under the leveling pad to 95% "Standard Proctor Density" or greater.
- If organic soils are encountered they must be removed and replaced with acceptable soils.

TIP:This may, be the proper time to install the drain pipe see the drain pipe guidelines on page XX)



Base stabilization

- The purpose of the leveling pad is to provide a level surface to place the first course of units on. More importantly, the leveling pad spreads out the load of the retaining wall units over a larger area. The strength and quality of your retaining wall depends greatly on the strength and quality of your leveling pad materials.
- Over time the sub-base material can migrate into the leveling pad, thus contaminating it and diminishing its structural integrity. Base stabilization fabric (SRW SS5) separates the leveling pad materials from the sub-base materials so that its strength will not be compromised.

Maytrx Walls come in 6" or 3" height may be used as single sided (Retaining Wall or double sided Freestanding Wall

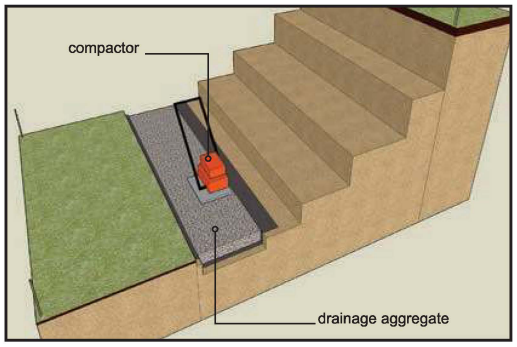
Sigma 6 wall has 4 knobs, install for 6 degree setback, or break off front knobs for near vertical (right)

Olde English Wall may be setback 3/8" to build a wall that can be combined with engineering to serve as a retaining wall

SIGMA-MAYTRX OLDE ENGLISH

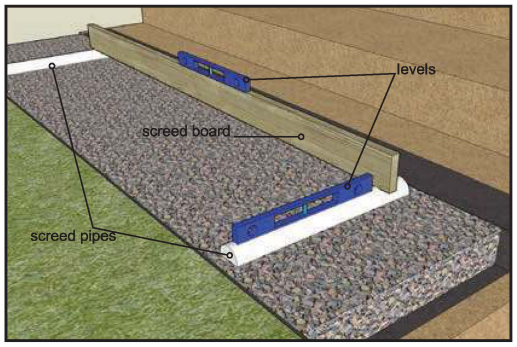
Leveling pad

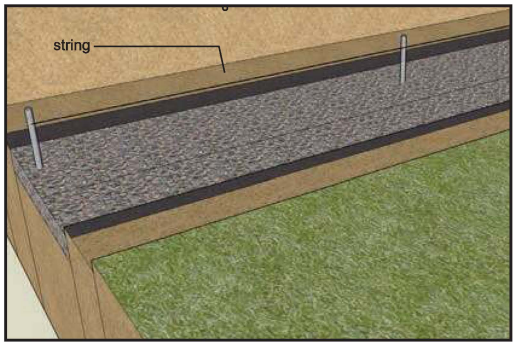
- If possible, start the leveling pad at the lowest elevation of the wall. It is easier to step up than to step down.
- Place well graded gravel or drainage aggregate in the leveling pad trench (see "Excavation" section for minimum leveling pad depths).
- Compact leveling pad to 95% Standard Proctor Density or greater.

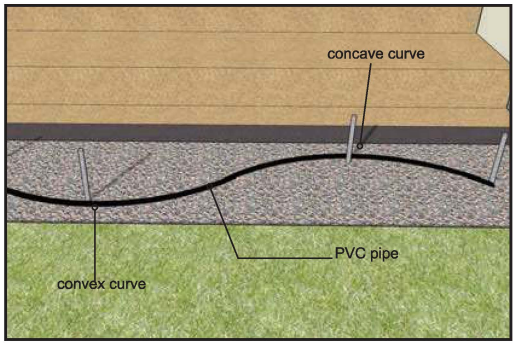


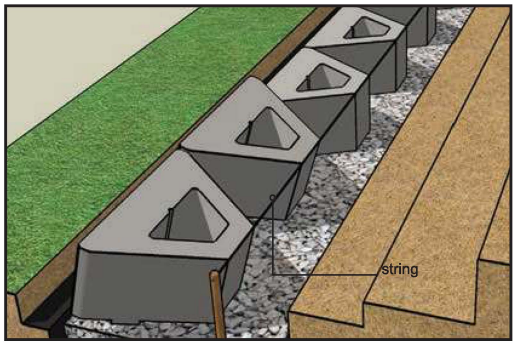
Screeding the leveling pad

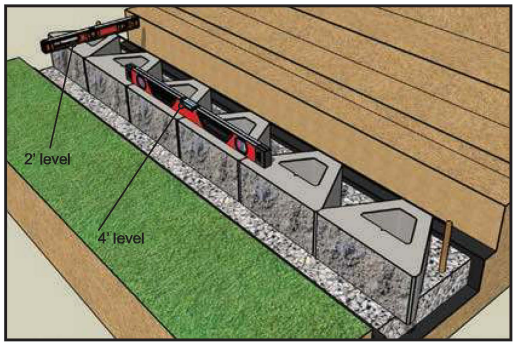
- Place screed pipes across the compacted leveling pad (see illustration).
- If a 10 foot screed is used, an 8 - 9 foot separation of screed pipes works well on straight walls. Screed pipes may need to be closer on curves or corners.
- Make sure the top of the screed pipes are at the correct bottom of the proposed block elevation and are level.
- Place the finish leveling pad material. (If more than 1 ½" is required, do the compaction again.)
- Screed the leveling pad material smooth, being careful that the screed pipes stay level and at the correct elevation.
- Repeat the screeding operation for the length of the leveling pad or if the wall steps up, to the 1st step of the leveling pad.
- Do not walk on or otherwise disturb the leveling pad prior to laying the first course of retaining wall units.





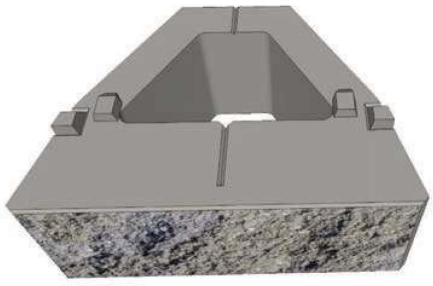






Laying first course: SIGMA

- Use steel stakes and a string line to lay out straight sections of the retaining wall.
- String lines should be placed so that they go along the BACK of the block in order to ensure a straight line. As opposed to the rock face surface on many retaining wall units.
- If the string line is placed at the correct elevation it can be used to check elevation and side to side levelness of the retaining wall unit.
- For laying out a retaining wall that curves, flexible 3/4" PVC pipe works well (see illustration for staking) (see curve and corner guidelines beginning on page 14).
- It is very important that the 1st course of block is laid correctly because it will determine the alignment of the rest of the retaining wall. Any deviations will be magnified as the height of the wall increases.
- It is usually best to start at the lowest elevation of the retaining wall. Again, it is easier to step up than to step down.
- If the bottom of the retaining wall unit has lugs, lips, or any other protrusions, use a hammer and chisel to break them off.
- Carefully place the unit on the screeded leveling pad, using the string line (for straight walls) or the flexible PVC pipe (for curved walls) as alignment guides.
- NEVER let the unit touch the string, because if each unit touches the string it will gradually push it out of alignment, which will result in a crooked wall. A good distance from the string is 1/16 - 1/8 inch away.
- For outside or convex curves, if the retaining wall unit has wings at the back of the unit they may be broken off to facilitate tighter curves.
- Always check the level of the retaining wall units, front to back, side to side, and the elevation in relation to the adjacent units.



Laying first course: Maytrx

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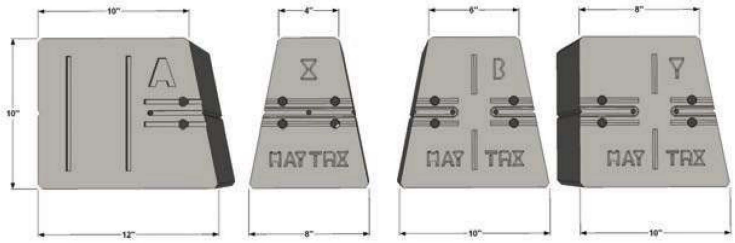

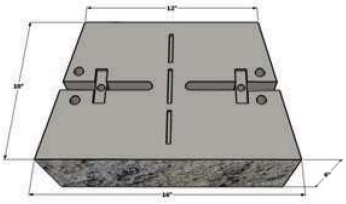

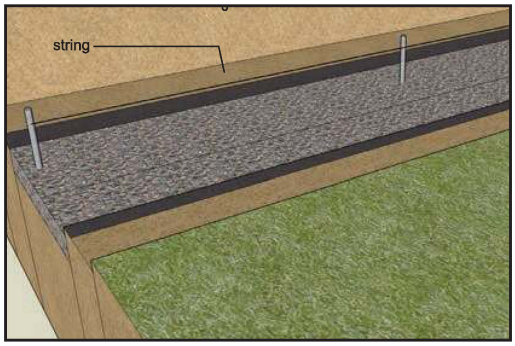

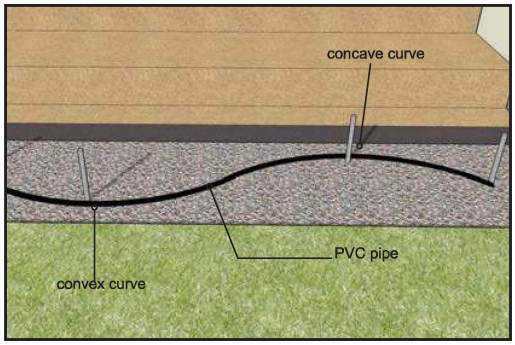

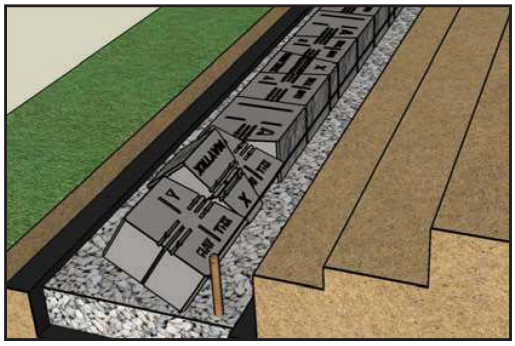

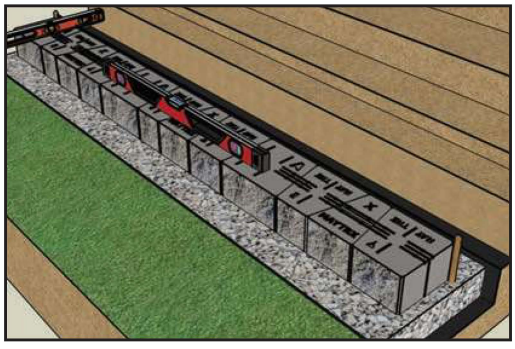

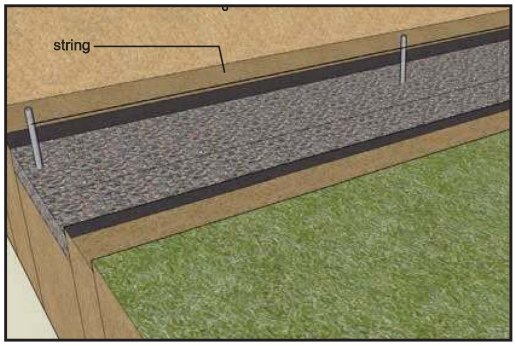

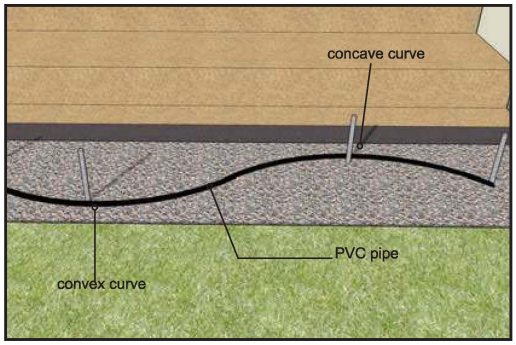

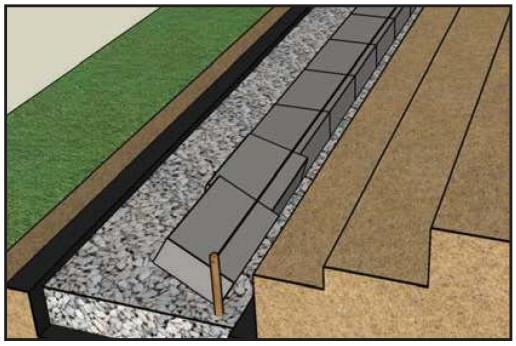

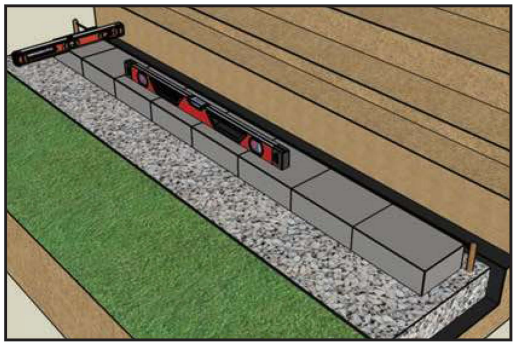

laying first course: Olde English

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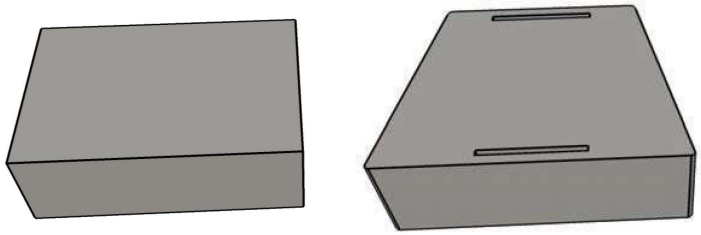
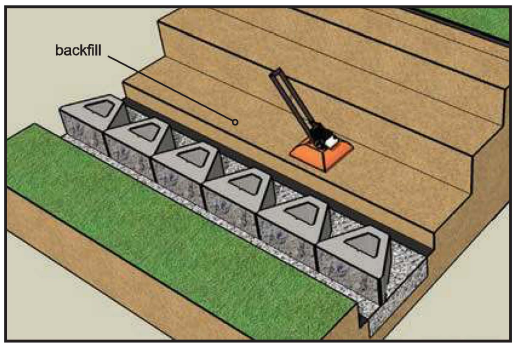


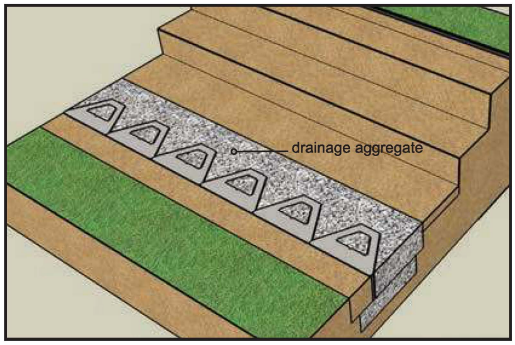
BACKFILL & COMPACTING

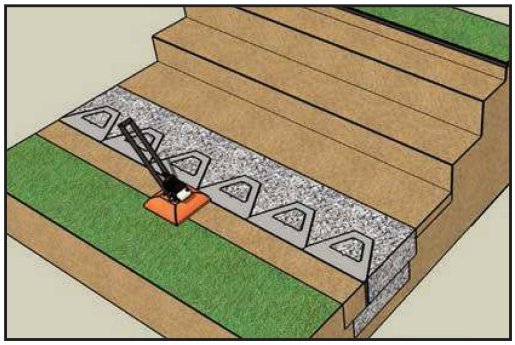
SIGMA

Backfill and compacting

- Always backfill and compact in 6 - 8" lifts, as each course of block is installed. Do NOT stack two or more courses and backfill in deeper lifts because it will be difficult, if not impossible, to achieve proper compaction.
- Place the backfill, leaving a minimum of 12 inches of space between the retaining wall unit and the backfill, for the drainage aggregate (1/2" to 3/4" angular gravel with a maximum of 5% fines).
- Compact the backfill to 95% Standard Proctor Density or better.
- Keep heavy compaction equipment at least 3 feet away from the retaining wall units. Lighter, walk-behind compaction equipment can be within the three foot area.
- Compact soil nearest the retaining wall units first, then work toward the back of the excavation.
- Clean out the 12 inch space behind the retaining wall unit with a shovel.
- Place the drainage aggregate behind and in between the retaining wall units and compact. (This sequence minimizes the tendency of units to tip forward during the compaction process)
- Drainage aggregate doesn't take as much force to compact correctly as the backfill material.
- If the retaining wall units have cores or openings, fill them with the drainage aggregate.
- Any backfill placed at the bottom (front) of the retaining wall should be compacted.

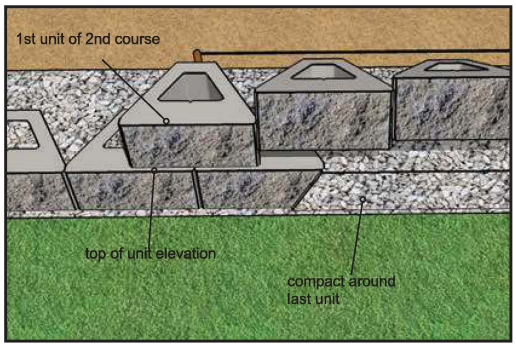


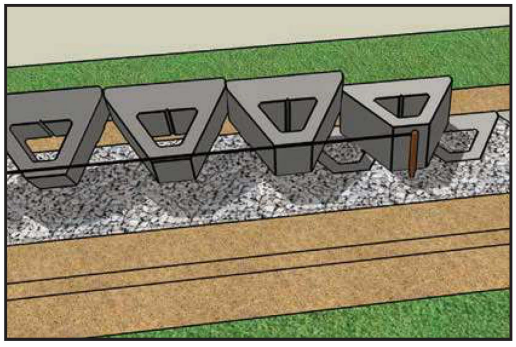


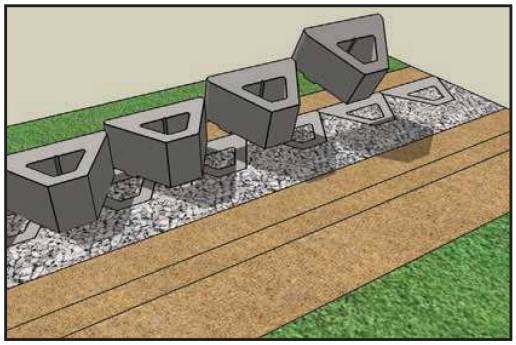


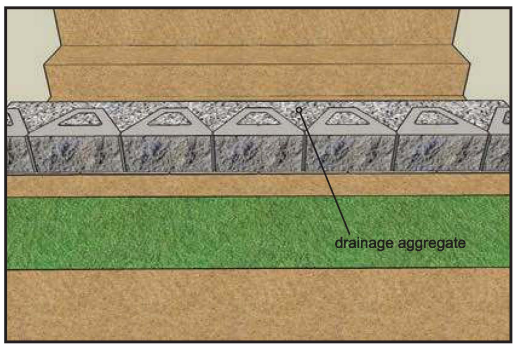
SIGMA

ELEVATION CHANGES & ADDITIONAL COURSES









Elevation changes (stepping)

- The top of the first course unit will be the elevation of the leveling pad. Add 1/8 - 1/4 inch extra, to allow for a little settlement.
- Make sure the soil is compacted in and around the last couple of units in the first course.
- Prepare the stepped up leveling pad as previously instructed for base leveling pad.
- Place the first unit of the stepped up course upon the last and second to last unit of the first course (straddling in a half bond fashion).
- Place the second unit of the step up on the last unit of the first course, 1/2 on that unit and 1/2 on the stepped up leveling pad.

»If geogrid is NOT going to be used, continue on to Additional Courses below.

»If geogrid IS going to be used, skip to page 13 for installation guidelines before continuing on to additional courses.

Additional courses

- Retaining wall units are connected by knobs, which align the units, provide unit to unit shear connection, and provide the automatic setback (otherwise known as batter).
- Sweep any drainage aggregate or soil off the top of the retaining wall units.
- Place the upper unit by straddling the 2 units below in a “half bond” fashion.
- Slide the unit forward, towards the face of the wall, engaging the connection device.
- Continue to install each course of retaining wall units, backfill and compact, place drainage aggregate, and core fill to the top of wall elevation.

BACKFILL & COMPACTING

OLDE ENGLISH

Backfill and compacting

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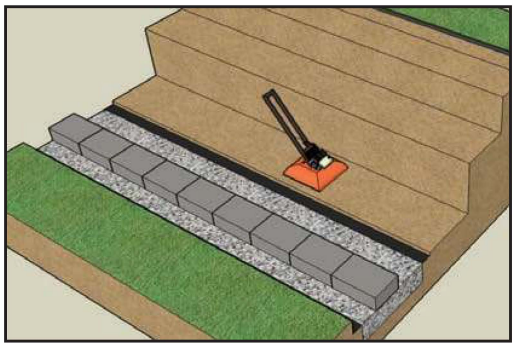
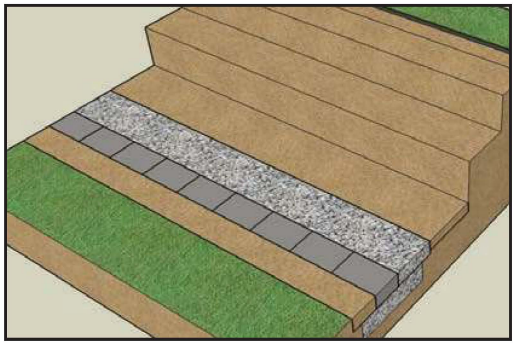
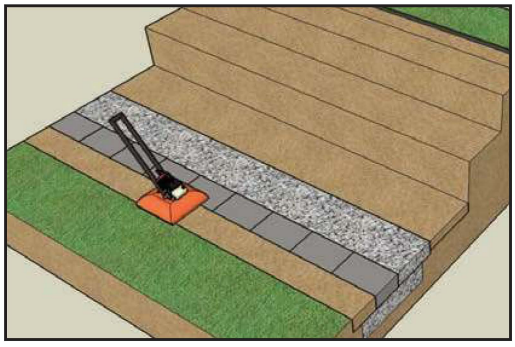
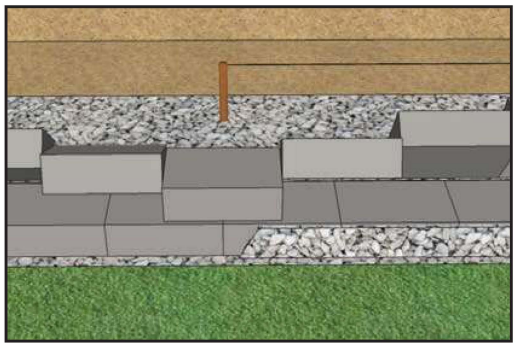


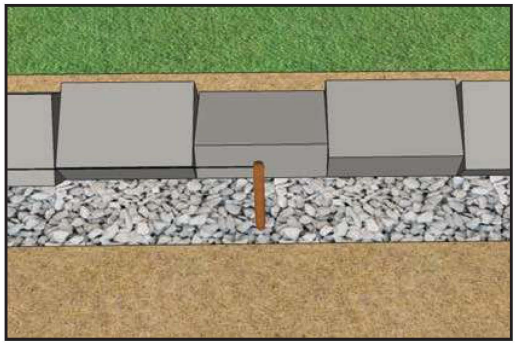


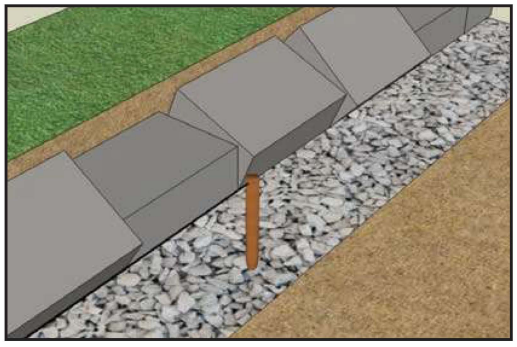


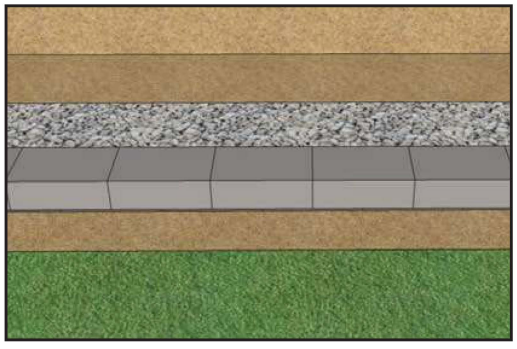
OLDE ENGLISH

ELEVATION CHANGES & ADDITIONAL COURSES









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Additional courses

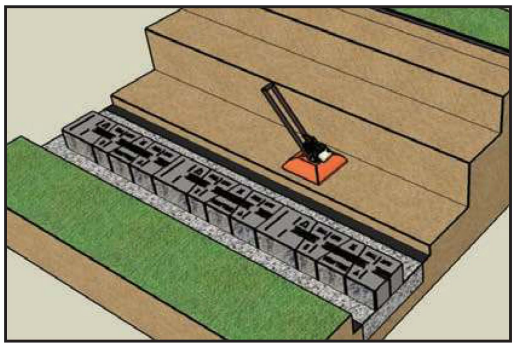
- Retaining wall units are connected by knobs, which align the units, provide unit to unit shear connection, and provide the automatic setback (otherwise known as batter).
- Sweep any drainage aggregate or soil off the top of the retaining wall units.
- Place the upper unit by straddling the 2 units below in a “half bond” fashion.
- Slide the unit forward, towards the face of the wall, engaging the connection device.
- Continue to install each course of retaining wall units, backfill and compact, place drainage aggregate, and core fill to the top of wall elevation.

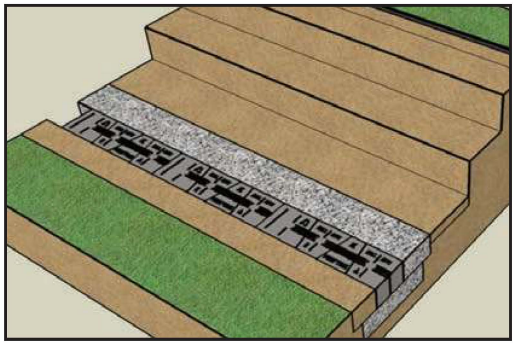
BACKFILL & COMPACTING

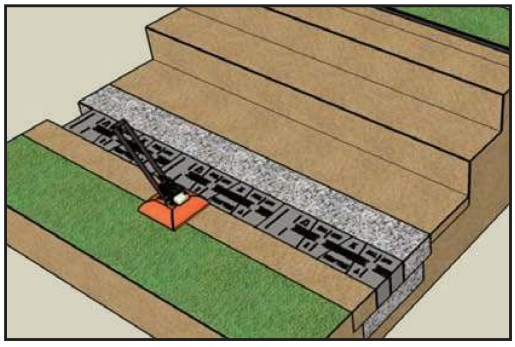
MAYTRX

Backfill and compacting

- Always backfill and compact in 6 - 8" lifts, as each course of block is installed. Do NOT stack two or more courses and backfill in deeper lifts because it will be difficult, if not impossible, to achieve proper compaction.
- Place the backfill, leaving a minimum of 12 inches of space between the retaining wall unit and the backfill, for the drainage aggregate (1/2" to 3/4" angular gravel with a maximum of 5% fines).
- Compact the backfill to 95% Standard Proctor Density or better.
- Keep heavy compaction equipment at least 3 feet away from the retaining wall units. Lighter, walk-behind compaction equipment can be within the three foot area.
- Compact soil nearest the retaining wall units first, then work toward the back of the excavation.
- Clean out the 12 inch space behind the retaining wall unit with a shovel.
- Place the drainage aggregate behind and in between the retaining wall units and compact. (This sequence minimizes the tendency of units to tip forward during the compaction process)
- Drainage aggregate doesn't take as much force to compact correctly as the backfill material.
- If the retaining wall units have cores or openings, fill them with the drainage aggregate.
- Any backfill placed at the bottom (front) of the retaining wall should be compacted.

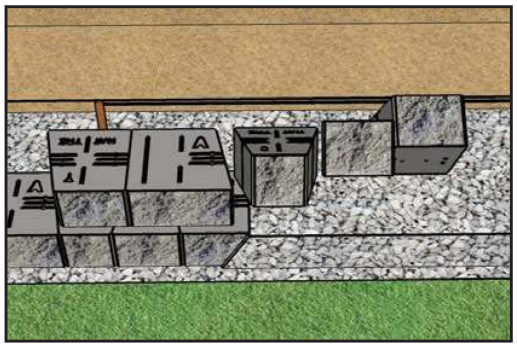


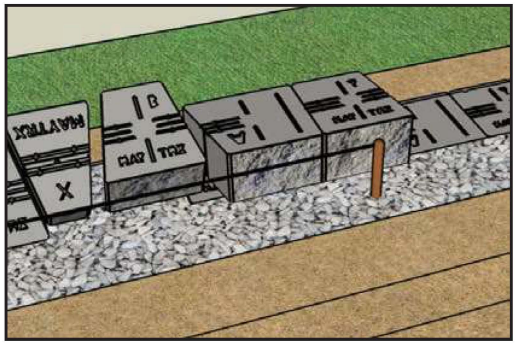


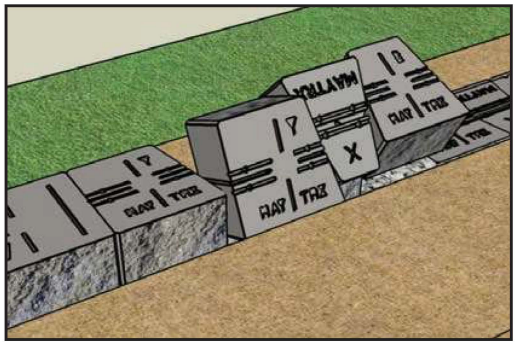


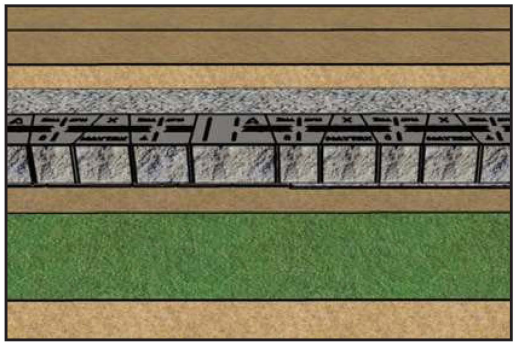
MAYTRX

ELEVATION CHANGES & ADDITIONAL COURSES









Elevation changes (stepping)

- The top of the first course unit will be the elevation of the leveling pad. Add 1/8 - 1/4 inch extra, to allow for a little settlement.
- Make sure the soil is compacted in and around the last couple of units in the first course.
- Prepare the stepped up leveling pad as previously instructed for base leveling pad.
- Place the first unit of the stepped up course upon the last and second to last unit of the first course (straddling in a half bond fashion).
- Place the second unit of the step up on the last unit of the first course, 1/2 on that unit and 1/2 on the stepped up leveling pad.

»If geogrid is NOT going to be used, continue on to Additional Courses below.

»If geogrid IS going to be used, skip to page 13 for installation guidelines before continuing on to additional courses.

Additional courses

- Retaining wall units are connected by knobs, which align the units, provide unit to unit shear connection, and provide the automatic setback (otherwise known as batter).
- Sweep any drainage aggregate or soil off the top of the retaining wall units.
- Place the upper unit by straddling the 2 units below in a “half bond” fashion.
- Slide the unit forward, towards the face of the wall, engaging the connection device.
- Continue to install each course of retaining wall units, backfill and compact, place drainage aggregate, and core fill to the top of wall elevation.

INSTALLATION

SIGMA-MAYTRX OLDE ENGLISH

Capping

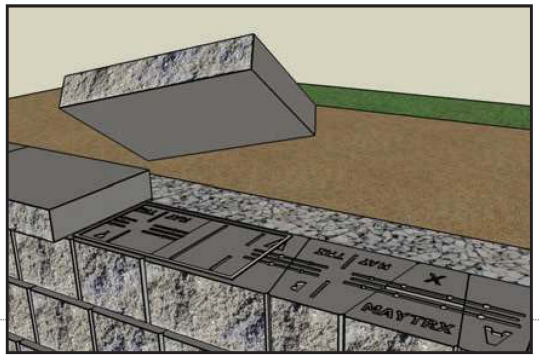
- Clean the top of the retaining wall units of all rock, dirt, and dust.
- Place a bead of retaining wall adhesive around the top of the last retaining wall unit.
- Place the cap on the retaining wall units. Note: A string line can be used to help line up the caps and straighten any waves that may have developed in the retaining wall.
- If a special cap unit is not used, bond the top course to the course just below.

filter fabric

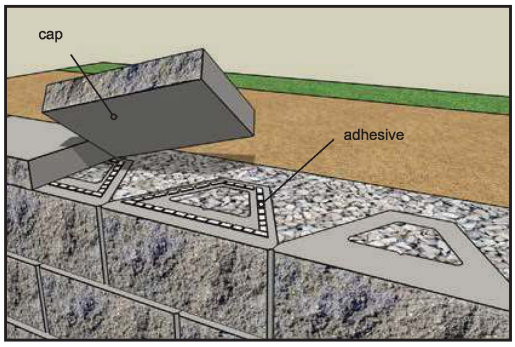
- Place filter fabric on top of the backfill, over the drainage aggregate, and up against the top units or caps before placing the top/planting soils.
- It is recommended that the top/planting soils should be an 8 inch layer of impermeable soils.
- The filter fabric will help prohibit the migration of the fines from the planting soil down into the drainage aggregate and out the face of the retaining wall, thus preventing the plugging of the drainage aggregate and staining of the wall face.

final steps of building the wall

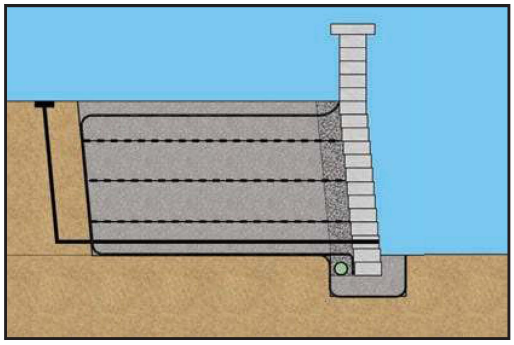
- When finishing the project make sure that the final grade, both the top and bottom of the wall, are shaped so as to divert any water runoff away from the retaining wall. Protect the planting soil from erosion during heavy rains.

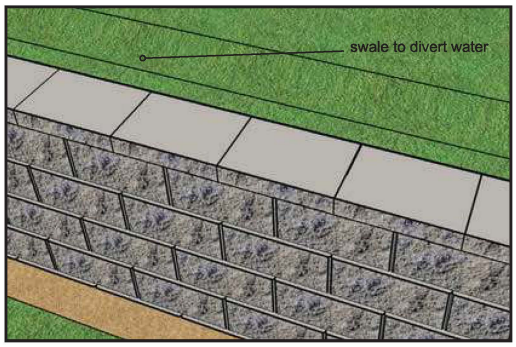


Applies to all the Wall Systems, 13" Caps and Large Caps are used on Maytrx and Sigma, Olde English uses the stone turned to make a cap

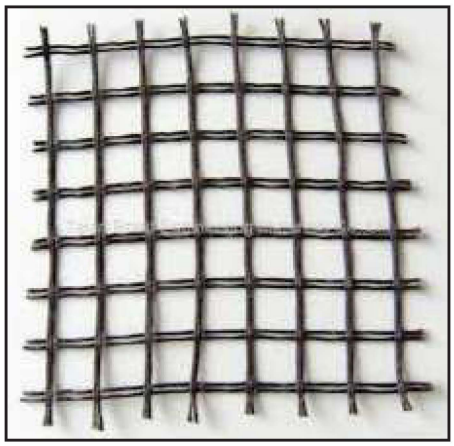


Bring the fabric under the Cap



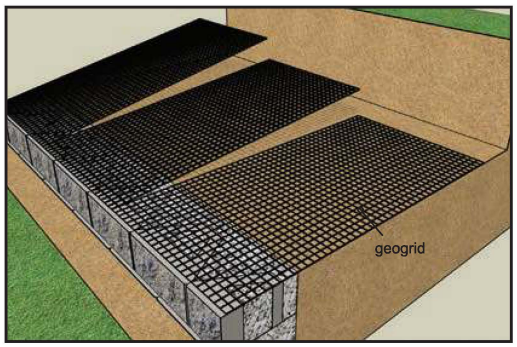


SIGMA-MAYTRX OLDE ENGLISH



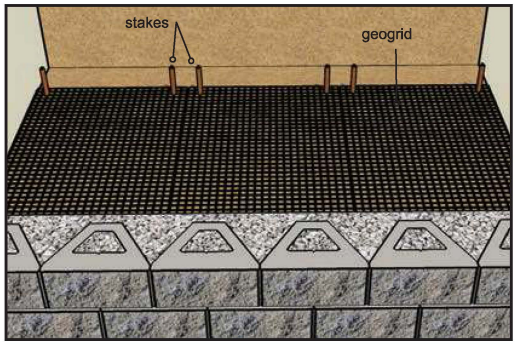
» Geogrid

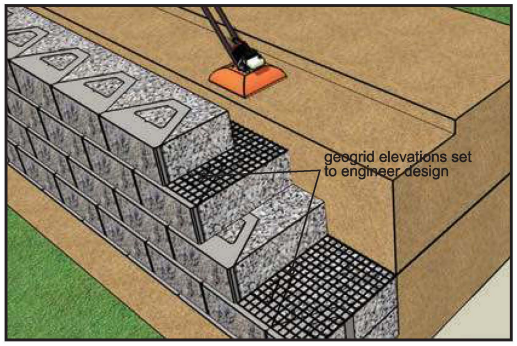
All installation instructions are the same as for gravity retaining walls EXCEPT for the addition of geogrid. Geogrid reinforces the soil, thus allowing taller walls to be constructed. Bi-directional/bi-axial geogrids, means the geogrid is the same strength in both directions. Because of that, this geogrid can be either rolled out parallel to the retaining wall or perpendicular to the retaining wall. If the geogrid depths are the same as the roll width, it may be more efficient to roll out the geogrid parallel to the retaining wall. If the geogrid depths called for are different than the roll width or if the wall curves, it is best to roll out the geogrid perpendicular to the retaining wall. (Not all geogrids are bi-axial, stronger geogrids must be rolled out perpendicular to the retaining wall.)



Using geogrid

- Geogrid depth is measured from the face of the retaining wall unit, to the back of the reinforced soil.
- Geogrid coverage should be 100%. However, the edges of the geogrid, should NEVER overlap. (See page 14 for curve and corner geogrid installation procedures.)
- Use your design table(s), found in page 26 of this guide to determine which course(s) of block to install the geogrid on and how deep it extends into the reinforced soil.
- Place the geogrid as far forward on the retaining wall unit as possible without it showing through the front/face of the retaining wall. Make sure that any connecting devices are engaged by the geogrid.
- Lay the geogrid flat from the wall units to the tail of the geogrid. The backfill, drainage aggregate, and core fill should be level with the top of the retaining wall unit and the geogrid should be as smooth as possible, with no pockets that would create voids under the geogrid.
- Place the next course of block on top of the geogrid and fill the cores with drainage aggregate, if applicable.
- Pull the geogrid taught, being careful not to pull the units back away from the connecting device or disturb the alignment of the units. Use landscape staples or stakes to hold the geogrid in place.



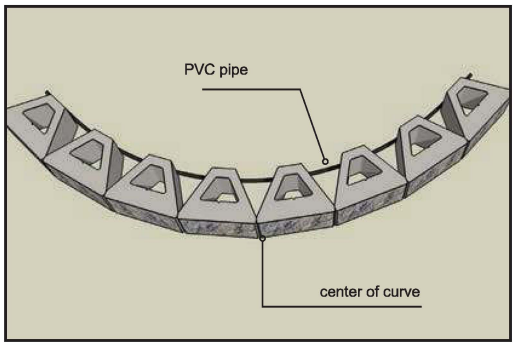


Using geogrid (continued)

- Do not drive or compact directly on the geogrid. A minimum of 6 inches of soil is recommended to cushion the geogrid.
- When backfilling over the geogrid, work the soil from near the retaining wall units toward the tail of the geogrid. When compacting over the geogrid, work from near the retaining wall units toward the tail of the geogrid. This procedure helps keep the geogrid taught.
- See the curve and corner instructions starting below, for geogrid placement.
- continue building wall
- Continue building the retaining wall by returning to “additional courses” on page 11.

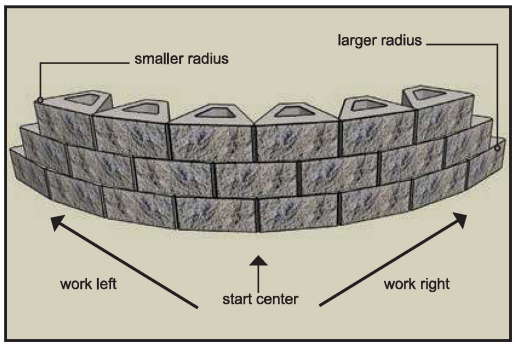
Convex • Outside • Curves

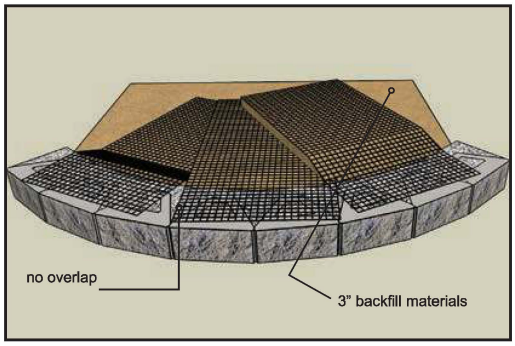
- To achieve desired curve alignment, use 3/4” flexible PVC pipe to outline the back of your retaining wall unit location. This will give you a guideline to help achieve smooth and accurate curves.
- If possible, it is best to start building a curve from the center of the curve and work outward in both directions.
- Start at the same location for all additional courses of retaining wall units.
- If the unit has wings at the back of the block, one or both may be broken off to achieve a tighter radius.
- Because of the batter (unit setback), the bottom course radius will be larger than the radius of the top course. The taller the wall the larger the bottom course radius needs to be in relation to the top course radius.



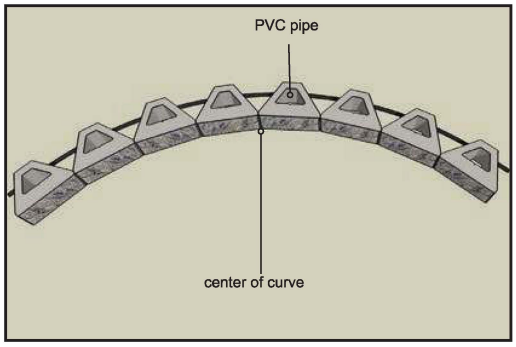
Convex curve geogrid placement

- Geogrid coverage should be 100% butted together, but NOT overlapped on the retaining wall units.
- The geogrid tail, starting just behind the unit will be overlapped. A minimum of 3 inches of soil must be placed between these overlapping geogrid layers.



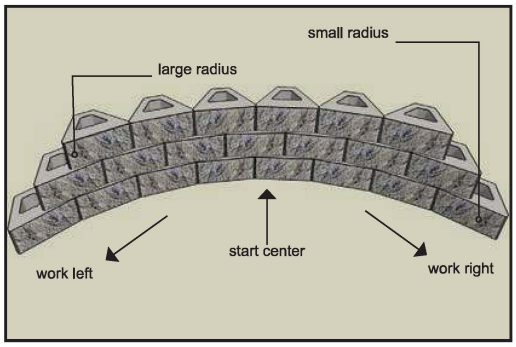


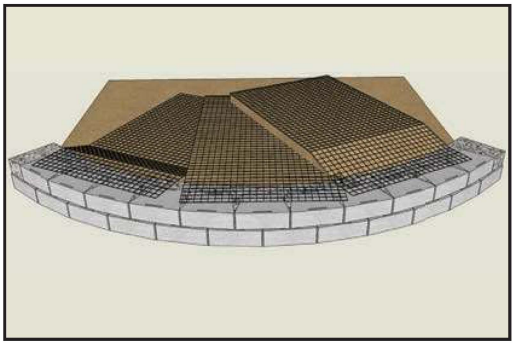
SIGMA-MAYTRX OLDE ENGLISH

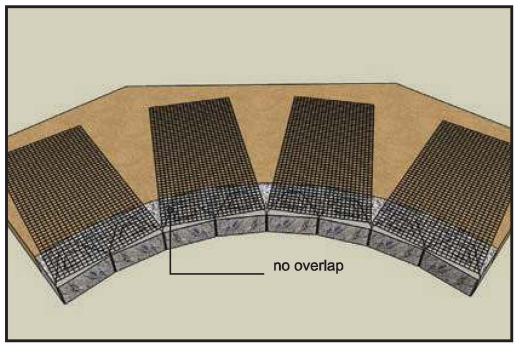


Concave • inside • curves

- To achieve desired curve alignment, use 3/4" flexible PVC pipe to outline the back of your retaining wall unit location. This will give you a guideline to help achieve smooth and accurate curves.
- If possible, it is best to start building a curve from the center of the curve and work outward in both directions.
- Start at the same location for all additional courses of units.
- Because of the batter (unit setback) the bottom course radius will be smaller than the radius of the top course. The taller the wall the smaller the bottom course radius will be in relation to the top course radius.

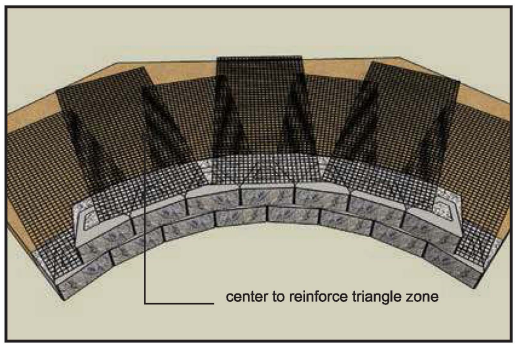


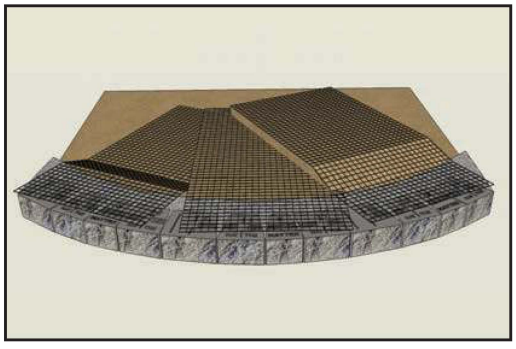




Concave curve

- geogrid placement
- Geogrid coverage should be 100% butted together, but NOT overlapped on the retaining wall units.
- There will be a V or pie shaped wedge of soil starting just behind the units which will not be reinforced. To compensate for the unreinforced section, on the next course of retaining wall units, geogrid is placed by centering over the pie shaped wedge of unreinforced soil below.



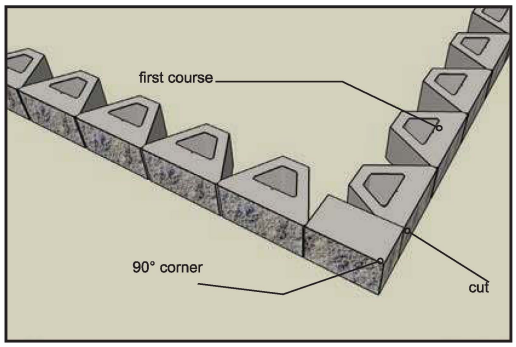


INSTALLATION

SIGMA

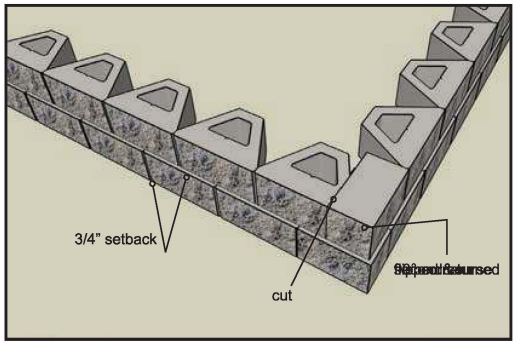
Outside 90° corner

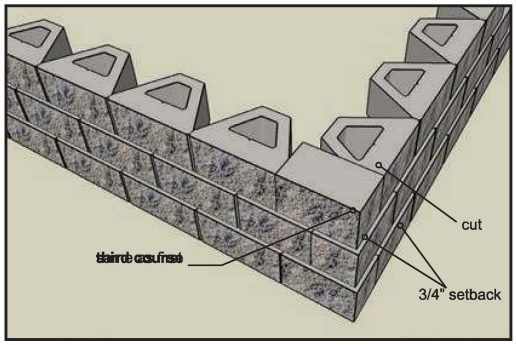
- Lay the corner according to the retaining wall system instructions. Some systems will have special corner units, some will have hand splitting lines, and others will require cutting.
- Each course is usually laid opposite of the course below.
- Where connecting devices cannot be used on corner blocks be sure to keep the same batter (setback) as the rest of the retaining wall.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.

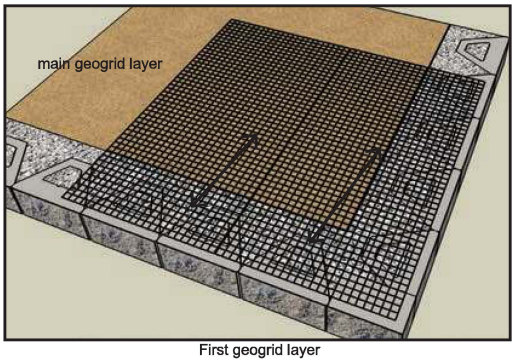


Outside corner

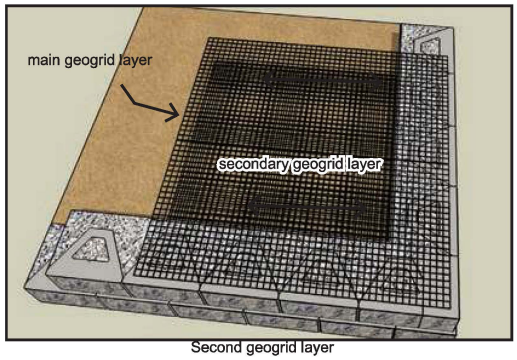
- geogrid placement
- On the 1st course, place the corner wallstone as shown in the top image.
- Then place a full wallstone next to the long face of the Sigma 8 Corner wallstone.
- Cut the wallstone that is placed next to the small face of the corner wallstone to 15 3/4".
- On the 2nd course the corner wallstone is placed in the opposite direction with a 3/4" setback from the bottom course in both directions.
- Again, place a full wallstone next to the long face of the corner wallstone.
- Then, leaving a space for the wallstone to be cut next to the small face of the corner wallstone, place a full wallstone over two wallstones of the lower course in a half bond fashion. Line up the knobs of the wallstone you are placing with the cores of the wallstones in the lower course.
- Measure between the corner wallstone and the full wallstone. Then cut a full wallstone to that dimension and place in the space that was left for it.
- Continue this process for each additional course.
- Fuller corner instructions are available in an additional sheet from your Sigma supplier.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.



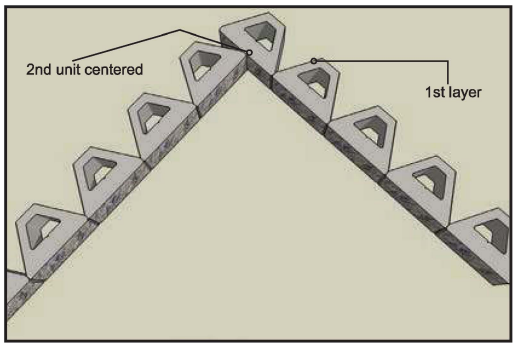




First geogrid layer

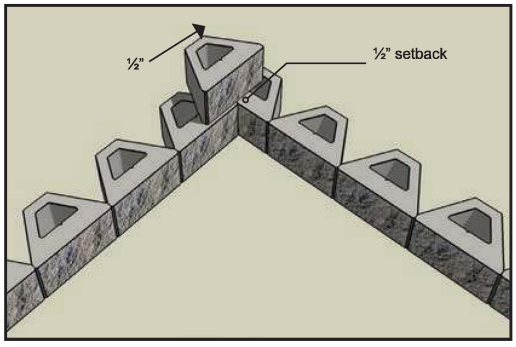


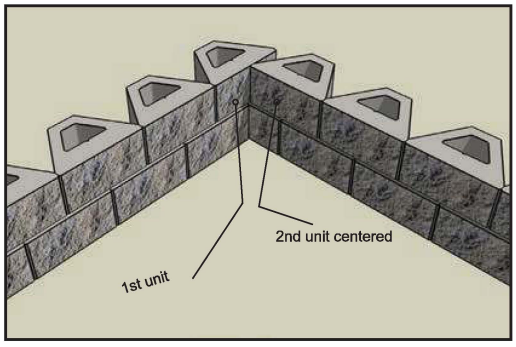
Second geogrid layer



Inside 90° corner

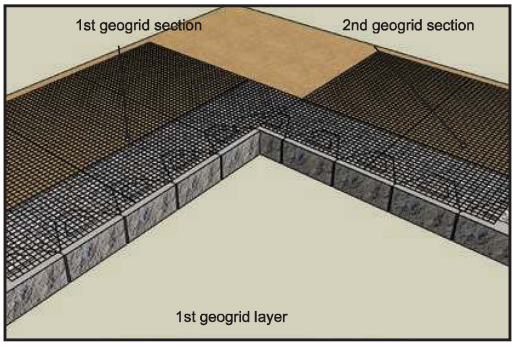
- On the first course, place the face of the first unit of the 90 degree corner at the center of and against the last unit of the wall that the corner is turning from (see illustration).
- On the second course, start the corner in the opposite manner with the first unit being laid straddling the 90 degree corner.
- That unit must be set with the same amount of batter (set back) and slid into the corner the same distance as the batter (set back) for each course.
- The 90 degree unit must be placed against the face of the corner unit.
- Repeat the above steps, alternating the corner units so that they are woven together, forming the 90 degree corner.

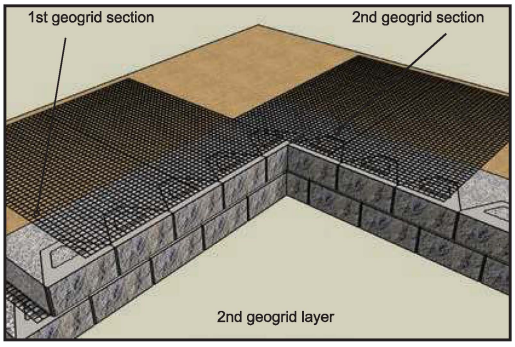




Inside curve geogrid placement

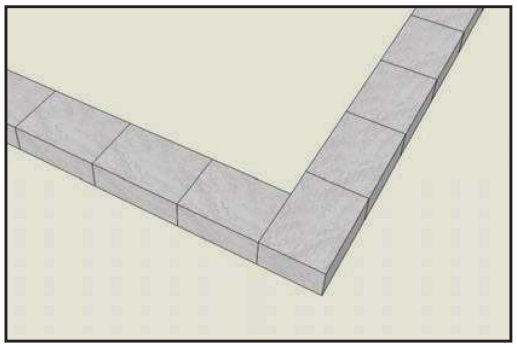
- The first layer of geogrid should extend past the corner a distance which equals the height of the retaining wall divided by 4 (Height of Wall ÷ 4).
- The second layer of geogrid is laid, butting to the 1st layer.
- Per your design table, when the next layer of geogrid is required, that layer of geogrid, on the other leg of the corner, should extend past the corner a distance which equals the height of the retaining wall divided by 4. (Height of wall ÷ 4)
- Continue to alternate the geogrid extending past the corner on every other layer.





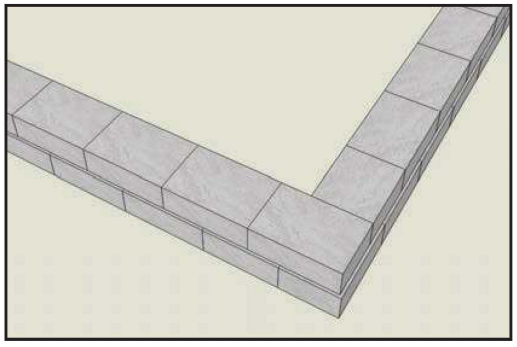
Outside 90° corner

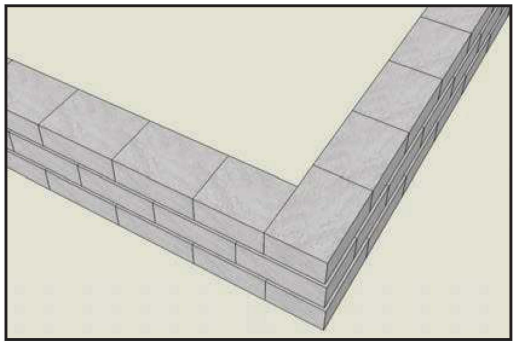
- Lay the corner according to the retaining wall system instructions. Some systems will have special corner units, some will have hand splitting lines, and others will require cutting.
- Each course is usually laid opposite of the course below.
- Where connecting devices cannot be used on corner blocks be sure to keep the same batter (setback) as the rest of the retaining wall.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.

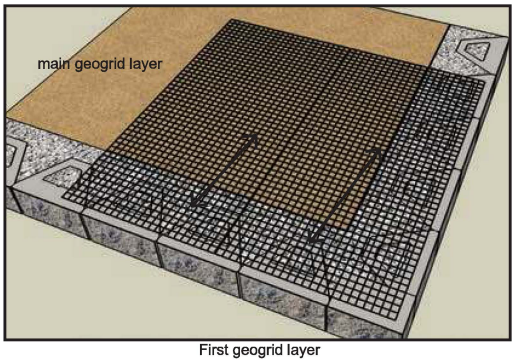


Outside corner

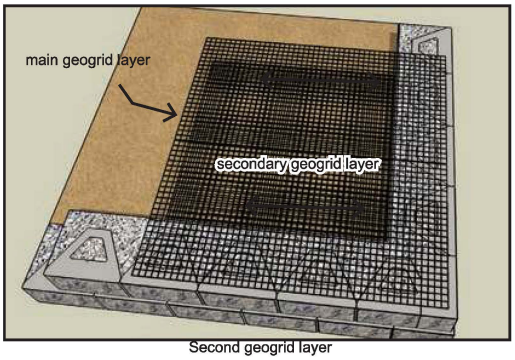
- geogrid placement
- On the 1st course, place the corner wallstone as shown in the top image.
- Then place a full wallstone next to the long face of the Sigma 8 Corner wallstone.
- Cut the wallstone that is placed next to the small face of the corner wallstone to 15 3/4".
- On the 2nd course the corner wallstone is placed in the opposite direction with a 3/4" setback from the bottom course in both directions.
- Again, place a full wallstone next to the long face of the corner wallstone.
- Then, leaving a space for the wallstone to be cut next to the small face of the corner wallstone, place a full wallstone over two wallstones of the lower course in a half bond fashion. Line up the knobs of the wallstone you are placing with the cores of the wallstones in the lower course.
- Measure between the corner wallstone and the full wallstone. Then cut a full wallstone to that dimension and place in the space that was left for it.
- Continue this process for each additional course.
- Fuller corner instructions are available in an additional sheet from your Sigma supplier.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.



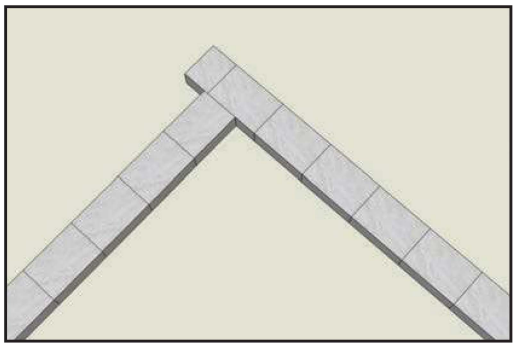




First geogrid layer

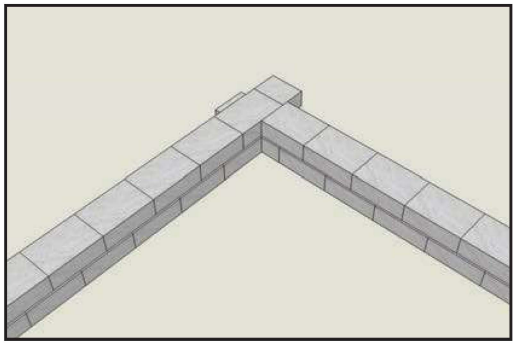


Second geogrid layer



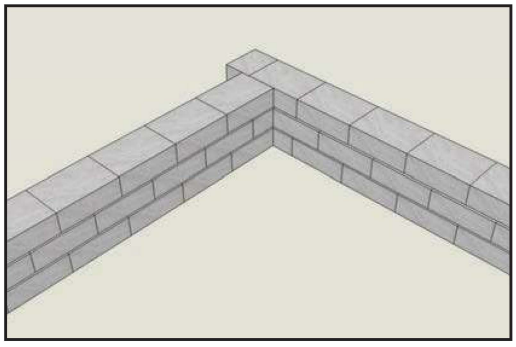
Inside 90° corner

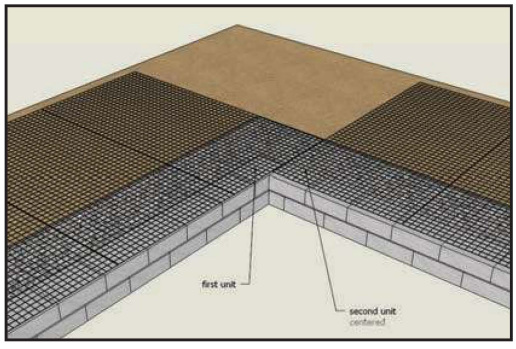
- On the first course, place the face of the first unit of the 90 degree corner at the center of and against the last unit of the wall that the corner is turning from (see illustration).
- On the second course, start the corner in the opposite manner with the first unit being laid straddling the 90 degree corner.
- That unit must be set with the same amount of batter (set back) and slid into the corner the same distance as the batter (set back) for each course.
- The 90 degree unit must be placed against the face of the corner unit.
- Repeat the above steps, alternating the corner units so that they are woven together, forming the 90 degree corner.

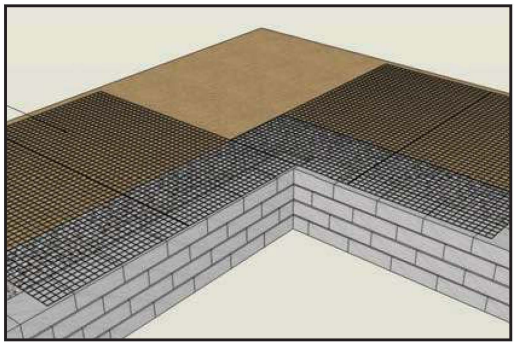


Inside curve geogrid placement

- The first layer of geogrid should extend past the corner a distance which equals the height of the retaining wall divided by 4 (Height of Wall ÷ 4).
- The second layer of geogrid is laid, butting to the 1st layer.
- Per your design table, when the next layer of geogrid is required, that layer of geogrid, on the other leg of the corner, should extend past the corner a distance which equals the height of the retaining wall divided by 4. (Height of wall ÷ 4)
- Continue to alternate the geogrid extending past the corner on every other layer.

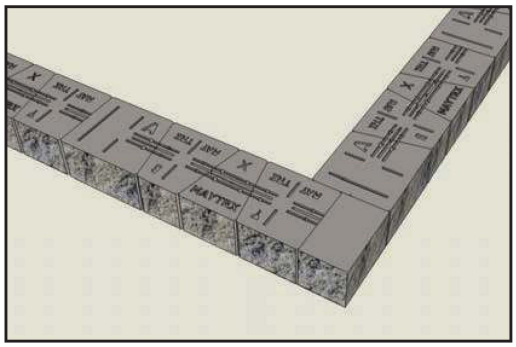






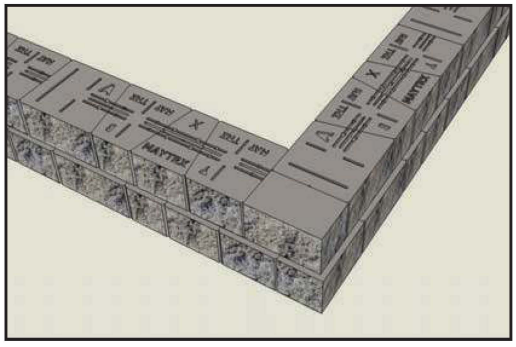
Outside 90° corner

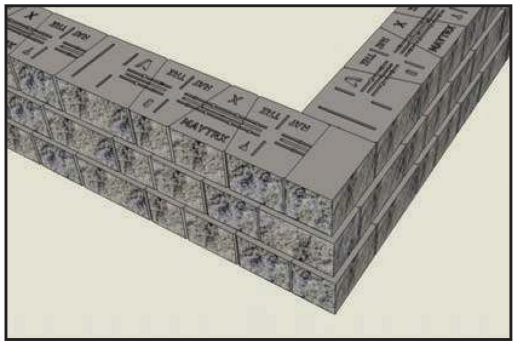
- Lay the corner according to the retaining wall system instructions. Some systems will have special corner units, some will have hand splitting lines, and others will require cutting.
- Each course is usually laid opposite of the course below.
- Where connecting devices cannot be used on corner blocks be sure to keep the same batter (setback) as the rest of the retaining wall.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.

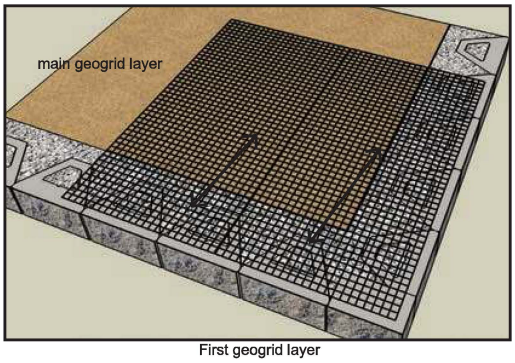


Outside corner

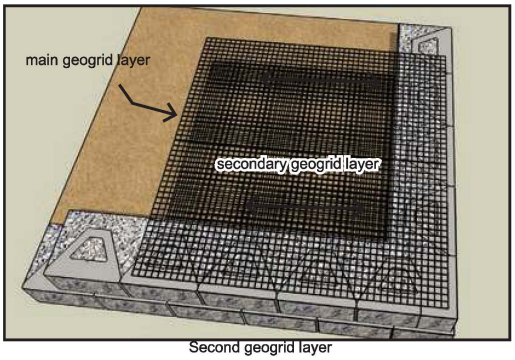
- geogrid placement
- On the 1st course, place the corner wallstone as shown in the top image.
- Then place a full wallstone next to the long face of the Sigma 8 Corner wallstone.
- Cut the wallstone that is placed next to the small face of the corner wallstone to 15 3/4".
- On the 2nd course the corner wallstone is placed in the opposite direction with a 3/4" setback from the bottom course in both directions.
- Again, place a full wallstone next to the long face of the corner wallstone.
- Then, leaving a space for the wallstone to be cut next to the small face of the corner wallstone, place a full wallstone over two wallstones of the lower course in a half bond fashion. Line up the knobs of the wallstone you are placing with the cores of the wallstones in the lower course.
- Measure between the corner wallstone and the full wallstone. Then cut a full wallstone to that dimension and place in the space that was left for it.
- Continue this process for each additional course.
- Fuller corner instructions are available in an additional sheet from your Sigma supplier.
- Outside corners should be bonded with retaining wall adhesive where connecting devices are unable to be used.



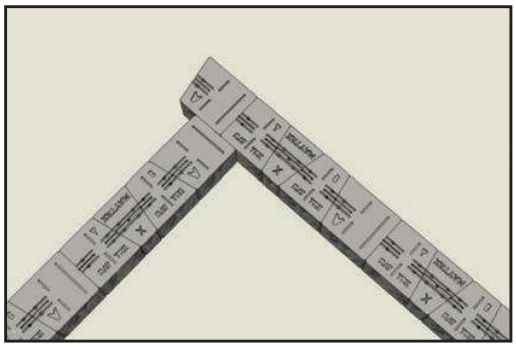


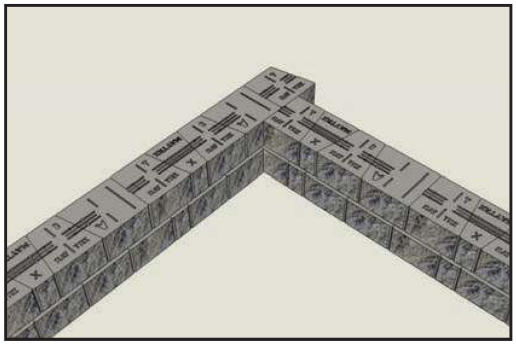


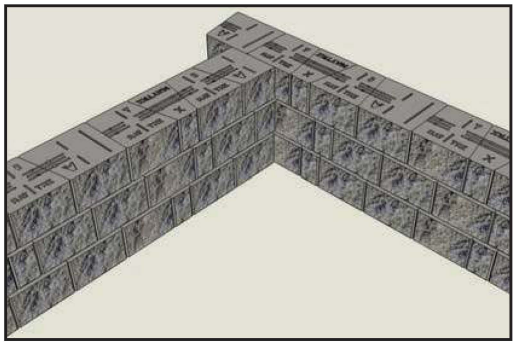
First geogrid layer



Second geogrid layer





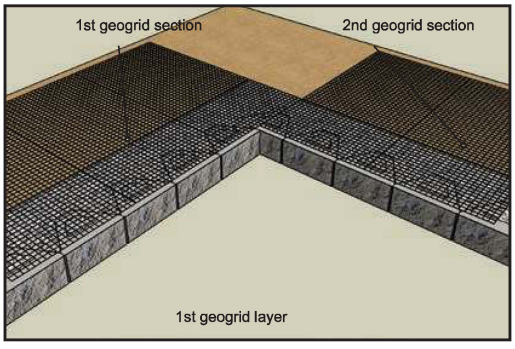


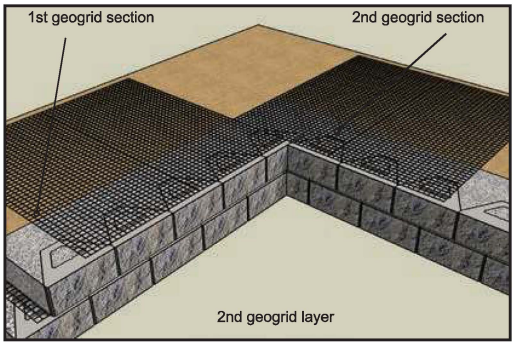
Inside 90° corner

- On the first course, place the face of the first unit of the 90 degree corner at the center of and against the last unit of the wall that the corner is turning from (see illustration).
- On the second course, start the corner in the opposite manner with the first unit being laid straddling the 90 degree corner.
- That unit must be set with the same amount of batter (set back) and slid into the corner the same distance as the batter (set back) for each course.
- The 90 degree unit must be placed against the face of the corner unit.
- Repeat the above steps, alternating the corner units so that they are woven together, forming the 90 degree corner.

Inside curve geogrid placement

- The first layer of geogrid should extend past the corner a distance which equals the height of the retaining wall divided by 4 (Height of Wall ÷ 4).
- The second layer of geogrid is laid, butting to the 1st layer.
- Per your design table, when the next layer of geogrid is required, that layer of geogrid, on the other leg of the corner, should extend past the corner a distance which equals the height of the retaining wall divided by 4. (Height of wall ÷ 4)
- Continue to alternate the geogrid extending past the corner on every other layer.





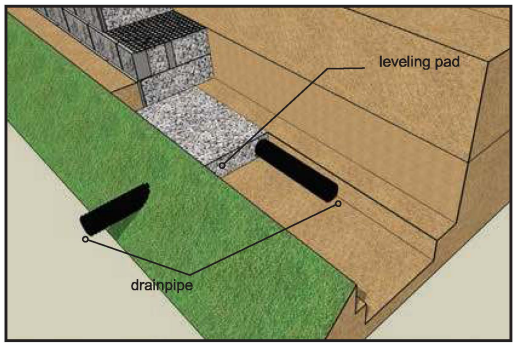
SIGMA-MAYTRX OLDE ENGLISH

» Drainage pipe specifications

- The drain pipe should a minimum diameter of 4 inches.
- Drain pipe outlets can be under the wall units, through the wall units or out the end of the retaining wall. An outlet must be placed at the lowest point of the retaining wall and a minimum of every 50 feet. The drain pipe must be sloped so water can gravitate out of the pipe.

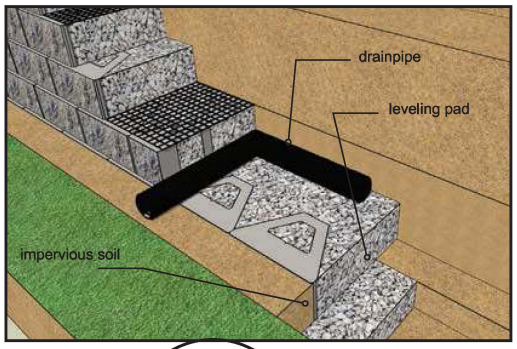
Drain pipe outlet (under/out end)

- Drainage aggregate is used for the leveling pad.
- The drainage aggregate chimney extends down to the leveling pad.
- The drain pipe is placed in the leveling pad directly under the drainage aggregate chimney.
- The outlets are either T'd out under the retaining wall units and daylight out of the slope in front of the retaining wall and/or the drain pipe daylights out of the end of the wall.



Drain pipe outlet

- (thru face of wall/out end)
- The leveling pad material can either be well graded gravel or drainage aggregate.
- Impervious soil (soil that water will not pass through) is placed over the leveling pad and extends to the back of the excavation, between the units, in the unit cores (if applicable), and in front of the retaining wall units, up to the finish grade elevation at the bottom (front) of the retaining wall.
- The drain pipe is placed at the bottom of the drainage aggregate chimney. The drain outlets are T'd out the face or out the end of the retaining wall.
- A notch will need to be cut in the bottom of the retaining wall unit for the outlet to exit through.



additional information

- The material quantities are not represented to be exact, but should be close if the finished retaining wall ends up as originally planned.
- When you first start to use this material estimation method, it would be wise to check the quantities against your usual method of estimating materials to check the accuracy of this method.
- There has been no provision for waste, breakage, or other contingencies that would change material quantities in this material estimating procedure.
- Hardscape Technical Services assumes no responsibility for the accuracy of the material quantities resulting from the use of this estimation method. The responsibility for accuracy of quantities is the user's sole responsibility.

HOW TO CALCULATE THE COST OF YOUR RETAINING WALL

MATERIAL ESTIMATING

step 1 » square feet of wall facing

a. Determine the total height of each end of the wall section using the accompanying design tables. The wall heights are shown directly under the design. Choose the design by picking the exposed wall height that is the same as the height of your proposed retaining wall or, if there is not an exact match choose the next taller design. Then for estimating purposes choose the total height of the design that is indicated below the design. In most cases there will be at least one block buried. Don't forget to include that in your height determination. Again, the total height without the cap is located below the wall in the design tables.

b. Add the total heights (1•a above) of the two ends of the wall section together and divide by 2 to determine the average height of the wall section.

_____ (beginning total hgt) + _____ (end total hgt) = _____ ÷ 2 = _____ (average wall hgt)

c. Multiply the average height (1•b above) by the lineal footage of the wall section to determine the number of square feet of wall facing.

_____ (average hgt) x _____ (lineal footage) = _____ (sq. ft. wall face)

d. If the wall section steps at either the top of wall or bottom of wall, add 1/2 course of block. Do this by dividing the length of the wall section by 2. **Multiply that result by the Sq ft of Wall System(*see note).** Then add that result to the square feet (1•c above) of wall facing.

_____ (wall length) ÷ 2 _____ x .(*see note) = _____ (additional sq. ft.)

NOTE: TO CALCULATE SQ FT (Per Unit) USE THESE NUMBERS
- For Sigma 6" use .6667, For Sigma 8" use 1.00 (Sq Ft)
- Maytrx use 1 (sq ft)
- Olde English use .333 (sq ft)

_____ (sq. ft wall face) + _____ (additional sq. ft.) = _____ (total sq. ft.)

GEOGRID

SIGMA-MAYTRX OLDE ENGLISH

Design tables
Table use guidelines

without or before requesting engineering

For determining Geogrid type, Soil Type, and Case for estimating costs before requesting stamped engineering or for walls that are low enough in height that they do not require a permit or stamped engineering, the procedure is as follows:

Geogrid type

a. For walls up to 6' exposed height either SRW Universal or SRW 3 Series geogrid may be used. The type used may be determined by which type is most economical or which type your dealer has in stock.
b. For walls that are over 6' exposed height and up to 8' exposed height, only SRW 3 Series geogrid may be used.

Soil type

Use the soil classification and approximate friction angle information below.
a. Chart A shows the symbols for the different soil types.
b. Use the Unified Soil Classification System table (Chart B) to determine your soil type.

Chart A: USCS Symbol Definitions

1st and/or 2nd Letters	Definition	2nd Letter	Definition
GG	ravelP		Poorly Graded (uniform particle sizes)
S	SandW		Well Graded (diversified particle sizes)
MS	iltH		High Plasticity
CC	layL		Low Plasticity
OO	rganic		

Chart B: Unified Soil Classification System

Major Divisions			USCS Symbol	Typical Descriptions
COURSE GRAINED SOILS More than 50% of the material is larger than the #200 (.075 mm) sieve	GRAVELS More than 50% of the course fraction is larger than the #4 (4.75 mm) sieve	CLEAN GRAVELS	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS with over 12% fines	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS More than 50% of the coarse fraction is smaller than the #4 sieve	CLEAN SANDS	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS with over 12% fines	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS More than 50% of the material is smaller than the #200 sieve	SILTS AND CLAYS Liquid limit less than 50		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS, ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS Liquid limit greater than 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILSP			T	PEAT, HUMUS, SWAMP SOILS WITH LIGHT ORGANIC CONTENTS

c. Chart C shows particle sizes for different soil types. National Concrete Masonry Association guidelines indicate that rocks/stones over 4" in diameter should not be used in the retaining wall backfill. Bigger diameter pieces in the backfill make compaction problems.

d. Choose the Friction Angle of the soil from Chart D. Be conservative. Choose the friction angle at the bottom of the range, i.e. 26° instead of 28°. If there is any question about soil type, it is wise to choose the 26° soils. It is best not to under-estimate the cost of the retaining wall. Also, the cost difference on retaining walls of these heights is not great enough to risk an under-designed retaining wall.

Chart C: USCS Particle Sizes

Inches	US Standard Sieve #	Particle Size
Over 8"		Boulder
8" to 3"C		obble
3" to 3/4"G		ravel (course)
3/4" minus	4	Gravel (fine)
-4	to 10	Sand (course)
-	10 to 40	Sand (medium)
-	40 to 200	Sand (fine)
-	200 & over	Silt or Clay
1 micron = .001"		

Chart D: Approximate Friction Angle of Soil Types

Soil Description	USCS Classification	Wall Backfill Use Range	Friction Angle Range
Sand, Gravel, Stone	GW, GP, GM, GC, SW, SP	Good	30° - 34°
Silty Sands, Clayey Sands	SM, SC	Moderate	28° - 30°
Silts, Low Plasticity Clays	ML, CL, OL	Difficult	26° - 28°
High Plasticity Silts & Clays, Organics	CH, MH, OH, PT	Bad	0° - 26°

Helpful hints

» Choosing the correct design table

Using your plans or the sketches made by following the Sketching Instructions, choose the Case(s) that is/are applicable to the proposed retaining wall. If the retaining wall configuration does not exactly match one of the cases use the next higher case. For example, if the grade is not flat at the top of wall but there will be less slope than a 4/1 slope, choose the 4/1 slope design. Always choose the more conservative option.

» Choosing the correct height

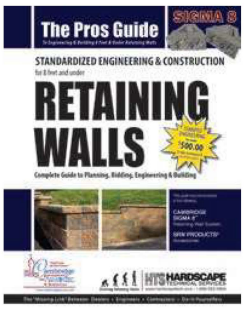
Choose the correct exposed height design. The designs will show how many layers of geogrid are required, the length that each layer is embedded into the soil, and the course of block that the geogrid is placed on top of. Below each design are numbers that will be needed in the material estimation process.

» Multi-height retaining walls

If the wall section has a different height on each end, when estimating and constructing your retaining wall it may make sense to skip some designs. For example, if a wall section begins with an exposed height of 2' and ends with an exposed height of 8', it may make sense to use only the 4', 6', and 8' exposed height designs to simplify the geogrid placement during construction. In that case, the 4' design would be used from the 2' height to the 4' height, the 6' design would be used between the 4' and 6' heights, and the 8' design would be used between the 6' and 8' heights. Also in that case, if the wall steps up at the bottom of wall, the bottom layer of geogrid should be moved up to the next course of block and not eliminated until the 2nd from the bottom layer of geogrid is encountered.

GEOGRID

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



SIGMA 8

These pages reference the Sigma 8 "Pro Guide" available for free download at: cambridgewallsupport.com

B-5

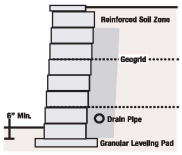
26 DEGREE SOIL for walls up to 8'

Sigma 8 • SRW Accessories

Geogrid: SRW Universal 635 LTDS or SRW 3 Series 1093 LTDS • Block Dimensions: 8"(H) x 18" (W) x 12"(D)

CASE A

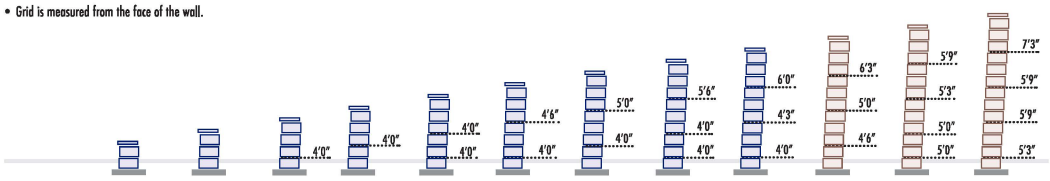
"CASE A" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- No Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.

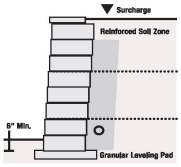


Geogrid Type	SRW Universal - or - SRW 3 Series Grid									SRW 3 Series Grid ONLY		
Exposed Hgt wo/cap	0'8"	1'4"	2'0"	2'8"	3'4"	4'0"	4'8"	5'4"	6'0"	6'8"	7'4"	8'0"
Amount Buried	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"
Total Hgt wo/cap	1.33'	2.00'	2.67'	3.33'	4.00'	4.67'	5.33'	6.00'	6.67'	7.33'	8.00'	8.67'
Grid Sq Yd per Ln Ft	0.000	0.000	0.444	0.444	0.889	0.944	1.000	1.500	1.583	1.750	2.333	2.667
Grid total depth	0.00	0.00	4.00	4.00	8.00	8.50	9.00	13.50	14.25	15.75	21.00	24.00
# Block per Ln Ft	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67
# Cap per Ln Ft"	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667

• See "Material Estimating" for Adhesive estimate.

CASE B

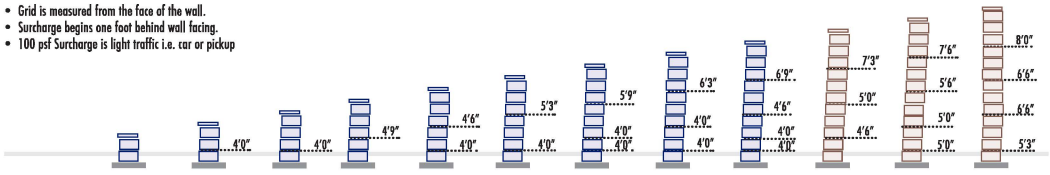
"CASE B" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 100 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins one foot behind wall facing.
- 100 psf Surcharge is light traffic i.e. car or pickup

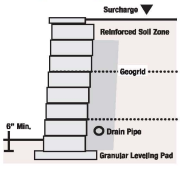


Geogrid Type	SRW Universal - or - SRW 3 Series Grid									SRW 3 Series Grid ONLY		
Exposed Hgt wo/cap	0'8"	1'4"	2'0"	2'8"	3'4"	4'0"	4'8"	5'4"	6'0"	6'8"	7'4"	8'0"
Amount Buried	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"
Total Hgt wo/cap	1.33'	2.00'	2.67'	3.33'	4.00'	4.67'	5.33'	6.00'	6.67'	7.33'	8.00'	8.67'
Grid Sq Yd per Ln Ft	0.000	0.444	0.444	0.528	0.994	1.028	1.528	1.583	2.139	1.861	2.556	2.917
Grid total depth	0.00	4.00	4.00	4.75	8.50	9.25	13.75	14.25	19.25	16.75	23.00	26.25
# Block per Ln Ft	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67
# Cap per Ln Ft"	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667

• See "Material Estimating" for Adhesive estimate.

CASE C

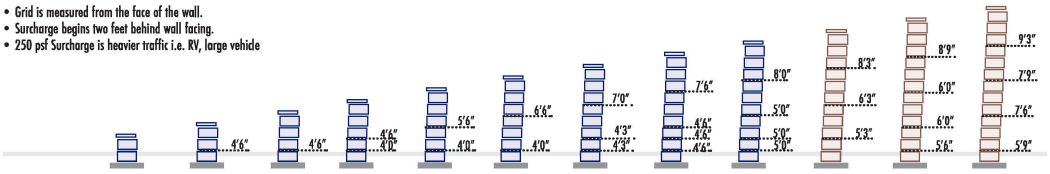
"CASE C" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 250 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins two feet behind wall facing.
- 250 psf Surcharge is heavier traffic i.e. RV, large vehicle

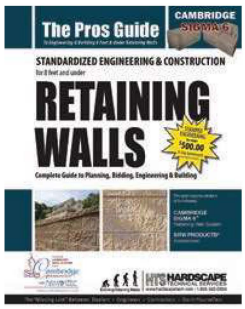


Geogrid Type	SRW Universal - or - SRW 3 Series Grid									SRW 3 Series Grid ONLY		
Exposed Hgt wo/cap	0'8"	1'4"	2'0"	2'8"	3'4"	4'0"	4'8"	5'4"	6'0"	6'8"	7'4"	8'0"
Amount Buried	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"	8"
Total Hgt wo/cap	1.33'	2.00'	2.67'	3.33'	4.00'	4.67'	5.33'	6.00'	6.67'	7.33'	8.00'	8.67'
Grid Sq Yd per Ln Ft	0.000	0.500	0.500	0.944	1.056	1.167	1.722	2.333	2.556	2.194	2.917	3.361
Grid total depth	0.00	4.50	4.50	8.50	9.50	10.50	15.50	21.00	23.00	19.75	26.25	30.25
# Block per Ln Ft	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67
# Cap per Ln Ft"	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667	.6667

• See "Material Estimating" for Adhesive estimate.

SIGMA 6

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



GEOGRID

These pages reference the Sigma 6 "Pro Guide" available for free download at: cambridgewallsupport.com

B-5

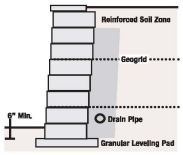
26 DEGREE SOIL for walls up to 8'

Cambridge Sigma 6 • SRW Accessories

Geogrid: SRW Universal 635 LTDS or SRW 3 Series 1093 LTDS • Block Dimensions: 6"(H) x 16" (W) x 12"(D)

CASE A

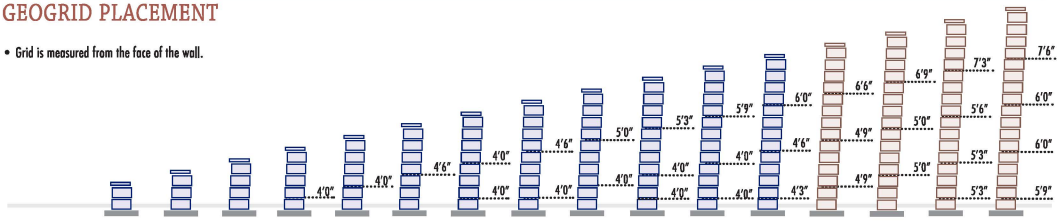
"CASE A" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- No Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.

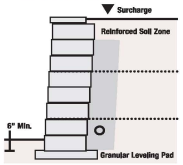


Geogrid Type	SRW Universal - or - SRW 3 Series Grid												SRW 3 Series Grid ONLY			
Exposed Hgt wo/cap	0'6"	1'0"	1'6"	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
Amount Buried	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
Total Hgt wo/cap	1.0'	1.5'	2'	2.5'	3'	3.5'	4'	4.5'	5'	5.5'	6'	6.5'	7'	7.5'	8'	8.5'
Grid Sq Yd per Ln Ft	0.000	0.000	0.000	0.444	0.444	0.500	0.889	0.944	1.000	1.472	1.528	1.639	1.778	1.861	2.583	2.806
Grid total depth	-	-	-	4.00	4.00	4.50	8.00	8.50	9.00	13.25	13.75	14.75	16.00	16.75	23.25	25.25
# Block per Ln Ft	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75
# Cap per Ln Ft*	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67

*Caps come in multiple sizes. Check with your local retailer for what size is available in your area. • See "Material Estimating" for Adhesive estimate.

CASE B

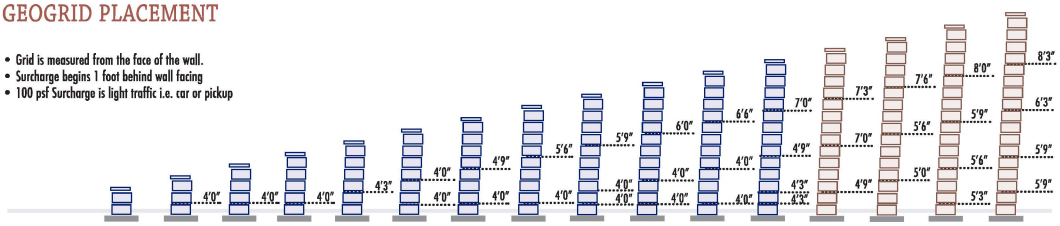
"CASE B" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 100 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins 1 foot behind wall facing
- 100 psf Surcharge is light traffic i.e. car or pickup

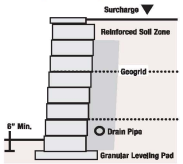


Geogrid Type	SRW Universal - or - SRW 3 Series Grid												SRW 3 Series Grid ONLY			
Exposed Hgt wo/cap	0'6"	1'0"	1'6"	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
Amount Buried	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
Total Hgt wo/cap	1.0'	1.5'	2'	2.5'	3'	3.5'	4'	4.5'	5'	5.5'	6'	6.5'	7'	7.5'	8'	8.5'
Grid Sq Yd per Ln Ft	0.000	0.444	0.444	0.444	0.472	0.889	0.972	1.056	1.528	1.556	1.611	2.250	2.111	2.000	2.722	2.889
Grid total depth	-	4.00	4.00	4.00	4.25	8.00	8.75	9.50	13.75	14.00	14.50	20.25	19.00	18.00	24.50	26.00
# Block per Ln Ft	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75
# Cap per Ln Ft*	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67

*Caps come in multiple sizes. Check with your local retailer for what size is available in your area. • See "Material Estimating" for Adhesive estimate.

CASE C

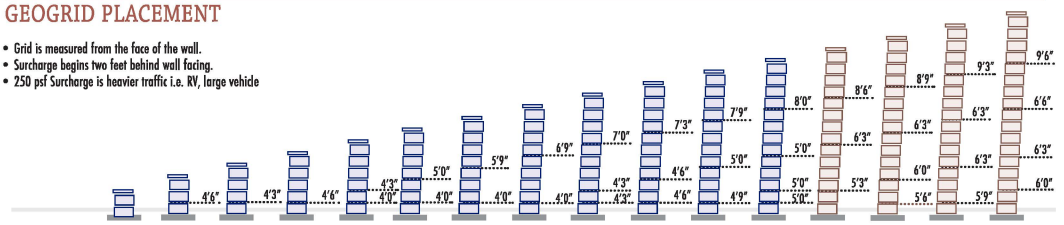
"CASE C" Retaining Wall:
- Flat Ground at Top of Wall
- Flat Ground at Bottom of Wall
- 250 psf Surcharge on Wall



IF STAMPED ENGINEERING IS REQUIRED FOR THIS RETAINING WALL: THIS DESIGN MUST BE STAMPED HERE BY A LICENSED ENGINEER.

GEOGRID PLACEMENT

- Grid is measured from the face of the wall.
- Surcharge begins two feet behind wall facing.
- 250 psf Surcharge is heavier traffic i.e. RV, large vehicle



Geogrid Type	SRW Universal - or - SRW 3 Series Grid												SRW 3 Series Grid ONLY			
Exposed Hgt wo/cap	0'6"	1'0"	1'6"	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
Amount Buried	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
Total Hgt wo/cap	1.0'	1.5'	2'	2.5'	3'	3.5'	4'	4.5'	5'	5.5'	6'	6.5'	7'	7.5'	8'	8.5'
Grid Sq Yd per Ln Ft	0.000	0.500	0.472	0.500	0.917	1.00	1.083	1.194	1.722	1.806	1.944	2.556	2.222	2.944	3.056	3.139
Grid total depth	-	4.50	4.25	4.50	8.25	9.00	9.75	10.75	15.50	16.25	17.50	23.00	20.00	26.50	27.50	28.25
# Block per Ln Ft	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75
# Cap per Ln Ft*	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67

*Caps come in multiple sizes. Check with your local retailer for what size is available in your area. • See "Material Estimating" for Adhesive estimate.

GEOGRID

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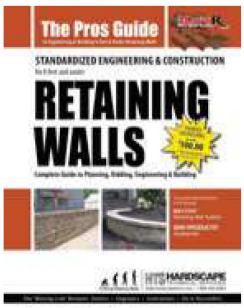


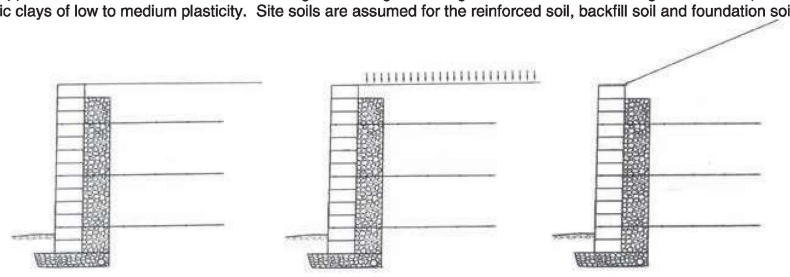
MAYTRX

These pages reference the Maytrx "Pro Guide" available for free download at: cambridgewallsupport.com

Maytrx Wall System & SRW3 Geogrid Placement Tables

Sample designs, **27 degree** friction angle soil

These charts are applicable for site soils when the friction angle is 27 degrees or higher and the moist unit weight is 120 lbs. per cubic foot. That is typical for inorganic clays of low to medium plasticity. Site soils are assumed for the reinforced soil, backfill soil and foundation soil.



Site Configuration: Flat at top and bottom of wall, no surcharge

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	5th/4.0'						
6.0'	6.5'	13	3	2nd/4.25'	5th/4.25'	9th/5.25'					
8.0'	9.0'	18	5	1st/6.0'	3rd/6.0'	6th/6.0'	10th/6.0'	14th/6.75'			
10.0'	11.0'	22	6	1st/7.25'	4th/7.25'	7th/7.25'	10th/7.25'	14th/7.25'	18th/8.25'		

Site Configuration: Flat at top and bottom of wall, 100 PSF surcharge (Light Traffic)

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	3	1st/4.0'	3rd/4.0'	7th/5.25'					
6.0'	6.5'	13	4	1st/4.25'	3rd/4.25'	7th/4.75'	11th/6.5'				
8.0'	9.0'	18	6	1st/6.0'	2nd/6.0'	5th/6.0'	8th/6.0'	12th/6.5'	16th/8.25'		
10.0'	11.0'	22	7	1st/7.25'	3rd/7.25'	6th/7.25'	9th/7.25'	12th/7.25'	16th/7.75'	20th/9.5'	

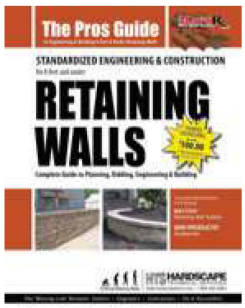
Site Configuration: Flat at bottom of wall, 3 horizontal to 1 vertical slope at top of wall

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	6th/4.75'						
6.0'	6.5'	13	4	1st/5.25'	2nd/5.25'	6th/5.25'	10th/6.5'				
8.0'	9.0'	18	6	1st/8.0'	3rd/8.0'	5th/8.0'	7th/8.0'	11th/8.0'	15th/8.75'		
10.0'	11.0'	22	8	1st/10.25'	2nd/10.25'	4th/10.25'	6th/10.25'	9th/10.25'	11th/10.25'	15th/10.25'	19th/10.5'

1) Sample designs are to be used for preliminary design only when actual soil, site geometry and surcharge conditions are conservatively represented by the assumptions of the tables in all situations. A qualified engineer using actual design conditions for the proposed site should perform the final as-built design.
2) Sample designs have been prepared exclusively for the use of SRW™ 3 series geogrid.
3) MINIMUM FACTORS OF SAFETY: 1.5 for internal reinforcement pullout and tensile overstress, 1.5 for external sliding, 2.0 for external overturning and bearing capacity. NO provision or analysis included for global stability.
4) Sample designs require adequate drainage provisions for both the reinforced wall fill and retained backfill.
5) Geogrid must be one continuous piece from the face of the retaining wall block to the back of the reinforced soil mass. No splicing of geogrid. Geogrid must butt together at edges but must not be overlapped. Geogrid must be pulled tight before backfill is placed.
6) Follow the installation instructions that are supplied with the retaining wall system that you are purchasing. (Which should include foundation preparation, block alignment, core filling of block, drainage rock placement, backfill placement, and compaction.)
7) See your local building department for permitting requirements.
8) Each design is to be used up to the indicated height only. When the retaining wall exceeds that height a higher design shall be used.
9) When the retaining wall steps up at the bottom of the wall, bottom geogrid layers should be moved up with the steps and not dropped off until the next layer of geogrid is encountered.
10) Light Traffic is auto or empty pickup truck loading. Any vehicle traffic or parking loads exceeding Light Traffic vehicle weights at the top of the retaining wall shall require a special site specific preliminary design.
11) If there is a slope at the bottom of the wall, additional embedment depth of the bottom courses may be required.
12) If your site does not fit the above site configurations, call SRW Products at (800) 752-9326 for a free site-specific preliminary design.

MAYTRX

Geogrid tables are for Illustration only and should be matched with soil, grade and load to the wall stone size and Geogrid you are using with the full set of tables available in the Pro Guide for walls under 8 feet.



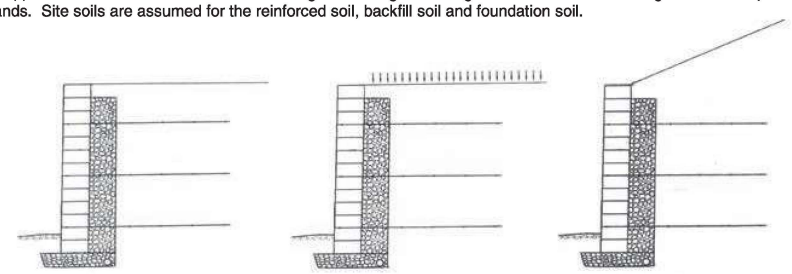
GEOGRID

These pages reference the Maytrx "Pro Guide" available for free download at: cambridgewallsupport.com

Maytrx Wall System & SRW3 Geogrid Placement Tables

Sample designs, **30 degree** friction angle soil

These charts are applicable for site soils when the friction angle is 30 degrees or higher and the moist unit weight is 125 lbs. per cubic foot. That is typical for silty sands. Site soils are assumed for the reinforced soil, backfill soil and foundation soil.



Site Configuration: Flat at top and bottom of wall, no surcharge

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	5th/4.0'						
6.0'	6.5'	13	3	2nd/4.25'	5th/4.25'	9th/4.75'					
8.0'	9.0'	18	5	1st/6.0'	3rd/6.0'	6th/6.0'	10th/6.0'	14th/6.25'			
10.0'	11.0'	22	6	1st/7.25'	3rd/7.25'	6th/7.25'	10th/7.25'	14th/7.25'	18th/7.5'		

Site Configuration: Flat at top and bottom of wall, 100 PSF surcharge (Light Traffic)

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	3rd/4.0'	7th/4.75'						
6.0'	6.5'	13	4	1st/4.25'	3rd/4.25'	7th/4.25'	11th/5.75'				
8.0'	9.0'	18	5	1st/6.0'	4th/6.0'	8th/6.0'	12th/6.0'	16th/7.5'			
10.0'	11.0'	22	7	1st/7.25'	3rd/7.25'	5th/7.25'	8th/7.25'	12th/7.25'	16th/7.25'	20th/8.75'	

Site Configuration: Flat at bottom of wall, 2 1/2 horizontal to 1 vertical slope at top of wall

Exposed Height	Total Height	Number of Block Courses	# of Geogrid Layers	Block course that geogrid is placed on top of and length of geogrid. (Block course/geogrid length)							
4.0'	4.5'	9	2	2nd/4.0'	5th/4.0'						
6.0'	6.5'	13	3	1st/4.25'	5th/4.25'	9th/5.75'					
8.0'	9.0'	18	5	1st/6.25'	4th/6.25'	6th/6.25'	10th/6.25'	14th/7.75'			
10.0'	11.0'	22	7	1st/8.25'	3rd/8.25'	5th/8.25'	8th/8.25'	10th/8.25'	14th/8.25'	18th/9.5'	

1) Sample designs are to be used for preliminary design only when actual soil, site geometry and surcharge conditions are conservatively represented by the assumption table in all situations. A qualified engineer using actual design conditions for the proposed site should perform the final as-built design.
2) Sample designs have been prepared exclusively for the use of SRW™ 3 series geogrid.
3) MINIMUM FACTORS OF SAFETY: 1.5 for internal reinforcement pullout and tensile overstress, 1.5 for external sliding, 2.0 for external overturning and bearing capacity. NO provision or analysis included for global stability.
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5) Geogrid must be one continuous piece from the face of the retaining wall block to the back of the reinforced soil mass. No splicing of geogrid. Geogrid must butt together at edges but must not be overlapped. Geogrid must be pulled tight before backfill is placed.
6) Follow the installation instructions that are supplied with the retaining wall system that you are purchasing. (Which should include foundation preparation, block alignment, core filling of block, drainage rock placement, backfill placement, and compaction.)
7) See your local building department for permitting requirements.
8) Each design is to be used up to the indicated height only. When the retaining wall exceeds that height a higher design shall be used.
9) When the retaining wall steps up at the bottom of the wall, bottom geogrid layers should be moved up with the steps and not dropped off until the next layer of geogrid is encountered.
10) Light Traffic is auto or empty pickup truck loading. Any vehicle traffic or parking loads exceeding Light Traffic vehicle weights at the top of the retaining wall shall require a special site specific preliminary design.
11) If there is a slope at the bottom of the wall, additional embedment depth of the bottom courses may be required.
12) If your site does not fit the above site configurations, call SRW Products at (800) 752-9326 for a free site-specific preliminary design.

GEOGRID

OLDE ENGLISH

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OLDE ENGLISH

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GEOGRID

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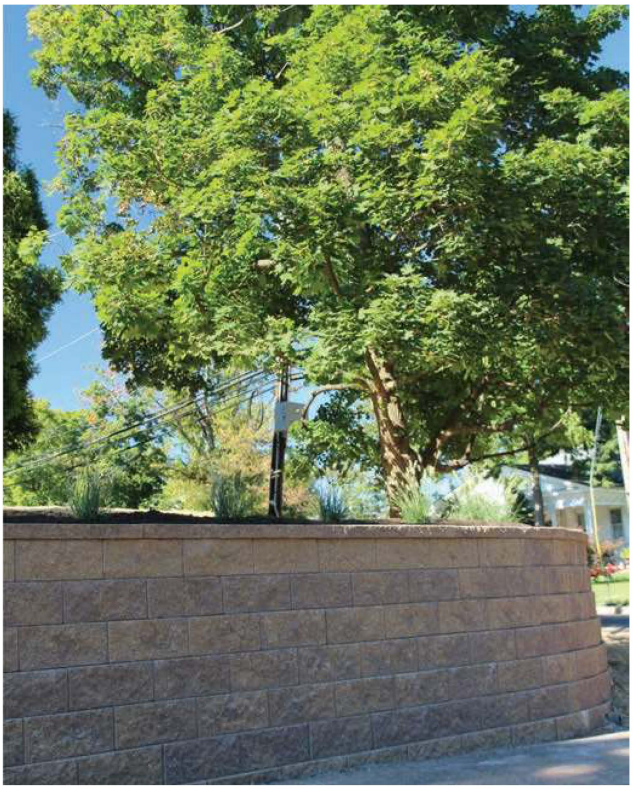
cambridgewallsupport.com

SIGMA-MAYTRX OLDE ENGLISH

How To Build An Engineered Retaining Wall And Obtain A Stamped Drawing For Submittal To A Local Municipality.



The best place to source design information or necessary drawings for MaytRx and Sigma Wall Systems is cambridgepavers.com. HTS (Hardscape Technical Services) has created a manual, "Complete Guide to Planning, Bidding, Engineering, and Building the MaytRx Wall", which is an excellent primer for building an engineered wall as well as a stamped drawing program that costs less than $500 in most cases. Their affiliate company SRW offers free takeoffs and geogrid layouts.

SRW/HTS has an arrangement with Cambridge Pavers to provide MaytRx and Sigma engineered wall designs if the geogrid needed for the project is purchased from Cambridge. Cambridge suggests that you consult an engineer, design professional or HTS for MaytRx and Sigma Walls higher than 36 inches or that involve loads, poor soil or other design factors such as water runoff. See program information below.

SRW Free Design Request Program

Fill out the design request form on cambridgepavers.com. Within 3 days of receiving your information SRW will provide:

- Geogrid layer drawing
- Wall Takeoff (Sq. Ft., Caps, Pins)
- Adhesive needed

Note: *This is not a "Stamped" drawing; it is a calculation based on your information using NCMA design software.*

HTS Stamped Drawing Program

Typically, when a homeowner or contractor discovers that their retaining wall project needs a permit by the local building department, it is also learned that to obtain a permit they must provide engineering stamped by an engineer registered in the state of the project. The stamped engineering requirement will vary, from locality to locality. The determining factor for requiring stamped engineering is usually the exposed height of the retaining wall. Some local building departments require stamped engineering on retaining walls as short as 2' in exposed height. Fill out the design request form and prepare a soil sample.

What To Expect

When stamped engineering services are requested, HTS:

- Insures that the project fits the 8' and under program,
- Verifies that all the required information is supplied, and forwards the package to the independently licensed engineer.

The engineer reviews the request and the customer receives:

- A cover letter from Hardscape Technical Services (HTS).
- A stamped cover letter from the engineer indicating the proper design table to use for construction.
- The proper design table stamped on the site configuration (case) to be used.
- Upon receipt of the stamped engineering document, you may proceed in obtaining the building permit from the local building department.

Find all forms requested on this page of the handbook along with processing instructions, and also information on Geogrid in the Professional Contractors Section of the Cambridge website (www.cambridgepavers.com).

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STAMPED DRAWINGS

LINKS

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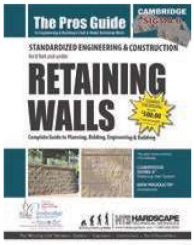
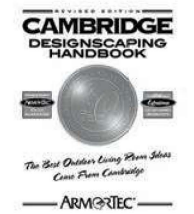
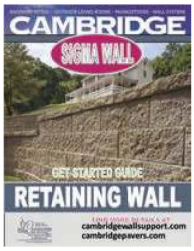


Separate Sigma 6 & Sigma 8 "Pro Guides" are available for free download at:
cambridgewallsupport.com

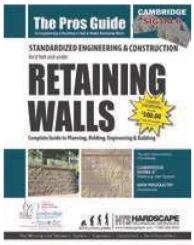


Cambridge Designscape Book is available for free download at:
cambridgewallsupport.com

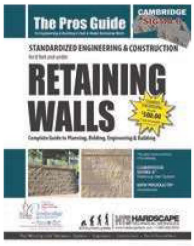
These pages reference the Cambridge Product Line Spec available for free download at:
cambridgewallsupport.com



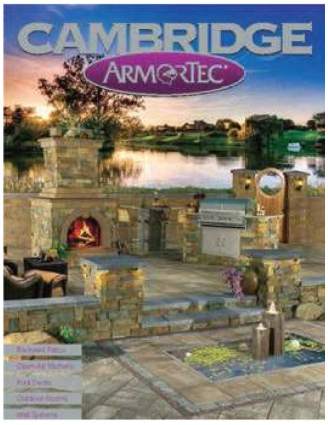
Sigma "Getting Started" Guide is available online for Tablet, Smartphone or PC access at:
cambridgewallsupport.com



Maytrx Wall "Pro Guide" is available for free download at:
cambridgewallsupport.com



Ideal guide for Retaining Walls. Sigma and Maytrx Wall preloaded for NCMA Software is available at:
cambridgewallsupport.com



Many of these pages reference the Cambridge Outdoor Living Brochure 2014. This is an invaluable tool in viewing color and textures as well as the full line of outdoor living products available from Cambridge.
available for free download at:
cambridgewallsupport.com
or Viewable at
cambridgepavers.com

YouTube

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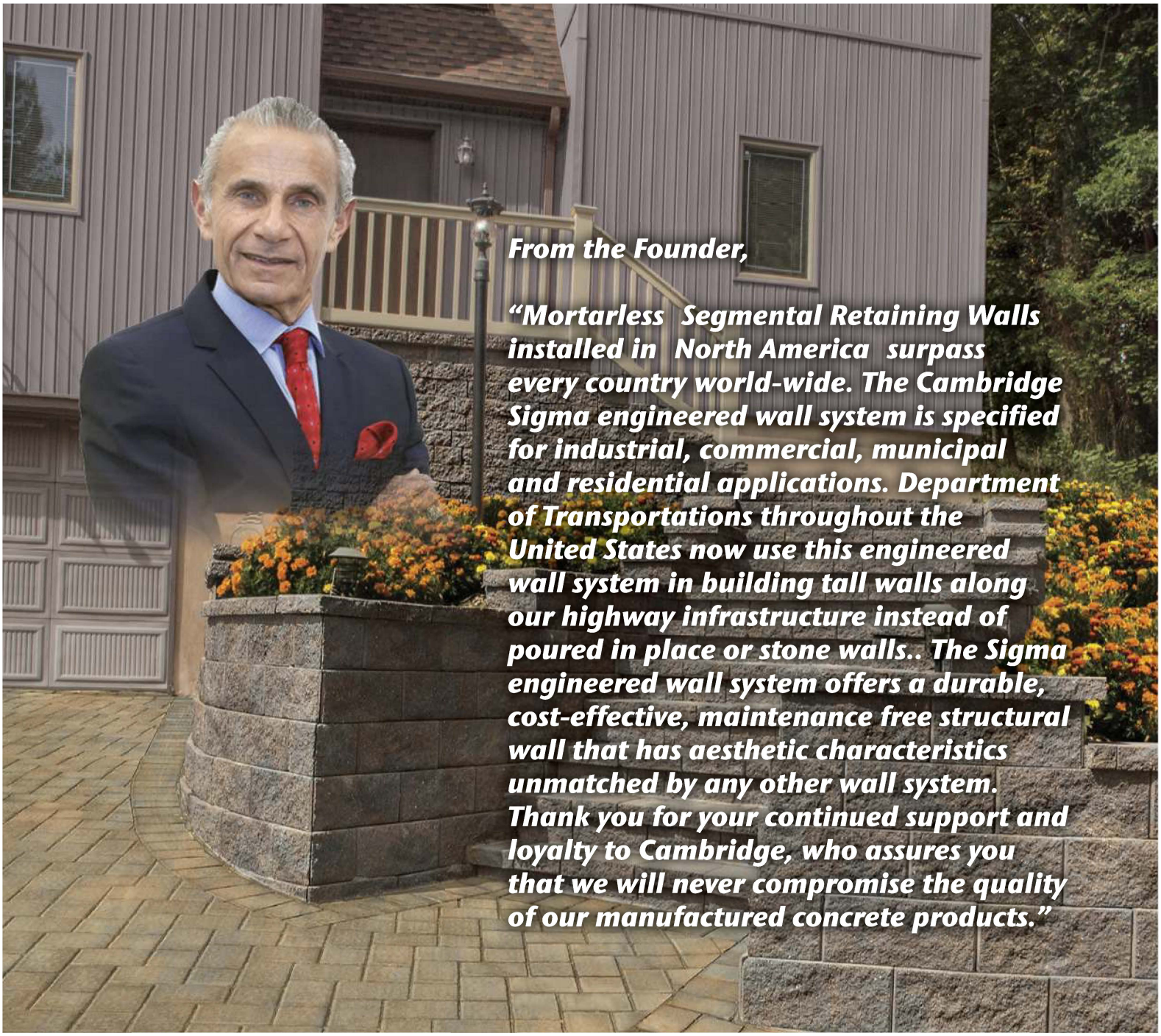
Cambridge Website is available at:
cambridgepavers.com

CAMBRIDGE WALL SYSTEMS SUPPORT

Cambridge Wall Support Website is available at:
cambridgewallsupport.com



Premium Quality Pavingstones, Wall Systems & Outdoor Living Room Components

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