The National Academies of
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TRANSPORTATION RESEARCH BOARD

Designing Pavement Subsurface Drainage Using DRIP Software

Tuesday, October 23, 2018
2:00-4:00 PM ET

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Discuss how to use Drainage Requirements in Pavement (DRIP) software to design effective drainage systems for pavements.

Learning Objectives

At the end of this webinar, you will be able to:

- Discuss the DRIP software, its capabilities, and its potential benefits
- Identify the source of water entering the pavement and potential damage due to water entrapment
- Identify characteristics of a well-performing drainage system

Transportation Research Board webinar

Designing Pavement Subsurface Drainage Using DRIP Software

Sponsoring Committee: Subsurface Drainage (AFS60)

Co-sponsoring Committee: Strength and Deformation Characteristics of Pavement Sections (AFD80)

Tuesday, October 23, 2018

2:00 – 4:00

Presenters

- **Mohamed Elfino, Ph. D, P.E., *Virginia Department of Transportation (retired)***
- **Gabriel Bazi, Ph.D, P.E., Assistant Professor, *Lebanese American University***
- **Clark Graves, Ph.D., P.E., P.G., Associate Director, Kentucky Transportation Center**

- **Moderator: Affan Habib, P.E., State Pavement Program Manager, Virginia Department of Transportation**

Brief Overview of DRIP

- **DRIP: Drainage Requirement In Pavement**
- **Developed by FHWA**
- **First release: September of 1997 (version 1.0)**
- **NHI course 131026 integrated DRIP version 1.0 in 1998**
- **Windows compatible version (version 2.0) was released in 2001.**
- **Reflects feedbacks from the users**
- **Incorporated several enhancement**
- **The program can be downloaded from below locations**
  - http://www.me-design.com/MEDesign/DRIP.html
  - https://sites.google.com/site/trbcomafs60/committee-documents/drip
- **AFS60 can provide technical assistance with using the program**

DRIP Capability

- **Roadway geometry calculation**
- **Sieve Analysis calculation**
- **Inflow calculation**
- **Permeable base design**
- **Separator layer design**
- **Edgedrain design**

Importance of Effective Drainage in Enhancing Pavement Performance

Mohamed Elfino, PhD, PE
“Retired”
Virginia Department of Transportation
TRB AFS 60 Emeritus Member

TRB AFS 60 & AFD 80 Webinar

October 23, 2018

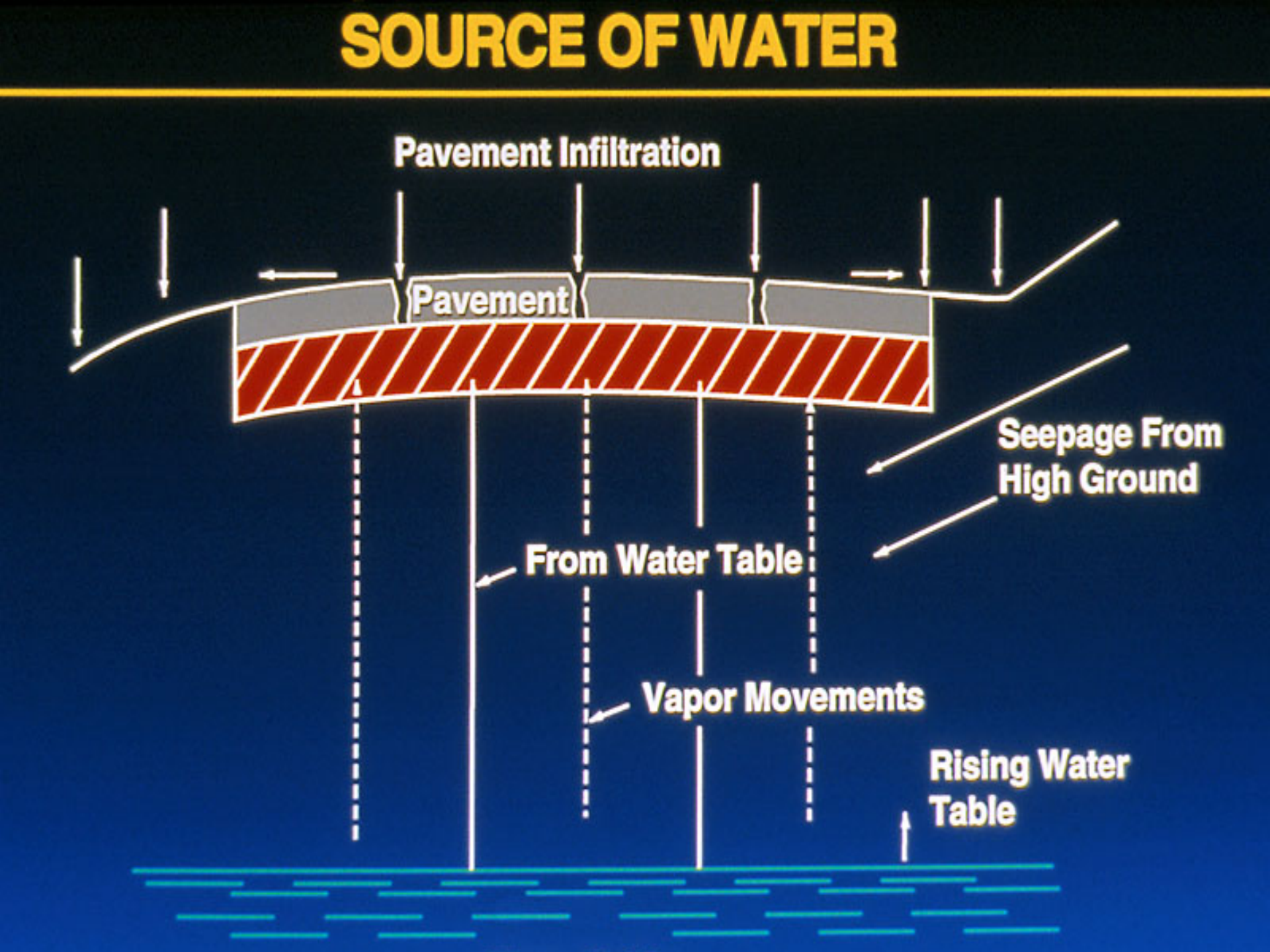
Outlines

- Sources of water entering the pavement.
- Impact of trapped water on pavement performance.
- Characteristics of effective drainage systems, Construction, and sample designs.

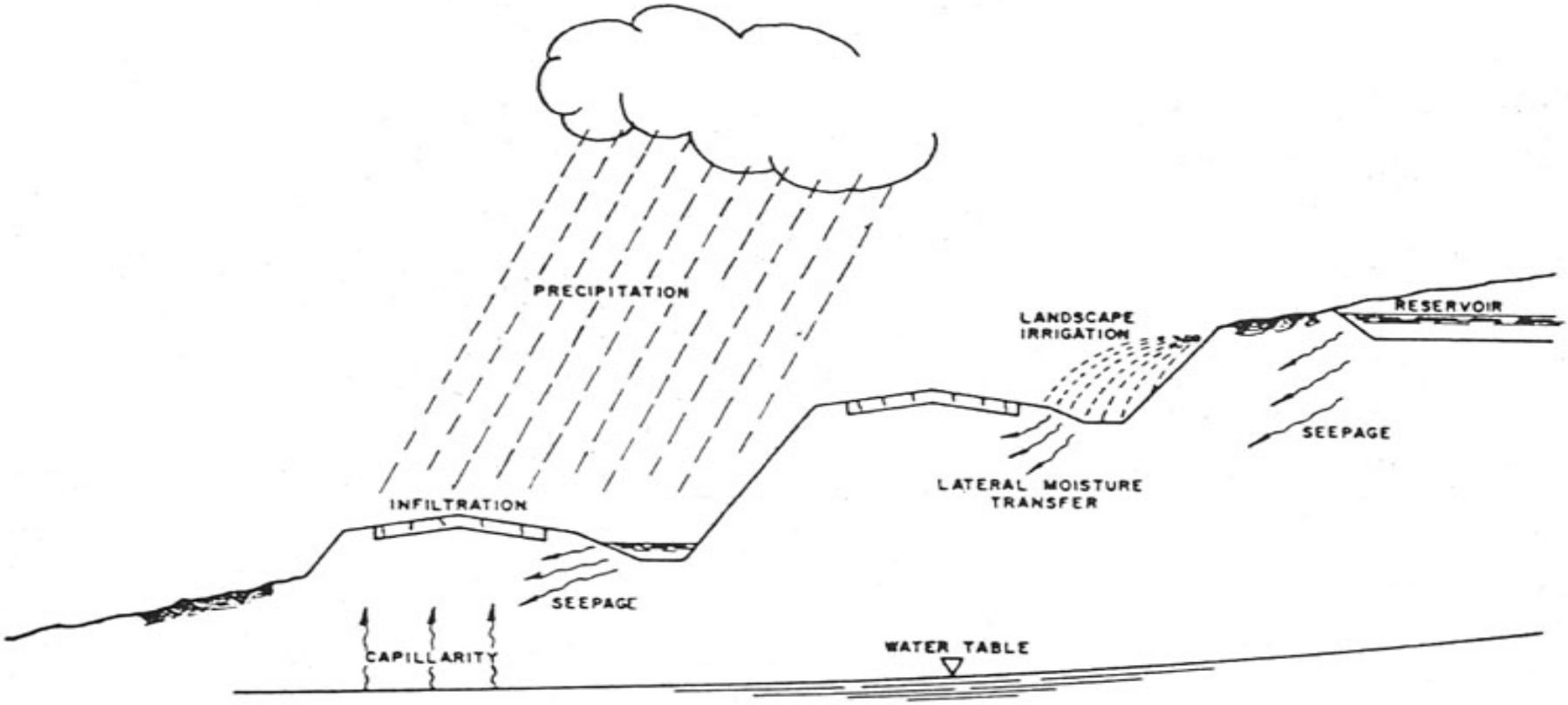
SOURCES OF WATER

- Surface Infiltration
- Rising Groundwater
- Capillary Action
- Seepage Water
- Vapor Movement

SOURCE OF WATER

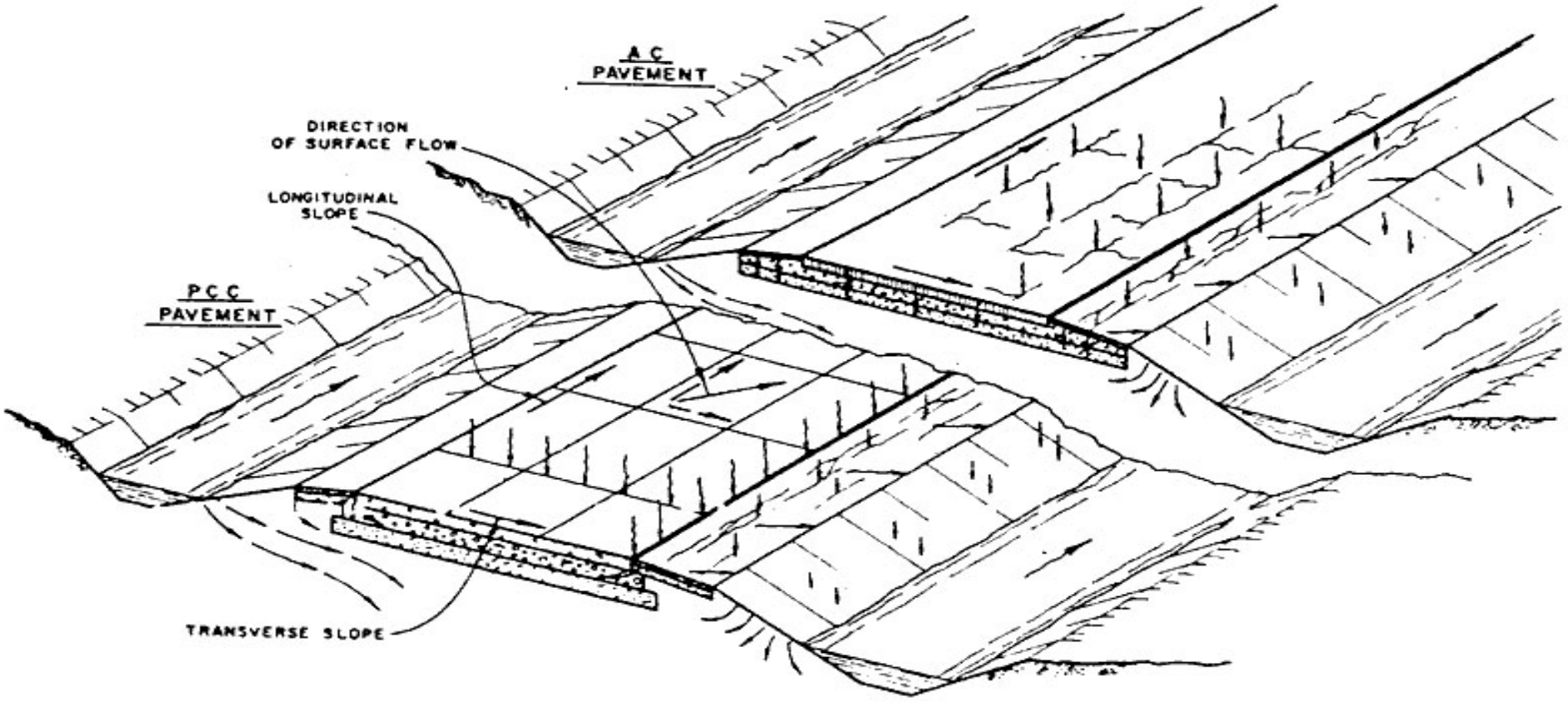


Sources of Water (Ref 2)



Sources of water entering highway pavement structural sections

Points of Entrance of Water into Highway (Ref 2)

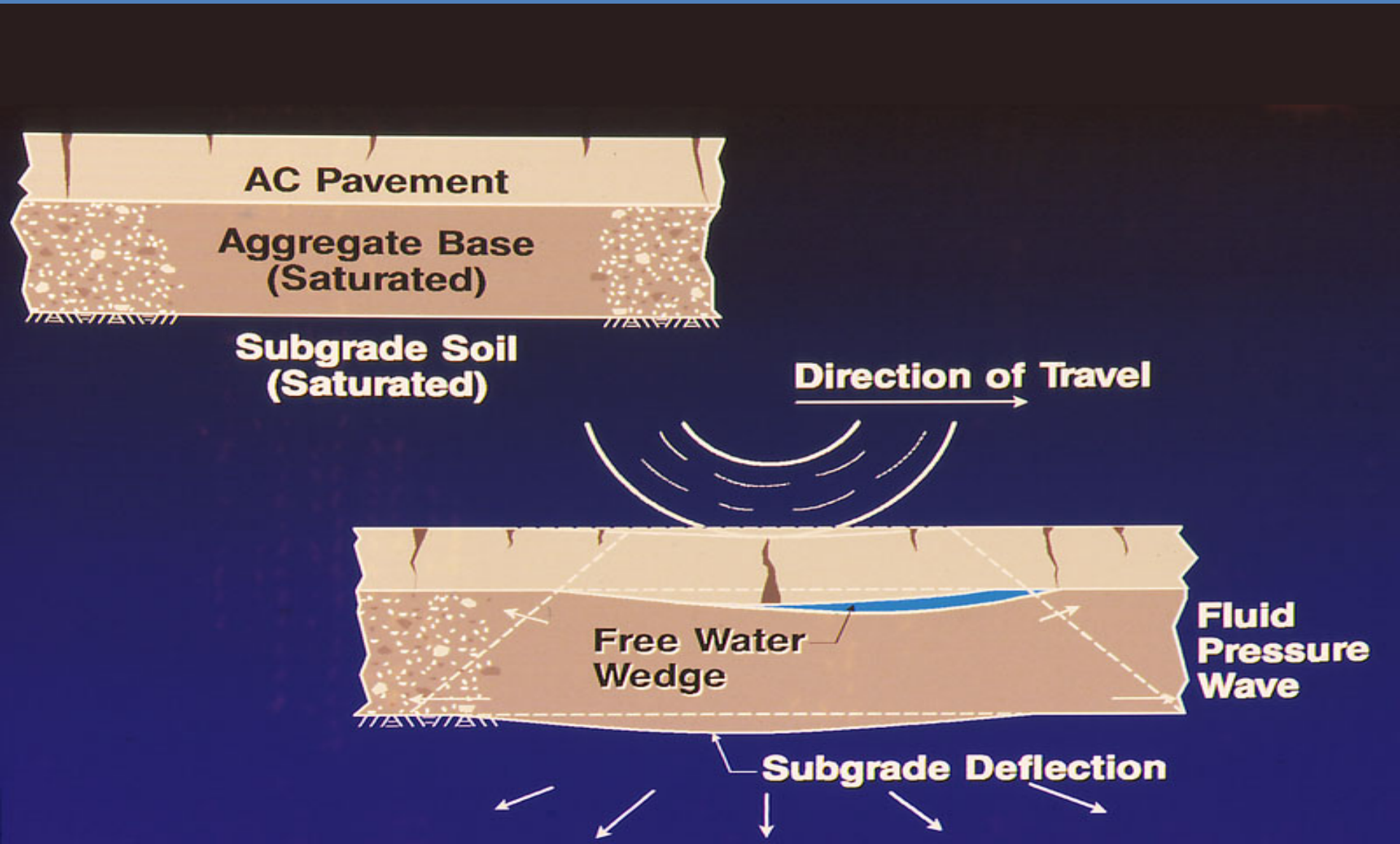


Points of entrance of water into highway pavement structural sections

Why do We Need Drainage?

Impact of trapped water on pavement performance.

Moisture Distress Mechanism in Asphalt (Ref 2)



Severe Cracking and Rutting

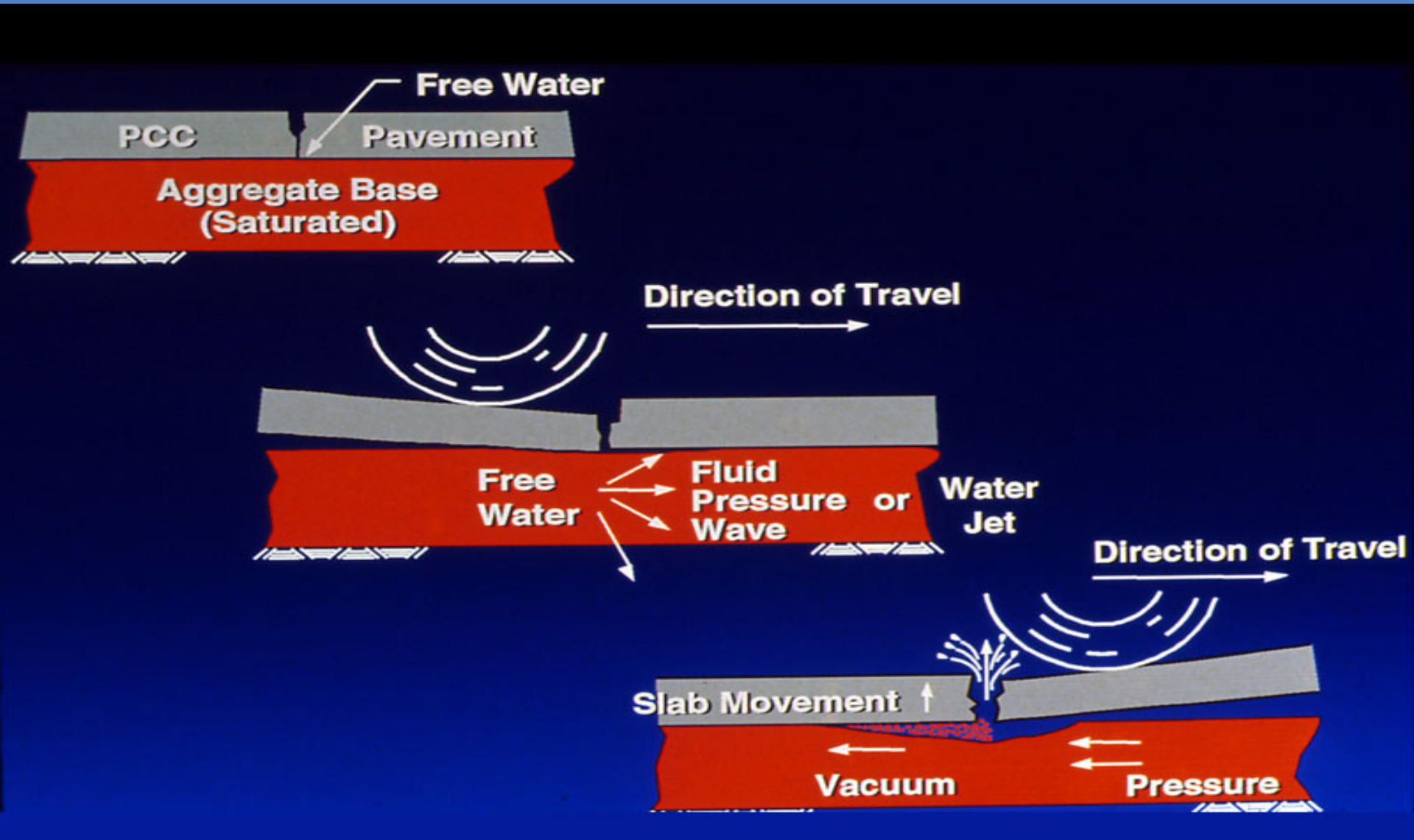
Fatigue Cracking in Saturated Thin Asphalt Pavement

Water Seepage at the Interface, One hour after rain Stopped

MOISTURE DISTRESS CONCRETE PAVEMENT

- Pumping
- Faulting
- D-Cracking
- Punchouts
- Corner Breaks

Moisture Distress Mechanism in Concrete (Ref 2)



Pumping in Concrete Pavement

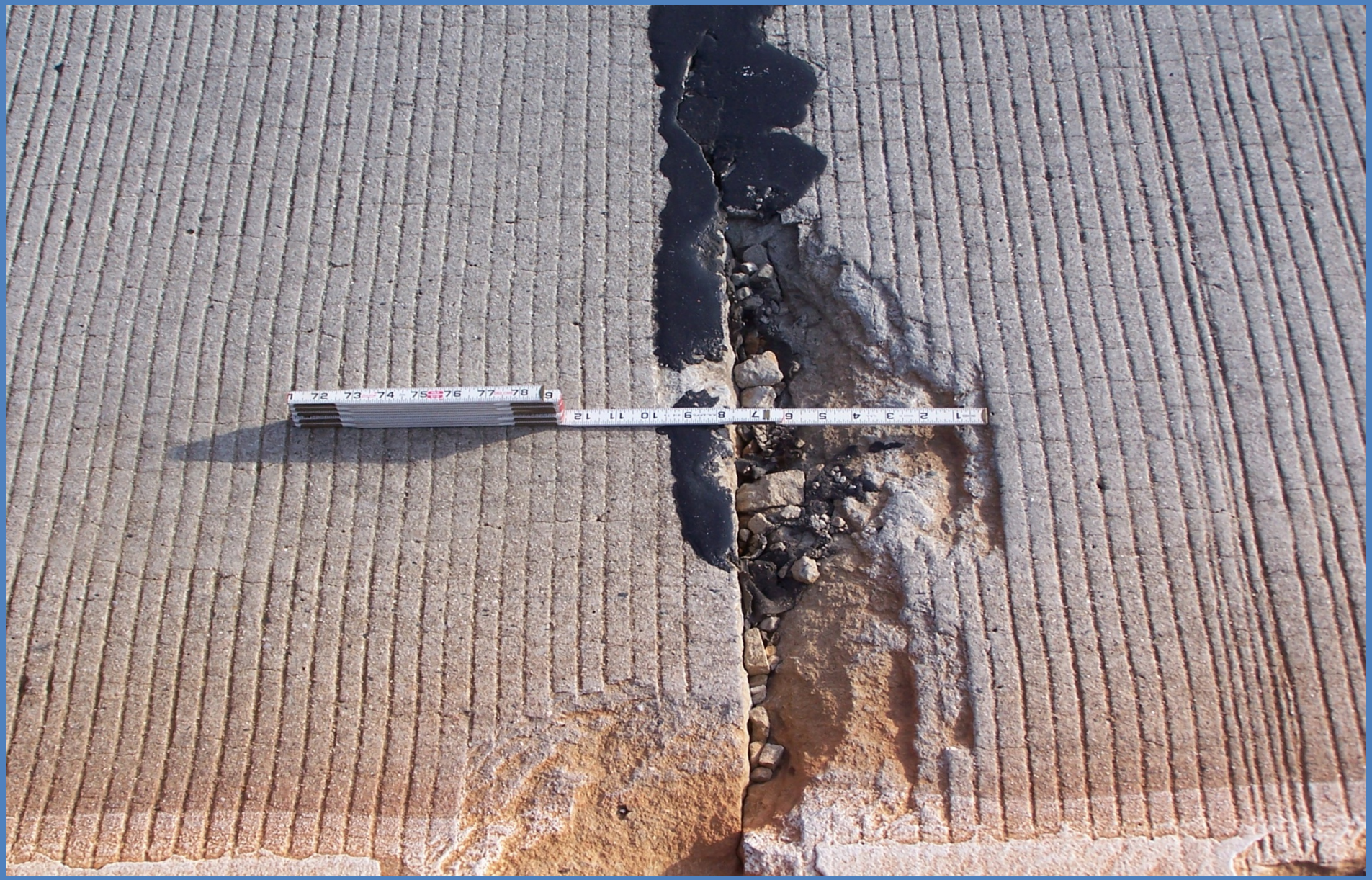
Cracking and Staining in Concrete Pavement

Staining in Two Lane Section, Cut Area

Spalling at Longitudinal Joint

One Inch Settlement between Travel Lane and Shoulder

Spalling at the Transverse Joint 2007



DRAINAGE

DRAINAGE

DRAINAGE

Current National Effort

NCHRP Project 01-54

"Guidelines for Limiting Damage to Flexible and Composite Pavements Due to the Presence of Water"

Characteristics of effective drainage systems, Construction, and sample designs.

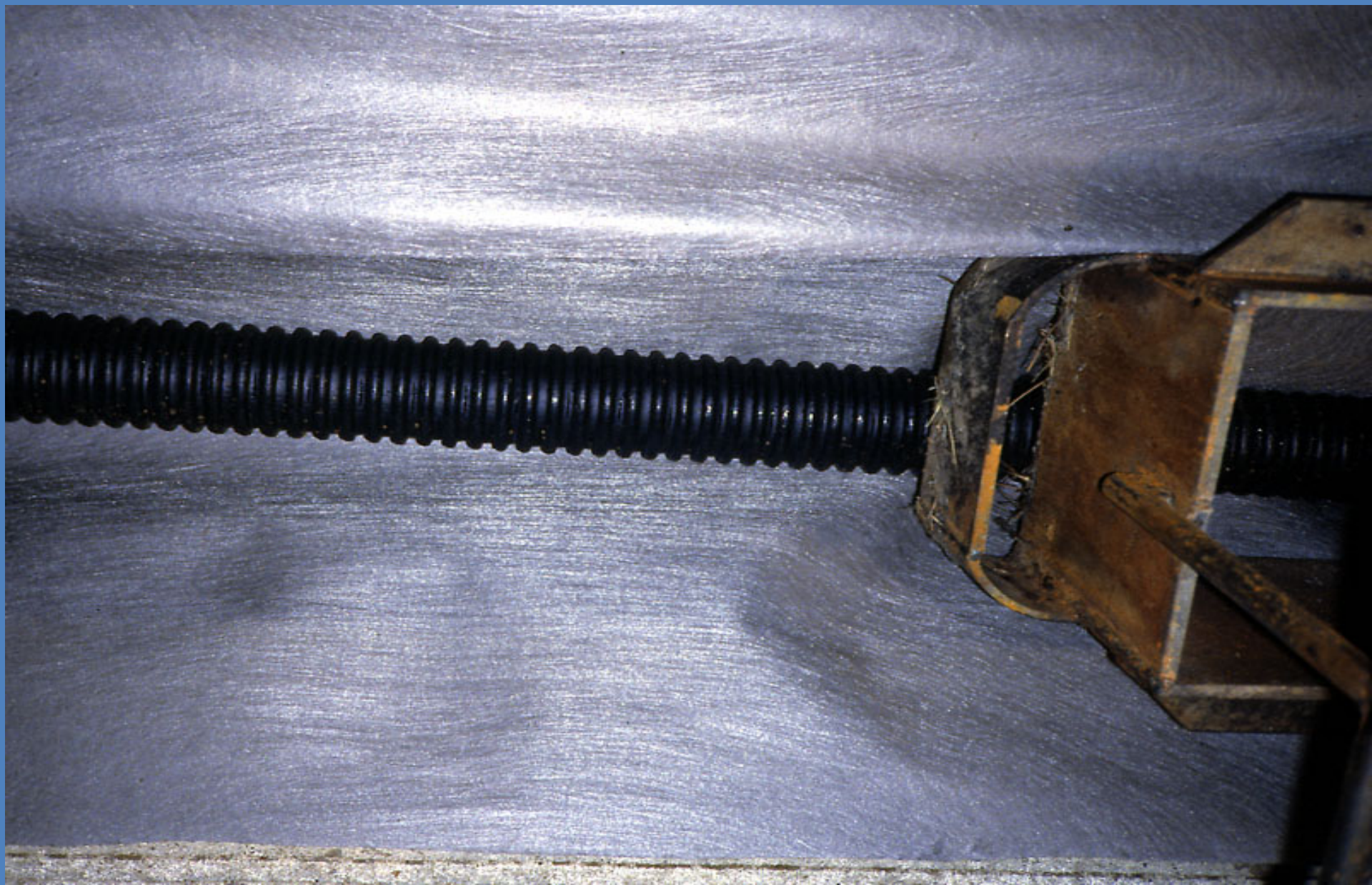
Functions of Good Drainage System

- Intercept
- Collect
- Discharge

Trenching Retrofitted Edgedrain

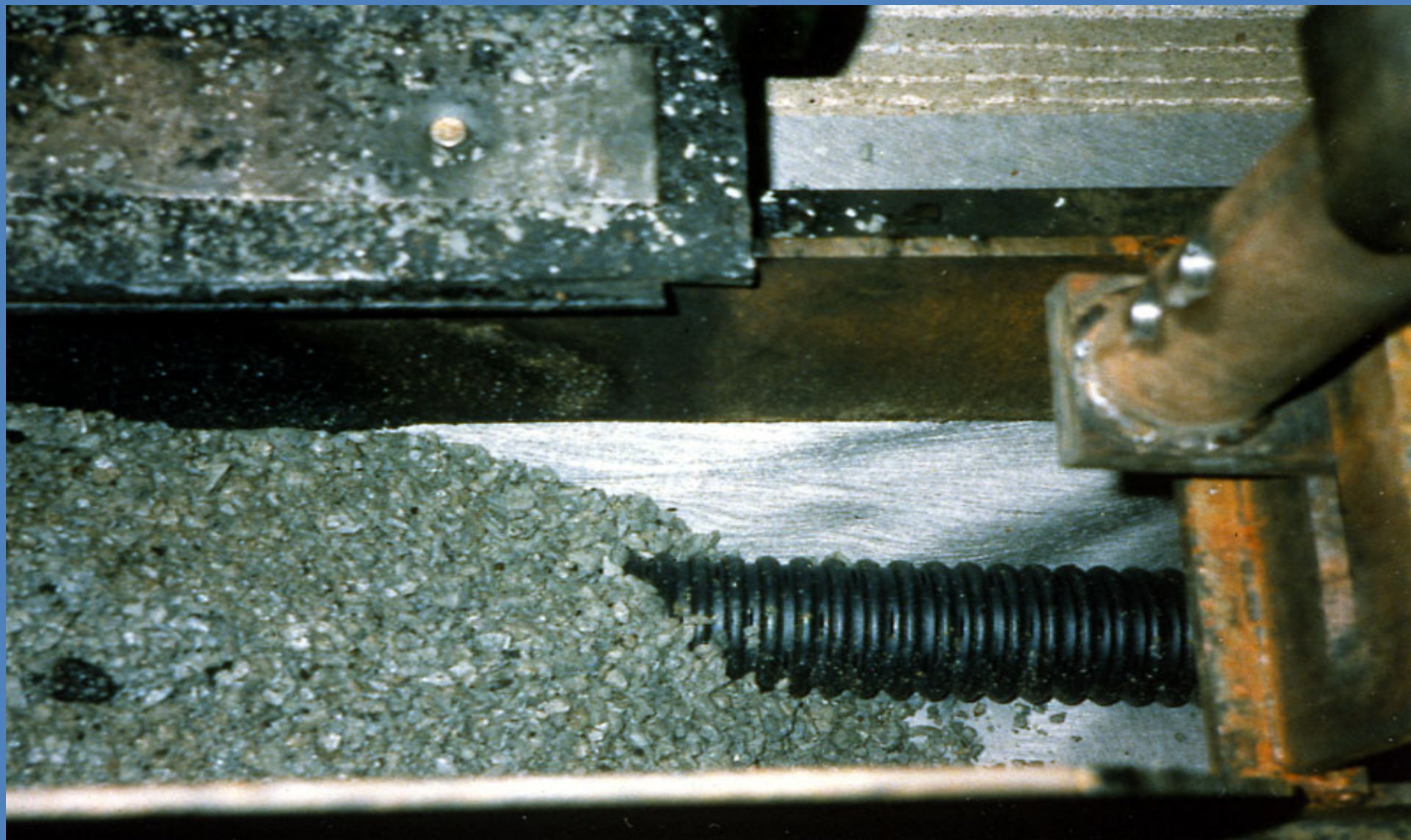
Laying out the Filter Fabric

Placing the Longitudinal perforated pipe



Automated System for Aggregate Backfilling

Free Draining Aggregate on Top of Pipe Without Bedding



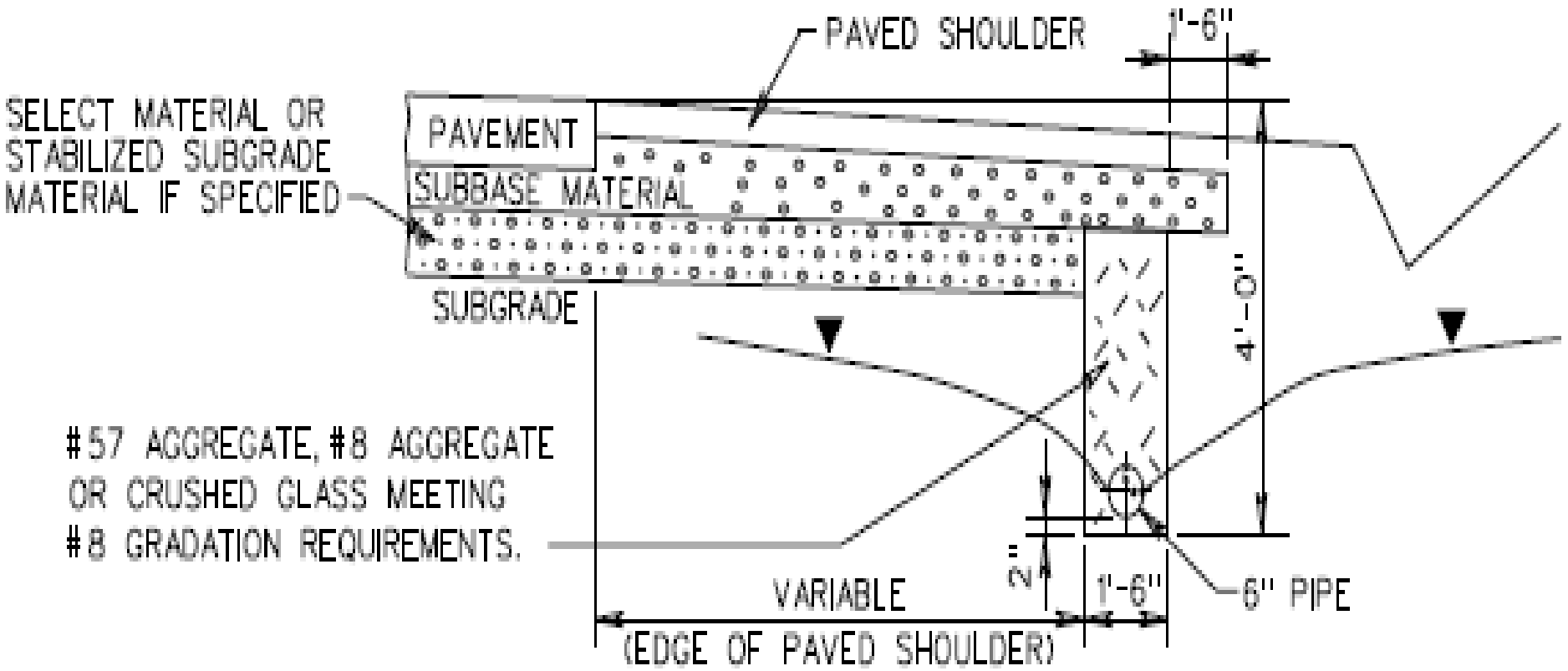
Completed Trench Backfilling

Filter Fabric Over Lapped and Marking Outlet Location

Types of Subsurface Drains in Virginia

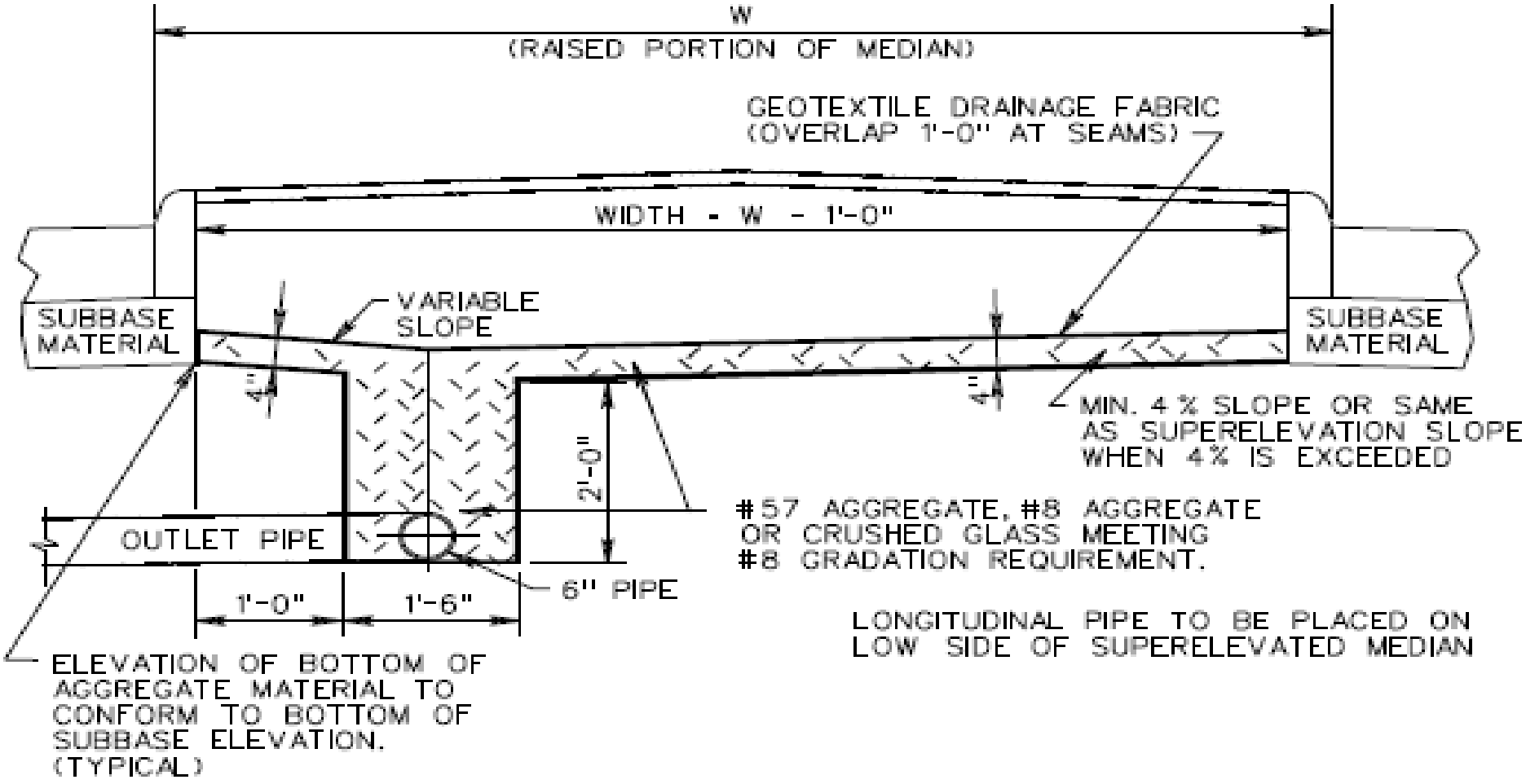
- UD-1: Deep longitudinal drains used in cut sections
- UD-2 : Shallow longitudinal drain at raised grass medians
- UD-3 : Shallow longitudinal drains at sidewalk sections
- CD-1 : Cross drains used in transition from cut to fill sections
- CD-2 : Cross drains at the sag points
- UD 4,5, 7 : Pavement edge-drains for flat sections

UD-1 Deep Longitudinal Drain Used in Cut Sections with High Watertable



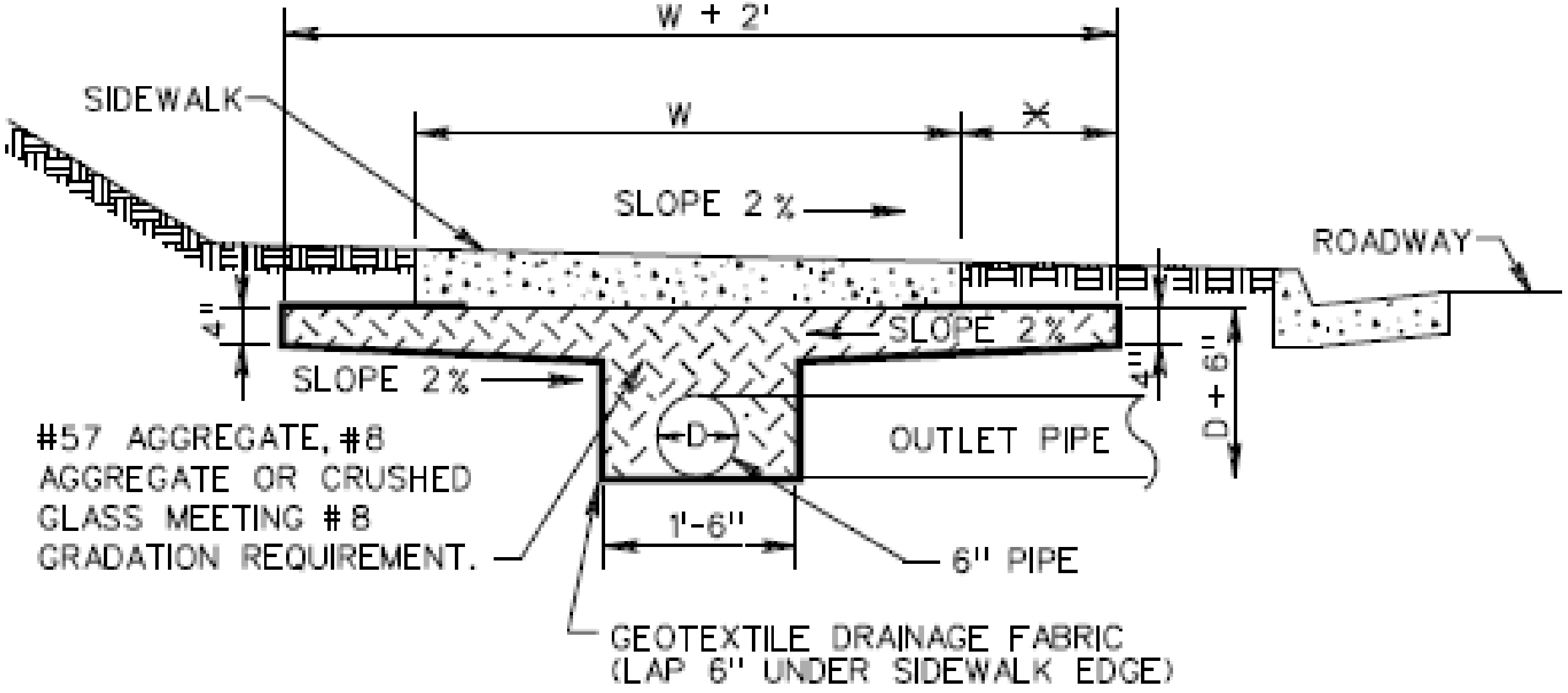
PAVED SHOULDER SECTION

UD-2 Shallow Longitudinal Drain at Raised Grass Median



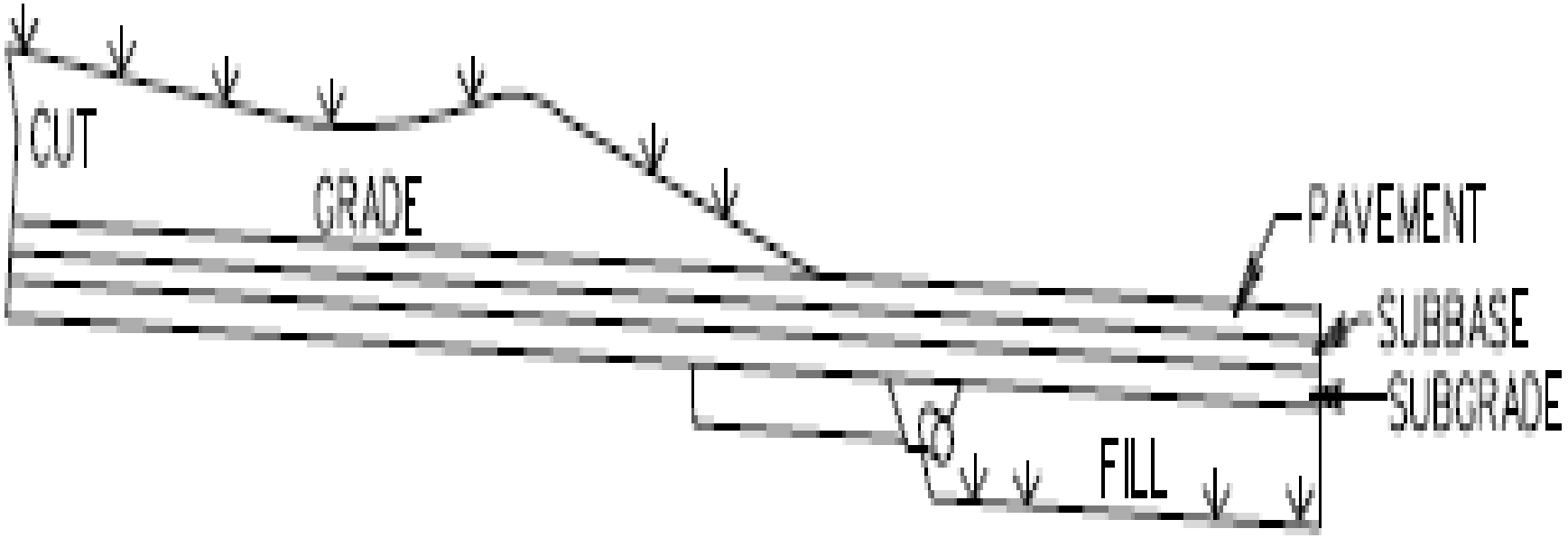
WITH SUBBASE MATERIAL

UD-3 Shallow Longitudinal Drains at Sidewalk Sections



* THIS PORTION TO BE DELETED WHEN SIDEWALK IS ADJACENT TO CURB OR CURB AND GUTTER WITH NO BUFFER STRIP.

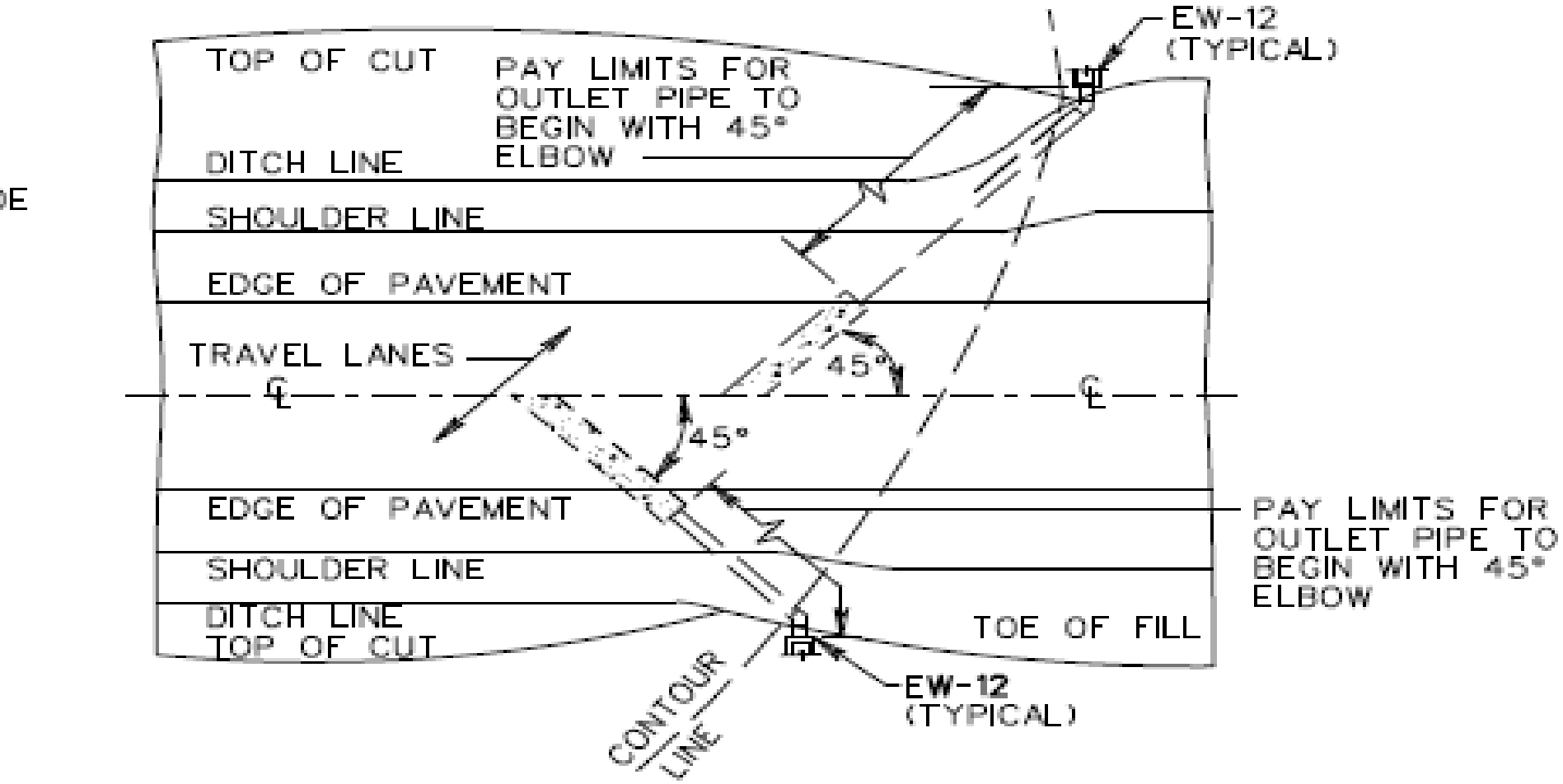
CD-1 Cross Drain From Cut to Fill Sections



COMBINATION UNDERDRAIN CD-1 AT LOWER END OF CUTS
CENTER LINE SECTION

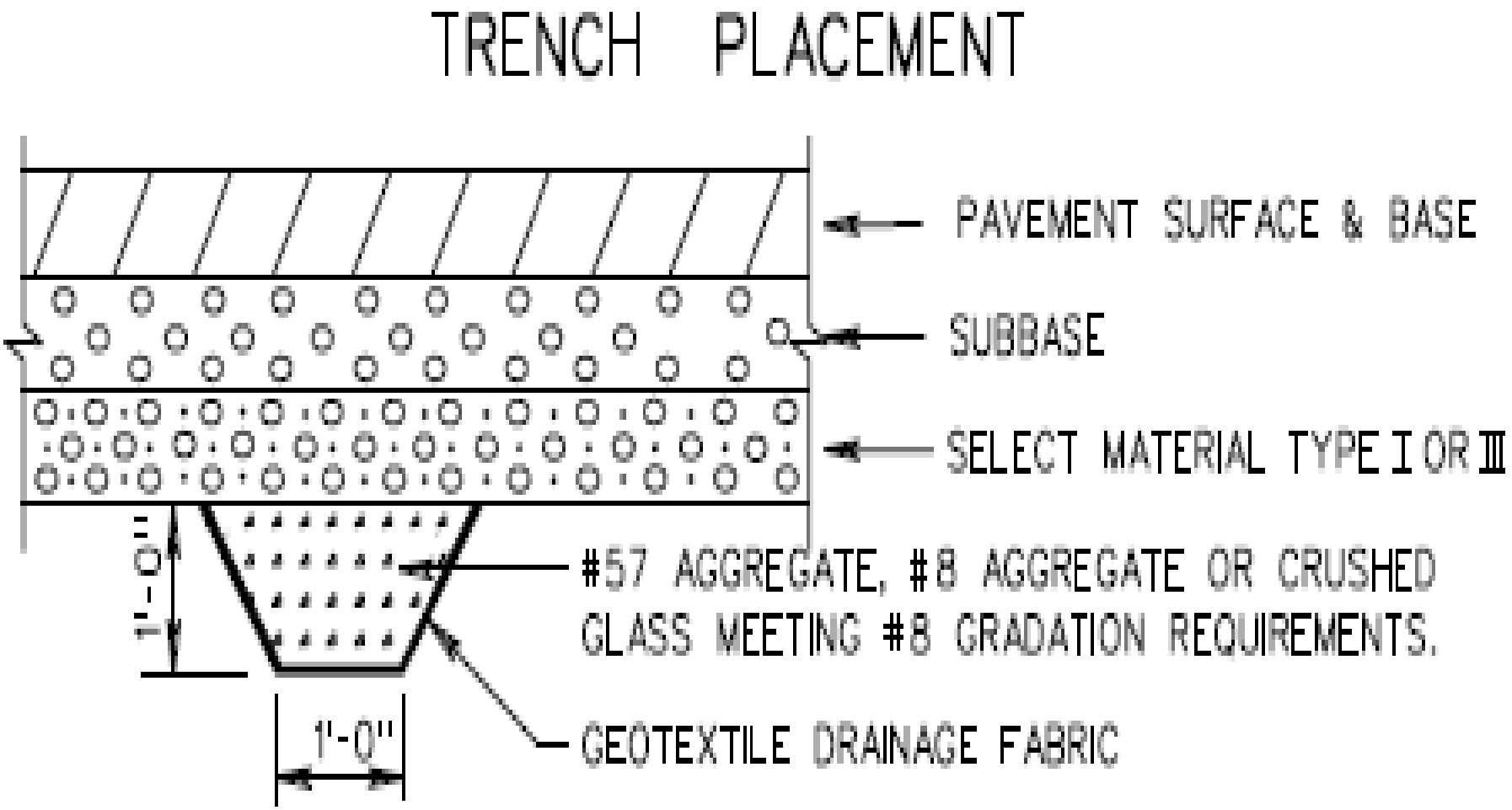
(WITH TYPE 1 SELECT MATERIAL)

CD-1 Plan View

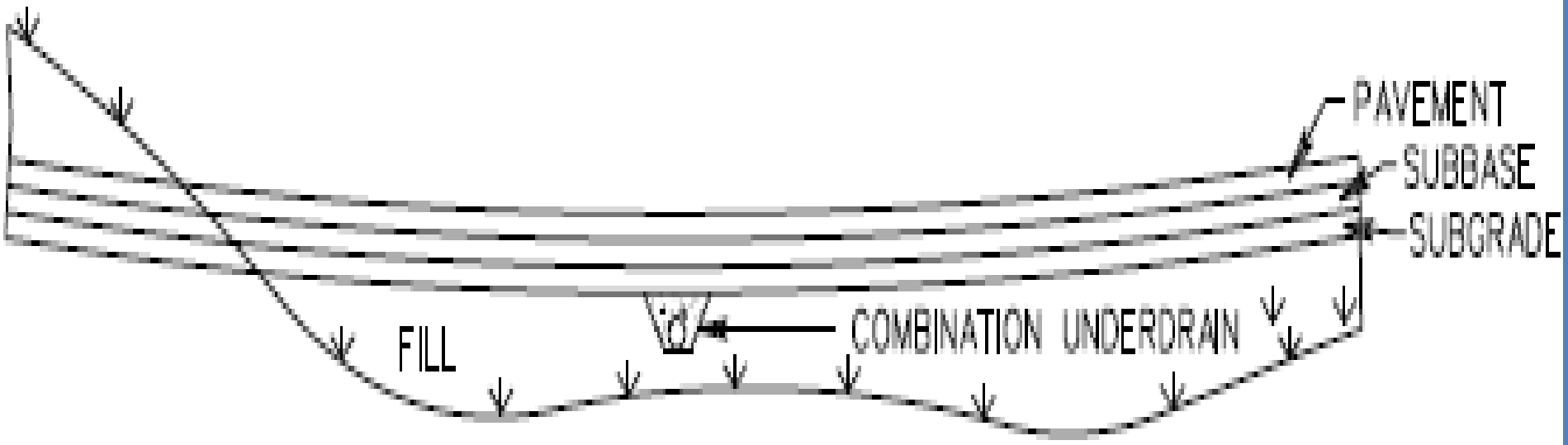


PLAN VIEW
(PLACEMENT OF CD-1 COMBINATION UNDERDRAIN)

CD-1 Trench Placement

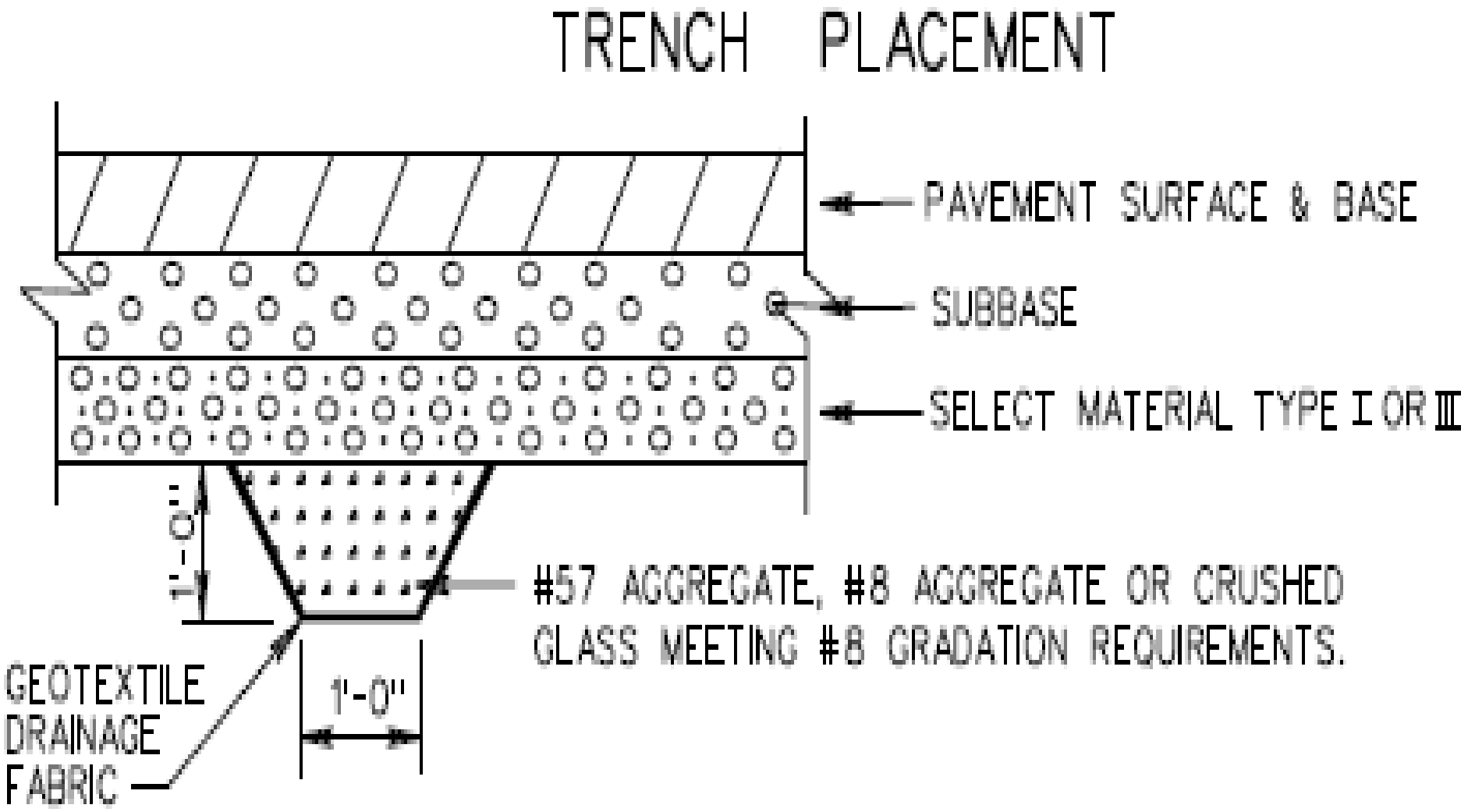


CD-2 Cross Drain for Sag Points



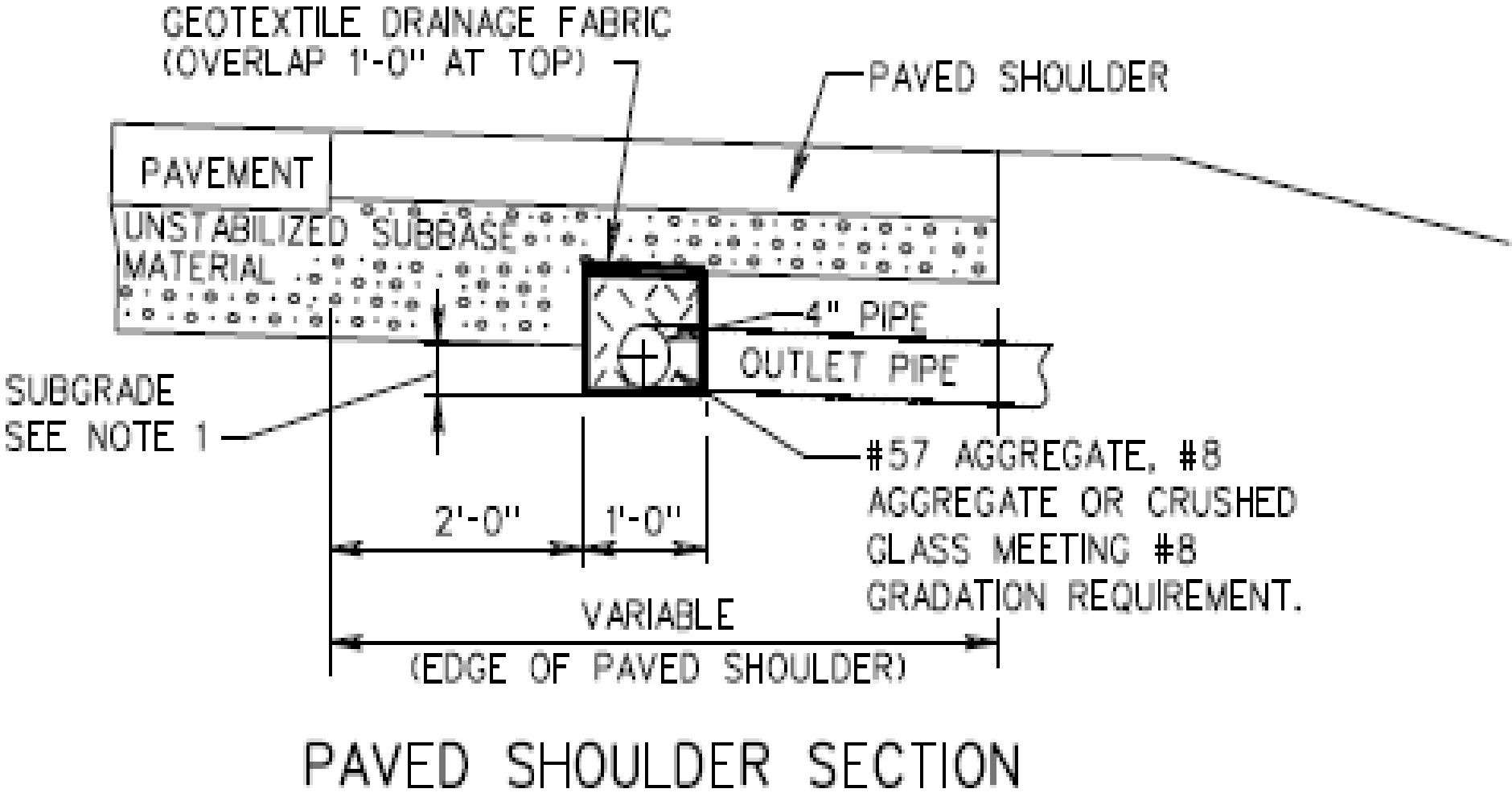
COMBINATION UNDERDRAIN CD-2 ON FILLS
CENTER LINE SECTION
(WITH TYPE 1 SELECT MATERIAL)

CD-2 Trench Placement



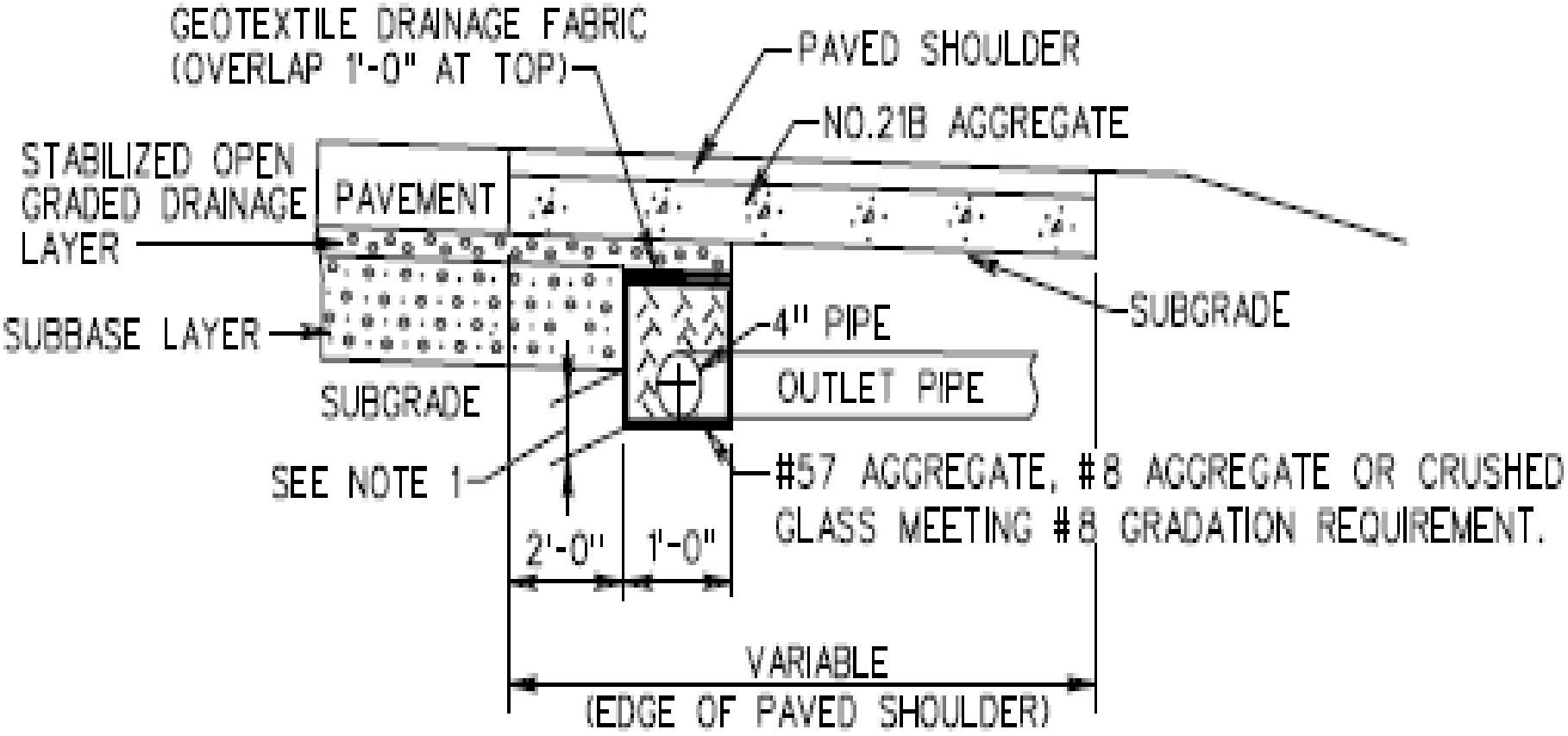
Outlet Pipe for UD-1,CD1or 2

UD-4 Pavement Edgedrain



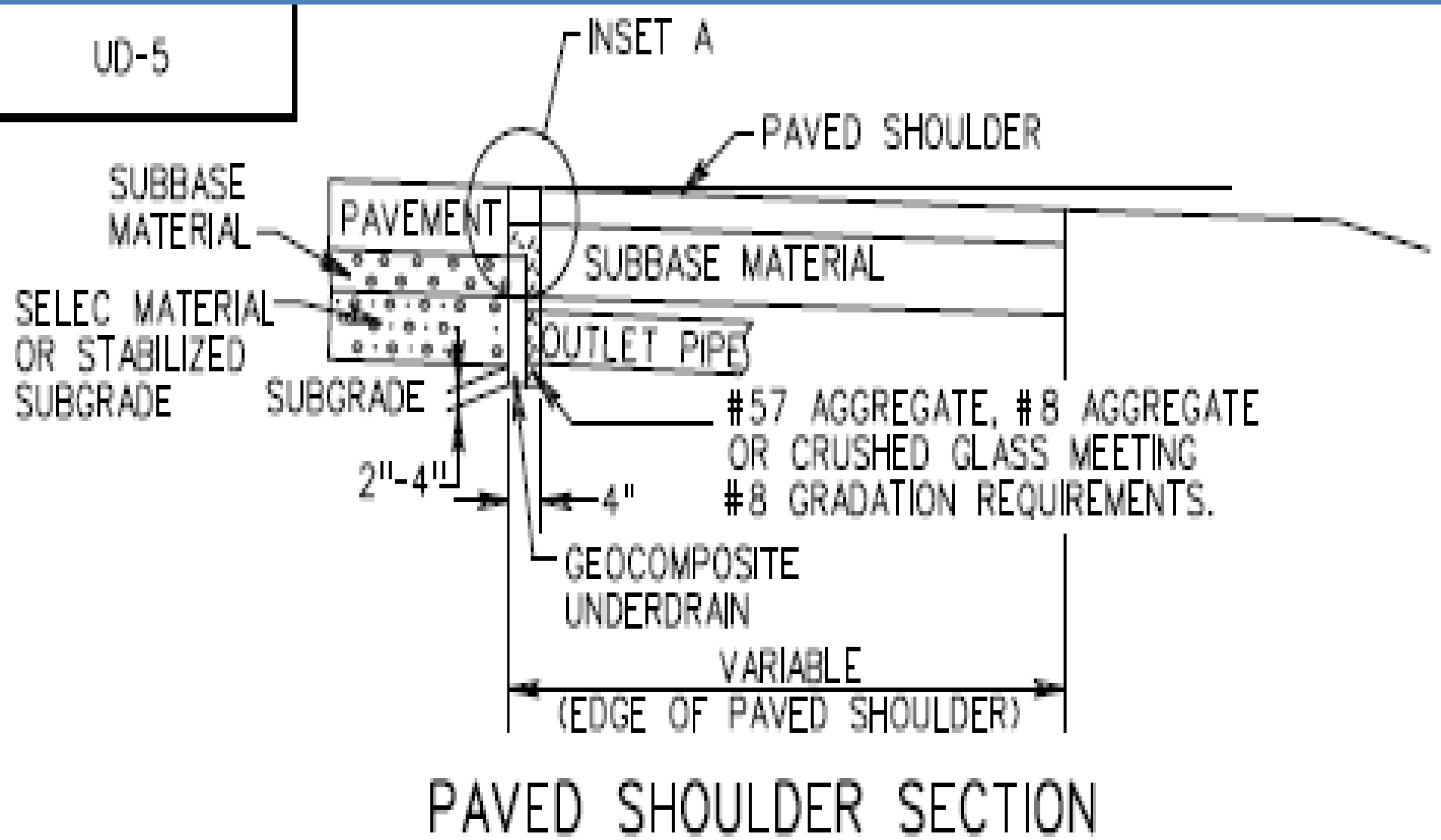
PAVED SHOULDER SECTION

UD-4 Pavement Edgedrain With OGDL



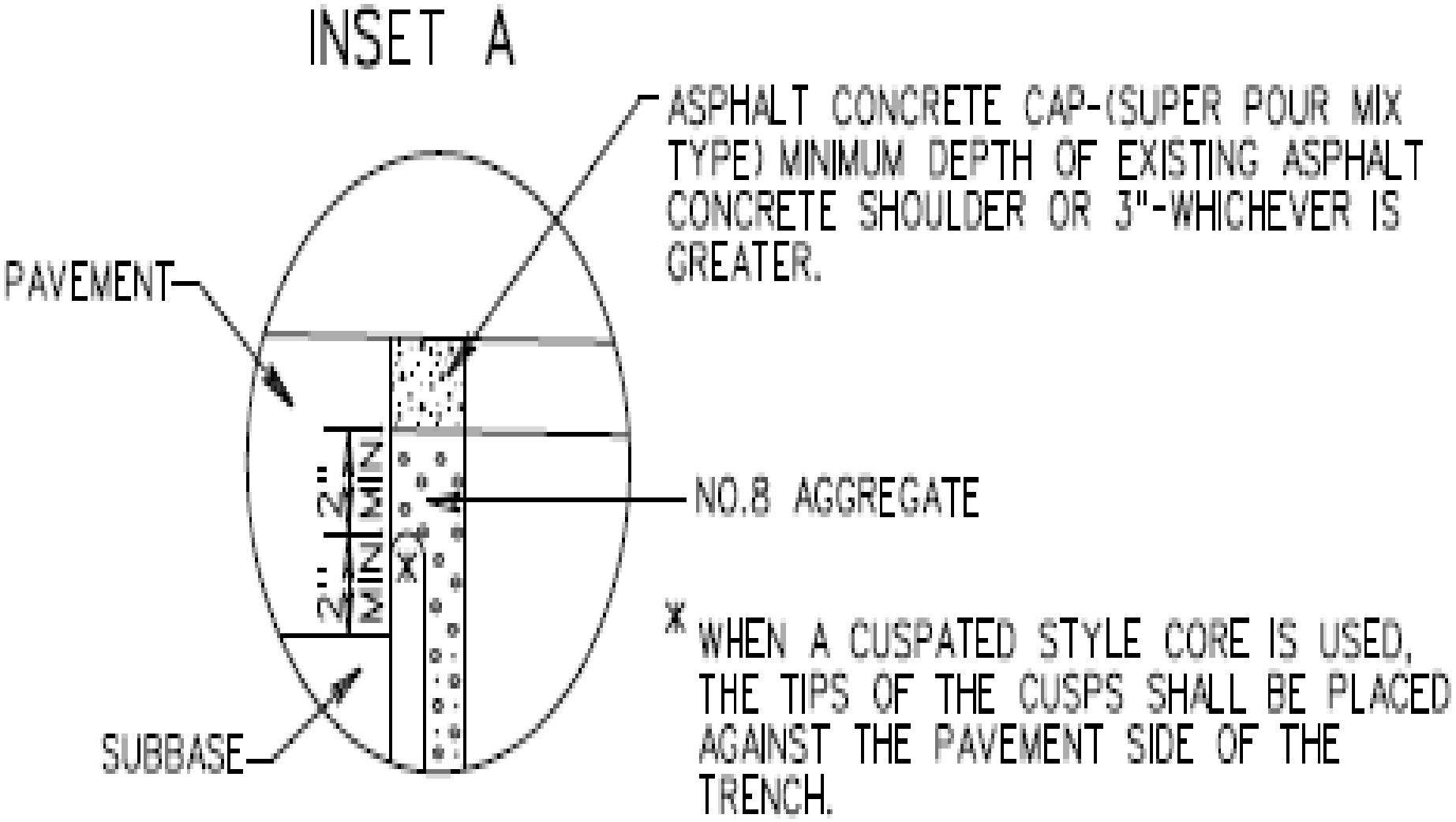
PAVED SHOULDER SECTION
(FOR USE WITH STABILIZED OPEN-GRADED DRAINAGE LAYER)

UD-5 Prefabricated Geo-composite Retrofit Edgedrain

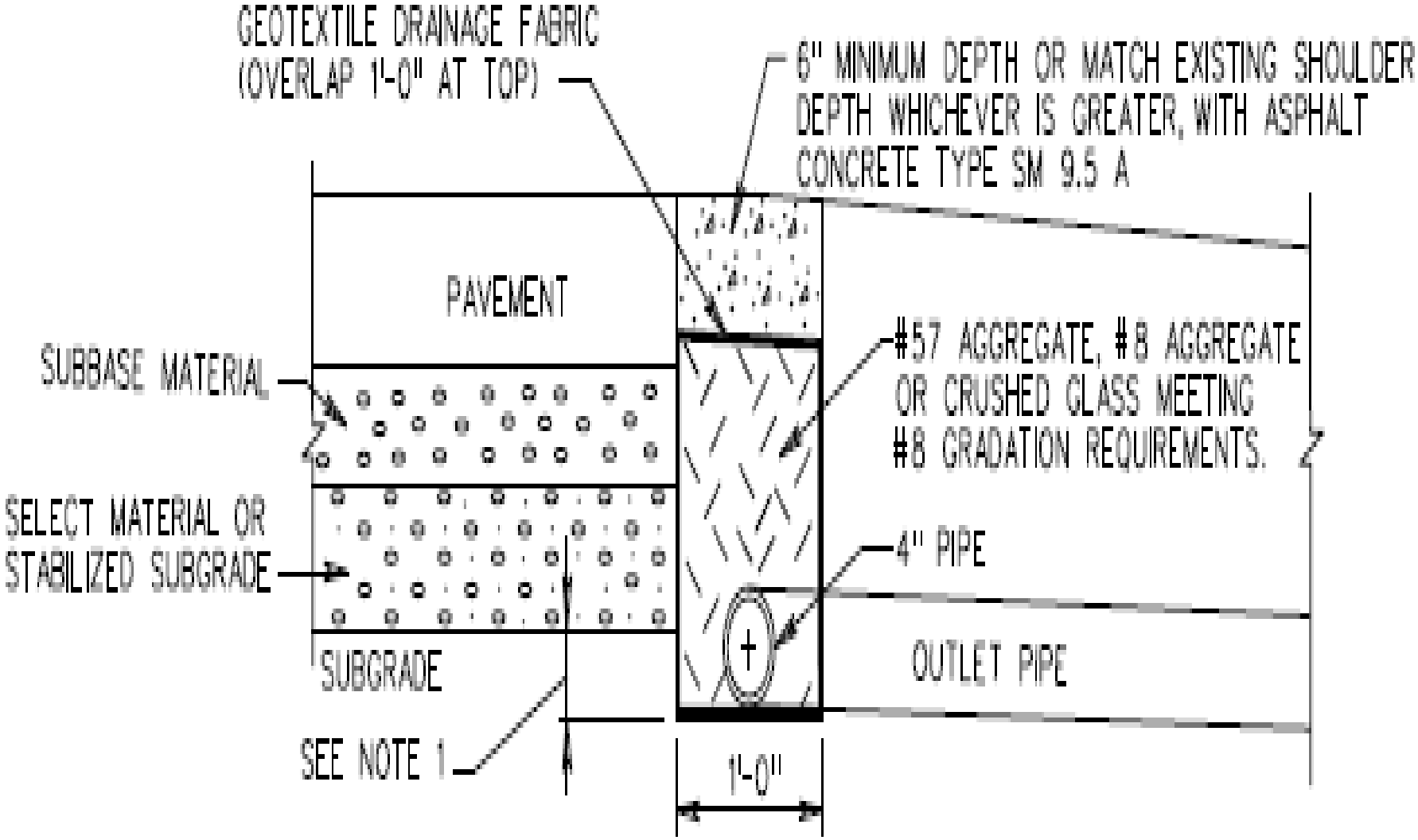


PAVED SHOULDER SECTION

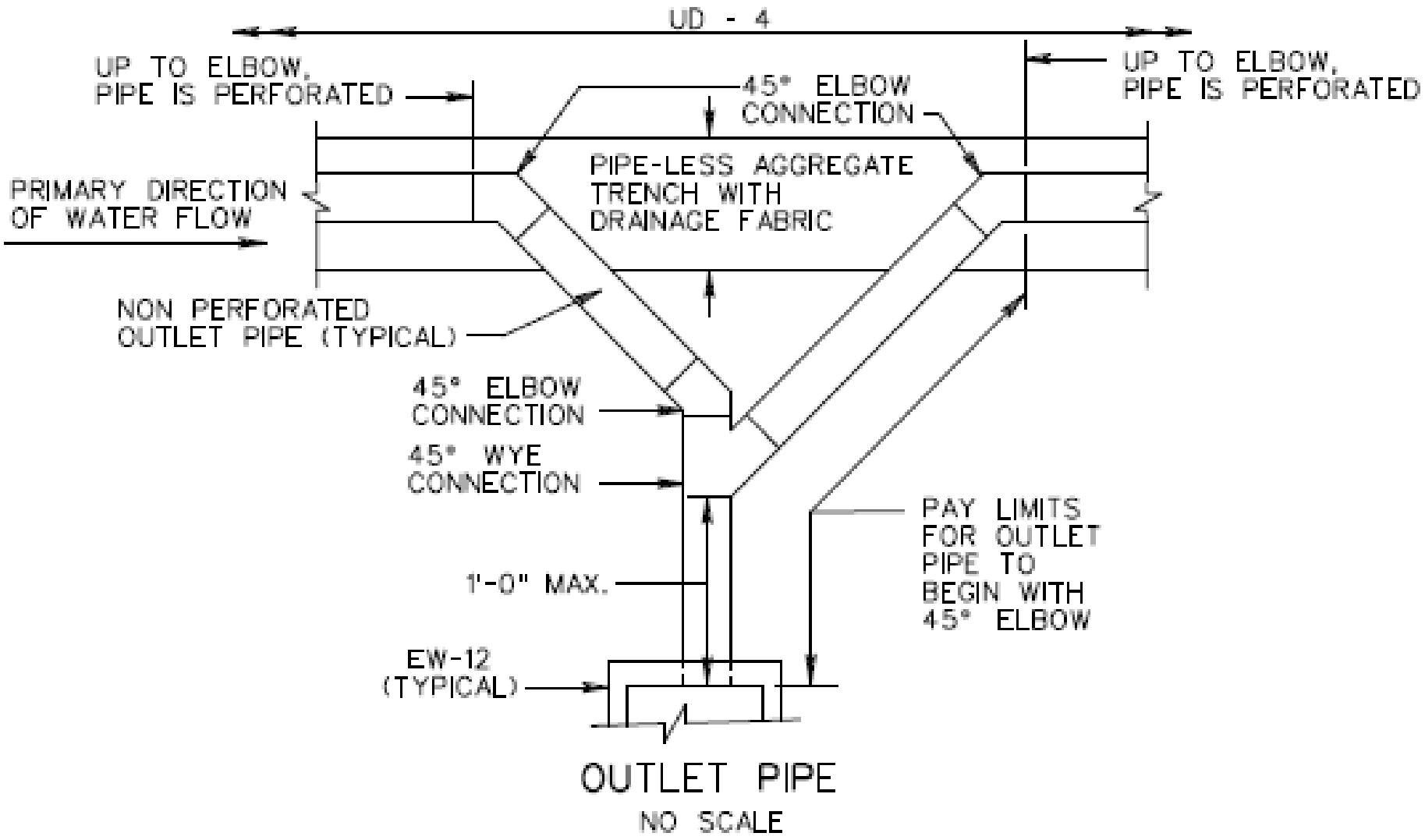
UD-5 Cover Details



UD-7 Retrofit Pavement Edgedrain



Outlet for Segmented Drainage System to Facilitate Inspection



Transporting Endwalls

2:1 Slope Endwall for UD 4, 5& 7 With Min. 6” Freeboard

4:1 slope Endwall for UD-4,5 &7 with Min 6” freeboard

Typical Spacing between Outlets (300 ft)

Water Flowing from Outlet Pipe at Endwall

Water Flowing from Cross Drains

Conclusions

1. Subsurface drainage considerations should start in the early stages of the project.
2. Cooperative effort between the road design, geotechnical, hydraulics, and pavement design personnel is essential.
3. The highway geometric, presence of ground water, and potential of water entry from the top of the pavement are interacting factors and should be considered collectively.

Conclusions

4. Longitudinal slope, cross-slope, and the permeability of the pavement materials should be constructed with effective drainage in mind.
5. Effective drain should be able to intercept, collect, and discharge water.
6. Quality construction and proper materials selection of the subsurface drainage system are essential to obtaining effective drainage system.
7. Use of proper tool to design pavement drainage such as DRIP software can provide an effective and economical approach.
8. Maintenance of subsurface drainage systems prolongs the effectiveness of the system.

References

1. Road Research Laboratory, Soil Mechanics for Road Engineers, Her Majesty's Stationary Office, London, England, 1955
2. US Department of Transportation, FHWA, Report NO. FHWA-Ts-80-224 " Highway Subdrainage Design", 1982
3. Cedergren, H.R. "Drainage of Highway and Airfield Pavements" John Wiley and sons, Inc. New York, 1974
4. VDOT "Road and Bridge Standards" Volume I, Richmond, Virginia, 2015

Thank You

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TRB Emeritus Member

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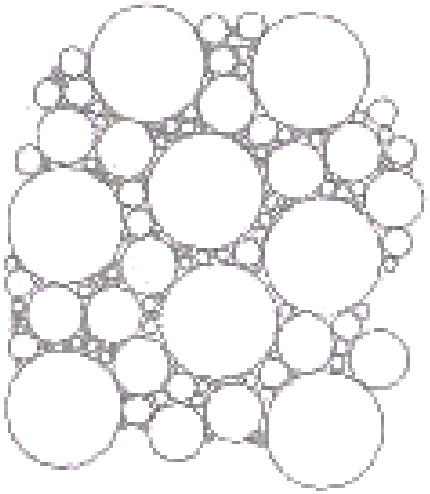
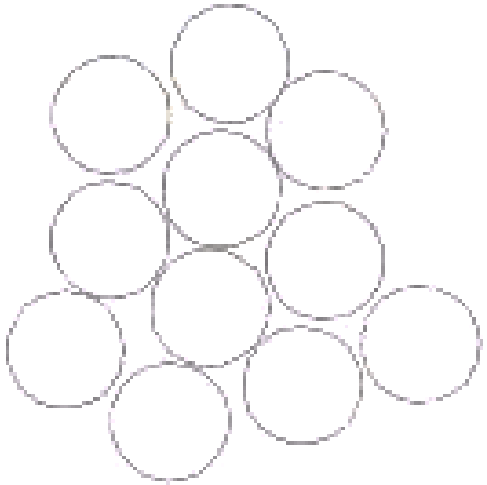
Designing Pavement Subsurface Drainage Using DRIP Software



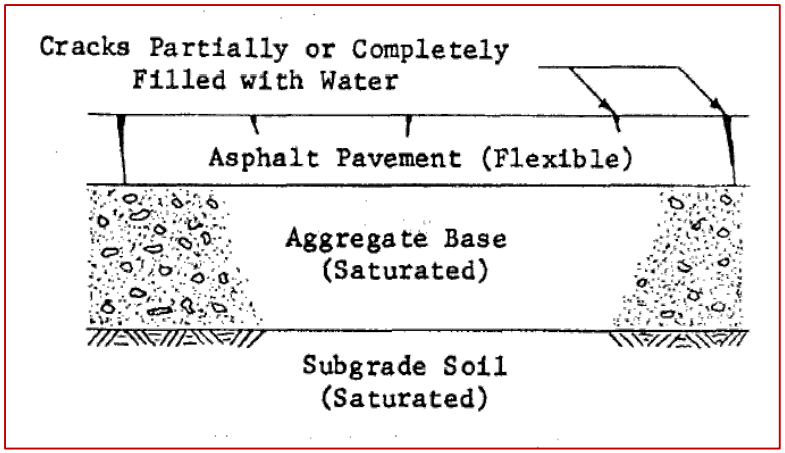


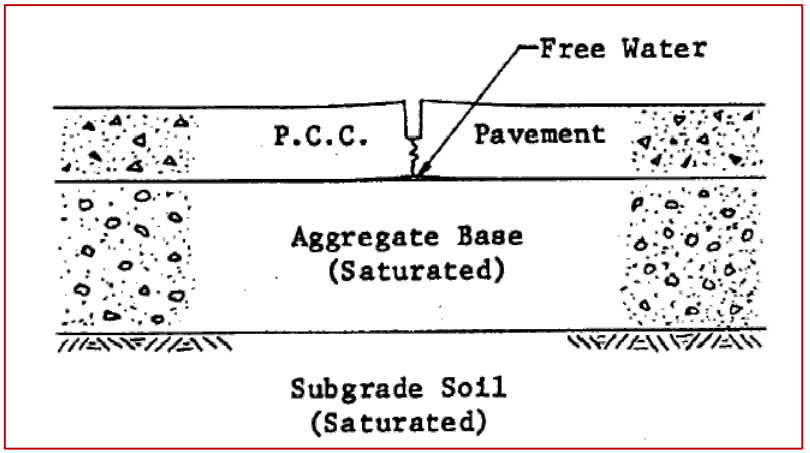
TRB Webinar

DRIP Capabilities

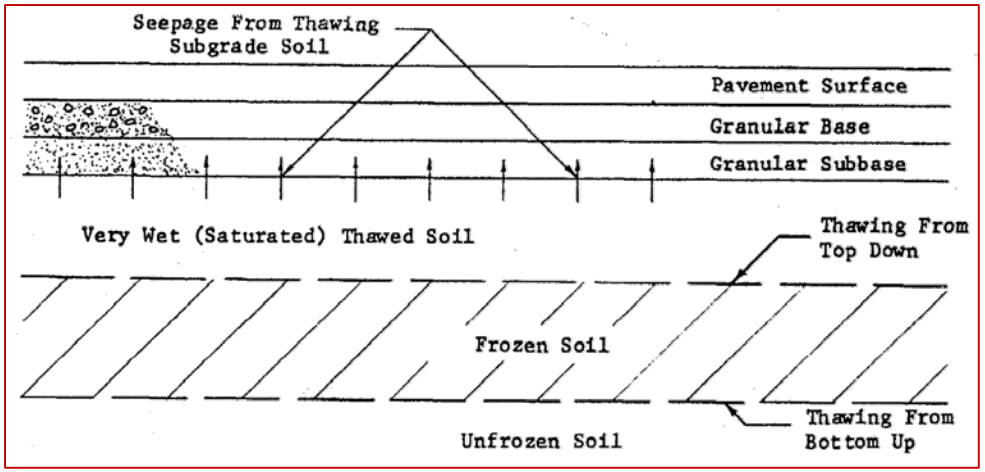
1. Moisture Infiltrating Pavement Structure

   a) Rainfall





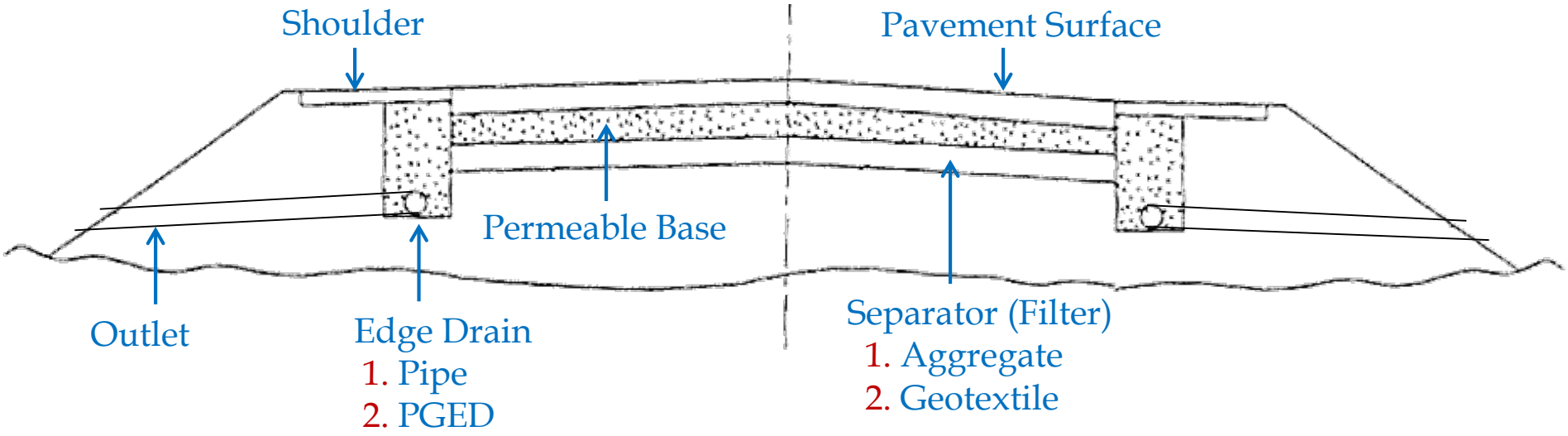
   b) Meltwater



Source: Moulton

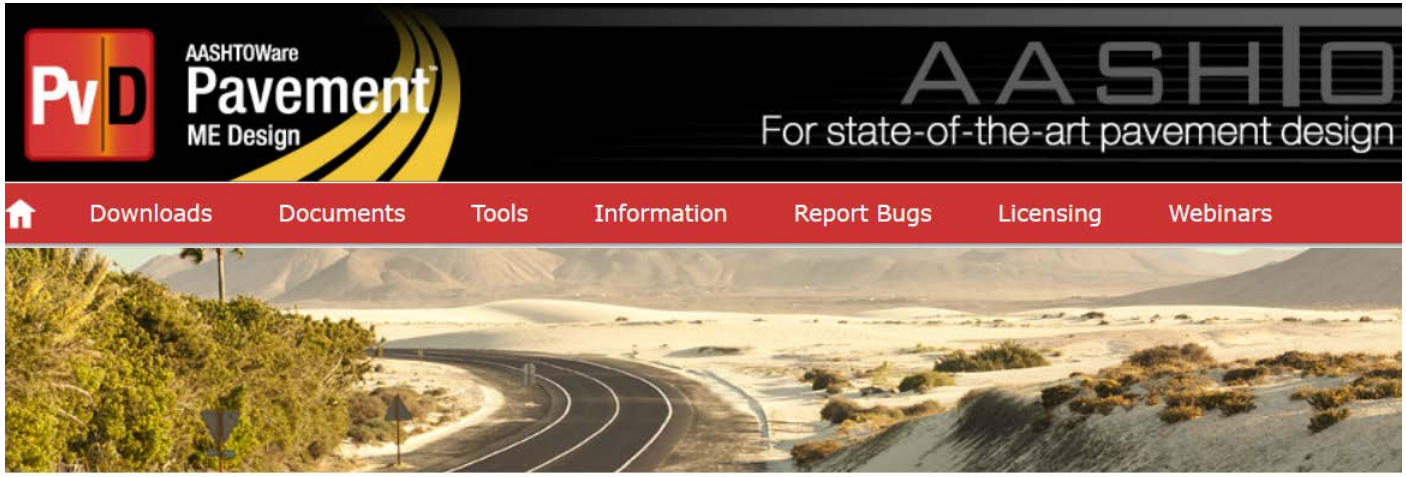
DRIP Capabilities

2. Permeable Base
3. Edge Drain
   - Outlets
4. Separator



DRIP Software

- **Drainage Requirement In Pavements (DRIP)**
  - www.me-design.com/MEDesign/DRIP.html



Drainage Requirement In Pavements (DRIP)

Version 2.0 now available to download![10/27/2014]

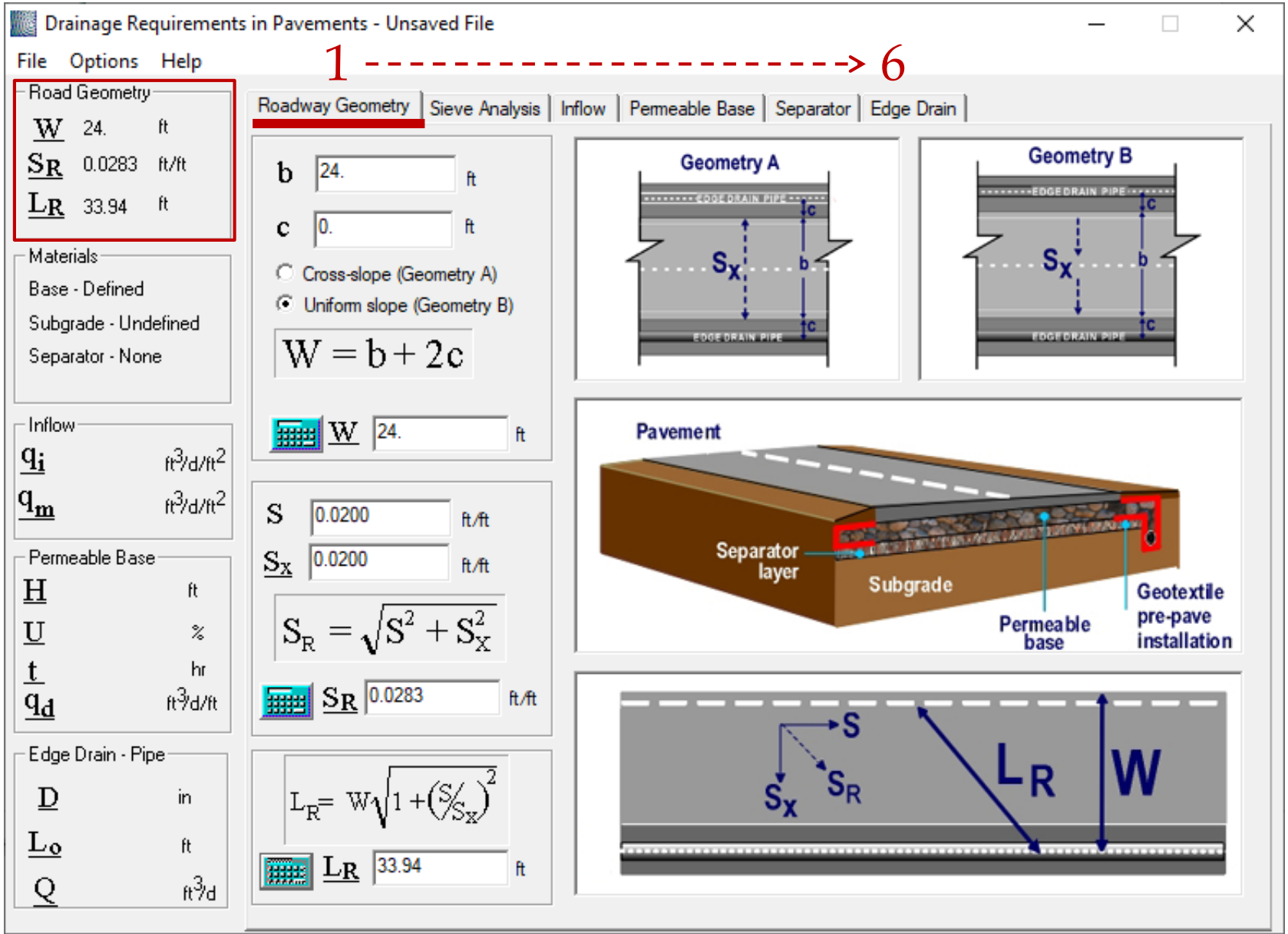
DRIP Microcomputer Program User's Guide (PDF) [10/24/2014]

DRIP is a Windows base microcomputer program, created by the Federal Highway Administration and Applied Research Associates, to perform hydraulic design computations for the subsurface drainage analysis of pavements. Features of DRIP include Roadway Geometry Calculations, Sieve Analysis Calculations, Inflow Calculations, Permeable Base Design, Separator Layer Design, and Edgedrain Design. Graphing of grain size distributions and sensitivity analysis plot provide engineers with a visual picture to aid in decision making.

DISCLAIMER

The DRIP software is provided *as is* and the user of the software assumes all responsibilities for its use and associated results.

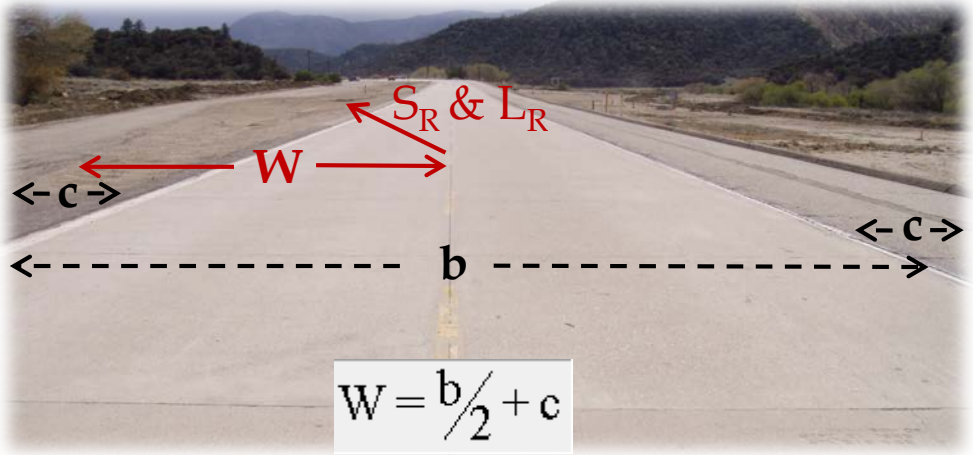
1. Road Geometry



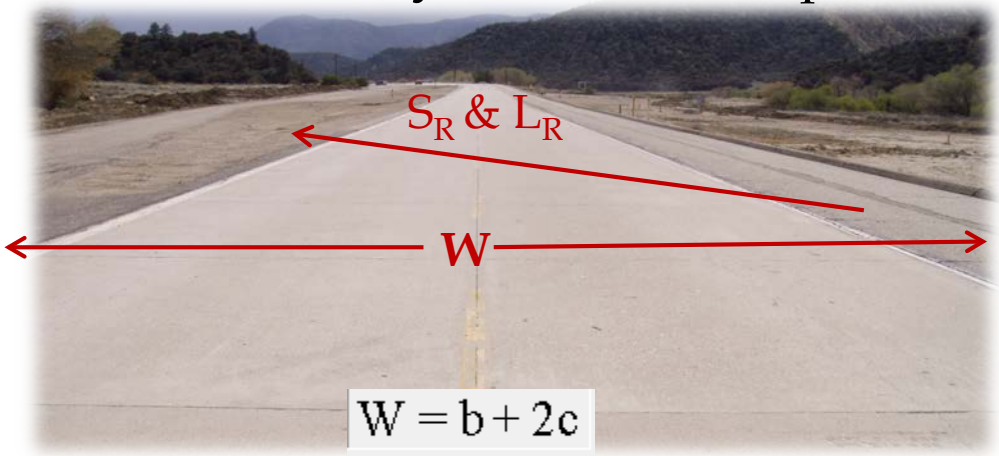
Road Geometry

- Drainage Path
  - Width W
  - Slope S_R
  - Length L_R

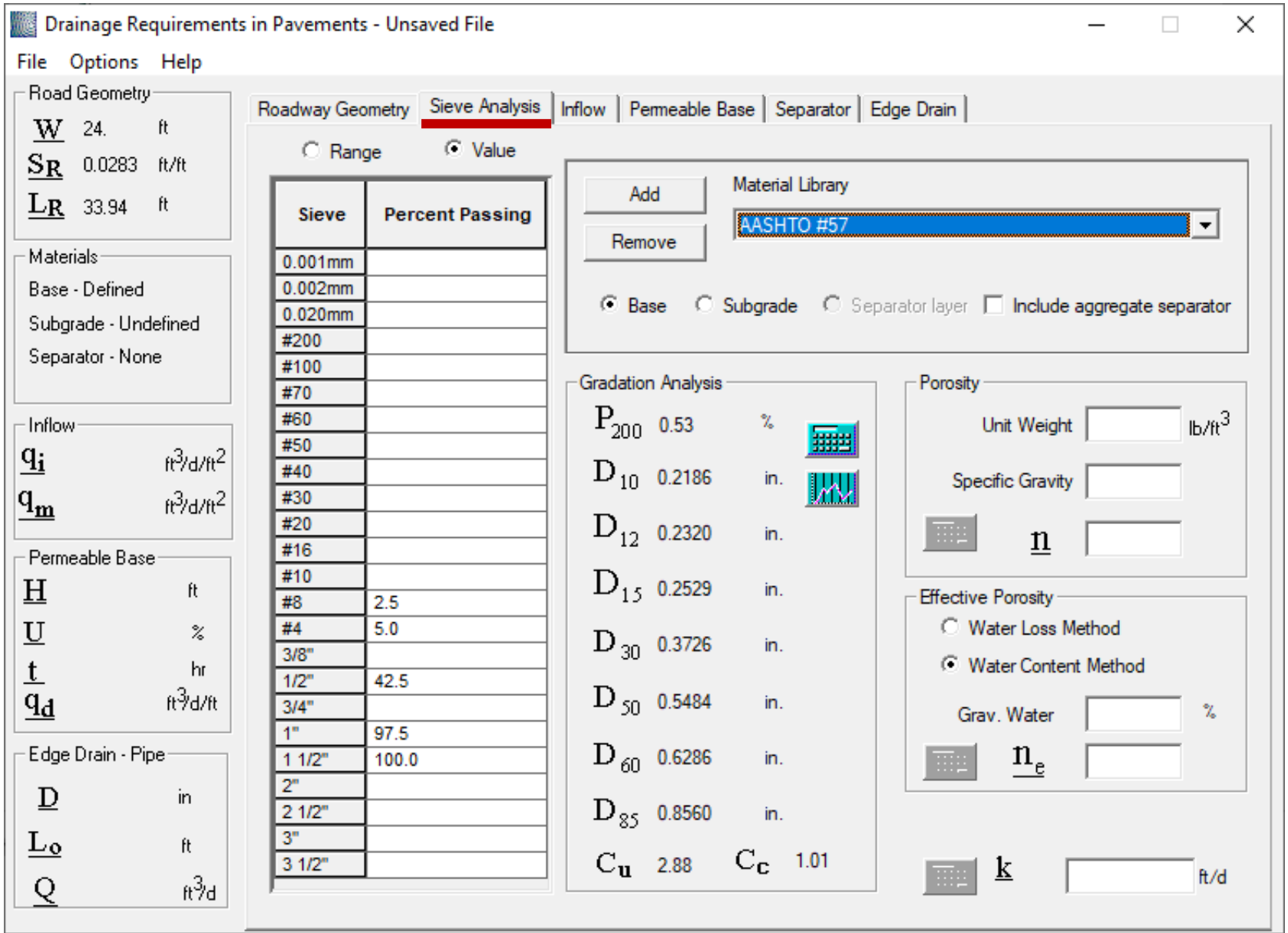
Geometry A: Crowned



Geometry B: Uniform slope

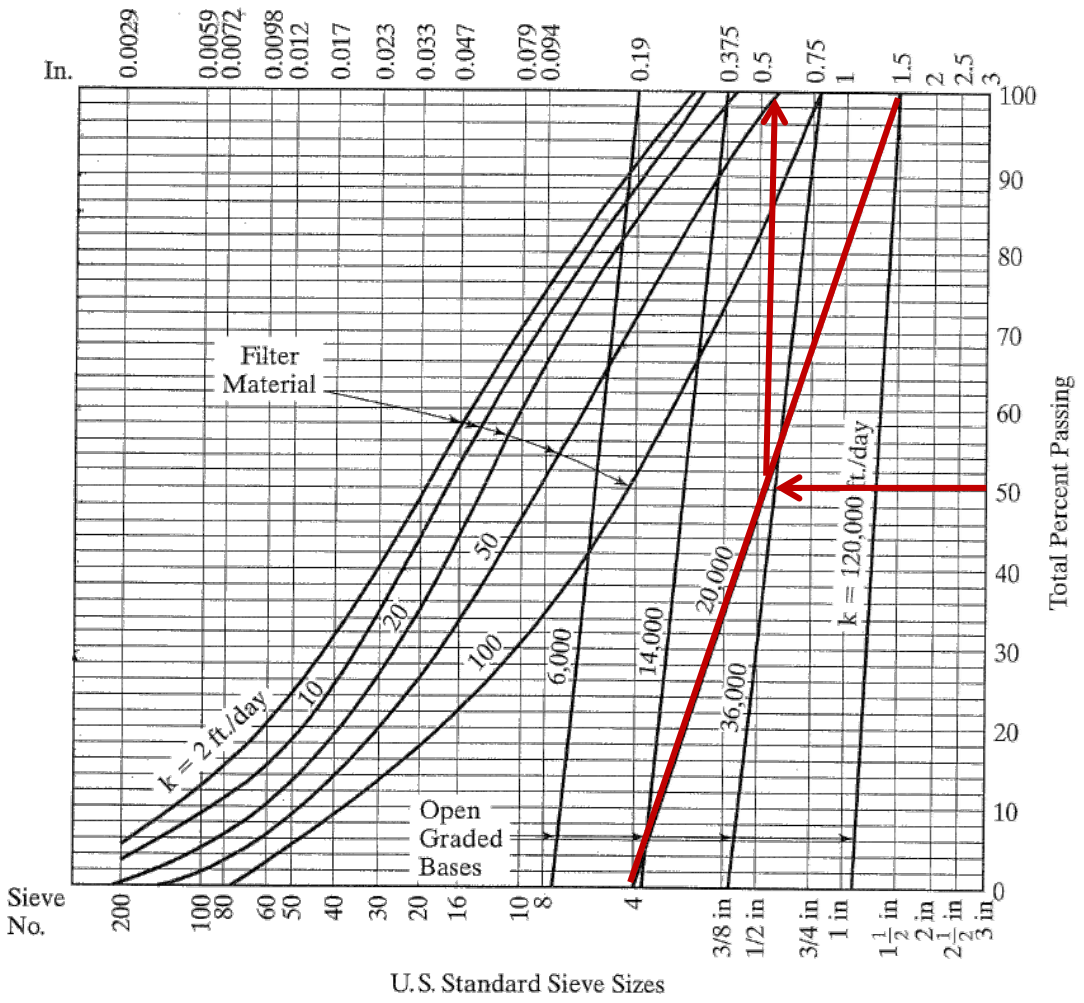


2. Sieve Analysis



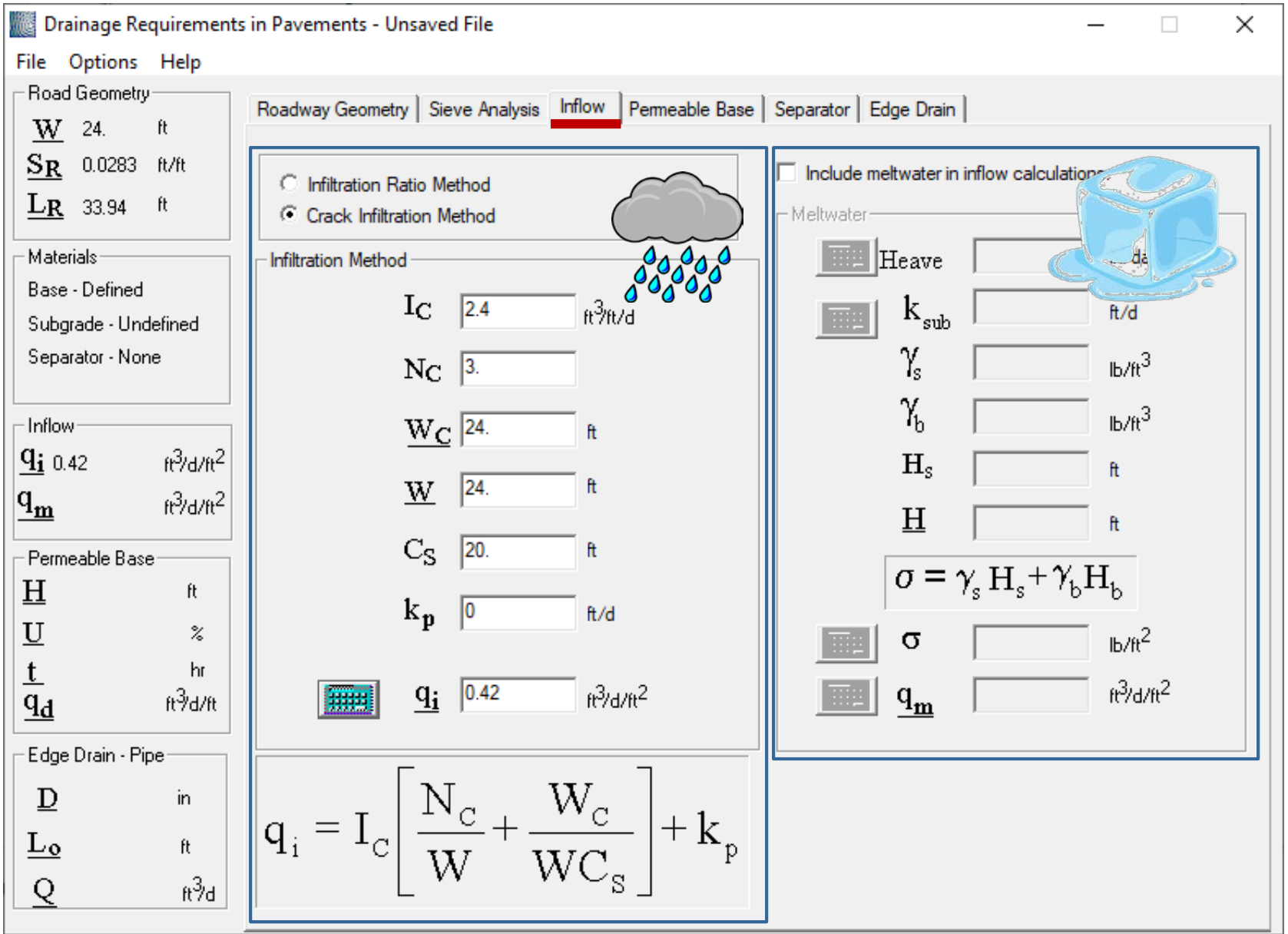
Effective Size D

- D_X = Effective size or grain size corresponding to X% passing



D_{50}

3. Inflow


Drainage Requirements in Pavements - Unsaved File
File Options Help
Road Geometry
W 24. ft
SR 0.0283 ft/ft
LR 33.94 ft
Materials
Base - Defined
Subgrade - Undefined
Separator - None
Inflow
qi 0.42 ft3/d/ft2
qm ft3/d/ft2
Permeable Base
H ft
U %
t hr
qd ft3/d/ft
Edge Drain - Pipe
D in
Lo ft
Q ft3/d
Roadway Geometry
Sieve Analysis
Inflow
Permeable Base
Separator
Edge Drain
Infiltration Ratio Method
Crack Infiltration Method
Infiltration Method
IC 2.4 ft3/ft/d
NC 3.
WC 24. ft
W 24. ft
CS 20. ft
kp 0 ft/d
qi 0.42 ft3/d/ft2
Include meltwater in inflow calculations
Meltwater
Heave
ksub ft/d
γs lb/ft3
γb lb/ft3
Hs ft
H ft
σ = γs Hs + γb Hb
σ lb/ft2
qm ft3/d/ft2
qi = IC [NC/W + WC/WCS] + kp

Surface Infiltration

- Surface infiltration of rain and melt water through (1) joints, (2) cracks & (3) shoulder edges

1. Infiltration Ratio
   - Cedergren et al., 1973
   - Infiltration ratio and rainfall rate
   - Highly empirical

2. **Crack Infiltration**
   - Ridgeway, 1976
   - Based on field measurements
   - Directly related to cracking
     - Rate = 2.4 ft^3/day/ft of crack

Recommended

Crack Infiltration Method

- q_i = Rate of pavement infiltration ($ft^3/day/ft^2$)

$$q_i = \frac{I_c}{W}\left[N_c + \frac{W_c}{C_s}\right] + k_p$$

$k_p = 0$

Surface joints/cracking

- I_c = Crack infiltration rate
  - ★ 2.4 $ft^3/day/ft$ (0.223 $m^3/day/m$)
- W = Width of drainage path

Rigid Pavement

Longitudinal Joints/Cracks

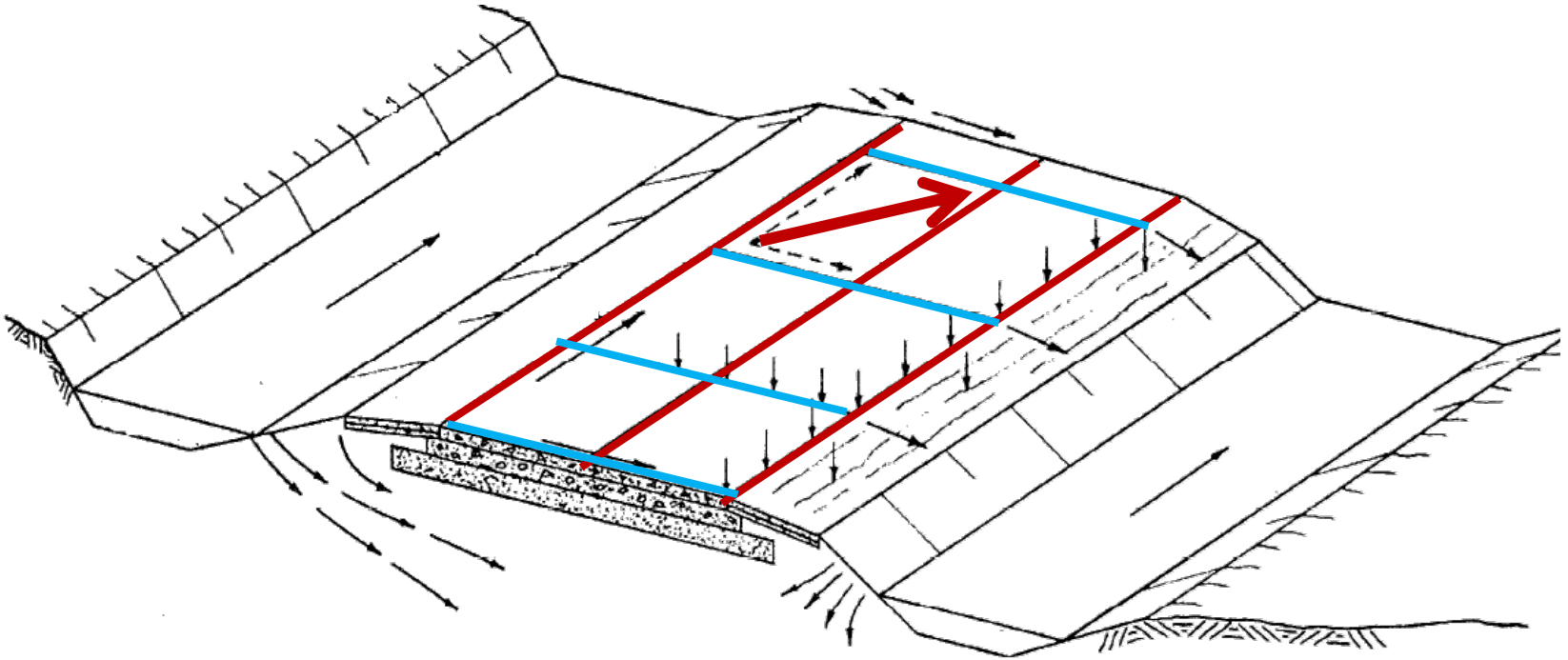
- N_c = Number

Transverse Joints/Cracks (contributing)

- W_c = Length
- C_s = Spacing

$$q_i = \frac{I_c}{W}\left[N_c + \frac{W_c}{C_s}\right] + k_p$$

Surface joints/cracking

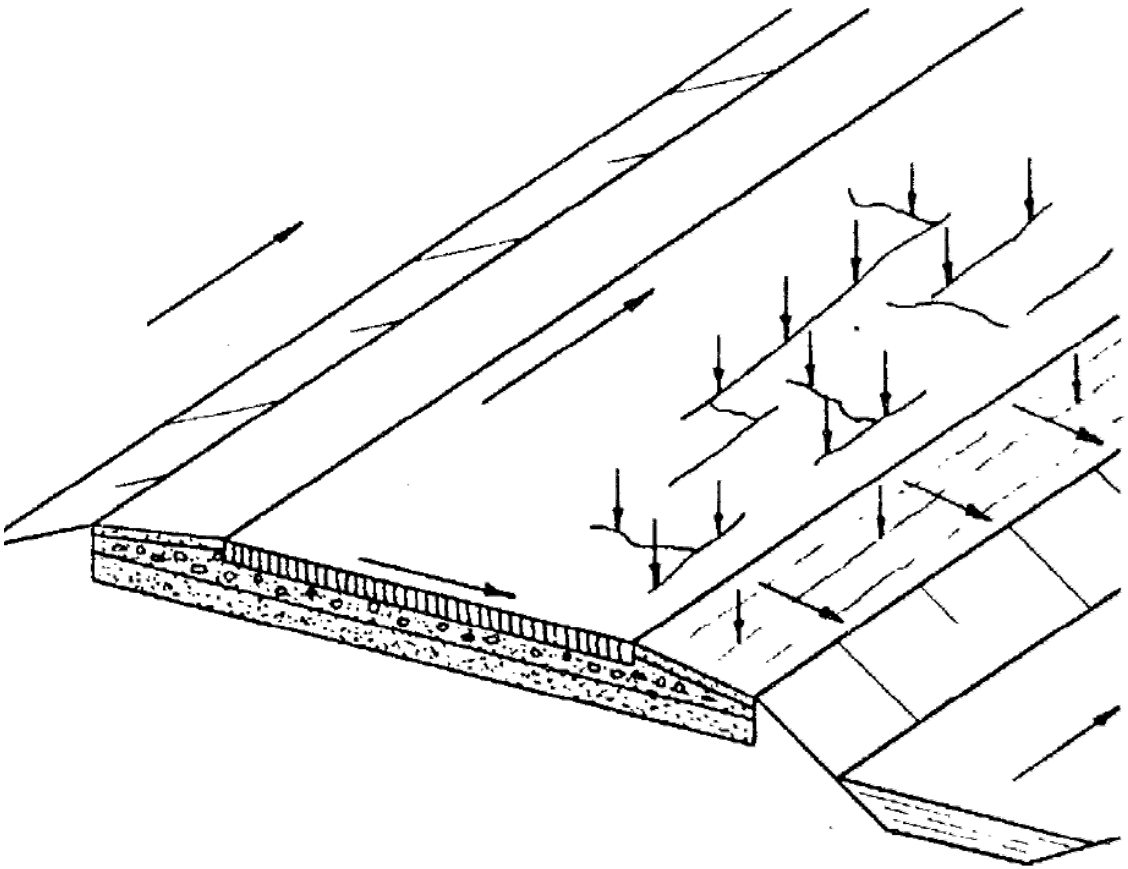


Flexible Pavement

- PMS
  - ★ Typical section

$$q_i = \frac{I_c}{W}\left[N_c + \frac{W_c}{C_s}\right] + k_p$$

Surface joints/cracking



4. Permeable Base

Drainage Requirements in Pavements - Unsaved File

File Options Help

Road Geometry

W	24.	ft
S_R	0.0283	ft/ft
L_R	33.94	ft

Materials

Base - Defined

Subgrade - Undefined

Separator - None

Inflow

q_i	0.42	$ft^3/d/ft^2$
q_m		$ft^3/d/ft^2$

Permeable Base

H	0.3333	ft
U		%
t		hr
q_d	44.811	$ft^3/d/ft$

Edge Drain - Pipe

D	in
L_o	ft
Q	ft^3/d

Roadway Geometry | Sieve Analysis | Inflow | Permeable Base | Separator | Edge Drain

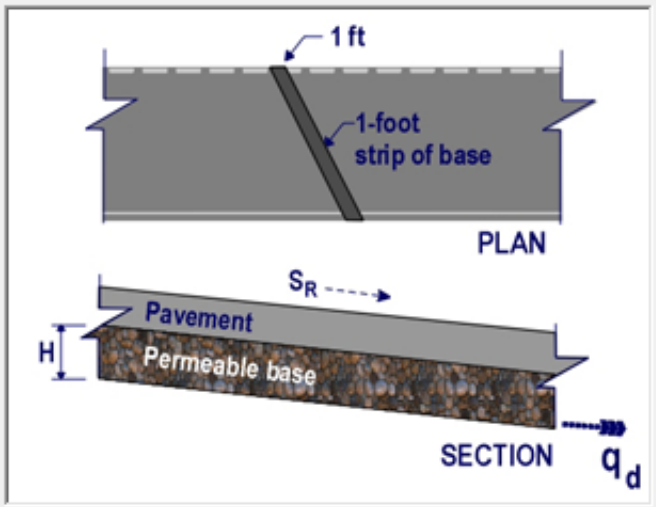
Analysis Type

- ○ Time-to-Drain
- ◉ Depth-of-flow

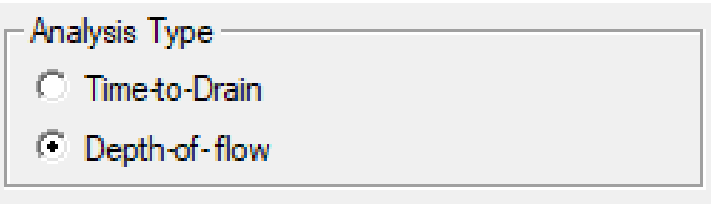
q_i	0.42	$ft^3/d/ft^2$
k	3000.	ft/d
S_R	0.0283	ft/ft
L_R	33.94	ft

The minimum required value of H is determined using Moulton's design chart. (FHWA-TS-80-224).

H_{min}	0.13058	ft
H	0.3333	ft
q_d	44.811	$ft^3/d/ft$



Permeable Base Analysis



1. Time to Drain
   - ★ From saturation to:
     - ➢ 50% drained (*AASHTO*) Conservative
     - ➢ 85% saturation (*Pavement Rehabilitation Manual*)
   - ★ Time Calculation
     - ➢ Casagrande and Shannon (1952)
     - ➢ Barber and Sawyer (1952)

AASHTO

Quality of Drainage	Time to Drain
Excellent	2 hours
Good	1 day
Fair	7 days
Poor	1 month
Very Poor	Does not drain

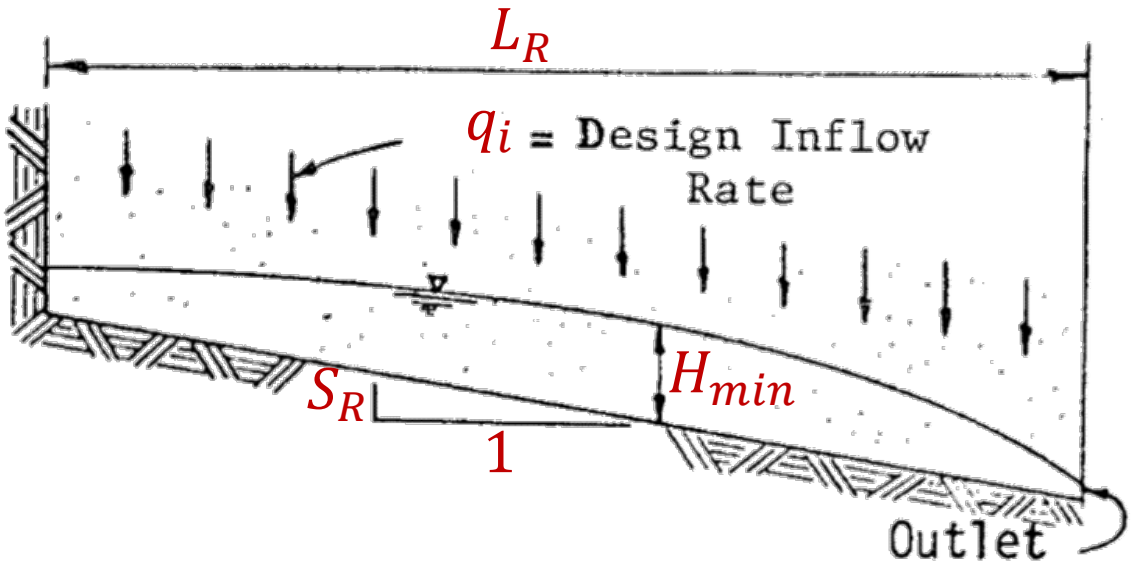
2. Depth of Flow
   - ★ Moulton, 1979
   - ★ Permeable base thickness ≥ Depth of flow

Permeable Base Analysis

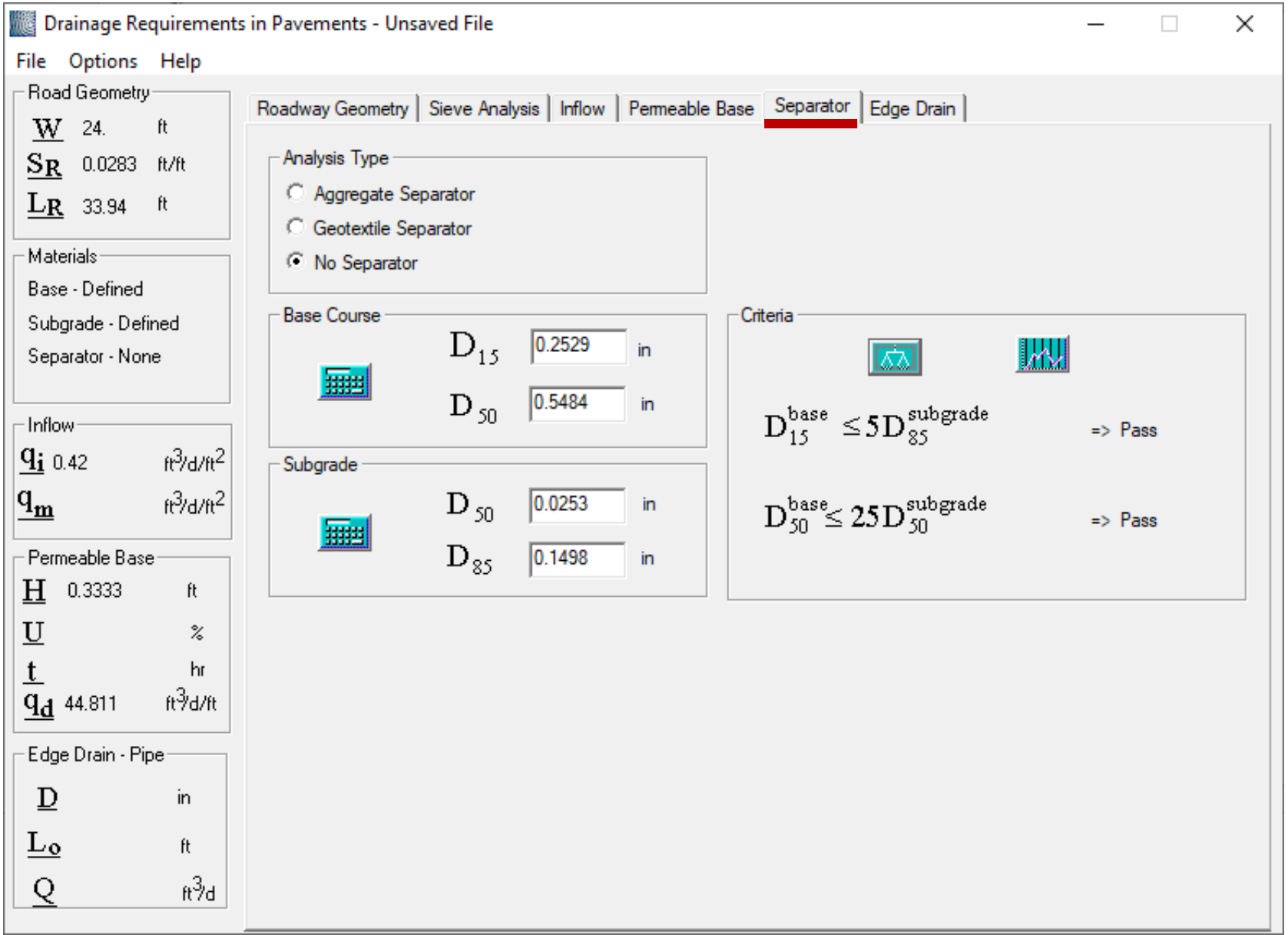
2. Depth of Flow

- ★ Inflow (q_i)
- ★ Permeability (k)
- ★ Slope (S_R)
- ★ Length of drainage (L_R)

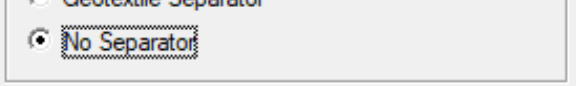
Permeable base thickness ≥ H_{min}



5. Separator


Drainage Requirements in Pavements - Unsaved File
File
Options
Help
Road Geometry
W 24. ft
SR 0.0283 ft/ft
LR 33.94 ft
Materials
Base - Defined
Subgrade - Defined
Separator - None
Inflow
qi 0.42 ft3/d/ft2
qm ft3/d/ft2
Permeable Base
H 0.3333 ft
U %
t hr
qd 44.811 ft3/d/ft
Edge Drain - Pipe
D in
Lo ft
Q ft3/d
Roadway Geometry
Sieve Analysis
Inflow
Permeable Base
Separator
Edge Drain
Analysis Type
Aggregate Separator
Geotextile Separator
No Separator
Base Course
D15 0.2529 in
D50 0.5484 in
Subgrade
D50 0.0253 in
D85 0.1498 in
Criteria
D15base ≤ 5D85subgrade => Pass
D50base ≤ 25D50subgrade => Pass

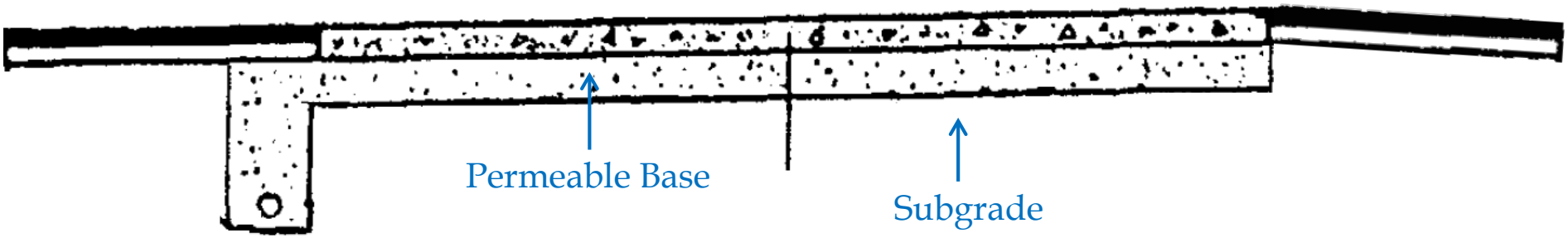
Separator



No Separator

$$D_{15}^{base} \leq 5 D_{85}^{subgrade}$$ Clogging

$$D_{50}^{base} \leq 25 D_{50}^{subgrade}$$ Parallel arrangement



Separator

Analysis Type
- (•) Aggregate Separator
- ( ) Geotextile Separator
- ( ) No Separator

Aggregate Separator

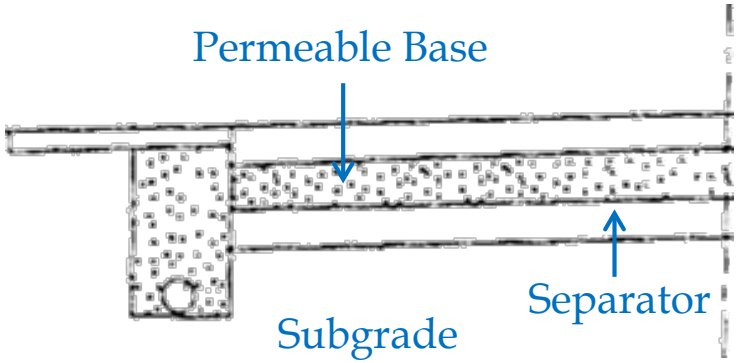
$D_{15}^{base} \leq 5 D_{85}^{separator}$ Clogging

$D_{50}^{base} \leq 25 D_{50}^{separator}$ Parallel arrangement

$D_{15}^{separator} \leq 5 D_{85}^{subgrade}$ Clogging

$D_{50}^{separator} \leq 25 D_{50}^{subgrade}$ Parallel arrangement

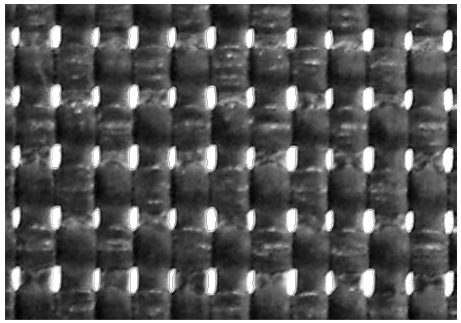
$D_{12}^{separator} \geq \#200$ Passing No. 200



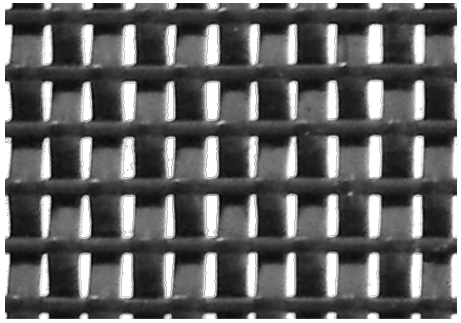
Separator

- Geotextile
  - Retention or pumping resistance
  - Permeability
  - Clogging

AOS = Apparent opening size
- ASTM D4751
- Defined as size of glass beads when 5% pass through the geotextile



70 AOS / 4-6 Percent Open Area



30-40 AOS / 12-15 Percent Open Area

6. Edge Drain

Drainage Requirements in Pavements - Unsaved File

File Options Help

Road Geometry
- W 24. ft
- S_R 0.0283 ft/ft
- L_R 33.94 ft

Materials
- Base - Defined
- Subgrade - Defined
- Separator - None

Inflow
- q_i 0.42 $ft^3/d/ft^2$
- q_m $ft^3/d/ft^2$

Permeable Base
- H 0.3333 ft
- U %
- t hr
- q_d 44.811 $ft^3/d/ft$

Edge Drain - Pipe
- D 4. in
- L_o 281.0 ft
- Q 12593.7 ft^3/d

Roadway Geometry | Sieve Analysis | Inflow | Permeable Base | Separator | Edge Drain

Edge Drain Type
- ○ Geocomposite
- ◉ Pipe

S 0.0200 ft/ft $n_{manning}$ 0.024

D 4. in

$$Q = \frac{\pi K S^{1/2} D^{8/3}}{4^{5/3} n} \quad \text{where } K = 1\frac{m^{1/3}}{s}$$

Discharge Rate Approach
- ○ Pavement Infiltration
- ◉ Permeable Base
- ○ Time To Drain

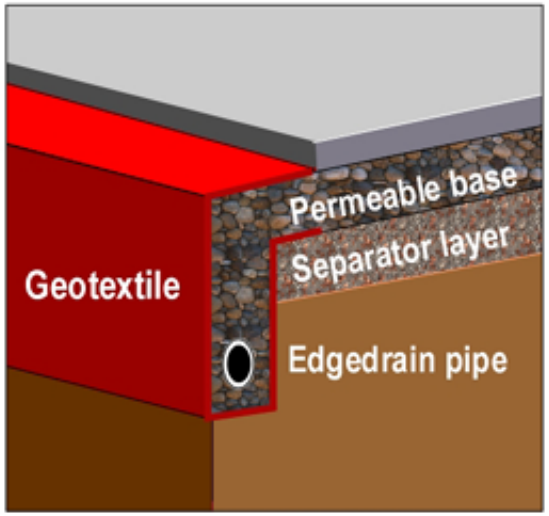
$$L_o = \frac{Q}{q_d}$$

q_d 44.811 $ft^3/d/ft$

Q 12593.7 ft^3/d

L_o 281.0 ft

Typical roughness coefficients for underdrain.
- ☐ Smooth Pipe (n=0.012)
- ☑ Corrugated Pipe (n = 0.024)



Edgedrains Design

- Edgedrains can be designed for:

1. Pavement infiltration flow rate

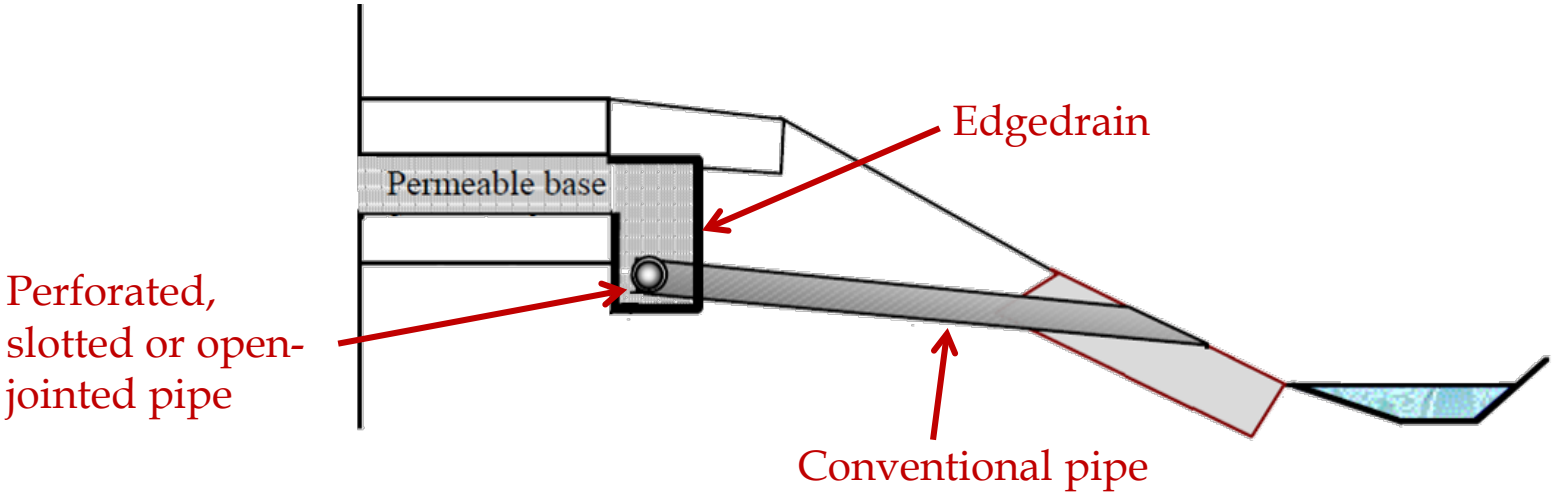
2. Peak flow from the permeable base
   - q_d
     - H, S and k

Capacity of edgedrain ≥ Peak capacity of permeable base

3. Average flow rate during the time to drain the permeable base

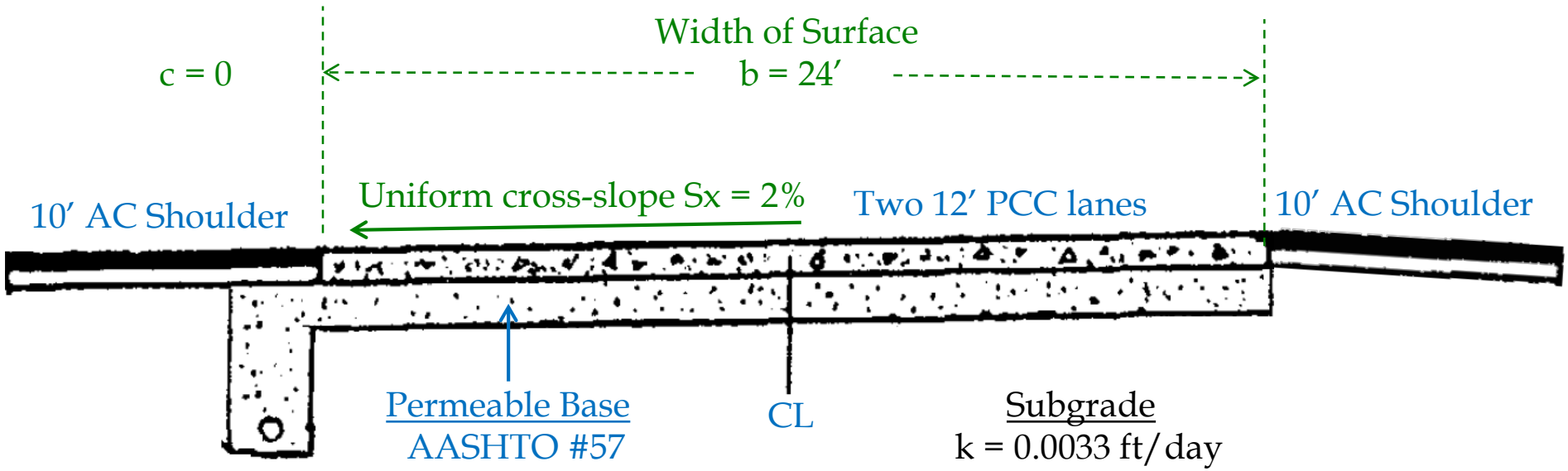
Edge Drains Design

- Maximum spacing of outlets
  - ★ 250 to 300 ft (75 to 100 m)
- Minimum pipe diameter
  - ★ 4 in. (100 mm)



Example 1

Longitudinal slope S = 2%



Sieve No.	Percent Passing
#4	92
#10	67
#20	55
#50	42
#200	31

$$q_i = \frac{I_c}{W}\left[N_c + \frac{W_c}{C_s}\right] + k_p$$

I_c: 2.4 ↓ — W: 24 ↑ — N_c: 3 ↓ — W_c: 24 ↓ — C_s: 20 ↑ — k_p: 0 ↓

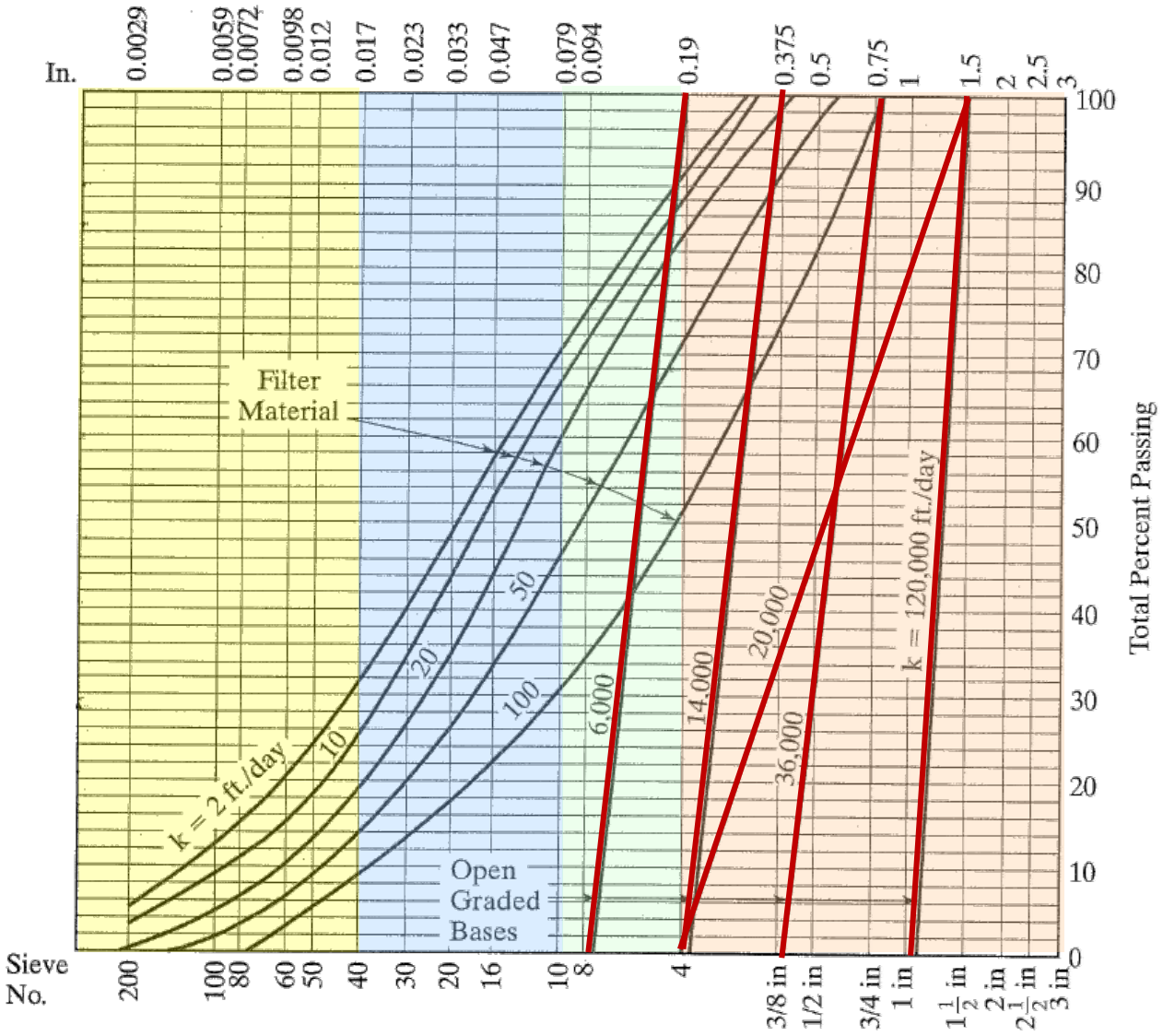
Typical Open-Graded Bases and Filter Materials

Fine Sand

Medium Sand

Coarse Sand

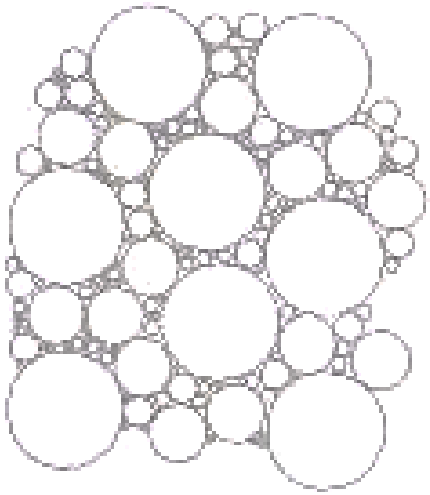
Gravel



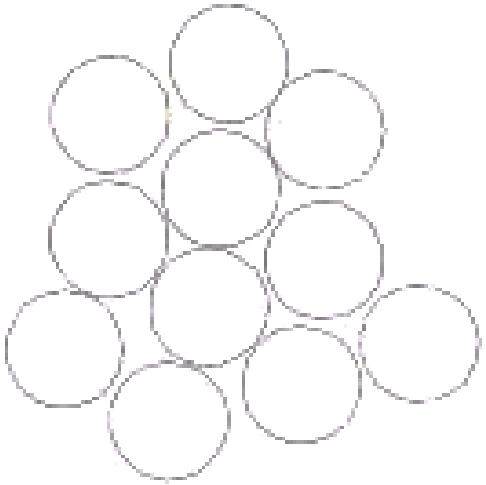
Source: Moulton

Dense vs. Open-Gradation

- Dense gradation
  - Coarse to fine aggregate
  - Stable material
  - Poor permeability



- Open-graded bases
  - No fines
  - Good permeability
  - Less stability



Effect of Stabilization on Permeability

- Open-graded bases
  - Less stability compensated by stabilizing drainage layer
    - Small amount of asphalt binder or Portland cement

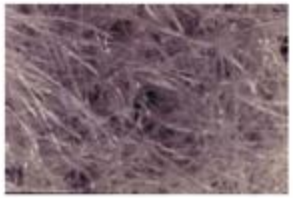
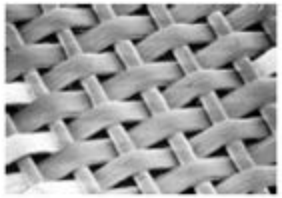
Aggregate size	Permeability (ft/day)	
	Untreated	Treated with 2% asphalt
$1\frac{1}{2}$ to 1 in.	140,000	120,000
$\frac{3}{4}$ to $\frac{3}{8}$ in.	38,000	35,000
No. 4 to No. 8	8000	6000

Source: Lovering and Cedergren (1962)

Example 2

- Same input as example 1 with the following exceptions
  - ★ Woven geotextile as separator
  - ★ Hydraway geocomposite edgedrain

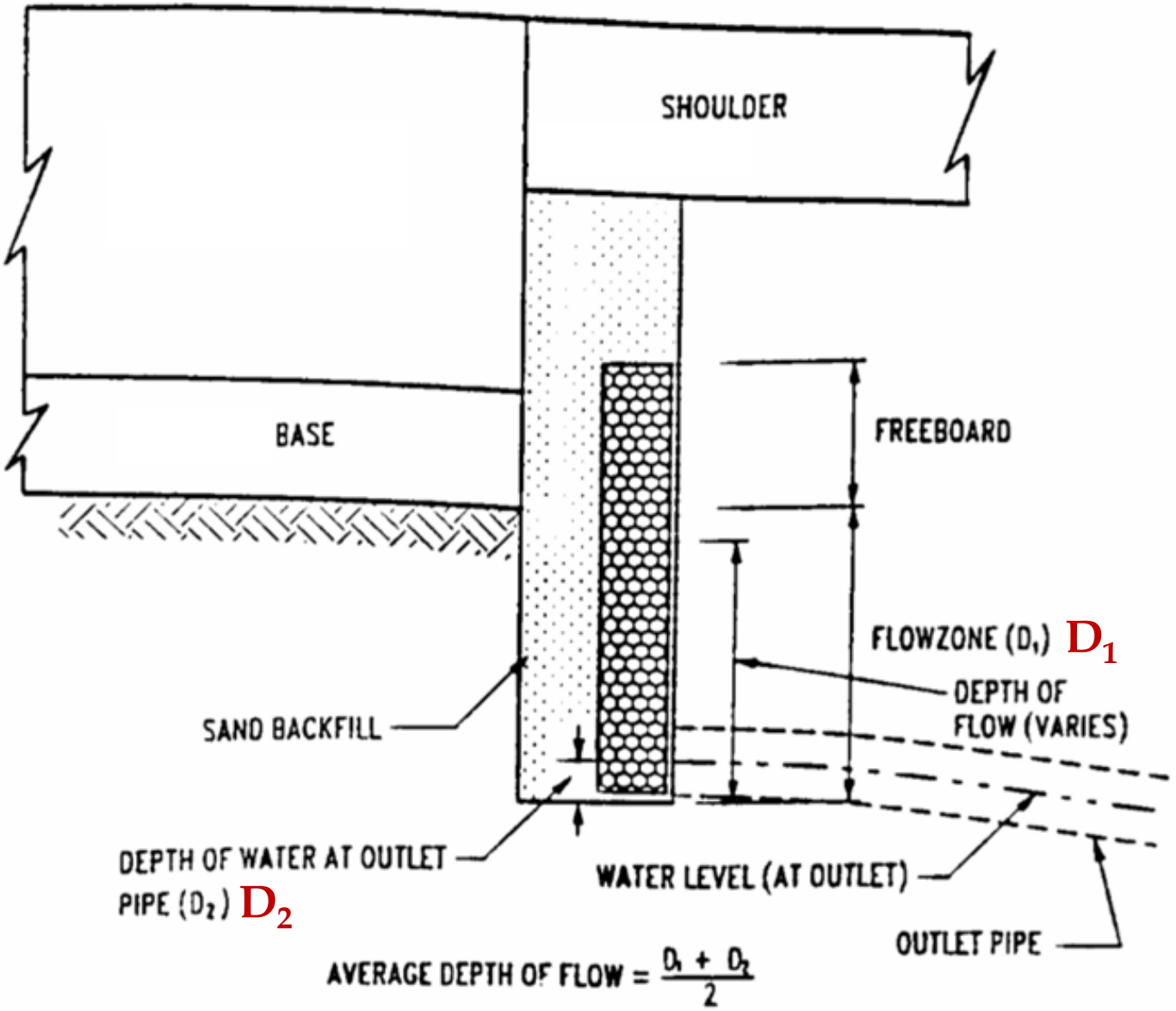
Nonwoven vs. Woven

1. Calculate the time to drain of the permeable base
2. Design the geotextile separator layer
3. Calculate the outlet spacing for the geocomposite edgedrain

Fin-Drain

Source: DRIP User's Guide



References

- FHWA-TS-80-224 Highway Subdrainage Design; August 1980
  - Lyle K. Moulton, PhD, PE
  - https://www.fhwa.dot.gov/pavement/pubs/009633.pdf
- Pavement Analysis and Design, 2nd Edition, Yang H. Huang, ISBN-13: 978-0131424739/ISBN-10: 0131424734 – Chapter 8.
- NCHRP, Guide for Mechanistic-Empirical Design; Part 3 - Design Analysis; Chapter 1 – Drainage.
  - http://onlinepubs.trb.org/onlinepubs/archive/mepdg/Part3_Chapter1_Subdrainage.pdf
- FHWA-SA-92-008 Demonstration Project 87 Drainable Pavement Systems; March 1992

Practical Design and Maintenance of Pavement Drainage Systems

CLARK GRAVES, PE, PG, PHD.

ASSOCIATE DIRECTOR, KENTUCKY TRANSPORTATION CENTER

Background

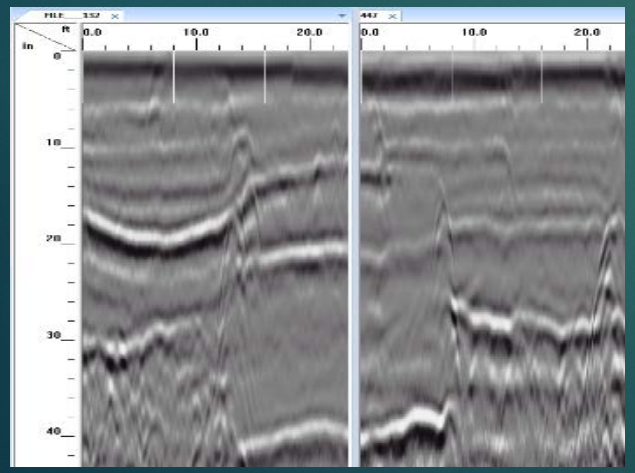
- Drainage systems with edge drains 1990's
- Early work with panel drains, pipe systems
- Many design changes early
- Standardized design for the last 20 years or so
- Construction inspection is generally routine.
- Maintenance is still a concern

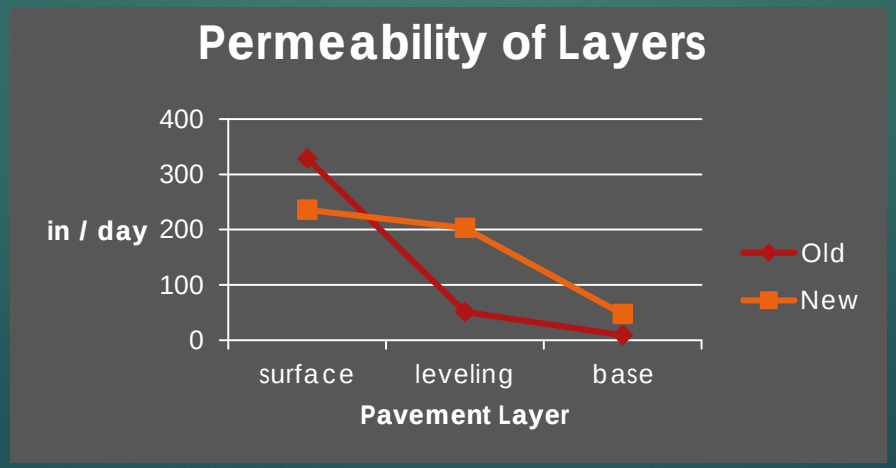
Type of Designs

- New Construction
  - Positive drainage layer
  - Daylighted
  - Positive pipe system with outlets
  - Closed System
- Rehabilitation/Widening
  - Permeability of new surfaces and layers
  - Adjacent pavement sections

Design Issues to Consider

- Different permeability between new and existing materials
- Drainage layer grade
- Depth of drains/outlets
- Is there an adequate flow path?
- We have standard design details, but not all designs are standard (DRIP)



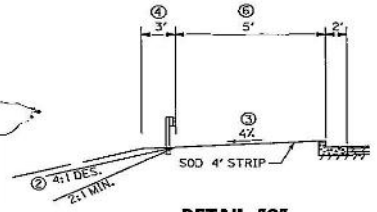


Case Study #1

APPROVED FOR CONSTRUCTION (10/9/2007)

COUNTY OF	ITEM NO.	SHEET NO.
TAYLOR	4-114.00	R2D

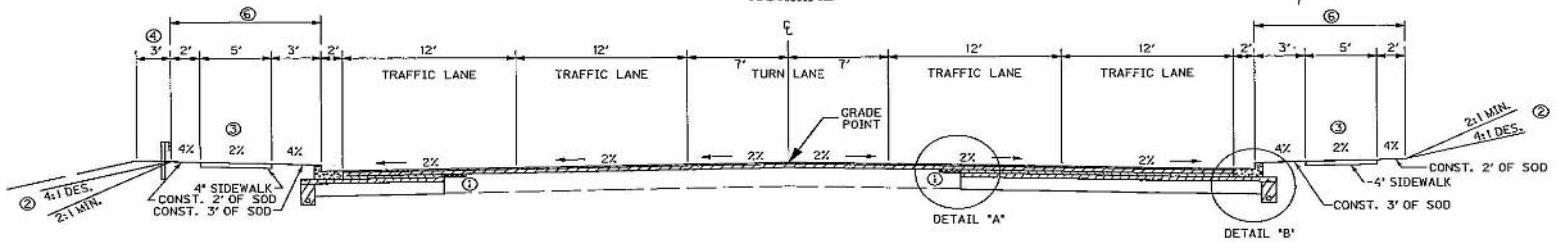
TYPICAL SECTIONS



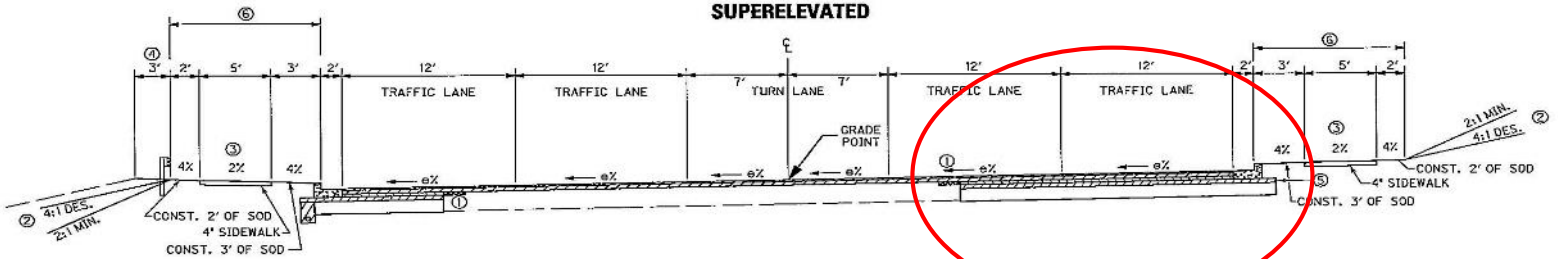
DETAIL "C"

MAINLINE FROM KY 3183 (OLD HODGENVILLE RD.) TO US 68 STA. 354+62.69 TO STA.420+41.45

NORMAL

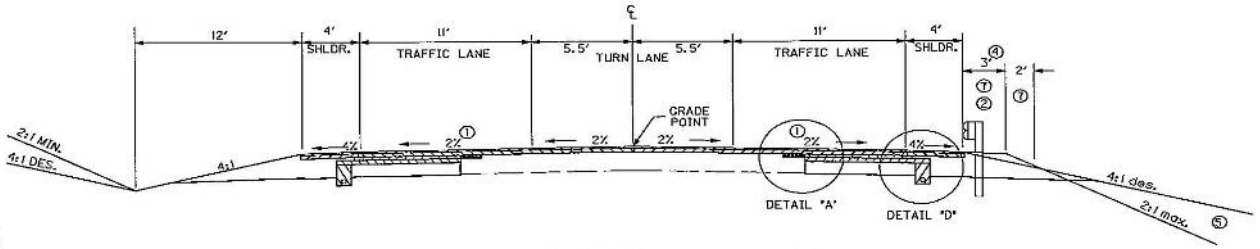


SUPERELEVATED



MAINLINE FROM BEGINNING AT KY 210 TO OLD HODGENVILLE RD (KY 3183) STA. 354+62.69 TO STA.356+00.19

NORMAL

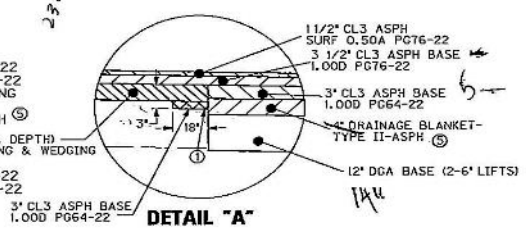


PAVEMENT SCHEDULE (OVERLAY)

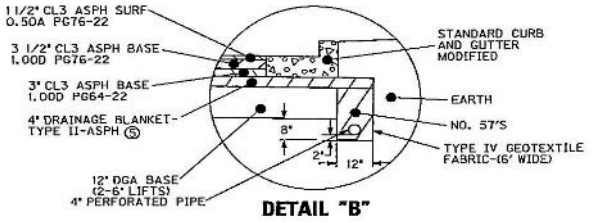
TRAFFIC LANE	1 1/2" CL3 ASPH SURF 0.50A PG76-22 3 1/2" CL3 ASPH BASE 1.00D PG76-22 LEVELING AND WEDGING

PAVEMENT SCHEDULE (NORMAL)

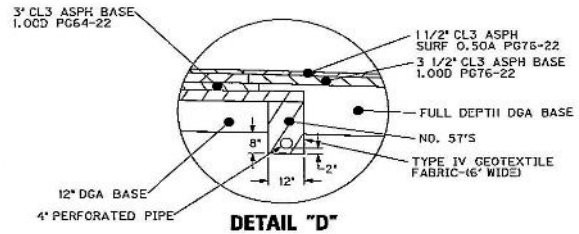
TRAFFIC LANE	1 1/2" CL3 ASPH SURF 0.50A PG76-22 3 1/2" CL3 ASPH BASE 1.00D PG76-22 5" (AVG. DEPTH) LEVELING & WEDGING 3" CL3 ASPH BASE 1.00D PG64-22 4" DRAINAGE BLANKET-TYPE II-ASPH ⑤ 12" DGA BASE (2-6" LIFTS)
SHOULDER	1 1/2" CL3 ASPH SURF 0.50A PG76-22 3 1/2" CL3 ASPH BASE 1.00D PG76-22 FULL DEPTH DGA BASE



DETAIL "A"



DETAIL "B"



DETAIL "D"

NOTE:

① MILLING (18" WIDE AND MIN. OF 3" DEEP) SHALL BE REQUIRED ALONG THE EDGE OF THE EXISTING PAVEMENT ADJACENT TO THE WIDENING. BACKFILL WITH ASPHALT BASE ON THE SAME PASS AS THE WIDENING. THIS CUTOUT SHALL ONLY BE USED WHEN IT ALIGNS WITH THE PROPOSED 3" BASE FOR WIDENING.

② FOR SLOPES OUTSIDE LIMITS OF BERM SEE CROSS-SECTIONS.

③ FOR DIRECTION OF SLOPES OF BERM SEE CROSS-SECTIONS.

④ WIDEN 3' WHEN GUARDRAIL REQUIRED.

⑤ ON HIGH SIDE OF SUPER-ELEVATED SECTION REPLACE 4" DRAINAGE-BLANKET WITH ASPHALT BASE.

⑥ FROM OLD GREENSBURG RD. TO U.S. 68 (STA. 415+34.5 TO STA. 420+41.5) ELIMINATE SIDEWALK AND REDUCE BERM WIDTH TO 5' AND MODIFY SLOPE AS SHOWN IN DETAIL 'C' SOD 4' STRIP BEHIND CURB

⑦ ASPHAL SEAL REQUIRED FROM OUTSIDE EDGE OF PAVED SHOULDER TO A POINT 2 FEET DOWN THE DITCH OR FILL SLOPE. TWO APPLICATIONS OF THE FOLLOWING:

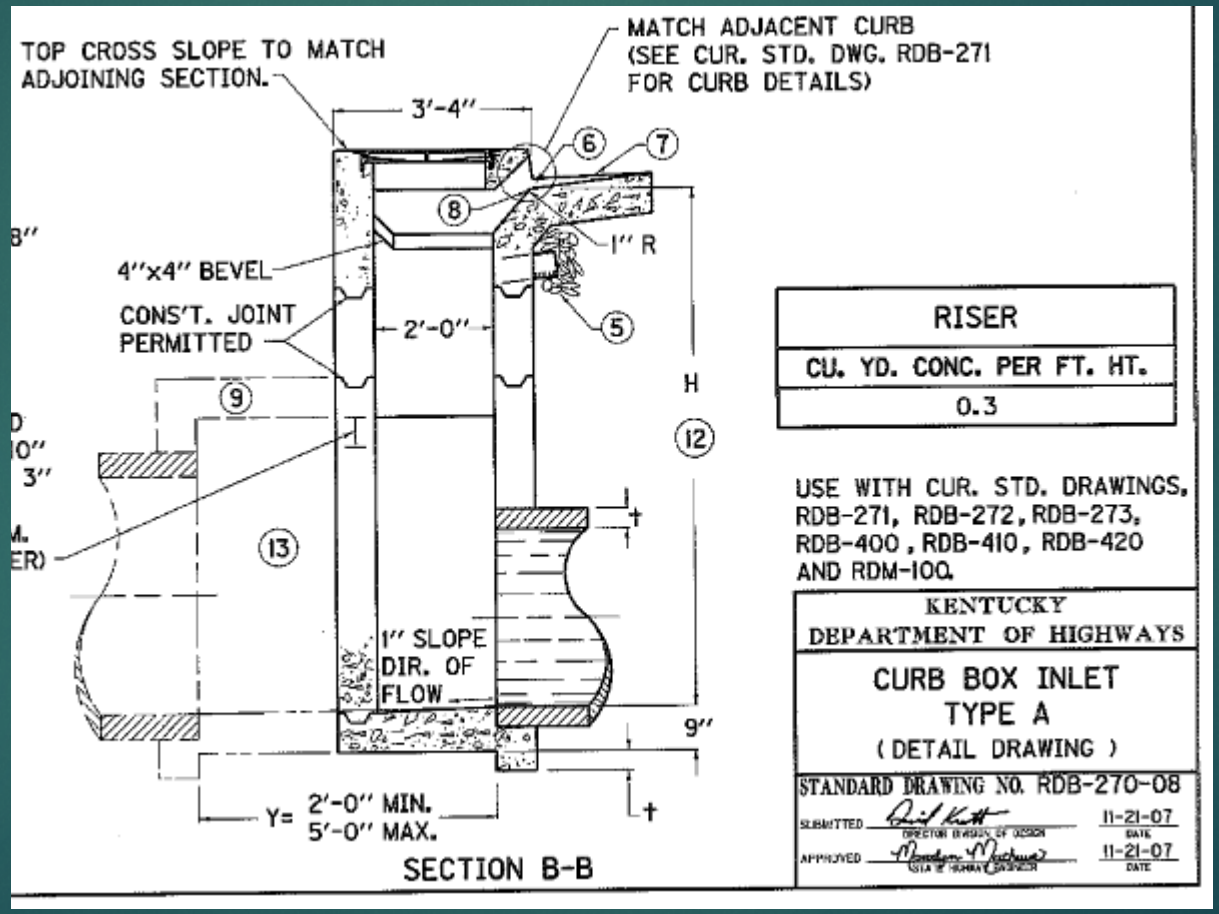
- EMULSIFIED ASPHALT RS-2 @ 2.40 LBS/SQ. YD.
- ASPHALT SEAL AGGREGATE @ 20 LBS/SQ. YD.

RIGHT OF WAY PLANS

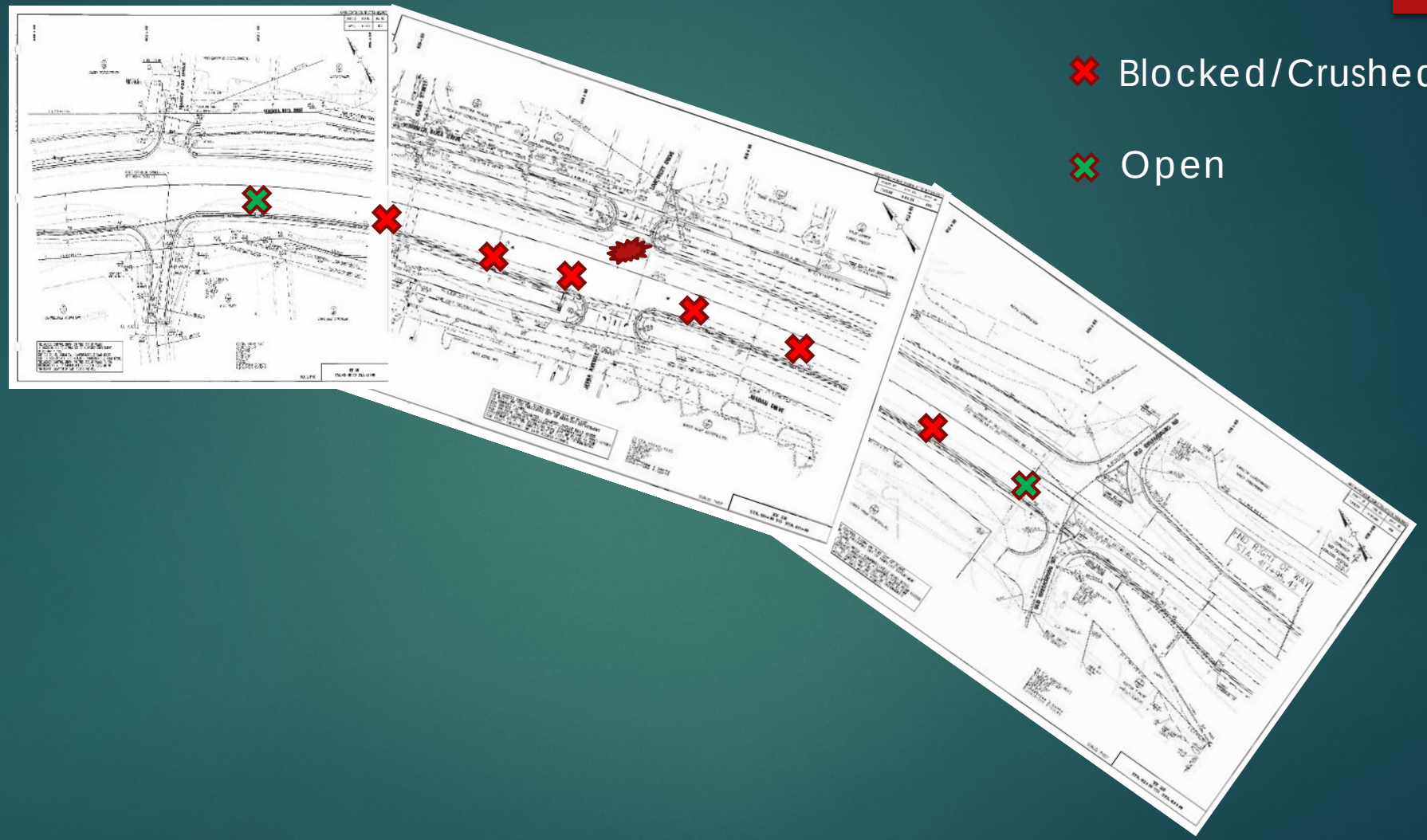
NOT TO SCALE

KY 210 TYPICAL SECTIONS

Outlet Detail

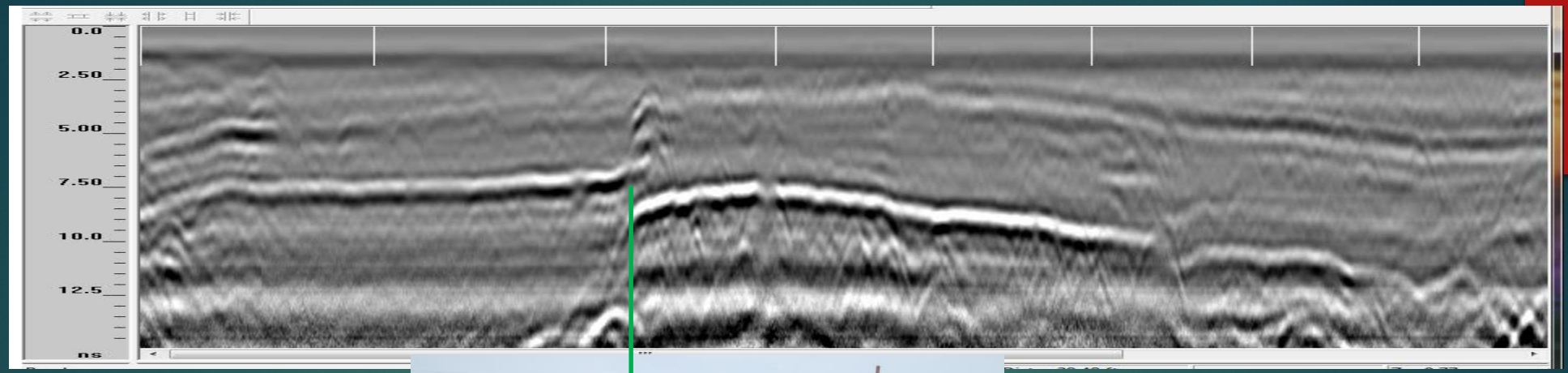


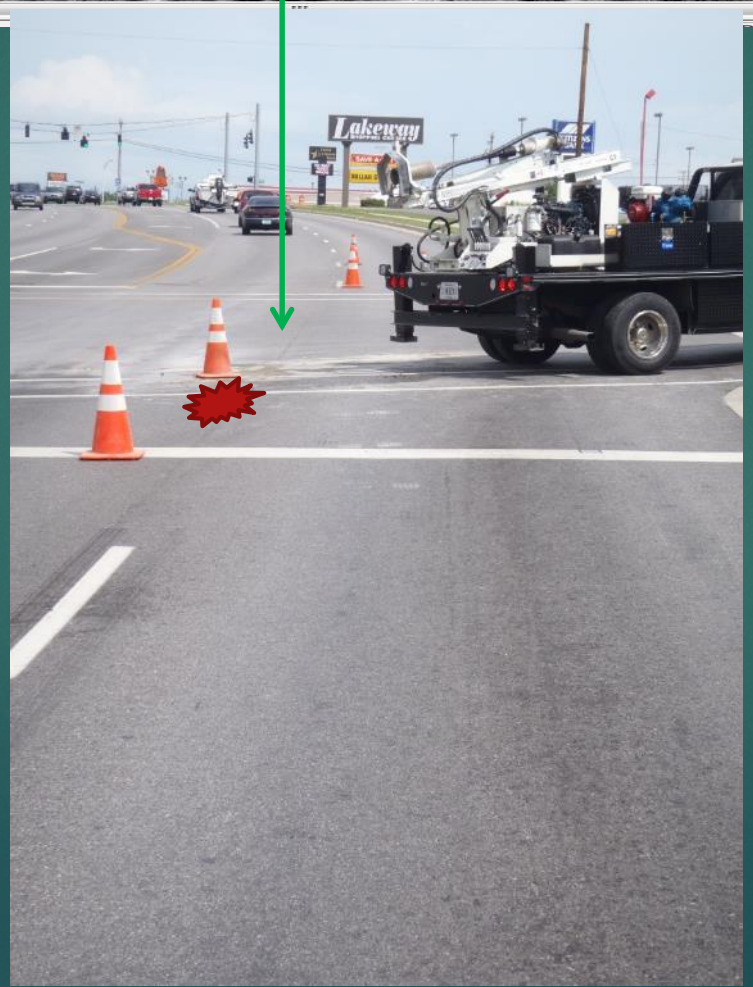
Blocked Edge Drains



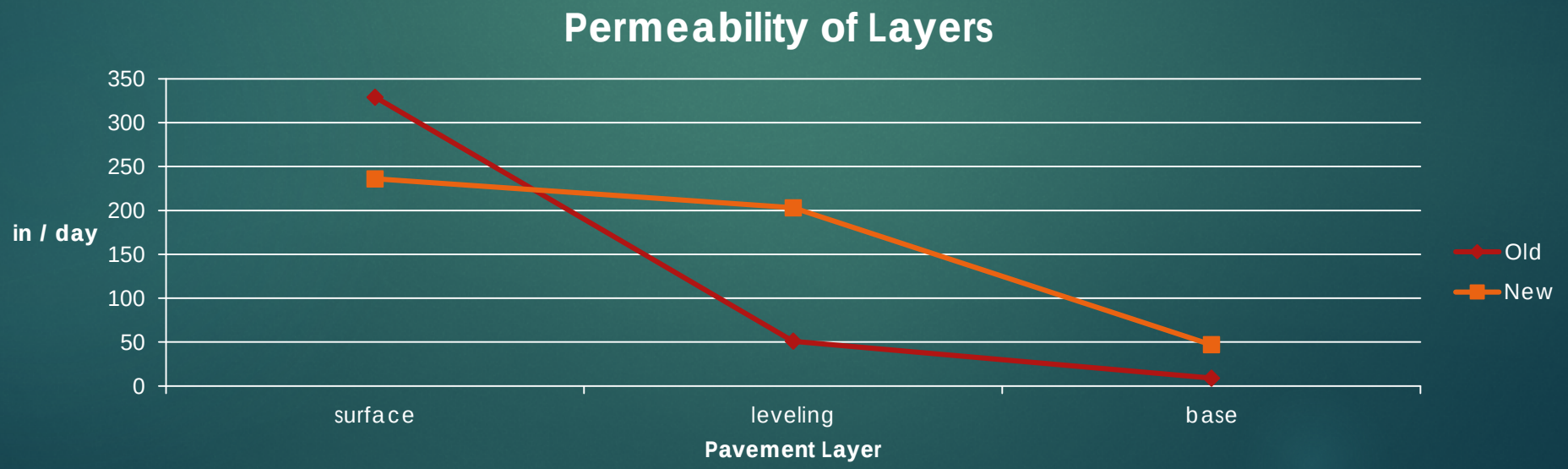
- Blocked/Crushed
- Open

Ground Penetrating Radar

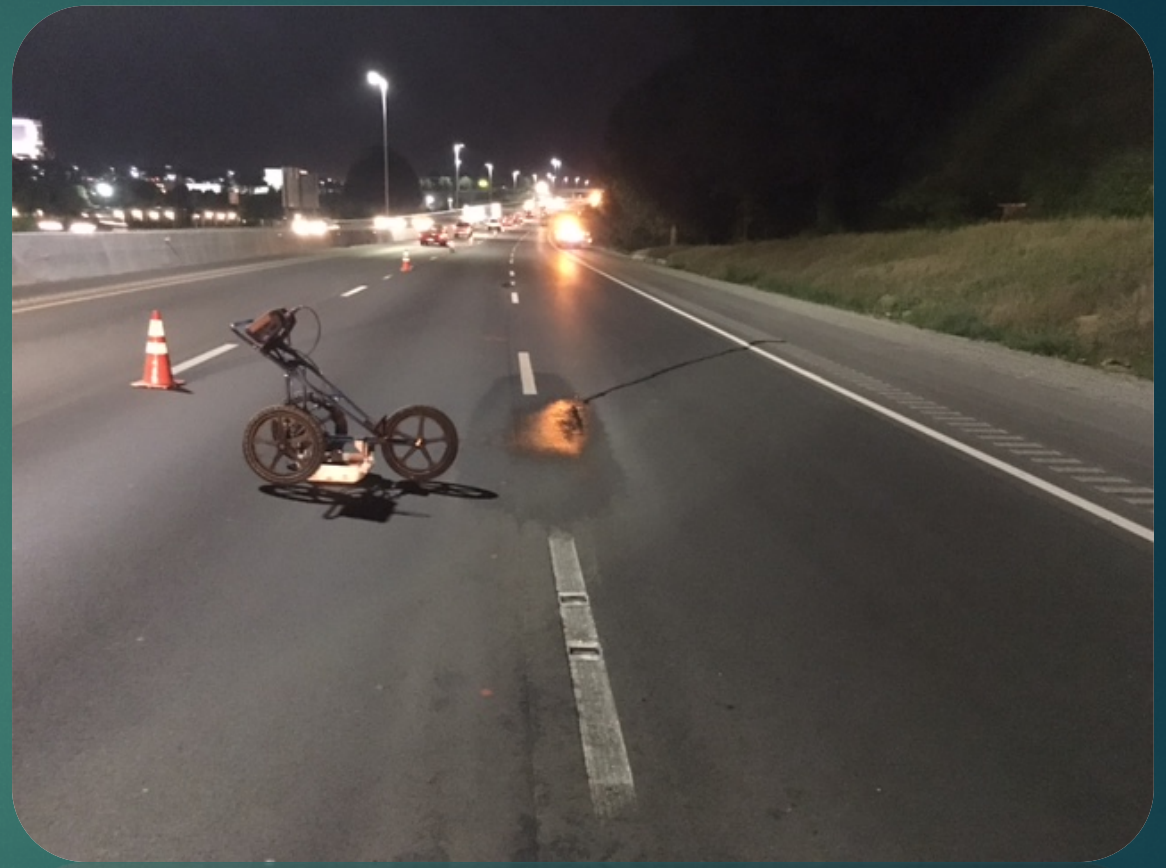

0.0
2.50
5.00
7.50
10.0
12.5
ns

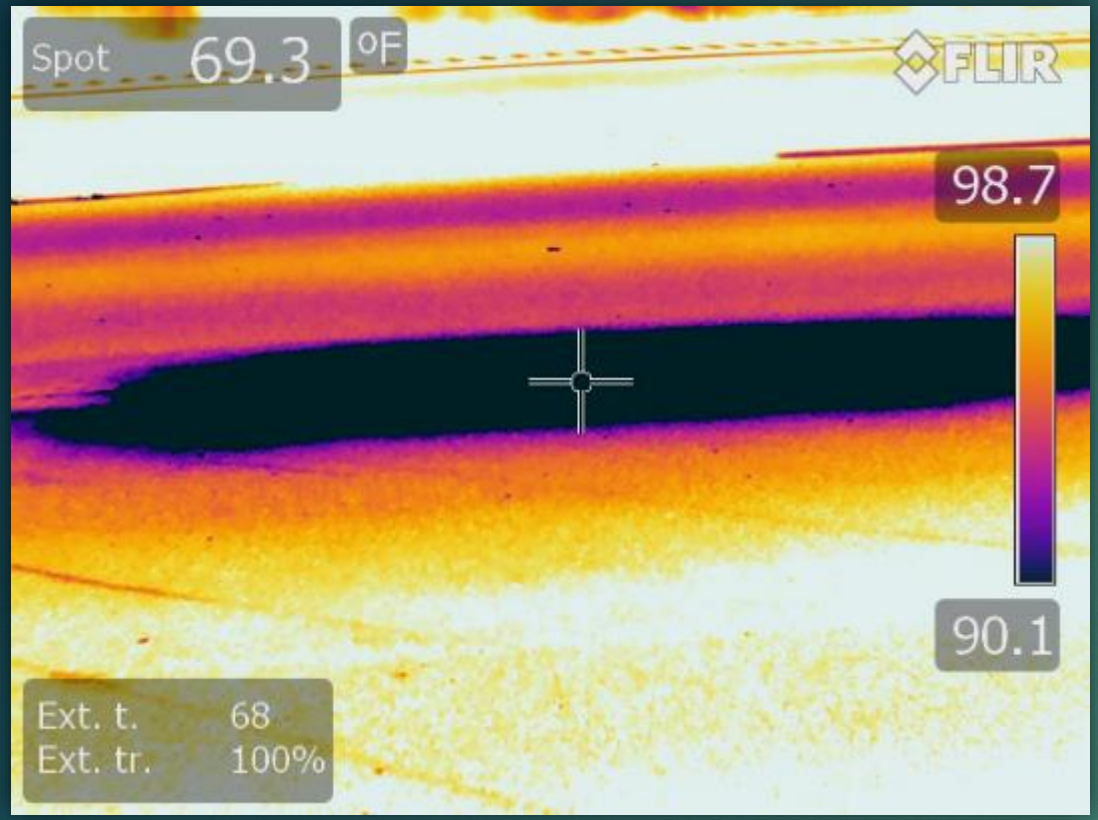

Lakeway

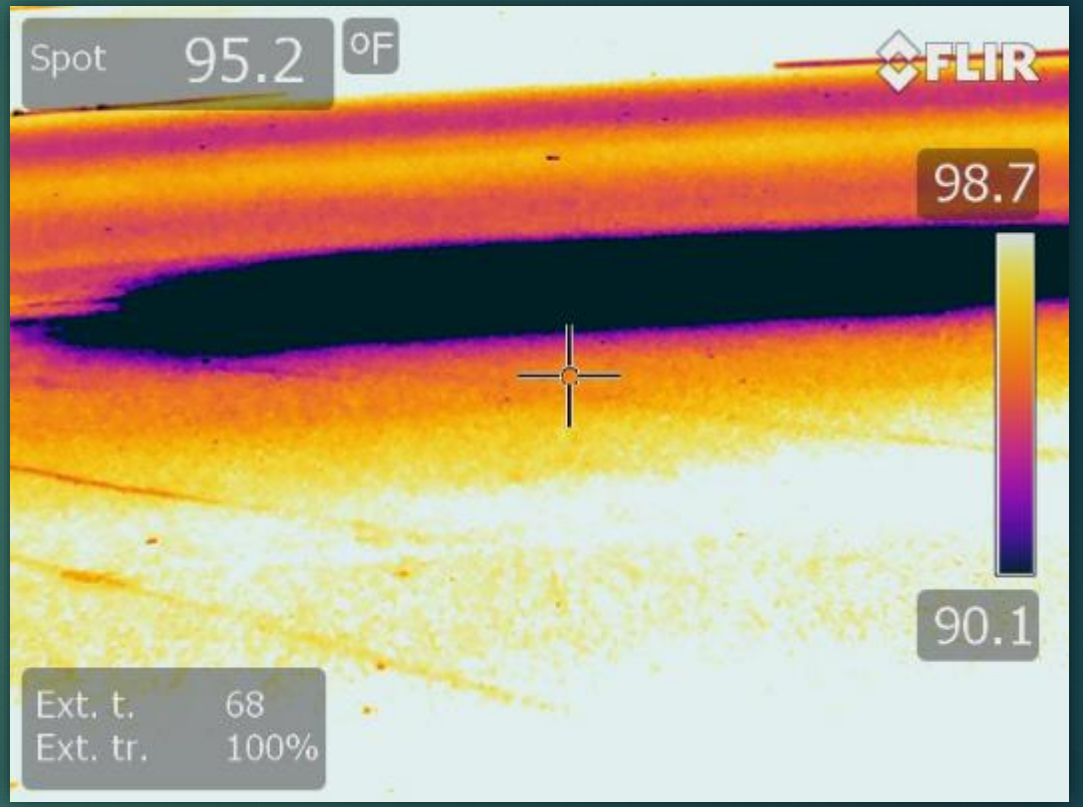
Blow
UP
LL
RL


Permeability of Layers
350
300
250
200
150
100
50
0
in / day
surface
leveling
base
Pavement Layer
Old
New

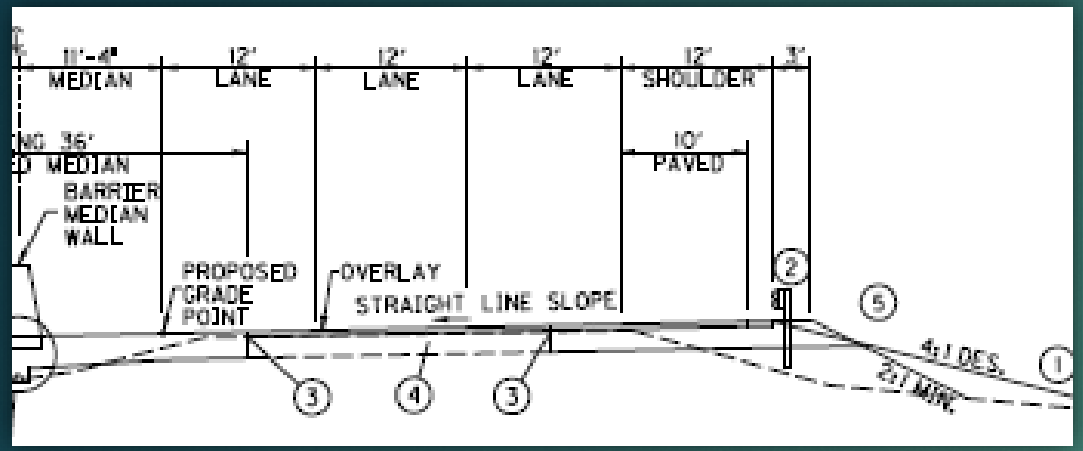
Case Study #2

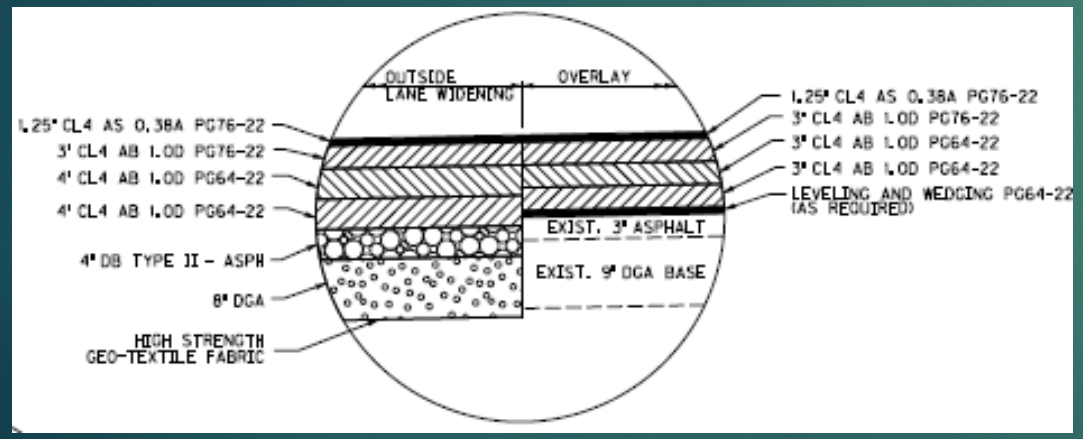


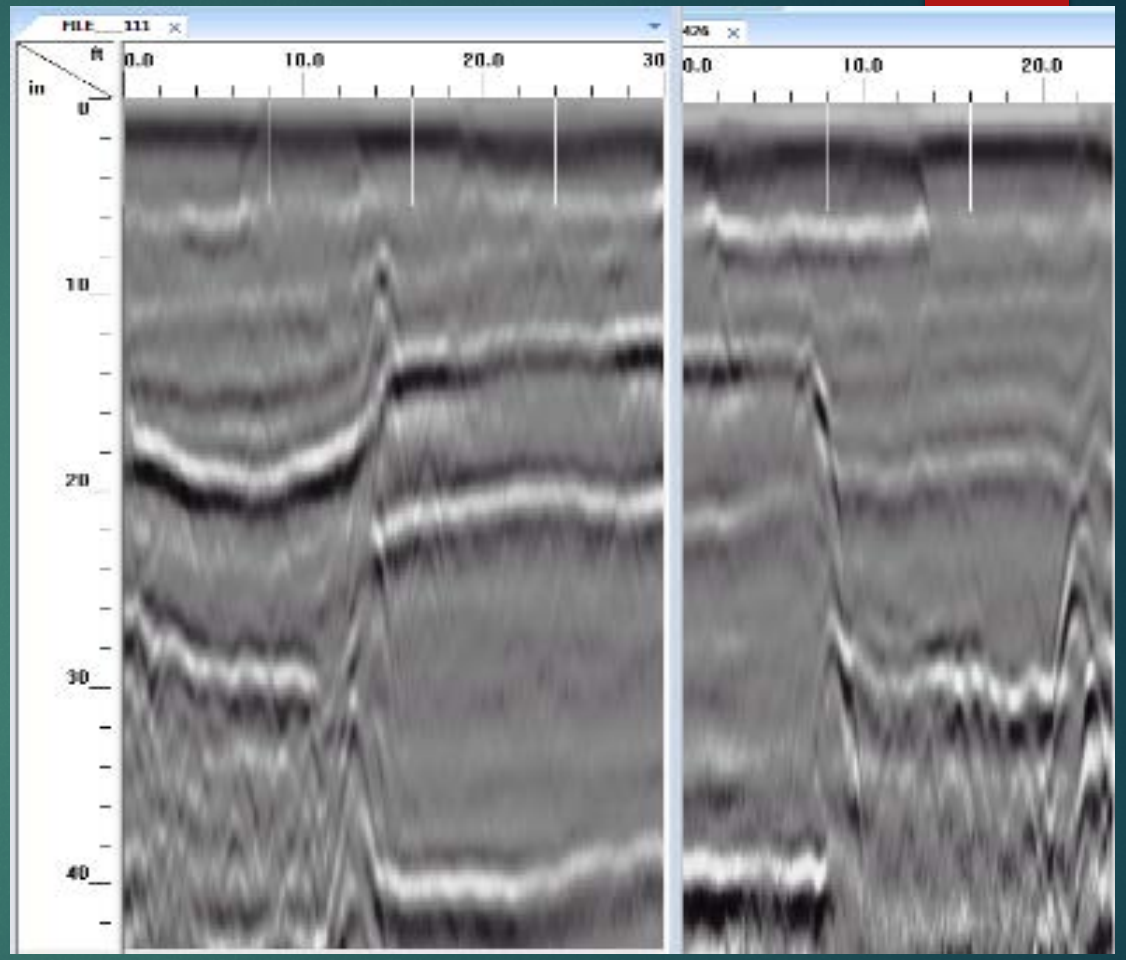

Spot 69.3 °F
FLIR
98.7
90.1
Ext. t. 68
Ext. tr. 100%


Spot 95.2 °F
FLIR
98.7
90.1
Ext. t. 68
Ext. tr. 100%

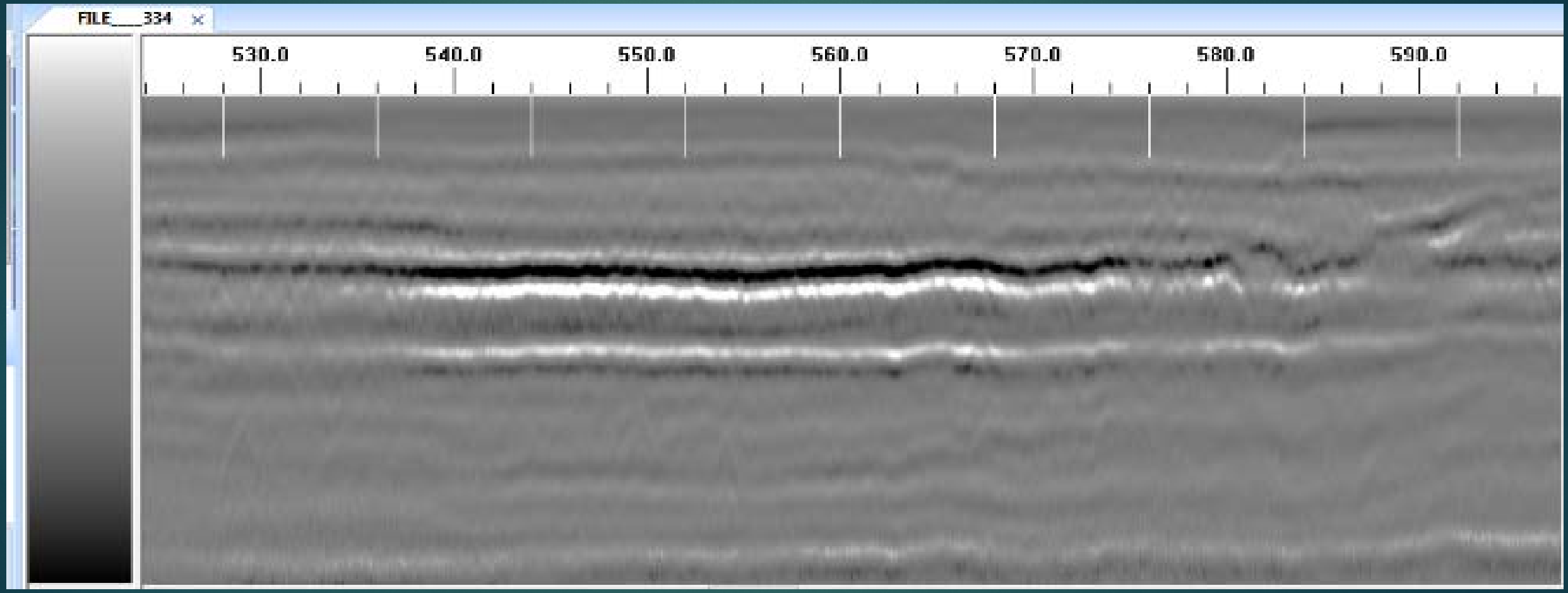
Transverse Ground Penetrating Radar scans

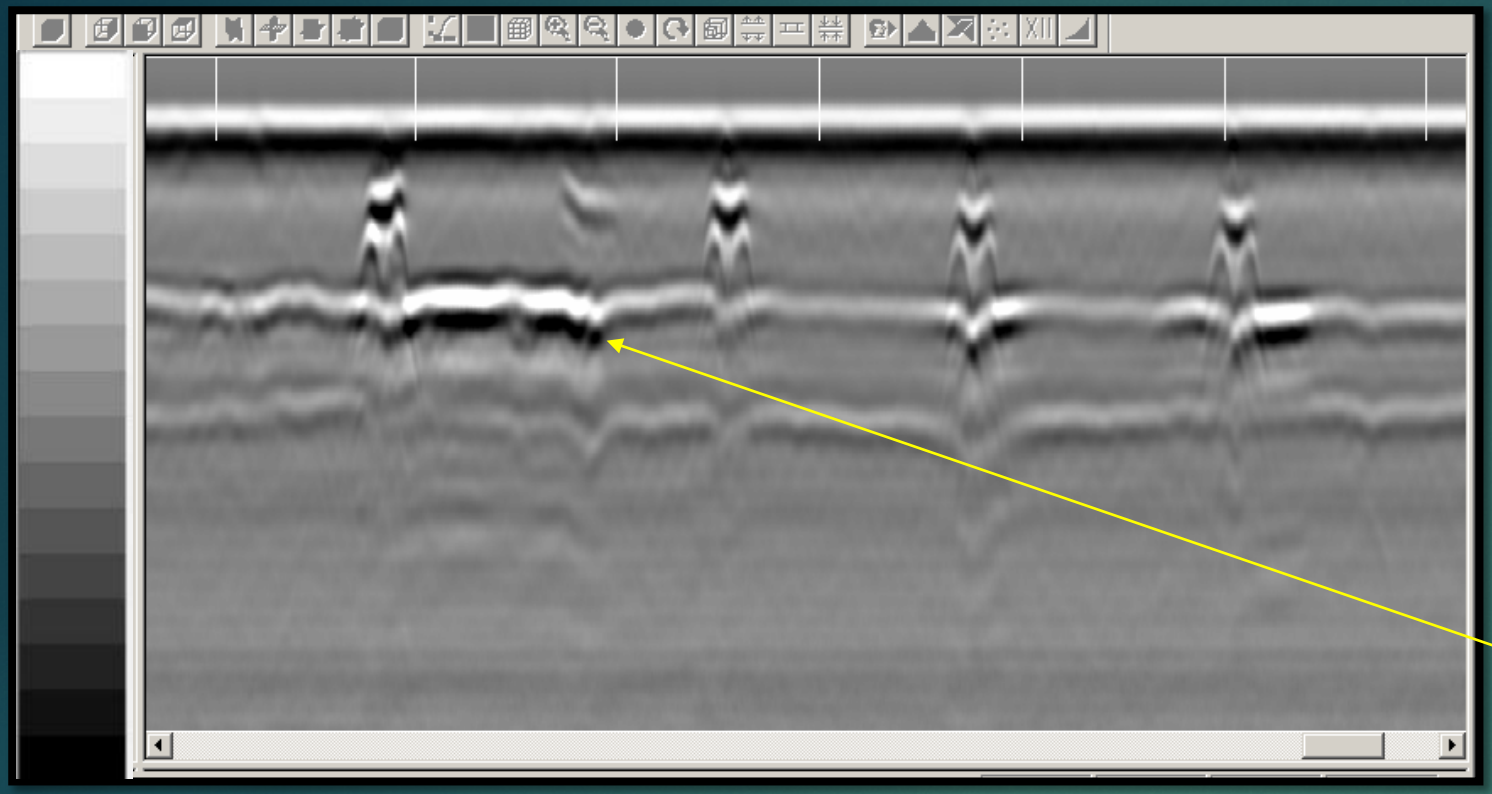




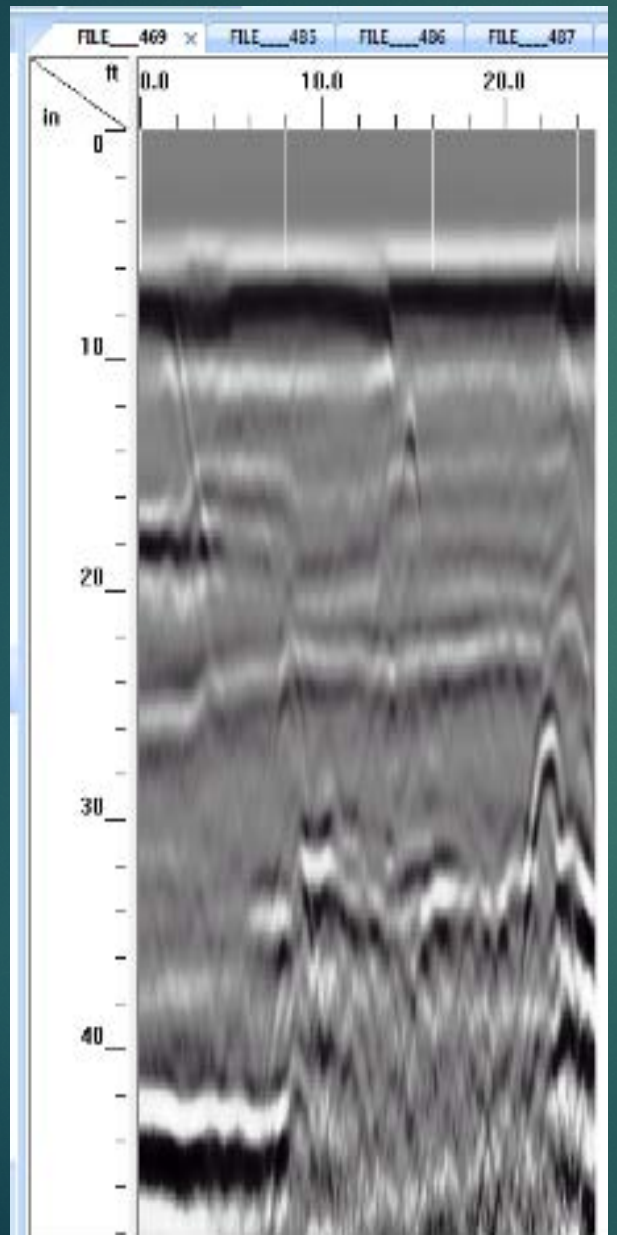


Longitudinal ground penetrating radar scans in problem areas

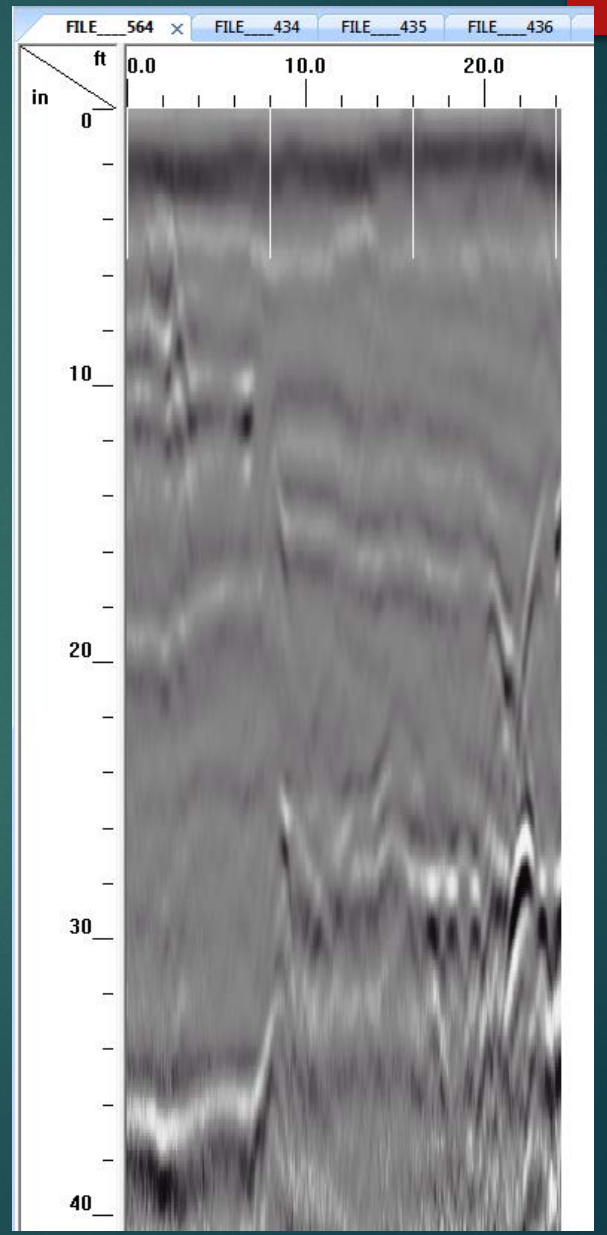


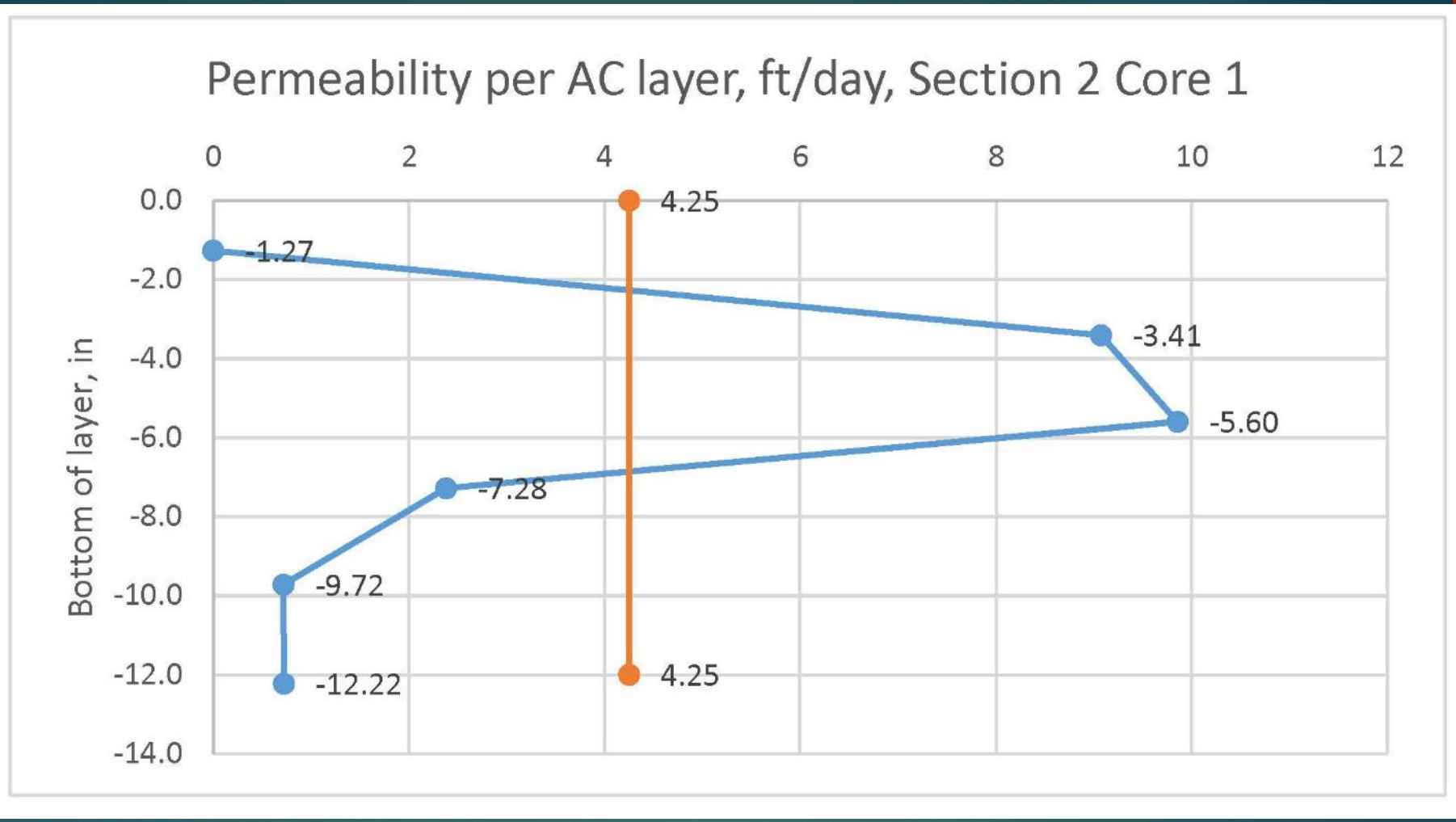


Transverse ground penetrating radar scans in problem areas



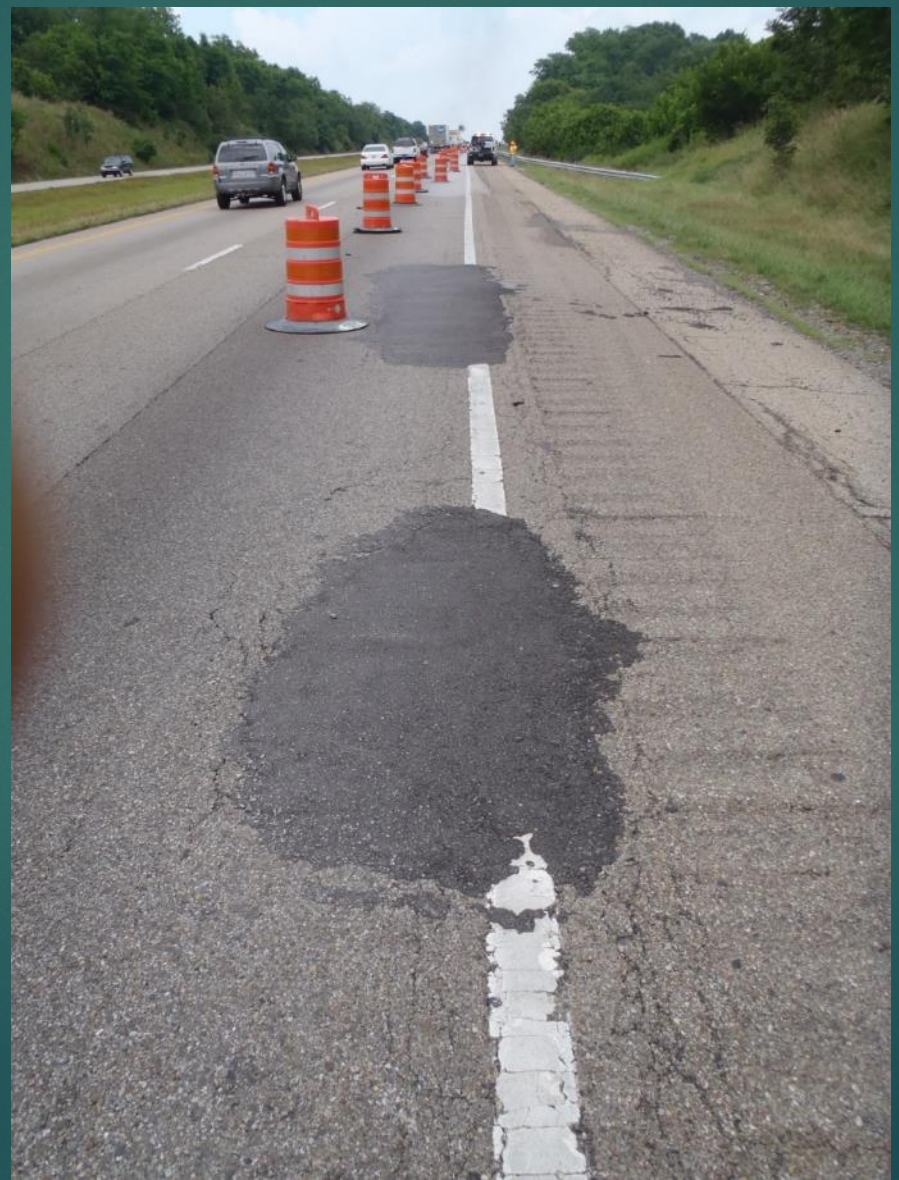
- Elevation of edge drains

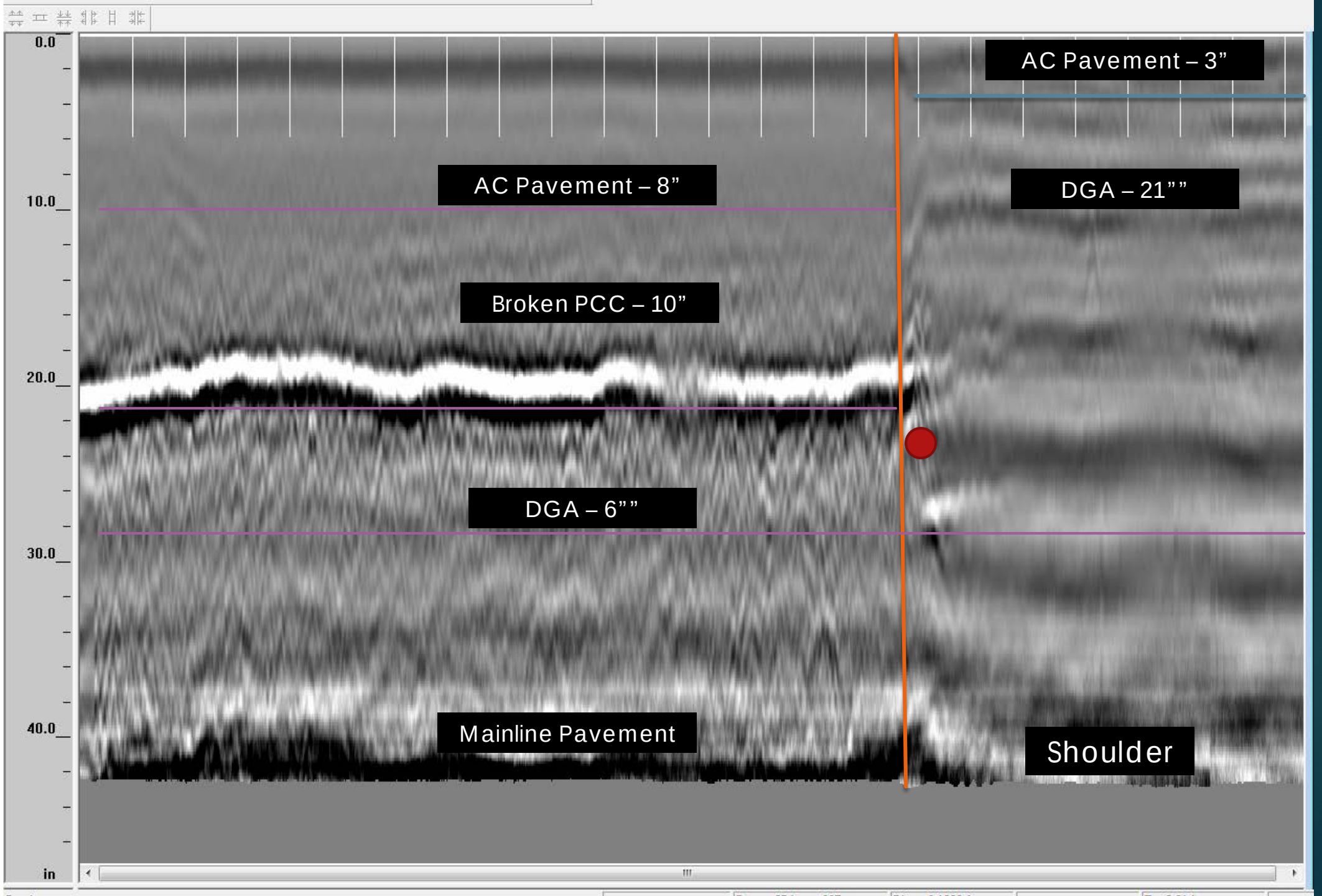



Permeability per AC layer, ft/day, Section 2 Core 1
0
2
4
6
8
10
12
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
Bottom of layer, in
4.25
-1.27
-3.41
-5.60
-7.28
-9.72
-12.22
4.25

Site 1, Core 4 near Station 266+75 had a 1-1/2 inch layer of dirt at a depth of 8-1/2 inches.

Case Study #3 Maintenance




0.0
10.0
20.0
30.0
40.0
in
AC Pavement – 3”
AC Pavement – 8”
DGA – 21”
Broken PCC – 10”
DGA – 6”
Mainline Pavement
Shoulder

WESTWARD

4x4

Maintenance, Maintenance, Maintenance

E
275
2
5
CIRCLEPORT
513-421-4884

Maintenance Problems

- Outlet below flow line of ditch
- Loss of rodent screen
- Vegetation
- Grass clippings
- Some of these issue can happen quite quickly
- Millings from resurfacing

So When Should I Clean the Drains?

Edge Drains (2 years old).

Edge Drains (4 years old).

Edge Drains (4 years old).

Edge Drains (8 years old).

Edge Drains (12 years old).

2 Years Old

4 Years Old

8 Years Old

12 Years Old

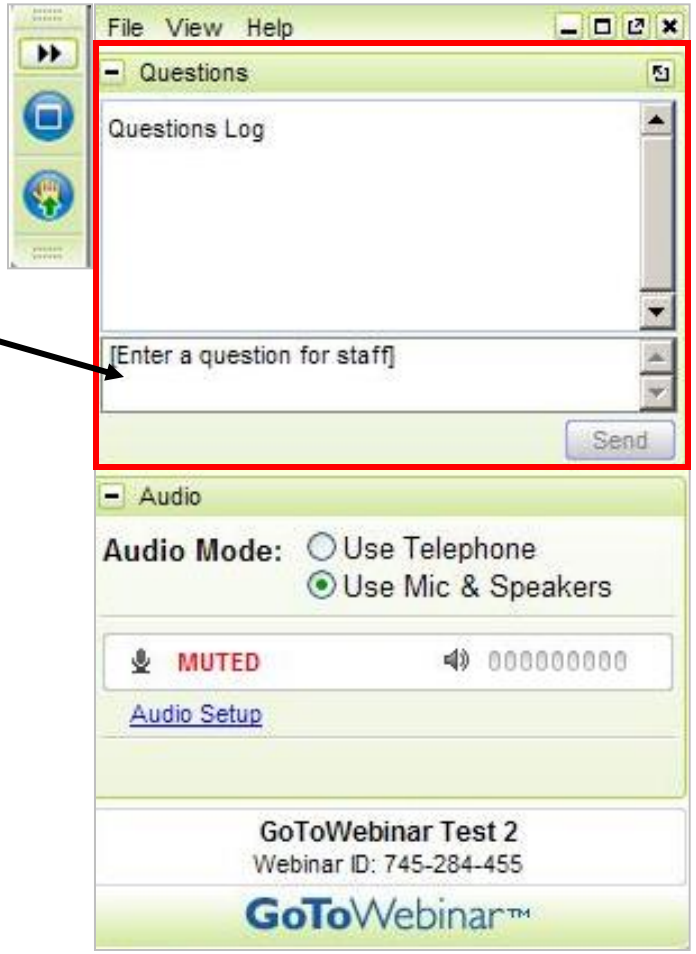
Conclusions

- We have standard design details, but all designs are not standard (DRIP)
- It is about more than just adding pipes along the roadway
- We must consider what we are draining
- Effective maintenance, 5 to 8 year mark appears to be critical

Thank You

Thank you for your time: Questions?

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's Speakers

- Affan Habib, *Virginia Department of Transportation,* affan.habib@vdot.virginia.gov
- Mohamed Elfino, *Virginia Department of Transportation (retired),* mkelfino@msn.com
- Gabriel Bazi, *Lebanese American University,* gbazi@gbazi.com
- Clark Graves, *University of Kentucky,* clark.graves@uky.edu

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