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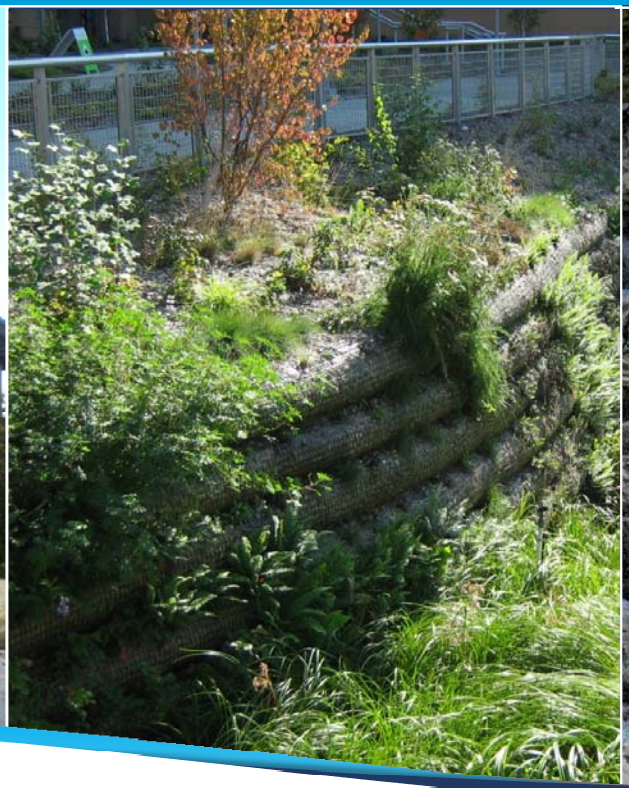

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AESI

PRESENTED SEPTEMBER 24, 2014 BY

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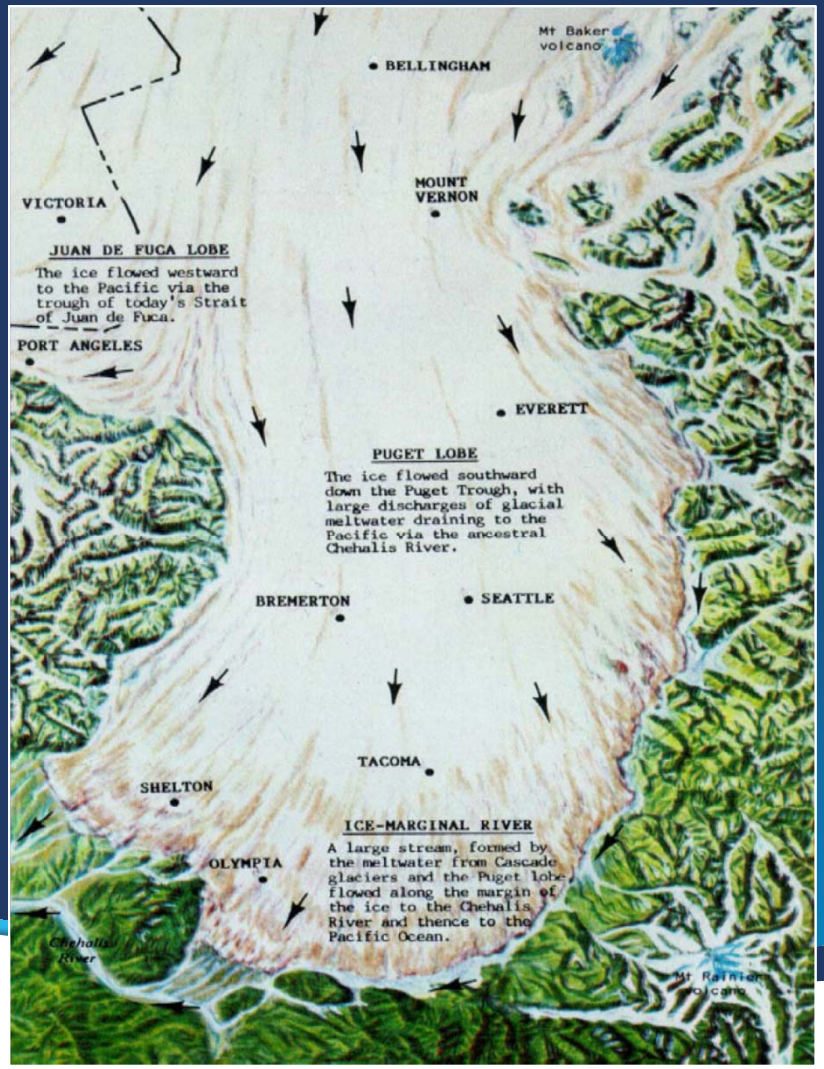
WASHINGTON STATE UNIVERSITY

PugetSoundPartnership
our sound, our community, our chance

www.aesgeo.com

HOW AND WHERE DOES INFILTRATION WORK?—

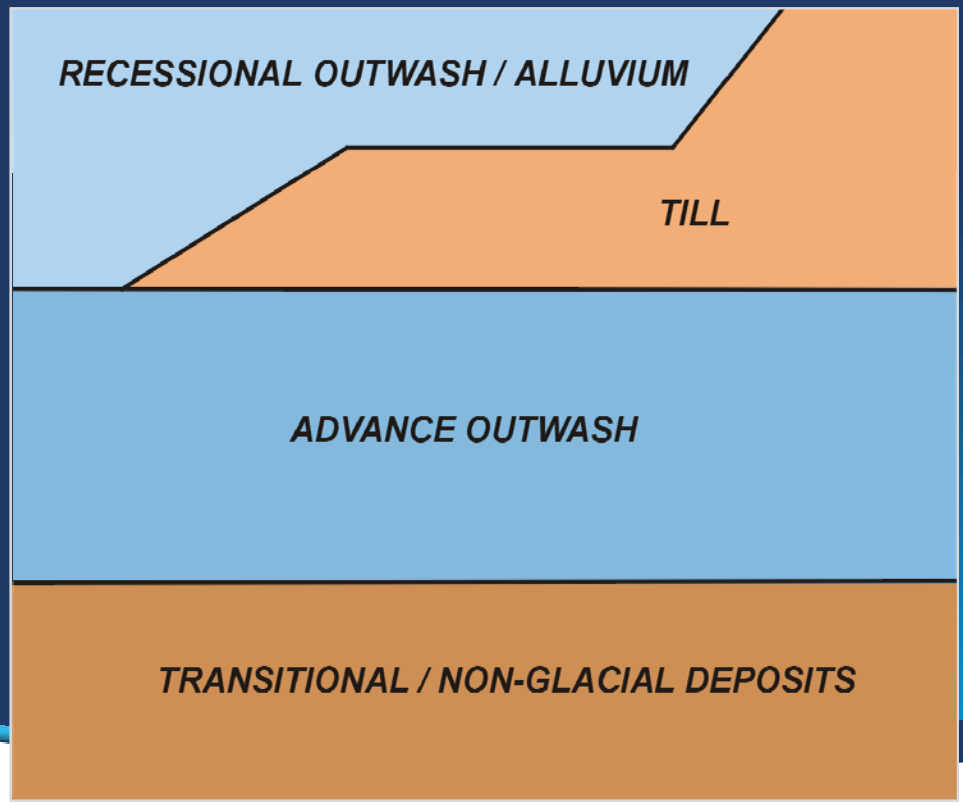
- Context: Summary of Geologic History
- Constraints/benefits for different geologic units
- Key geologic and groundwater flow parameters critical to site planning/engineering
- Brief Project Example:
  - Lakewood Crossing



Reference: D. Molenaar, 1987

TYPICAL PUGET SOUND STRATIGRAPHY

- Recessional outwash: Bedded and sorted sand, gravel. River deposits flowing from wasting and retreating ice
- Till: Unsorted mixture of clay, silt, sand, gravel, cobbles – nature's concrete 5 to 30 feet thick on average. Compacted beneath ice sheet
- Advance outwash: Bedded and sorted gravel and sand at top: River deposits flowing from advancing ice; well-bedded clay and silt at base: deposits of lakes (or salt water) farther in front of the ice

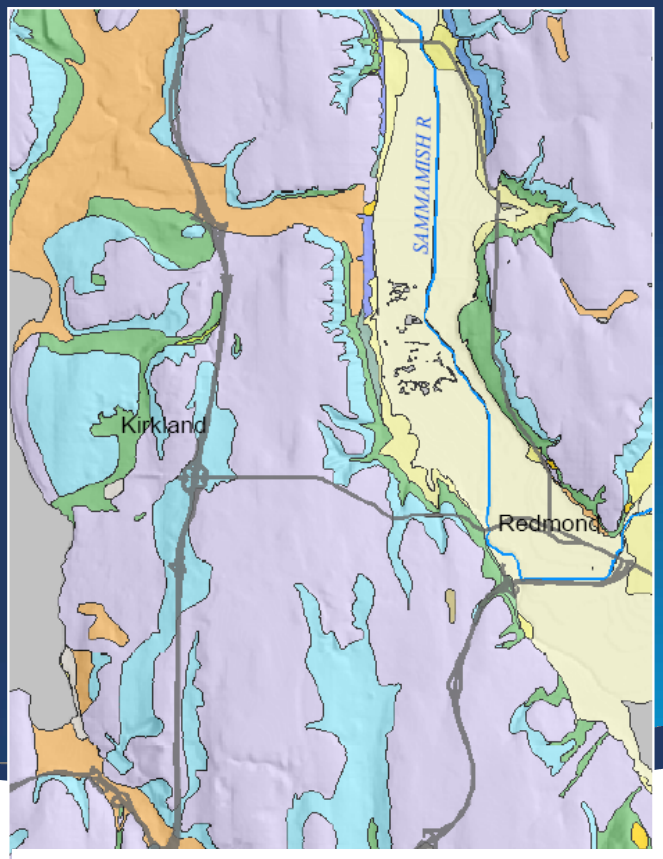


PUGET SOUND AREA GEOLOGY

In the Lowland:

- Vashon till is the most abundant material **by surface area,** but commonly a thin veneer
- Vashon advance outwash is the majority **by volume** of the Vashon-age glacial material

GeoMapNW



http://geomapnw.ess.washington.edu/index.php

Map Source:
Geologic Map of King County Compiled by Booth, Troost, and Wisher, May 2006

RECESSIONAL OUTWASH

Constraints:

- Thin
  - Removed during grading
  - Shallow ground water
  - Downslope impacts (slope stability, springs, wetland hydrology

Benefits:

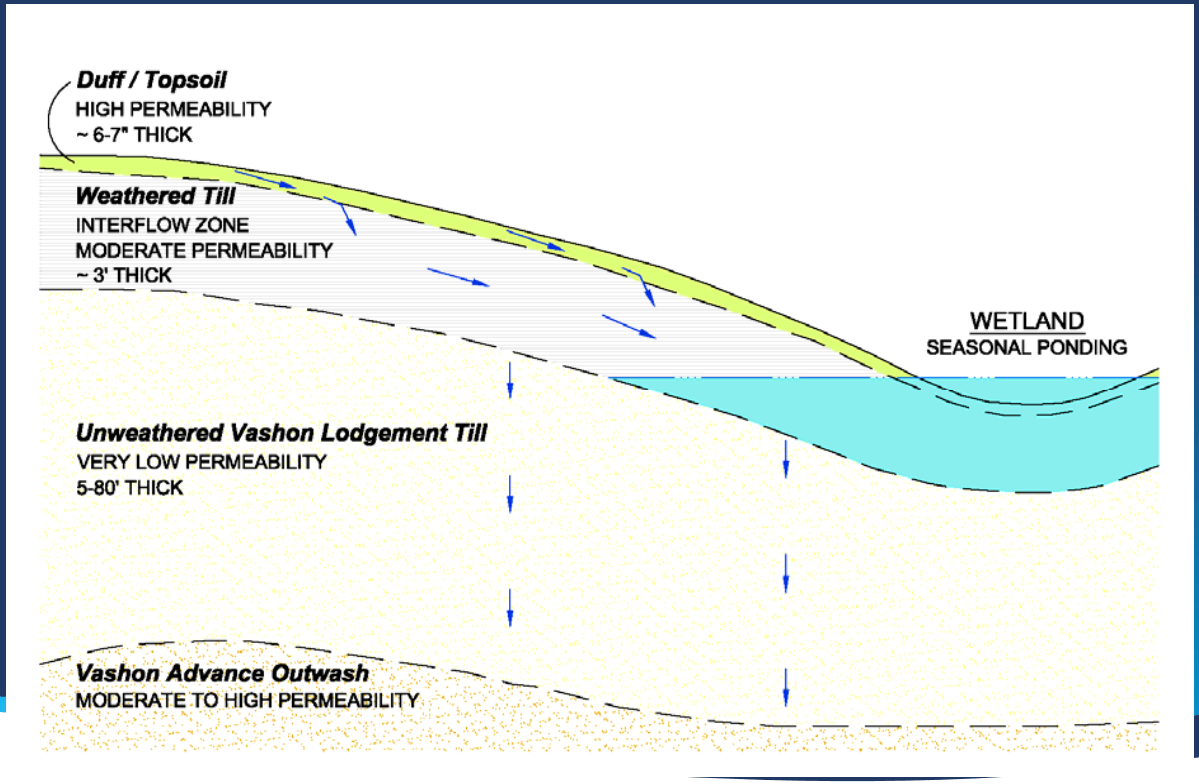
- High permeability
- Dispersed infiltration options

LODGEMENT TILL

Constraints:

- Thin weathered horizon removed during grading
- Very low permeability parent material
  - Good for earthen dams/berms
  - In-situ amendments not feasible
- Ground water mounding
- 1 to 1-1/2 inches/month of recharge through till
- 0.001 to 0.002 inches/hour

STORM WATER FLOW ON TILL SITE



RECESSIONAL DEPOSIT, UNDERLAIN BY TILL

ADVANCE OUTWASH

- Constraints
  - Depth
  - Variable receptor soil characteristics
  - Downslope impacts (slope stability)
- Benefits
  - Adequate receptor soil
  - Recharges aquifer system
  - Only viable solution at many sites

SITE ASSESSMENT OVERALL PROJECT LEVEL CONSTRAINTS

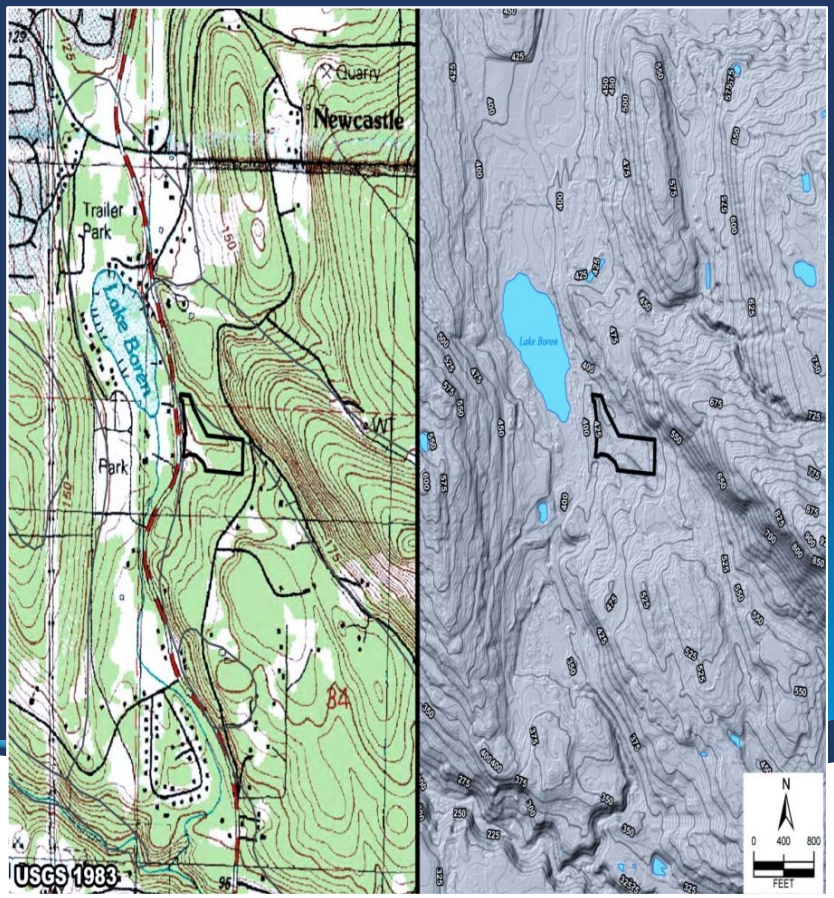
- Geology/soil characteristics
- Ground water conditions
- Infiltration potential
- Water balance issues
  - Wetlands
  - Springs
  - Water Supply
- Final Site Use
  - Commercial
  - Residential
  - Industrial

SITE ANALYSIS

- Exploration
  - Exploration pits
  - Deep exploration borings
- Testing
- Modeling

READILY AVAILABLE RESOURCES

- USGS and DNR Geologic Maps
- USDA Maps
- In House Previous Work



INFILTRATION RATE TESTING

SPECIAL CASE ONLY:

- Grain Size Distribution
- Published Soil Infiltration Rates

OUTDATED:

- Percolation Test (Single Standpipe)
- Double Ring Infiltrometer

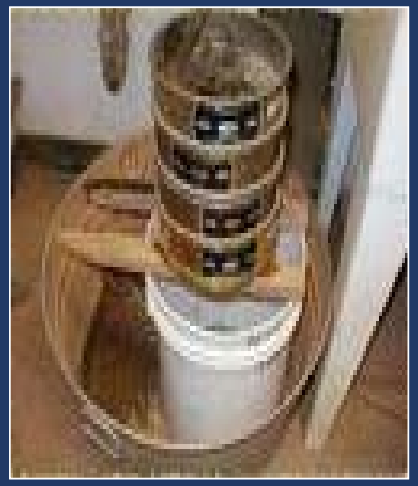
PREFERRED:

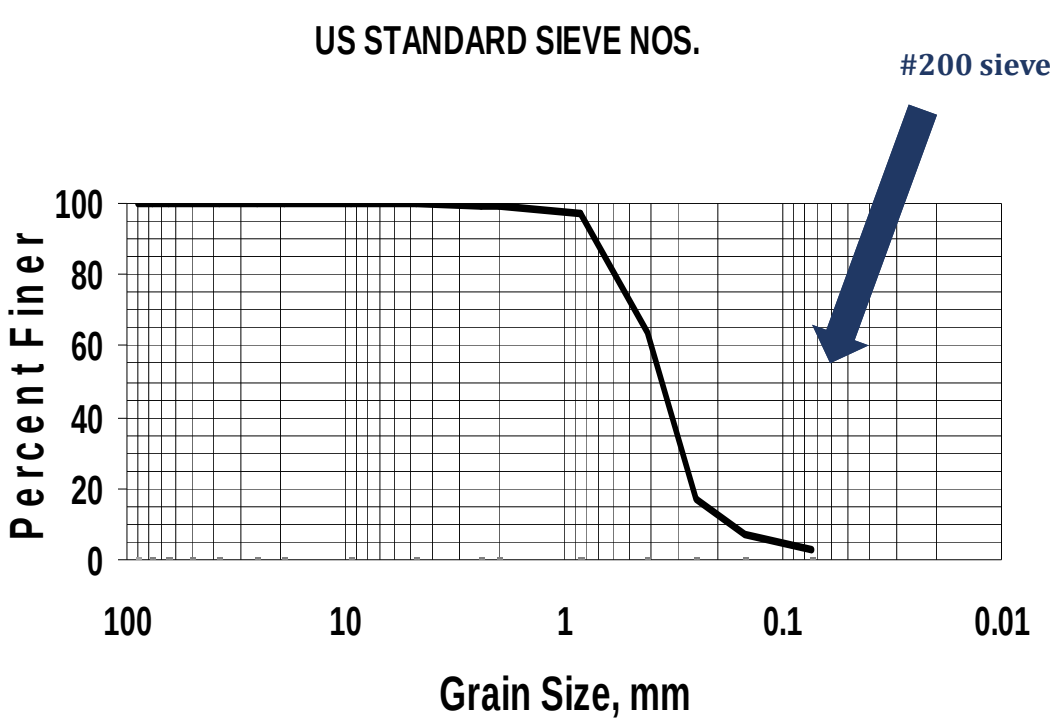
- Large-Diameter Single Ring
- Pilot-Scale PIT

INFILTRATION RATE DETERMINATION

Ecology 2012, Sieve Analysis (USDA/ASTM)

Recessional Outwash or Holocene only





$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

USDA METHOD, ECOLOGY 2005 REMOVED FROM ECOLOGY 2012

Table 3.7—Recommended Infiltration Rates based on USDA Soil Textural [illegible]tion			
	*Sho[illegible]Term Infil[illegible]n Rate (in/hr)	Correction **Factor**	Estimated Long-Term (Design) Infiltration Rate (in/hr)
Clean sandy gravels and gravelly sands	20	2	10
Sand	8	4	2
Loamy Sand	[illegible]	4	0.5
Sandy Loam	4	4	0.25
Loam	0.5	4	0.13

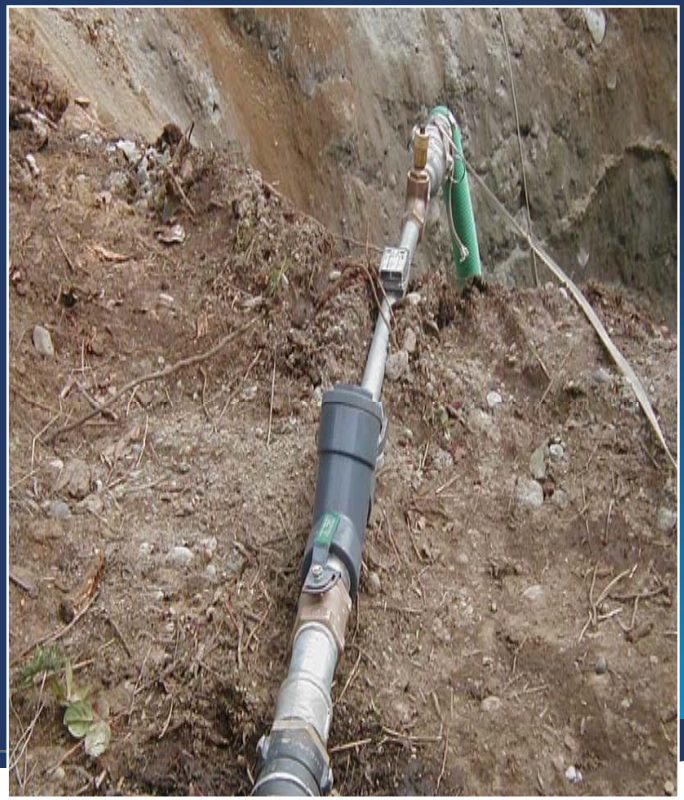
OLD SCHOOL INFILTRATION

Falling Head Test (EPA)

Double Ring Test

SMALL SCALE INFILTRATION

Pilot Infiltration Test (PIT)

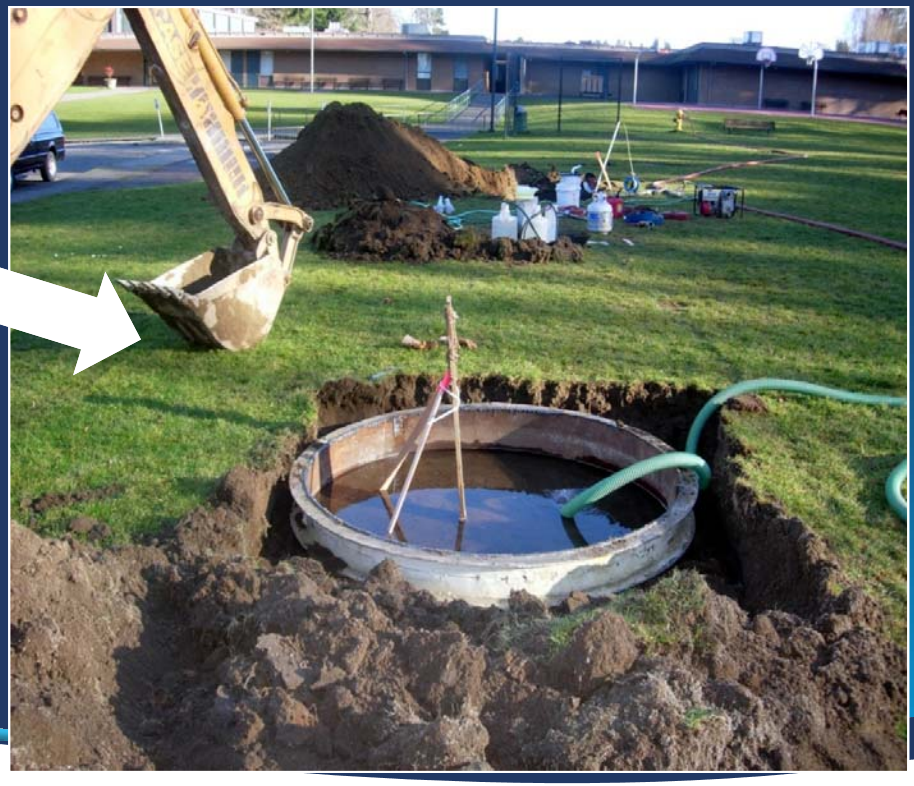


LARGE SCALE INFILTRATION

Pilot Infiltration Test (PIT)

LARGE DIAMETER RING INFILTRATION TEST (AESI)

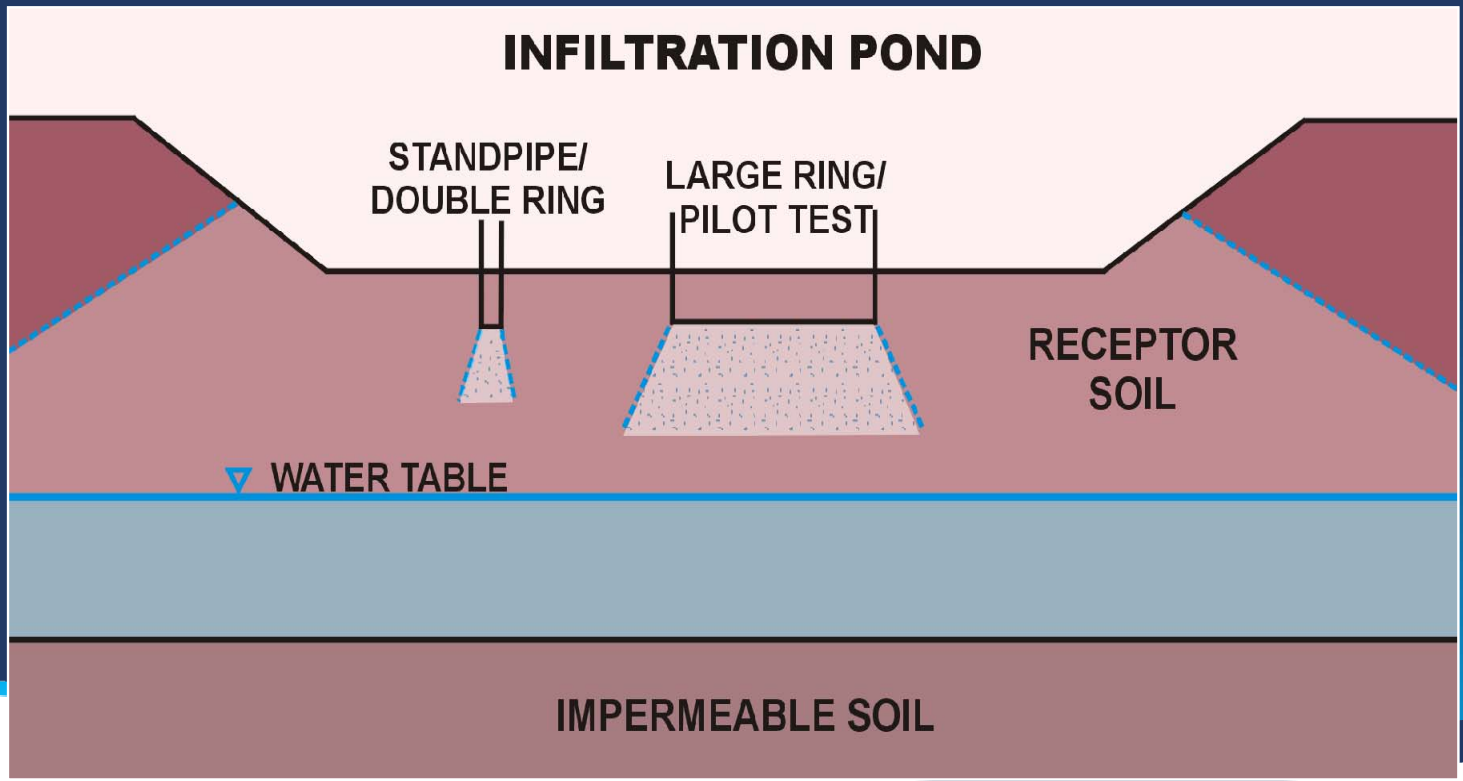
Modified PIT Test



TESTING FREQUENCY | 2012 ECOLOGY MANUAL

- Commercial Sites
  - 1 test per 5,000 sq. ft.
  - Groundwater thru wet season
- Residential Sites
  - 1 Test per 200 feet of road and every lot
  - Groundwater thru wet season

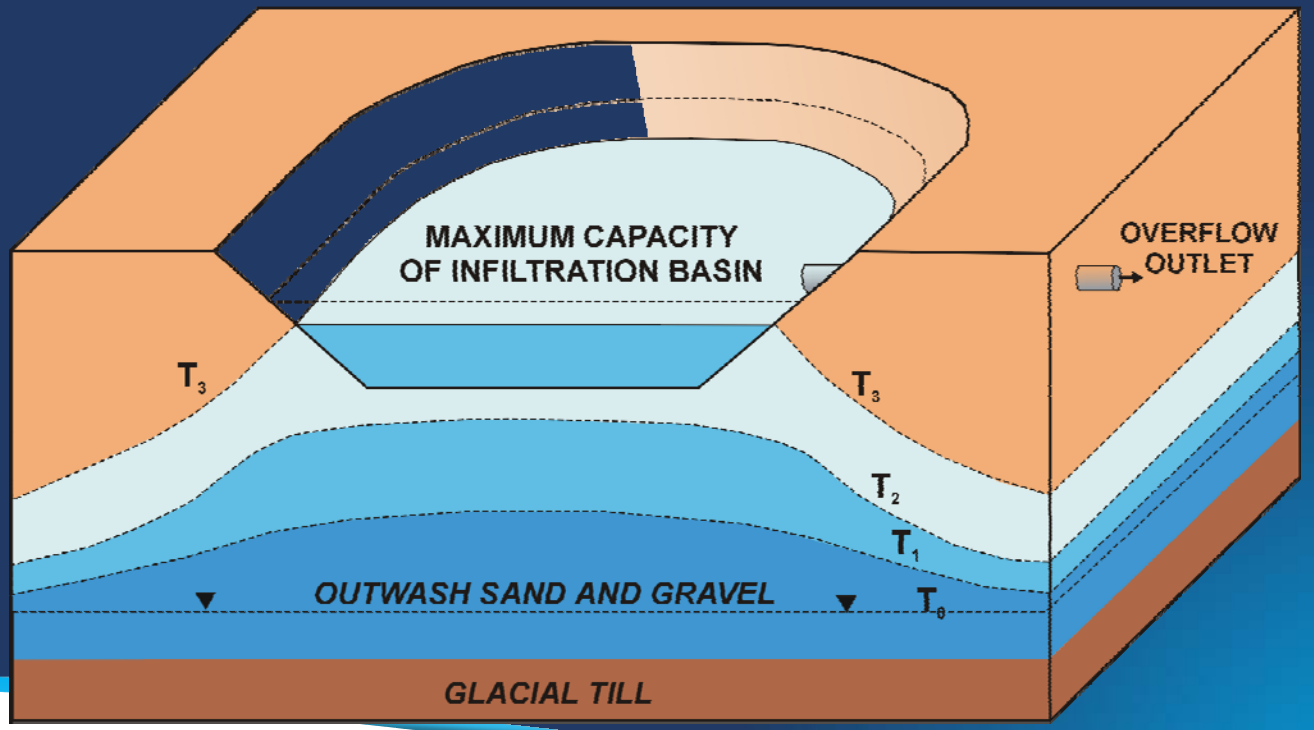
SCALE OF INFILTRATION TESTS



MODELING ANALYSIS

- Depth to water table
- Infiltration rate of native soils
- Hydrographs
- MODRET

GROUND WATER MOUND DEVELOPMENT



RECEPTOR SOILS

- Organic Content
- Infiltration rate of native soils
- Cation Exchange Capacity
- Grain Size Distribution

STORMWATER INFILTRATION -SUMMARY

- Characterization of Receptor Soils – Hydraulic Parameters
- Infiltration Rate – Laboratory/Field Measurements
- Depth to Water Table – Thickness of Unsaturated Zone
- Groundwater Flow Direction – Impacts to Environment/Wells
- Depth of Aquitard – Aquifer Capacity
- Design Storm Event – Peak Flow Rate/Total Volume

SUMMARY

- Geologic constraints and opportunities must be fully and correctly incorporated prior to site planning and engineering.
- Geology can help predict the nature of the physical environment.

LAKEWOOD CROSSING

Project Team:

Powell Development

City of Marysville

Dowl Engineers

Associated Earth Sciences, Inc

PROJECT LOCATION

SITE CONDITIONS

- Previous use:
  - Nursery
  - Farm Land
  - Residential
- Topography:
  - Flat

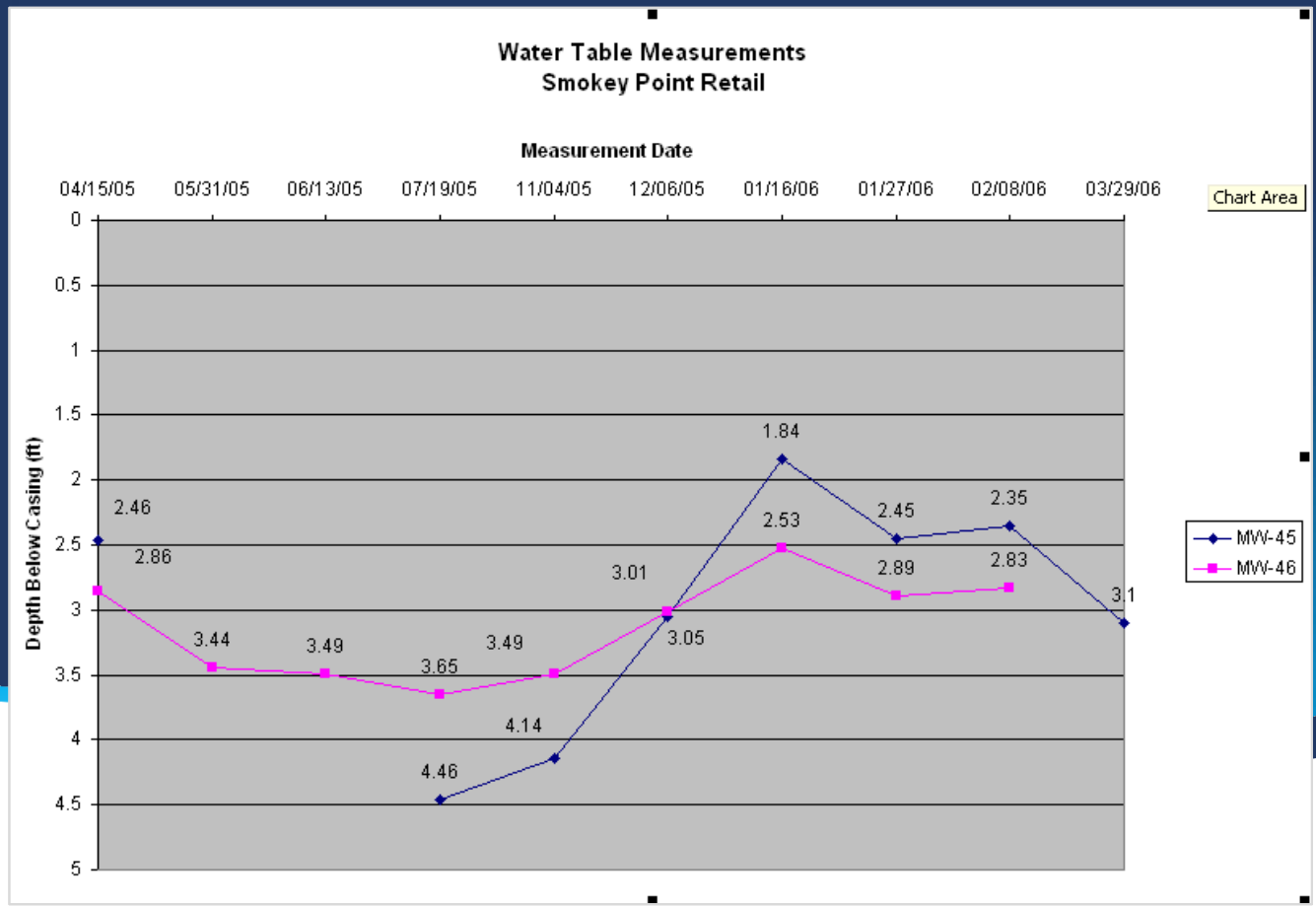
SITE EXPLORATION

- 58 Hollow stem auger borings
  - 12 to 40 feet
- 30 exploration pits
  - Tracked excavator
- 2 monitoring wells

SOIL CONDITIONS

- Typical Marysville Sand Sequence
  - Topsoil 6 to 12 inches
  - Brown Silty Sand (weathered zone) 6 to 12 inches
  - Fine to medium gray sand with trace silt at a depth of 18 to 24 inches
  - Water table 24 to 36 inches

WATER TABLE


Water Table Measurements
Smokey Point Retail
Measurement Date
04/15/05
05/31/05
06/13/05
07/19/05
11/04/05
12/06/05
01/16/06
01/27/06
02/08/06
03/29/06
Chart Area
Depth Below Casing (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
2.46
2.86
3.44
3.49
3.65
3.49
3.01
3.05
4.14
4.46
1.84
2.53
2.45
2.89
2.35
2.83
3.1
MW-45
MW-46

SITE CONSTRAINTS

- Flat topography
- Parking requirements
- Site design

ALTERNATIVE

- Conventional Collection:
  - Off-site pond
  - Acquire more land
  - Discharge into existing ditch which flows into salmon bearing Quilceda Creek
- *This option required raising the entire site 8 feet at $1M per foot*

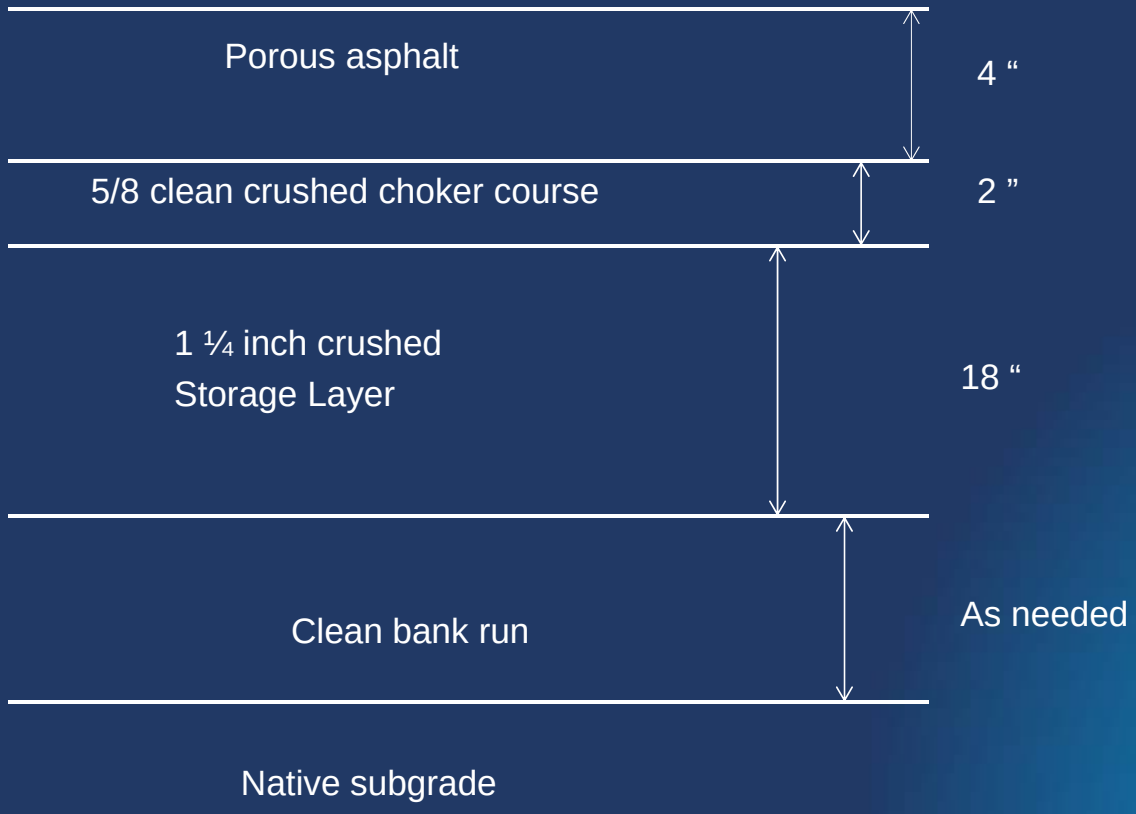
LID OPTIONS

- Pervious surfacing
- Biofilters Cartridge
- Curb cuts to bio-swales

DESIGN ELEMENTS

- Infiltration rate 9 inches per hour
- Separation to water table 1 foot from the bottom of the storage layer
- Very large parking area

POROUS PAVEMENT SELECTION



SUBGRADE

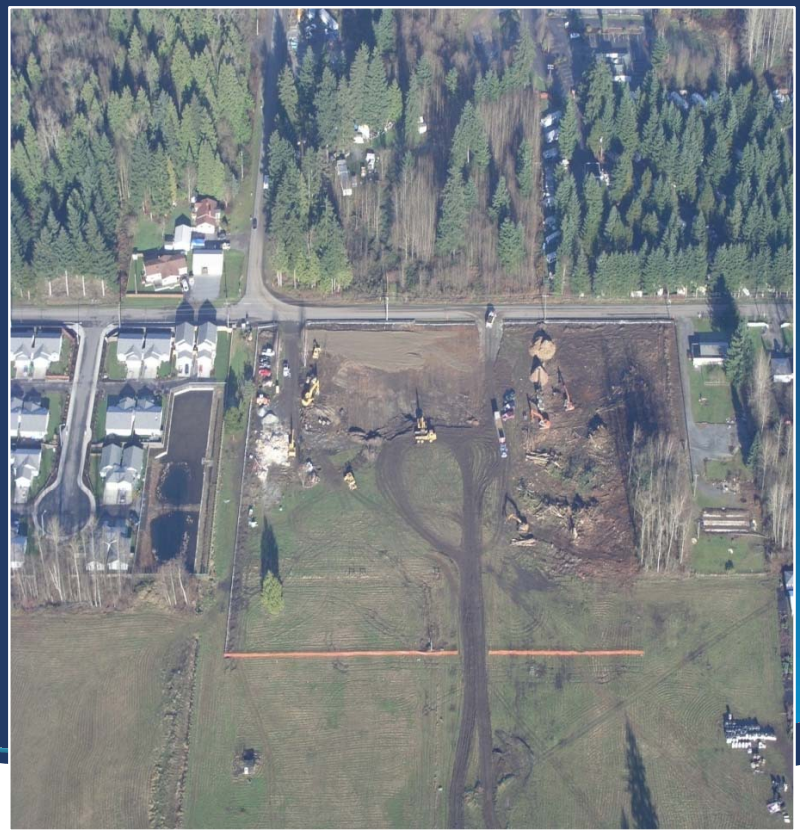
- Choker Course
  - ¼" to 5/8" inch clean crushed rock (no fines)
- Storage Layer
  - 1 ¼" Clean crushed rock
  - No fines
  - WSDOT 9-03.09(2) Permeable Ballast
  - Specification 30% voids (tested at 42%)
- Bank Run
  - Less than 5% minus #200 standard sieve
  - Greater permeability than the native subgrade

SUBGRADE PREPARATION

- Stripping depth
- Uniformity of subgrade support
- Static Roll
- Geotextile

CONSTRUCTION

- Static roll or No roll
- Truck traffic to a minimum, establish haul routes
- Erosion control
- Finished product protection



SUBGRADE PROTECTION

- Siltation from other areas
- Truck Traffic
- Concrete washouts

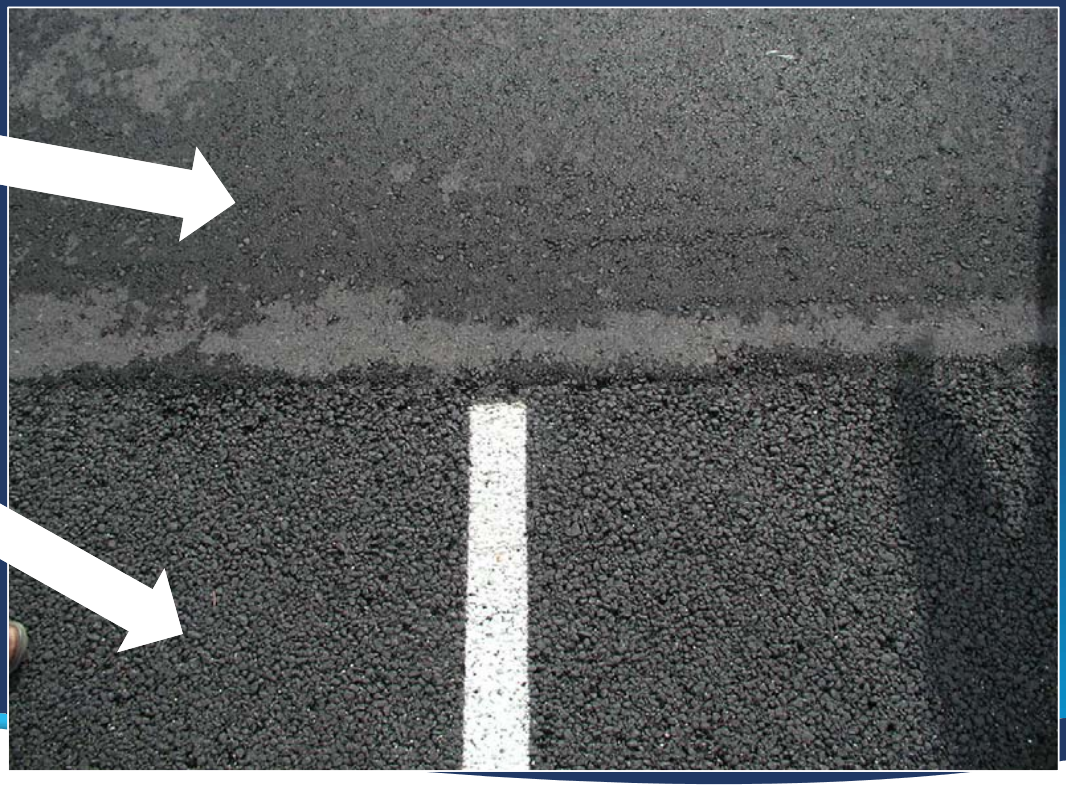
SECTION PLACEMENT

- Geotextile use
- Ballast placement
- Static Roll

CONSTRUCTION JOINT

Class B

Porous



TARGET PARKING LOT

Class B

Porous

PROBLEMS?!?