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# Particle Size Analysis: How Selecting the Correct PSA Test can Change Applicable Regulatory Standards

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## Safety moment – PPE

Plan ahead!

1. Know what your tasks are and the required PPE
2. Read the SDS for any chemicals that you may be using including preservatives
3. Evaluate hazards to ensure PPE is appropriate



# Agenda

- An introduction to Particle Size
- Particle Size Methodology
  - Sieving and Sedimentation
- Applications of Particle Size Analysis
- Regulations and how Particle Size can shape remediation requirements.



# Particle Size Analysis

- Sometimes also referred to as 'Grain Size'
- The measurement of the amount of a particles of a specified size in a sample
- Can be expressed in several ways
  - % passing : Percentage of a sample that passes a specified size
  - % Retained : Percentage of sample retained by a specific sieve size
  - Discrete size ranges : Defined size ranges meaningful to specific classification systems
    - Sand, silt, and clay. But what are they?
  - Texture classification
  - d-values: particle size of the particles where a specified percentage will pass (e.g. d10)





# Particle Size Analysis Methods

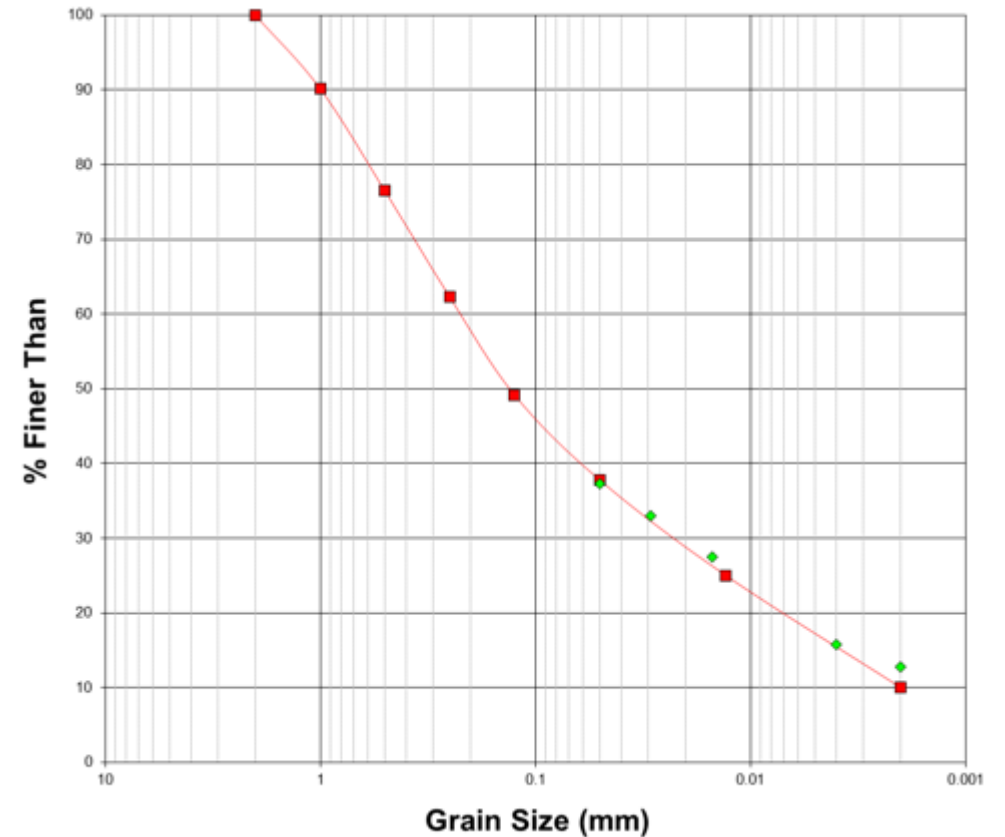
- ASTM D422-63 was the primary standard method used for many years
  - Has been withdrawn as of 2017
  - Still present in various references, guidance manuals, and regulations
- ASTM D7928 and ASTM D6913
  - Splits Particle Size analysis into two separate methods
    - ASTM D7928 Sedimentation Analysis by Hydrometer
    - ASTM D6913 Sieve Analysis
- Soil Sampling and Methods of Analysis
  - Standard for Canadian soil testing
- CCME Method Manual Vol 4
  - Used for primary guidance on both Texture Class and Fine/Coarse



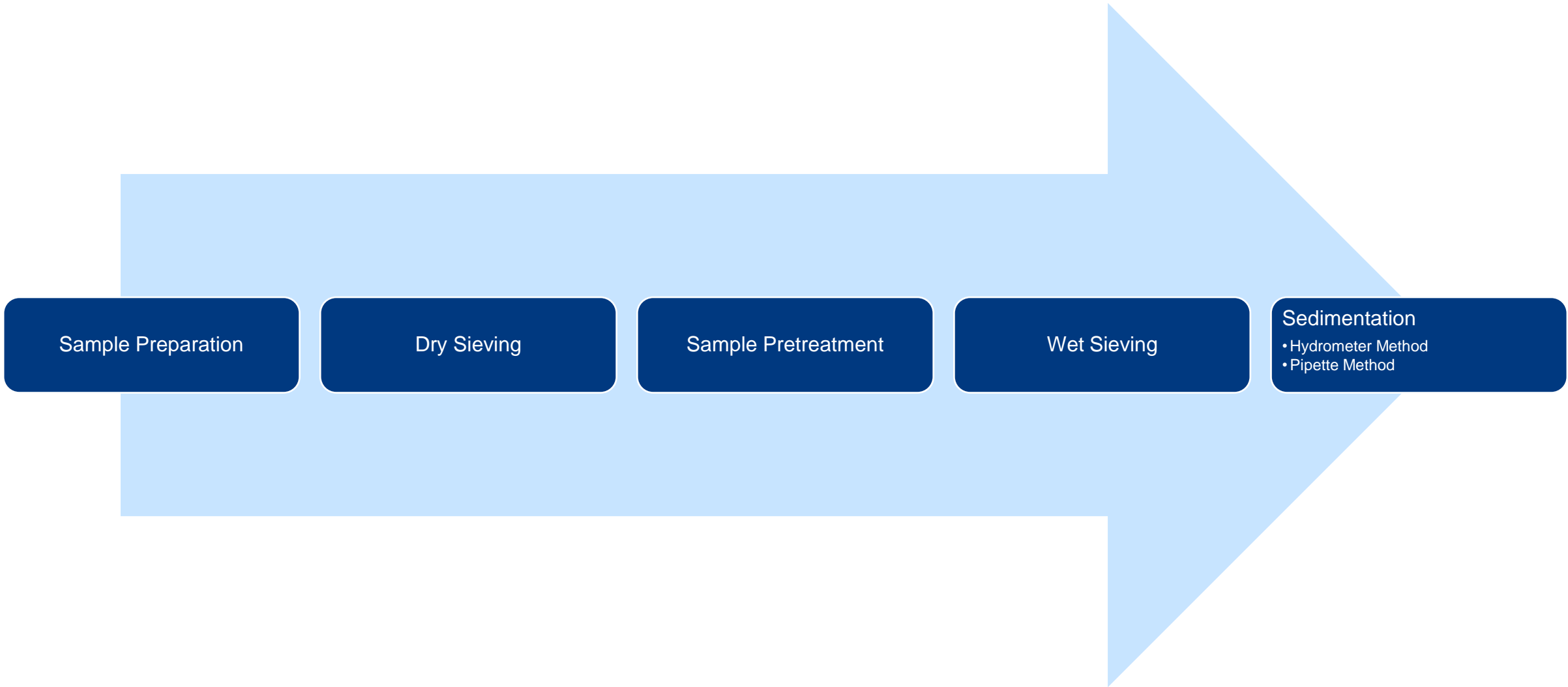
# How to test Particle Size in Soil



- Several methods are used for Particle Size testing:
  - Sieving
    - Dry Sieving
    - Wet Sieving
  - Sedimentation
    - Hydrometer
    - Pipette
- Other methods are available for testing as well:
  - Laser PSD
  - High speed photography



# Particle Size Workflow



# Specimen Size

- The maximum particle size will define the minimum aliquot size
- For typical soils, we may assume maximum particle size of 2 mm
- Is it representative?
- Analytical uncertainty of size fractions may increase as you increase particle size

Maximum Particle Size, mm	Method A Results Reported to Nearest 1 %	Method B Results Reported to Nearest 0.1 %
0.425	50 g	75 g
2.00	50 g	100 g
4.75	75 g	200 g <sup>B</sup>
9.5	165 g <sup>C</sup>	D
19.0	1.3 kg <sup>C</sup>	D
25.4	3 kg <sup>C</sup>	D
38.1	10 kg <sup>C</sup>	D
50.8	25 kg <sup>C</sup>	D
76.2	70 kg <sup>E</sup>	D



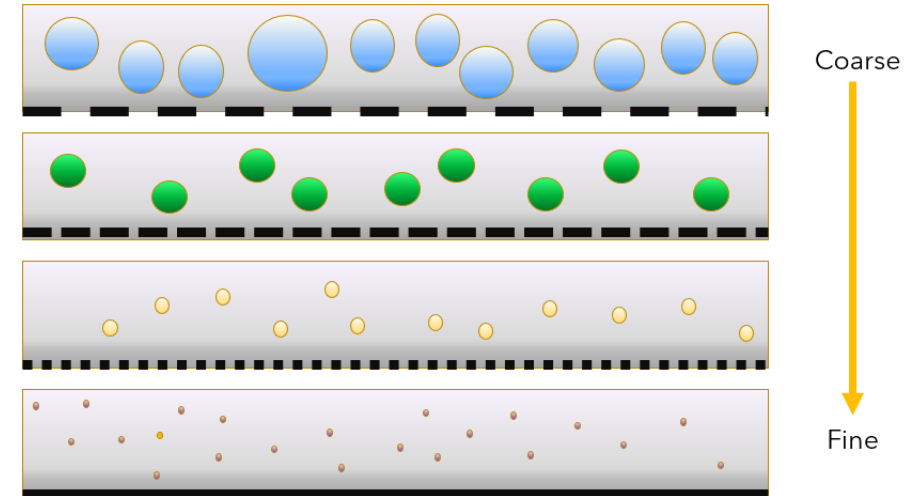
- Method A: Composite Sieve
- Method B: Single Set Sieve



# Sieve Analysis



- Specimen is separated into individual size fractions using a series of sieves
- Two different sieving methods
  - Dry Sieving – Sieving with mechanical agitation
  - Wet Sieving – Sieving with the aid of water



- Two different approaches
  - Composite sieving
    - Split the sample into two portions: fine and coarse
  - Single set sieving
    - A single set of sieves used over the entire range
    - Sand fractionation

# Sample Pretreatment



- Sample properties to consider for pretreatments

- Is there material which can interfere?

- Organic Matter
- Carbonates
- Salinity (Salts)

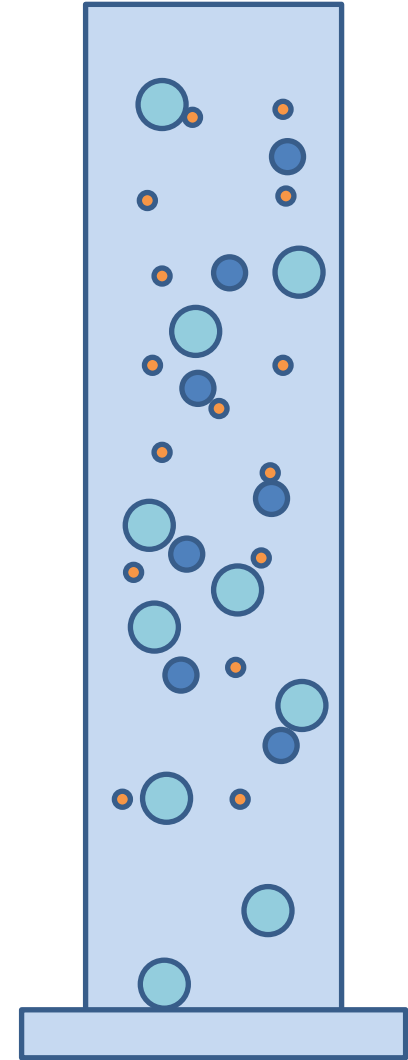
- Are there aggregates?

- Clumps of fine material clumped together
- Could be treated as larger particles unless dispersed
  - Physical Dispersion: Shaking, Milkshake mixer, Mortar and Rubber Pestle
  - Chemical Dispersion: Using a chemical such as Calgon to chemical disperse the sample



# Sedimentation Methods

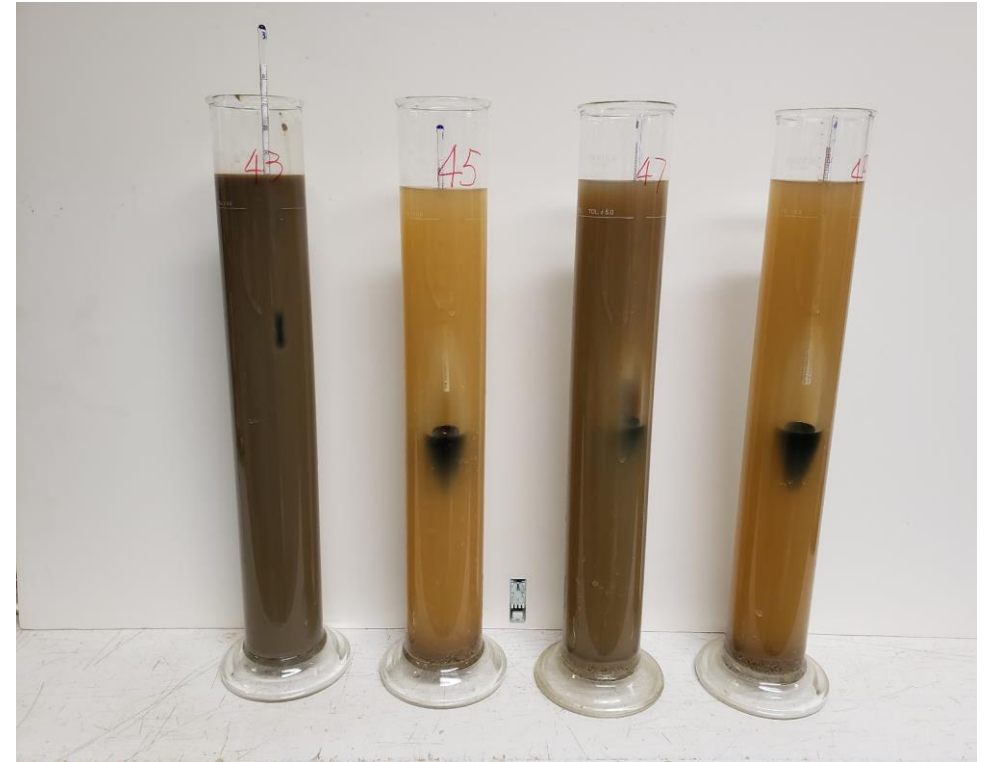
- Used to determine the smaller particle sizes.
  - Too small for sieves
- Based on the principles of Stokes' Law
- Certain Assumptions are made
  - Spherical Particles
  - Smooth Surfaces
  - No inter-particle interactions
- Principle:  
Larger Particles will settle faster than Smaller Particles



# Sedimentation Methods



- Two methods typically used
  - Hydrometer Method
    - Referee Method
    - Determines relative density of the suspension
    - The more particles in solution, the higher the fluid density
  - Pipette Method
    - Direct measurement of the suspension
    - Gravimetric determination of the suspension

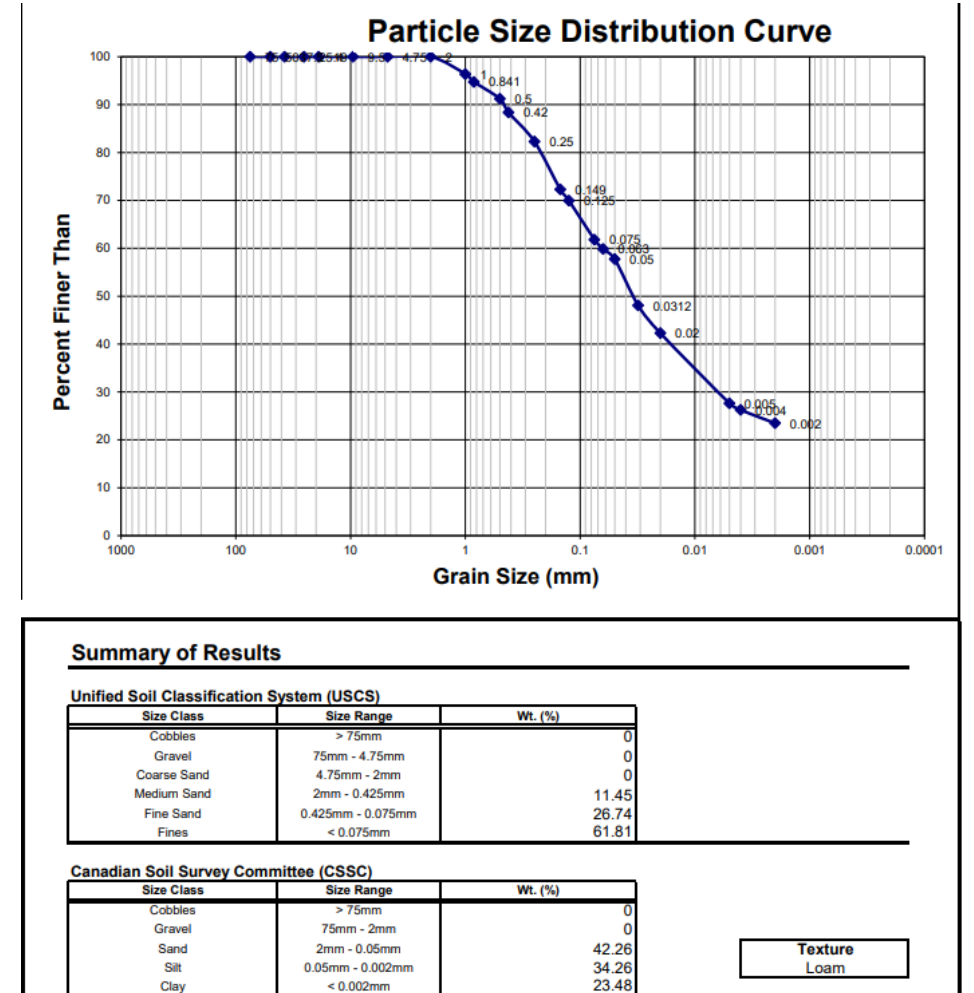


- Both methods are equivalent but sometimes may be prescribed

# Reporting for Particle Size



- Typical reports are based on the classification used
- Can be simple or complex
- Simple Reporting
  - Fine/Coarse
  - “PSA-1” Soil Texture classification
  - Sand Fractionation
- Complex reporting
  - Different classification systems
  - Grain Size Curve
  - D% reporting



# PSA Applications



- Applications can be based on the classification systems

— Wentworth

— AASHTO

— Unified

— CSSC

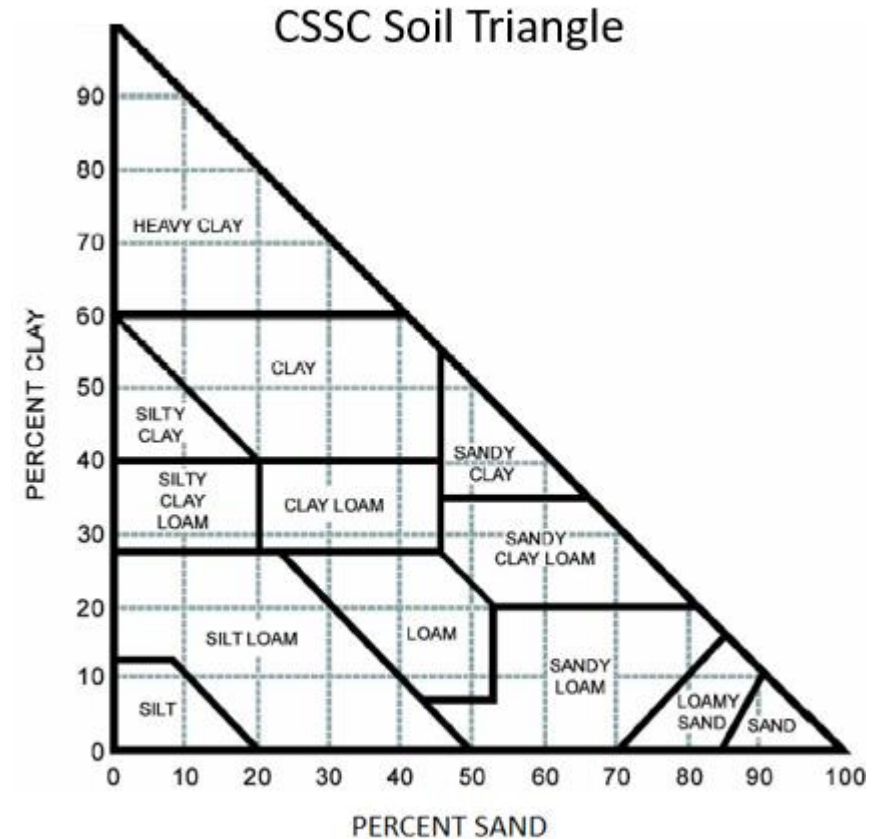
- Clay: < 0.002 mm
- Silt: 0.05 mm – 0.002 mm
- Sand: 2.0 mm – 0.05 mm

	FINE EARTH										ROCK FRAGMENTS												
	Clay		Silt		Sand						Gravel			6" 150	15" 380	24" 600 mm							
USDA	fine	co.	fine	co.	v.fi.	fi.	med.	co.	v.co.	fine	medium	coarse	channers	flagst	stones	boulders							
millimeters:	0.0002	.002 mm	.02	.05	.1	.25	.5	1		2 mm	5	20	76	250 mm	600 mm								
U.S. Standard Sieve No. (opening):			300	140	60	35	18	10		4	(3/4")	(3")	(10")	(25")									
International	Clay	Silt	Sand						Gravel	Stones													
millimeters:		.002 mm	.02	fine		coarse				2 mm	20 mm												
U.S. Standard Sieve No. (opening):										10	(3/4")												
Unified	Silt or Clay		Sand			Gravel		Cobbles	Boulders														
millimeters:			.074	.42	2 mm	4.8	19	76	300 mm														
U.S. Standard Sieve No. (opening):			200	40	10	4	(3/4")	(3")															
AASHTO	Clay	Silt	Sand		Gravel or Stones			Broken Rock (angular), or Boulders (rounded)															
millimeters:		.005 mm	.074	.42	2 mm	9.5	25	75 mm															
U.S. Standard Sieve No. (opening):			200	40	10	(3/8")	(1")	(3")															
phi #:	12	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-12
Modified Wentworth	← clay		silt		sand						pebbles			cobble		boulders →							
millimeters:	.00025	.002	.004	.008	.016	.031	.062	.125	.25	.5	1	2	4	8	16	32	64	128	256				4092 mm
U.S. Standard Sieve No.:								230	120	60	35	18	10	5									

# PSA Applications



- Applications can be based on the classification systems
  - Wentworth
  - AASHTO
  - Unified
  - CSSC
- Can be used for texture classification (sand, silt clay)
  - Used in determining soil properties, fertilizer applications
- Texture classification (Fine/Coarse)
  - Used in regulatory evaluations

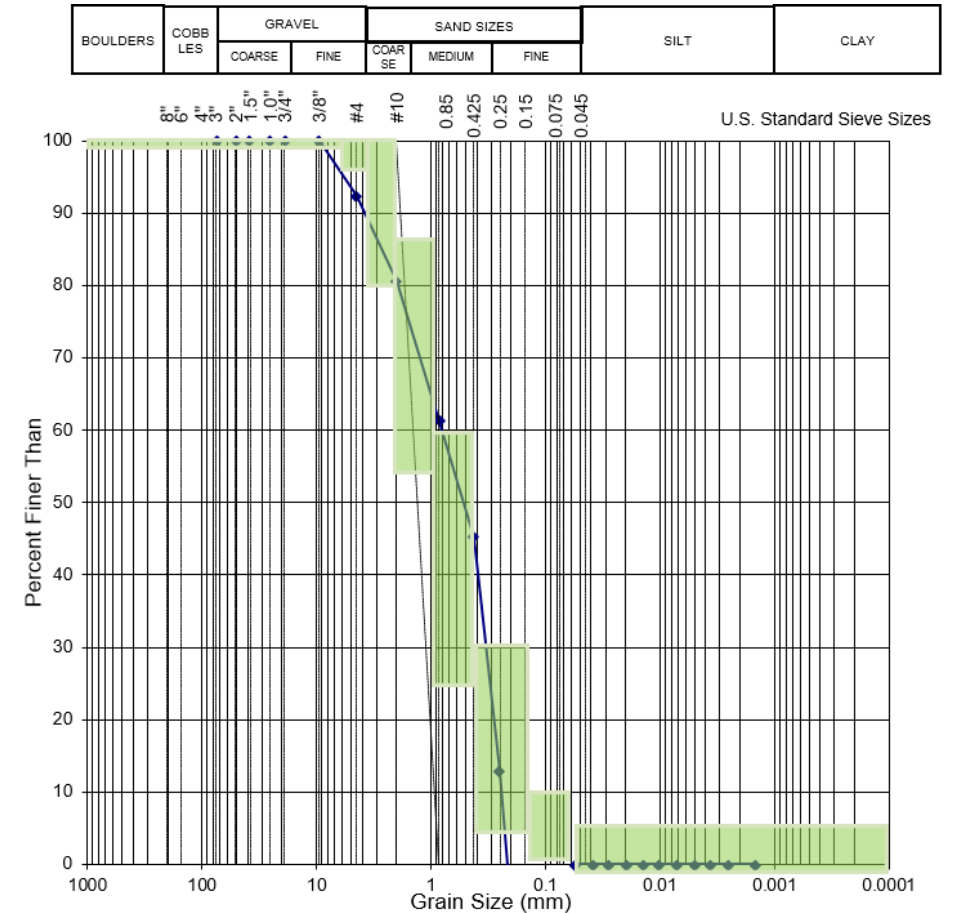


Courtesy of AAFC CSSC

# PSA Applications



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- Texture classification (Fine/Coarse)
  - Used in regulatory evaluations
- Other regulatory applications
  - Septic field requirements
  - MMER Applications (Metal and Diamond Mining Effluent Regulations)





# PSA for Regulatory Purposes

- Fine/Coarse texture class is defined based on material passing a 0.075 mm sieve
  - > 50% passing = Fine
  - $\leq$  50% passing = Coarse
- Typical analysis is sieving the material with the aid of water (Wet sieve)
- But what gets testing for fine/coarse?
  - CCME & SK - Whole sample used for evaluation (including > 2mm)
  - Ontario – Perform fine/coarse evaluation on < 2mm portion
  - Alberta
    - Evaluate >2mm. If > 70%, treat as coarse
    - Otherwise, perform fine/coarse evaluation on < 2mm portion





# Applications to CCME guidelines

- The texture of a soil can impact the regulatory guidelines
- Typically, soil texture will impact the mobility of the analytes
  - Coarse material allows for higher mobility
- For example, Xylene in Soil (Residential/Parkland)

Concentration (mg/kg dry weight) Residential/ parkland Table

<i>Guideline</i>	<i>Coarse</i>	<i>Fine</i>
Xylenes (mg/kg)		
Surface ( $\leq 1.5\text{m}$ )	11	2.4
Subsoil ( $> 1.5\text{m}$ )	11	2.4

Retrieved from CCME.ca on 2-Oct-2023



# Alberta Guidelines

- Particle size can impact how to classify the sample
- Risk-based approach
  - If there is significant (>70% > 2 mm) larger particles, a tier 1 approach is not appropriate.
  - Fine and coarse can be further evaluated on the < 2mm
- Alberta soil and ground water guidelines give values based on fine and coarse for evaluation. For example, F3 Direct Soil Contact

Receptor	Overall Guideline		Human		Ecological								Other		
	Pathway		Protection of Domestic Use Aquifer	Direct Soil Contact	Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life	Protection of Wildlife Water	Management Limit					
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse	-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Benzene	0.046	0.078	0.046	0.078	120	62	-	na	na	7.9	0.17	15	0.33	-	-
Toluene	0.52	0.12	0.52	0.95	220	150	-	na	na	63,000	0.12	NGR	1,000	-	-
Ethylbenzene	0.073	0.14	0.073	0.14	240	110	-	na	na	NGR	540	NGR	17,000	-	-
Xylenes	0.99	1.9	0.99	1.9	130	190	-	na	na	NGR	41	NGR	16,000	-	-
F1	420	420	1,100	2,200	420	420	-	na	na	30,000	1,300	NGR	30,000	800	700
F2	300	300	1,500	2,900	300	300	-	na	na	30,000	520	NGR	30,000	1,000	1,000
F3	2,600	600	-	-	2,600	600	-	na	na	-	-	-	-	3,500	2,500
F4	10,000	5,600	-	-	11,200	5,600	-	na	na	-	-	-	-	10,000	10,000



# Alberta Tier 2 requirements

- Very coarse textured Materials
- Enhances groundwater or vapor transport
- Requires a risk-based assessment of contaminants



Review of pathways including

- Groundwater
- Soil Contact
- Ingestion by Wild Life

# Alberta Analytes affected by PSA



- Soil and Groundwater guidelines can be affected
  - VOCs including BTEX
  - PHC F1-F4
  - Pesticides and Herbicides
  - Polycyclic Aromatic Hydrocarbons (PAHs)

Water Use	Lowest Guideline	
	Fine	Coarse
Soil Type		
Unit	(mg/L)	(mg/L)
Pyrene	0.71	0.000092
Methoxychlor	0.90	0.00017

Some analytes have guideline differences orders of magnitude different!

# Summary



- Particle Size Determination can be used in a number of different applications
- Used in determining regulatory needs
- For Fine/Coarse, It's important to know which method ap



CCME Federal and SK	'As Received'
Ontario	< 2mm evaluated only
Alberta	>70% 2mm Tier 2 Fine/coarse on < 2mm

- More complex particle sizes needed for construction, roadways, engineering projects
- Contact the laboratory as part of your sampling plan to identify your analytical and sampling needs

# Thank you!

Questions?



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