A method to quantify soluble sulfate from carbonate using HHXRF

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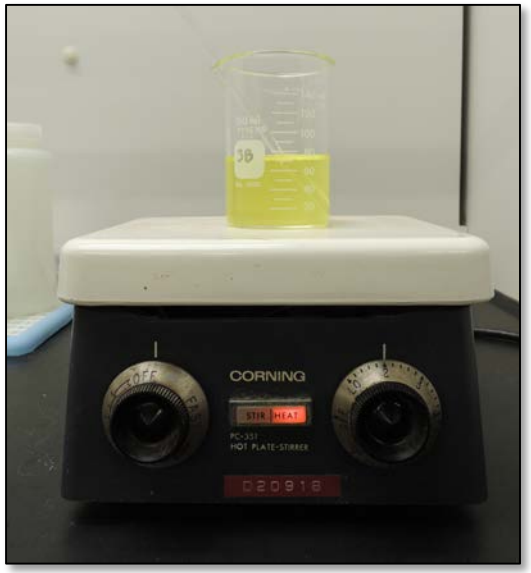
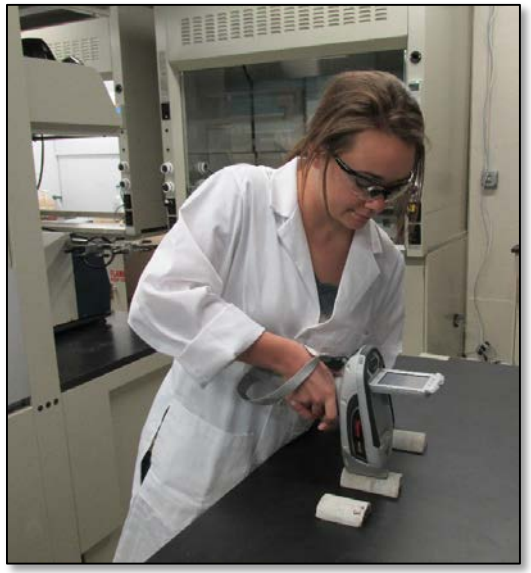
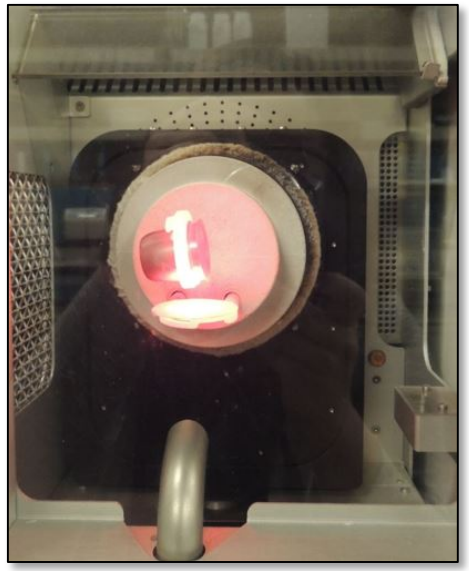
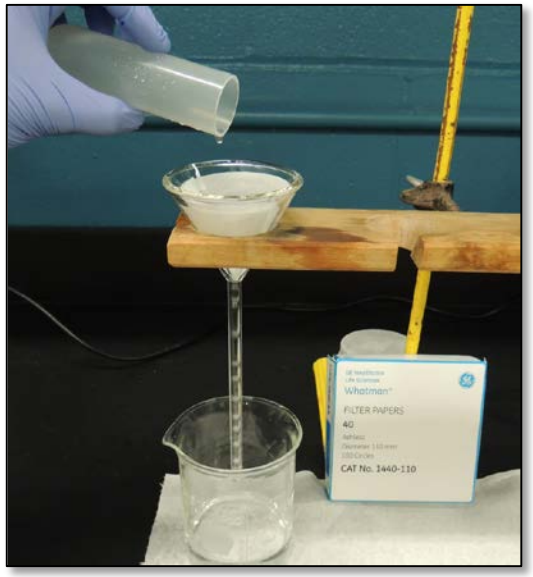
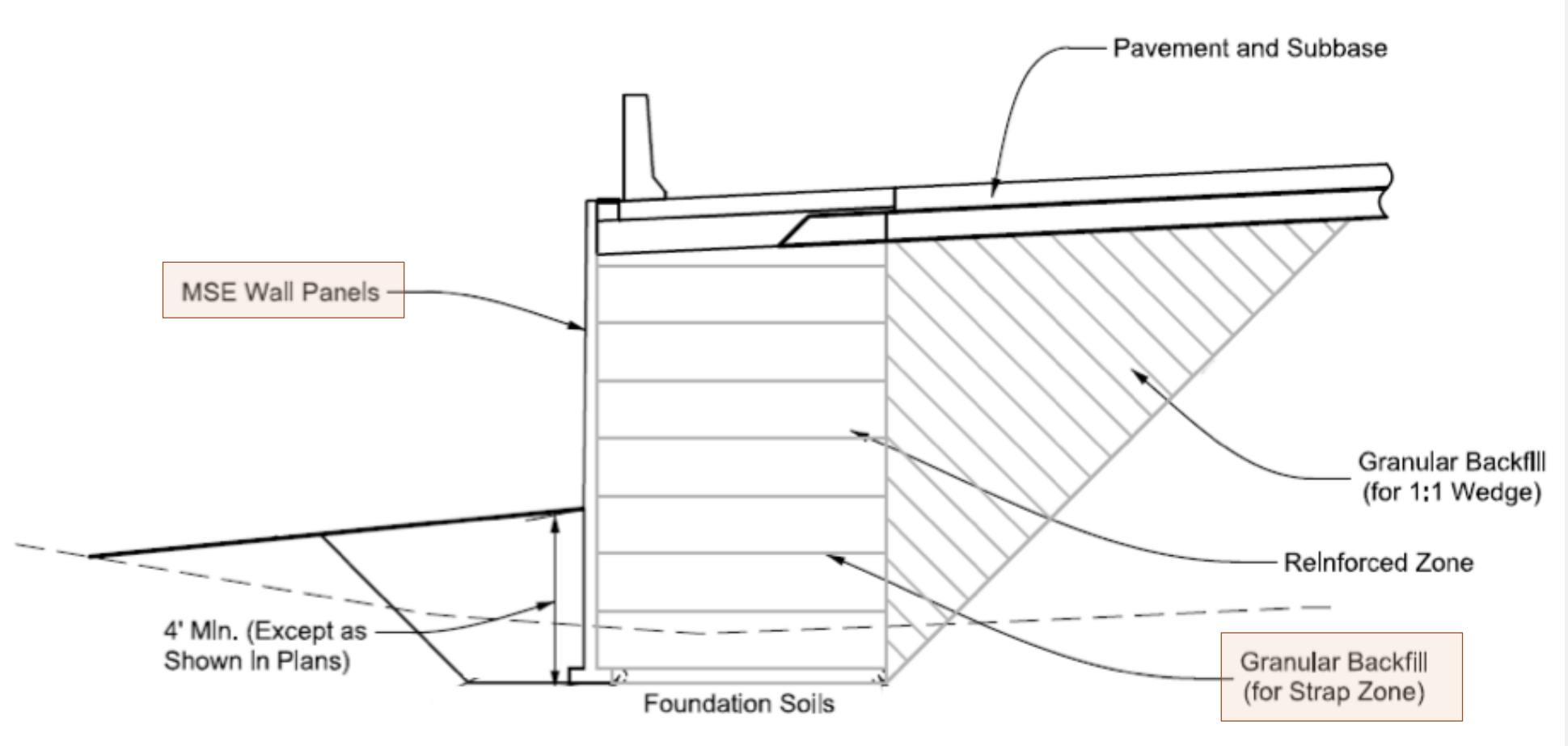


IDOT MATERIALS LAB

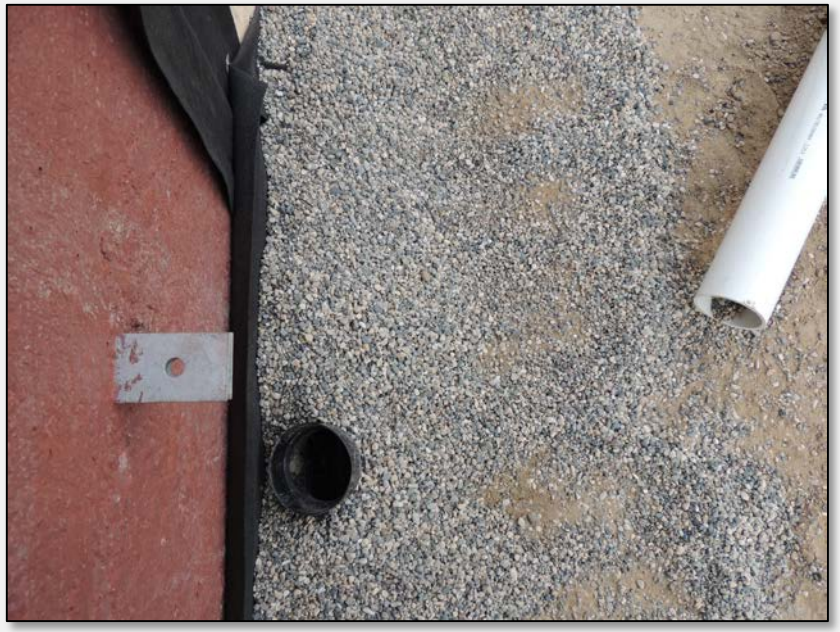

MSE WALL

MSE WALL


Pavement and Subbase
MSE Wall Panels
Granular Backfill
(for 1:1 Wedge)
Reinforced Zone
4' Min. (Except as
Shown in Plans)
Granular Backfill
(for Strap Zone)
Foundation Soils

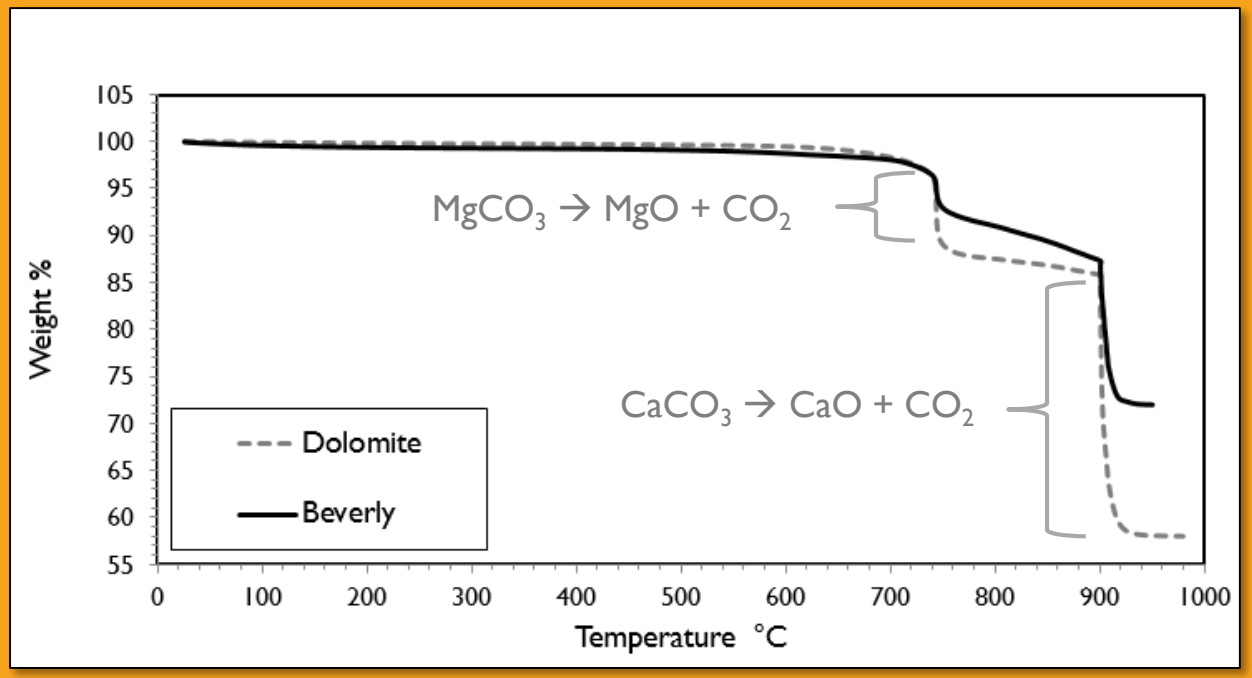
PANELS

GALVANIZED STRAPS & BACKFILL



CHANGE IN BACKFILL

BEVERLY CARBONATE - **235 PPM**



Source	CaO	MgO	SiO2	Al2O3	Fe2O3	TiO2	Cl	S	Na2O	K2O	MnO
Beverly	27.006	2.95	31.698	3.403	1.287	0.014	0.154	0.359	0.346	0.855	0.037

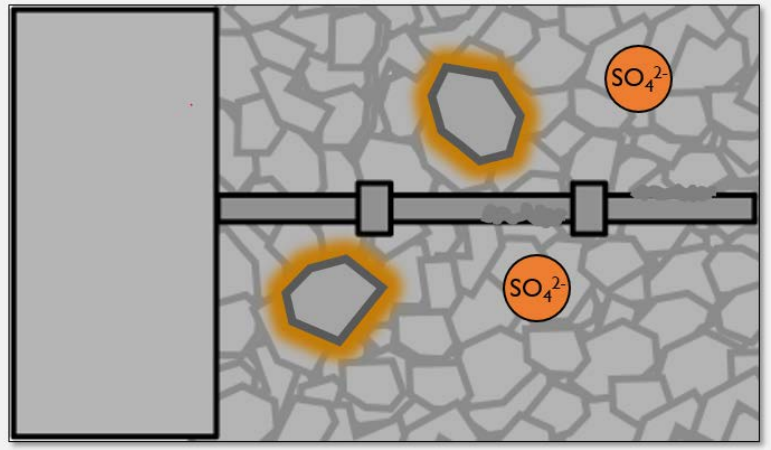
AASHTO METHOD T 290

Standard Method of Test for

Determining Water-Soluble Sulfate Ion Content in Soil

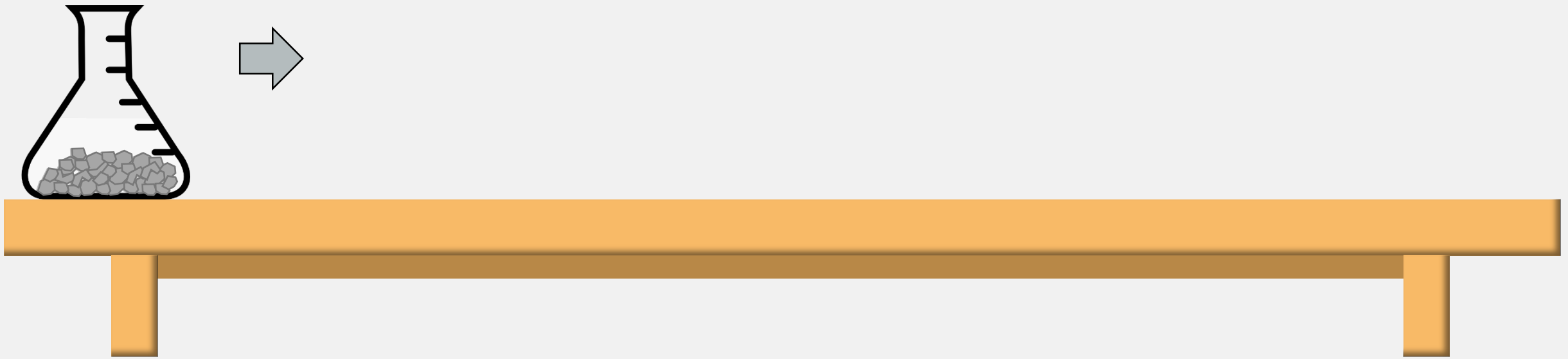
AASHTO Designation: T 290-95 (2016)[1]
Release: Group 3 (August 2016)

AASHTO

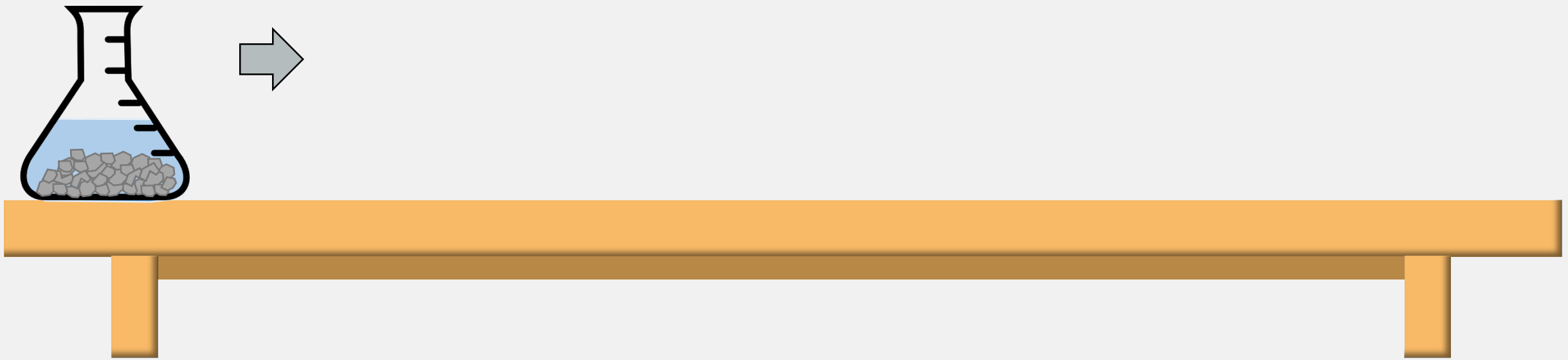


- 200 ppm SO_4 max

AASHTO T 290



AASHTO T 290



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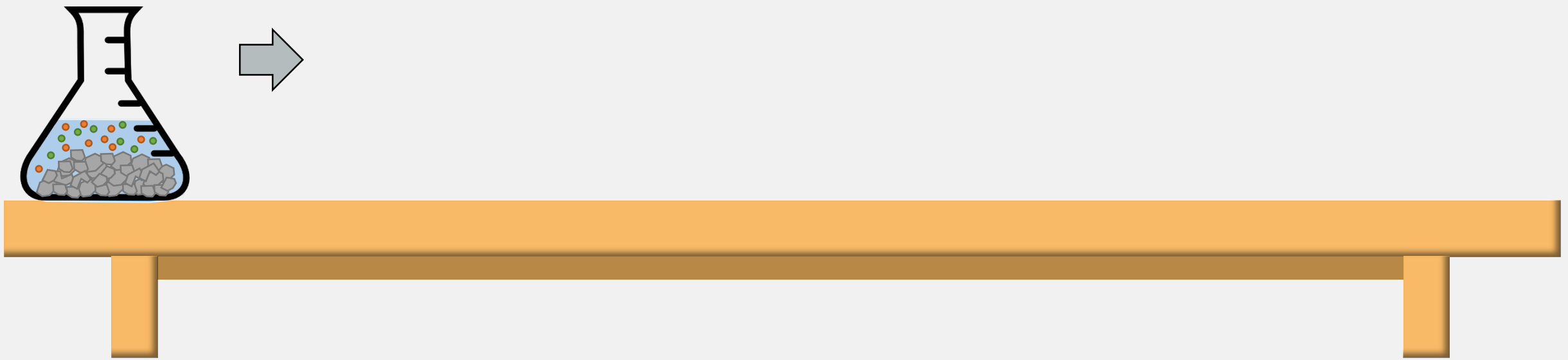
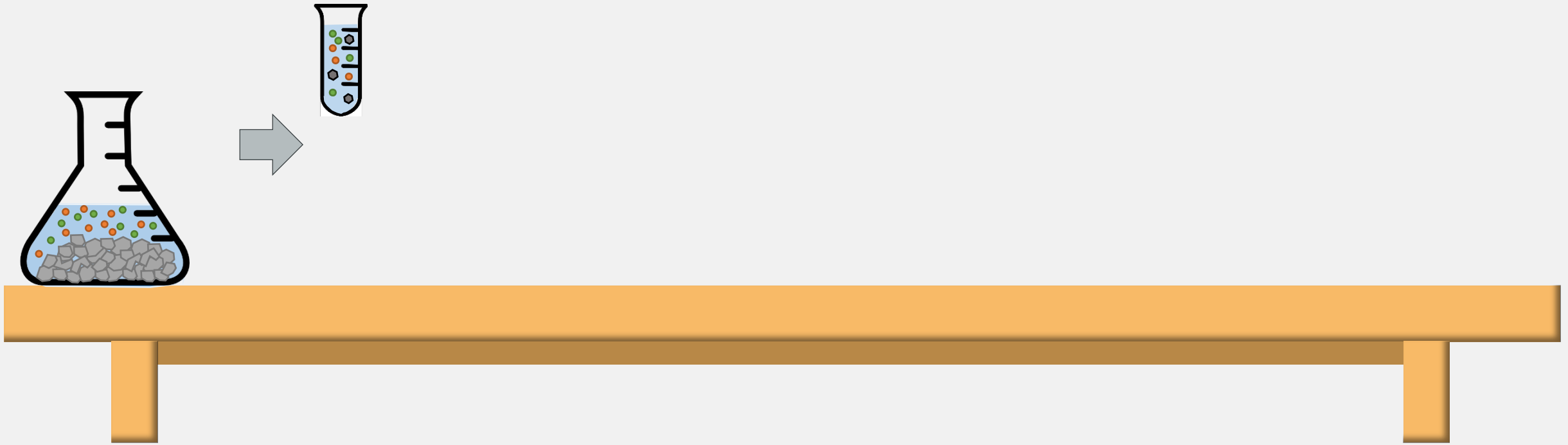
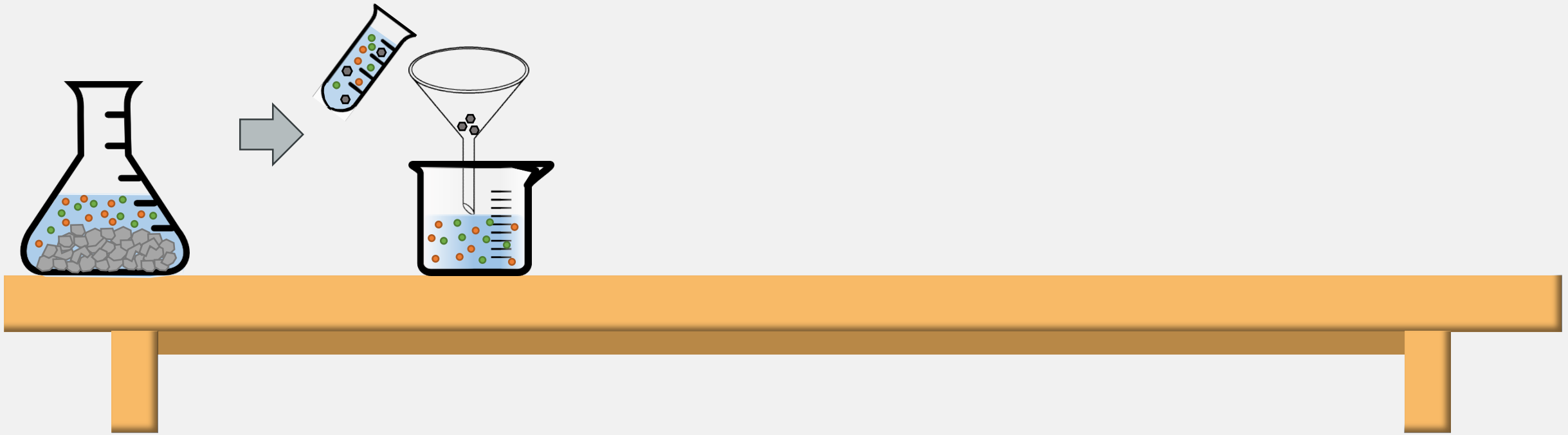


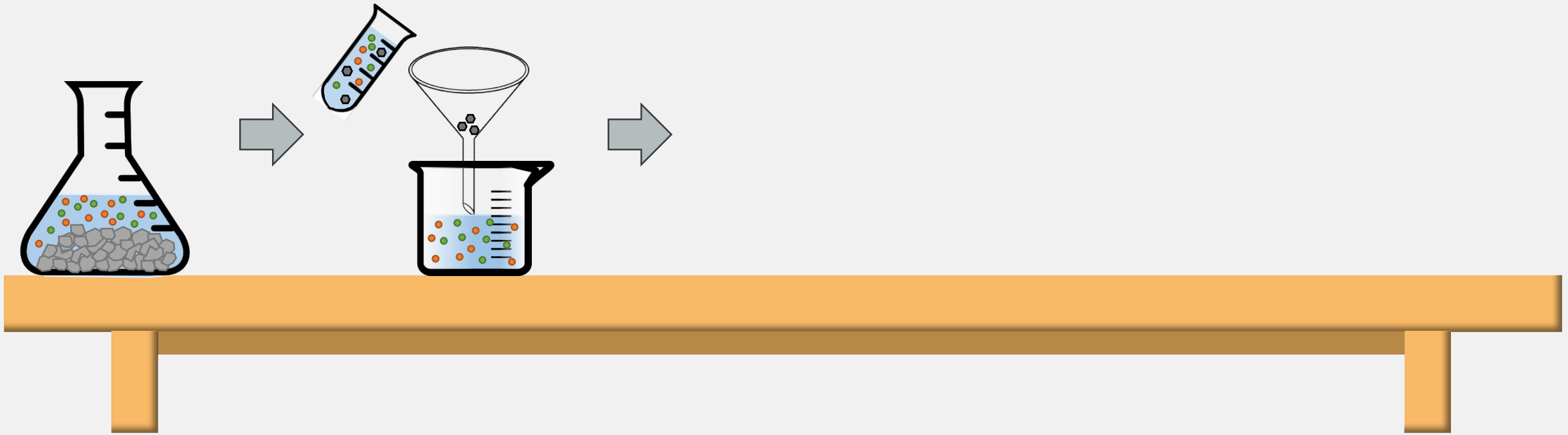
AASHTO T 290



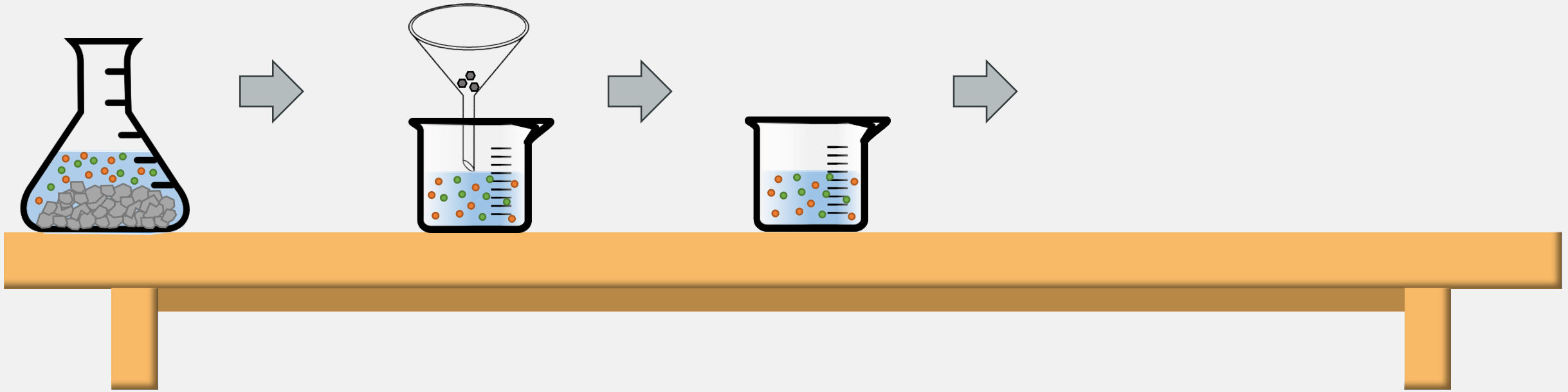
AASHTO T 290



AASHTO T 290

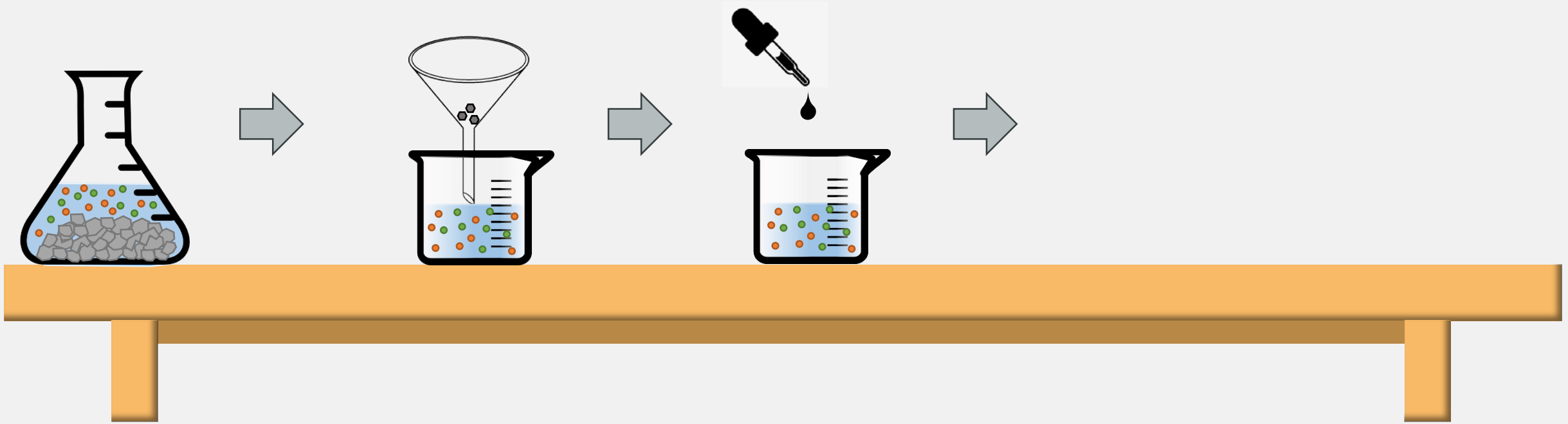


AASHTO T 290



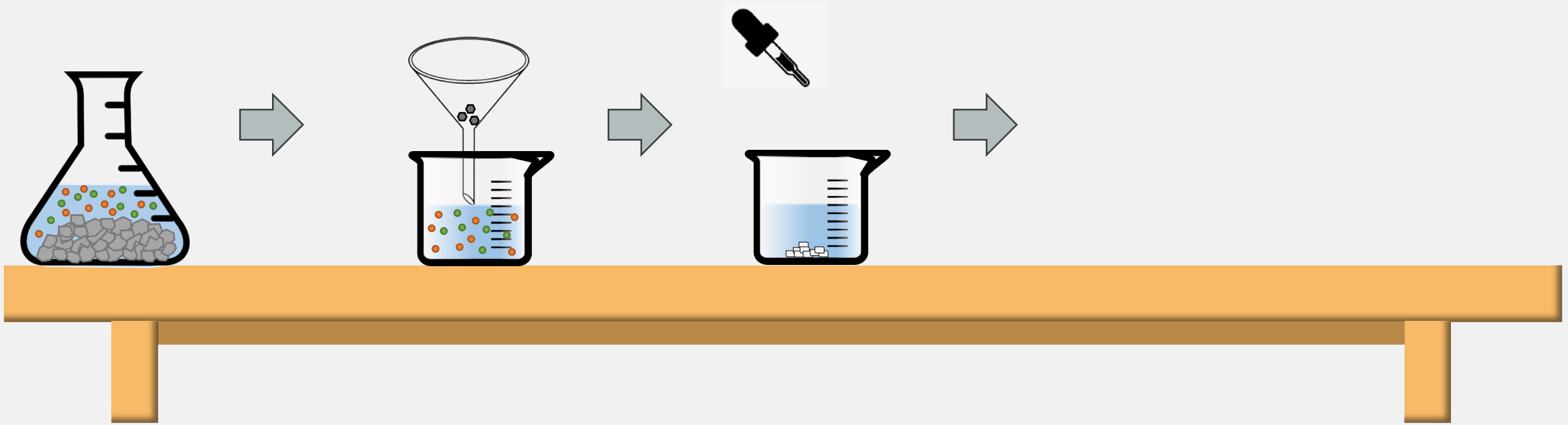
AASHTO T 290

$BaCl_{(aq)} + SO_{4(aq)} \rightarrow$

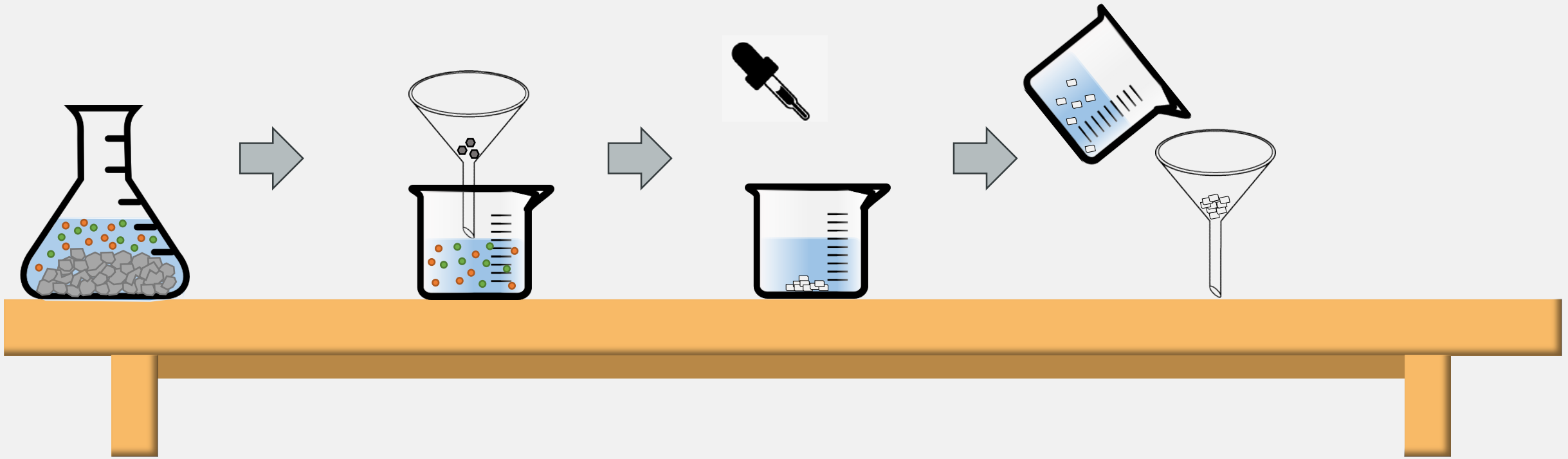


AASHTO T 290

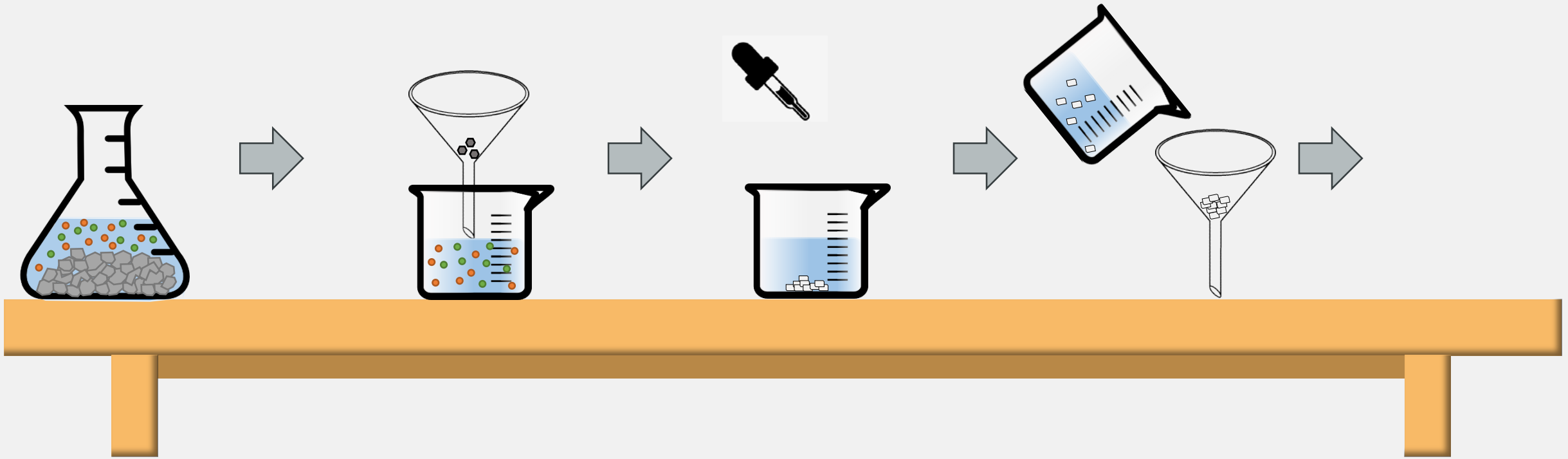
$$BaCl_{(aq)} + SO_{4(aq)} \rightarrow BaSO_{4(s)} + Cl_{(aq)}$$



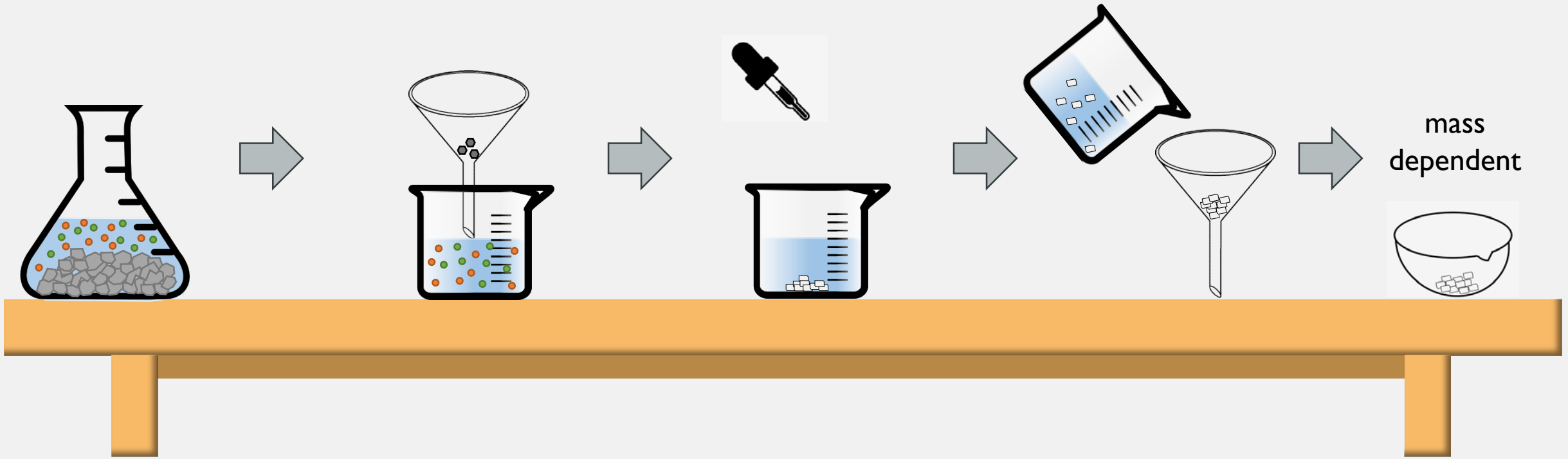
AASHTO T 290



AASHTO T 290



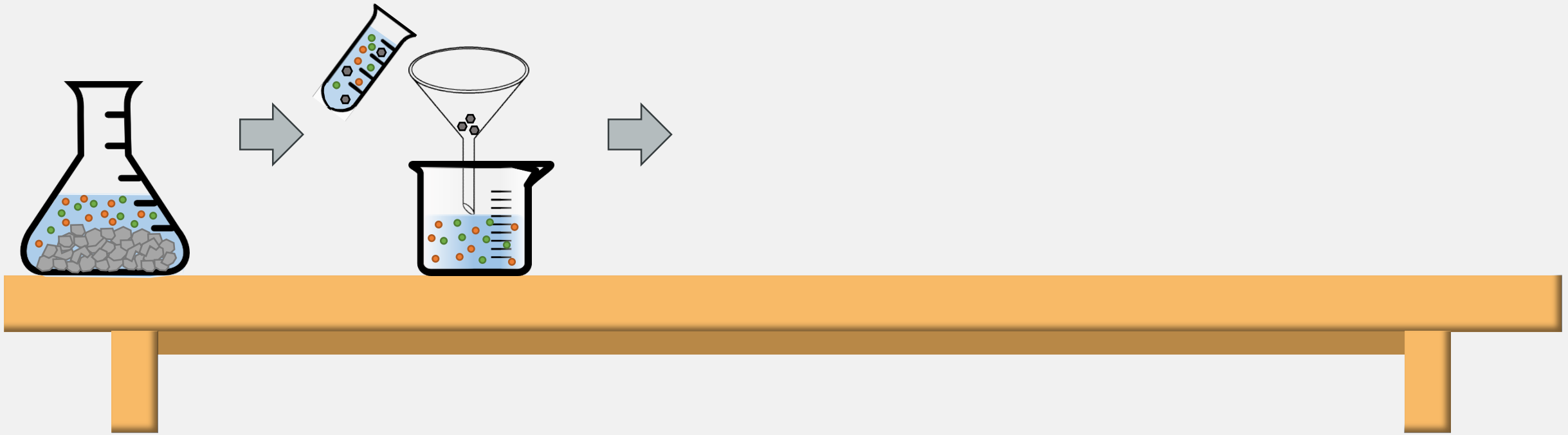
AASHTO T 290



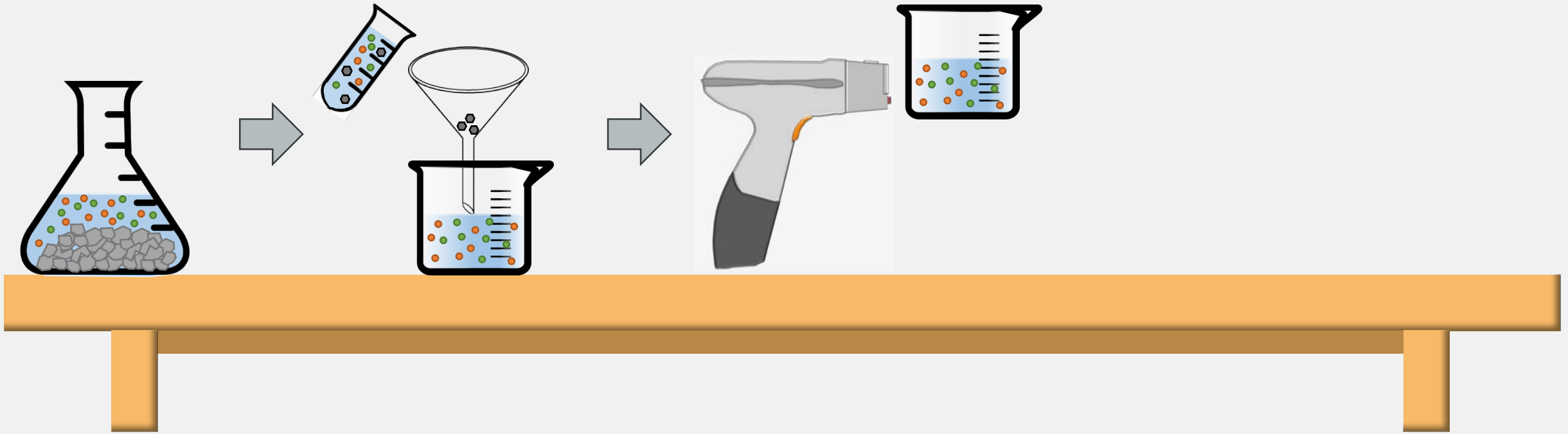
HHXRF METHODOLOGY

ThermoScientific Niton
XL3t GOLD handheld XRF

HHXRF METHODOLOGY



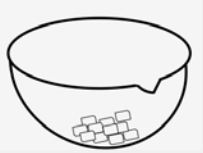
HHXRF METHODOLOGY



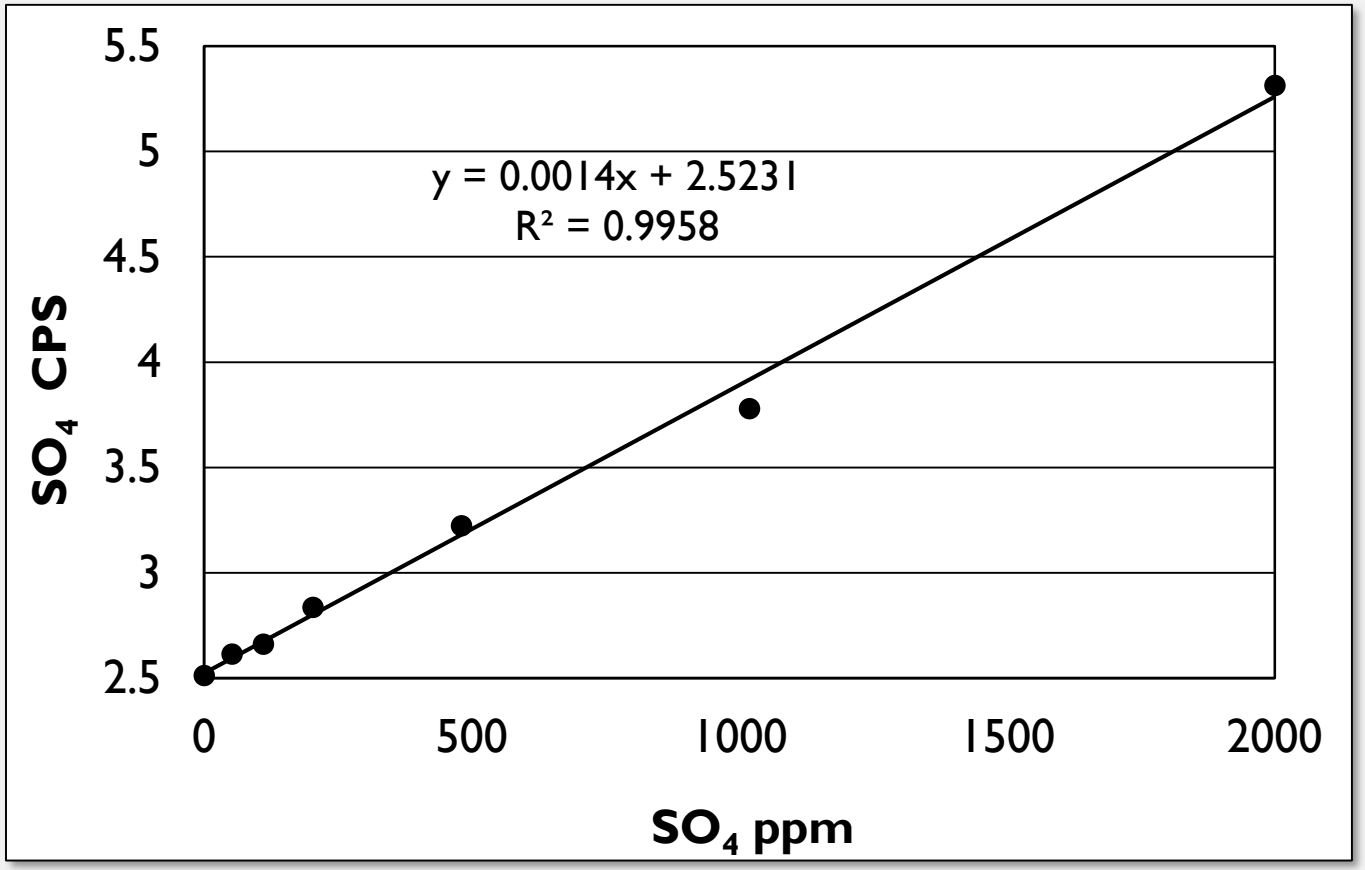
OBJECTIVES

1) Develop a method for quantifying soluble sulfate using HHXRF

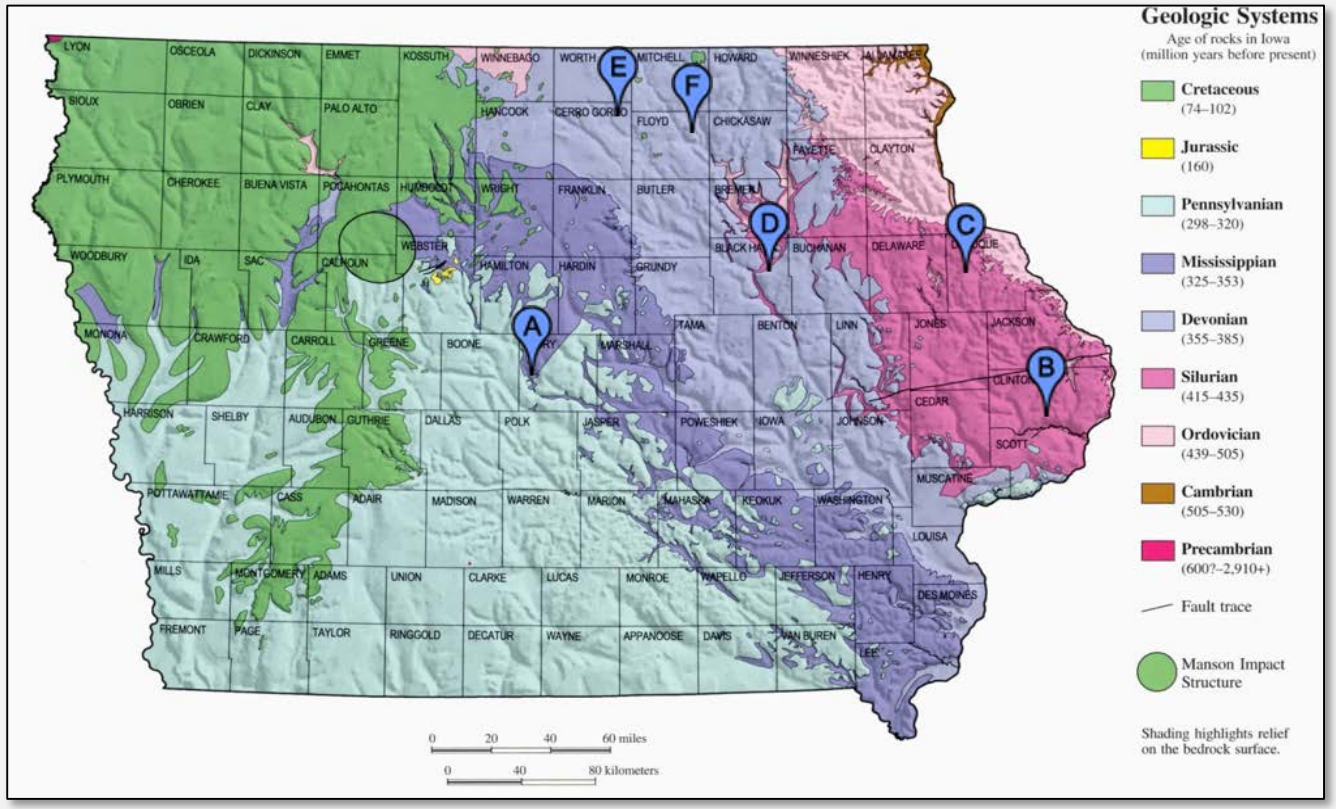
2) Determine why AASHTO method is yields unexpected sulfate



CALIBRATION



COMPARISON – AASHTO VS HHXRF

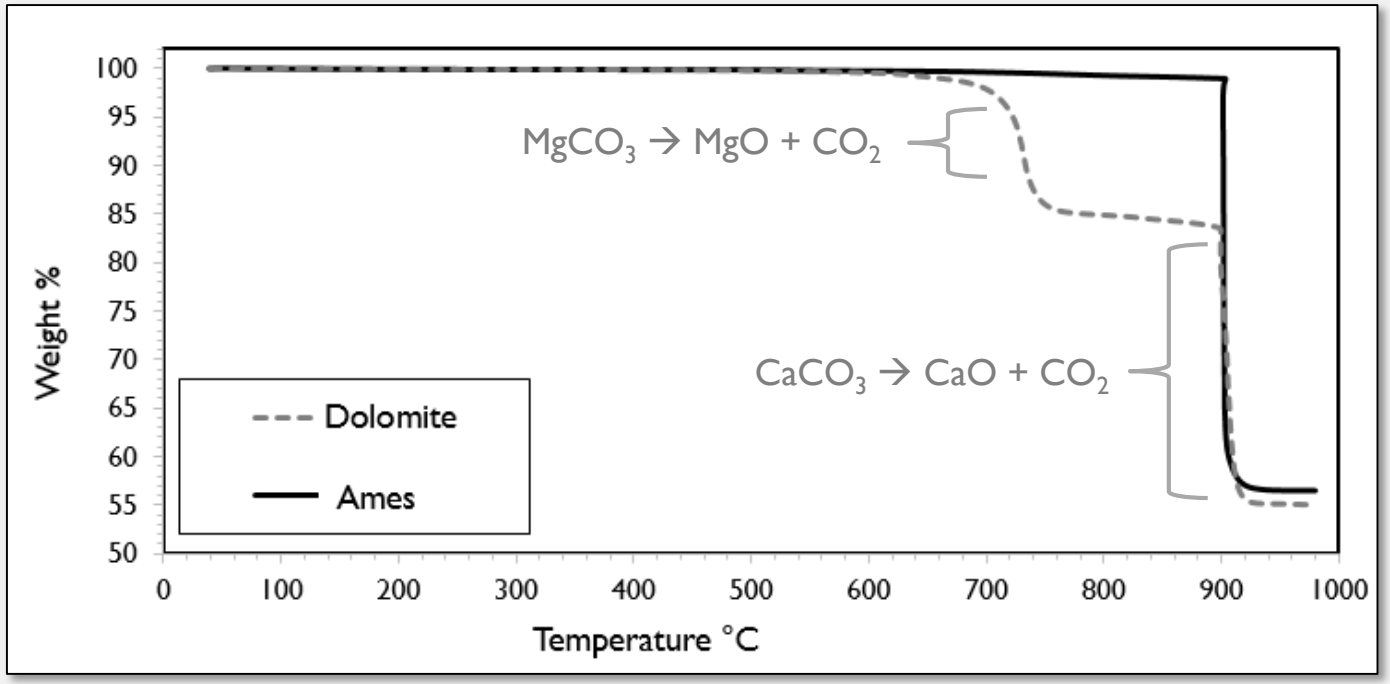


Source	HHXRF SO4 (ppm)	AASHTO SO4 (ppm)
Ames (A)	5	53
Beverly (B)	32	235
Dyersville (C)	BDL	134
Morgan (D)	BDL	14.8
Portland (E)	BDL	24.8
Warnholtz (F)	82	122

HHXRF consistently below AASHTO T 290

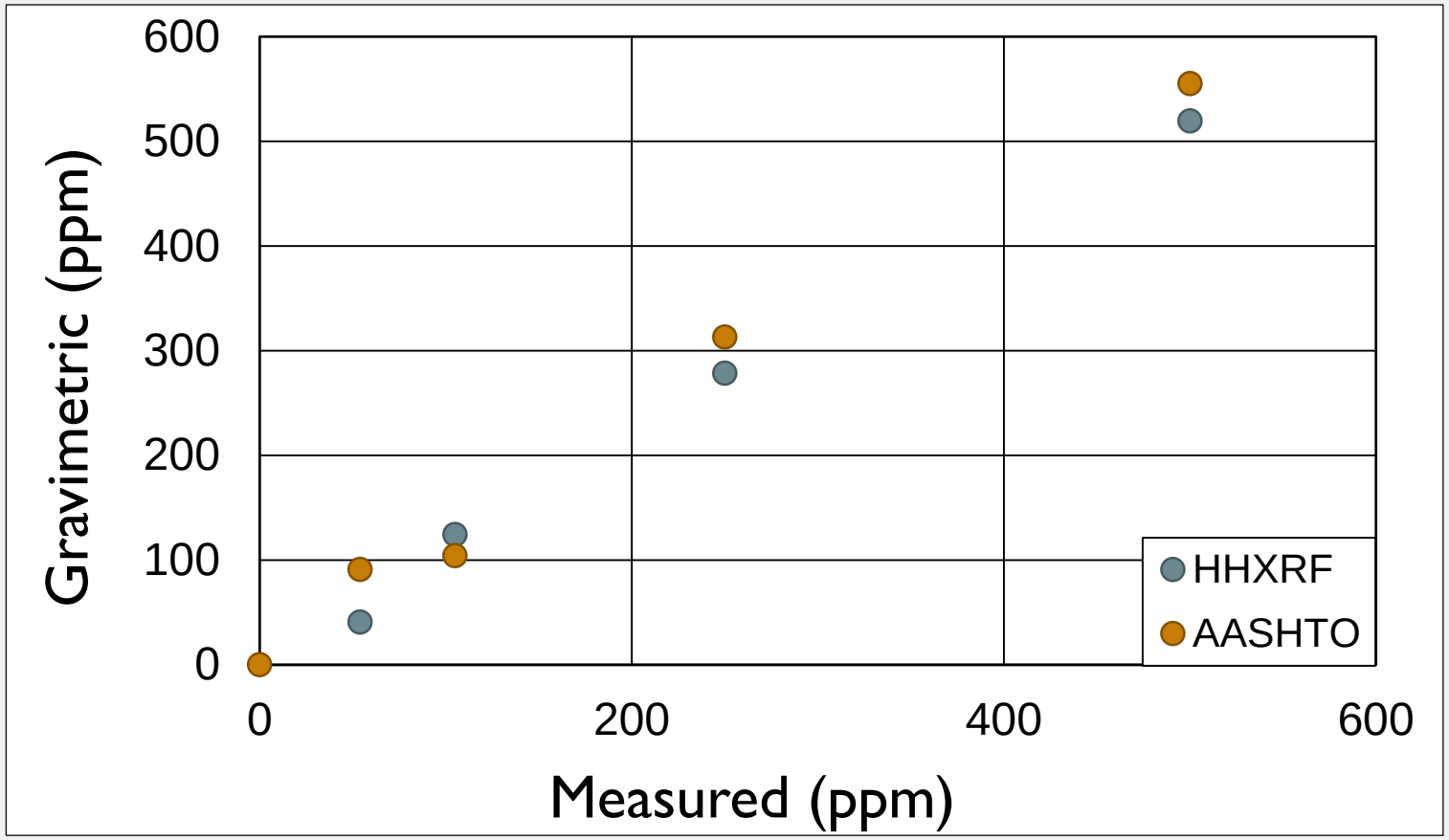
What is causing this discrepancy between the methods?

AMES LIMESTONE AS CONTROL



Source	CaO	MgO	SiO2	Al2O3	Fe2O3	TiO2	Cl	S	Na2O	K2O	MnO
Beverly	27.006	2.95	31.698	3.403	1.287	0.014	0.154	0.359	0.346	0.855	0.037
Ames	54.8	0.26	0.356	0.133	0.164	0.009	0.007	0.073	0.015	0.034	0.008

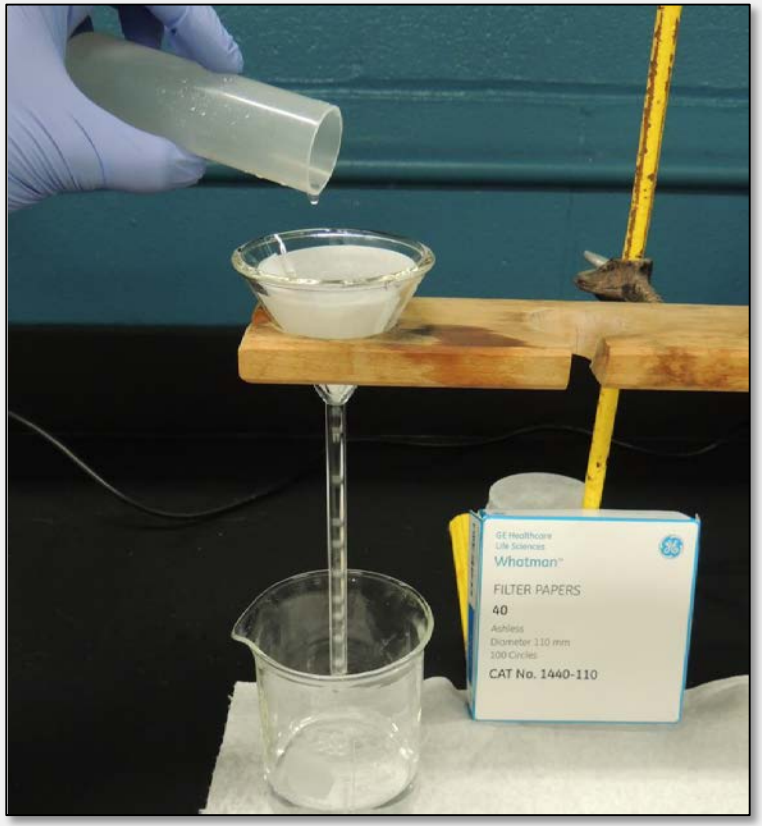
METHOD COMPARISON WITH CONTROLS



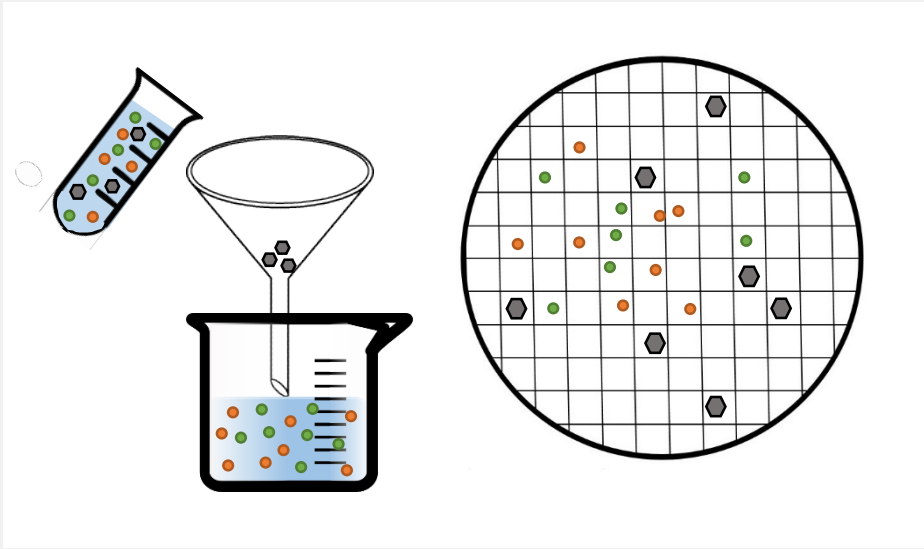
	HHXRF SO4 (ppm)	AASHTO SO4 (ppm)
0	BDL	0
50	41	91
100	124	105
250	278	393
500	519	557
1000	1090	1155

50 PPM

WHY IS THERE A DIFFERENCE?



WHATMAN FILTER

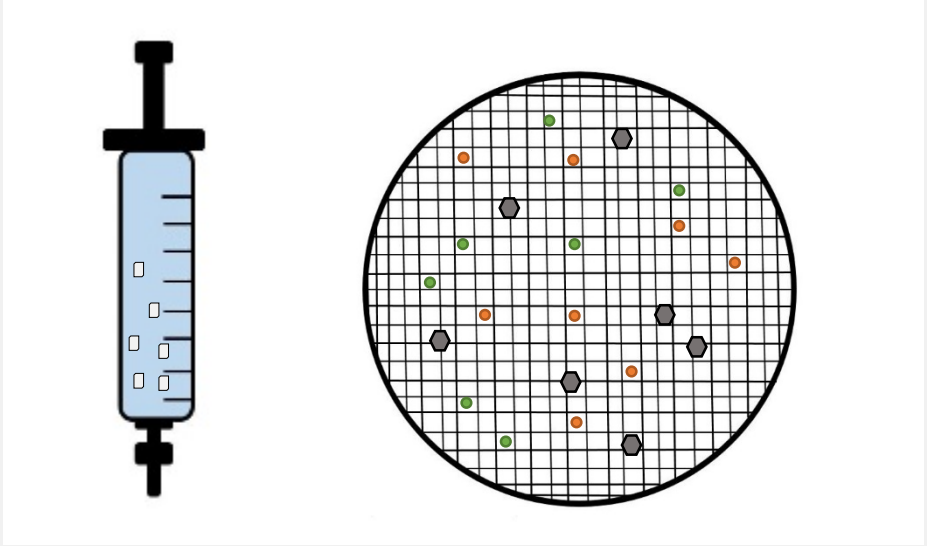


Allows ions and fine particles to pass

WHY IS THERE A DIFFERENCE?

Collected $BaSO_4$ precipitate onto finer filter

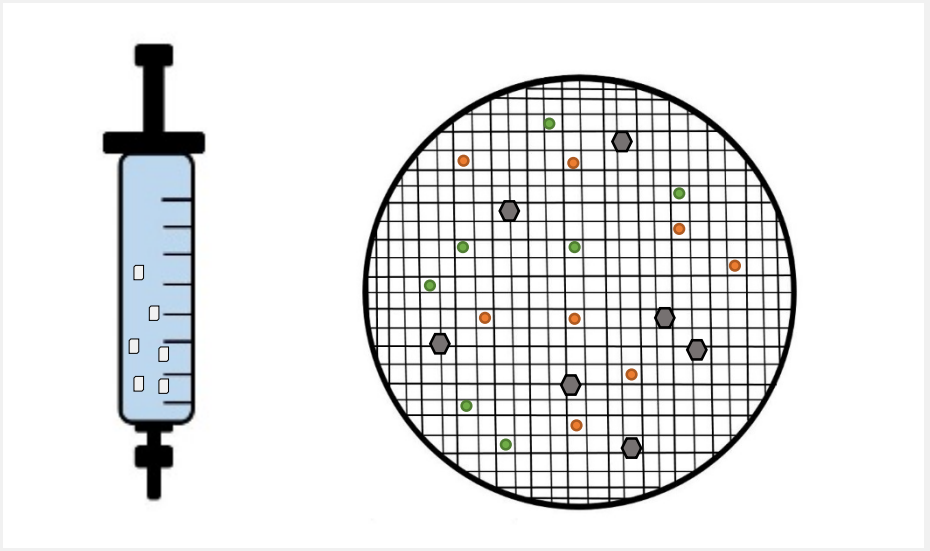
MICRON FILTER



Stops fine particles 0.45µ

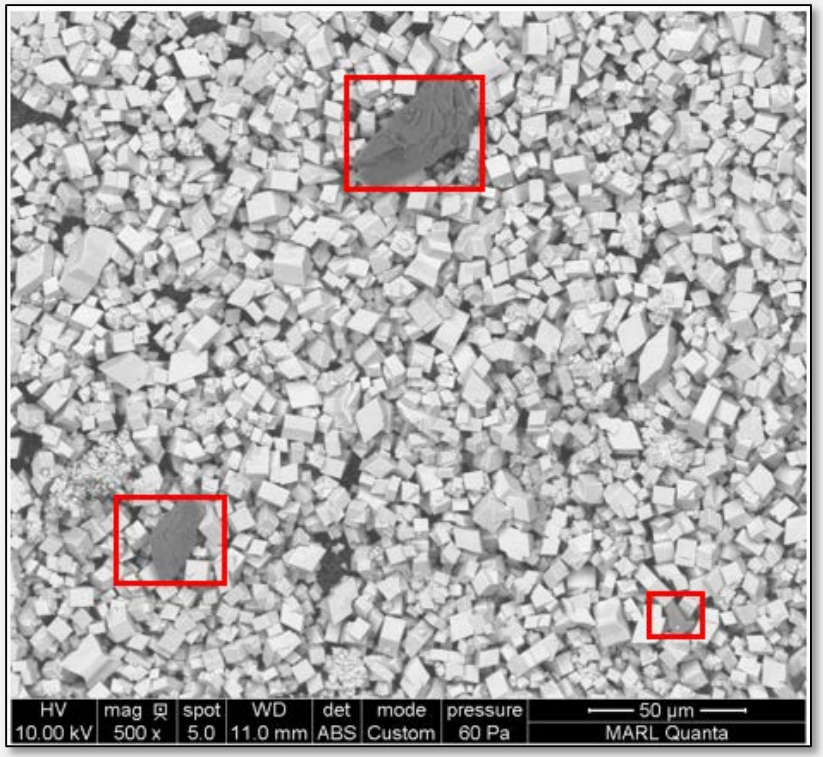
WHY IS THERE A DIFFERENCE?

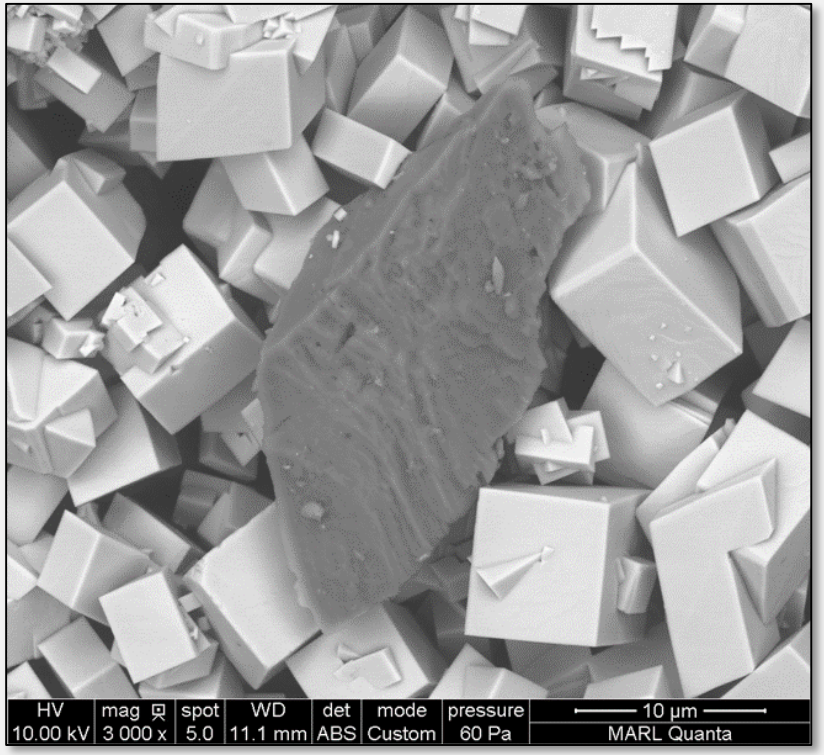
MICRON FILTER

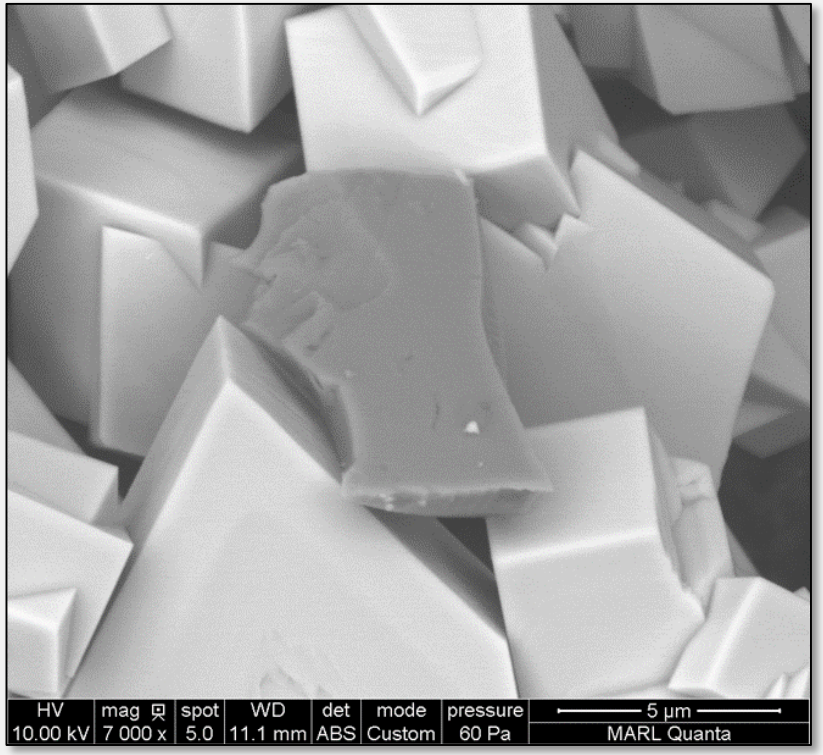


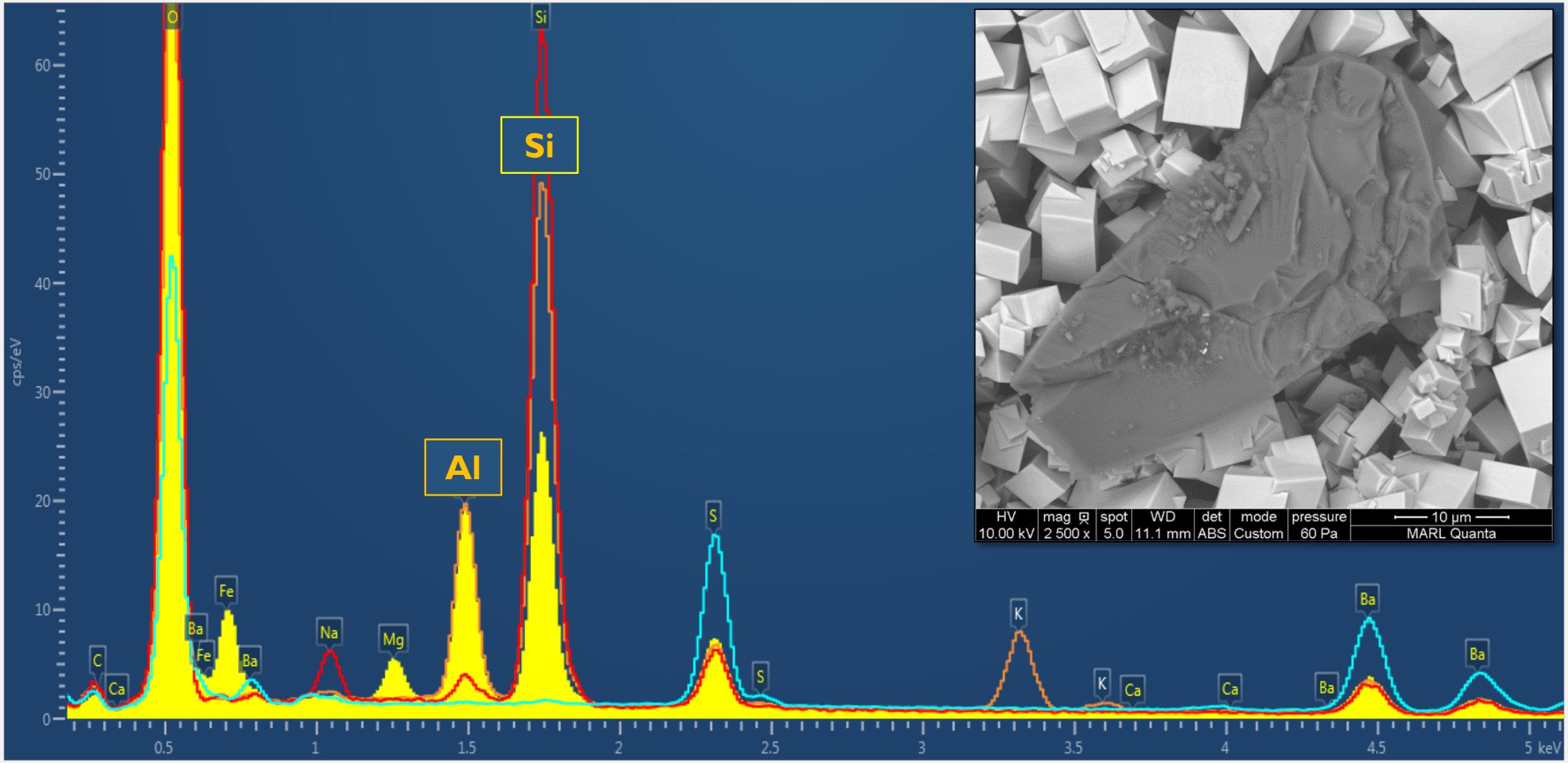
Stops fine particles 0.45µ

SEM ANALYSIS OF FILTER







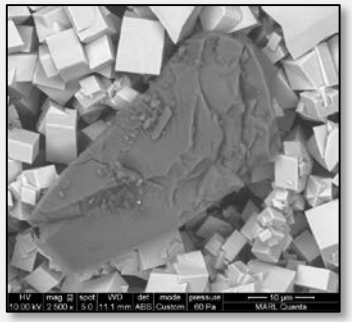


O	Na	Mg	Al	Si	S	K	Ca	Fe	Ba
41.27	1.94	BDL	7.41	22	3.78	8.52	BDL	BDL	23.83

CONCLUSIONS

- Preliminary HHXRF method for determining sulfate
  - Control data promotes trust analysis
  - HHXRF is faster and is ion specific

- Resolved AASHTO T 290 discrepancy
  - Carbonates can contain clay-fines



QUESTIONS