

Leaching Studies

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Billings Symposium / ASMR Annual Meeting

**Assessing the Toxicity Potential
of Mine-Waste Piles Workshop**

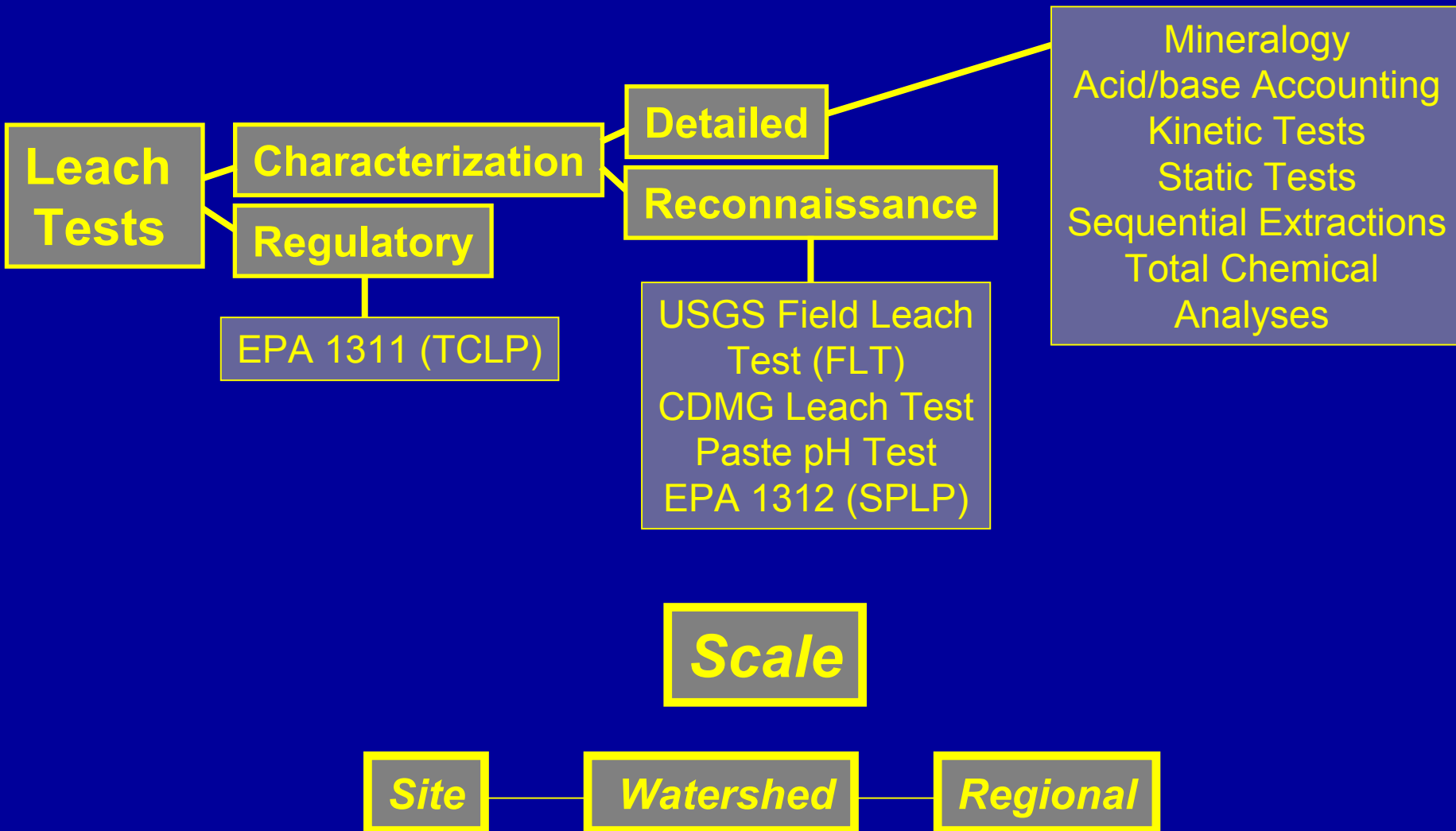
June 1, 2003

**U.S. Department of the Interior
U.S. Geological Survey**

Topics Covered

- General Overview of Common Leaching Tests Used in Studies of Mine Wastes
- Development and Use of the USGS Field Leach Test (FLT)

Flow Chart for Ranking and Prioritization



Some Reasons Why Leach Tests are Important ?

➤ Leach Tests:

- Reveal the soluble phases of a sample
- Aid in predicting the geochemical effects of a “flush” of a material
- Help quantify toxic inputs due to mobilization of contaminants
- Reveal the soluble constituents of a sample that are made available to organisms

Golden Rule

Before starting any leach study
the geoscientist must
thoroughly address “**What is
the question**” they are trying
to answer with the study?

(So many leach tests, so little time)

In Answering This Question, the Following Must be Addressed:

- ✓ What is the sample medium?
- ✓ Are there regulatory issues or is the study strictly for scientific or research purposes?
- ✓ How am I going to collect and prepare the samples (investigator must design a sampling scheme)?
- ✓ What is the size of the study (e.g., 1 sample or many sites in a watershed)?
- ✓ Do I need a reconnaissance geochemical “fingerprint” of the materials or a detailed prediction?

-After fully answering these questions the investigator can choose from a number of well-established, effective leach procedures to meet the particular goals of the proposed study

Two Primary Types of Leaching Tests Available

Static tests :

Short term (minutes to days) and relatively inexpensive. Tests include both agitated (shake), and passive (non-shake tests)

Kinetic tests :

Long term (weeks to years) and relatively expensive

Examples of Some Frequently Used Leaching Tests for Prediction of Metal Mobility

EPA Method 1312 - Synthetic Precipitation Leaching Procedure (SPLP)

- Method is designed to predict and determine the potential for leaching metals into ground and surface waters
- Procedure is time and resource intensive
- Uses a 1:20 solid-to-liquid ratio

EPA Method 1312 - Synthetic Precipitation Leaching Procedure (SPLP) Cont.

- Provides a rigorous leach of the materials (18-hour agitation)
- Extraction fluid used is intended to simulate precipitation. (East of the Mississippi River the fluid is slightly more acidic at pH 4.20 (+/-) 0.05, reflecting industrialization and air pollution impacts on precipitation. A pH of 5.0 (+/-) 0.05 is used west of the Mississippi, reflecting less of an impact on precipitation from industrialization.)

EPA Method 1311 – Toxicity Characteristic Leaching Procedure (TCLP)

- **Regulatory method.** TCLP is the only leaching procedure approved by the EPA for characterizing hazardous waste under RCRA.
- Method is designed to evaluate metal mobility in a landfill
- Uses a 1:20 solid-to-liquid ratio

EPA Method 1311 – Toxicity Characteristic Leaching Procedure (TCLP) Cont.

- Requires end-over-end rotation for 18 hours
- Extraction fluid used is a function of the alkalinity of the solid phase
- Provides a rigorous leach of the materials (18-hour agitation)
- Procedure is time and resource intensive

Simple Leach Tests: USGS Field Leach Test (FLT) and CDMG Leach Test

- Simulate how natural precipitation would leach historical mine waste or other materials in order to determine acid and metals release from these materials
- Require short-term agitation
- Use DI water as the extraction fluid
- Methods are fast and inexpensive
- USGS FLT Method uses same extraction ratio as EPA 1312 (1:20), so results can be compared with other leach studies.

Nevada Meteoric Water Mobility

Procedure (MWMP)

- Designed for laboratory evaluation of the potential of dissolution and mobility of constituents from mine waste by leaching with meteoric water
- Involves a metered single pass column leach in a down-flow mode over a 24-hour period
- Extraction fluid is Type II reagent grade water
- Uses a 1:1 solid to liquid ratio
- Requires ~5 kg of sample
- Requires specific columns (PVC) and other components
- ASTM method is in review

Humidity Cell Tests

- Simulate long-term weathering reactions and predict future potential for acid generation and metals migration from the subject materials
- Use DI water used as the extractant
- Require 1 kg of sample
- Require periodic, labor intensive application and collection of extract
- Require laboratory space for long-term studies
- Require the use of custom-made “cells”

Why the USGS Field Leach Test (FLT) was Developed

1. PROVEN NEED

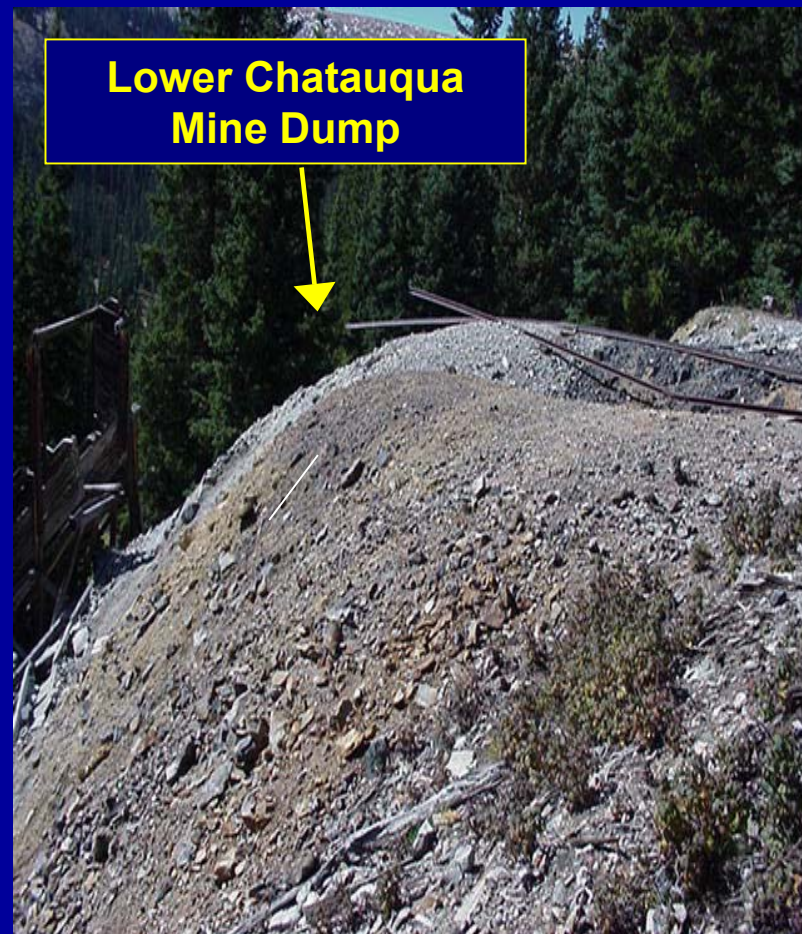
Leaching tests are frequently used for characterization of waste materials

- ✓ The USGS had a specific need for a cost effective, rapid, qualitative leaching test that could be used in-situ to provide geochemical data (*fingerprints*) for field prioritization of a large number of *historical mine dumps* on a watershed scale

Examples of Historical Mine Dumps

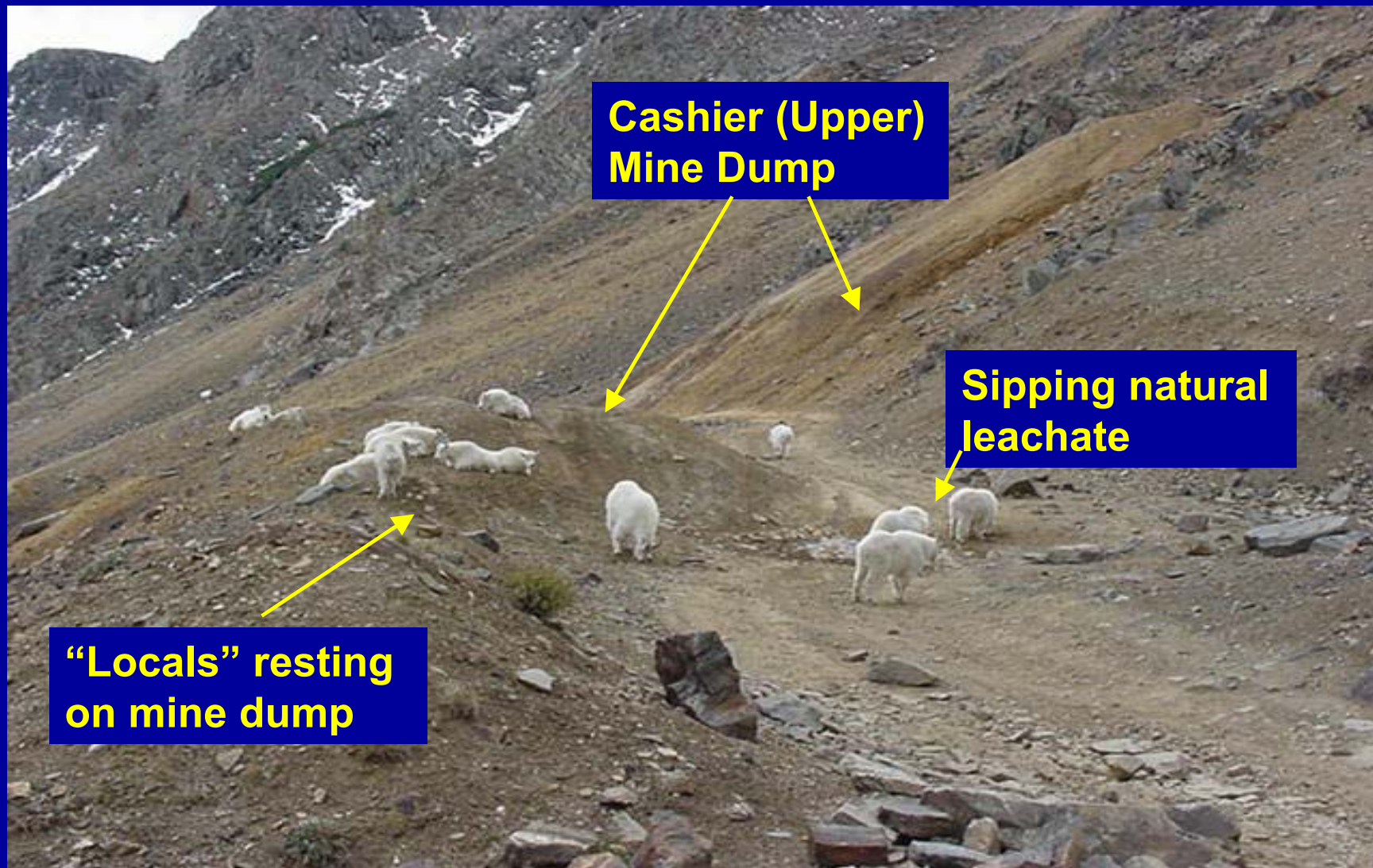


Santiago Mine



Lower Chatauqua
Mine Dump

Another Historical Mine Dump



“Unique” Mine Dump Fingerprint



Why the Field Leach Test (FLT) was Developed (Cont.)

2. THERE WAS ROOM FOR IMPROVEMENT OF LEACHING METHODOLOGY

Leaching tests for mine wastes in use at the time:

- Were intended for prediction of weathering or used as regulatory tests
- Were complicated and expensive
- ✓ **USGS needed a quick and qualitative test for prediction of surface runoff from weathered historical mine-waste piles.**

3. THERE WAS ROOM FOR REASSESSMENT OF GEOCHEMICAL ASSUMPTIONS

- ✓ We felt that many of the readily releasable metals and acid from historical mine-dump piles would be rapidly solubilized (eliminating the need for extended agitation times and the use of specialized equipment and extensive, involved procedures)
- ✓ We predicted that the majority of the geochemically reactive material of an historical mine-dump sample would be found in the fine fraction (<2 mm) of a composite sample (eliminating the need for the collection, preparation, and storage of large bulky samples)

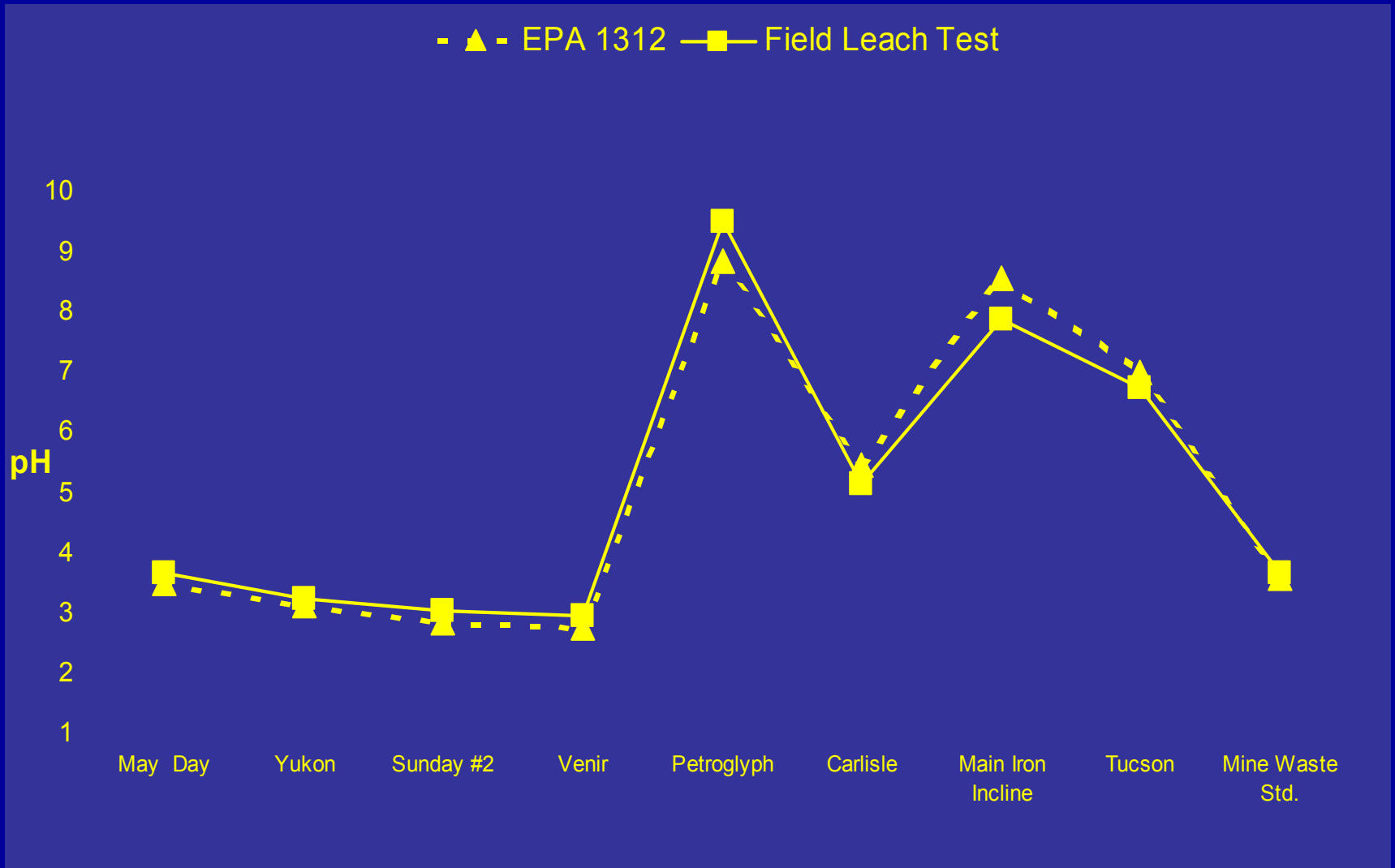
Important Parameters for Development of the USGS FLT

- Leach Test had to be practical, relatively quick, realistic (**predict surface runoff**), and simple.
- To be useful in-situ, the test needed to use readily available labware, simplified extractant (DI water), simplified agitation (wrist action), and simplified filtration (syringe and capsule filter).
- The leach test had to produce enough leachate for all desired elemental analyses (**tests like paste pH do not provide this**).
- Geochemical results obtained from leachate analyses needed to be comparative (geochemical signature and trends) to those produced by EPA Method 1312 (SPLP), which was the standard at the time.

Some of the Tests Done in Order to Evaluate Effectiveness of the USGS FLT

- **Comparative Studies:** Compared FLT leachate data with data from other leach tests (*Comparative studies were carried out on < 2mm splits of the same composite samples*)
(After initial comparative studies, other leaching tests were eliminated and we focused on comparisons between the USGS FLT and EPA Method 1312 (SPLP))

Pre-Filtration Leachate pH Data for Composite Mine-Dump Samples Showing Comparison of EPA Method 1312 (SPLP) and the Field Leach Test

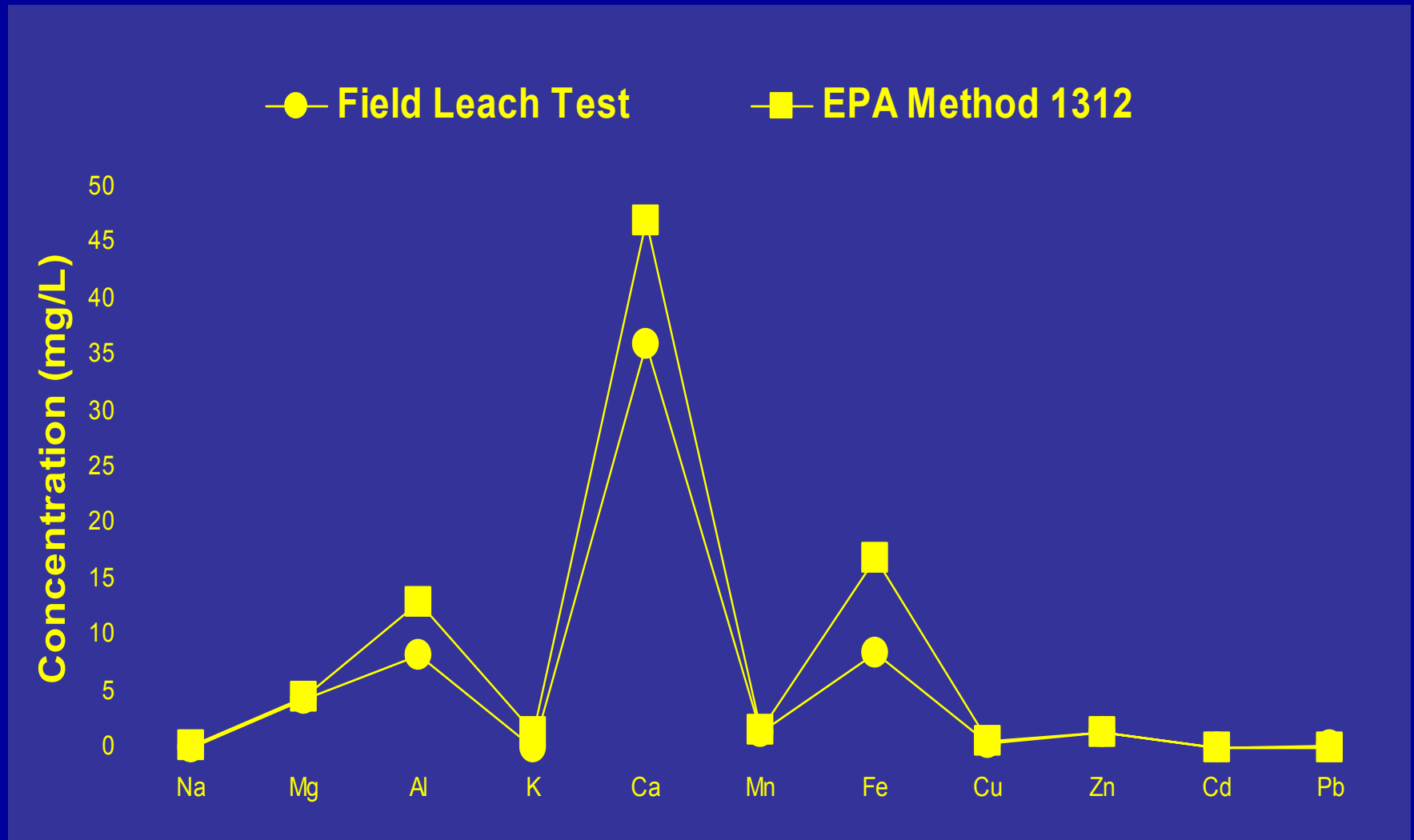


Leachate pH Data and Relative Ranking for All Composite Samples Using EPA 1312 and the Field Leach Test (1=Sample with lowest pH; 8=Sample with highest pH)

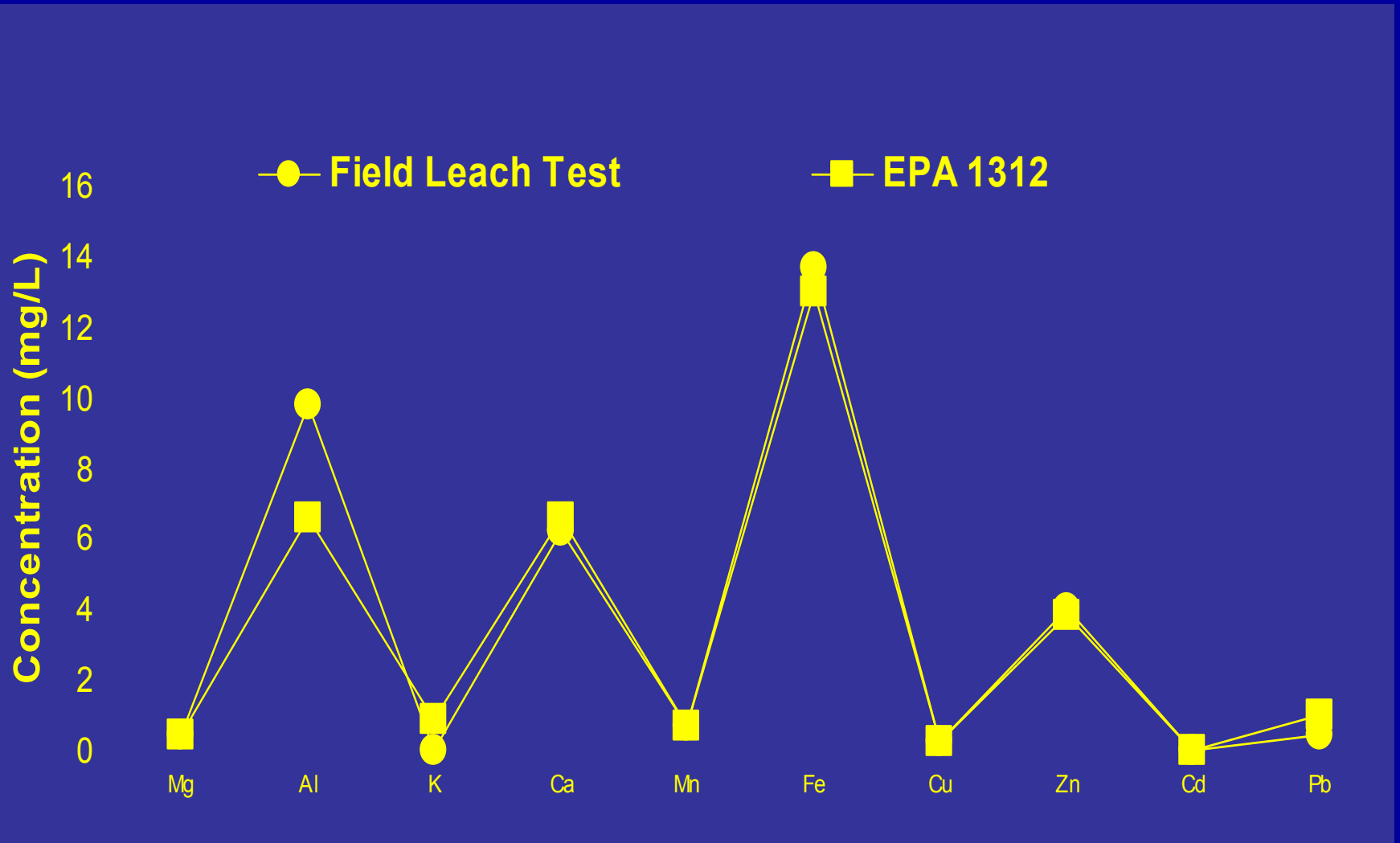
Sample	1312	Rank	FLT	Rank
May Day	3.5	4	3.6	4
Yukon	3.1	3	3.2	3
Sunday #2	2.8	2	3.0	2
Venir	2.7	1	2.9	1
Petroglyph	8.8	8	9.5	8
Carlisle	5.4	5	5.1	5
MII	8.5	7	7.8	7
Tucson	7.0	6	6.7	6

Comparison of EPA 1312 (SPLP) and Field Leach Test

Yukon Mine Waste Near Silverton, Colorado



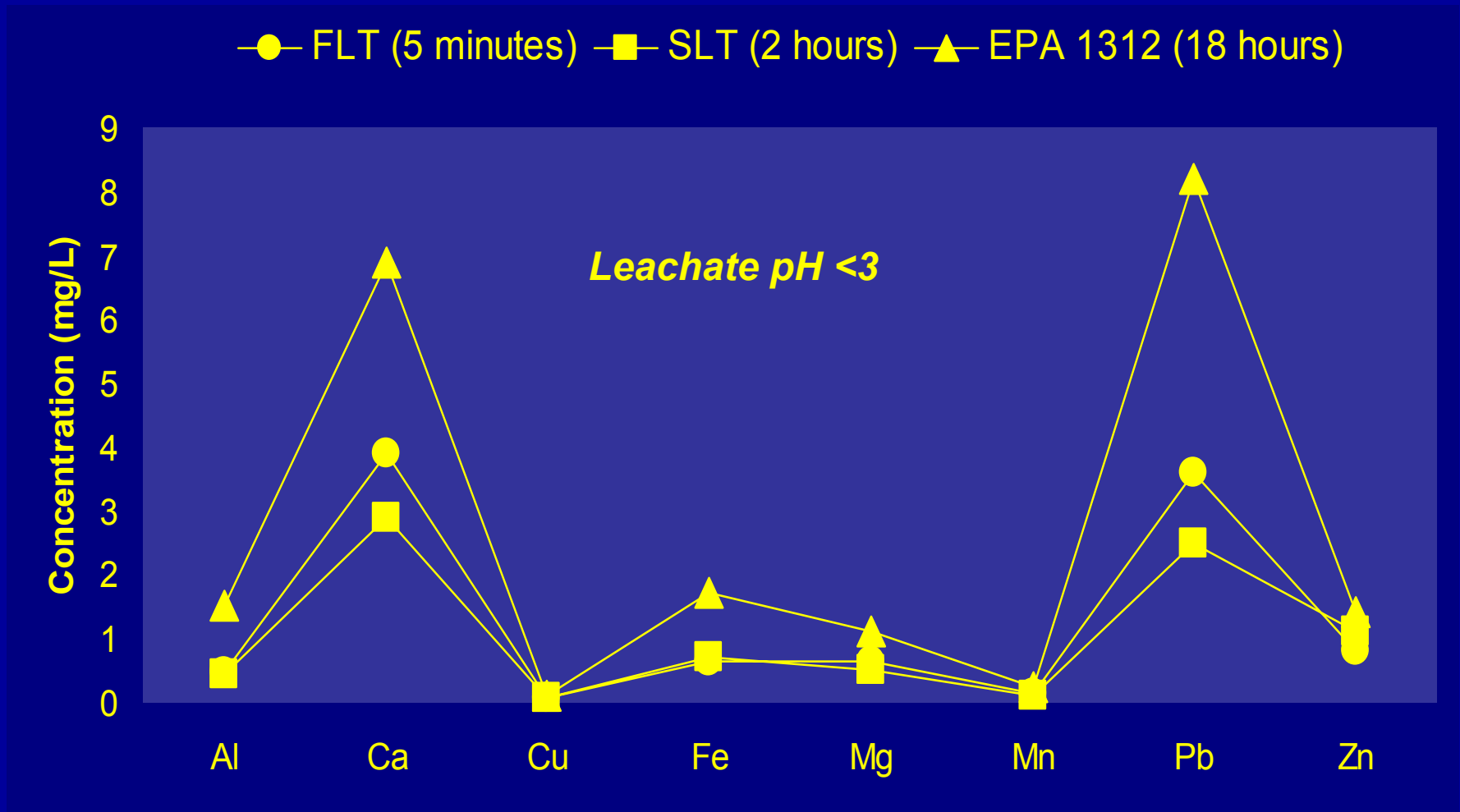
Comparison of EPA 1312 (SPLP) and Field Leach Test Sunday Mine Waste Near Leadville, CO



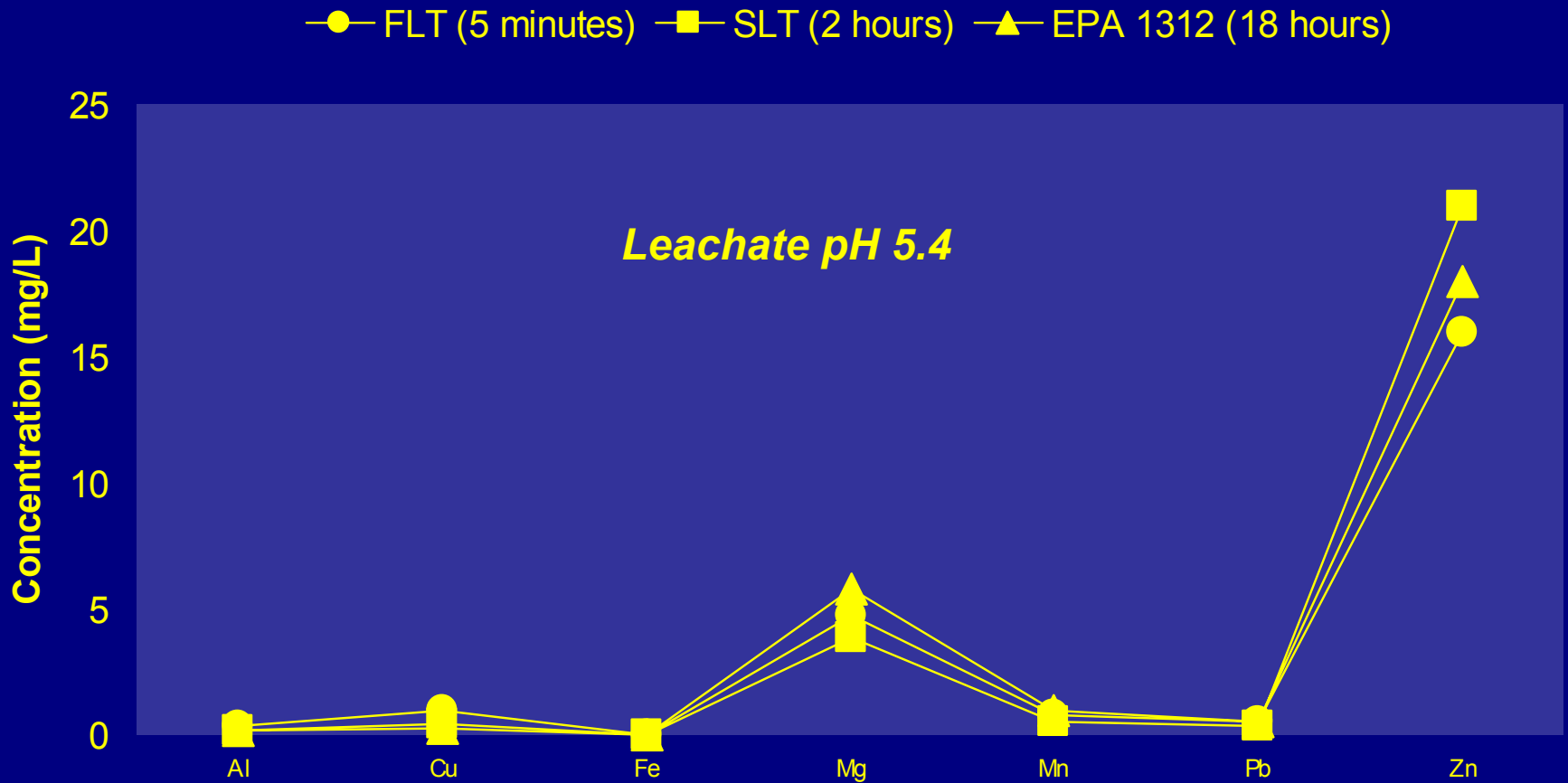
- **Time studies:** These studies compared how various leachate characteristics changed over time. Leachate sub-samples were collected at time intervals and measurements made for leachate pH, conductivity, ICP-AES, ICP-MS, and IC.

Results showed that the leaching potential of historical mine-waste samples is achieved in a relatively short period of time. Although some metal concentrations increase over time, the geochemical trend and the fingerprint are effectively established using the 5-minute Field Leach Test.

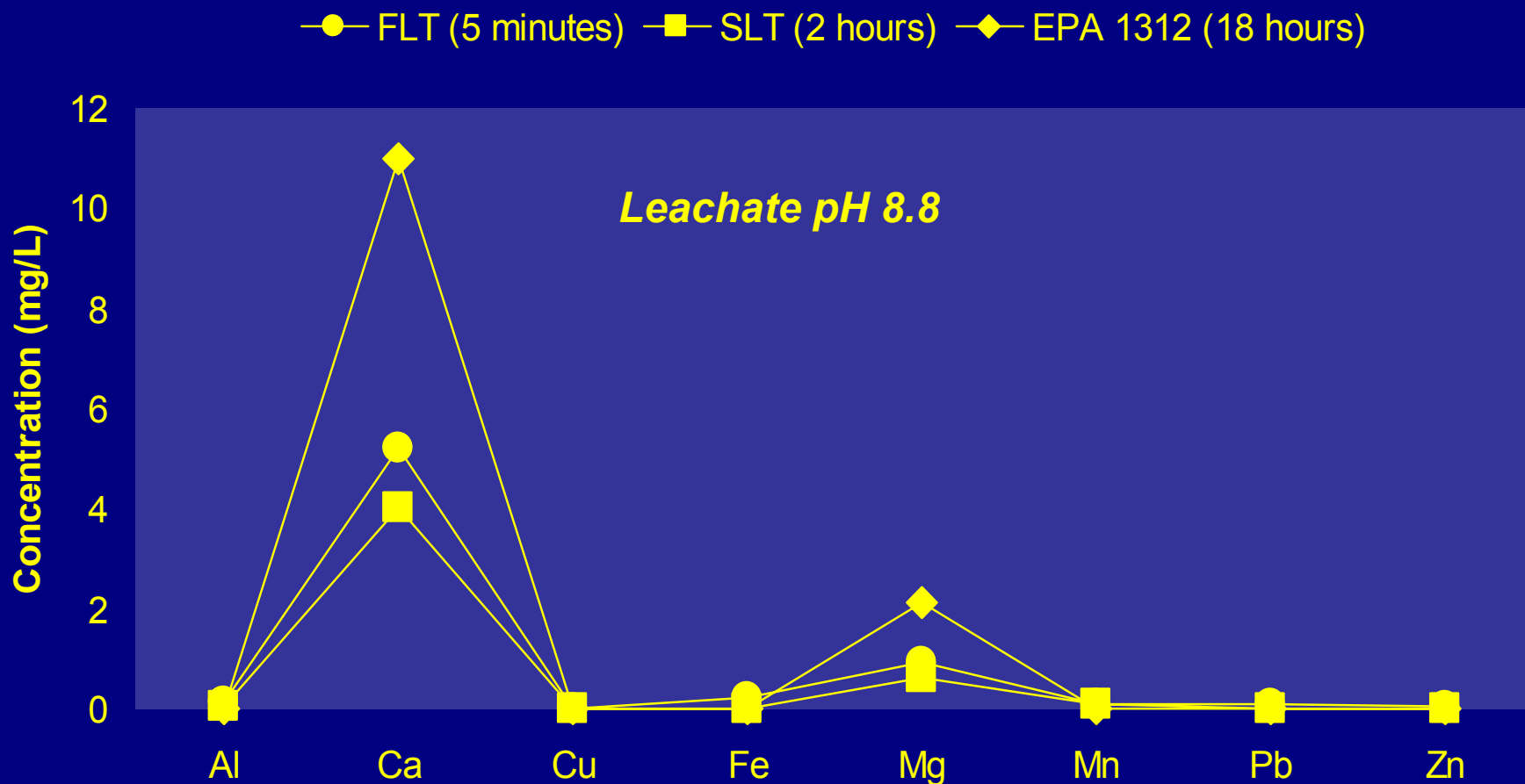
ICP-AES Leachate Data for the MWS Sample Showing Comparison of the 5-minute Field Leach Test, 2-hour Static Test, and the 18-hour EPA 1312 (SPLP)



ICP-AES Leachate Data for the Carlisle Mine Dump Composite Sample Showing Comparison of the 5-minute Field Leach Test, 2-hour Static Test, and the 18-hour EPA 1312 (SPLP)



ICP-AES Leachate Data for the Petroglyph Mine Dump Composite Sample Showing Comparison of the 5-minute Field Leach Test, 2-hour Static Test, and the 18-hour EPA 1312 (SPLP)



Observations After Development and Use of the USGS Field Leach Test

- The Field Leach Test met all of our design criteria
- Since its inception, it has been used extensively for characterization of historical mine dumps throughout the United States (incl. Alaska)
- Because it simulates a meteorological precipitation event, the FLT has also been used to leach a broad spectrum of other matrices including:
 - Naturally mineralized soils
 - Agricultural soils
 - Mine-dump drill core intervals
 - Mining impacted wetland sediments
 - World Trade Center dusts
 - Atmospheric dusts
 - Forest fire burned soils

All that's needed for Collecting, Sieving, Compositing, Mixing, and Leaching a Sample in-Situ using the USGS FLT



DI Water

Containers with bottles, pH, field balance, conductivity meter, etc.

Mike

Composite Mixing Tub

Sieves

Increment Collection Buckets

General Conclusions

- It is very likely that leach tests will remain an important tool in studies of mine wastes and other materials in order to define the soluble, reactive geochemical characteristics, to determine bioaccessibility issues, and in predictive modeling.
- Development of the USGS Field Leach Test and other “quick and qualitative” leach tests have proven to be effective indicators of readily leachable metals and acidity from mine-dump material and other matrices, and are useful leach tests for both in-situ and laboratory geochemical characterization of these materials.

