So You Think Putting Dirt in a Jar is Easy? (Environmental Field Sampling)

Prepared For:

California Integrated Waste Management Board

LEA Support Services Branch

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Agenda

- Section 1: Introduction
- Section 2: Sampling Plan Development
  - Types of plans
  - Guidance documents
  - Data quality objectives
  - Sampling design
- Section 3: Reporting Results
  - Data validation
  - Detection limits
  - Data tables
- Section 4: Health & Safety Plans
  - Personal Protective Equipment (PPE)
  - Instrumentation

Section 1
Introduction

Introductions

- Name and organization
- Job duties for CIWMB
- Expectations for this training class

Why Take This Class?

- You collect samples for analysis
- You want legally enforceable data
- You collect data of any type
- Understand how to develop a sampling plan
- Understand how to properly collect & handle samples
- Understand how to report data
- Understand how sampling effects health & safety issues

Course Objectives

- How to design sampling plans
- How to implement quality controls in plans
- How to collect environmental samples
- How to obtain legally defensible data
- How to report data
- How to incorporate health & safety into plans

Definitions and Terms

- Matrices
  - Soil
  - Groundwater
  - Surface water
  - Air or gas
  - Hazardous waste
- Data collection
  - Sampling and analysis
  - Meteorological data
  - Hydrological data
  - Modeling

Definition and Terms (cont.)

- Sampling: collection of a matrix (e.g. soil) with a sampling device (e.g. trowel)
- Analyte: element (e.g. lead) or compound (e.g. benzene)
- Analysis: method (e.g. EPA 6010) to determine the concentration of one or more analytes
- Quality Assurance (QA): process to ensure data & decisions based on the data are technically sound, statistically valid and properly documented
- Quality Control (QC): tools to measure the degree which QA objectives are met

Definitions and Terms (cont.)

- VOC: volatile organic compound
- SVOC: semivolatile organic compound
- PAH: polyaromatic hydrocarbon
- PCB: polychlorinated biphenyl
- TRPH: total recoverable petroleum hydrocarbon
- CO_2: carbon dioxide
- CO: carbon monoxide
- CH_4: methane
- See acronym list

Section 2
Sampling Plan Development

Where Does It All Begin?

- Quality Management Plan (QMP) or Quality Assurance Program Plan (QAPrP)
  - Organizational level for quality system
- Quality Assurance Project Plan (QAPP)
  - Project level
- Field Sampling Plan (FSP)
  - Part of QAPP
  - One FSP for each specific data collection activity
- Sampling and Analysis Plan (SAP)
  - Combination of QAPP and FSP
  - One specific data collection activity

QMP Elements

1. Management and Organization
2. Quality System and Description
3. Personnel Qualifications and Training
4. Procurement of Items and Services
5. Documentation and Records

QMP Elements (cont.)

6. Computer Hardware and Software
7. Planning
8. Implementation of Work Processes
9. Assessment and Response
10. Quality Improvement

EPA Program Guidance

- EPA Requirements for QMPs (QA/R-2)
- EPA Region 9 Requirements for QAPrP (R9QA/03.1)
- Overview of the EPA Quality System for Environmental Data and Technology
- Guidance for Developing Quality Systems for Environmental Programs (QA/G-1)
- Guidance on Assessing Quality Systems (QA/G-3)

QAPP Elements

1. Project Management (9 subsections)
   - Project Organization
   - Problem and Project Description
   - Quality Objectives

2. Measurement/Data Acquisition (10 subsections)
   - Sampling Design & Methods
   - Sample Custody & Analytical Methods
   - Quality Control & Data Acquisition

QAPP Elements (cont.)

3. Assessment/Oversight (2 subsections)
   - Assessments & Response Actions
   - Reports to Management

4. Data Validation and Usability (3 subsections)
   - Data Review, Validation, and Verification
   - Reconciliation of Data Quality Objectives

EPA QAPP Guidance

- EPA Requirements for QAPPs (QA/R-5)
- Guidance for QAPPs (QA/G-5)
- Guidance for Geospatial Data QAPPs (QA/G-5G)
- Guidance for QAPPs for Modeling (QA/G-5M)

SAP Elements

1. Introduction
2. Background
3. Project Data Quality Objectives (DQOs)
4. Sampling Rationale
5. Request for Analysis
6. Field Methods and Procedures
7. Sample Containers, Preservation and Storage

SAP Elements (cont.)

8. Disposal of Residual Materials
9. Sample Documentation and Shipment
10. Quality Control
11. Field Variance
12. Field Health and Safety Procedures

Guidance: EPA Region 9, Sampling and Analysis Plan (SAP) Guidance and Template Version 2, Private Analytical Services Used (R9QA/002.1, April 2000)

FSP Elements

1. Introduction
2. Background
3. Project Objective
4. Sampling Rationale and Design
5. Analytical Laboratory Methods

FSP Elements (cont.)

6. Field Methods and Procedures

7. Disposal of Investigation-Derived Waste

8. Sample Identification, Documentation and Shipment

9. QA/QC

Guidance: No official guidance available

Which One Do I Use?

- QAPP
  - Multiple and different data collection activities
  - Complicated projects
  - FSP for each activity or matrix, if needed

- SAP
  - One or two data collection events
  - Simple projects
  - Addresses all activities or matrices

Advantages / Disadvantages

- QAPP
  - Advantage: Simplifies plan with multiple DQOs
  - Disadvantage: Large document with redundancy
- FSP
  - Advantage: Simple plan for field crew
  - Disadvantage: Requires supporting QAPP
- SAP
  - Advantage: One concise plan
  - Disadvantage: More complicated with multiple DQOs

EPA Sampling Design Guidance

- Guidance on Systematic Planning using the Data Quality Objectives Process (QA/G-4)
- Systematic Planning: A Case Study for Hazardous Waste Site Investigations (QA/CS-1)
- Guidance on Choosing a Sampling Design for Environmental Data Collection (QA/G-5S)
- Decision Error Feasibility Trials (DEFT) Software (QA/G-4D)

EPA Data Assessment Guidance

- Guidance on Environmental Data Verification and Data Validation (QA/G-8)
- Data Quality Assessment: A Reviewer's Guide (QA/G-9R)
- Data Quality Assessment: Statistical Tools for Practitioners (QA/G-9S)

Other EPA Guidance

- Guidance for Preparing Standard Operating Procedures (QA/G-6)
- Guidance on Technical Audits and Related Assessments for Environmental Data Operations (QA/G-7)
- Guidance for Developing a Training Program for Quality Systems (QA/G-10)
- Guidance on Quality Assurance for Environmental Technology Design (QA/G-11)

The Fascinating and Intriguing World of Data Quality Objectives

EPA Data Quality Objective (DQOs)

- 7 step process to develop a sampling design
- Ensures sufficient & correct data collection
- Focused data requirements & optimized design
- Documented procedures & requirements
- Clearly developed analysis plans with sound, comprehensive, QAPPs
- Early ID of sampling design & data collection process

DQO Process

- Step 1: State the problem
- Step 2: Identify the Goals of the Study
- Step 3: Identify Informational Inputs
- Step 4: Define the Boundaries of the Study
- Step 5: Develop the Analytic Approach
- Step 6: Specify Performance or Acceptance Criteria
- Step 7: Develop the Plan for Obtaining Data

Example Project

- Mr. Burns Burn Dump
- CIWMB conducts investigation per “Protocol for Burn Dump Site Investigation and Characterization,” Cal EPA, DTSC, 6/30/06

Mr. Burns Burn Dump Soil Samples

- Potential burn dump contaminants of concern (COCs)
  - Metals (As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Zn)
  - Organics
    - SVOCs
    - TRPH
    - PCBs
    - PAHs
    - Dioxins and Furans
  - Radioactive materials
  - Explosives

- Lab analysis
  - Metals

Step 1: State the Problem

- Describe problem
- Identify planning team
- Determine resources
  - Budget
  - Personnel
  - Schedule

Mr. Burns Burn Dump: Step 1

- Problem
  - Metal contaminated soil poses a threat to the environment.
- Team
  - Project Manager
  - Engineer
  - Chemist
  - Geologist
- Resources
  - $56,000

Step 2: Identify the Goals

- Identify principal study question(s)
- Specify alternative actions
- Develop decision statement(s)

Mr. Burns Burn Dump: Step 2

- Principal Study Question
  - Are concentrations of metals in soil above California Administrative Manual (CAM) 17 or Resource Conservation and Recovery Act (RCRA) hazardous waste levels?
- Alternative Actions
  - Remediate the soil
  - No action
- Decision Statement
  - Determine if contaminated soil is a hazardous waste.

Step 3: Identify Inputs

- Identify information needed to solve the study question(s)

- Select appropriate sampling and analysis methods; i.e. detection limits below action levels

Mr. Burns Burn Dump: Step 3

- Information
  - Concentrations of CAM 17 metals
  - Spatial location of samples
- Action level
  - CAM 17 and RCRA hazardous waste criteria
- Analysis by EPA Method 6010B

Step 4: Define Boundaries

- Define the target population of interest
- Define spatial boundaries
- Specify temporal boundaries and other practical constraints with sample/data collection

Mr. Burns Burn Dump: Step 4

- Population of Interest
  - Soil metal contaminants, surface to 10 feet bgs
- Spatial boundaries
  - Site geographical boundaries (2 acres total area)
- Temporal boundaries
  - Completion of investigation before rainy season

Step 5: Develop Analytic Approach

- Specify appropriate population parameters for making decisions or estimates
- Choose Action Level and generate an "If … then … else" decision rule

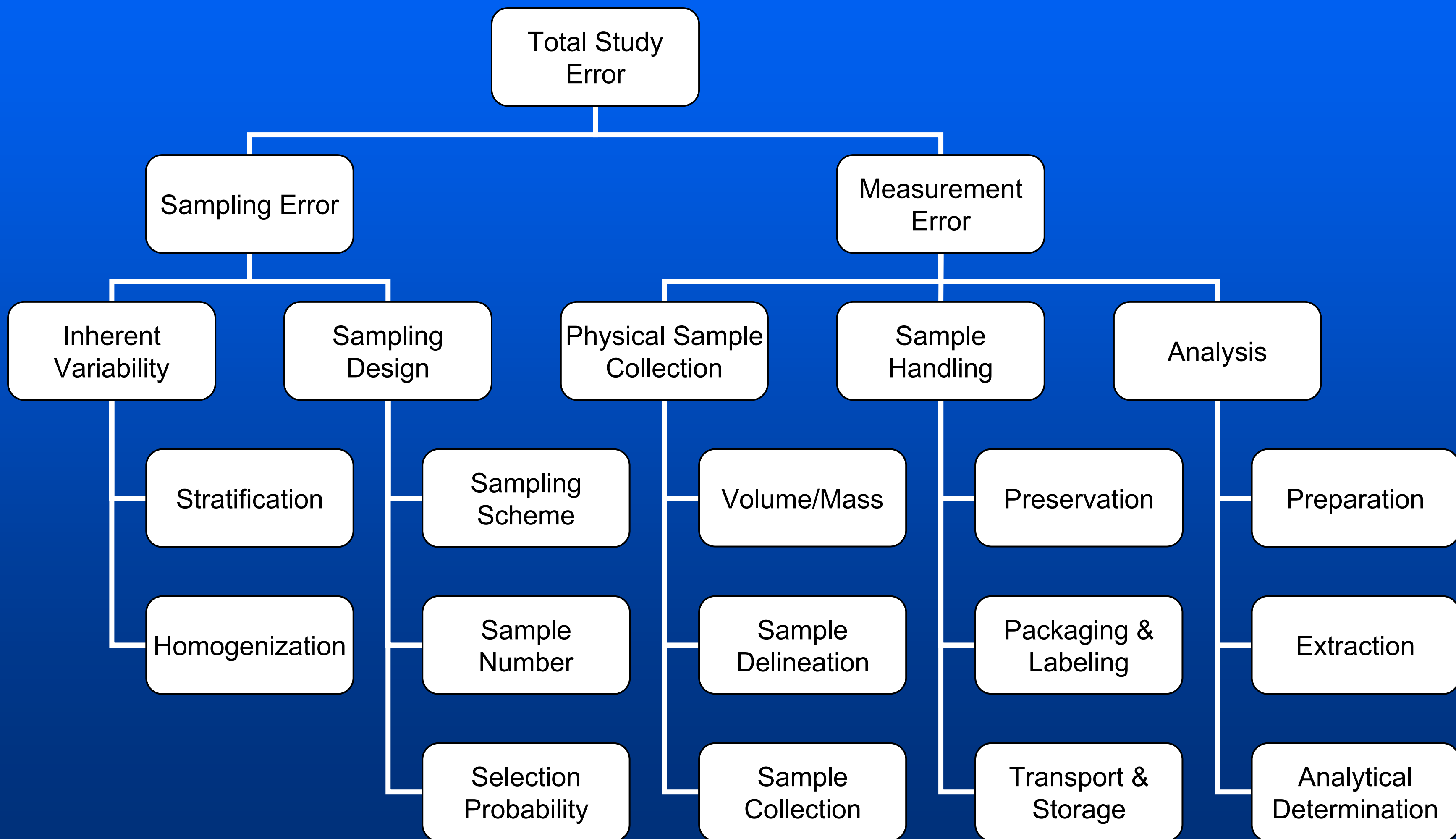
Mr. Burns Burn Dump: Step 5

- Population parameter
  - Individual results (because samples will be collected on a judgmental basis)
- Decision rule
  - ***If*** contamination concentrations in soil exceed CAM 17 metals or RCRA hazardous waste criteria, ***then*** the soil will be removed for disposal, ***else*** no action.

Step 6: Specify Performance Criteria

- Specify decision rule as a statistical hypothesis test
- Examine consequences of making incorrect decisions
- Place acceptable limits on the likelihood of making decision errors

Total Study Error



Mr. Burns Burn Dump: Step 6

- **Note**: If comparing individual sample results to an action level then no need for statistical test

- To fulfill the requirement of this step use similar language as follows:
  - "Individual data results will be compared to hazardous waste criteria thus no statistical test is required. Errors will be reduced by using standard field and analytical procedures."

Step 7: Design Sampling Plan

- Compile information from Steps 1 - 6
- Identify sampling and analysis designs
- Select & document a design to get data that achieves performance criteria

Mr. Burns Burn Dump: Step 7

- 5 soil borings sampled at surface, 5 feet bgs, and 10 feet bgs (3 samples per boring) per acre
- Boring locations selected based on field judgment and biased to areas of contamination
- Analyses for CAM 17 metals by EPA Method 6010B

Burn Dump Protocol Summary

- Potential burn dump COCs
  - Metals (As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Zn)
  - Organics (SVOCs, TRPH, PCBs, PAHs, Dioxins & Furans)
  - Radioactive materials
  - Explosives
- Determine horizontal and vertical extent
  - Minimum 5 locations per acre
  - 3 depths (surface, mid-level, deep)

Burn Dump Protocol Summary (Cont.)

- Metals analysis
  - TTLC (CAM17) and soil acidity
  - WET (Top 3 TTLC samples for CAM5 – Cd, Cr^{+3}, Cr^{+6}, Ni, Pb, Zn)
  - WET for samples exceeding 10 times STLC
  - TCLP (Top 3 Pb for RCRA metals and DI WET)
- Organic
  - Select samples, minimum 5 or statistically valid number to meet DQOs (which ever is greater)
  - If burn ash then minimum 2 samples of burn ash analyzed for SVOCs, TRPH, PCBs, Dioxin & Furans
- Data validation per page 19 of protocol

DQO Practice

- Complete DQO Worksheet found in the back of manual
- Take 15 minutes to complete
- When completed take a 5 minute break
- We will review after break

Step 1: State the Problem

- Problem: Contamination from a dump may be impacting the water quality of a nearby stream and effecting salmon fry survival rates.
- Team: Project manager, water quality specialist, wild life biologist, field technician
- Resources: N/A

Step 2: Identify the Goals of the Study

- Principal Study Question: Determine if contamination from the dump is impacting the water quality of the stream.
- Alternative Actions: If the dump is impacting the stream water quality then the dump will be remediated. If the dump is not impacting the stream water quality then no action.
- Decision Statement: Determine if water quality has been impacted.

Step 3: Identify Informational Inputs

- Concentrations of potential contaminants in surface water samples
  - Metals by EPA Method 6010B
  - VOCs by EPA Method 8260B
  - SVOCs by EPA Method 8270C
  - PCBs by EPA Method 8082
  - Pesticides by EPA Methods 8081B (organochlorine pesticides), 8141A (organophosphorus pesticides), and 8151A (chlorinated herbicides)
- Location of water samples
- Action levels for water samples

Step 4: Define the Boundaries of the Study

- Population of Interest: Contaminant concentrations in surface water samples.

- Spatial: 100 feet upstream to 500 feet downstream of boundary of site

- Temporal: None

Step 5: Develop the Analytic Approach

- Population of Parameter: Individual results will be compared to action levels.

- "If, then, else" Decision Rule: If contaminant concentrations exceed the action levels then remediation actions will be implemented else no action will be taken.

Step 6: Specify Performance or Acceptance Criteria

- Statistical Test: Individual data results will be compared to surface waste action levels thus no statistical test is required. Errors will be reduced by using standard field and analytical procedures.

Step 7: Develop the Plan

- Collect surface water samples 100 and 500 feet upstream.
- Collect three surface water samples near dump site.
- Collect surface water samples at 100 and 200 feet downstream.
- Collect water quality parameters with a portable meter at each sample location.
- Analyze all samples for
  - Metals by EPA Method 6010B
  - VOCs by EPA Method 8260B
  - SVOCs by EPA Method 8270C
  - PCBs by EPA Method 8082
  - Pesticides by EPA Methods 8081B (organochlorine pesticides), 8141A (organophosphorus pesticides), and 8151A (chlorinated herbicides)

Sampling Design for the Non-Artistic Scientist

Sampling Design

- Sampling Schemes
- Sampling Locations
- Sampling Methods and Equipment
- Analytes of Concern
- Analytical Methods
- Containers, Holding Times, & Preservation

Sampling Design (cont.)

- Decontamination Procedures
- Field QC Samples
- Lab QC
- Cost Considerations
- Field Documentation
- Sample Handling and Shipping

Where Do I Collect the Samples?

- Authoritative / Biased / Judgmental

- Random
  - Simple Random
  - Systematic Random
  - Stratified Random

- Types of Samples
  - Grab
  - Composite

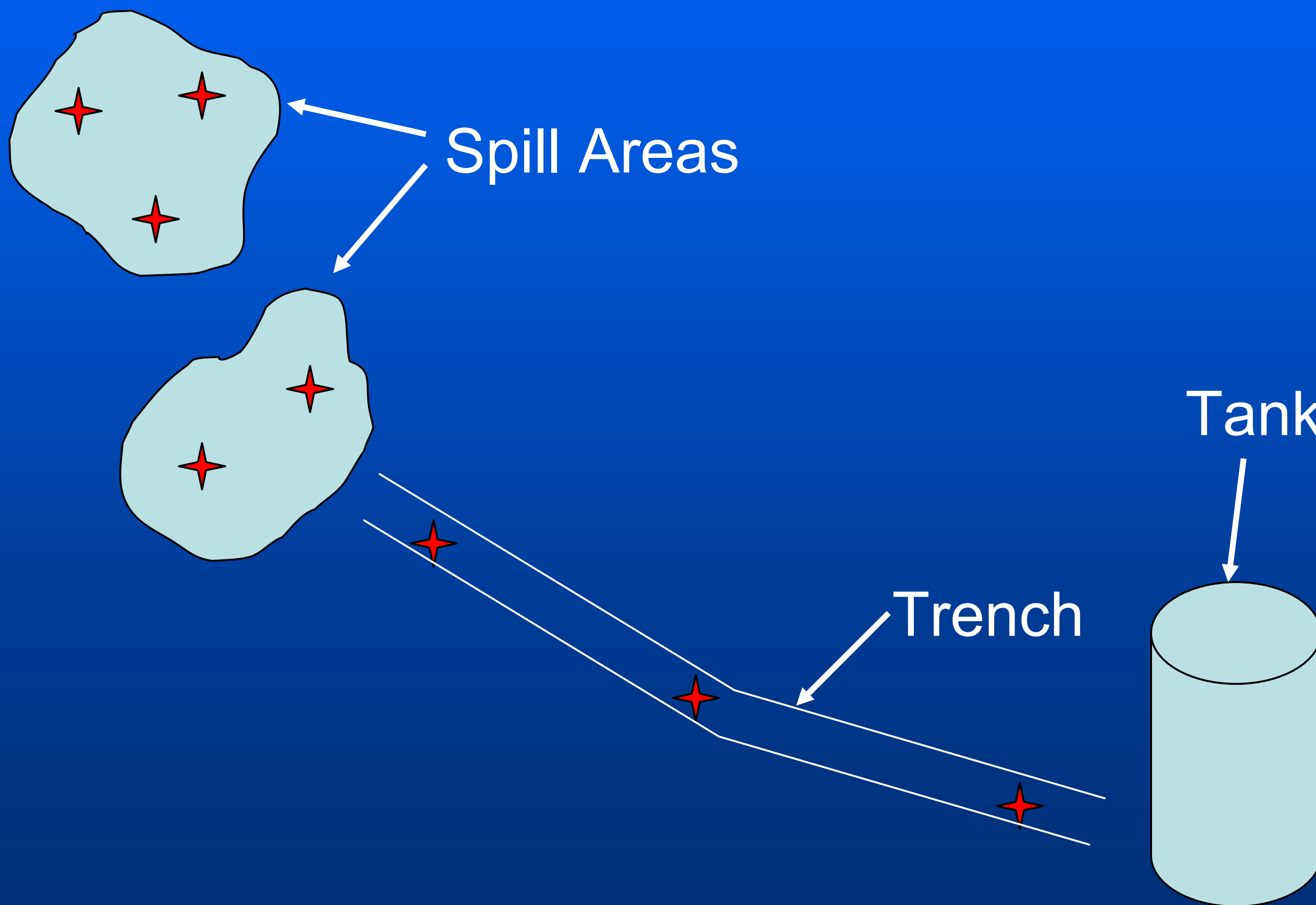
Definitions

- Homogenous: contaminant concentration is the same throughout the investigation area
- Heterogeneous: contaminant concentration is varies throughout the investigation area
- Random: occurring without specific pattern
- Random Sampling: same chance of occurrence

Authoritative

- Locations selected based on knowledge of the contaminant distribution or location
- Used mostly for
  - Enforcement - waste exceeds legal limit
  - Determine worst case scenario
  - Known homogenous waste
- Not statistically based

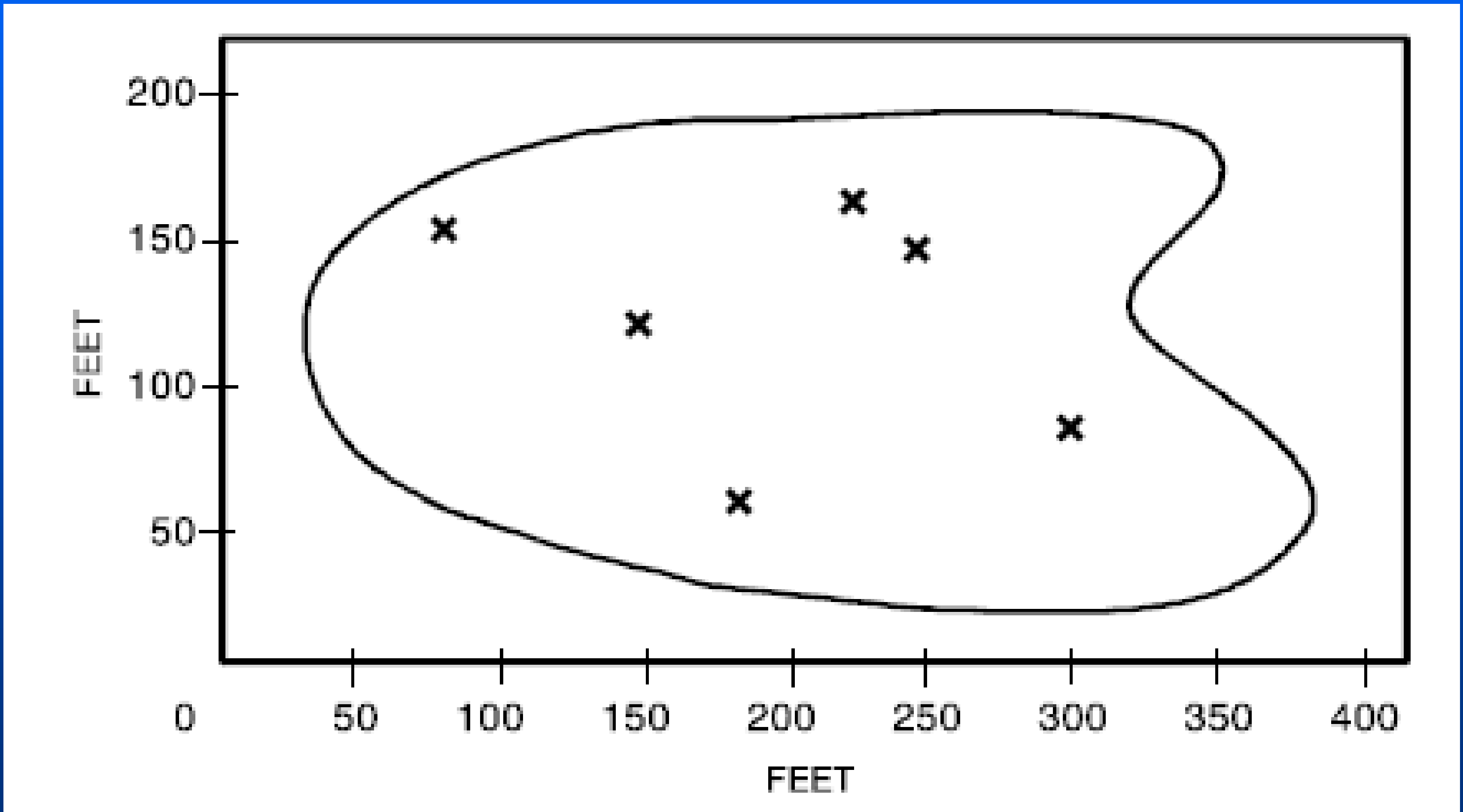
Authoritative Example



Simple Random

- Waste is randomly heterogeneous
- Waste area is divided into equal locations (grid)
- Random locations are selected & sampled
- Random locations generated by random number generator (Microsoft® Excel has this function)

Simple Random Example

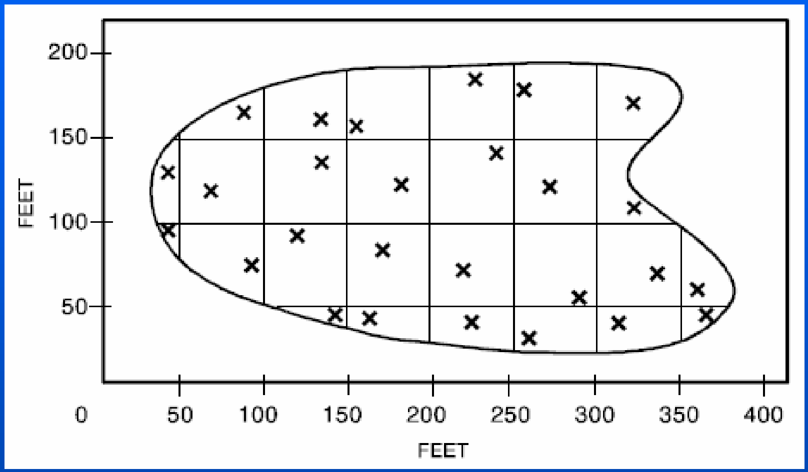


Systematic Random

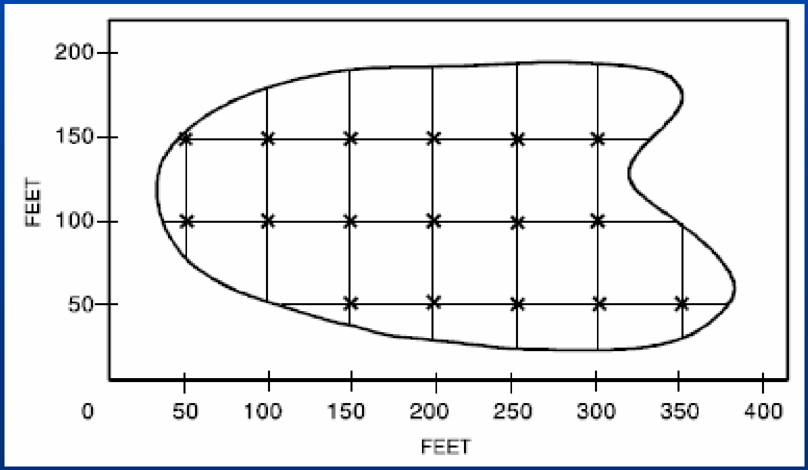
- Waste is randomly heterogeneous
- Waste area is divided into equal locations (grid)
- First location is selected at random
- Subsequent locations selected on grid based from the first random location

Systematic Random Example

- Systematic random
  - Random start
  - Grid plotted
  - Sample at random locations in each grid



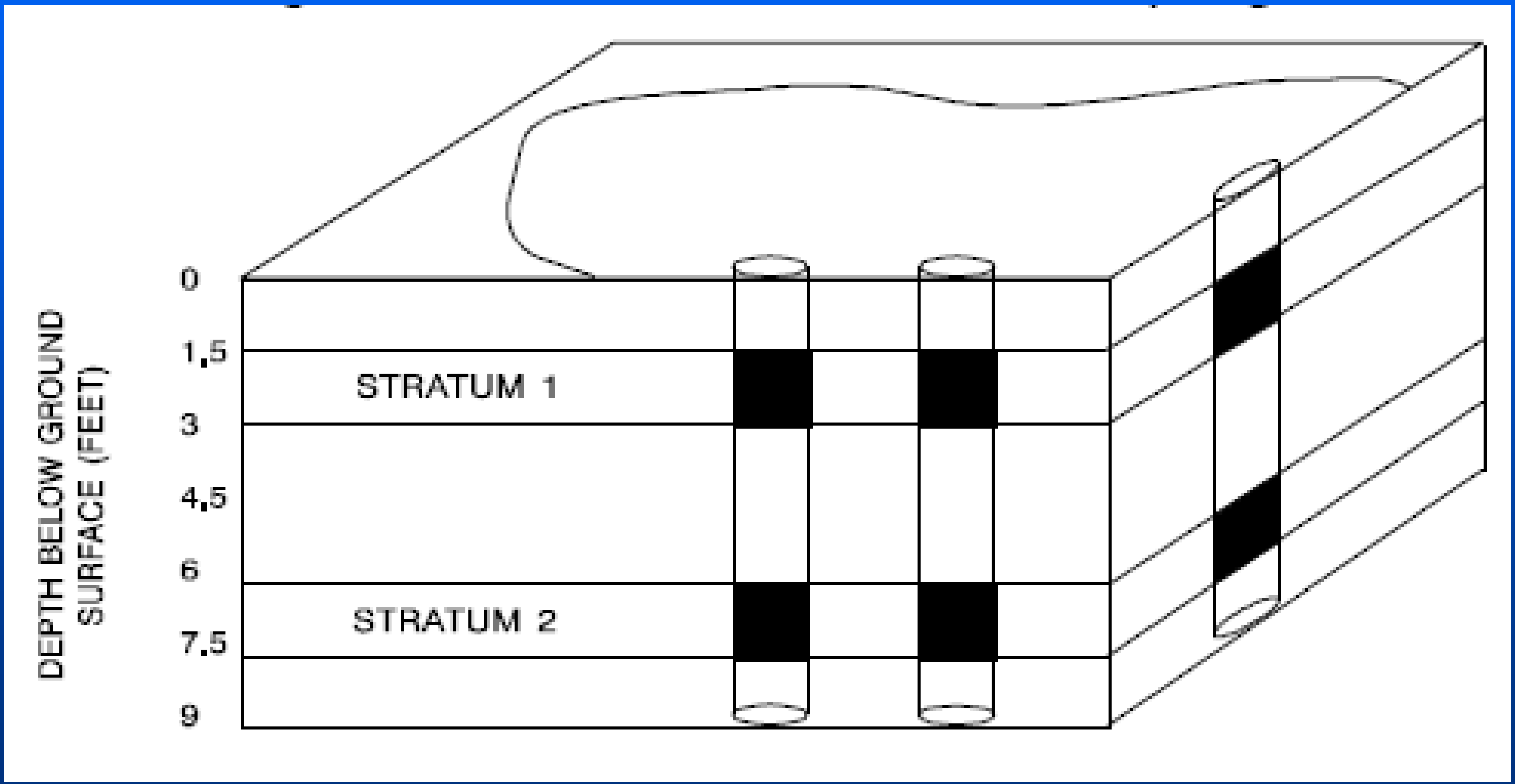
- Systematic grid
  - Random start
  - Grid nodes are sampled



Stratified Random

- Waste is non-randomly heterogeneous or in separate areas (strata)
- Waste area is divided into equal locations (grid)
- Random locations are selected & sampled
- Data is statistically assessed by each strata
- Rarely used

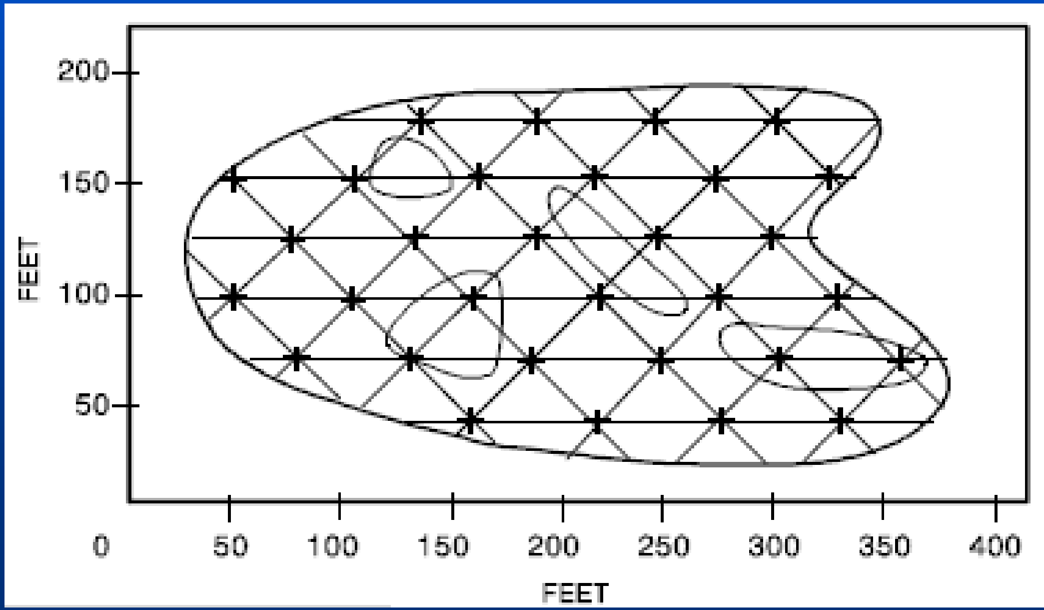
Stratified Random Example



Grid Sampling

- Grids have limitations like all sampling schemes
  - Size of contaminated area
  - Shape of contaminated area
  - Extent of contaminated area

- It's all about probability!



Sampling Approach Matrix

Sampling Objective	Judge-mental	Simple Random	Systematic Random	Systematic Grid	Stratified Random
Establish Threat	1	4	3	2	3
Identify Source	1	4	3	2	2
Delineate Extent of Contamination	4	3	1	1	3
Evaluate Treatment & Disposal Options	3	3	2	2	1
Confirm Cleanup	4	1	1	1	3

1 = Preferred
2 = Acceptable
3 = Moderately Acceptable
4 = Least Acceptable

Visual Sampling Plan (VSP)

- Statistical solutions to sampling design
- World-class statistical algorithms
- User-friendly visual interface
- Answers two important questions
  - How many samples are needed?
  - Where should the samples be collected?

VSP (cont.)

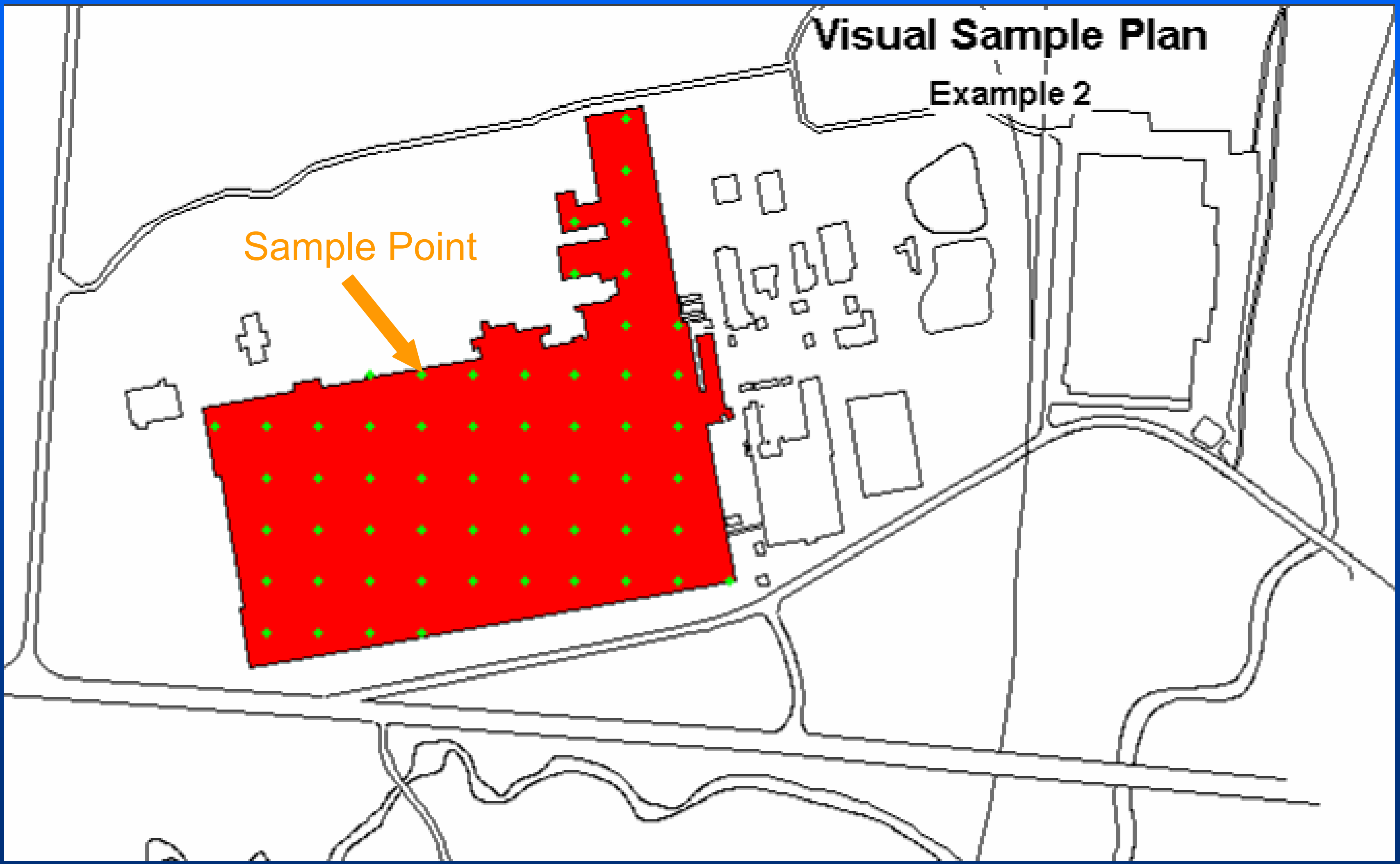
- Sponsored by
  - EPA
  - Department of Energy
  - Department of Defense
  - Department of Homeland Security
- http://dqo.pnl.gov/ (It's Free!)

VSP (cont.)

- Numerous sampling designs including
  - Hot spot
  - Compare to threshold
  - Estimate the mean

- Plot sampling points on your map
  - Generate sample coordinates
  - Add background detail
  - Export map

Example VSP Sample Map



How Many Samples Should I Collect?

Sample Mean

- 5 soil samples analyzed for lead: 13, 94, 77, 171, 134 mg/kg
- Number of samples (n) = 5
- $\frac{13 + 94 + 77 + 171 + 134}{5} = 98$
- Sample Mean ($\bar{x}$) = 98 mg/kg

True Mean & Sample Mean

- True Mean (μ): average of all true values
- Sample Mean ($\bar{x}$): average of all measured values
- Sample Mean $\neq$ True Mean
- It is impossible to know the True Mean, although we can come close with a large data set

Variance of Sample

Step 1: Values - Mean   Step 2: Square results

13	–	98	=	-85	*	-85	=	7225
94	–	98	=	- 4	*	- 4	=	16
77	–	98	=	-21	*	-21	=	441
171	–	98	=	73	*	73	=	5329
134	–	98	=	36	*	36	=	1296
								14307

Step 3: Add squares

Step 4: Divide by n - 1

$$\frac{14307}{5 - 1} = 3577$$

Variance of Sample (s^2)

Standard Deviation and Error

Step 5: Square root of Variance of Sample (s^2)

$\sqrt{3577} = 60$ Standard Deviation of Sample (s)

Step 6: Standard Deviation (s) divided by square root of n

$$\frac{60}{\sqrt{5}} = 27$$

Standard Error ($s_{\bar{x}}$) or
Standard Error of Mean or
Standard Deviation of Sample Mean

Confidence Interval

Step 7: Mean ± $t_{0.20}$ times Standard Error ($s_{\bar{x}}$)

98 + (1.533 * 27) = 139 mg/kg — Upper Confidence Level (UCL)

98 - (1.533 * 27) = 57 mg/kg — Lower Confidence Level (UCL)

$\mathbf{t_{0.20}}$: student's "t" (see student's "t" table)

Confidence Interval (cont.)

- **Confidence interval (CI)** is the range of values that the true mean falls within
- We have calculated the 80% CI, which means that there is a 90% chance the mean is within CI
- You can calculate a different CI based on DQOs

Number of Samples

Step 9: Calculate number of samples

$$n = \frac{(t_{0.20})^2 (s^2)}{(RT - \overline{x})^2}$$

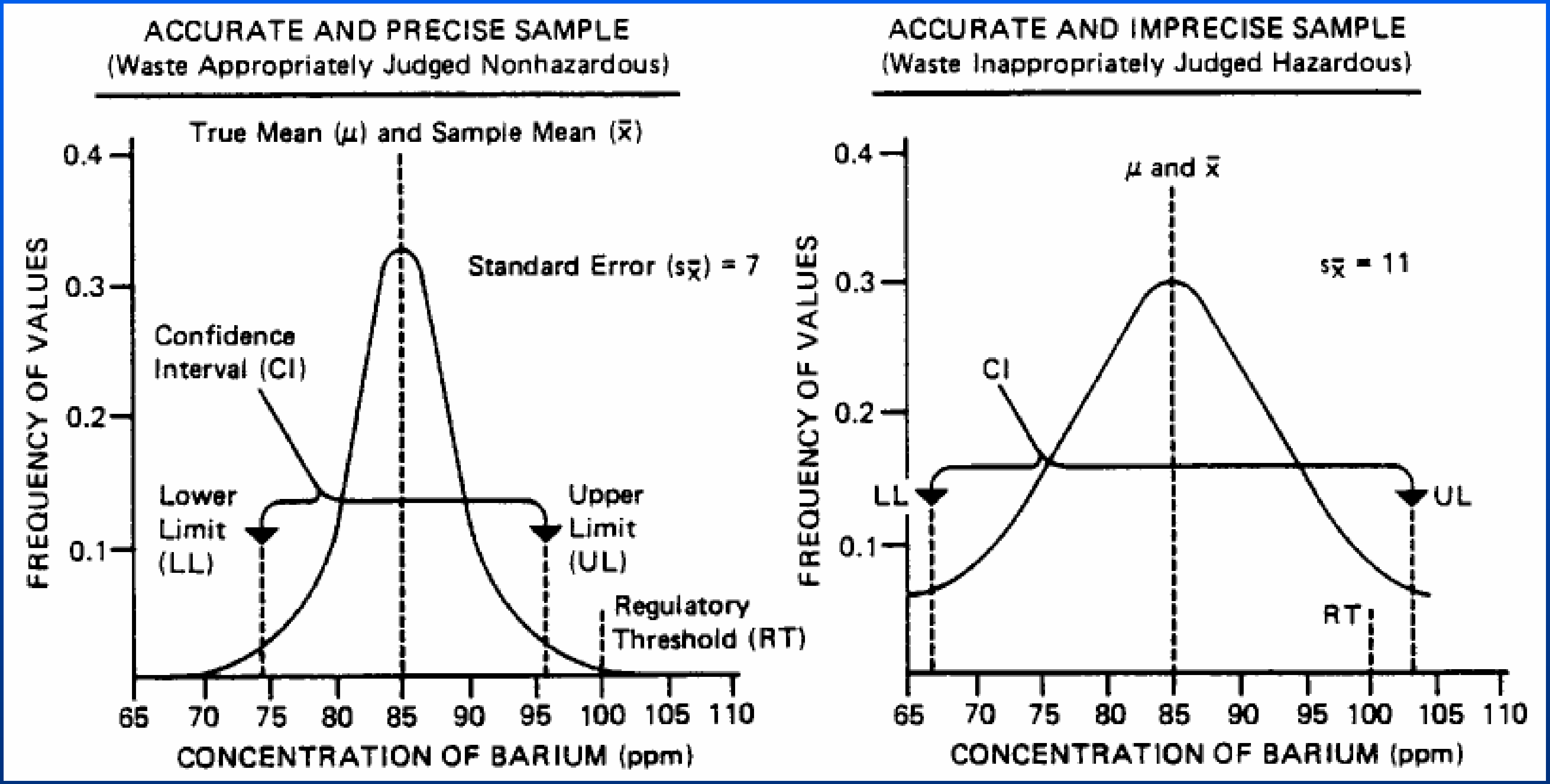
Regulatory Threshold (RT) = 150 mg/kg for lead
(Cal PRG Residential Soil)

$$n = \frac{(1.533)^2 (3577)}{(150 - 98)^2} = 3 \text{ samples}$$

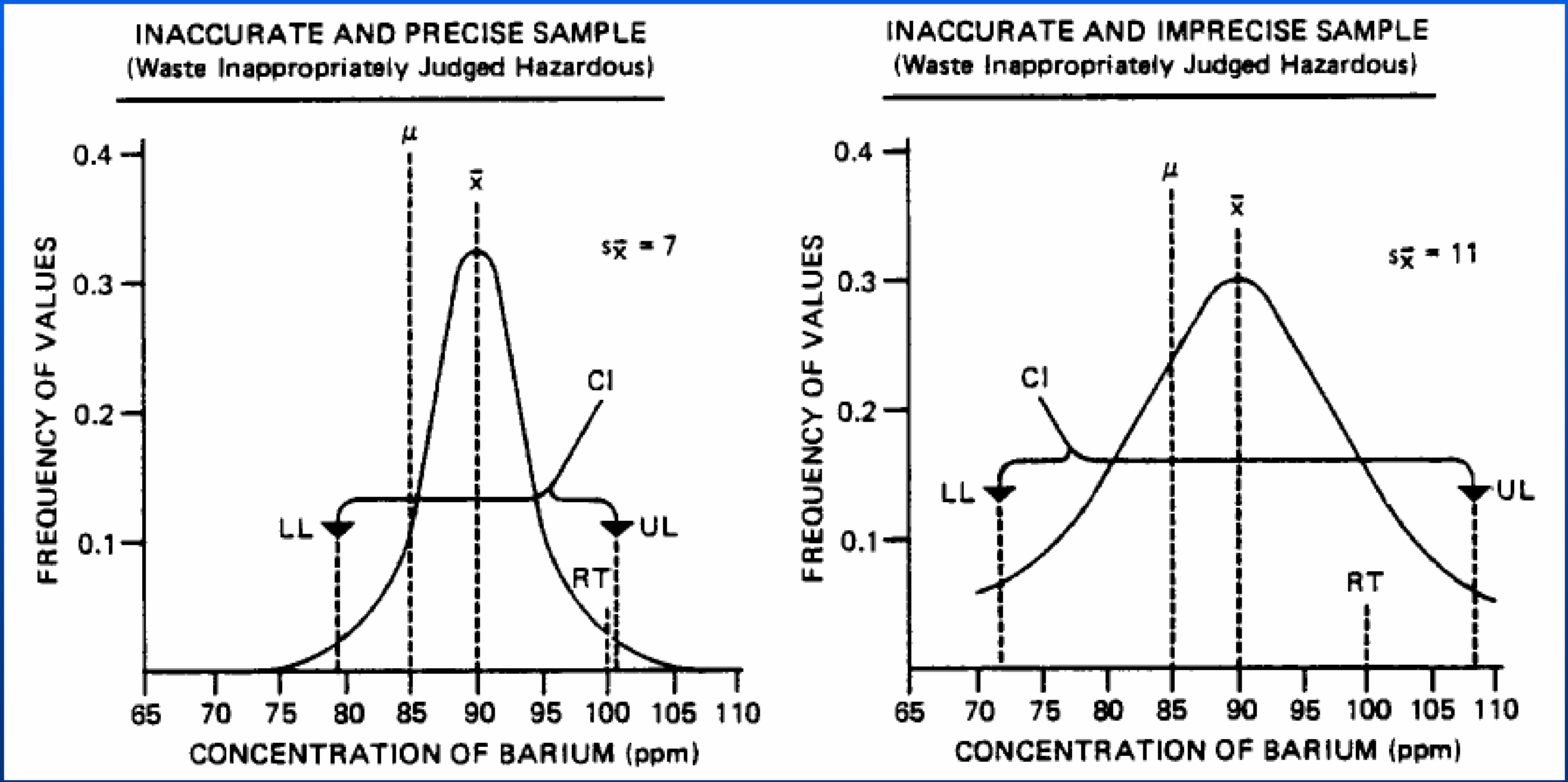
Hazardous or Not?

- If UCL is below the RT → Not Hazardous Waste
- If UCL is above the RT → Hazardous Waste
- 139 mg/kg < 150 mg/kg → Not Hazardous Waste

Accuracy & Precision



Accuracy & Precision (cont.)



Number of Samples

- Based on random, representative samples
- n depends on level of precision and CI needed
  - n = 2 ➡ 4 decreases CI by 62%
  - n = 4 ➡ 8 decreases CI by 39%
- n is the least number required to show UCL for the true mean is < RT
- If little information is known about waste then use simple random sampling, but as collect more info then consider others sampling schemes

Samples Almost as Tasty as the Ones at Costco

Types of Samples

- Grab: one physical location or specific time
- Composite: two or more samples combined into one sample
  - Spatial (space)
  - Temporal (time)
- Composite samples save analytical costs but decrease the action level

Composite Samples

- Compositing dilutes contaminant concentrations
- Example composite scenario
  - Is surface soil in 100 ft x 100 ft area contaminated?
  - Collect one grab sample from each quadrant
  - Composite 4 samples and analyze for lead
  - Action level is 100 mg/kg
- Four hypothetical scenarios
  - What is the composite average concentration?
  - What is the conclusion based on the composite result?

Composite Scenario 1

- Composite average = 100 mg/kg
  - Conclusion = Site fails
- Adjusted action level = 25 mg/kg
  - Conclusion = Site fails (100 > 25)
- Individual results = 100, 100, 100, 100 mg/kg
  - Conclusion = All quadrants fail
- You got lucky!!

Composite Scenario 2

- Composite average = 100 mg/kg
  - Conclusion = Site fails
- Adjusted action level = 25 mg/kg
  - Conclusion = Site fails (100 > 25)
- Individual results: 0, 0, 0, 400 mg/kg
  - Conclusion = One quadrant contaminated
- You cleaned up most of the site unnecessarily!

Composite Scenario 3

- Composite average = 90 mg/kg
  - Conclusion = Site passes (90 < 100)
- Adjusted action level = 25 mg/kg
  - Conclusion = Site fails (90 > 25)
- Individual results: 60, 100, 100, 100 mg/kg
  - Conclusion = Three quadrants contaminated
- You almost released a contaminated site!

Composite Scenario 4

- Composite average = 20 mg/kg
  - Conclusion = Site passes (20 < 100)
- Adjusted action level = 25 mg/kg
  - Conclusion = Site passes (20 < 25)
- Individual results: 50, 0, 20, 10 mg/kg
  - Conclusion = All quadrants are uncontaminated
- Lucky again!

Composite Sampling (cont.)

- Retain individual samples in case the composite sample result exceeds the adjusted action level
- Action level is not adjusted if determining average contamination; i.e. you do not care if one of more samples exceed an action level

Waste Pile Sampling Strategy

- Types of waste piles
  - Contaminated soil
  - Compost
  - Municipal waste
  - Construction and demolition debris

- Rule of thumb
  - One 4 point composite per 250 to 500 cubic yards
  - Random sampling
  - Analyze for contaminants of concern
  - Analyze for contaminants required by disposal company

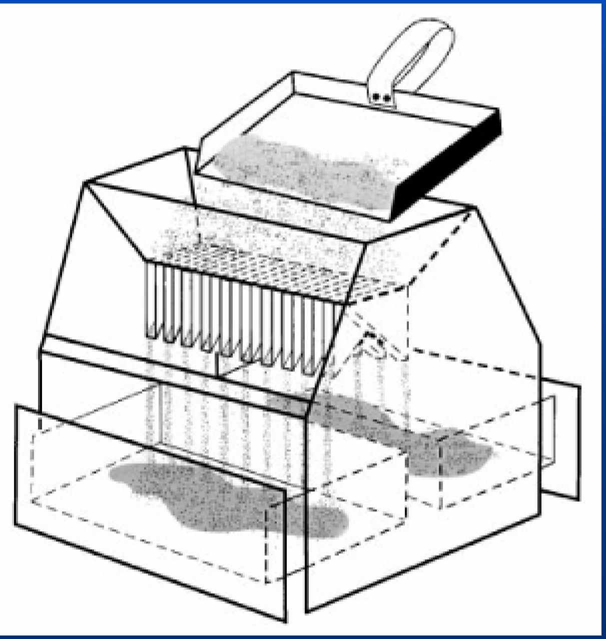
Sampling Grammar

- “Five surface soil samples were taken from the background area for metals analysis.”
- “Five surface soil samples were collected from the background area for metals analysis.”

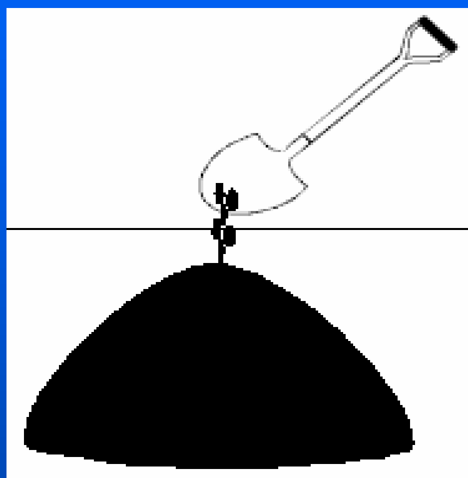
Fool are taken!
Samples are collected!

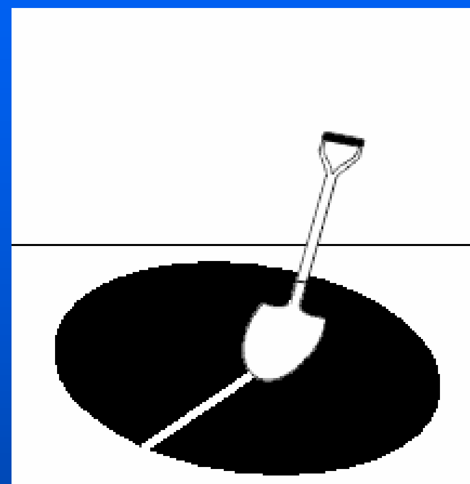
Homogenization

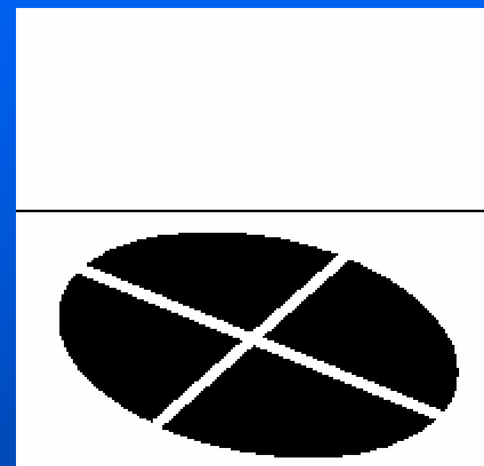
- Mix sample to create uniform distribution of contaminants (or pay laboratory to do it for you)
- Samples must be homogenized before analysis
- Methods
  - By hand (quartering or mixing)
  - By mechanical device (Riffle splitter)



Quartering







Step 1: Form cone
Step 2: Flatten cone
Step 3: Divide cone into quarters
Step 4: Mix two opposite quarters and discard the others
Step 5: Reform cone
Step 6: Repeat minimum 5 times

Sampling Requires Skill, Patience, and Serious Equipment

Sampling Methods & Equipment

- Manual methods
  - Soil
  - Water
  - Air/Gas

- Mechanical methods
  - Drill rigs
  - Direct-push rigs
  - Direct reading instruments

Soil Sampling Methods

- Spoon, scoop, trowel
  - Directly scoop soil

- Shelby tube
  - Hollow tube pushed into ground and removed
  - Sample pushed out of tube
- Auger
  - Hollow tube with cutting blades screwed into ground and removed
  - Sample pushed out of tube

Shelby Tube & Corer

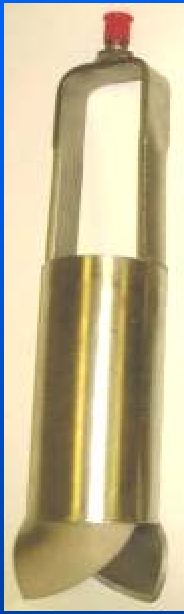
- Shelby tube is a brass tube for soil collection
- Corer cuts into soil for soil collection
- Slam bar pushes corer into soil

Shelby Tube

- Extract Shelby tube from corer
- Place Teflon tape over ends
- Cap ends (red = top, blue = bottom)

Hand Augers

- Tube with blades cut into soil
- Soil is removed from tube
- Handle with extensions used to screw auger into soil



Water Sampling Methods

- Directly submerse container into surface water
- Point container opening downstream
- Add preservative after collecting sample
- Sample from downstream to upstream

Air/Gas Sampling Methods

- Summa canister

- Tedlar bag
- Air pump with sample media

- EPA TO (organic) and IO (inorganic) methods

Summa Canisters

- Stainless steel vessel under vacuum with chemically inert internal surfaces
- Various sizes from 1 liter to 15+ liters
- Evacuated canister holding time is 30 days
- Not for sulfur compounds!
- Two methods of collection
  - Grab sample
  - Integrated sample

Summa Grab Procedure

- Remove cap and attach gauge and filter
- Check vacuum pressure (should be >25” Hg)
- Open valve to collect sample
- When gauge reaches zero, close valve, remove gauge and filter, and cap

Summa Integrated Procedure

- Remove cap and attach controller (use controller set for desired flow rate) and filter

- Check vacuum pressure (should be >25” Hg)

- Open valve to collect sample
- When sampling period ends, close valve, remove controller and filter, and cap

Tedlar Bags

- Tedlar is polyvinyl fluoride (PVF)
- Various sizes from 1 liter to 3 liters
- One time use after opening
- Good for sulfur compounds
- Two methods of collection
  - Pump
  - Pump with vacuum lung

Pump Procedure

- Purge sampling port
- Attach tubing to port and purge
- Attach tubing to pump and purge
- Attach tubing from pump outlet to Tedlar bag
- Open valve and fill until 2/3 full
- Shut valve and stop pump

Sampling Gas Points

- Purge tubing adequately
- If water is present in tube then sample may be compromised
- Take care if sample point is under vacuum or pressure

Pump & Vacuum Lung

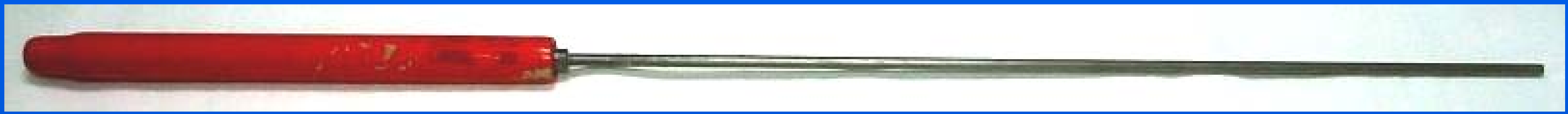
- Best procedure since air does not contact pump
- Set up equipment as shown
- Create vacuum in lung with pump
- Stop pump after Tedlar bag is 2/3 full
- Open lung and close valve

Summa Canister vs. Tedlar Bag

	Summa Canister	Tedlar Bag
Pros	Lower detection limits (ppbv)	Less expensive
	Longer holding time (up to 30 days)	More portable with simpler equipment
	Clean to ppbv/pptv	Some VOCs at 0.5 – 45 ppbv
Cons	More expensive	Shorter holding times (24 - 72 hours)
	Lab must provide can	Will leak sample
	Not for sulfur compounds	Higher detection limits (ppmv)
	Gauges can malfunction	One time use

Temperature Gauge

- Bar hole probe creates hole in soil



- Insert thermometer into hole

- Read temperature after reaching equilibrium

Drill Rigs

- Hollow stem auger
  - Flight augers rotated to depth of interest
  - Split spoon sent inside auger, pounded to depth interval, and removed to collect
- Direct mud (water) rotary
  - Drill bit on rods rotated into ground
  - Mud slurry pumped through rods and back up between rods and wall of hole to remove cuttings
  - Split spoon sampling like hollow stem auger
- Air-rotary
  - Similar to direct mud rotary except uses air
  - Split spoon sampling like hollow stem auger

Direct-Push Rigs

- Geoprobe
  - Pushes rods with core sampler to depth
  - Open corer and push to fill sample tube
  - Withdraw and collect sample

- Backhoe or excavator digs to depth
  - Collect sample directly from bucket
  - Collect sample with hand auger

Direct Reading Instruments

- GEM 2000 for gas emission compliance
- Draeger tubes
- Radiation instruments

Where Did I Collect that Darn Sample?

Sampling Locations

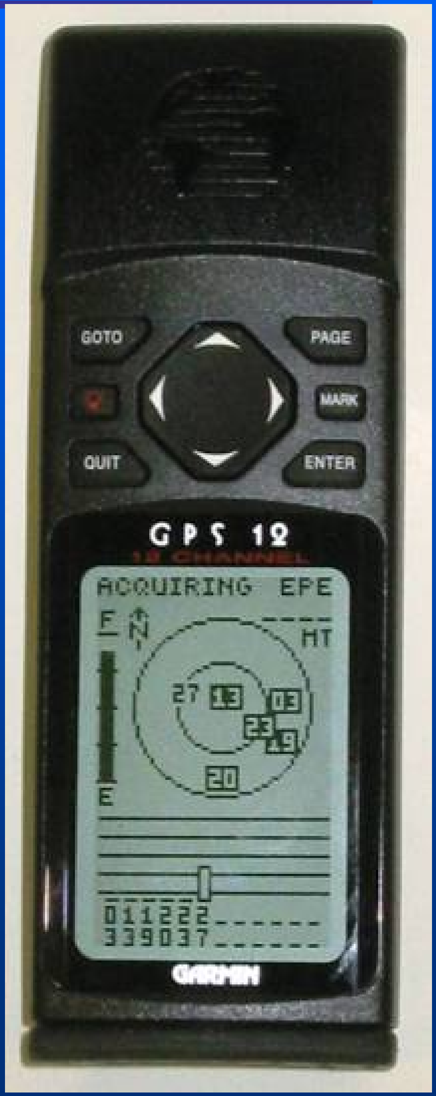
- Sampling location map
  - Grid
  - Survey controls
  - Scaled map
- GPS sample locations
  - Correct GPS for best accuracy
  - Use GPS to build site map if necessary

Terminology

- GPS: Global Positioning System
- DGPS: Differential GPS (corrects for error from Dept. of Defense Selective Availability Program)
- Selective Availability Program: Dept. of Defense program to reduce accuracy of GPS for civilian users
- Latitude: North/south position perpendicular to earth's polar axis
- Longitude: East/west position compared to Prime Meridian that passes through north and south poles
- Waypoint: specific location (latitude, longitude)

Garmin GPS 12

- 12 channel; i.e. 12 satellites
- Position accuracy
  - 15 meters (depending on Selective Availability Program)
  - 1-5 meters with DGPS correction
- 4 AA batteries (24 hours of use)
- Stores 500 waypoints (locations)



Garmin GPS 12 - Store Waypoint

- Step 1: Press “MARK”
- Step 2: Highlight “AVERAGE?” & press “ENTER” which displays estimated accuracy of average position
- Step 3: Highlight waypoint name & press “ENTER” then enter location name; i.e. S1 for sample 1, then press “ENTER”
- Highlight “SAVE?” & press “ENTER”

Garmin GPS 12 - View Waypoint

- Step1: Go to “Main Menu”
- Step 2: Highlight “WAYPOINT LIST” & press “ENTER”
- Step 3: Highlight the waypoint name of interest & press “ENTER”

Garmin GPS 76

- 12 channel; i.e. 12 satellites
- Position accuracy
  - <15 meters (depending on Selective Availability Program)
  - 3-5 meters with DGPS correction
- 2 AA batteries (16 hours of use)
- Stores 500 waypoints (locations)

New York Times Best Seller
"Analytes and Their
Analytical Methods"
by Poly Ester

Typical Analytes of Concern

- Waste/Burn Ash
  - Metals
  - PCBs
  - TRPH
  - Pesticides
  - Dioxins
  - SVOCs / PAHs

- Landfill Gas
  - Fixed gases (CH_4, CO_2, N_2, O_2, H_2)
  - Trace gases (H_2S, CO, VOCs)

Analytical Methods

- EPA Methods
- California Methods
- Other Methods
  - Research
  - Laboratory developed
  - ASTM
  - National Environmental Methods Index (www.nemi.gov)

EPA Methods

- Over 1,600 EPA method
  - SW-846 – hazardous waste
  - 600 series – water
  - 900 series – radiological
  - Toxic Organic (TO) & Inorganic (IO) Methods - air quality
- Index to EPA Test Methods (http://www.epa.gov/epahome/index/)
- Sources of EPA Methods (http://www.epa.gov/epahome/index/key.htm)

California Methods

- CAM 17: California Administrative Manual (CAM) analytical method for 17 analytes
- TTLC: total threshold limit concentration
- STLC: soluble threshold limit concentration
- WET: waste extraction test for STLC

Hazardous Characteristic Waste

- TCLP: toxicity characteristic leaching procedure – Federal EPA
- STLC – California State (by WET)
- TTLC – California State
- TCLP and WET are extractions to simulate landfills leachate for samples with > 0.5% solids

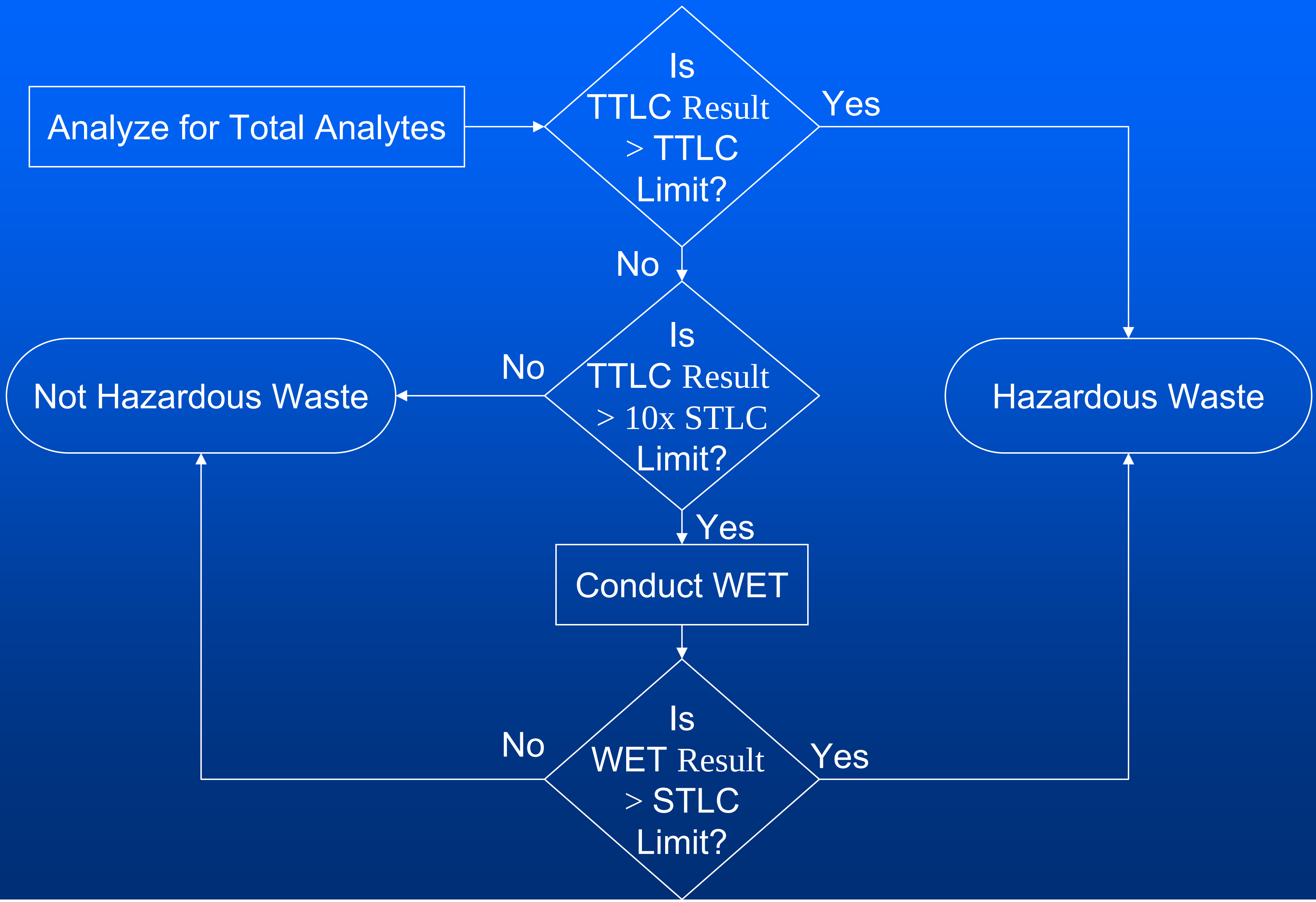
TTLC 10X Rule

- If total analyte result is < TTLC limit,
  but > 10 times STLC limit,
  then WET required

- If WET results > STLC limit,
  then classify as hazardous waste

- Example for lead
  - TTLC = 1,000 mg/kg
  - STLC = 5 mg/kg
  - TCLP = 5 mg/kg

Hazardous Waste Flow Chart



Hazardous Waste Exercise

- Total Lead = 1200 mg/kg → Hazardous Waste
- Total Lead = 45 mg/kg → Not Hazardous Waste
- Total Lead = 52 mg/kg → Conduct WET
- STLC Lead = 4.5 mg/L → Not Hazardous Waste
- STLC Lead = 5.2 mg/L → Hazardous Waste
- TCLP Lead = 5.2 mg/L → Hazardous Waste

Contain, Preserve, and Hold (We're Not Talking About Jam)

Sampling Containers

- EPA requirement "Specifications and Guidance for Contaminant-Free Sample Containers"

  (Publication 9240.0-05A, EPA/540/R-93/051, December 1992)

- Use proper container
  - EPA published standards
  - Ask laboratory
  - Based on analytical method

- Collect proper volume and quantity of containers

Sample Containers

40 ml
VOA Vial

1 L
Poly

1 L
Glass Amber

4 oz Glass
Wide Mouth

8 oz Glass
Wide Mouth

16 oz Glass
Wide Mouth

EPA Region 9 Standards

- Sampling and Analysis Plan Guidance and Template, Version 2, Private Analytical Services Used, R9QA/002.1, April 2000
- SW-846, Tables 2-36, 3-1, and 4-1
- Other EPA documents referenced in the Index to EPA Test Methods

Preservation

- Analytical method specifies the preservative and quantity

- Aqueous preservative is added to the field sample immediately after collect to prevent chemical changes to analytes of concern

- Many aqueous preservatives are hazardous materials (acid, base, flammable)

Preservation (cont.)

- Many samples require cooling to $4^{o} \pm 2^{o}C$
- Lab will check temperature of cooler upon arrival
- If sample is delivered to lab within a few hours of collection then temperature does not apply

Holding Times

- Holding time (H.T.) is the amount of time (days) a field sample can be stored before extraction/analysis
- Pre-extraction holding time – collection to extraction
- Post-extraction holding time – extraction to analysis
- Depends on matrix and analytes of concern

Metal Requirements

- Soil
  - One 8 ounce wide mouth glass jar
  - No preservative (if mercury then $4^{o} \pm 2^{o}C$)
  - H.T. < 180 day holding time (mercury < 28 days)
- Water
  - One 1 liter polyethylene bottle
  - Nitric acid to < 2 pH
  - H.T. < 180 day holding time (mercury < 28 days)

Organic Requirements

- Soil (except for VOCs)
  - One 8 ounce wide mouth glass jar
  - Cool to $4^o \pm 2^oC$
  - H.T. < 14 days to extraction, < 40 days after extraction
- Water
  - Two 1 liter amber glass jars
  - Cool to $4^o \pm 2^oC$
  - H.T. < 14 days to extraction, < 40 days after extraction

VOC Requirements

- Soil
  - Collect two EnCore samplers
  - Cool to $4^{o} \pm 2^{o}C$ or freeze
  - H.T. < 2 days if cooled or < 4 day if frozen

- Water
  - Three 40 ml VOA vials
  - Hydrochloric acid to < 2 pH, Cool to $4^{o} \pm 2^{o}C$
  - H.T. < 7 days

Alternate VOC Requirements

- Soil (medium/high level > 200 µg/kg)
  - Collect 5 gram sample with coring device
  - Place sample in 5 ml methanol, pre-weighed glass jar
  - Weigh jar in the field
  - H.T. < 14 days

- DTSC Guidance on Method 5035
  (http://www.dtsc.ca.gov/SiteCleanup/upload/HWMP_Guidance_Method-5035.pdf)

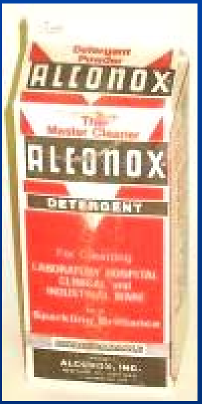
Container Labels

- Sample number
- Date and time of collection
- Name of sampler
- Sample location
- Optional
  - Analytical method
  - Preservation
- Preprinted labels save time
- Use clear tape to cover label

Cleanliness Next to Godliness

Equipment Decontamination

- Decon all equipment before use unless
  - Certified clean
  - No concern for contamination
- Decon non-dedicated equipment before use
- Procedure should be modified for each site



Decon Procedure for Metals Analyses

- Step 1: Physical removal
- Step 2: Non-phosphate detergent wash
- Step 3: Tap water rinse
- Step 4: Distilled/deionized water rinse
- Step 5: 10% nitric acid rinse
- Step 6: Distilled/deionized water rinse
- Step 7: Air dry
- Step 8: Wrap in plastic or aluminum foil

Decon Procedure for Organic Analyses

- Step 1: Physical removal
- Step 2: Non-phosphate detergent wash
- Step 3: Tap water rinse
- Step 4: Distilled/deionized water rinse
- Step 5: Solvent rinse (pesticide grade) - solvent depends on analyte list of concern)
- Step 6: Air dry
- Step 7: Distilled/deionized water rinse (optional)
- Step 8: Air dry (optional)
- Step 9: Wrap in plastic or aluminum foil

QA/QC is so GQ

Field Quality Control Samples

- QC sample analysis provides information about
  - Variability
  - Usability of data
  - Identify analytical discrepancies
  - Validate analytical results
- Types
  - Duplicate or replicate
  - Collocated
  - Blanks (field, trip, rinsate)
  - Performance evaluation (PE)
  - Splits

Field Duplicate/Replicate Sample

- Field sample from one location, homogenized, divided into separate containers with separate sample numbers
- Used to determine
  - Total error (field and lab)
  - Indicate non-homogeneity
- Collect 10% of field samples
- Statistical analysis requires minimum of 8 replicates

Field Collocated Sample

- Collected adjacent (6” to 3’) to another sample
- Determine localized variability
- Not collected very often
- Collection rate dependant on project

Field Blanks

- Field blank: contaminant free water collected in the field
  - Check cross-contamination during sample collection, preservation, shipping, and in lab
  - Check sample container and preservatives
  - Collection rate dependant on project
- Trip blank: VOC free water prepared before going in field
  - Check for cross contamination during handling, storage, and shipping
  - Only for VOC samples
  - Put one in each cooler containing VOC samples

Field Blanks (cont.)

- Rinsate or Equipment blank
  - Checks field decontamination procedures
  - Typically collect one per day per type of equipment or per decon procedure

- Pour contaminant free water over decontaminated equipment and collect water into proper container

Field Performance Evaluation

- Laboratory prepared sample with known concentration of contaminants
- PE samples given to project lab blind
- Evaluate overall bias of project lab
- Expensive to make and not used often
- Send in one or more per project

Field Splits

- Duplicate or replicate sample sent to a different lab for the same analysis
- Check for lab error
- Typically used during oversight of a Potentially Responsible Party (PRP)
- Collection rate depends on project

Laboratory Quality Control

- QC sample analysis provides information about
  - Variability in precision and accuracy
  - Usability of data
  - Identify analytical discrepancies
  - Validate analytical results

- Types (most common)
  - Method blank
  - Duplicate
  - Matrix Spike (MS)/ MS Duplicate (MSD)
  - Laboratory Control Sample (LCS)/ LCS Duplicate (LCSD)
  - Interference Control Sample (ICS)
  - Surrogates
  - Internal standards

Lab QC Definitions

- Method blank: contaminant free extract handled like a sample to determine cross contamination
- Duplicate: extract two portions of one field sample to determine method precision
- MS: Add known amount of target analyte(s) to sample to determine matrix interferences
  - Sometimes requires extra sample volume
  - MSD is duplicate of MS
  - 5% of samples are designated for MS/MSD analysis
  - Used to determine accuracy and precision

Lab QC Definitions (cont.)

- LCS: Blank matrix spiked with known amount of target analytes to determine accuracy
- LCSD: Duplicate of the LCS (called LCD also) to determine precision
- ICS: Interference control sample (metals analysis)

Lab Organic QC

- Surrogates: Organic compound added to every field and QC sample before preparation
  - Compounds different than analytes
  - Monitor matrix effects
  - Monitor analytical method

- Internal standards: Similar to surrogates but added to extract before analysis
  - Used to quantitate results
  - Monitors instrument variables

Lab QC Requirements

- Metals
  - Duplicates (5%)
  - MS (5%)
  - LCS/LCSD (5%)
  - ICS (5%)
- Organics
  - Duplicates (5%)
  - MS/MSD (5%)
  - LCS/LCSD (5%)
  - Surrogates (100%)
  - Internal standards (100%)

Laboratory Accreditation

- California State Environmental Laboratory Accreditation Program (ELAP)
- EPA National Environmental Laboratory Accreditation Program (NELAP)
- NIST National Voluntary Laboratory Accreditation Program (NVLAP)

Laboratories

- Will not homogenize sample unless requested
- Will not reanalyze sample unless requested
- Will open soil container and remove sample quantity from top

Why Does it Cost so Much?

Cost Considerations

- Cost per Sample Analysis
- Cost per Field and Lab QC Sample
- Cost for Labor and Equipment
- Field Screening versus Laboratory Analysis

Sample Analysis Cost

- Cost of sample analysis is typically much less than cost of collection because of:
  - Mobilization costs
  - Field team costs
  - Drilling subcontractor costs
  - Equipment & shipping costs
- Lab charges unit analysis price for:
  - Field samples included field QC
  - Reanalysis upon your request (matrix interference)
- Lab does not charge for:
  - Reanalysis due to their error (QC value out of limit)

QC Sample Cost

- Lab charges unit analysis price for:
  - Field duplicate
  - Field blank
  - Matrix spike (negotiable)
  - Matrix spike duplicate (negotiable)
  - Other submitted QC samples

- Lab does not charge for:
  - Method blank
  - Method duplicate
  - LCS or LCSD
  - Method required analyses or QC

Labor and Equipment Cost

- Labor is typically most of project cost
- Cost savings
  - Field team that has multiple skills; i.e. Project manager/geologist
  - Balance field days versus team size; i.e. more staff to complete multiple tasks faster
- Equipment
  - Typically fixed and unavoidable
  - Malfunctions cost mucho dinero while in the field!

Field Screening

- Field screening analysis is the determination of a measurement by field test kit
  - X-ray fluorescence (XRF) - metals
  - Immunoassay – various organic analytes
  - Synsidyne HAZCAT® – hazardous waste
- Not definitive analyses
- Typically requires definitive (lab) confirmation on 10% of field screened samples

Write Everything Down!

Field Documentation

- Logbook Notes
- Photographic/Videographic
- Maps and Diagrams
- Sampling Plan Deviations
- Chain-of-Custody (C-O-C)

Sample Tracking Tables

- Make sample collection & analysis tables to track collection and analysis requirements
- See attached example table in back of manual

SOIL SAMPLE TRACKING
No Name Site
Project Number: 123

Sample Number	Sample Depth (feet)	Date Collected	Time Collected	Sampler	FS PCP (4oz)	FS XRF	Lab VOC (4 oz)	Lab SVOC (8 oz)	Lab Metals (8 oz)	Lab PCBs (8oz)	Lab Dioxin (8oz)
OLD MILL											
Dip Tank											
OMDT-1-1	0.5				1	y		1	1		
OMDT-1-2	2				1	y		1	1		
Work Areas											
OMWA-1-1	0.5				1	y	6	3	3		
OMWA-2-1	0.5				1	y	2	1	1		
BOX FACTORY											
Transformers											
BFT-1-1	0.5									3	
BFT-2-1	0.5									1	
Burner											
BFB-1-1C	0.5										1+
EAST TRUCK SHOP											
ETS-1-1	0.5						2				
ETSBK-1-1	0.5				1	y	2	1	1	1	1
WETLANDS											
WT-1-1	0.5				1	y		1	1		*
WT-1-2	2				1	y		1	1		**
WT-2-1	0.5				1	y		1	1		*
WT-2-2	2				1	y		1	1		**

Key:
+ = Composite of five grab samples
* = Grab for composite sample WT-1C
** = Grab for composite sample WT-2C
FS = field screening

Sample Numbers

- Sample number control is extremely important!
  - Keep it simple
  - Use sequential numbers
  - Maintain a sample number log
- Date-sequential no: 092406-12, 092406-13,…
- Location-sequential no: OMDT-01, OMDT-01,…
- Borehole no: B1-2-1, B1-2-2, B1-2-3,…

Logbook Notes

- Observations, times, dates, weather, sample collection, deviations, who, what, when, why, where
- Boring and direct push logs
- Geological logs
- Trench logs
- Sample logs
- Sample number control log

Photographic/Videographic

- Take photos and/or videos of
  - Sample locations
  - Equipment
  - Procedures
  - Site conditions before and after investigation
  - Overview of site (aerial is extra helpful)

- Keep a photo log
  - Date, time, direction, description, photographer

- Digital photos are practically free so take lots!!

Maps and Diagrams

- Site map
  - Use GPS
  - Use aerial

- Sketch maps of site
  - Overview
  - Each survey area
  - Deviations from sampling plan
  - Unusual features

Sampling Plan Deviations

- Use a Field Deviation Form to document changes to the sampling plan
- Typical deviations
  - Sample location moved
  - More or less samples collected
  - Change in sampling procedure
- Deviation forms make writing the report easier!

Please Don't Fondle the Samples

Chain-of-Custody

- Four ways to maintain custody
  - In person's physical possession
  - In physical view of person
  - Secured (seals) so that no one can tamper with it
  - Secured in area restricted to authorized personnel

- C-O-C documents possession from collection to final disposition (cradle to grave)

- Required for legally enforceable data

Chain-of-Custody (cont.)

- Fill out C-O-C form completely!
- Release to person
  - Releaser signs with date & time
  - Receiver signs (with date & time, if available)
- Release to shipping company
  - Sign, date & time
  - Include shipping company name with shipping tracking number (airbill, waybill, etc.)
  - Place C-O-C form inside shipping container (cooler)

Excelchem
Environmental Labs

500 Giuseppe Court, Suite 9
Roseville, CA 95678
(916) 773-3664

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Supreme Dictator | Phone #: 999-123-4567

Company/Address: Good Luck, Somewhere, CA | FAX #: 999-123-4568

Project Number: 666 | P.O.#: 999 | Project Name: Nasty Waste

Project Location: 100 Noroad, Nothere, CA | Sampler Signature: [signature]

ANALYSIS REQUEST — W.E.T. (✓) / TOTAL (✓) ❄ | **TAT**

Sample ID	Sampling DATE	Sampling TIME	Container: VOA Tedlar	Container: SLEEVE	Container: 1L GLASS	Container: 1L PLASTIC	Container: 8 oz glass	Method Preserved: HCl	Method Preserved: HNO_3	Method Preserved: ICE	Method Preserved: NONE	Matrix: WATER	Matrix: SOIL	Matrix: Air	BTEX (602/8020)	BTEX/TPH as Gasoline (602/8020/8015)	TPH as Diesel (8015)	TPH as Oil (8015)	Total Oil & Grease (5520 B/E,F)	Total Oil & Grease IR (5520 B/E,F,C)	96 - Hour Fish Bioassay	EPA 601/8010	EPA 602/8020	EPA 615/8150	EPA 608/8080 - Pesticides	EPA 608/8080-PCBs	EPA 624/8240	EPA 625/8270	ORGANIC LEAD	Reactivity, Corrosivity, Ignitibility	CAM - 17 Metals	EPA - Priority Pollutant Metals	LEAD(7420/7421/239.2)	Cd, Cr, Pb, Zn, Ni	EPA TO15 Hydrogen sulfide					RUSH SERVICE (12 hr) or (24 hr)	EXPEDITED SERVICE (48 hr) or (1 wk)	STANDARD SERVICE (2wk)
B1-1	9/1/06	1430					❄				❄		❄																		❄											❄
B1-2	9/1/06	1444					❄				❄		❄																		❄											❄
W1	9/1/06	1023				❄		❄				❄			❄				❄						❄						❄										❄	
A1	9/1/06	0932	❄								❄			❄																					❄					❄		

Relinquished by:	Date	Time	Received by:	Remarks:
[signature]	9/2/06	1230	FedEx	condition of sample Airbill #: 6836479876354109
Relinquished by	Date	Time	Received by:	
Relinquished by	Date	Time	Received by Laboratory:	Bill To:

ENVIRONMENTAL
Analytical Service, Inc.

173 Cros... ...reet
San Luis Obispo, CA
93401 - 7597
805.781.3585
Fax 805.541.4550

CHAIN OF CUSTODY RECORD

Project Number	Project Name:	Quote Number:

REPORT TO:

Company

Address

City/State/Zip

Phone (FAX)

ATTENTION

MATRIX LEGEND
A - Ambient Air, Low Level
I - Indoor Air
S - Source Air, High Level
G - Gas/Product

SAMPLE DESCRIPTION	SAMPLE DATE	SAMPLE TIME	CANISTER NUMBER	COMP	GRAB	MATRIX A	MATRIX I	MATRIX S	MATRIX G	INITIAL PRESSURE	FINAL PRESSURE	EAS LABORATORY ID	ANALYTICAL TESTS						REMARKS

COMMENTS

BILLING INFORMATION

Company

Address

City/State/Zip

ATTENTION

Purchase Order/Billing Reference

	Date	Time		Date	Time
SAMPLED BY:			Received by:		
Relinquished By:			Received by:		
Relinquished By:			Received by:		
Relinquished By:			Received for lab by:		

Sample Handling and Shipping

- Custody Seal
- Ice Preservation
- Container packaging
- Shipping Carriers
- Hazardous Materials Shipment

Custody Seal

- Used to detect tampering of sample container or storage container (cooler)
- Sign and date the seal
- Place seal over opening of closed container
- Tape the ends of the seal if needed

Ice Preservation

- Ice required for preservation for most samples
- Double plastic bag ice to prevent leakage
- Use lots of ice to surround samples
- Put samples into plastic bags

Ice Preservation (cont.)

- Dry ice can be used but more hazardous and creates space upon sublimation
- If cooler is delayed by shipper then %*&@$#! (ice will melt)
- Laboratory will check temperature upon arrival

Container Packaging

- Place each sampling container in a ziplock bag
  - Prevents label from getting wet
  - If container breaks, sample is contained
- Glass sample containers can break
  - Ice will act as padding
  - Fill extra space with padding (bubble wrap, etc.)

Golden Rule of Packing

If It Can't Move, It Can't Break!

Shipping Carriers

- Next morning service preferred
  - FedEx
  - Airborne
  - UPS
  - California Overnight
- Courier Service
- Hand carry

Hazardous Materials Shipment

- Review shipping regulations if shipping hazardous materials
- Typical hazardous materials
  - Flammables
  - Highly toxic
  - Reactives
- May need a hazardous materials shipping form and appropriate packaging and labeling

Section 3
Reporting Results

Data Validation

- Assess the usability of data for use in project decision making processes

- Various data validation criteria
  - EPA programs
  - EPA regions

- Three general levels
  - Level 1: In-depth review not required
  - Level 2: Focused evaluation on selected analytes
  - Level 3: In-depth review of raw data

Level 1 Data Validation

- Completeness of data
- Chain of custody forms
- Holding times
- QC summaries
- Blank samples
- Random checks of results against raw data
- Random checks of raw data for interference problems or system control problems

Data Validation Qualifiers

- Data validation qualifiers
  - J: analyte result is estimated
  - U: analyte was not detected above RL
  - UJ: analyte was not detected and RL is estimated
  - R: result is rejected

- Laboratory qualifiers
  - B: analyte was detected in blank
  - E: result exceeded calibration range

Laboratory Detection Limits

- IDL: Instrument detection limit
- MDL: Method detection limit (49 CFR 136B)
- QL: Quantitation limit
  - PQL: practical quantitation limit
  - LOQ: limit of quantitation
- RL: Reporting limit

Laboratory Detection Limits (cont.)

- IDL: Minimum amount of analyte detected with specified degree of confidence that the amount is greater than zero
  - Instrument specific
  - Qualitative value
  - Only accounts for instrument variables

- MDL: Minimum amount of analyte detected with 99% confidence that the amount is greater than zero
  - Method specific
  - Qualitative value
  - Accounts for method procedure and instrument variables

Laboratory Detection Limits (cont.)

- QL: Minimum amount of analyte quantitatively measured with a specified degree of confidence and within the accuracy and precision guidelines of an instrument
  - Typically 2-10 times the MDL)
- RL: Concentration that is reported for the analyte
  - Based on the MDL
  - Considers sample size, dilution, other specific sample or analysis variables

Project Objectives

- After data validation, determine if data meets the DQOs.
- If yes, then yahoo!
- If no, then recollect data or change DQOs
- Perform statistical test, if required

Sampling Methods & Procedures

- Did you follow the SOPs exactly?
- If yes, then yahoo!
- If no, then describe the differences or deviations
- Explain the reason for SOP deviations

QA/QC Sample Results

- Discuss field QA/QC sample results
  - Blanks
  - Duplicates

- Discuss lab QA/QC sample results
  - Blanks
  - Duplicates
  - MS/MSD
  - LCS/LCSD

Field Sample Data Results

- Report in tables with complete title
- Make it simple and easy to read
- Include detection limit if undetected
- Include data qualifiers if applicable
- Highlight results above action limit

Field Sample Data Results (cont.)

- Include key for abbreviations, explanations, etc.
- Use one table per matrix
- Include action limits for clarity
- If a table cell is blank, use NA (not applicable)
- Include units! (μg/kg, mg/l, etc.)

Table 1
Old Mill Dip Tank Surface Soil Metal Results
Mt. Shasta
Mt. Shasta, CA
Sept 1, 2006
(mg/kg)

Analyte	OMDT-1-1	OMDT-1-2	OMDT-1-3	OMDT-1-4	OMDT-1-5	PRG[A]
Arsenic	1 U	**1.2** J	1 U	1 U	1 U	0.062[B]
Beryllium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	150
Cadmium	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	37
Lead	**230**	**175**	15	20	1 U	150[B]
Mercury	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	23
Selenium	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	390
Silver	10 U	10 U	10 U	10 U	10 U	390
Zinc	NA	NA	NA	NA	NA	2,300

Key:
A = EPA Region 9 PRG Residential Soil
B = California modified PRG Residential Soil
U = analyte was undetected at the reported detection limit
UJ = analyte was undetected at the estimated detection limit
J = value is estimated
NA = not applicable
Bold = result exceeds PRG

Data Discussion

- Always include units with values!
  - "Lead was 23 in surface soil at the Dip Tank area."
  - "Lead results at the Dip Tank area indicated 23 mg/kg in surface soil."
- Make comparisons
  - "Mercury in surface soil was elevated."
  - "Mercury in surface soil was elevated above the EPA Region 9 PRG for residential soil."

Deviations

- Discuss all deviations from the sampling plan
- Include a rationale
- Attached Field Deviation Forms in appendix
- Combination of the sampling plan and deviations should represent what was actually done

Conclusions & Recommendations

- Conclusion and recommendations are difficult to impossible to state definitively for most projects
- Use words like
  - Appears
  - Potentially
  - Approximately
  - Indicates
- Consult stakeholders for consensus

Appendices

- Lab data packages
- Logs (geological, air sampling, etc.)
- Maps
- Photographs
- Field Deviation Forms

Section 4
Health & Safety Plans

Health & Safety Program

- Federal OSHA regulations
- Cal/OSHA regulations
- Injury & Illness Prevention Program (IIPP)
  - Medical monitoring program
  - Agency policies
- Site Specific Safety & Health Plan (SSSHP)

Sampling PPE

- Use appropriate PPE according to SSSHP
- Typical PPE
  - Gloves (nitrile, vinyl, rubber, etc.)
  - Coveralls (Tyvex®, Cleanguard®, etc.)
  - Booties (rubber, latex, etc.)

- Change gloves after collecting each sample!

NIOSH Manual of Methods

- NIOSH Manual of Methods (www.cdc.gov/niosh/nmam/)
- Occupational air sampling & analysis methods
- Analytical methods are similar to EPA Methods
- Typically require several blank media

Health & Safety Instruments

- GMI 442R GasSurveyor or Scott Scout (multigas)
- MiniRae 2000 (volatile gas)
- Draeger tubes (various gaseous substances)
- Gilian Gilair (air pump)
- Radiation instruments (various types)

GMI Gasurveyor 442R

GMI Gasurveyor 442R

- Combustible Gas or lower explosive limit (LEL) (% and ppm)
- O_2 (%)
- CO (ppm)
- H_2S (ppm)
- Two Modes
  - Confined space monitor (CGM)
  - Combustible gas indicator (CGI)
- Data logging
- Alarms only in CGM mode

Safety Precautions!

- Service in safe area
- Change batteries in safe area
- Use only GMI parts

Bad Atmospheres

- Do not use in the presence of:
  - O_2 is >21%
  - Silicones: lubricants, hydraulic oil
  - Free Halogens: chlorine, fluorine, bleach/pool chlorine
  - Halogenated hydrocarbons: Freon, refrigerants, dry cleaning fluid, degreasers
  - Metallic oxides: tetra ethyl lead (leaded gasoline), antimony

- Careful in low O_2 areas because LEL will not work

Operating Parameters

- Temperature range = 14^o to 104^o F
- Pressure = 1000mBar +/- 50 mBar
- Relative Humidity = 0% to 95%
- Minimal pressure changes at the inlet
- Do not use is certain atmospheres; i.e. O_2 > 21%

Detector Operating Ranges

Parameter	Range	Accuracy
LEL	0% to 10%	+/- 0.5%
Methane	10% to 100% LEL	+/- 2.0%
	0 to 1,000 ppm	+/- 50 ppm
	5% to 10%	0.5%
	10% to 100%	2.0%
O_2	0% to 21% (30%)	+/- 0.5%
H_2S	0 to 200 ppm	+/- 2 ppm
CO	0 to 1,000 ppm	+/- 15 ppm

Response Times

- Flammable Gases = 15 secs to 95% of reading
- Toxic Gases = 30 secs to 95% of reading

Filters

- Probe has two filters
  - Particulate (cotton)
  - Hydrophobic

- Never turn instrument on without the probe attached!
- Replace filters if blocked or water ingress
- Hydrophobic filter can be dried and reused

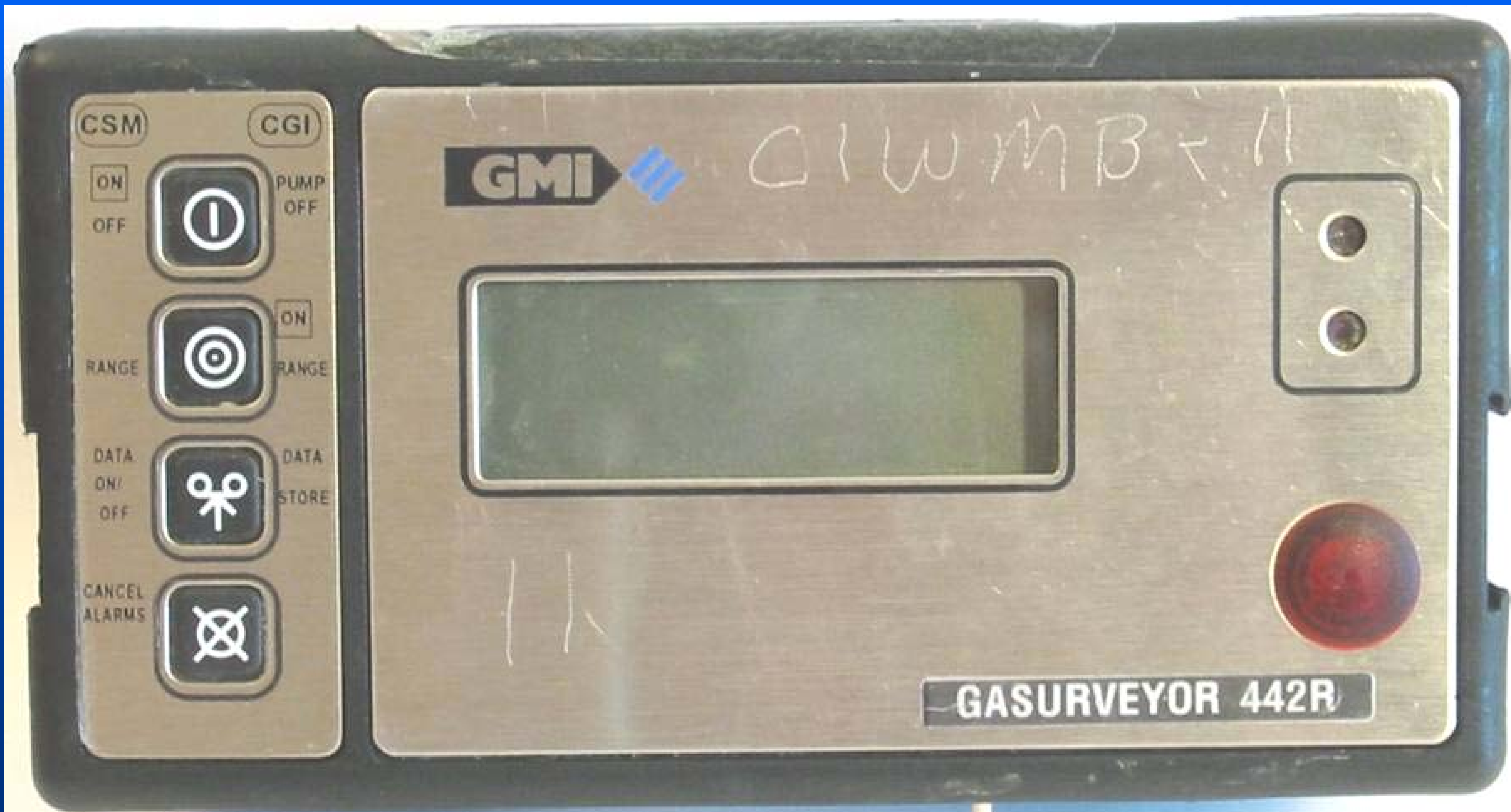
Calibration

- GMI Manual Calibration System – calibrate linked to a computer
- GMI Workshop System – calibrate without manually changing gas cylinders
- GMI Instrument Management System – calibrate remotely and record operation

On and Off

- CSM mode = press Switch One for one second (rarely used by CIWMB)
- CGI mode = press Switch Two for one second
- Off = press Switch One twice; cancel by pressing Switch One once

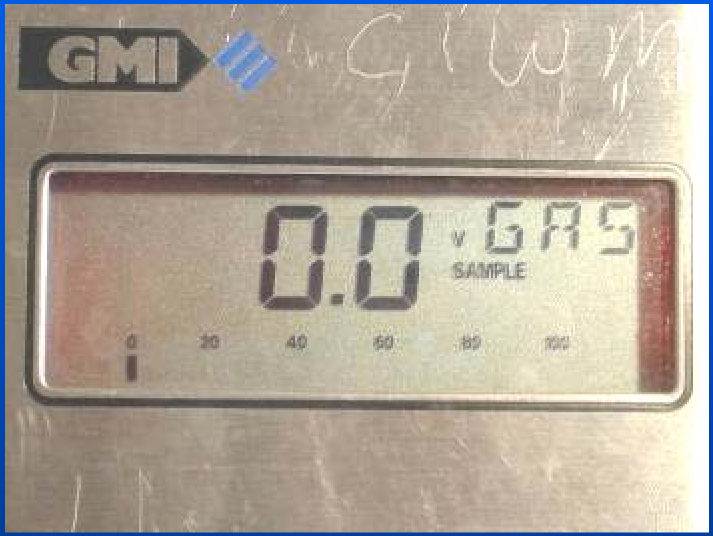
GMI Gasurveyor 442R

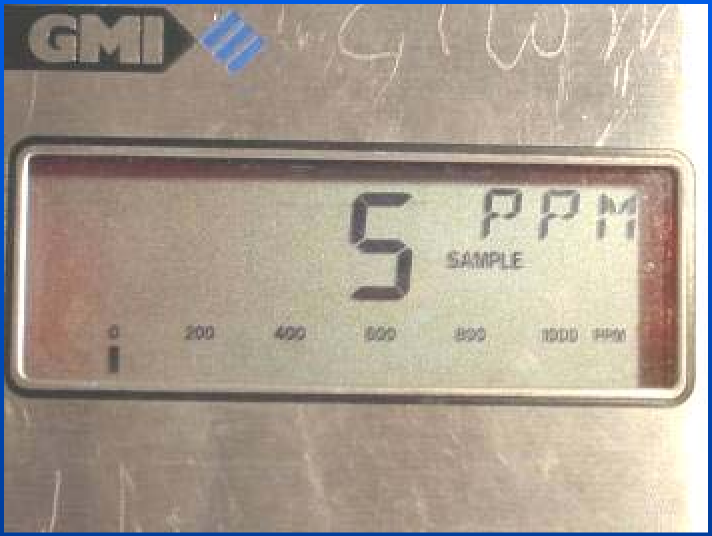


Switch Two

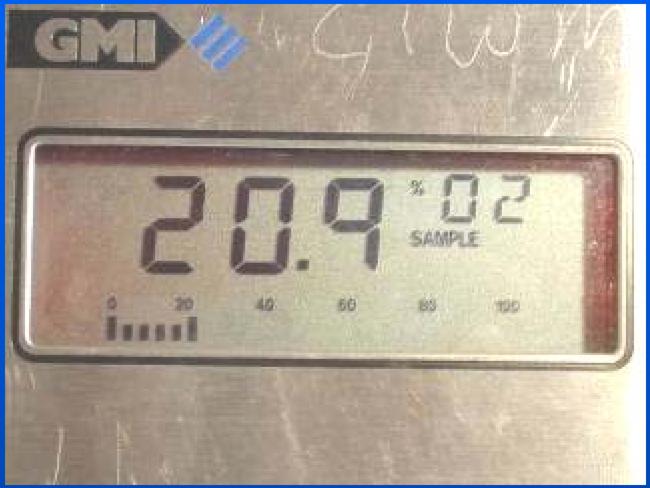
CSM
CGI
ON
OFF
PUMP
OFF
ON
RANGE
ON/
OFF
DATA
STORE
CANCEL
ALARMS
GMI
0.0
GAS
SAMPLE
0
20
40
60
80
100
GASU

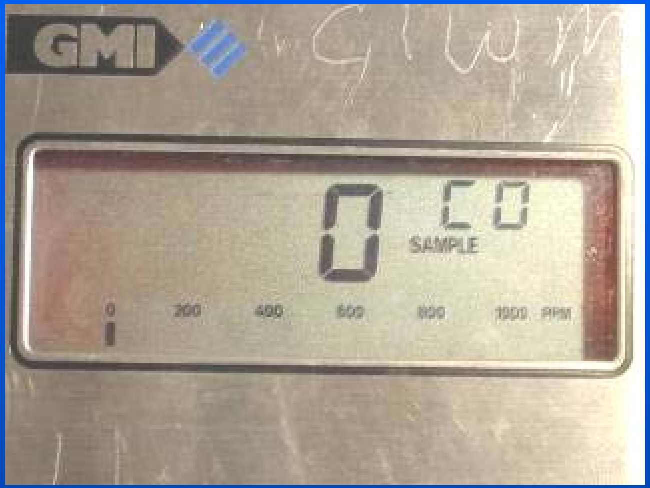
Gas Percentage & ppm





O_2, CO, H_2S


GMI
20.9
% 02
SAMPLE
0 20 40 60 80 100


GMI
0
CO
SAMPLE
0 200 400 600 800 1000 PPM


GMI
0
H2S
SAMPLE
0 200 400 600 800 1000 PPM

Scott Scout

Scott Scout

- Sensors
  - Combustible Gas (% and ppm)
  - Oxygen – O_2 (%)
  - Carbon Monoxide – CO (ppm)
  - Hydrogen Sulfide – H_2S (ppm)
- Warning and Alarm levels
- Passive and Active Monitoring
- Three modes
  - General user
  - Technical user (secret password)
  - Setup user (super top secret password)

Safety Precautions!

- Service in safe area
- Batteries
  - Change in safe area
  - Use only approved batteries
- Use only Scott parts

Bad Atmospheres

- Do not use in the presence of:
  - Silicones: lubricants, hydraulic oil
  - Free Halogens: chlorine, fluorine, bleach/pool chlorine
  - Halogenated hydrocarbons: Freon, refrigerants, dry cleaning fluid, degreasers
  - Metallic oxides: tetra ethyl lead (leaded gasoline), antimony

- Do not use in low O_2 areas (<10%) because LEL will not work

Operating Parameters

- Temperature range = -40º to 122º F
- Do not use is certain atmospheres; i.e. $O_2 < 10\%$
- Battery Life
  - 24 hours with continuous pump (500 ml/min)
  - 50 hours without pump
- Sensor specific operating parameters

Detector Operating Ranges

Parameter	Range
LEL / % Gas	0% to 100%
O_2	0.0 to 25.0%
H_2S	0 to 100 ppm
CO	0 to 500 ppm

Filters

- Probe has two filters
  - Particulate (cotton)
  - Hydrophobic

- Never turn instrument on without the probe attached!
- Replace filters if blocked or water ingress
- Hydrophobic filter can be dried and reused

Calibration

- Must be calibrated using appropriate calibration gas for the instrument detectors
- Daily calibration (bump test) check required
  - Use gas mixture
  - Results within ±10%
- Perform zero calibration in clean air

On and Off

- On
  - Press two buttons and hold
  - "Hold" - hold for about 5 secs
  - "Release"

- Off
  - Press two bottom buttons
  - "Turn off"
  - Press upper left button

Monitoring Modes

- Passive mode (sensor shield open) for general surveying

- Active mode (sensor shield closed) for monitoring a single point or area

Read Out

% Gas Reading

COMBUSTIBLE LEAK
0.0 %Gas
PPM
5000
1500
500
150
50
Tick
Next
Scout

Probe and Tubing Attached

MiniRAE 2000

MiniRAE 2000

- Photoionization Detector (PID)
- Detects VOCs within specific range of ionization dependant on lamp strength (9.8, 10.6, or 11.7 eV)

Safety Precautions!

- Service in safe area

- Batteries
  - Change in safe area
  - Replace in a safe area
  - Use only RAE Systems battery packs

- Use only MiniRAE parts

Caution

- Understand the accuracy of PID
- Use correction factors (CF)
- PID can not detect all compounds
- Correct action levels for mixtures
- Humidity affects reading
- Interfering gases affects reading (10% methane)
- High concentration gases affects reading (>1,000 ppm)

Operating Parameters

- Temperature range: 32^{o} to 113^{o} F
- Humidity: 0% to 95% (affects performance)
- Electromagnetic interference: up to 0.43 W/cm^{2} RF
- Pump: 450 – 550 cc/min
  - Teflon or metal tubing
  - Up to 200 ft horizontal + up to 90 ft vertical @ 3 ft/min
  - Auto shutoff if moisture detected or inlet blocked

Sensor Specifications

- Detector: 9.8, 10.6, or 11.7 eV UV lamp

- Isobutylene (calibration gas):

Range	Resolution	Response time (t_{90})
0-99 ppm	0.1 ppm	2 sec
100-1,999 ppm	1.0 ppm	2 sec
2000-10,000 ppm	1.0 ppm	2 sec

- Accuracy:
  - 0-2,000 ppm = ± 2 ppm or 10% reading
  - >2,000 ppm = ± 20% reading

Sensor Life Span

Lamp	Life Span	Warranty	Price
9.8 eV	1 year	6 months	$245
10.6 eV	1-3 years	up to 3 years	$195
11.7 eV	1-3 months	30 days	$295

Lamp Cleaning

- MiniRAE 2000 self cleans lamp while charging
- Generates ozone to clean
- Does not decrease lamp life
- Increases stability
- See RAE Systems TN-165: Combating Drift
  - Use gas chromatography grade methanol
  - Never touch lamp!
  - Never use acetone or aqueous solution!

Filters

- External prefilter (0.45 micron PTFE)
  - Stops dust & water
  - Always Use the Filter!
  - Replace when visually dirty
  - Replace when movement causes a reading

- Internal filters
  - C-filter: optional cellulose filter for dust & water
  - Metal frit: dust

Calibration

- Calibrate daily with known cal gas before use
- Two point calibration
  - Zero
  - Span gas
- Use a regulator with a flow rate that matches the MiniRAE flow rate (500ml/min)
- Calibration regulator in kit is 500ml/min

Operating Modes

- Survey mode
  - Manual start and stop
  - Current, average, peak concentration
- Hygiene mode
  - Run continuously after turned on
  - Current, TWA, STEL, & peak concentration
- Programming Mode
  - Switch modes
  - Change calibration gas, alarm limits, datalogging, monitor setup
- Special diagnostic mode
  - Fix minor malfunctions
  - Use by only qualified personnel!

Keys

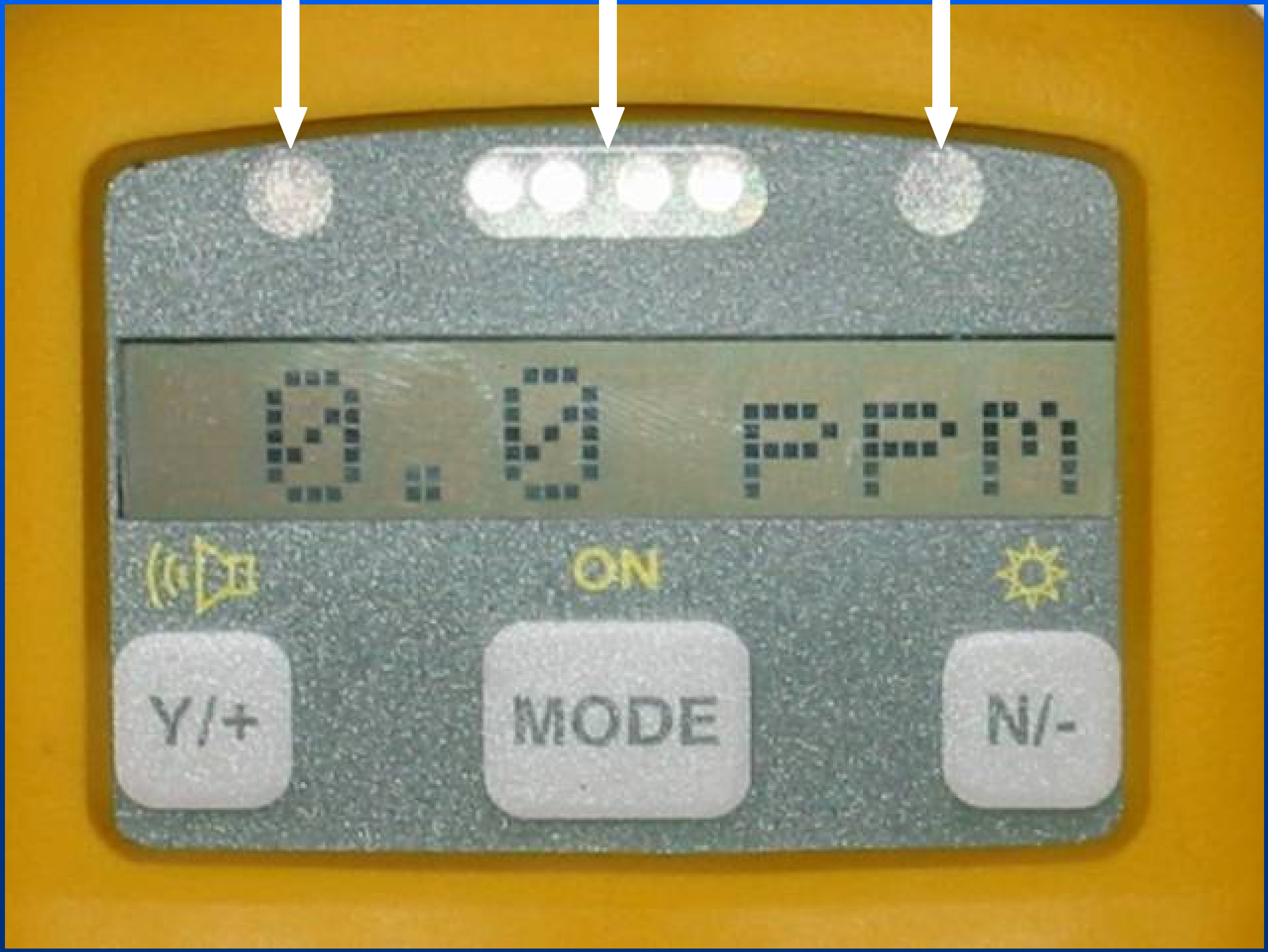
- Keys
  - [MODE]: turn on/off & menu advance
  - [N/-]: toggle back light, no answer & decrease value
  - [Y/+]: start measurement, yes answer & increase value
- Turn on: press [MODE] for 1 second
- Turn off: press [MODE] for 5 seconds
- When in doubt press [MODE]

Display

Light Sensor

Alarms LCDs

Charge LED



Draeger System

Draeger Pump & Tubes

- Detect chemicals in air within minutes
- Detects over 160 chemicals
- Hand pump or automatic pump
- Caution: tubes have short shelf life (~1 year or less)

Draeger Procedure

- Step 1: Select tube for gas of concern
- Step 2: Break ends of tube and attach to pump (arrow toward inlet)
- Step 3: Pump recommend number of strokes
- Step 4: Read tube

Draeger Tubes

SO_2 PERC VC Benzene H_2S

Gilian Gilair-5

Gilian Gilair-5

- Constant flow: 750-5000 cc/min
- Low flow: 1-750 cc/min
- Rechargeable battery pack system
- Built-in rotameter & flow adjust
- Multiple sorbent tube capability

Gilian Gilair-5 (cont.)

- Programmable LCD clock timer
- Instant-fault function
- UL listed intrinsically safe

Personal Air Monitoring

- Pump and sample media is placed on worker
- Sample collected over 8 hour work day
- Sample analyzed for contaminants of concern
- Compare results to OSHA regulations
- Upgrade PPE or implement engineering controls if exceed OSHA limits

Radiation Instruments

Radiation Instruments

- Radiation Alert Monitor 4
- Radalert 50 pocket GM
- Radiation Alert Inspector with pancake GM
- Bicron Surveyor 2000 meter with pancake GM
- Ludlum Model 2241-2 meter
  - Model 44-2, 44-10, 44-20 gamma detectors
  - Model 44-9 alpha/beta/gamma detector
- Inovision 451P ion chamber
- SAIC PD10i dosimeter

Calibration

- All instruments require yearly calibration
- Instrument will function if not calibrated
- Perform a daily operational check with an appropriate source

Geiger-Mueller (GM) Detector

- Detects alpha, beta, gamma, and X-ray
- Pros
  - Detects all types of radiation
- Cons
  - Does not discriminate between radiation types
  - Low gamma detection efficiency
  - Does not determine exposure

Radiation Alert Monitor 4

- Small Geiger-Mueller detector
- Range
  - Dose rate: 0 μR/hr – 50 R/hr
  - cpm: 0 – 50,000
- Audio on/off: beeps with each count
- Red LED flashes with each count
- Battery check (9 volt battery = 2,000 hours)
- Sensitivity = 1000 cpm/mR/hr (Cs-137)

Radalert50

- Halogen-quenched GM detector
- Operating range: 0-50 mR/hr & 0-50,000 cpm
- Sensitivity: 1000 cpm/mR/hr (Cs-137)
- Alert: User-adjustable
- One 9-volt alkaline battery
- Red LED flashes & beeper chirps with each count

Rad Alert Inspector

- Internal and external GM detectors
- Operating Range
  - mR/hr: 0.001 - 100 mR/hr
  - cpm: 0 - 350,000
- Gamma Sensitivity
  - 3500 cpm/mR/hr (Cs-137)

Bicron Surveyor 2000

- Internal energy compensated GM tube: 0 - 2 R/hr range for gamma
- External detector: PGM operates at 900 Volts

- Switch
  - Audio on\off
  - Battery check
  - Fast/Slow switch
- Response depends on range
  - Slow: 1 - 25 sec
  - Fast: <1 - 6 sec

Ludlum Model 2241-2

- Ratemeter / scaler switch & multiple detector switch
- Digital Auto Ranging:
  - 0 μR/hr – 9,999 R/hr
  - 0 cpm – 999,000 cpm
- Fixed response
  - FAST adjustable from 2 - 50 seconds
  - SLOW response is 5 times fast setting

- Variable response is dependent on number of counts
  - FAST ~ 4 - 25 seconds
  - SLOW ~ 4 - 60 seconds (10% to 90% of final reading)
- Adjustable perimeters via internal PC board

Ludlum 44-9 PGM

- Detector: Pancake halogen quenched GM
- Sensitivity: Typically 3300 cpm/mR/hr (Cs-137)
- Energy dependent
- Efficiency (4pi geometry)
  - 22%-Sr-90 (beta)
  - 15%-Pu-239 (alpha)
- Operating Voltage: 900 volts

NaI Scintillation Detector

- NaI (sodium iodide) inorganic crystal
- NaI detects gamma and X-ray
- Pros
  - Highly efficient
  - Durable
- Cons
  - Specific to only gamma and X-rays

Ludlum 44-2 & 44-20

- Energy dependent
- Sensitivity (Cs-137)
  - 1 x 1 = 175 cpm/microR/hr
  - 3 x 3 = 2700 cpm/microR/hr
- Operating Voltage
  - 500 - 1200 volts

44-2
1” x 1”

44-20
3” x 3”

Ion Chamber Detector

- Gas filled chamber
- Detects high energy beta and gamma
- Pros
  - Accurate measurement of exposure rate
- Cons
  - Not sensitive to low energy radiation
  - Delicate

Inovision 451P

- Detector: 300 cc volume pressurized air ionization chamber to 6 atmospheres
- Gamma and high energy beta
- LCD analog/digital display in dose rate and dose
- Auto scaling range: 0 – 5,000 mR/hr
- Response time: 2 – 5 sec

SAIC PD-10i Pocket Dosimeter

- Miniature Geiger-Mueller tube detector
- Detects gamma and high energy beta
- Dose Range: 0 μR to 999 R
- Dose Rate Range: 0 μR/hr to 500 R/hr

The End

Do you know what time it is?

A. Go home?

B. Tip instructor with large unmarked $100 bills?

C. Take a nap?

D. Take a TEST!