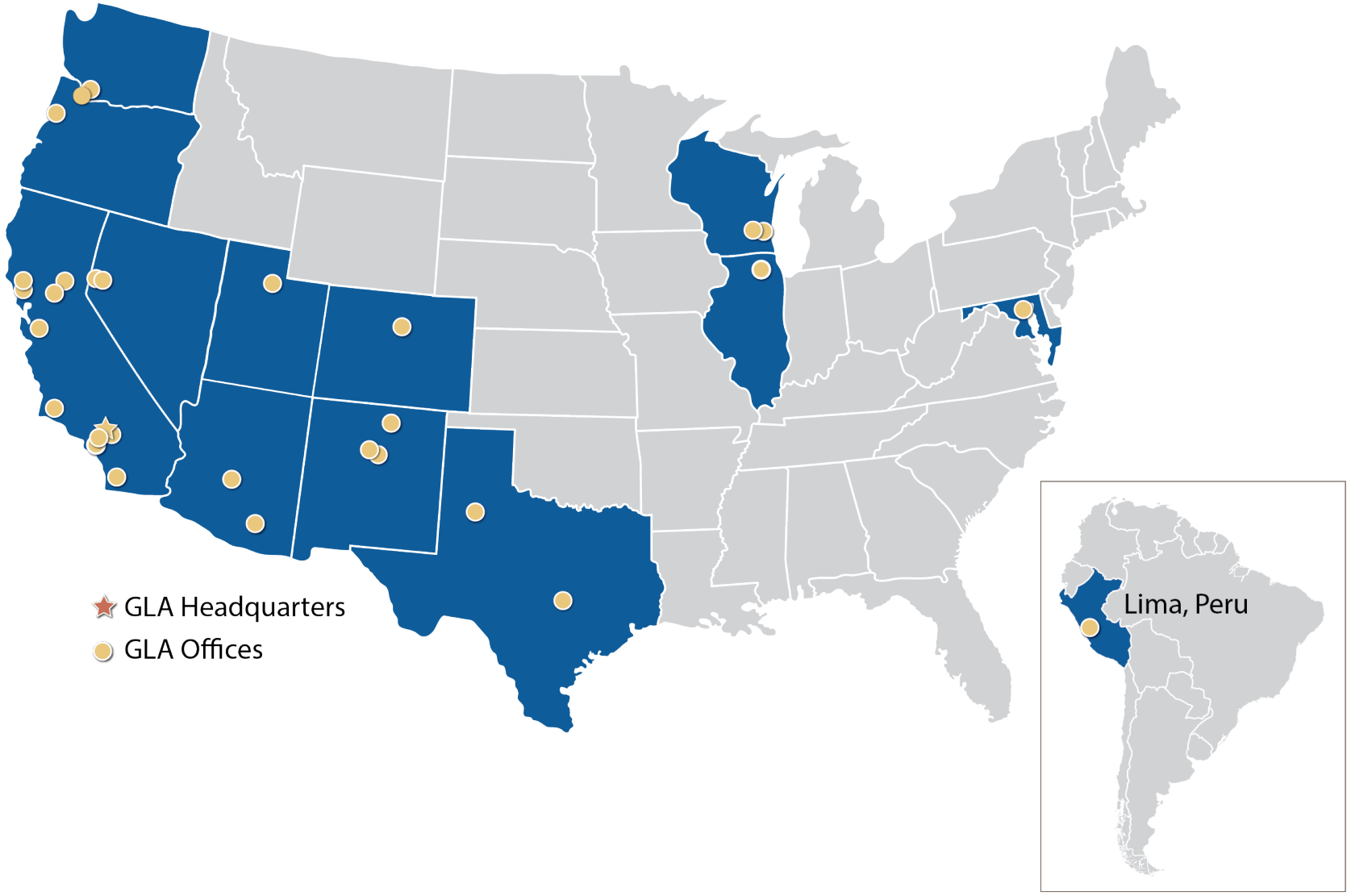
Beneficial Reuse of Petroleum Contaminated Soils

Matthew Koch, PE
Senior Engineer
Geo-Logic Associates
7100 E Belleview Ave
Greenwood Village, CO

April 23,2026

Geo-Logic ASSOCIATES

GEO-LOGIC ASSOCIATES TODAY



ENR TOP 200 ENVIRONMENTAL FIRMS

Geo-Logic ASSOCIATES

KUNKEL engineering group · summit · DBS&A · LOUGHLIN · CLEAR CREEK ASSOCIATES · THE MINES GROUP · Geo-Logic Perú

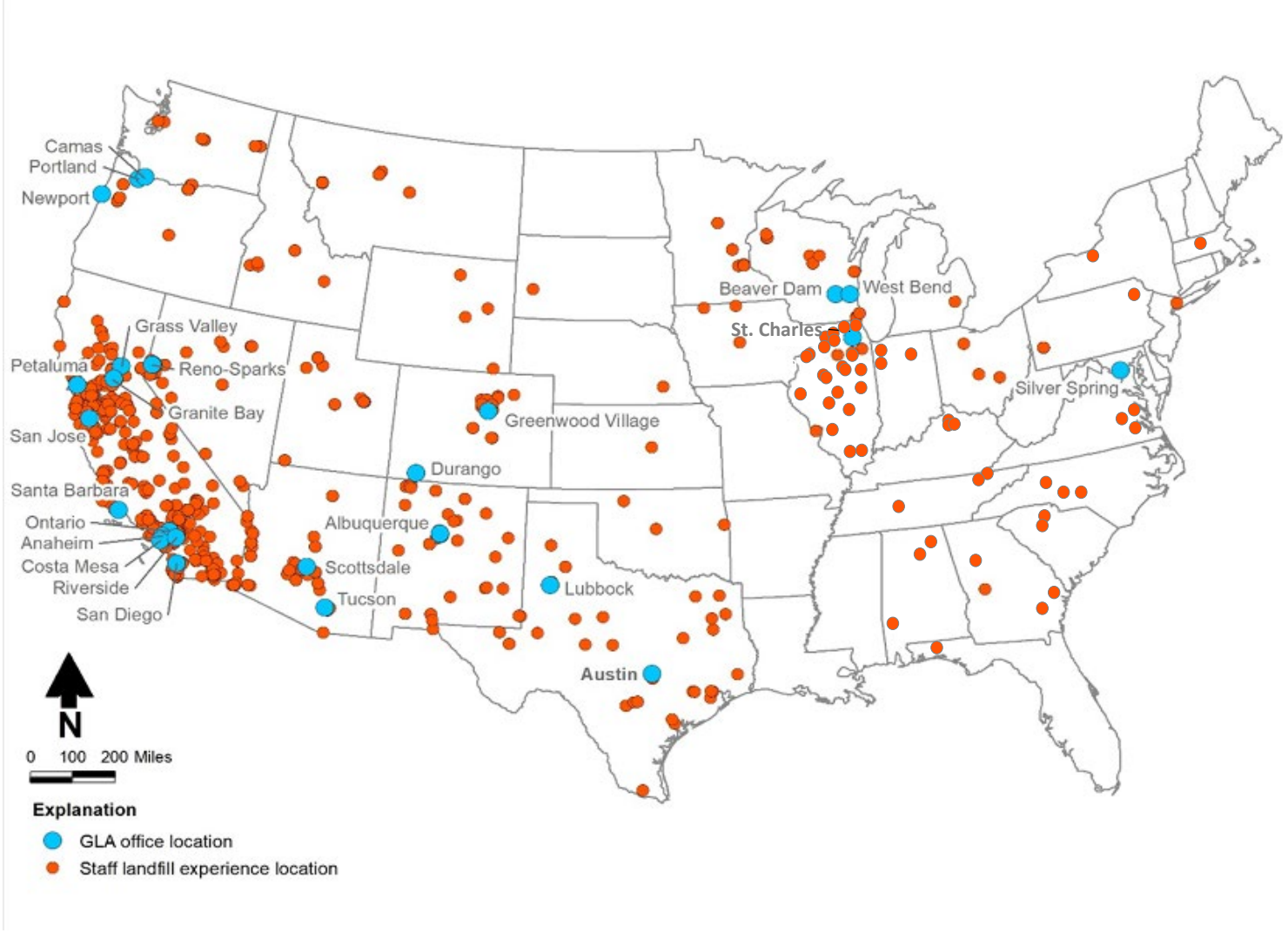
Engineering News-Record

- 29 offices (US and Peru)
- More than 300 employees
- 90 Professional Engineers
- 82 Professional Geologists
- Nationally-recognized technical experts
- Founded in 1991

Geo-Logic ASSOCIATES

SOLID WASTE SERVICES

Solid waste services at more than 500 disposal sites across the nation.



- Planning/Permitting
- Siting Studies
- Budget Modeling
- Engineering & Design
- Landfill Gas System Design and O&M
- Operational Support
- Environmental Monitoring and Reporting
- Environmental Remediation
- Construction Quality Assurance

Geo-Logic ASSOCIATES

What is Petroleum Contaminated Soil?

Regulatory

- RCRA – source dependent
- CERCLA – exempt
- OPS – 500 ppm TPH
- ECMC – 500 ppm TPH

Chemically

- Petroleum: *A broadly defined class of liquid hydrocarbon mixtures. Included are crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids. Note: Volumes of finished petroleum products include non hydrocarbon compounds, such as additives and detergents, after they have been blended into the products.*

Source: Terradis Australasia LTD

Geo-Logic ASSOCIATES

What is Petroleum Contaminated Soil?

Chemical of Concern	Surficial Soil RBSLs [mg/kg] (Ingestion, Dermal, Inhalation)	Subsurface Soil RBSLs [mg/kg] (Leachate to GW, Ingestion)
Benzene	1.6	0.52
Toluene	4,889	91
Ethylbenzene	8	212
Xylenes	577	364
Naphthalene	3.8	143
TVPH[1]	500	500
TEPH[1]	500	500
TRPH[1]	500	500
Polycyclic Aromatic Hydrocarbons (PAHs)		
Acenaphthene	3,586	1,389
Anthracene	17,932	22,583
Benz(a) anthracene	1.3	18.6
Benzo(a) pyrene	0.1	6.2
Benzo(b) fluoranthene	1.3	63
Benzo(k) fluoranthene	13	617
Chrysene	131	1,898
Dibenz(a,h) anthracene	0.1	20
Fluoranthene	2,391	10,202
Fluorene	2,391	1,687
Indeno (1,2,3-cd) pyrene	1.3	205

OPS

- *Petroleum* means crude oil or any fraction thereof that is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute).
- *Contamination* means the presence of a regulated substance at or below ground that originated from a regulated storage tank system.
- *Table 5-1* Tier I Risk Based Screening Levels

Chemical of Concern	Surficial Soil RBSLs [mg/kg] (Ingestion, Dermal, Inhalation)	Subsurface Soil RBSLs [mg/kg] (Leachate to GW, Ingestion)
Pyrene	1,793	7,498
Gasoline Additives[3]		
Tetraethyl lead (TEL)[2]	0.01[3]	N/A
Ethylene dibromide (EDB)[2]	0.05	0.001
1,2-Dichloroethane (1,2-DCA)[2]	0.63	0.012
Methyl tert-butyl ether (MTBE)	N/A	N/A

Geo-Logic ASSOCIATES

What is Petroleum Contaminated Soil?

ECMC

- *OILY WASTE* means those materials containing unrefined petroleum hydrocarbons in concentrations in excess of the concentration levels in Table 915-1. Oily waste may include crude oil, condensate, or other materials such as soil, frac sand, drilling fluids, cuttings, and Pit sludge that contain hydrocarbons.

Table 915-1
CLEANUP CONCENTRATIONS

Contaminant of Concern	Concentrations
Soil TPH (total volatile [C_6-C_{10}] and extractable [C_{10}-C_{36}] hydrocarbons)	500mg/kg
Soils and Groundwater - liquid hydrocarbons including condensate and oil	below visual detection limits
Soil Suitability for Reclamation	
Electrical conductivity (EC) (by saturated paste method)[1,2]	<4mmhos/cm
Sodium adsorption ratio (SAR) (by saturated paste method)[1,2,3]	<6
pH (by saturated paste method)[1,2]	6–8.3
boron (hot water soluble soil extract)[1,2,3]	2mg/l

Contaminant of Concern	Concentrations	
	Residential Soil Screening Level Concentrations (mg/kg)[7]	Protection of Groundwater Soil Screening Level Concentrations (mg/kg) Risk Based (R) and MCL Based (M)[7,8]
Organic Compounds in Soils[5, 9, 10]		
benzene	1.2	0.0026 (M)
toluene	490	0.69 (M)
ethylbenzene	5.8	0.78 (M)
xylenes (sum of o-, m- and p- isomers = total xylenes)	58	9.9 (M)
1,2,4-trimethylbenzene	30	0.0081 (R)
1,3,5-trimethylbenzene	27	0.0087 (R)
acenaphthene	360	0.55 (R)
anthracene	1800	5.8 (R)
benz(a)anthracene	1.1	0.011 (R)
benzo(b)fluoranthene	1.1	0.3 (R)
benzo(k)fluoranthene	11	2.9 (R)
benzo(a)pyrene	0.11	0.24 (M)
chrysene	110	9 (R)
dibenzo(a,h)anthracene	0.11	0.096 (R)
fluoranthene	240	8.9 (R)
fluorene	240	0.54 (R)
indeno(1,2,3-cd)pyrene	1.1	0.98 (R)
1-methylnaphthalene	18	0.006 (R)
2-methylnaphthalene	24	0.019 (R)
naphthalene	2	0.0038 (R)
pyrene	180	1.3 (R)
Metals in Soils [1, 6, 9, 10, 11]		
arsenic	0.68	0.29 (M)
barium	15000	82 (M)
cadmium	71	0.38 (M)
chromium (VI)	0.3	0.00067 (R)
copper	3100	46 (M)
lead	400	14 (M)
nickel	1500	26 (R)
selenium	390	0.26 (M)
silver	390	0.8 (R)
zinc	23000	370 (R)

Geo-Logic ASSOCIATES

What is Petroleum Contaminated Soil?

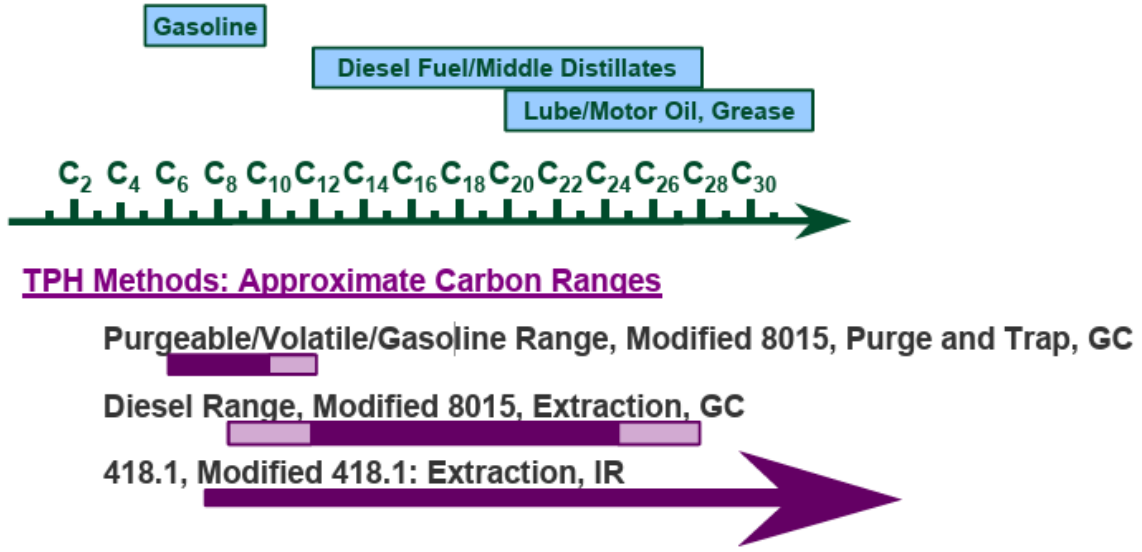
Total Petroleum Hydrocarbons

- Compound and analytical method dependent
- Says little about toxicity or mobility!

TPH Fractions	Number of Carbons	Equivalent Carbon Number Index	Representative Compound (RfD/RfC)	Representative Compound (Chemical Parameters)
Low aliphatic	C5-C8	EC5-EC8	cyclohexene/n-heptane and n-hexane	average of cyclohexene, n-heptane, and n-hexane
Medium aliphatic	C9-C18	EC>8-EC16	midrange aliphatic hydrocarbon streams	n-nonane*
High aliphatic	C19-C32	EC>16-EC35	white mineral oil	white mineral oil
Low aromatic	C6-C8	EC6-EC<9	benzene	benzene
Medium aromatic	C9-C10	EC9-EC<11	1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, and 1,2,3-trimethylbenzene	average of 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, and 1,2,3-trimethylbenzene
High aromatic	C10-C32	EC>11-EC35	benzo[a]pyrene	benzo[a]pyrene

Source: EPA Regional Screening Levels Frequently Asked Questions

FIGURE 1. CARBON NUMBER RANGES ADDRESSED BY TPH ANALYTICAL METHODS



Source: API Publication 7409 Frequently Asked Questions about TPH Analytical Methods for Crude Oil

Geo-Logic ASSOCIATES

When is PCS a problem?

Regulatory

- Landfill acceptance
- Redevelopment
- OPS cleanup levels
- ECMC cleanup levels

Always?

Source: Minnesota Head & Neck Pain Clinic

Chemically

- Human health impacts
  - Carcinogens
  - Endocrine disruptors
  - Central nervous system
- Environmental impacts
  - Leaching potential
  - Ecotoxicity
  - Emissions

Geo-Logic ASSOCIATES

Beneficial Reuse

Regulatory

- Solid Waste Regulations
- Air Quality Control Commission Regulations

Available Technologies

- ~~Landfill Alternative Daily Cover~~
- ~~Landfarms~~
- Remediation
- Construction Materials

Geo-Logic ASSOCIATES

Beneficial Reuse

Colorado Solid Waste Regulations Section 8.6

- Category 1 – Unrestricted use (below total elemental and mobility criteria standards)
- Category 2 - Limitations on use
- Category 3 – Non-hazardous material may be reused for solidification basins at same facility
- Table 1A – Total Element Analysis
- Table 1B – Analyte Mobility Analysis
- Table 2 – Use-by-category
- Table 3 – Preapproved Uses
- If not preapproved, submit a beneficial use determination

Beneficial Use-by-Category			
	Waste Category		
	1	2	3
1) Raw material for product manufacture	X	X	
2) Waste Stabilization/Solidification at CDPHE Approved Solid Waste Disposal Site	X	X	X
3) Landfill Daily Cover at CDPHE Approved Solid Waste Disposal Site	X	X	X
4) Solidified products: concrete, mortar, manufactured stone, brick	X	X	
5) Confined Geotechnical Fill:	X	X	
a) commercial, industrial or institutional building subbase	X	X	
b) paved lot base, subbase and subgrade fill	X	X	
c) paved roadway base, subbase & subgrade fill	X	X	
d) utility trench backfill	X	X	
e) bridge abutment backfill	X	X	
f) tank, vault, or tunnel abandonment	X	X	
g) slabjacking material	X	X	
h) soil and pavement base stabilization	X	X	
i) controlled low strength material (flowable fill)	X	X	
6) Unconfined Geotechnical Fill	X		
7) Unbonded Surface Course	X		
8) Bonded Surface Course	X	X	
9) Decorative Stone	X	X	
10) Cold Weather Road Abrasive	X		

Geo-Logic ASSOCIATES

Beneficial Reuse

Regulatory

- AQCC Reg 24 Part B Section III
  - *III. Disposal of Volatile Organic Compounds*
    - *III.A. No person shall dispose of volatile organic compounds by evaporation or spillage unless RACT is utilized.*

- PS Memo 12-01: contains three definitions of PCS:
  - Storage tank associated
  - E&P associated
  - TPH > 500 mg/kg

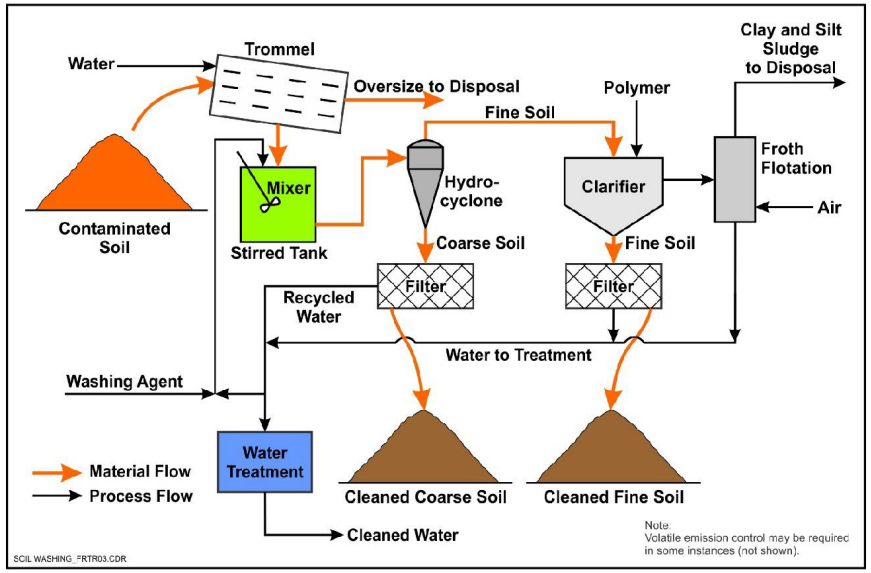
Geo-Logic ASSOCIATES

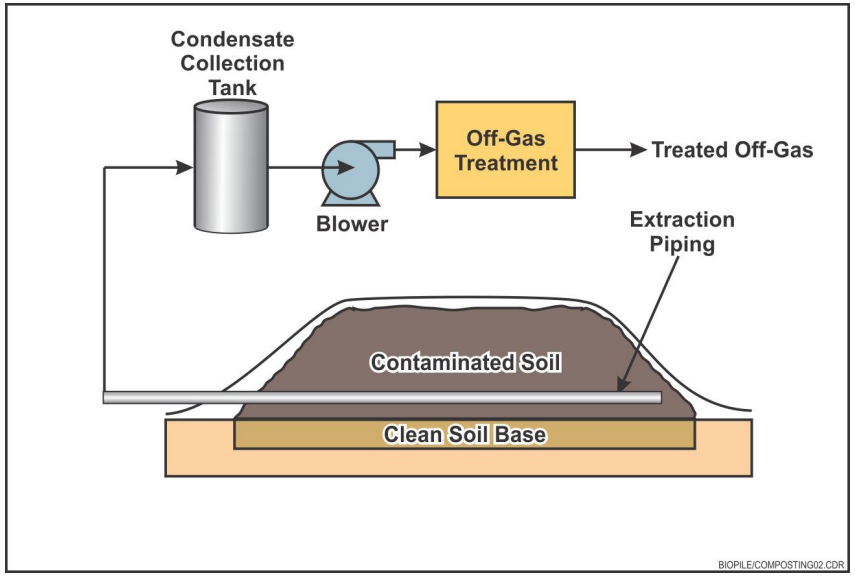
Remediation

Ex-Situ Technologies

- Aerobic Respiration
  - Landfarming, Composting, Biopile
- Soil Washing
- Free Product Recovery

Soil health can be degraded by both contamination and remediation process, amendments can help with both





Source: Federal Remediation Technologies Roundtable

Geo-Logic ASSOCIATES

Remediation Case Study

Case Study – Santa Fe County Judicial Complex

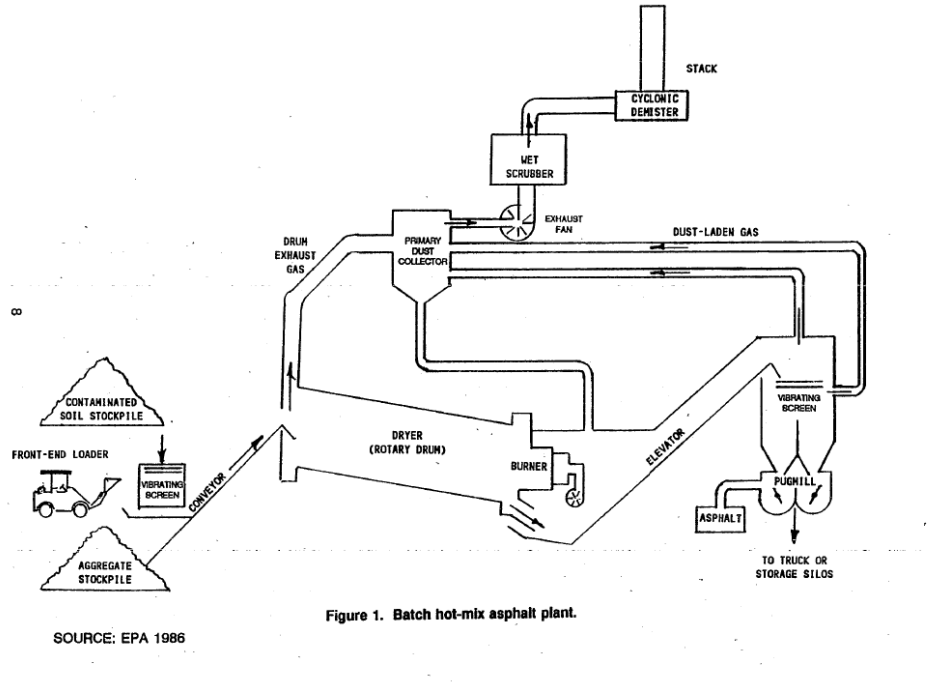
- Grout barrier to prevent NAPL migration
  - 600 LF of jet-grouted columns tied into 185 LF slurry wall
- Thermally enhanced soil-vapor extraction system
  - 3 horizontal wells (2 for soil vapor extraction, 1 for hot air injection)
  - First application of horizontal SVE wells by the NME
- Extracted vapors treated by traditional oxidizer
- Ozone and hydrogen peroxide sparging to reduce dissolved phase constituents
- Removal of all apparent NAPL, mass removal calcs indicate 120,000 pounds of contaminant removed by SVE alone

Geo-Logic ASSOCIATES

Construction Materials

Applications

- HMA – up to 7% inclusion
  - Incorporates PCS with aggregate
  - Lighter fractions may act as solvents
  - Limited by fines content
- Cold Mix
- Road base and aggregate mixtures
  - Higher blend ratio
- Cement
- Brick
  - can manage highly plastic clays



Source: EPA ORD, Potential Reuse of Petroleum-Contaminated Soil

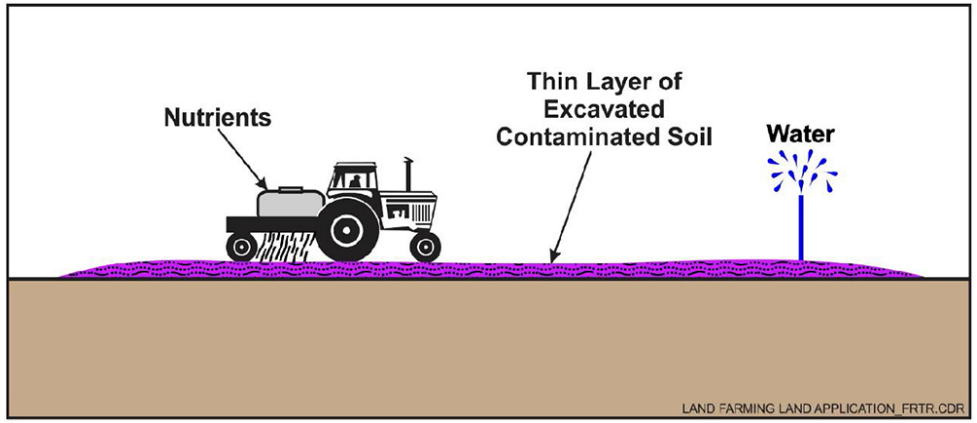
Does anyone actually do this in Colorado?

Geo-Logic ASSOCIATES

Land of Enchantment

N.M. Admin. Code § 19.15.36.15

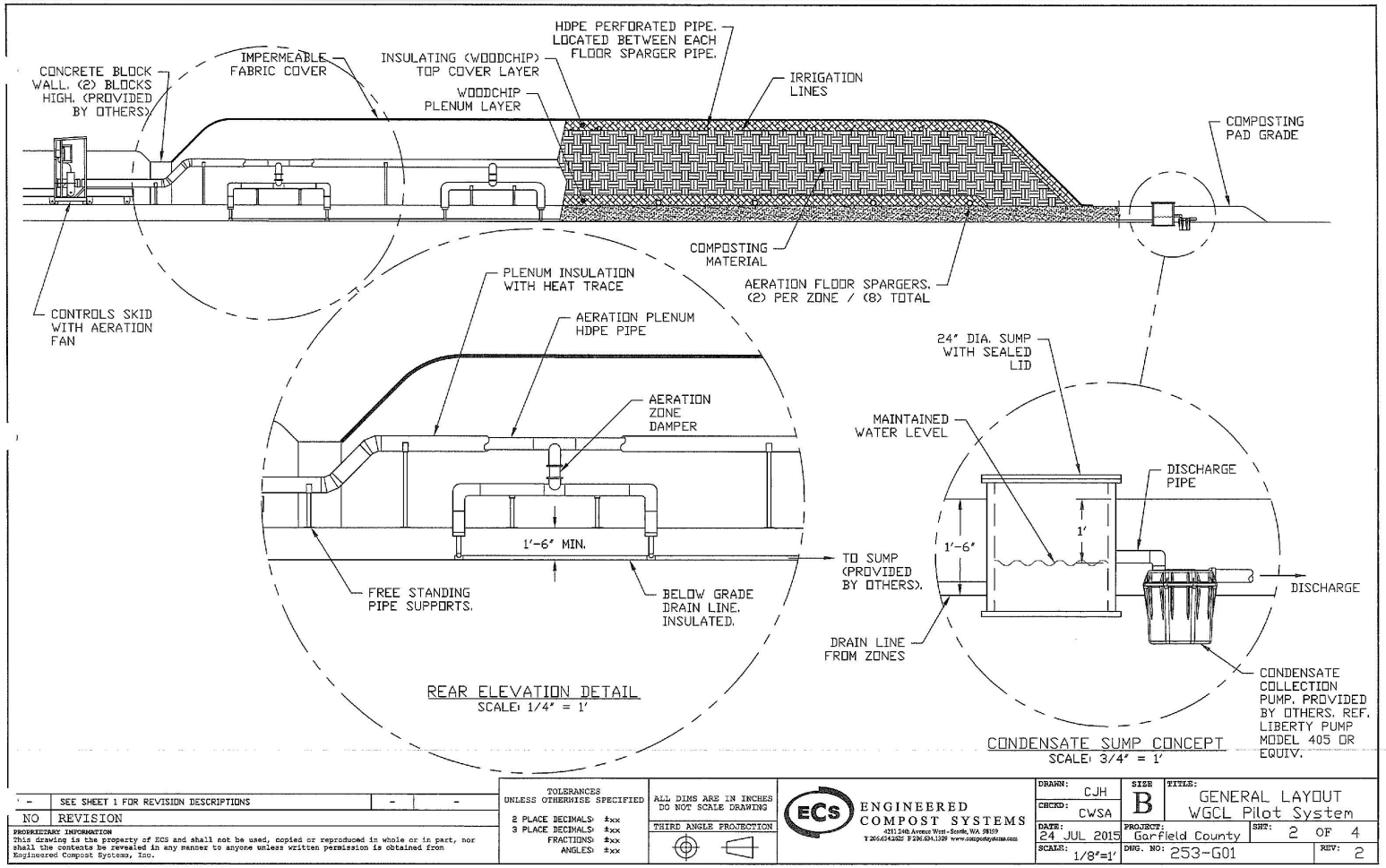
- Aerobic respiration of PCS
- Build 8” lifts until reaching max 2-ft thickness (3,000 CY/acre)
- BTEX, TPH, Cl, Metals standards
- 5 year timeline to meet treated soil objectives
- Treated soils can remain in-place, or be reused (with Division approval)
- Bioremediation alternative: 80% reduction in TPH concentration, rate of change is negligible



Source: Federal Remediation Technologies Roundtable

Geo-Logic ASSOCIATES

Landfill Case Study



PCS Remediation Pilot Project

- Treat Garfield county E&P waste
- Biopile with aerated static pile
- Scrub emissions with biofilter consisting of compost and moist wood chips
- Then PCS can be used to make up soil deficit for cover material
- Decommissioned in 2024 due to reduced influx of E&P waste

Geo-Logic ASSOCIATES

GEO-LOGIC SUBSIDIARIES

Geo-Logic ASSOCIATES

KUNKEL engineering group

CLEAR CREEK ASSOCIATES

DBS&A

Geo-Logic PERÚ

THE MINES GROUP INC

summit WATER RESOURCES

LOUGHLIN WATER ASSOCIATES LLC

ENR
TOP 500 DESIGN FIRMS
TOP 200 ENVIRONMENTAL FIRMS
TOP INTERNATIONAL FIRMS
TOP MOUNTAIN/SOUTHWEST & WEST REGIONS DESIGN FIRMS
Engineering News-Record

Geo-Logic ASSOCIATES