

Overview – Technologies for the Remediation of Heavy Metals in Soil and Water

Dr. R. Mark Bricka



What is Environmental Remediation

The removal of Contaminants form
Environmental Media

- Soil
- Groundwater
- Sediment
- Surface Water

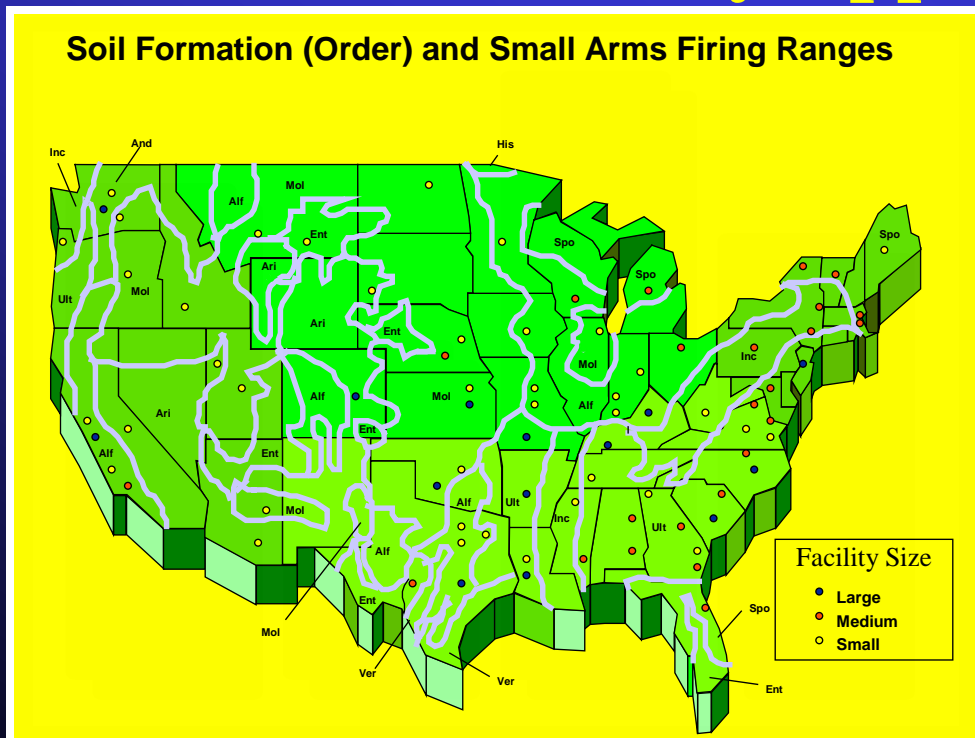


Example Remediation

Project: Lead Immobilization at Small Arms Firing Ranges

Objective: To Cost Effectively remove or reduce the toxicity of Lead at SAFR

Many Approaches



SAFR



Remediation Approaches

- **Dig and Haul**
- **Containment**
- **Water Treatment**
- **Biological Treatment**
- **Sorption**
- **Physical Treatment**
- **Phyto Remediation**
- **EK**
- **ETC.**



Dig and Haul



Source: http://www.gatewayparts.com.au/wp-content/uploads/2016/12/EX2600-6_big_img_gallery.jpg



Source: <https://www.mining3.com/wp-content/uploads/2016/08/Shovel-and-truck-Almay-stock-image-inverted.jpg>

- Most used technique
- Involves
 - Landfill
 - SWMU
- Only Transfer Issue
- Long Term Liability
- Relative Low \$
- Depends on Many Factors

Containment

- **Landfills**
- **Slurry Walls**
- **Solidification/Stabilization**
- **Vitrification**
- **Calcination**



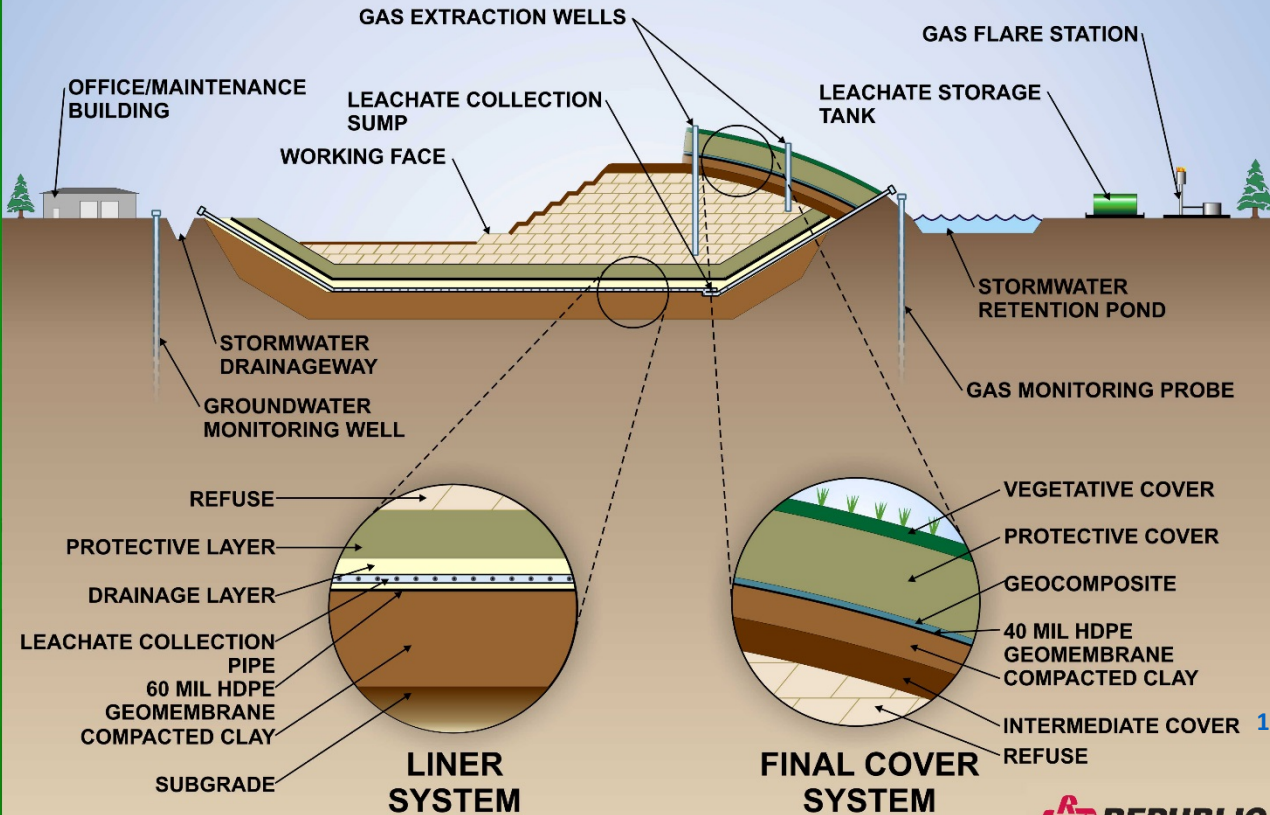
Landfills

- Types C & D
- Issues



Cherry Island Landfill

CONCEPTUAL LANDFILL DESIGN CROSS SECTION

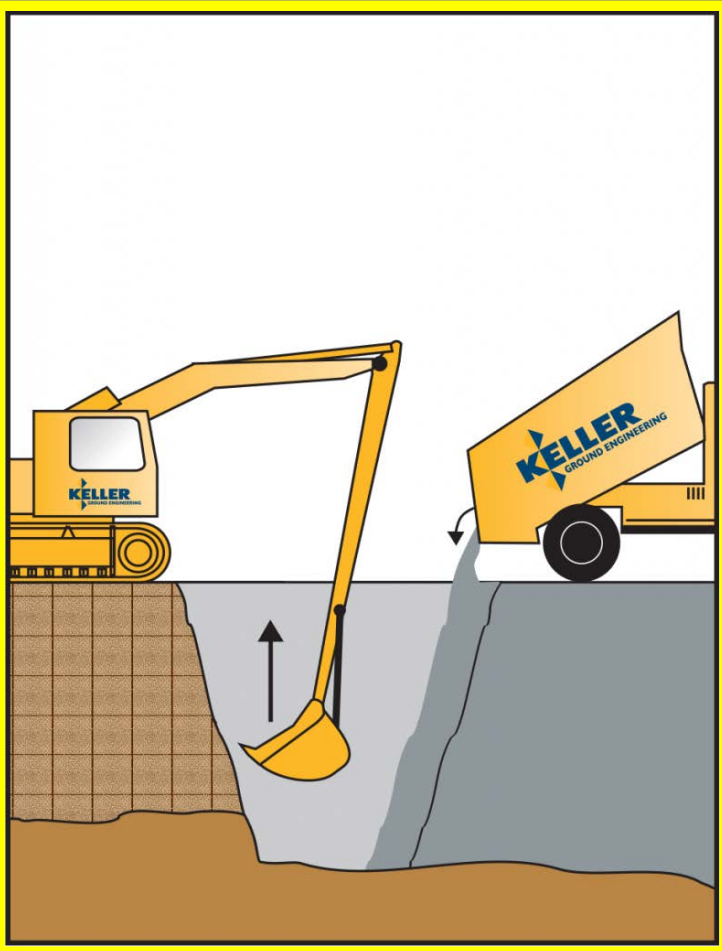


Source: <http://dswa.com/wp-content/uploads/2015/02/Cherry-Island-Landfill-Expansion.jpg>

Source: http://site.republicservices.com/publishingimages/7_2_landfill-cross-section.jpg



Slurry Walls



Source:<http://www.kellerge.com.au/wp-content/uploads/2014/06/Slurry-Wall-782x1024.png>

Source:
<http://reports.mckinneydrilling.com/Slurry%20Wall%20Dam.jpg.dimg.aspx>

Solidification/Stabilization

Source: Boulanger

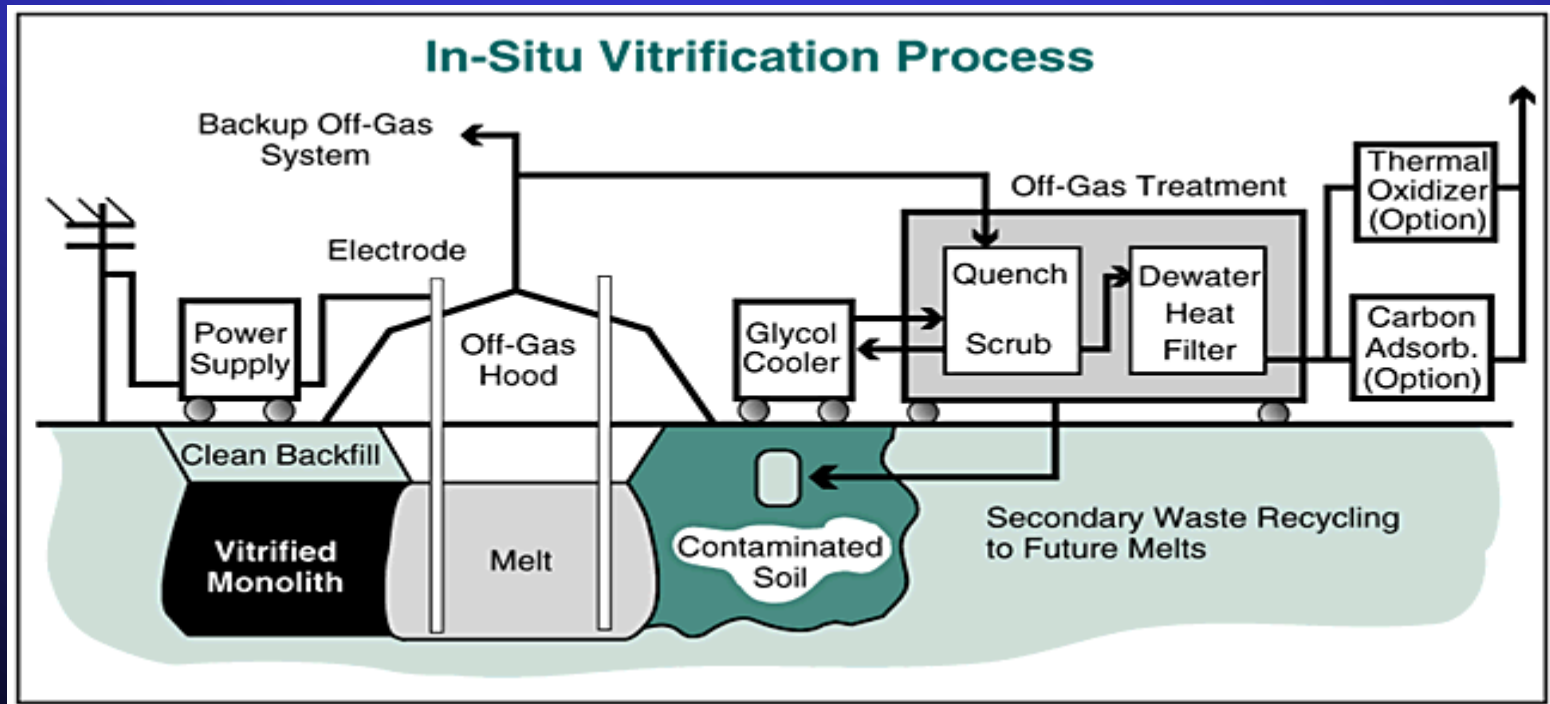


- Exsitu & Insitu
- Lime, Fly Ash, Portland, Adsorbents
- Mixing Critical



Vitrification

- **Primarily Nuclear Waste**
- **Energy Intensive**
- **\$\$\$\$\$\$\$\$**



Insitu Vitrification



Source: http://i.vimeocdn.com/video/462872563_640.jpg

Calcination

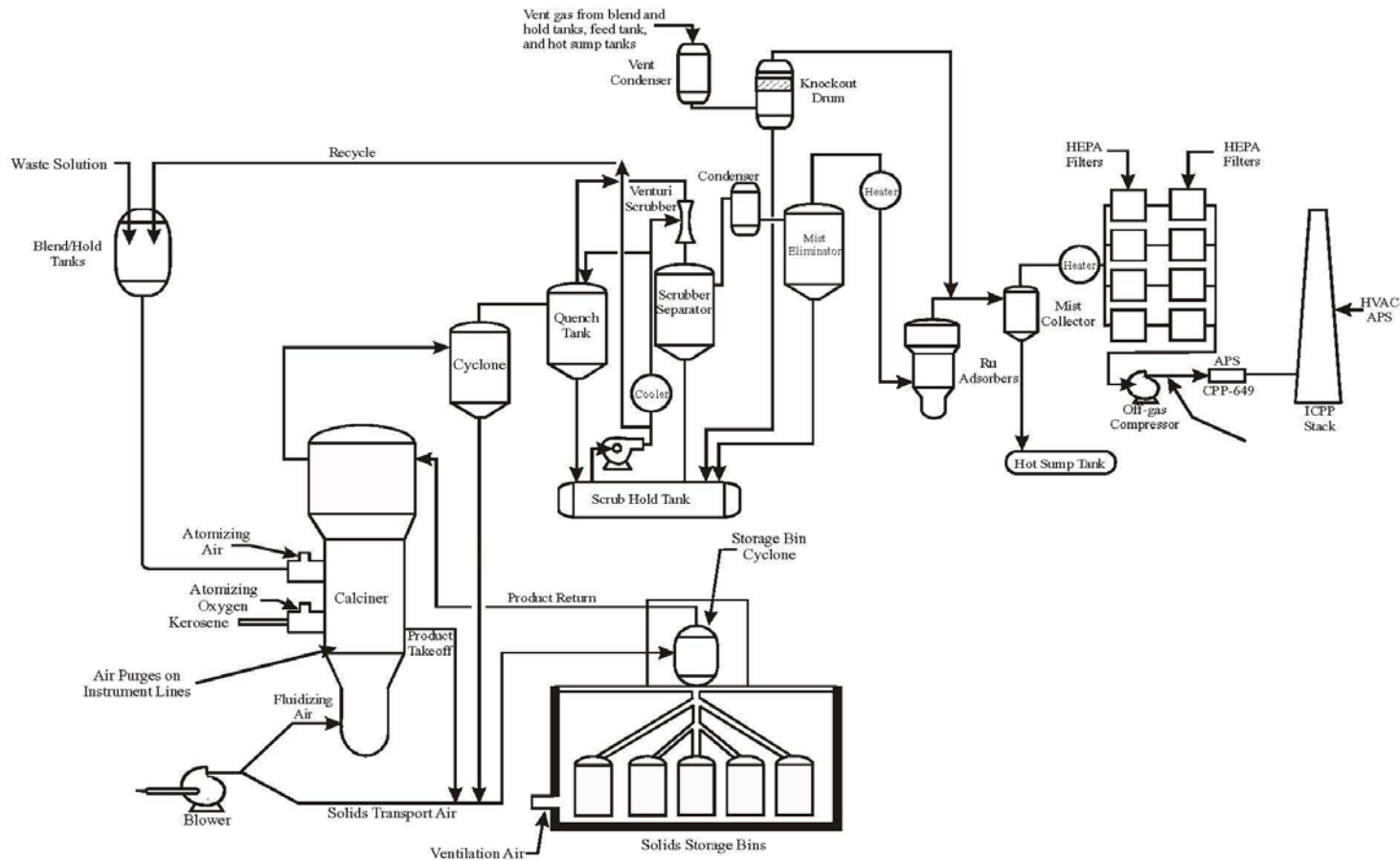


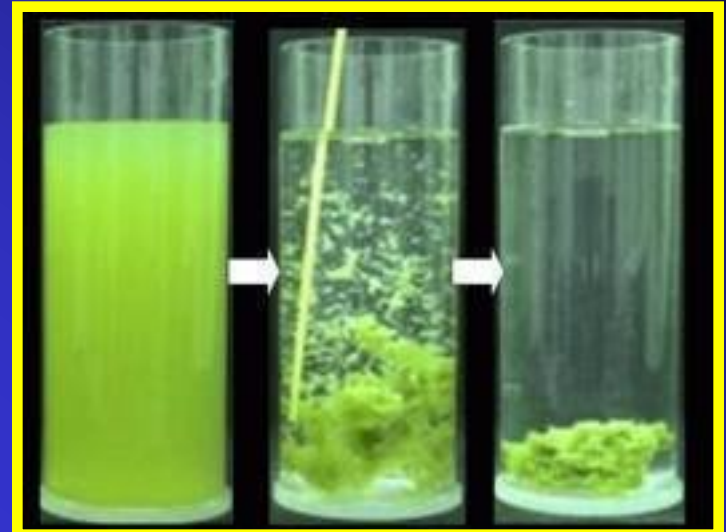
Figure 1. Schematic of the NWCF Calcination process.

NWCF Process wo.cdr

Source: Newby 7 O'Brien "Summary of Waste Calcination at the Idaho Nuclear Technology and Engineering Center, INEEL/EXT-200-01200, OCT 2000.

Water Treatment

- **Water Treatment**
- **Neutralization**
- **Precipitation**
- **Flocculation**
- **Sedimentation**
- **Membrane Treatment**
- **Ion Exchange**
- **Electro Techniques**
- **Flotation**
- **Electro winning**
- **Filtration**

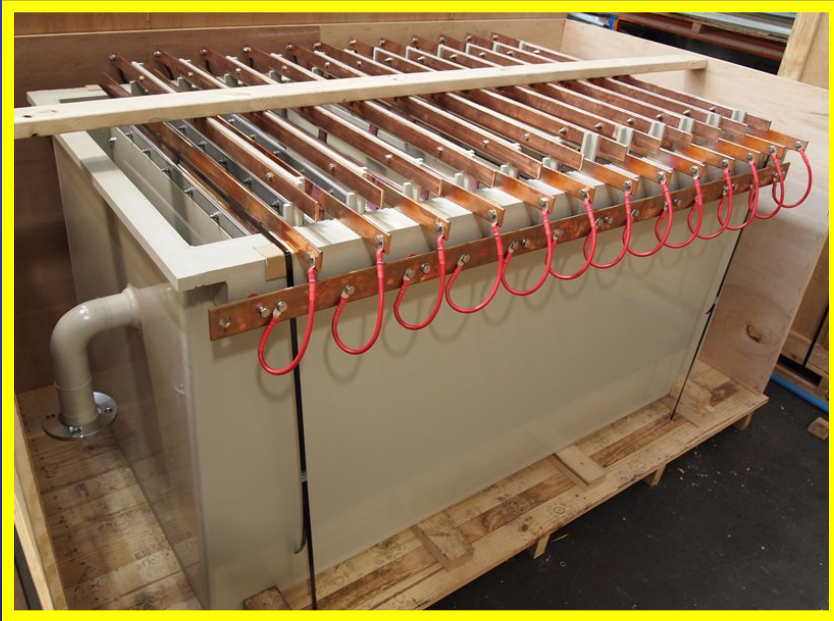


Source: <http://www.tech-faq.com/wp-content/uploads/2011/02/Flocculation.jpeg>



Source: <http://aquabluechemical.com/wp-content/uploads/2017/07/Treatment.jpg>

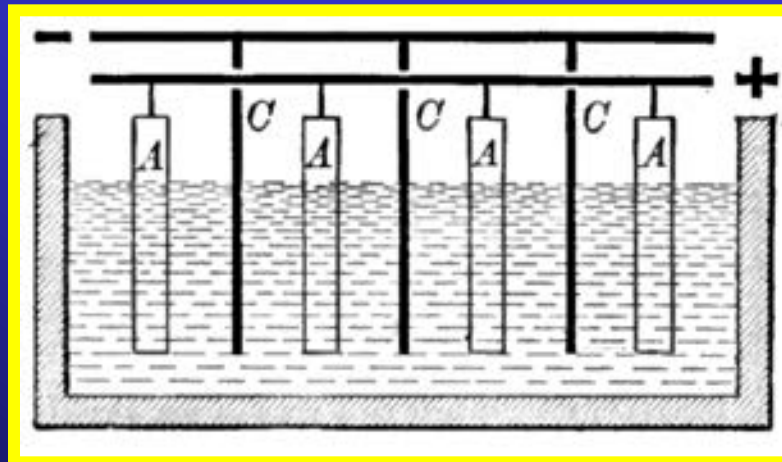
Electrowinning



Source: <http://www.pfwa.com.au/wp-content/uploads/gallery/electrowinning-cells/Custom-Electrowinning-Cell.jpg>



Source: <http://www.constructionphotography.com/imageThumbs/A175-00151/3/A175-00151-Worker-Cleaning-Copper-Cathodes-in-Escondidas-Electro-Winning-Shed-Chile.jpg>



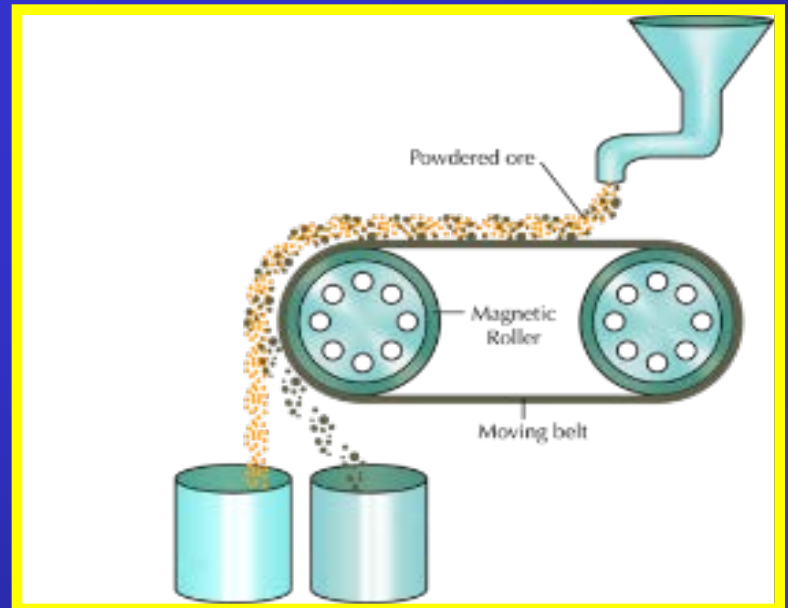
Source: <https://upload.wikimedia.org/wikipedia/commons/thumb/6/68/CuElectrolyticRefineApparatus.png/300px-CuElectrolyticRefineApparatus.png>

Physical Separation

- **Tabling**
- **Flotation**
- **Classification**
- **Trammels**
- **Magnetic and Electrostatic Separation**
- **Density segregation**
- **Soil Flushing/Washing**



Source: <http://www.suntechgeomet.co.za/images/images/Physical-SeparationL.png>



Source: <http://www.mstworkbooks.co.za/natural-sciences/gr9/images/gr9eb03-gd-0022.png>

Other Remediation Technologies

- Heap leaching
- Phyto Remediation
- Chemical and Supercritical Water Oxidation
- Adsorption/Absorption
- Freeze Crystallization
- Electrokinetics



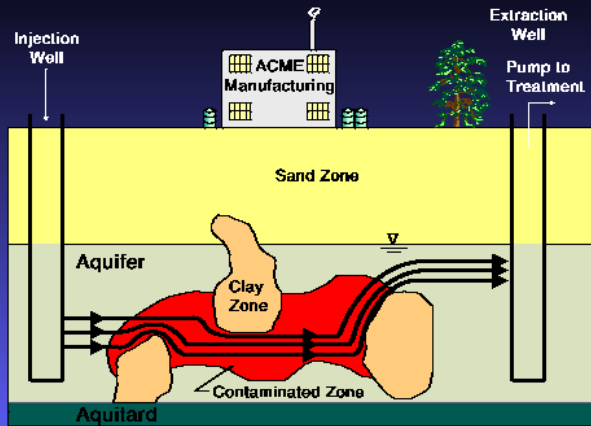
Source: <http://3.bp.blogspot.com/-jYD43dAZvVg/T6vWDXjJYEI/AAAAAAAAATU/XsI0tVaH-fM/s1600/spraying+sodium+sianide+on+the+system+heap+leaching..jpg>



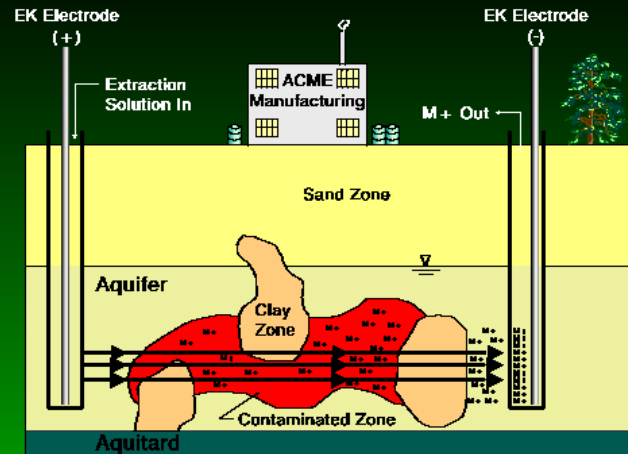
Source: <http://2.bp.blogspot.com/-02814-WdINs/VfmFhrbeXKI/AAAAAAAAABAA/9NiCCLVXtCxxG/s1600/Heap%2Bleach%2Bin%2Bnortheastern%2BNevada.jpg>

Application of EK

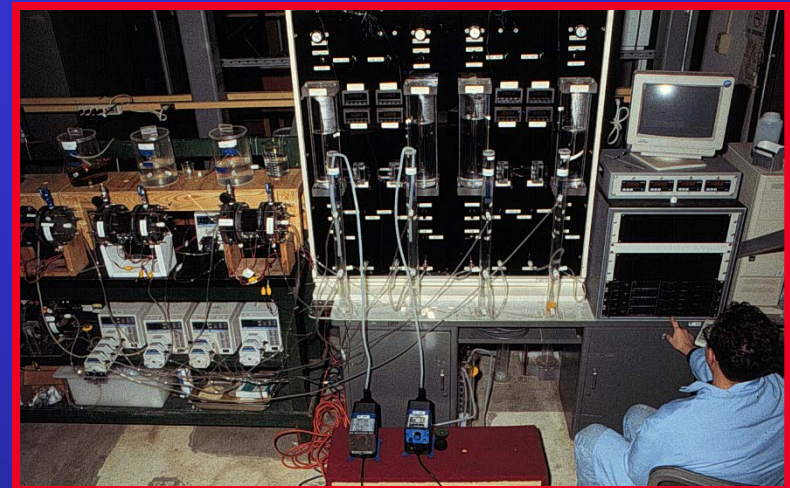
Pump and Treat Remediation



Insitu Heavy Metals Remediation Using EK



- Electromigration
- Electroosmosis
- Electrophoresis
- pH



EK

Pt. Mugu NAWS EK Field Project



- DoD 6.4 Dem/Val Project
- EPA SITE Project
- ESTCP



Biological Treatment



Source: <http://napier-reid.com/wp-content/uploads/2015/02/DSC04498.jpg>

- **Aerobic**
 - **Activated Sludge**
 - **RBC**
 - **Aerated Lagoons**
 - **Trickling Filters**
 - **Composting**

- **Anaerobic**
 - **Anaerobic Digestion**
 - **Composting**
 - **Stabilization Ponds**
 - **Engineered Wet Land**



Source: <https://3.imimg.com/data3/CA/GV/MY-1555992/windrow-turner-250x250.jpg>

Requirement for Application

- **Site assessment**
 - **CoC**
 - **Soil Characteristics**
 - **Geology**
- **Costs**
- **Regulations**
- **Public - NIMBY**
- **PRG**
- **Clean Closure**

Remediation Reclamation Results



Latvia - Flambeau Minerals

Remediation Reclamation Climax Mine



Storke Yard at Climax in 2008 (left) and in 2012 after revegetation activities that included using compost produced at the site's award-winning Biosolids Composting Operation. These activities were part of a larger project to restore the Arkansas River channel and habitat at Storke Yard, both of which had been impacted by historic mining activities.

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