Mining & Mercury in Nevada

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Nevada Division of Environmental Protection

Air Pollution Control Program

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Mining & Mercury in Nevada

- **Voluntary Mercury Reduction Program (VMRP)**
  - Voluntary Program: 2002-2006
- **Nevada Mercury Control Emissions Program (NMCP)**
  - State Regulation: 2006 - Present
- **Federal Gold Mine NESHAP (40 CFR PArt63 Subpart E[7])**
  - Federal Regulation: 2010 - Present
- **Mercury Research**
  - Ambient mercury deposition network
  - Ambient mercury passive sampler
  - Fugitive mercury emissions

Mining & Mercury in Nevada

- Mercury not from historical mining operations.
- Mercury is naturally occurring and geologically concentrated.
- Mercury co-located with gold deposits in ~1:1 ratio.

Mining & Mercury in Nevada

- Gold recovery utilizes thermal processes that volatize Hg.
- Nevada has ~50 permitted mines; ~25 with various thermal processes.
- Mercury is *not* used or added for gold recovery.

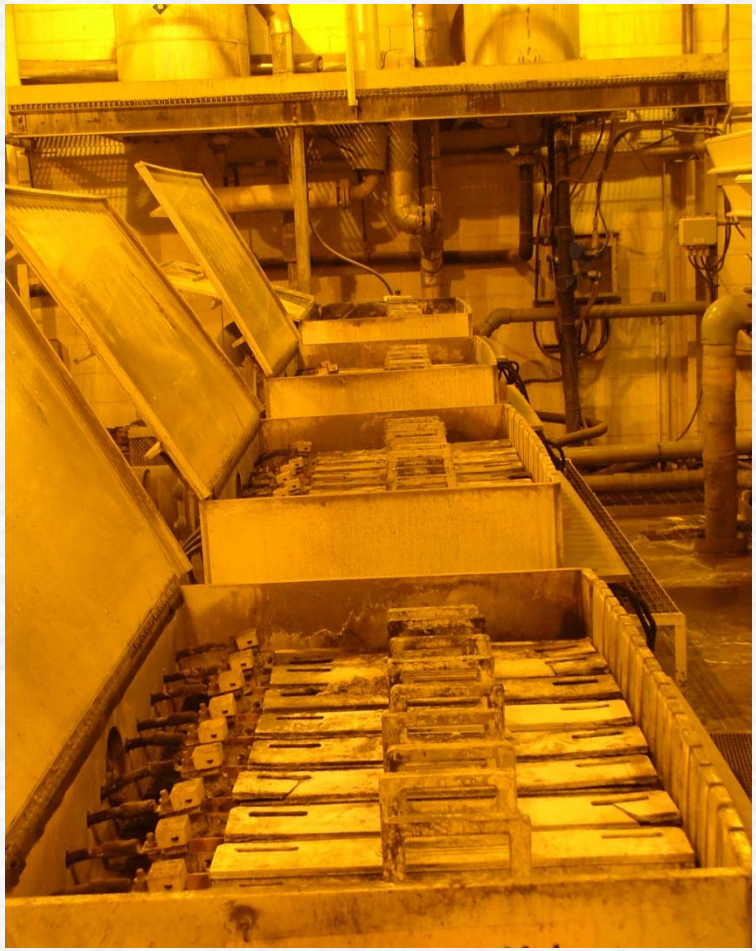
Mining & Mercury in Nevada

Thermal Units

(a source of direct or indirect heat)

- Roaster
- Autoclave
- Electro Winning
- Melt furnace
- Retort
- Oven
- Lab equipment
- Pregnant & Barren tanks
- Other

Voluntary Mercury Reduction Program



- 1998: 1st time metal mining industry required to estimate & report mercury emissions for TRI.
- 2000: TRI reports that Nv mining emitted 10.5 tons of mercury in 1998. Four mining companies (5 facilities) accounted for more than 90% of emissions.
- 2002: NDEP & EPA develop Voluntary Mercury Reduction Program (VMRP) with four mining companies with largest emissions.

Nevada Mercury Control Program

- State Program, effective March 8, 2006.
- Applies to *all* precious metal facilities with thermal process units.
- The NMCP requires best available mercury emission controls technology to reduce emissions.
- The NMCP is a control-based program—not a health risk-based program.

NMCP Overview

- Program requires NvMACT mercury controls on existing and new thermal units.
- To address existing sources a transitional or "phased" approach was implemented.
- Phase-1: Industry inventory, data collection & permit for existing processes w/ work practice standards.
- Phase-2: Determine NvMACT technology and emission limit and issue final Hg permit.
- 24 months to install & operate control technology.

Control Technology Review

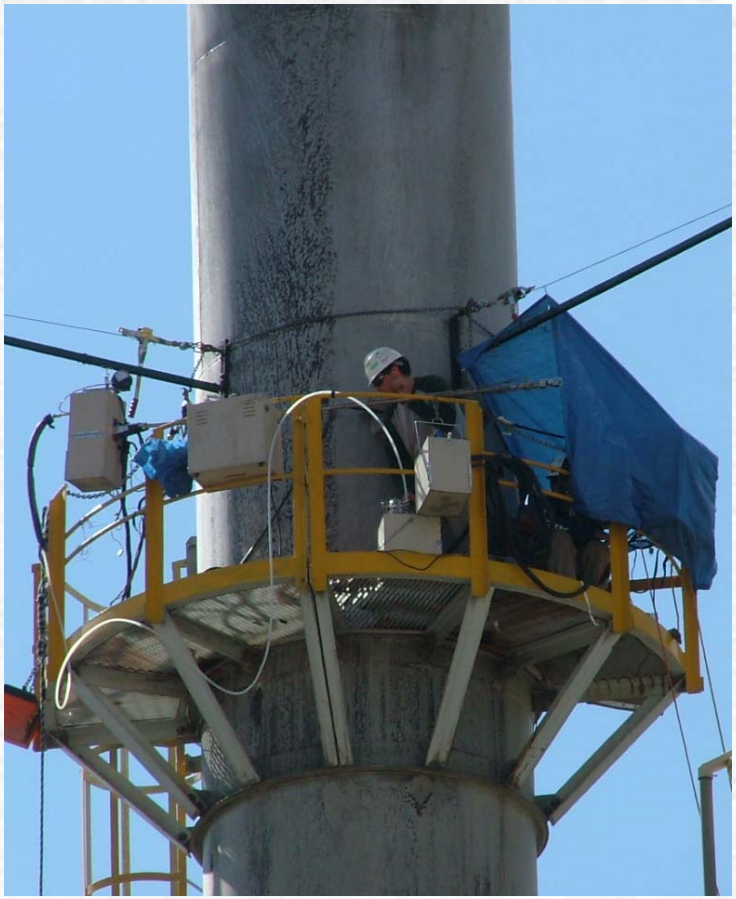
- Determine best technology on a performance basis.
- Determine what of the best is applicable (engineering-wise)
  - Include cost & mine life factors
  - Include collateral pollutant increase & available resources (eg: water, power)
  - Select a technology
  - Determine a case-by-case Hg emission limit
  - Public Notice

Performance Demonstration Through Emissions Testing

- Testing started in 2006 for VMRP facilities. Testing in 2007 and each consecutive year after for all facilities, for all thermal units, not designated de-minimis.

- Develop modified M29 test method specific to industry.
  - High mercury concentration
  - High moisture
  - Particulate-bound mercury

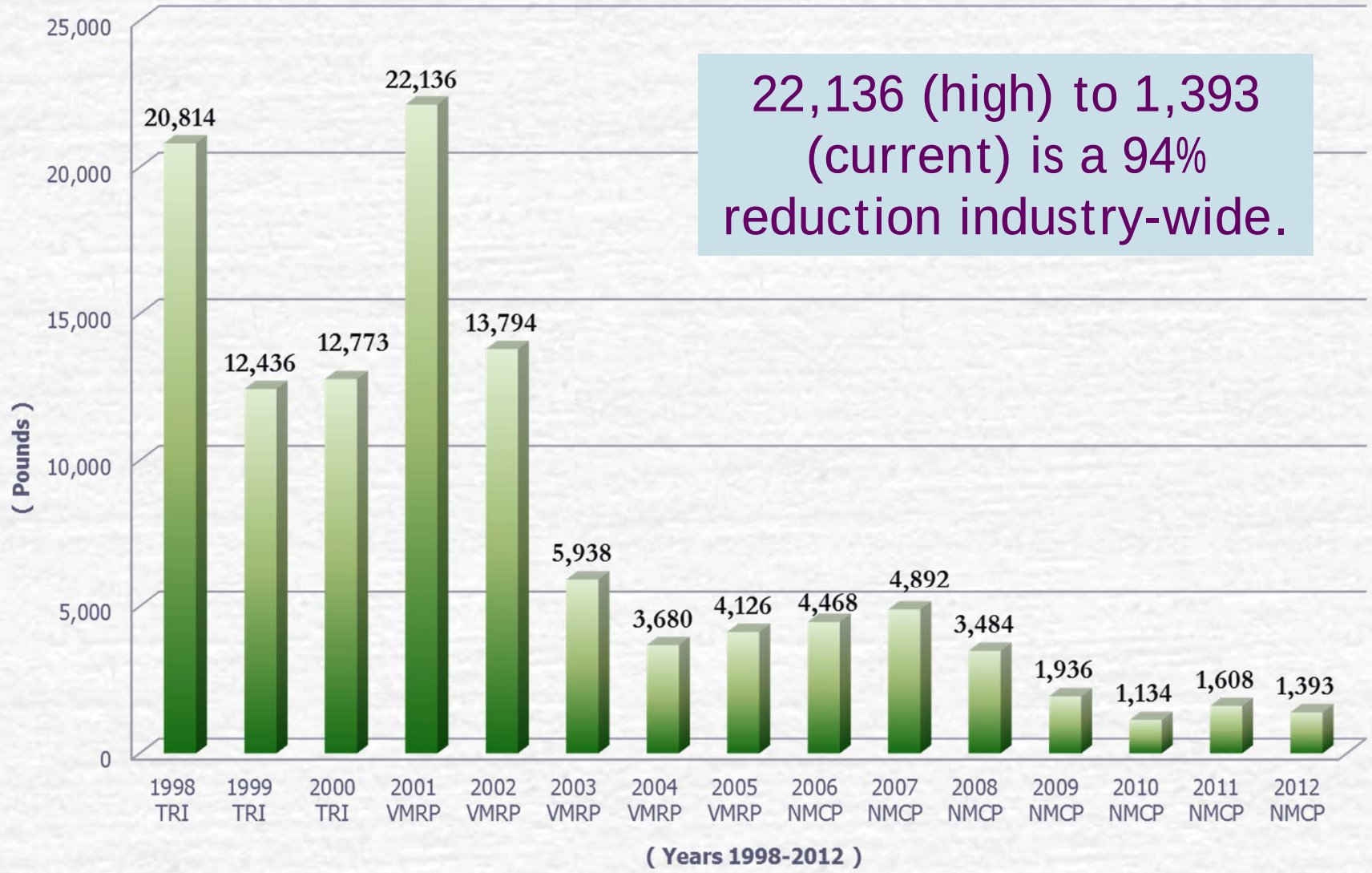
Annual Emissions Reporting



- Facilities required to report annually based on actual production and annual source test.
- Annual Emissions Report demonstrates effectiveness of the Program.
- Online at: ndep.nv.gov/baqp/hg/aer.html

Reported Mercury Emissions

from Nevada Mines (lbs/yr)



22,136 (high) to 1,393 (current) is a 94% reduction industry-wide.

NMCP Progress

- Prior to 2002 mercury emission estimates from mining in excess of 22,000 lbs/yr.
- Through implementation of VMRP and NMCP mercury emissions reported below 2,000 lbs/yr (2009).
- Once all NvMACT controls implemented project <1,000 lbs/yr.

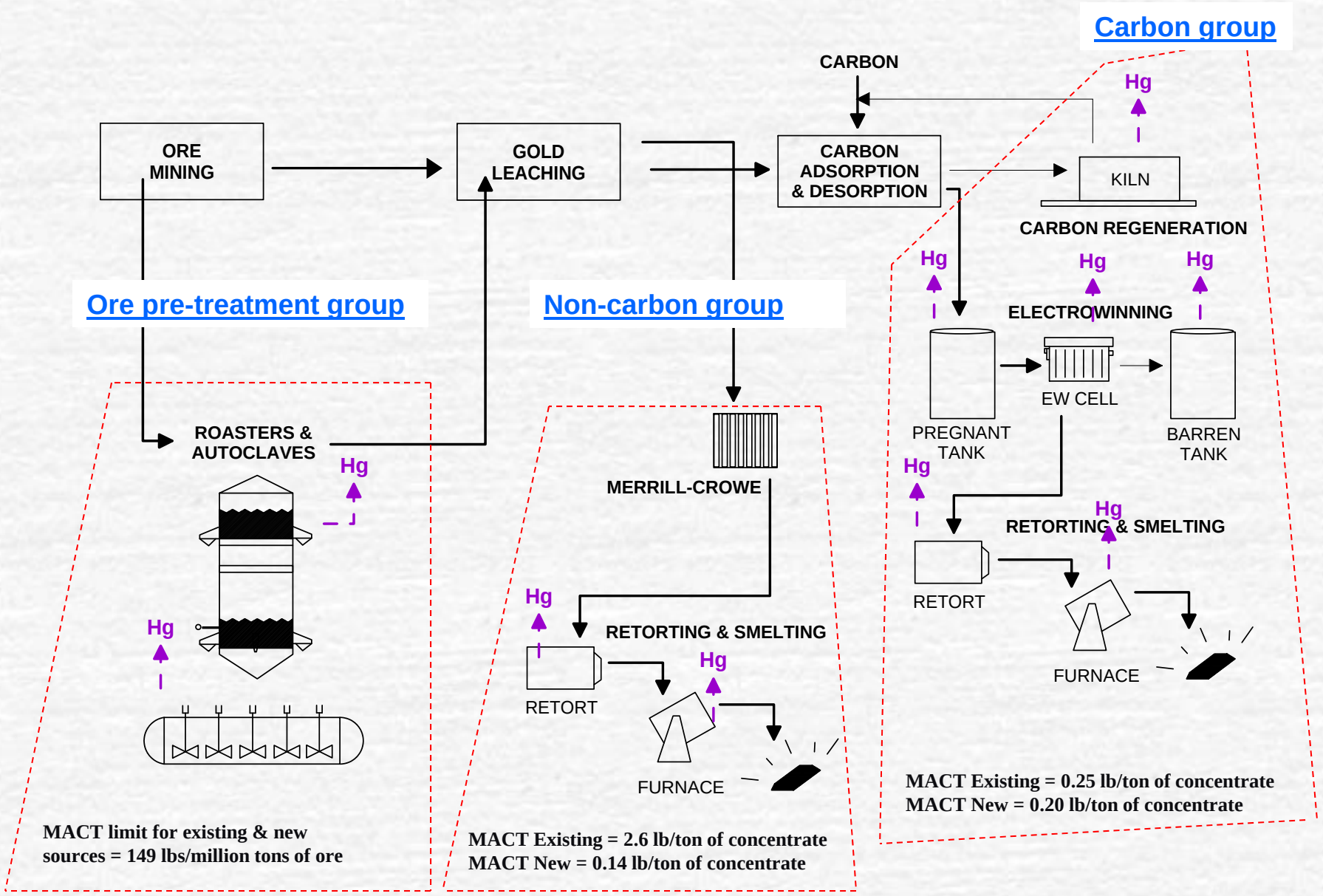
Federal Gold Mining NESHAP

- NESHAP: National Emissions Standard for Hazardous air Pollutants. Contained in 40 CFR Part 63.
  - Hg is defined as a HAP under the CAA.
- USEPA implements Subpart EEEEEEE (E^7) April 2013, applicable to gold mines in US and sets Hg emission limits for 3 source categories.
  - "Source categories" are a group of units; NMCP has unit level emission limits.
- Control technology-based program like NMCP and was developed from 5 years of NMCP data.
  - E^7 limits established 1x; NMCP re-evaluated each time.

Federal Gold Mining NESHAP

- Effective April 24, 2013.
- E^7 applies to gold mines only; not silver or other non-ferrous metal mines.
- E^7 requires a Title V permit for applicable sources.
- During promulgation of E^7, EPA did not include fugitive emissions in definition of source category:
  - Data limited for site characterization & time.
  - Little info on how fugitives may be controlled.

Federal Gold Mining NESHAP



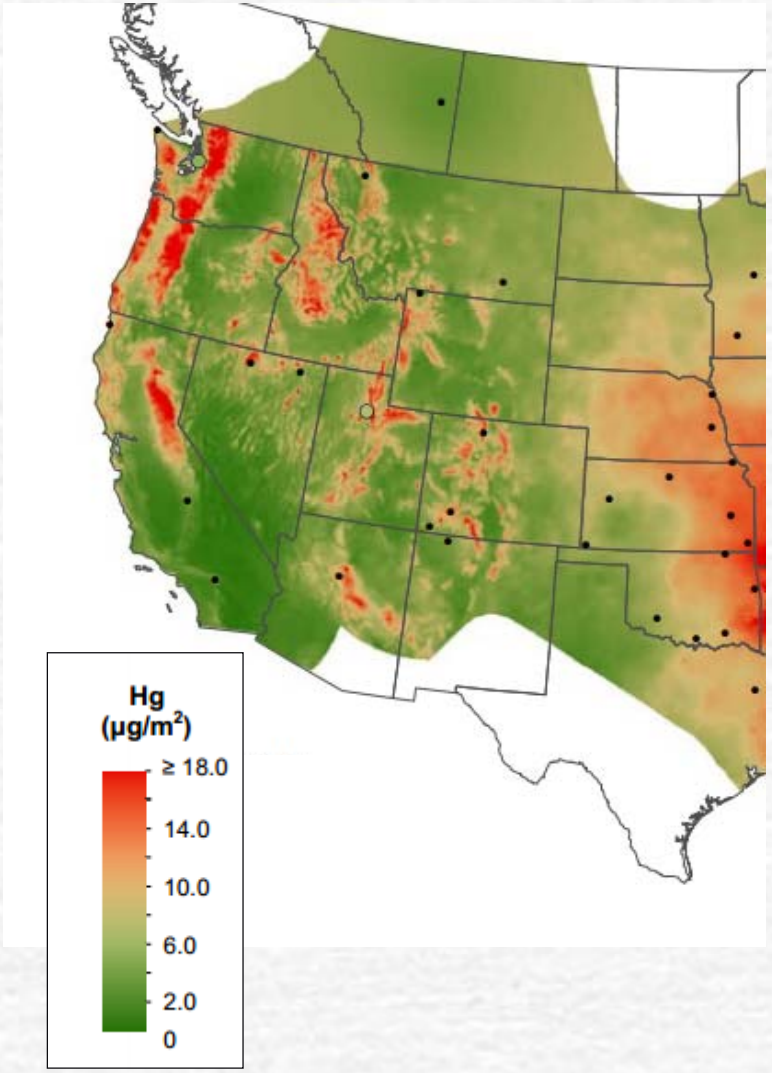
Other Mercury-Related Projects

- Mercury Deposition Network
- Ambient Air Monitoring: Passive Samplers
- Characterization of Fugitive Emissions at Mine Sites

Other Mercury-Related Projects

Mercury Deposition Network

- NDEP funds and participates in operation of National MDN sites in Nevada.
  - Sites would have otherwise closed due to lack of funding.
- MDN is the only network providing a long term record of total Hg concentration and deposition in precipitation.
  - 88 MDN sites across the US, but only two in the Great Basin area (NV).



Other Mercury-Related Projects

Development of a Passive Hg Sampler

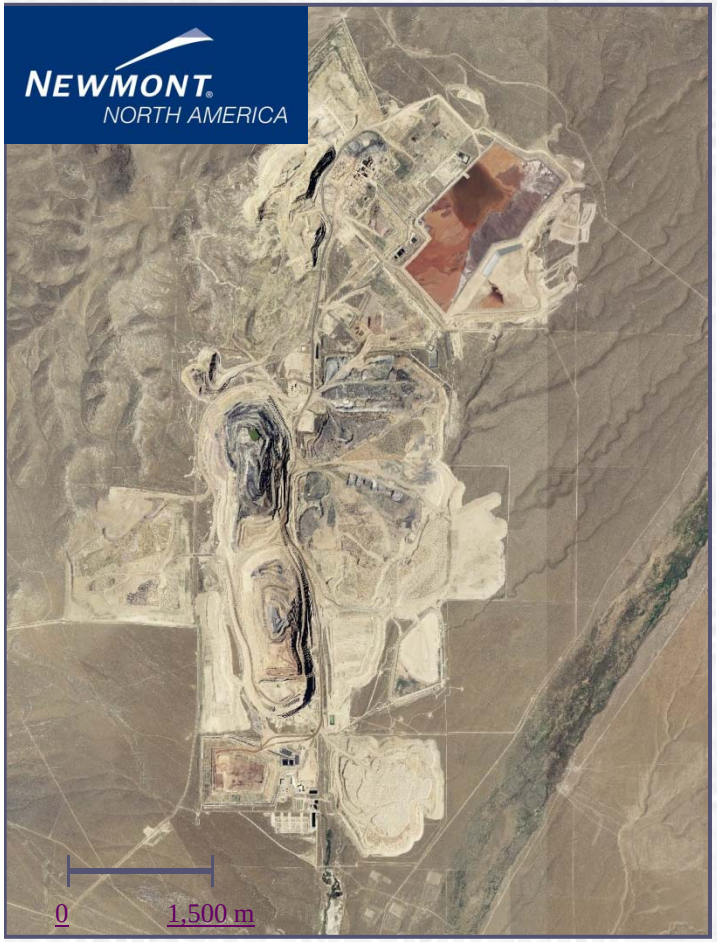
- Current samplers are expensive, difficult to operate & require electricity.
- UNR passive sampler will be relatively cheap, simple and require no electricity.
- Passive methods under development are tested against established active sampling methods along with air quality and meteorology measurements.
- Field testing at UNR Agricultural Experiment Station.
- NDEP was awarded a $364,000 research grant from EPA to fund UNR's development.

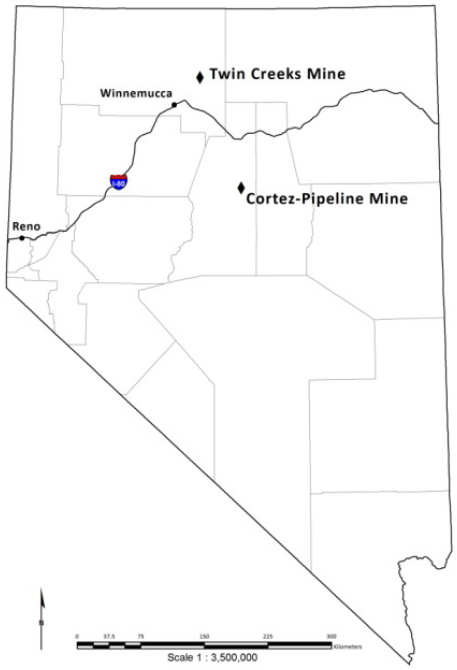
Fugitive Mercury Emissions

UNR funded to study factors that affect fugitive Hg emissions

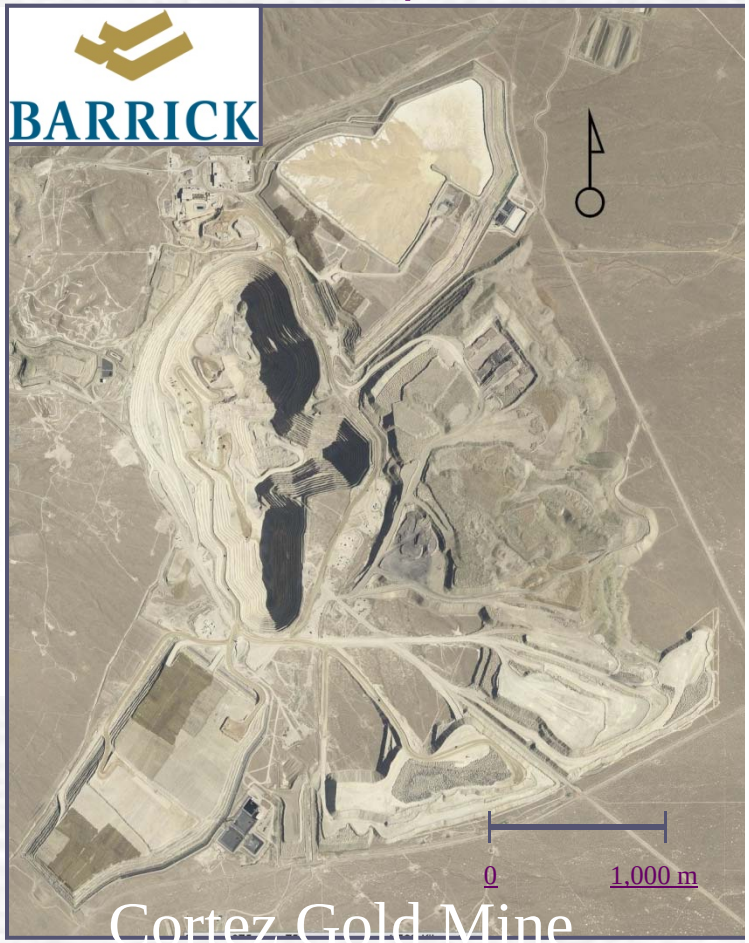
Two mines chosen for study:

Twin Creeks





Cortez Pipeline

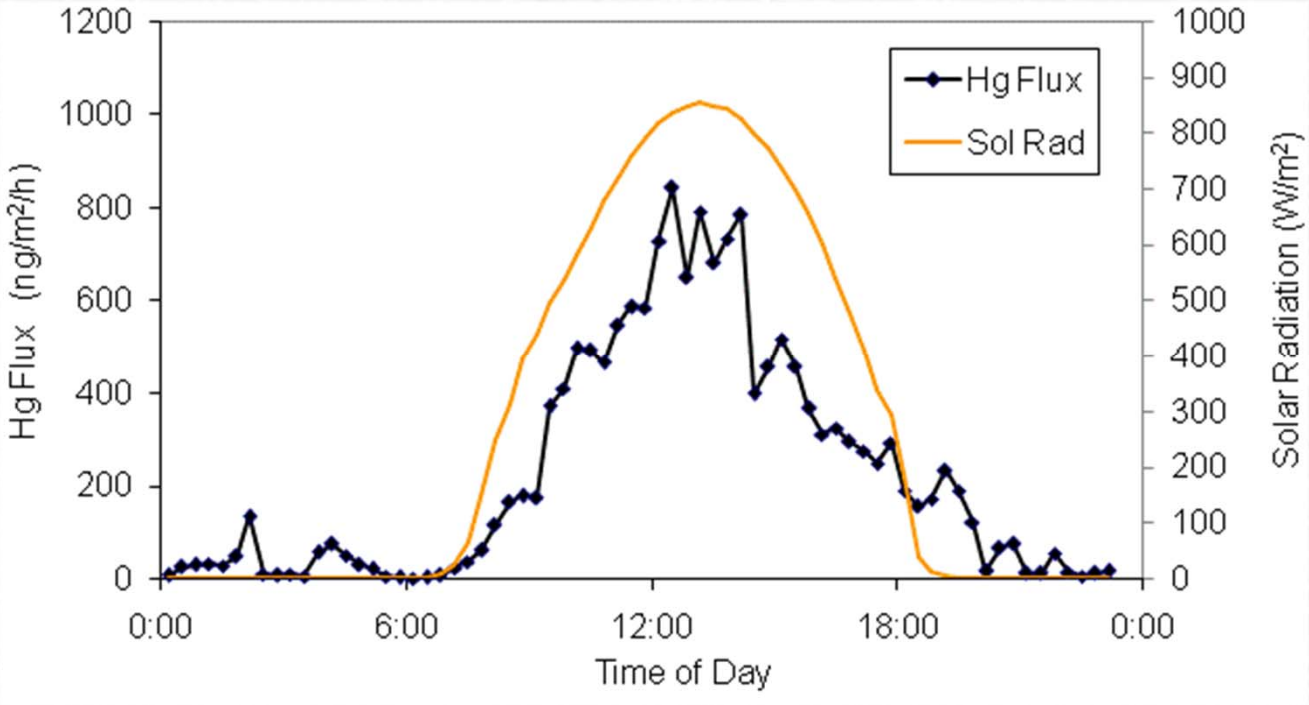


Fugitive Mercury Emissions

Laboratory & Field Components

Factors that effect Hg emissions:

- Material type
- Environmental conditions

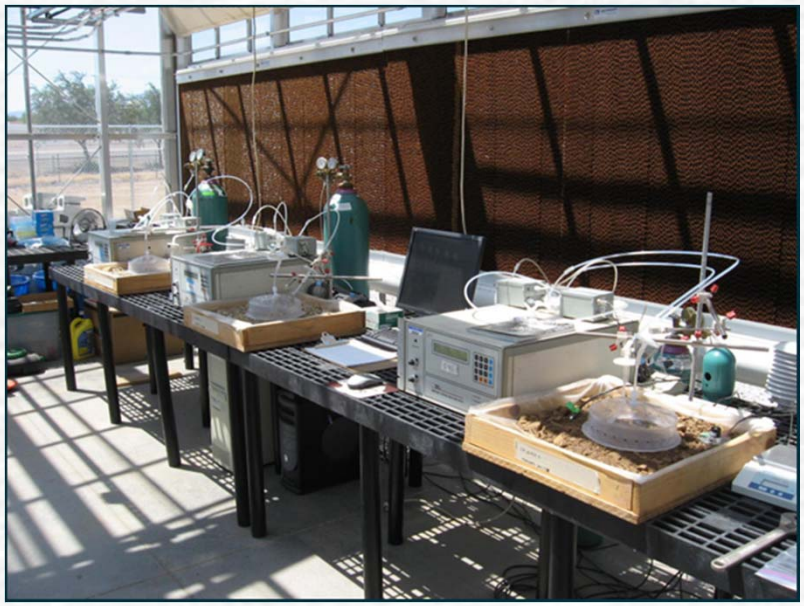


Fugitive Mercury Emissions

- Fugitive Hg emissions are ~20% of point source emissions.
- Large differences in emissions between mines (no "universal" emission factors).
- Emission estimate reflects one stage in the life of a mine
  - emissions will vary depending on activity, age, and reclamation
- Factors important to consider:
  - mercury concentration/host rock characteristics
  - surface area of mining disturbed materials
  - characteristics of tailings impoundments
  - climatic conditions
  - ore-processing techniques
  - age of materials and reclamation
  - natural background & global pool

Fugitive Mercury Emissions

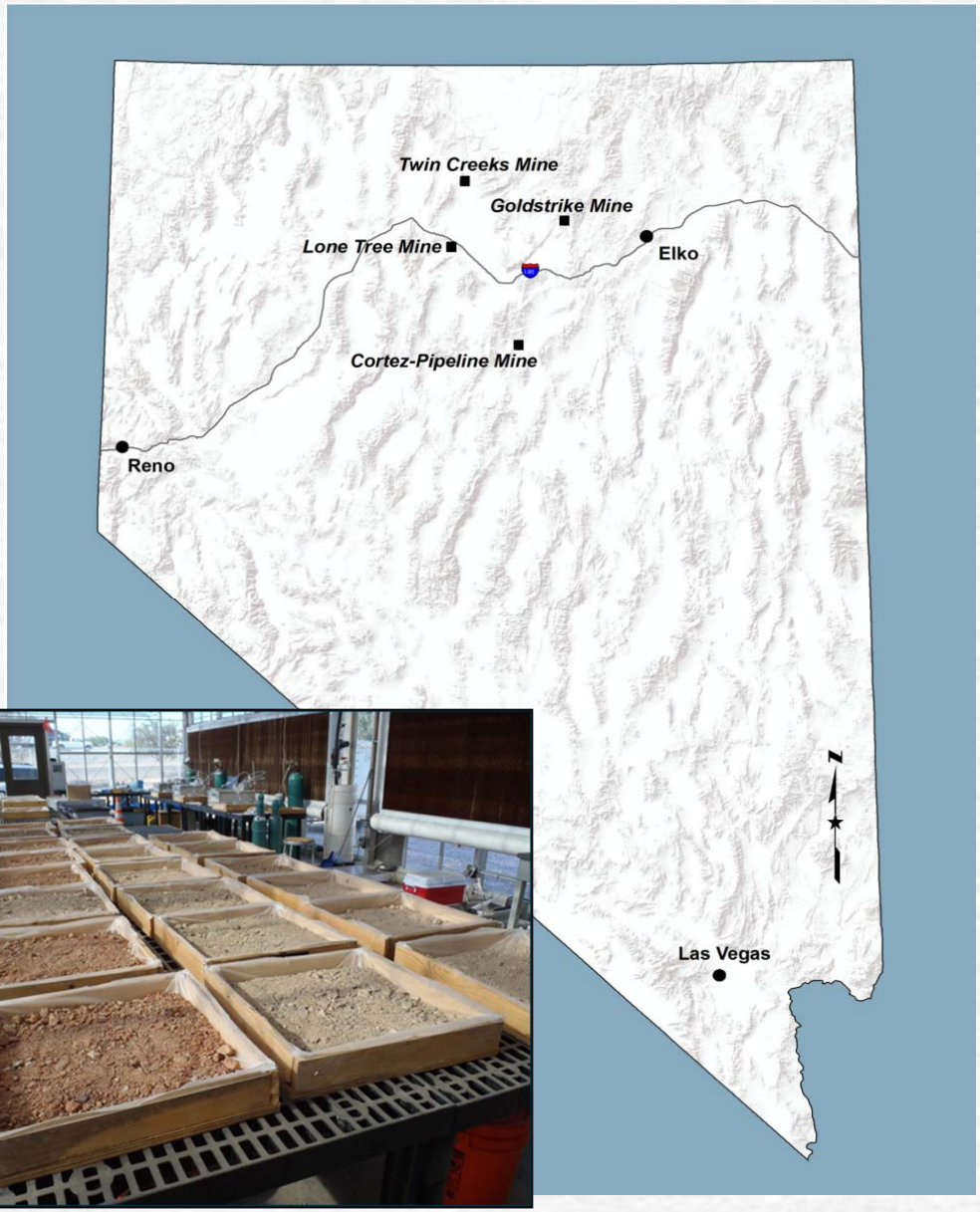
- Remediation study
  - Techniques or methods that may reduce Hg emissions from mine surfaces.
- Hg Emission Model validation
  - Testing model regression equations developed in Eckley et al.
- Emission estimates for additional mines
  - Estimated annual Hg release for Goldstrike and Gold Quarry mines for 2010.



Fugitive Mercury Emissions

Remediation Study

- Materials collected from four mine sites:
  - Waste Rock/Cap
  - Leach ore
  - Tailings
  - Dust control solution
  - Wetting of materials
- Returned to UNR greenhouse for remediation treatments and tests.



Fugitive Mercury Emissions

Remediation Study Results

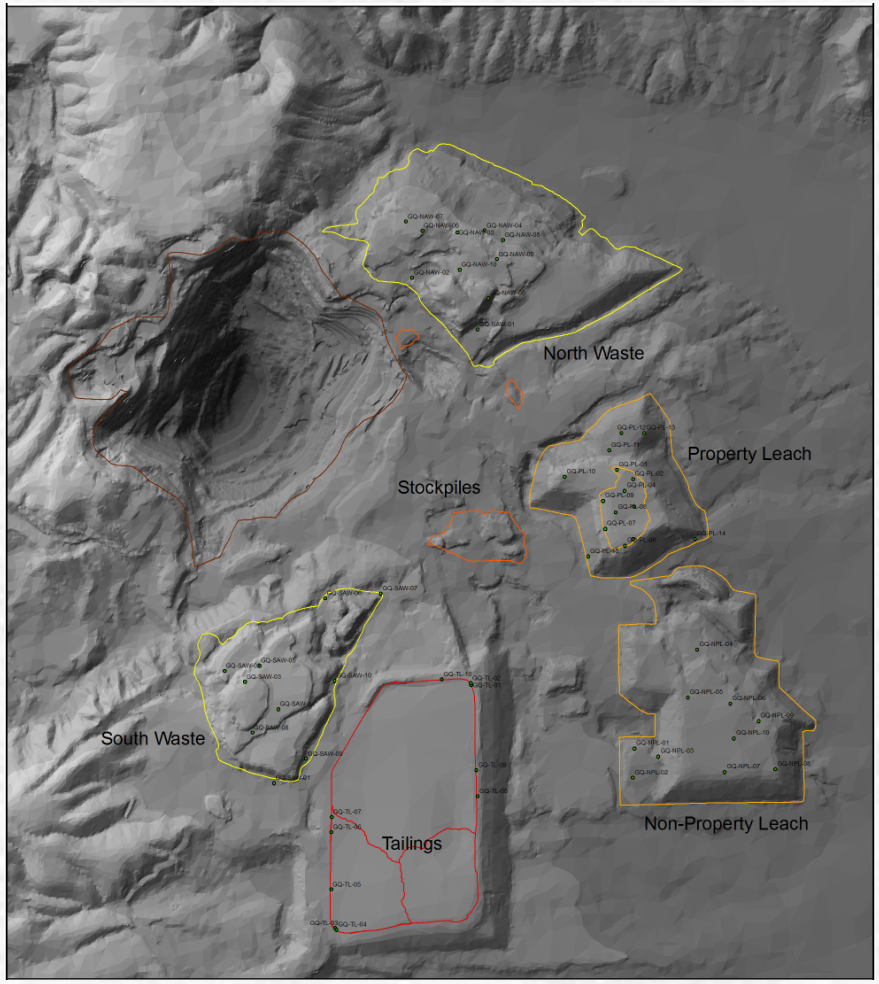
- Results showed that capping mining waste materials with a low-Hg substrate can reduce Hg emissions from between 50 to nearly 100%.
- The spraying of typical dust control solutions often results in higher Hg emissions, especially as materials dry after application.
- The concentrated application of a dithiocarbamate Hg control reagent appears to reduce Hg emissions, but further testing is needed to make a definitive assessment.

Fugitive Mercury Emissions

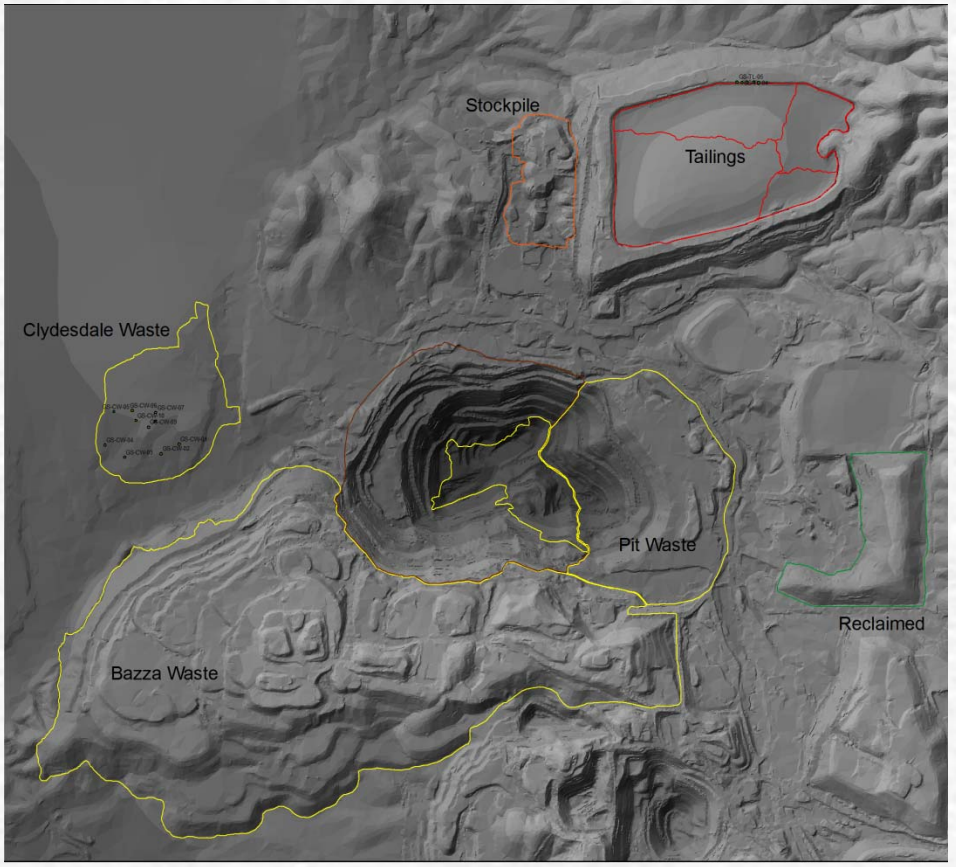
Modeling of Annual Site Emissions

- Site-specific model inputs:
  - Total Hg concentration of substrate
  - Substrate area
  - Environmental conditions: # of days in each solar level and # of days wet/dry.
- Hg flux calculated for a waste rock, dry leach, dry tailings, and reclaimed areas using appropriate regression equation for each solar level.
- Most significant emission surfaces were the heap leach pads and the tailings ponds.
  - Capped for remediation and bonded.

Fugitive Mercury Emissions



Modeled emissions:



- **Gold Quarry**: 39–42 kg yr^{-1}
  Mean Hg = 5.2 ug g^{-1}
  Area = 15.2 km^2

- **Goldstrike**: 14–17 kg yr^{-1}
  Mean Hg = 2.7 ug g^{-1}
  Area = 19.7 km^2

Fugitive Mercury Emissions

Modeled emissions: limitations and questions

- Relatively few data points.
- Assumption of a 10% disturbed area for heap leach and waste rock.
- Very limited pit data.
- Age factor needs to be better understood and could influence timing of remediation.
- Cyanide solution as a source of Hg to the air versus actual material wetness unclear and this could influence emissions.
- Limited tailings and heap leach data – model results very sensitive to changes in how these materials are handled.
- Assumption that carbonaceous ore measurements can be translated to all stock piles.

Fugitive Mercury Emissions

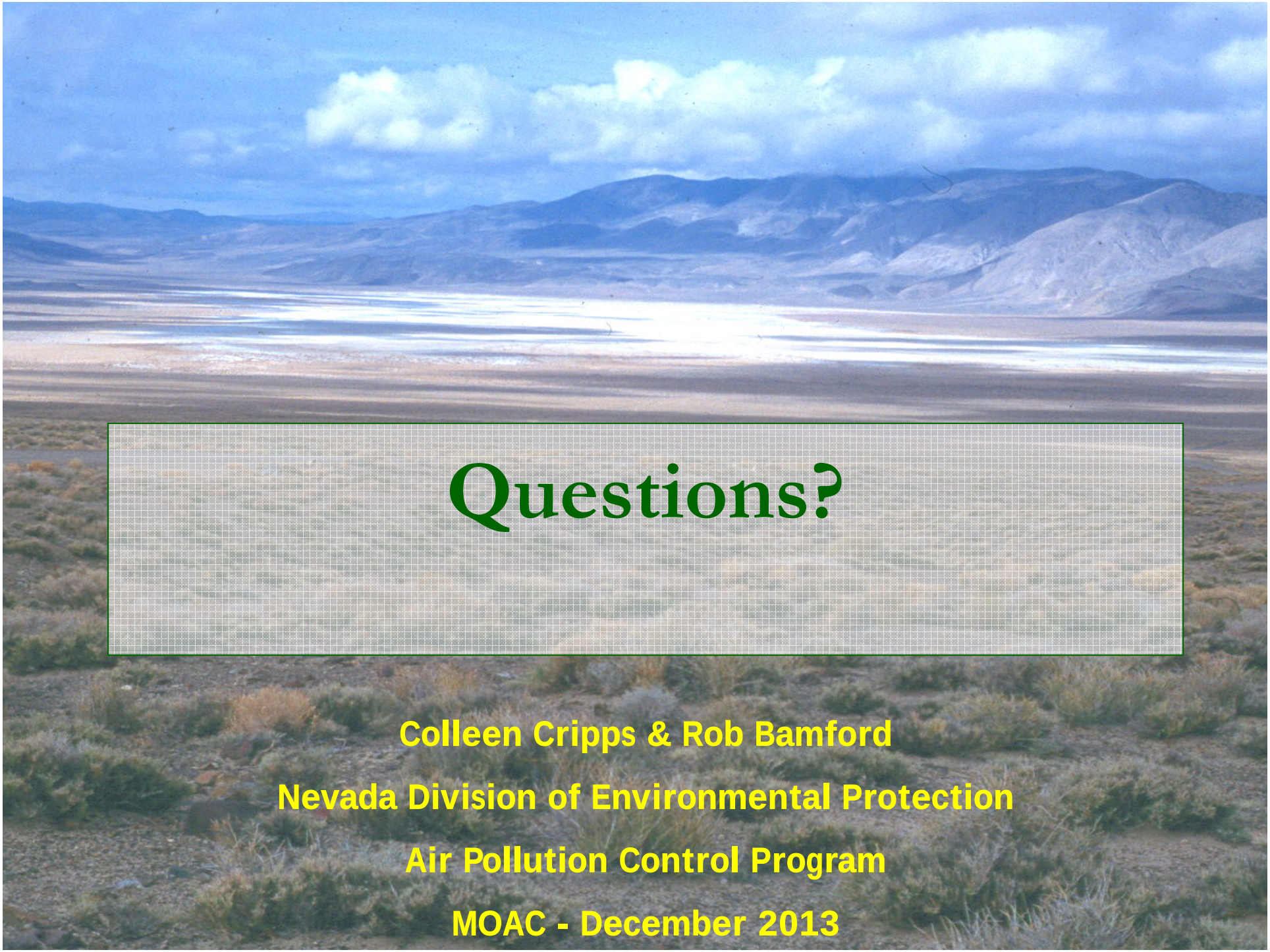
Research needs to improve model of fugitive Hg emissions:

- Wetting and material age affect the magnitude of Hg released from specific materials.
- More field data points for model testing
  - Only have one season
  - Tailings and heap leach data very limited and emission estimates complex.
- Application of model to other mines
  - Could be helpful for TRI estimates.
  - Application to other mines not trivial.
- Speciation of Hg emissions from nonpoint sources needs to be determined- lab and field study.

Fugitive Mercury Emissions

Research needs to improve model of fugitive Hg emissions:

- Lab studies to better understand if Hg released from tailings and active heap leaching is from solution or solid materials
- More soil concentration measurements with depth would be useful for understanding potential impacts.
- All measurements made in this study were conducted in an enclosed greenhouse on a relatively limited selection of mine materials at a smaller scale; may not be directly representative of conditions and results that would occur with capping on actual mine surfaces.


Questions?
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