MINING IN THE UPPER SOUTH PLATTE WATERSHED

Best Management Practices for Treating Legacy Issues and Tools for Responsible Mineral Development

NORTH FORK OF THE SOUTH PLATTE

OUTLINE

- Brief summary of historic and current mining operations in the Upper South Platte Watershed
  - Historical mining (hardrock vs placer), processing (mills and smelters), historical surface uranium mines in the watershed
  - Current operations (aggregate/gravel dominated, small gem mines and prospecting (both illegal and by clubs), gold mines – placer, CCV creed
- Discussion of abandoned mine inventories and reclamation efforts (what has been done)
- Discussion of natural sources of metal loading ARD and uranium/NORM
- Potential mines of concern / sources of concern (what needs to be done)
- Best Management Practices
  - Actions at abandoned mines
  - Green Remediation
  - Existing operations

MIDDLE FORK OF THE SOUTH PLATTE

LEGACY ISSUES

- Colorado's heritage is mining. It's what led many people to the state in 1859, and was the most important economic activity for many years.
- Historic mining activities left an estimated 23,000 hazardous mining features unsafeguarded, and approximately 1,300 miles of streams impacted by past mining practices (DRMS).
- There are 36 active and 115 inactive mining permits within the USPW (DRMS permit data accessed 10/2014)
- Between 1859-1989 mines in Park County produced in excess of 9,404,623 oz Ag 1,366,374 oz Au, 12,668,632 lbs Zn, 63,333,051 lbs Pb, and 3,334,886 lbs Cu. (Scarbrough, 2001)
- The USGS compiled data on over 235 mines and prospects in Park County and it has been estimated that there are at least 600 old workings, in the northwest Park County over 3,000 patented mining claims were documented. (Scarbrough, 2001)

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DISCUSSION OF ABANDONED MINE INVENTORIES AND RECLAMATION EFFORTS

- An inventory of known abandoned mine lands (AMLs) on National Forest land was conducted by the Colorado Geological Survey in the mid-1990s. Approximately 18,000 abandoned mine-related features were inventoried state wide, including about 900 features that are considered significant enough environmental problems to warrant further investigation.
- Data collected at these mines included: mapping of the features at the sites, environmental information at the AML, environmental and safety ratings, and water and waste samples from select sites. DRMS conducted an inventory of AML throughout Park County in the 1980s.
- *Many AML hazards have been addressed within the watershed and mine sites causing significant degradation have been identified*
  - *Reclamation efforts have been made on the Paris Mill Site, South London Mine, American Mill Site and many other volunteer cleanup actions*

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ACID ROCK DRAINAGE
NATURAL SOURCES OF METAL LOADING

- During the AML inventory, evidence of naturally occurring water quality degradation was found in areas where little or no evidence of mining activity exists. These areas include the upper Alamosa River, the Middle Fork of Mineral Creek, Peekaboo Gulch, and Handcart Gulch. Water from these natural sources has been found to significantly exceed Colorado water quality standards for several metals.

- Acid rock drainage (ARD) in Handcart Gulch has resulted in natural degradation and therefore Handcart Gulch was given a Load Allocation (LA) in the 2008 TMDL rather than a Waste Load Allocation (WLA), which was given to the Missouri Mine, considered an unpermitted point source for Cu loading. The TMDL for this segment of the North Fork is split 80% LA and 20% WLA (CWQCC, 2008).

- "Acid rock drainage" occurs when the sulfur that is displaced by the oxygen combines with water to form weak sulfuric acid. The acidic water then dissolves minerals from the bedrock, often adding significant amounts of dissolved metals to these headwater streams. Natural acid rock drainage has been active in Colorado for thousands, possibly millions of years.

- **Abandoned Mines and Naturally Occurring Acid Rock Drainage on National Forest System Lands in Colorado** *Matthew A. Sares1, Daryl L. Gusey2, and John T. Neubert1*

URANIUM AND NORM

- uranium-238 does not decay directly to lead but passes through several daughter elements including thorium, radium, radon (a gas), and bismuth on its path to a stable isotope of lead.

- Epigenetic deposits of uranium in sedimentary rocks form the bulk of uranium deposits in Colorado. These include the many mines of the Uravan, Cochetopa, Maybell, and Rifle districts, and other scattered places including the Front Range and Denver Basin.

- Primary uranium deposits in Colorado occur in hydrothermal veins, especially in the Front Range.

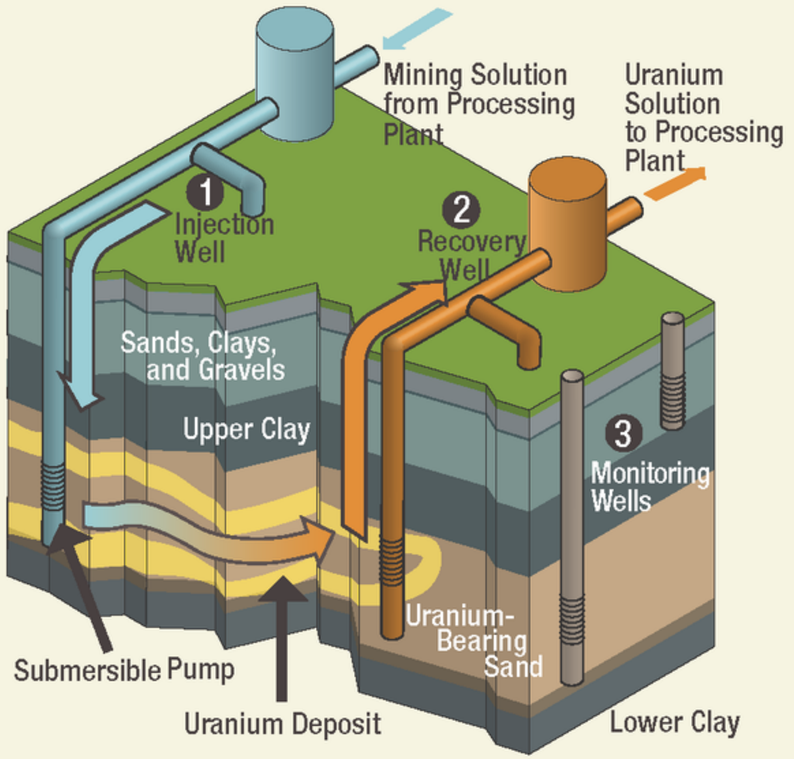
URANIUM AND NORM

- The most important factor in uranium's behavior in the crust is its sensitivity to *redox* conditions.
- In its oxidized form, uranium is very soluble, and hence highly mobile, and able to dissolve in water, often traveling coupled with carbonate ions (CO^3 ions).
- In an oxygen-starved environment, uranium's solubility is greatly reduced and it can't remain dissolved, dropping out of solution to form solids – commonly the mineral uraninite (UO^2). (Burnell CGS)
- Naturally occurring radioactive elements such as uranium, radium, and radon are dissolved in very low concentrations during normal reactions between water and rock or soil.
- Ground water that coexists with deposits of oil can have unusually high concentrations of dissolved constituents that build up during prolonged periods of water/rock contact. Many oil-field waters are particularly rich in chloride, and this enhances the solubility of other elements including the radioactive element radium.

URANIUM AND NORM

- Uranium was historically mined in Park County –
  - Boomer Mine – southwest of Lake George beryllium area, patented in 1905 as a molybdenum prospect but rehabilitated in 1955 as a uranium prospect and beryllium production. 0.02-0.7% uranium oxide
  - Gold Star Uranium Mine – Tarryall Springs District no reported production but geochemical sampling indicated uranium oxide of 0.06-3.21%
  - Last Chance Uranium Mine – Tarryall Springs District – known production from 30 ft deep pits and drifts producing one ton of ore containing 0.25% uranium oxide additional assays reported 0.8-2000 ppm equivalent uranium
  - Goermer Uranium Mine – Guffey District 30 tons of uranium-vanadium ore were produced from small surface workings in 1966 and contained 0.28% uranium oxide and 0.59% vanadium oxide
  - In the Guffey District there are pegmatite hosted beryllium-uranium-rare earth mineral deposits additionally there are volcanic and sediment hosted uranium deposits
  - In the Hartsel area uranium mineralization occurs in an irregular shear zone traversing breccia deposits of the lower member of the Oligocene Thirtynine Mile andesite
  - In the upper sandstone units of the Florissant Lake Beds uranium occurs as roll deposits similarly the Carson Uranium deposit occurs in the lake beds as well as the Tallahassee Creek Conglomerate

Figure 37. The In Situ Uranium Recovery Process



Injection wells (1) pump a chemical solution—typically groundwater mixed with sodium bicarbonate, hydrogen peroxide, and oxygen—into the layer of earth containing uranium ore. The solution dissolves the uranium from the deposit in the ground and is then pumped back to the surface through recovery wells (2) and sent to the processing plant to be processed into uranium yellowcake. Monitoring wells (3) are checked regularly to ensure that uranium and chemicals are not escaping from the drilling area.

In 2013, 47% of world uranium mined was from ISL operations. Most uranium mining in the USA, Kazakhstan and Uzbekistan is now by in situ leach methods, also known as in situ recovery (ISR).

NORTH
FORK
MINES

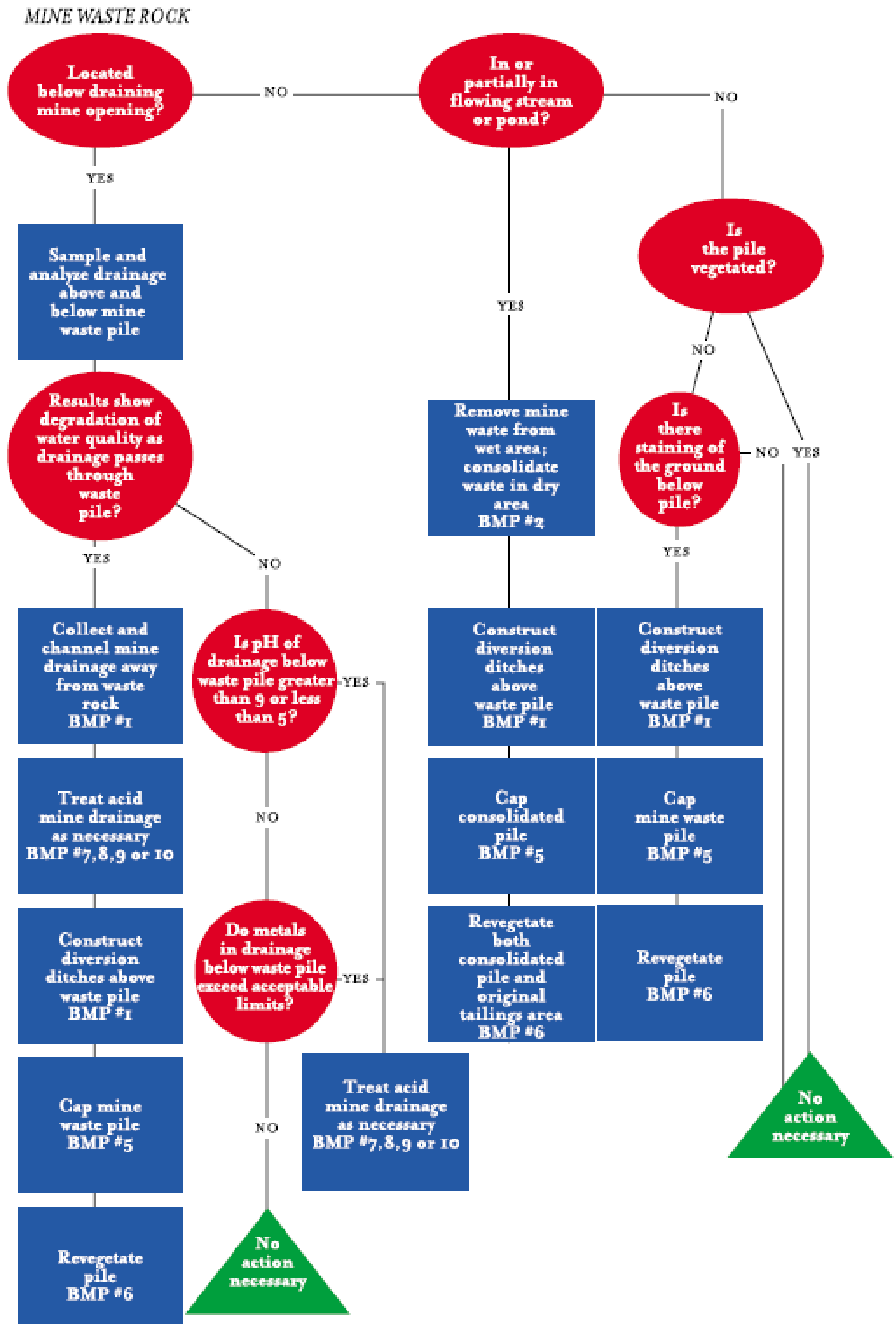
POTENTIAL MINES OF CONCERN / SOURCES OF CONCERN (WHAT NEEDS TO BE DONE)

- Orphan Boy
- Buckskin Joe
- Mineral Park Mill Ponds
- Minor Cu loading in North Fork above natural ARD
- Placer mining current and historical source of sediment
- Sources from transmountain diversion (Mo - Climax)
- Uranium deposits in many formations and aquifers

AMD AND TREATMENT?

MINE WASTE PILE REMEDIATION

Goal: Keep water away from mine waste



DRMS

HANDBOOK

BEST MANAGEMENT PRACTICES HYDROLOGIC CONTROLS

- Diversion ditches (run-on/run-off controls)

  Effective where quality of rainwater, snowmelt or surface flow is degraded by flowing over or through mine waste. Can also be used to intercept shallow groundwater that may enter a mine. Consider seasonal peak flows and flood flows when designing

- Mine waste rock/tailings removal and consolidation

  Move reactive material away from water sources, effective where there are several small waste piles in an area or where there is a large pile in direct contact with flowing water, need suitable repository area. Cost dependent on amount of material and distance to repository area

- Stream diversion

  Applicable where waste rock or mill tailings pile is in direct contact with flowing stream and there is no place to remove and consolidate pile (generally better to move rock than the stream), requires 404 permit and could require extensive excavation

BEST MANAGEMENT PRACTICES HYDROLOGIC CONTROLS

- Erosion control by regrading

  This BMP is generally followed by vegetation if the waste rock or tailings are not too toxic or capping then vegetation if needed. Requires periodic maintenance to ensure no pools (leaching), or rills develop

- Capping

  In most cases simple covers are adequate, composite covers are used when the material is highly reactive, complex caps are used in situations of highly toxic materials and are often combined with liners under the material.

  Simple cover- minimum of 6 in – 1ft of soil from borrow pit near by, no pooling areas, glacial till or good mix of clan, sand and organic mater

  Composite cover- at least 2 layers of different soil types, the lower layer next to the waste rock is fine grained, high density and low permeability, the upper layer consists of coarser material to encourage plant growth and act as a capillary barrier

  Complex cover- interlayered synthetic filter fabrics and fine and coarse material, generally requires very site specific design and can be costly

- Revegetation

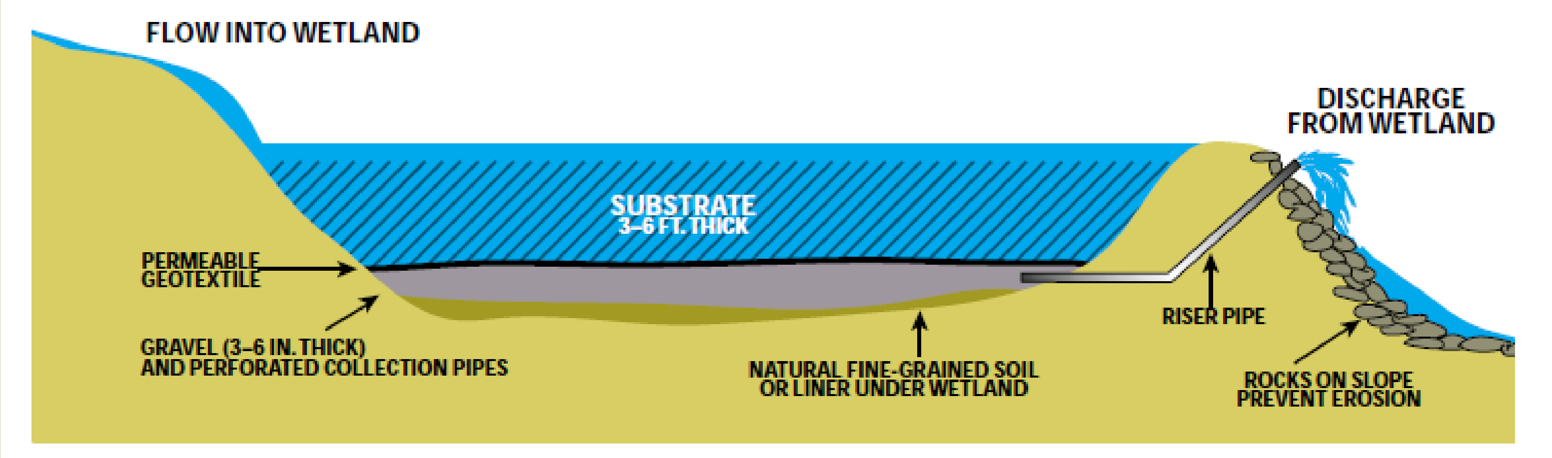
  helps to contain reactive material, reduces erosion and water infiltration (leaching). Really need at least a shallow later of uncontaminated soil,

BEST MANAGEMENT PRACTICES PASSIVE TREATMENT

- Aeration and settling ponds

  Promote the precipitation of heavy metals through oxidation process, effective when mine drainage water is high in total suspended solids but near neutral pH. Need to retain water for a minimum of 24 hr. Steep site may offer good possibilities for aeration of the drainage but limited area for settling pond. Pond will need to be maintained due to sediment and metal precipitation

- Sulfate-reducing wetlands



BEST MANAGEMENT PRACTICES PASSIVE TREATMENT

- Oxidation wetlands
  - Metals such as iron, manganese and arsenic are precipitated through oxidation by aquatic plants and algae. 1 gpm of drainage will require a 200-900 square foot wetland. pH needs to be 6.5 or higher, winter decreases efficiency of the system
- Other BMPs to treat acid mine drainage
  - Diversion of surface water
  - Dilution
  - Bulkhead seals
  - Anoxic limestone drains
  - Aqueous limestone injection
    - More intensive requiring ongoing maintenance and higher costs

BMPS FOR CURRENT OR FUTURE

- Dust suppression
- Interim remediation
- Lines of communication with agencies making a difference
  - DRMS
  - CDPHE
  - County governments
  - Inter agency abandoned mine team
  - Colorado rural water
  - Local water operators