WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

DGER NEWS

DIVISION OF GEOLOGY AND EARTH RESOURCES
"Washington State's Geological Survey since 1890"

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USING REMOTE SENSING TO REGULATE MINE RECLAMATION

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Introduction

According to the Washington Aggregates and Concrete Association, Washington State consumes about 80 million tons of sand, gravel, and crushed-rock products every year, which is approximately 15 tons per capita. This aggregate resource comes from surface mines, and most of it is used for road and building construction that benefits every citizen of the state to some degree.

Increased aggregate consumption means more land is disturbed by mining. To ensure that this disturbed land will be reclaimed, the legislature passed the Surface Mining Act in 1971 and amended it in 1993. The Act requires a reclamation permit for each mine that results in more than 3 acres of disturbed ground or has a highwall that is both higher than 30 feet and steeper than 45 degrees (Chapter 78.44 Revised Code of Washington [RCW], Chapter 332-18 Washington Administrative Code [WAC]). Reclamation means that the areas disturbed by mining are rehabilitated for an approved future use.

Surface mines in Washington are primarily sand and gravel pits and rock quarries, but also include some metal and industrial mineral mines. The Department of Natural Resources (DNR) is charged with regulating surface mine reclamation. DGER's Surface Mine Reclamation Program issues reclamation permits and monitors the approximately 1100 permitted mine sites across the state (Fig. 1) to make sure that they are thoroughly reclaimed.

The Reclamation Plan

Applicants for a reclamation permit must submit a detailed reclamation plan to DNR before a permit will be issued. The plan must describe how the mine will be reclaimed and include a pre-mining topographic map, a segmental reclamation map showing the progression of mining and reclamation, and a final topographic map that shows how the mine will appear upon completion of reclamation. These requirements are detailed in "Best Management Practices for Reclaiming Surface Mines in Washington and Oregon" (http://www.dnr.wa.gov/geology/pdf/bmp.pdf), which also covers many other facets of surface mining.

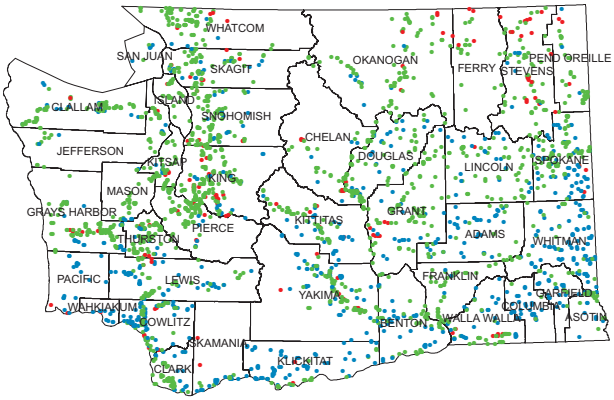

Figure 1. Permitted mines in Washington: green points are sand and gravel pits, blue are rock quarries, and red are metal and industrial mineral mines.

The Performance Security

Another requirement for a reclamation permit is the performance security or reclamation bond. Reclamation bonds are required for each mine site and reflect the actual cost of reclamation in case the permit holder abandons the mine without reclaiming the site and DNR is forced to seize the bond and contract out the reclamation work. The reclamation bond is held by DNR until the reclamation of the mine site is complete and successful.

A MESSAGE FROM THE STATE GEOLOGIST

Ron Teissere
State Geologist

The 2005 Legislature adopted an 05-07 Biennium budget that did not fund any of our enhancement requests. The final budget also did not fund the salary increase that the geologists received in the middle of the 03-05 Biennium. We are awaiting the decision of our parent agency, the Department of Natural Resources, regarding the reduction in management mandated by the governor, to see how the Division might be affected, but the end result is less funding. The Division will have to make further reductions in staff, services, or both to meet the lower funding levels.

The most significant loss will be the virtual elimination of our work on geological hazards. Given the level of risk from these phenomena in Washington, the lack of this work will have eventual consequences. Our ability to assist local government with the identification and designation of geologically hazardous areas, to respond to emergencies involving geologic phenomena, and to produce maps of geologically hazardous areas for other government agencies and the public will be gone. Restoring funding for these activities will be very difficult until after the next major disaster.

The real tragedy is that we do not need to be at the mercy of these "acts of God". As has been pointed out by Robert Siske in a column for The Wall Street Journal, a moderate, consistently funded program could, over time, significantly improve our ability to provide valid hazard assessments and move the science towards some predictive capability. These assessments could then serve as a firm basis for land-use planning and targeted mitigation measures that would reduce the number of people in harm's way. These efforts would also reduce the potential damage from geologic events and the economic recovery time after the event. Until we are willing to make this investment in the future, we will remain uncertain about the impacts of these phenomena. ■

A simple formula was created in 2000 to facilitate fair and accurate bond assessments. The formula was back-calculated using the actual cost to reclaim average sand and gravel mines and resulted in a cost-per-acre average (currently $4000/acre) for determining the reclamation bond amount. In 2002, DGER reclamation inspectors began using Global Positioning Systems (GPS) to accurately map disturbed acreage at mine sites. The cost-per-acre average was then used to calculate the appropriate bond amount. Prior to using GPS, acreage assessments were less reliable and bond amounts were more frequently contested.

Migration to Aerial Images and GIS

After a permit is issued, DGER's reclamation inspectors monitor the mine, making sure that mining remains within the permitted area and that reclamation is proceeding according to plan. Due to budget cuts in 2003, the number of inspectors was reduced from six full-time positions to three, and DGER began looking at using aerial photos and a geographic information system (GIS) as tools to increase inspector efficiency. GIS software allows a user to stack layers of spatial data so that one set of data can be analyzed in relation to another.

DNR's Resource Mapping Section periodically produces broad-area aerial photos, primarily for forestry use. If the images are recent enough, these photos can be used to assess disturbance at a mine site, and the reclamation bond can be accurately calculated without physically inspecting the site. This method was already being used by some inspectors prior to migrating to GPS.

The Oregon Department of Geology and Mineral Industries (DOGAMI) began using air photos in the late 1990s and contracted their own aerial photography vendor to fly individual mine sites. These large-scale images were better for determining disturbed area, bonding, and other reclamation compliance responsibilities than the broad-area photos, but without the aid of GIS, it was more difficult to manage the data.

The Remote Sensing Program

In 2004, DGER officially started the Remote Sensing Program. Following DOGAMI's lead, DGER retained an aerial photography vendor to fly mine sites at a large scale. This approach produces a greater quantity of high-quality mine images at a much lower cost than flying traditional flight lines, and the photos are more efficiently managed by the GIS software than the smaller scale images. Also, since the vendor has GPS data for all permitted mines, he can photograph any disturbed areas he sees that have no associated GPS points, thus helping DGER track down unpermitted mines.

Figure 2. A 1-foot pixel orthophoto of a surface mine (basalt quarry).

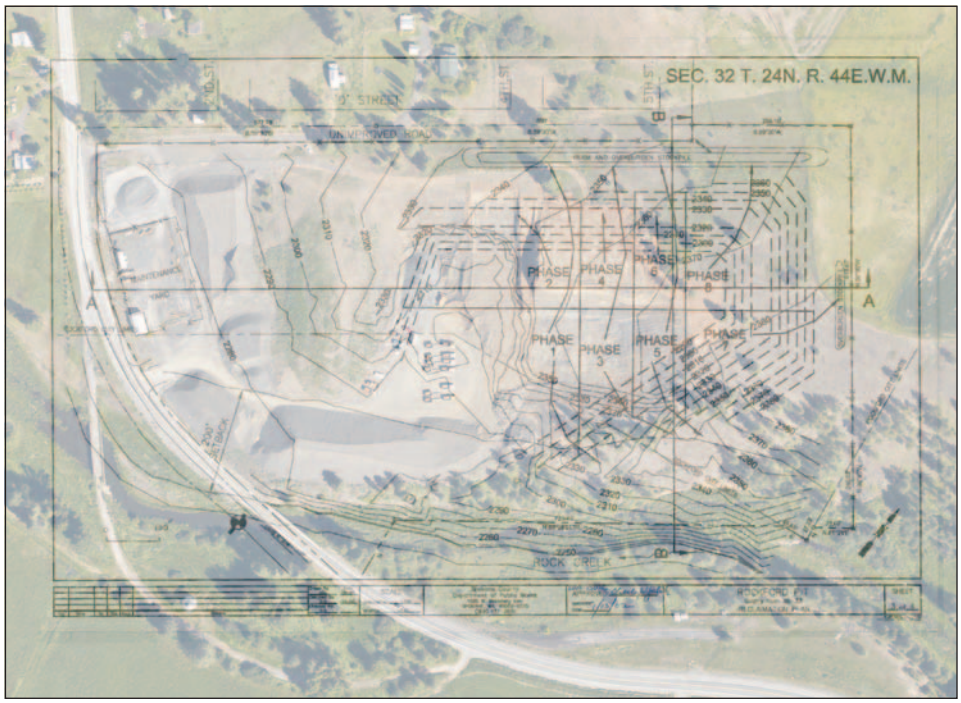

Figure 3. The approved reclamation map for the surface mine has been appropriately scaled to the orthophoto and placed on top of it. ArcGIS software allows the user to make layers semi-transparent so that the orthophoto can be still seen underneath the reclamation map.

The aerial photography vendor provides DGER with accurately scaled, ortho-rectified digital images of individual mine sites. Ortho-rectification means that spatial distortions in the air photo due to variable elevation (hills and valleys) have been removed. In other words, the image has been corrected so that it can be used like a flat, plan-view map. This type of image is called an orthophoto. The orthophoto allows reclamation maps to be accurately located over the mine-site image without distortion.

The Remote Sensing Program is currently using four GIS data layers: the orthophoto (Fig. 2), the reclamation map of the mine site (Fig. 3), a permit-area boundary polygon, and a disturbed-area boundary polygon (Fig. 4).

The permit-area and disturbed-area boundaries are determined from the reclamation map and aerial image, respectively, using the methodology described below.

The reclamation map is scanned into a digital file and imported into the GIS, but without any spatial or coordinate data. The orthophoto is spatially referenced, which means that it loads into the GIS where it geographically belongs according to the appropriate coordinate system. The map is then correctly geo-referenced using the map scale bar and common site features, such as roads, buildings, lot lines, etc., that are visible on both the orthophoto and the reclamation map. Finally, the permit boundary from the reclamation map and the disturbed area from the orthophoto are drawn and corresponding acreages are calculated. Figure 4 shows all four layers and is a typical product provided to the reclamation permit holder.

The GIS process produces three important results: location and calculation of the permit area, calculation of the reclamation bond, and determination of whether the mine disturbance is within the permit boundary or not. The permit holder is provided with an accurate bond calculation and a current image of the specific mine site that can be used as a map to aid in monitoring mining and reclamation activities.

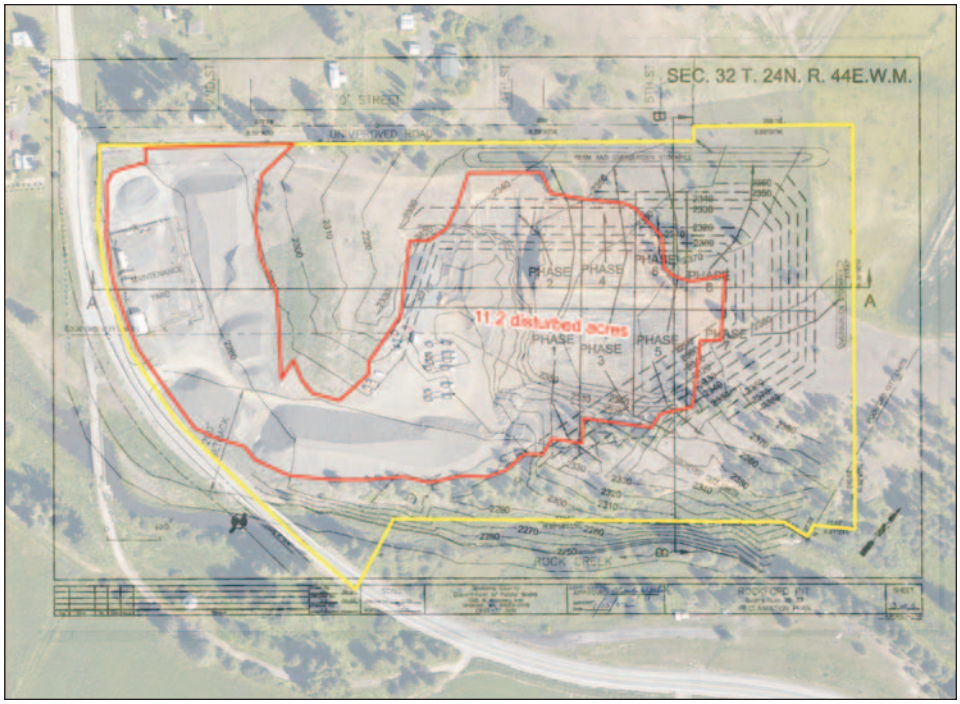

Figure 4. Permit-area (yellow) and disturbed-area (red) polygons produced using GIS software. The acreage in red is used to calculate the appropriate reclamation bond.

What's Next?

While the DGER remote sensing program doesn't eliminate the need for physical site inspections or site-specific bond calculations, it greatly increases our ability to identify potential compliance problems quickly and with extraordinary spatial accuracy. The obvious limitation is the missing elevation data component. When elevation data from field inspections is coupled with the remote sensing data, volumes of earth material required for reclamation may be calculated and added as another layer to the GIS. Maps provided as part of reclamation permit applications can also be verified for accuracy using GIS prior to the permit being approved.

The image and data layers are currently being maintained in a GIS geodatabase that may be available as an interactive website in the future. DGER plans to fly about 500 mine sites per year, which will provide images of the most active sites every other year. Mining is driven by market demand and not all sites are used annually. Less-active mines may be flown on a three- or five-year schedule instead of biennially. This will allow DGER to more effectively monitor the progression of mining and reclamation at every mine site throughout the state. For more information, contact Matt Brookshier at 360-902-1470 or matt.brookshier@wadnr.gov. ■

INACTIVE AND ABANDONED MINES LANDS (IAML) PROJECT

DGER is building a database and geographic information system (GIS) coverage of major mines in the state called the Inactive and Abandoned Mine Lands (IAML) inventory. The project was initiated in 1999. DGER was chosen to do the work because of our technical background and unique and extensive library collection. The work is funded through interagency grants from the U.S. Forest Service, Region 6. Other agencies sharing in the project are the U.S. Bureau of Land Management, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology (DOE).

Mining geologist Fritz Wolff has been leading the project, conducting field investigations, and documenting conditions left by previous operations, many of them dating back to 1900. The data we have collected are available to any interested parties, including present-day companies seeking precious metals.

Figure 1. Abandoned mines present hazards to the unwary hiker, such as the 300-foot-deep Moonlight shaft at the Gladstone Mine, Stevens County.

More than 3800 mineral properties have been located in the state during the last 100 years. Many are undeveloped prospects of little economic importance. The mines were worked and abandoned before requirements for reclamation and cleanup were enacted. Many of the mines present serious surface hazards to the unsuspecting hiker—vertical pit walls, unmarked shafts (Fig. 1), and acid water containing dissolved toxic metals. All of the mines are dangerous underground. These hazards present obvious and significant liability problems for landowners, the public, and government.

Mines included in the inventory had to meet one of the following criteria: (a) more than 2000 feet of underground development, (b) more than 10,000 tons of

Figure 2. United Copper mine tailings. Note motorcycle jumps. Arsenic and copper levels in the tailings exceed State standards for health and safety.

production, (c) location of a known mill site or smelter.

Although these sites are no longer in operation, we have chosen to use the term *inactive* in the project's title in addition to the term *abandoned* because it more precisely describes the land-use situation and avoids any political or legal implications of surrendering an interest to a property that may re-open with changes in economics, technology, or commodity importance.

Not all the news is bad. We have examined 62 properties, and many discharge water that meets drinking quality standards. We discovered several, however, with levels of arsenic, lead, and zinc that exceed DOE standards by hundreds of orders of magnitude. Unprotected shafts are a common occurrence. Finely ground tailings left over from concentrating mills cover vast areas of smooth terrain used as recreation sites by dirt bikes and other off-road vehicles (Fig. 2). Unfortunately, this material and its associated dust are loaded with toxic metals.

The IAML database focuses on physical characteristics and hazards (openings, structures, materials, and waste) and water-related issues (acid mine drainage and/or metals transport; Fig. 3). Accurate location, current ownership, and land status information are also included. Acquisition of this information is a critical first step in any systematic approach to determine if remedial or reclamation activities are warranted at a particular mine. Published reports provide documentation on mines or groups of mines within specific mining districts or counties.

Published reports to date include: *Chelan County:* Red Mountain mine; *Ferry County:* Talisman mine; *King County:* Apex mine; *Lewis County:* Roy and Barnum–McDonnell mines; *Okanogan County:* Alder mine, Cecile Creek watershed; *Snohomish County:* Mystery and Justice mines, Spada Lake watershed, Sunset mine; *Stevens County:* Gladstone and Electric Point mines, Iroquois mine, Sierra Zinc mine, United Copper Group mines; *Whatcom County:* Azurite mine, Boundary Red Mountain mine, Great Excelsior mine, Lone Jack mine, New Light and Mammoth mines. IAML reports are online at http://www.dnr.wa.gov/geology/pubs/pubs_ol.htm. For more information, contact Fritz Wolff at 360-902-1468 or fritz.wolff@wadnr.gov. ■

Figure 3. Acid mine drainage from the main adit at the Lockwood Pyrite mine in Snohomish County.

PEND OREILLE MINE REOPENS

The Pend Oreille zinc mine near Metaline Falls in northeastern Washington started production again in 2004 and achieved commercial production in the third quarter. Production in 2005 is estimated to be 50,000 tons of zinc in concentrate and 8000 tons of lead in concentrate. The concentrate will be hauled by truck to the Trail smelter in British Columbia, 50 miles away.

The mine was acquired in 1996 by Teck Cominco Limited, based in Vancouver B.C. Since acquisition, drilling campaigns have delineated and expanded the reserves. In 2000, a further resource at Washington Rock, 1 mile south of the mine, was discovered and increased the resource base.

A major development and construction project was required to bring the mine, on care and maintenance since 1977, into production. Included in the construction was a complete upgrade of the surface and underground electrical systems and refurbishment of administration, dry, and surface shop buildings. The existing concentrator was fitted with new flotation and filtering facilities; the grinding circuit was refurbished. A double-lined tailings disposal facility was constructed.

Underground work included development of a 1300-foot internal shaft, three ventilation boreholes, and mine infrastructure including shop, electrical, and pumping facilities. The existing crushing chamber was reused and fitted with jaw and cone crushers.

Mining is by room and pillar method with a design production rate of 2000 tons per day. Zinc concentrate (~60% Zn) is produced at an annual rate of 80,000 tons.

For more information, visit http://www.teckcominco.com/. ■

CHEVRONTEXACO DONATES SEISMIC DATA TO AGI

ChevronTexaco has donated of thousands of miles of historic 2D and 3D seismic data to the American Geological Institute (AGI). AGI has partnered with the U.S. Geological Survey (USGS) to place the data in a newly created repository called the National Archive of Marine Seismic Surveys (NAMSS), giving the scientific community access to the data (http://walrus.wr.usgs.gov/NAMSS/).

In the 1960s, ChevronTexaco acquired seismic data to image and evaluate the oil and gas potential of the continental shelf off the west coast of the U.S. Over the decades, the magnetic tapes containing the seismic data have been deteriorating. The data needs to be transferred to a new digital recording medium, or it will be permanently lost. The plan is to begin the initial transfer of more than 30,000 tapes immediately.

"The data is a valuable resource for understanding the offshore structural geology, marine sedimentation, and even the mapping of the complex fault systems associated with earthquakes," said AGI president Stephen Testa. ■

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