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Developing Priorities for Verifying and Inventorying Suspected Abandoned Mine Sites on Public Lands

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ABSTRACT

In an effort to begin to deal with the potential public and environmental health problems that could result due to inactive and abandoned mine sites on the 22% of U.S. land mass managed by the Department of the Interior, the Department is developing an initial inventory of potential sites where some activity related to mineral exploration or development may have occurred. Such an inventory, based upon existing information sources, may contain over 50,000 potential sites. This inventory will, in general, not contain enough information to allow either detailed assessments of the potential public and environmental health risks for each of these sites, or identification of which sites, if any, should be remediated prior to others. An exercise to gather even minimal additional information could easily cost millions of dollars. Field verification alone, at a cost of $500 per site, could cost over $25 million; preliminary sampling could increase these costs by more than an order of magnitude.

Given that such resources are unlikely to be available, it is necessary to first develop a national prioritization system that will identify sites and areas with the greatest likelihood for creating potential risks to public and environmental health. Such a system could then be used to cost-effectively focus the efforts of any expensive and time consuming information collection exercise prior to detailed site characterizations or remediations. This paper presents a status report on developing such a prioritization system and testing it on the Bureau of Mines' Minerals Availability System (MAS), a data base identifying over 200,000 locations in the U.S. where some mining related activity may have occurred.

INTRODUCTION

The Department of the Interior (Interior) is the steward for 22% of the U.S.'s land area (about 445 million acres) and the natural resources associated with them including biological, energy, mineral, water and recreational resources. Over the years a substantial amount of mining and related activities have occurred on these lands. These activities, undertaken mainly by private parties, range from sample collection and mineral exploration to development and construction of mines, shafts, processing facilities, tailings and waste piles. Estimates of the number of locations where such activities have taken place on Federal lands have ranged from tens of thousands to as many as several hundred thousands. These include inactive and abandoned mines (IAMs) as well as mines that are currently active and operating.

Over the last few years there has been increasing concern in Congress, in the States and within Interior that, in addition to constituting a public safety hazard, some of these inactive and abandoned mines contain contaminants which could pose significant risks to human populations and biological resources on Federal and adjacent lands.

The estimated costs of obtaining information on a site varies depending upon the level of effort. U.S. Bureau of Mines (USBM) experience has shown that paper inventories based upon existing records and reports cost about $40 a site. Field verification of sites to check if there is a potential for environmental hazards runs about $500 per site. This assumes a high density of sites and relatively large economies of scale. Preliminary sampling of potentially hazardous sites commences at $8,000 a site. Site characterizations can cost hundreds of thousands of dollars each. Remediation, of course, is even more expensive, possibly by an order of magnitude or more.

Considering the large number of sites on Federal lands, obtaining additional information could cost the taxpayer millions of dollars. Given the tight budgets and the numerous other claimants for Federal funding, it is, incumbent upon Interior to devise a cost-effective, common-sense methodology to deal with the IAML problem. First, it should help identify on a national scale, locations associated with mining and related activities which are more likely (than others) to create public health and environmental problems. Second, it should develop priorities among these locations/areas to target a subset for site visits, detailed inventories and eventually site characterization. Subsequently, the information obtained from site or area visits could be processed to develop priorities for, and scale of, remediation.

The USBM, in conjunction with the Department of the Interior, Office of Policy Analysis is developing a methodology for accomplishing the first two steps utilizing existing databases and generally available information. Specifically, the objective is to develop nationwide priorities prior to undertaking costly and resource intensive site visits and studies at this stage. Of necessity this forces us to use data that are readily available or accessible at low cost and which provide national coverage.

This paper provides a status report on this exercise as of the end of February, 1995. The exercise is expected to be completed over the next several months. This status report provides preliminary estimates of the number of mine sites on Federal and Interior lands which could potentially have contaminant and public safety problems associated with them. It also analyzes the sensitivity of these estimates to the use of higher resolution land ownership maps and geographic information system (GIS) data sets. Using information developed from a case study undertaken for the Coronado National Forest, this report estimates the potential number of inactive and abandoned mine sites

which may not currently be included in computerized and easily accessible data bases. Taking this further, we estimate the number of sites which may require environmental site characterization and measures to reduce public safety hazards, and costs associated with these activities.

STUDY APPROACH

The starting point for this methodology is the USBM's computerized Minerals Availability System/Minerals Industry Location System (MAS/MILS) data base. From the perspective of land managers, this data base is useful because it contains spatial information in digital formats which can be used in conjunction with other digitized information sets in a GIS analysis to help identify areas where past mining activities may cause adverse effects on public health and the environment.

For this study, USBM personnel linked the MAS/MILS data base with nationwide information from other sources (utilizing GIS technology) to prioritize sites based upon estimates of the likelihood and magnitude of public health and environmental risks. The general approach to developing national priorities for site investigations is illustrated in Figure 1. Starting with the MAS/MILS data base, sites are identified on Federal and Interior lands that have had some hard rock production activities associated with them. Sites or clusters of sites can be prioritized based on their relative risks to public safety and the environment using the following criteria:

- Proximity to streams and rivers
- Distance to populations
- Proximity to threatened and endangered species habitat
- Precipitation (less evaporation) for the site location
- Commodity mined at the site
- Geology in the vicinity of the site.

As of this writing, the first step has been completed, and the sites identified in that step have been screened with respect to their proximity to rivers and streams.

DATA BASES AND OTHER INFORMATION SOURCES

The data used for this exercise, and their geographical resolution, are dictated by our overall objective, namely, to develop nationwide priorities.

Following is a brief description of these data.

Minerals Availability System/Minerals Industry Location System (MAS/MILS)

Originally developed as a source of information on the mineral supply potential within the United States, MAS/MILS contains the most comprehensive collection of data on mineral deposit

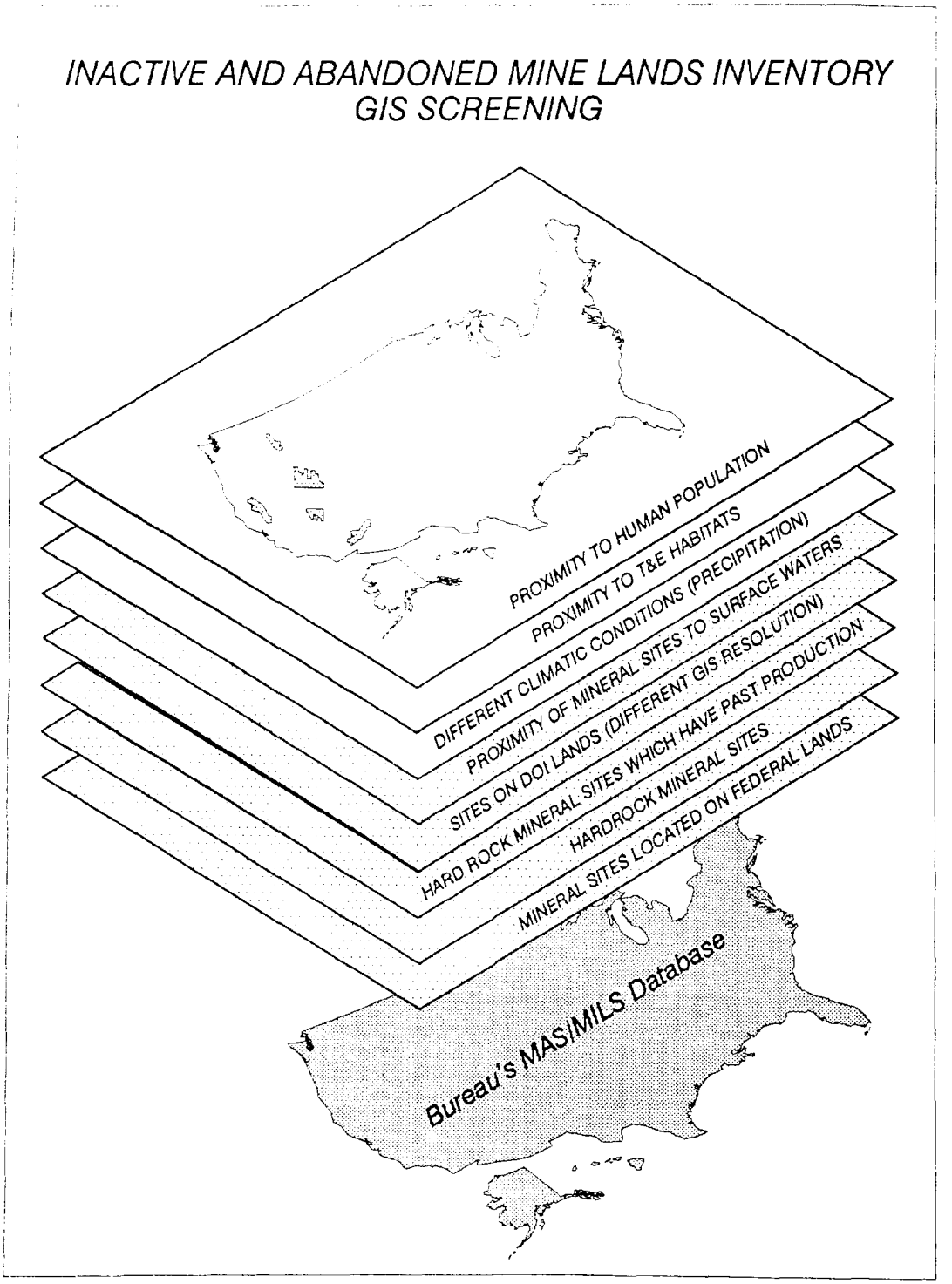

Figure 1 - Study Approach.

locations and past activities. It identifies over 220,000 mineral locations worldwide, of which over 208,000 are located in the United States.

MAS/MILS covers a wide variety of commodities including ferrous and non-ferrous metals, industrial materials, and some coverage of fossil fuels. It contains information on the status of each site (that is, whether it is active or inactive). It indicates whether any production was ever associated with the site, as well as the type of mining/mineral processing undertaken. Each site record contains latitude/longitude coordinates which allows the MAS/MILS data to be combined with other spatial information through GIS processing.

Production related earth moving activities significantly increase the land disturbance and probability of both environmental and physical hazards. The current status information identifies whether the site was an exploration activity, a past producing operation, a current producing operation, or temporarily inactive. Therefore, using this information, we can identify sites that have the highest potential for physical and environmental hazards.

Federal land boundaries.

A GIS data set which defines Federal land boundaries on a nationwide basis is available from U.S. Geological Survey (USGS), Branch of Resource Assessment, Reston, Virginia. It was used to determine which MAS/MILS sites were located within or near Federal Lands. The resolution of the nationwide Federal land boundaries data is 1:2,000,000. Higher resolution (1:100,000) digitized Federal land ownership data are available for a few states. A sensitivity analysis of the number of hard rock mine sites on Federal lands was performed using the higher resolution data for Colorado, Idaho, Nevada, Utah, and Wyoming.

Environmental data bases

A GIS data set which defines river and stream patterns is available from Environmental Systems Research Institute (ESRI) ARCUSA database. It was used to determine the proximity of mine sites to water sources. The resolution of the river and stream map is 1:2,000,000.

Other GIS data bases containing information on population centers, threatened and endangered species habitat, and levels of precipitation have been identified and are available at relatively low cost. Analysis using these data sets have not yet been completed.

IDENTIFYING HARD ROCK MINING OPERATIONS ON INTERIOR LANDS

The USBM performed a series of queries on the MAS/MILS database and GIS screens using 1:2,000,000 land ownership maps to identify sites on Interior lands which may warrant further investigation. Figure 2 shows a density plot of all of the MAS/MILS locations in the conterminous United States. This graphic represents about 201,700 locations. When Federal land boundary data were combined with MAS/MILS points, about 92,400 sites were situated within Federally administered lands.

Figure 3 illustrates the results of successive queries and screening of the MAS/MILS database to arrive at the potential IAM sites on Federal and Interior lands that may need site verification.

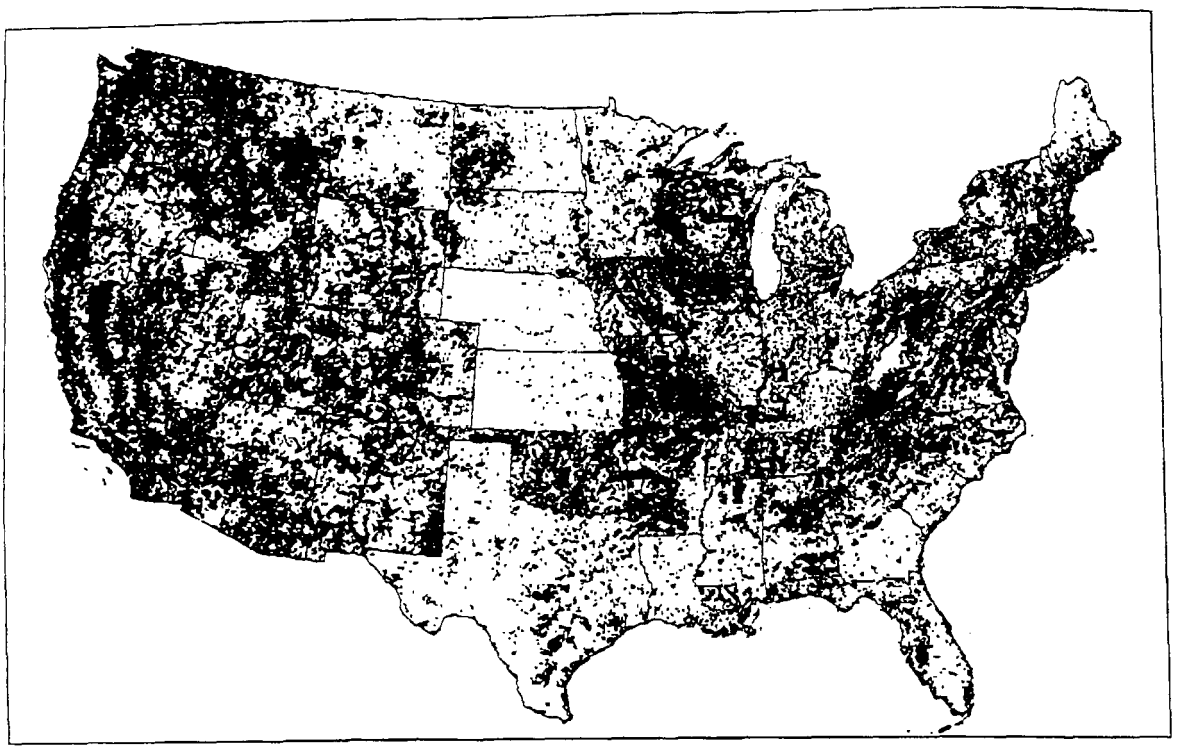

Figure 2 - Density plot of MAS/MILS locations in the contiguous U.S.

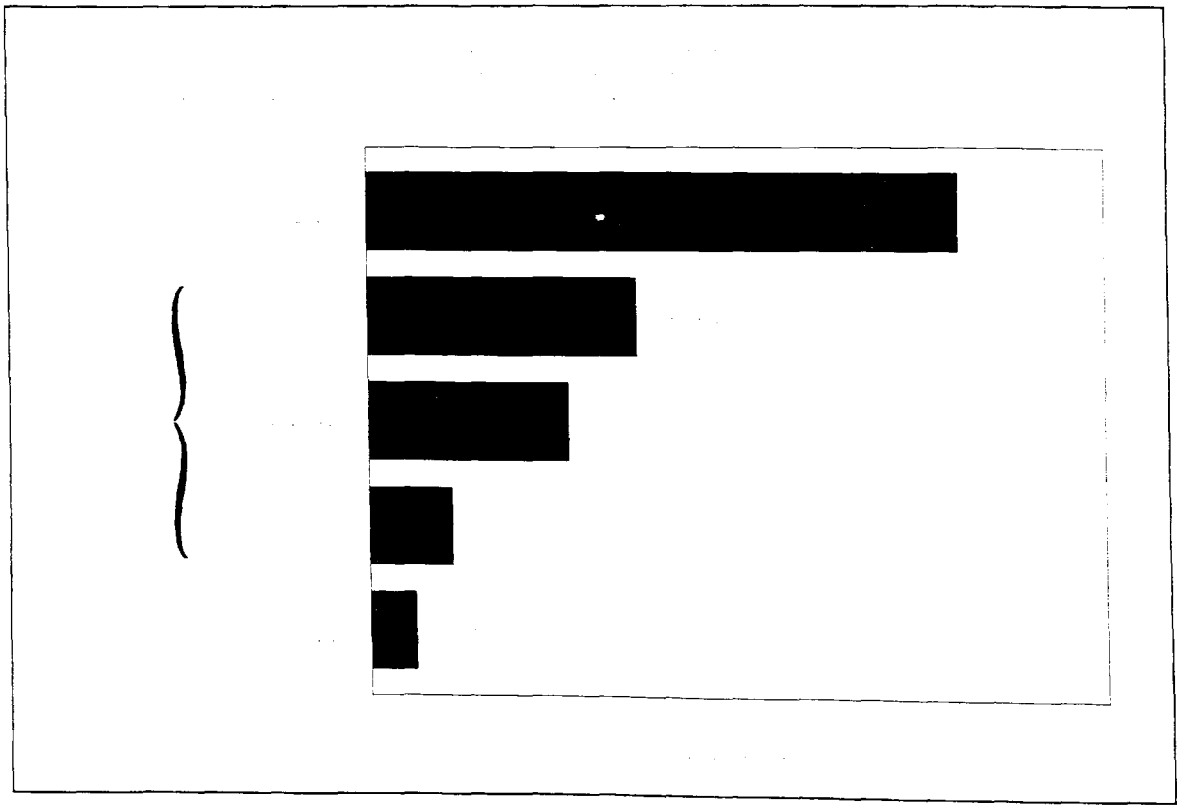

Figure 3 - Distribution of MAS/MILS sites by land ownership.

The hard rock commodity sites on Federal lands number 68,600. Coal, uranium, sand & gravel, oil & gas, and geothermal well sites were excluded, because they either are covered in greater detail by other programs and agencies (for example, the Department of Energy or Nuclear Regulatory Commission) or they are viewed as having a lower potential for environmental concerns (e.g. sand and gravel sites).

A query of sites which have evidence of past or present mineral production indicated 28,200 of these mineral sites are on Federal lands. Figure 4 displays the distribution of this set according to Federal agency responsible for administering the land. Of the 28,200 hard rock sites which have evidence of production, 15,300 of the sites are on or in close proximity to Interior administered lands. The Bureau of Land Management (BLM) has administrative responsibility over 94% of these; the Fish and Wildlife Service, the Bureau of Indian Affairs, and the National Park Service administer the remaining 6% (see Figure 5). Most of the remaining producer sites on Federal lands are managed by the Department of Agriculture's U.S. Forest Service (USFS).

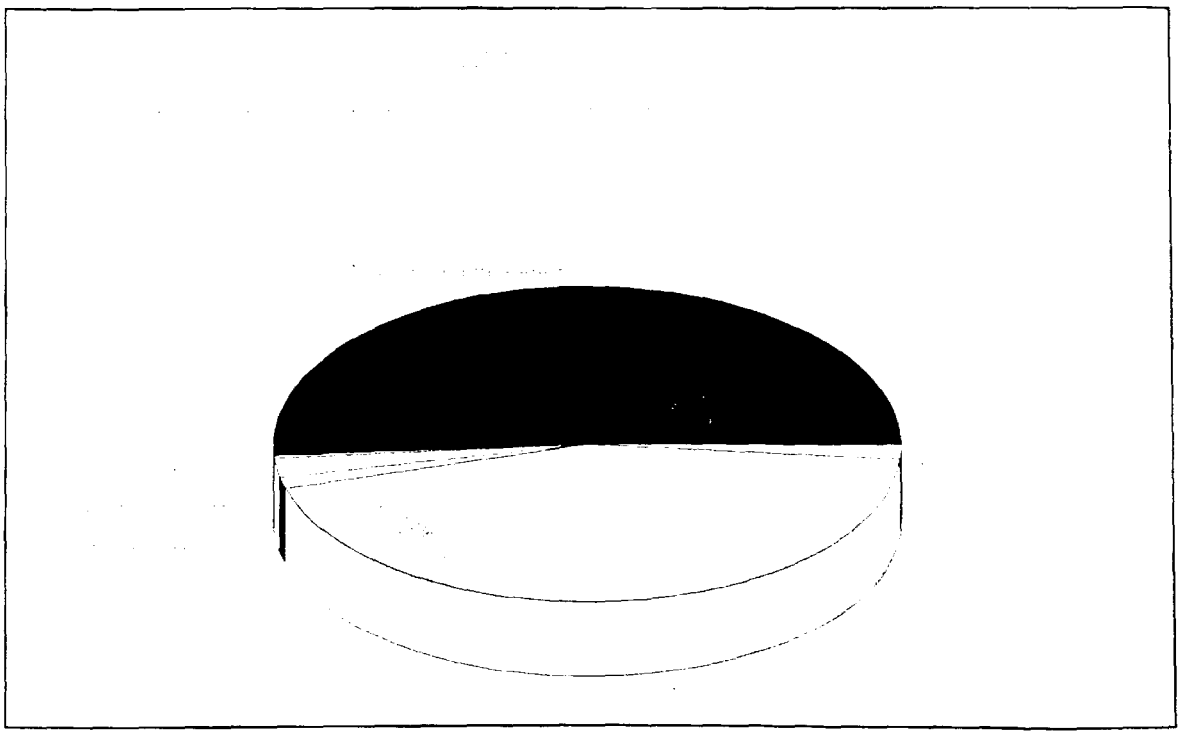

Figure 4 - Distribution of hard rock producers on all Federal lands.

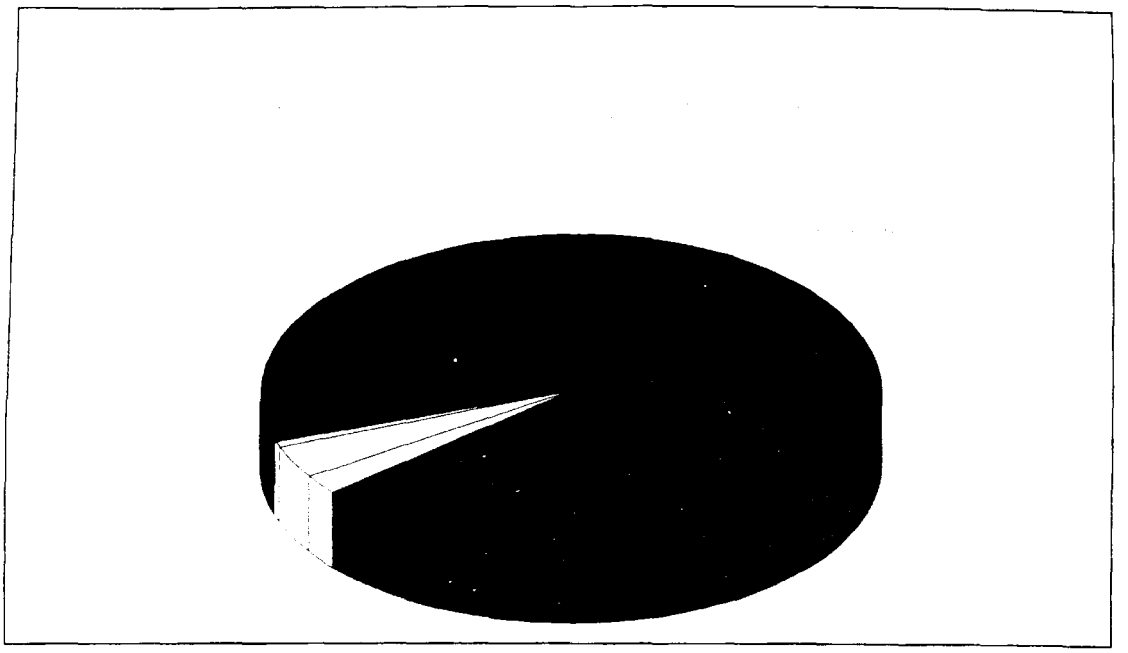

Figure 5 - Distribution of hard rock producers on Interior lands.

PROXIMITY OF MINING SITES TO RIVERS AND STREAMS

A GIS river and stream data set (1:2,000,000) was combined with the reduced set of 15,300 hard rock producers. Buffers were established around each river and stream. In this manner the number of sites which are found a given distance from a river and stream can be identified. Four buffering radii of 1-, 2-, 3-, and 4-miles were selected.

The results of this analysis indicates that of the 15,300 producer sites on Federal land, 18 percent are within a mile of a river or stream and 62 percent are within four miles (Figure 6). This is a first step in helping land managers better, and more cost-effectively, target sites which pose the most immediate threat to contamination of surface waters.

SENSITIVITY ANALYSIS—THE EFFECTS OF HIGHER RESOLUTION LAND OWNERSHIP MAPS

When using GIS data and technology in an analysis of this type, the resolution of the data is a critical concern. When this analysis was performed, the only complete national Federal land coverage available was at the 1:2,000,000 resolution, or 31.6 miles per inch. This resolution is not adequate to identify privately-held mining claims, with approximate dimensions of 1,500 by 600 feet, which lie within the land boundaries of Federal land management units. To approximate the detail of these "inholdings" a resolution of at least 1:100,000 is needed. This resolution approximately corresponds to a map scale of one inch equals 1.6 miles.

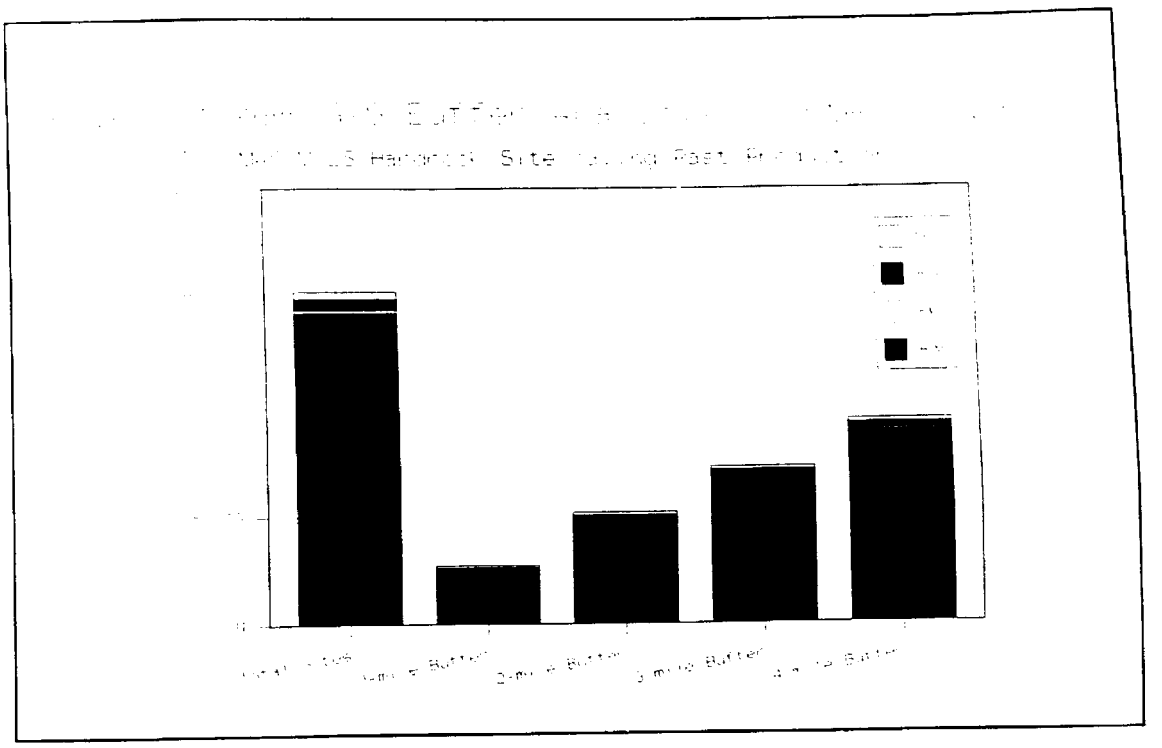

Figure 6 - Distribution of IAM sites within mile buffers of Rivers/Streams.

Figure 7, shows the difference in map resolutions. The land ownership is at a resolution of 1:100,000. It clearly shows private property within the boundaries of both BLM lands and the US Forest Service lands. By contrast, the bold dotted-line indicates the 1:2,000,000 resolution. It is obvious from this comparison that the number of sites identified on Federal lands is significantly dependent on the resolution of the digitized map. The small "x's" indicate the location of MAS/MILS sites.

Some states have digitized maps for land ownership at the 1:100,000 resolution, or 1.6 miles per inch. At the time of this analysis, Colorado, Idaho, Nevada, Utah, and Wyoming had complete digitized 1:100,000 coverage. Other states had only partial coverage at this resolution. To address the inherent concern of the sensitivity of our results to the level of digitized map resolution, a comparison of our analysis for these five states was made.

The results of the 5-state comparison is shown in Figure 8. A total of over 15,000 MAS/MILS hard rock sites with evidence of past mineral production were identified within the 5-state study. At the 1:2,000,000 resolution, over 14,000 sites were located on Federal lands. Using the same criteria at the 1:100,000 GIS resolution, 40 percent of these sites were actually located on privately owned lands, i.e., the greater detail found in the 1:100,000 resolution map reduces the number of sites on Federal lands to about 8,400.

By extrapolating the results from the five-state comparison to the rest of the nation, the estimated hard rock producers on Interior lands would be reduced to approximately 9,000 sites. It should be recognized that while the other 6,000 or so sites may not be on Interior lands, they may well have negative environmental impacts on resources managed by Interior or for which it is a trustee.

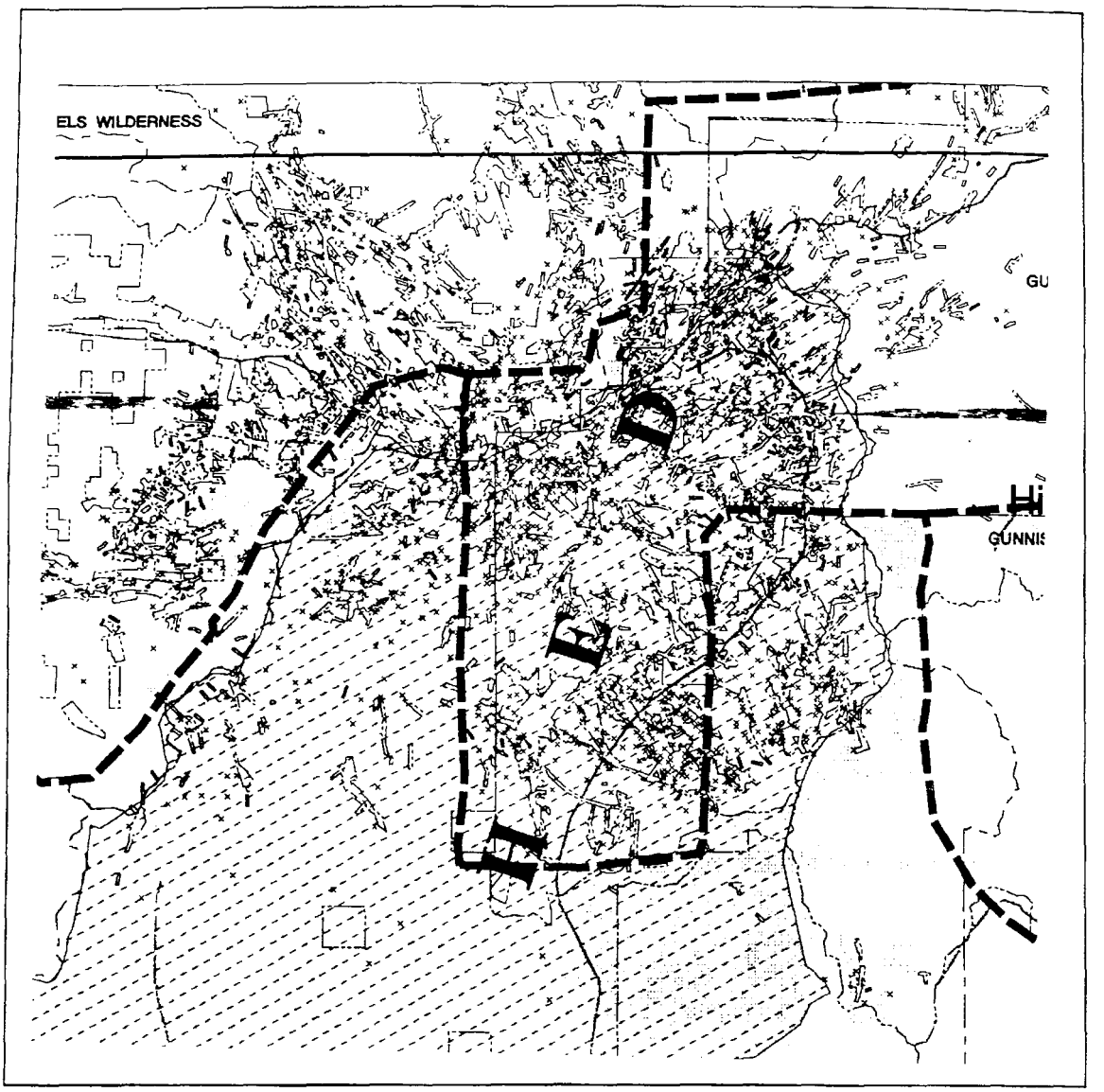

Figure 7 - Map of the Upper Animas watershed, Colorado showing differences in GIS resolution.

CORONADO NATIONAL FOREST—A CASE STUDY

Although the MAS/MILS data base is the most comprehensive set of mineral site information currently available, experience has shown that it does not contain all the mineral locations in the Nation. Over the past several years, the USBM, in partnership with the USFS, investigated the mineral potential and the impacts of past mining in the Coronado National Forest (CNF) of southeastern Arizona. Field engineers from the Intermountain Field Operations Center (IFOC) located in Denver, Colorado performed a field assessment of mineral sites in the CNF.

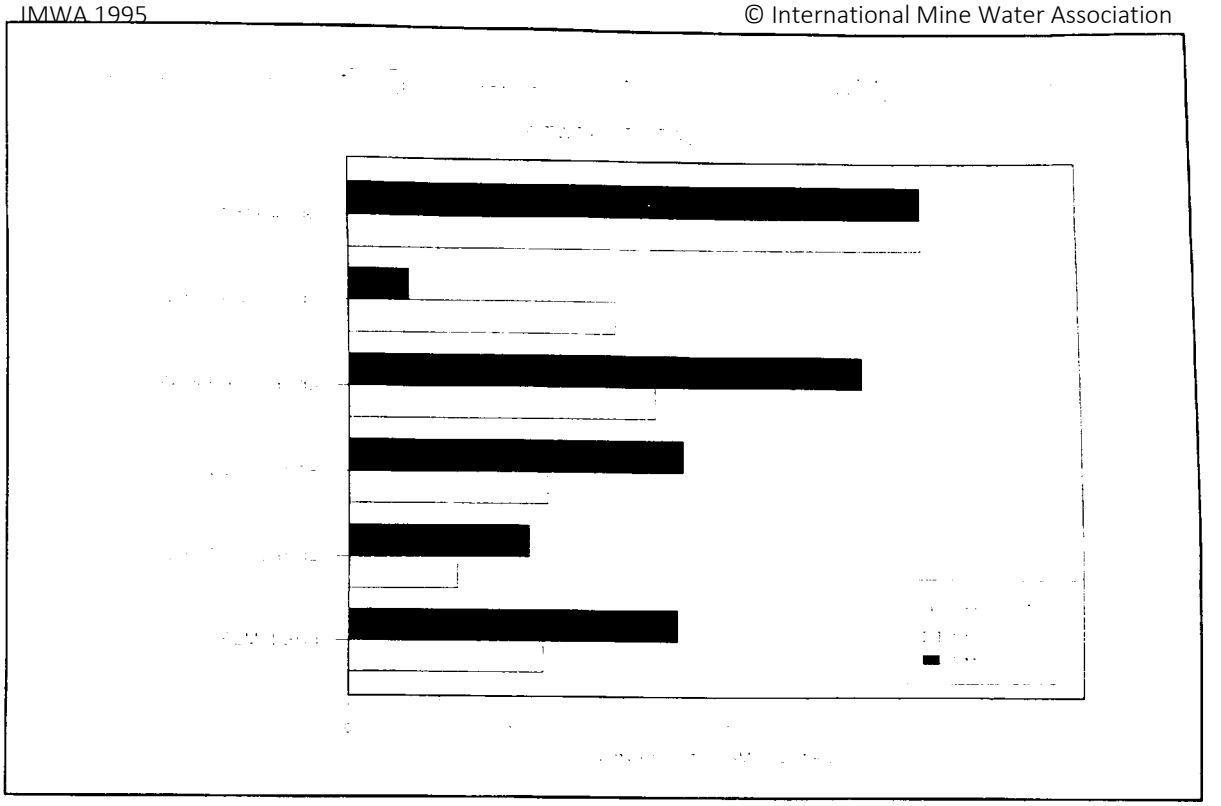

Figure 8 - Comparing the effect of different GIS map resolutions in identifying inactive mines on Federal lands.

In the course of conducting the mineral assessment and the subsequent IAM inventory, IFOC engineers identified 1,136 mineral sites in CNF. This field investigation identified nearly 56 percent more sites than were found in the MAS/MILS data base. Assuming that the experience in the CNF is representative of the rest of the nation, the number of sites on Interior lands can be estimated. Combining this with the results of the sensitivity analysis on higher resolution land ownership maps would raise the estimate of hard rock producers on Interior lands from 9,000 to 14,000.

The USBM defines a site as a logical mining unit which may contain several physical features such as mine adits or tunnels, open shafts and prospect pits, structures, and equipment. As shown in Figure 9, over 3,500 mining features were found to be associated with the 1,136 mineral sites located in the CNF, some of which represent public safety hazards. This finding hints at one explanation for the wide difference in the estimated numbers of IAM sites between agencies may simply be that it is due to variations in the definition of what constitutes a mining unit. Some Agencies count individual features as mining sites resulting in an larger number of IAM sites. From this and other studies, the USBM estimates that on average there are 3 to 4 features associated with each site. Many of these features pose safety hazards to both humans and animals. On the positive side, mine openings also produce a favorite habitat for wildlife, particularly bats.

To further refine the 1,136 mine sites to focus only on those most likely to cause public and environmental health hazards, the USBM *Abandoned Mine Land Inventory and Hazards Evaluation Handbook* was used to provide a logical screening of sites. This handbook ranks hazards according to a system which assigns numerical values to attributes of the site and the conditions observed there. These attributes and conditions include commodity, current status, size of operation, milling

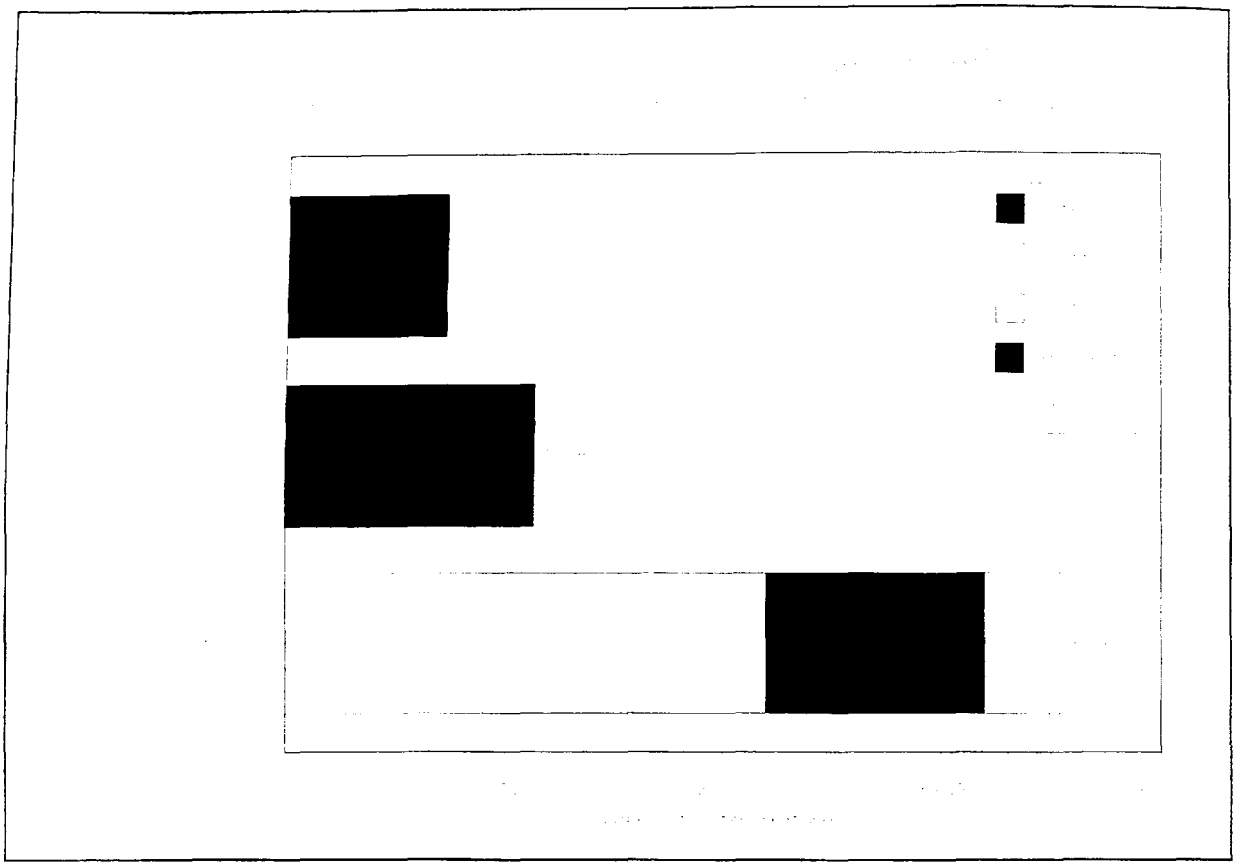

Figure 9 - Site investigations of the Coronado National Forest, Arizona.

method, property type, and acid generating potential. Aggregated values were then analyzed to identify those sites which have the greatest potential for environmental hazards and, therefore, warrant additional field work.

As a result of this hazards rating, of the 1,136 site, 160 sites were identified as requiring additional field examination (see Figure 10). In the spring of 1994, field engineers visited the 160 sites to gather additional information on the environmental hazard potential. The results of these field examinations indicated that 19 sites showed enough problems to be considered candidates for detailed site-characterizations, less than 2% of the entire population of mining sites within the CNF. The USBM and the USFS are currently examining these 19 sites to see if they indeed warrant Preliminary Assessments and Site Investigations (PA/SI) using protocols established by the Environmental Protection Agency. It is unlikely that all will require a PA/SI.

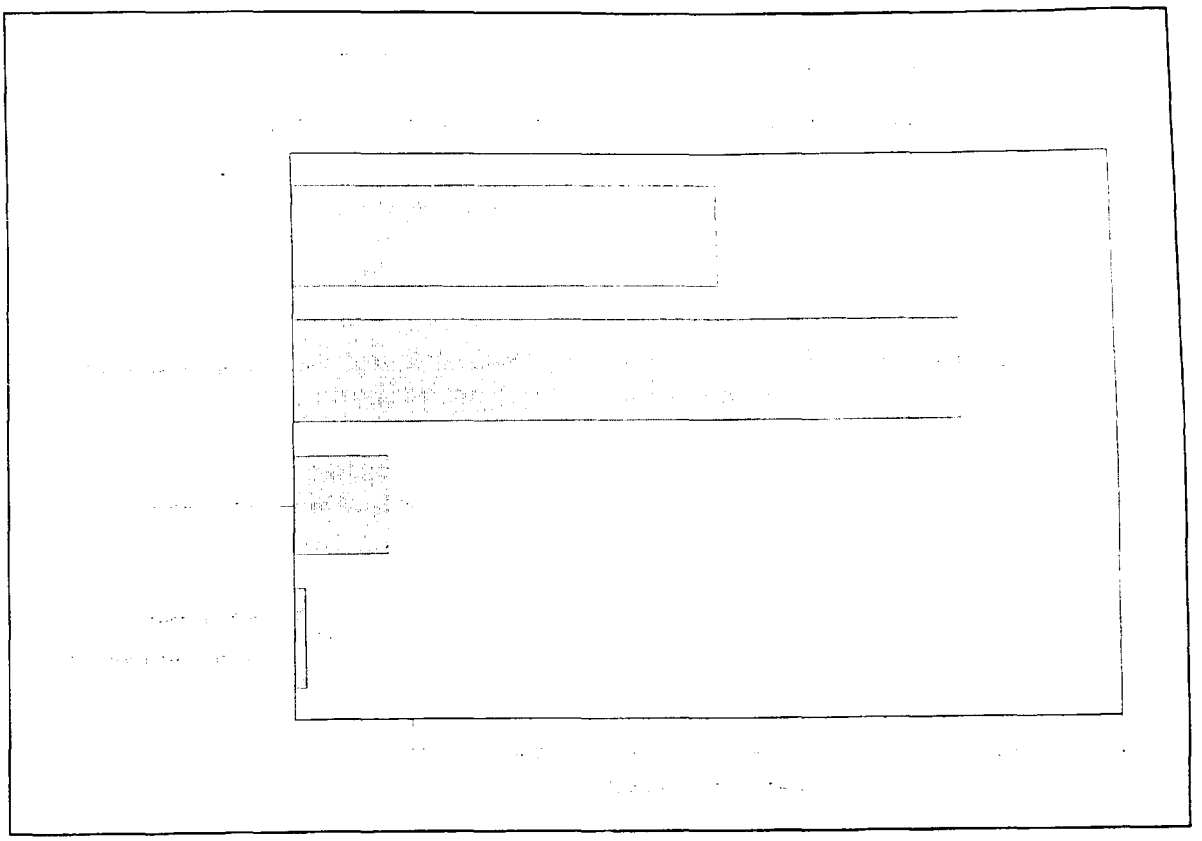

Figure 10 - USBM's environmental screening of mining sites within the CNF.

ESTIMATING THE NUMBER OF POTENTIAL SITE CHARACTERIZATIONS

Using information from the case study and the results of the sensitivity analysis using the higher resolution land ownership maps, we can make crude estimates of the number of sites on Interior lands that could potentially be candidates for site characterization.

Assuming that the number of hardrock producers and non-producers on Interior lands are in the same proportion as those on Federal lands, we estimate that there are 37,200 hard rock sites (producers and non-producers) on Interior lands. Next, reducing the number of sites on Interior lands by 40% to correct for higher resolution (1:100,000) land boundary data would reduce the number of sites to 22,300 hard rock sites on Interior lands. Using the 1.56 factor developed in the CNF study to correct for sites not in the MAS/MILS data base, this number would be increased to 34,800. Finally, assuming the results of the CNF study are nationally representative (i.e. less than 2 percent of the sites have a high potential for environmental hazards), we estimate that about 700 sites are potential candidates for site characterization on Interior lands.

An alternate estimate was developed using a different set of assumptions. First, correcting for the overestimation due to the low resolution map (1:2,000,000) and the underestimation due to missing data, we estimate about 14,000 hard rock producer sites exist on Interior lands. Let us assume that the 14,000 hard rock producers are analogous to the 160 sites identified for field

examination in the CNF study. Of the latter, 19 (or about 12%) were identified as having a high potential for environmental hazards. Using this, we estimate that about 1,700 sites are potential candidates for site characterization.

Based upon the above sets of estimates, between 700 and 1,700 Interior IAML sites may require site characterization.

ESTIMATING THE COST OF SITE CHARACTERIZATION

The cost of obtaining information on a site varies, depending on the size and complexity of the site. Costs associated with the sequence of inventory activities such as literature searches, field verification and preliminary sampling for all IAM producing sites on Interior lands could be between $100 million and $200 million. Clearly, a targeted approach identifying areas where we should focus our efforts is necessary.

For the CNF study, literature searches cost about $40 per site and field verification, about $500 per site. Based on that, similar levels of effort for identifying hard rock producers on Interior lands and locating sites missing from MAS/MILS could cost in the range of $10 million to $20 million. However, it should be noted that the CNF exercise was geographically well-bounded and based in part on prior mineral land assessment work. A similar nationwide effort could cost substantially more. Thus, a prioritization scheme would be cost-effective even for these preliminary data gathering exercises.

The USBM experience suggests that site characterization, at a level consistent with EPA guidelines, would average about $500,000/site. For the 700 to 1,700 potential candidates, this projects a cost of between $350 million and $850 million. The cost of remediation which, per site, could easily cost an order of magnitude or more than characterization, will be above and beyond that. There is currently no budget allocated for site characterizations or remediation for IAM sites on Federal lands.

ESTIMATING THE COST OF ADDRESSING PUBLIC SAFETY HAZARDS

While the focus of this study has been on environmental contaminants, we can use the above estimates of 34,800 for the number of producer and non-producer hard rock mine sites on Interior lands to also estimate the number of IAM-related public safety hazards on Interior lands and costs associated with reducing these hazards.

The CNF study indicated that there are three to four safety hazards for each mine site, i.e., there may be between 104,400 and 139,200 hazards on Interior lands. Based upon the experience of the National Park Service (NPS), we can assume as an upper bound that about 50% of these may require some action. If each such action costs an average of $10,000, then the total cost may be between $520 million and $700 million. However, it is possible that the NPS estimate of 50% is high for the majority of non-NPS Interior lands because the latter are less likely to attract visitors. Assuming, arbitrarily as a lower bound, that 25% require some remediation, we estimate the lower bound to

be $260 million rather than $520 million. Thus, fixing public safety hazards may cost between $260 million and $700 million.

FUTURE ACTIVITIES

Building on this initial effort in merging the MAS/MILS site specific minerals information on land status and proximity to rivers/streams, the USBM will continue its analysis by performing GIS intersections with additional spatial data sets. This will be done at two geographical levels. The first, will be the completion of the national level study using information on precipitation/evaporation, and proximity to human populations and threatened and endangered species habitats, as outlined in the Study Approach. Results from these screens will be used to further identify locations and areas where land managers should concentrate their efforts and investigations. Results of this analysis may be restricted by the accuracy of the digital resolution of the information at the national level.

The second level will test the national level methodology for a state. Colorado has digitized information at the 1:100,000 resolution for many of the screens which are being examined at the national level. Land ownership boundaries, geology, population, precipitation/evaporation, hydrology and other data will be merged with site specific minerals information from the MAS/MILS. Results should help regional land managers determine priorities for focusing their scarce resources assigned to deal with contaminant-related public health and environmental risks at inactive and abandoned mines sites.

CONCLUSIONS

Although estimates of inactive and abandoned mines range in excess of 500,000 on Federal lands, the results of this study indicate the number that represent an environmental concern is in the 30,000 site range. One explanation for this difference may simply be a definitional one. The USBM defines a mining site as a logical mining unit which may contain several mine entries, structures, and equipment (i.e. features). On average, for each site there may be 3 to 4 features associated with that site. Many of these features pose safety hazards to both humans and animals. More importantly, recognition that not all mining activities (claims) resulted in significant earth moving disturbance of land may account for the majority of the differences in site estimates.

To successfully and cost effectively resolve the IAM liability issue on Department of the Interior lands, a prioritization process based upon the likelihood and magnitude of potential public and environmental health risks is needed. This process will help identify locations and areas upon which Interior agencies should focus upon. A valuable approach to doing this is to use existing data bases and GIS technology. The USBM's MAS/MILS data base is an excellent starting point for such a prioritization process. Combining this data with GIS digitized data on land status, human populations, river and streams, precipitation and evaporation, etc. provides a useful screening methodology for prioritization.

A significant consideration when performing GIS analysis is identifying the appropriate map resolution. By going from the currently available 1:2,000,000 nationally digitized base for land

ownership to 1:100,000 for several states, the number of sites on Interior lands was reduced by 40%. The CNF study and field verification indicates that about two-third of the sites are included within MAS/MILS data base. The CNF study also suggests that, using the USBM's screening methodology, only about 2 percent of the total number of sites may require detailed site characterization because of their potential foe environmental hazards, represent.

We estimate that there are about 14,000 hard rock producers and about 21,000 non-producers on Interior lands. Associated with these sites are between 104,000 and 140,000 features which could cause public safety problems. Preliminary inventories and field verification of all IAM sites could cost between $10 million and $20 million. Between 700 and 1,700 site characterizations may be needed for environmental contaminants at a potential cost of between $350 million and $850 million. Moreover, between 26,000 and 70,000 public safety hazards may need to be fixed at a cost of between $260 million and $700 million. Prioritization schemes would help reduce these costs substantially and increase the cost-effectiveness of these efforts.

Additional digital data on population density, precipitation, and endangered species habitat are being gathered for inclusion for future national analysis. Subsequently, we plan to test the methodology for a specific state to see whether it provides the Department with a realistic approach to dealing with IAML issue.

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