0014

March 13, 1992
250 S. Rock Blvd., Ste. 130
Reno, Nevada 89502

Ms. Susan White, Biologist
Utah Department of Natural Resources
Division of Oil, Gas, & Minerals
3 Triad Center, Ste. 350
355 West North Temple
Salt Lake City, Utah 84180-1203

Dear Ms. White:

Attached please find the proposed Erosion Control Plan for the J.B. King Mine site (a.k.a., the Dog Valley Coal Mine) of Western States Minerals Corporation, Permit ACT/015/002, located in Emery County, Utah.

This Erosion Control Plan is in response to Utah Notices of Violation No's. N91-35-6-1, N91-35-7-1, N91-32-6-1, Stipulation Response R614-301-742.113, and the Informal Appeal Conference of 11 February, 1992, between UDOGM and WSMC. As requested by Dr. Dianne Nielson, Director, this plan is a written version of the proposals presented in conceptual form at the Informal Appeal Conference, and it is understood that the actual physical and mechanical means of implementing these concepts in the Final Erosion Control Plan will be discussed and decided in concert with UDOGM personnel.

Western States Minerals Corporation believes that the current reclamation situation at J.B. King is unworkable and untenable for both WSMC and UDOGM. Further, WSMC is convinced that the negotiation of a workable erosion control scheme as proposed in this report is crucial to attaining the correct and necessary reclamation at the J.B. King site. Finally, WSMC appreciates the responsiveness of UDOGM personnel in addressing these issues.

I will be contacting you shortly to arrange the necessary meetings once you have had time to review the document. Please call me if you have questions or need further information.

Sincerely,

Dwight J. Crossland

cc.: E. Gerick
S. Bamberg
D. Dragoo, Esq.

EROSION CONTROL PLAN
J.B. KING MINE
EMERY COUNTY, UTAH

FOR COMPLIANCE WITH UTAH
STATE DIVISION OF OIL, GAS AND MINING REQUIREMENTS

Submitted by
WESTERN STATES MINERALS CORPORATION
290 S. Rock Blvd.
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MARCH 1992

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This report written and produced by:

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1.0 INTRODUCTION

This erosion control plan has been prepared in response to a need to reassess the erosion problems and control experienced at the Western States Minerals Corporation's (WSMC) J.B. King Mine since the start of reclamation activities in 1985. There were three recent Notices of Violation (NOVs) issued by the Utah Division of Oil, Gas, and Mining (UDOGM) in the Fall of 1991 that cited failure to minimize erosion and properly construct ditches, and required an erosion control plan and reconstruction of the ditches. These types of problems have occurred repeatedly in the past, and WSMC has instituted corrective measure and rebuilt and installed control structures. These measures and reconstruction have, in general, been unsuccessful resulting in a perpetuation of numerous NOVs as discussed in the next section. There was an Informal Hearing held on February 11, 1992, to review and assess the recent NOVs concerning erosion and drainage control structures; and to discuss the concepts that could be initiated to prevent future problems and achieve final sign off on reclamation in the shortest possible time.

The purpose of this erosion control plan is to present conceptual proposals for future actions as discussed at the Informal Hearing. This erosion control plan will present information on the general regional and specific site factors of the climatic and geomorphologic processes that affect erosion and sedimentation rates. This information is based on published literature, and an annotated bibliography is provided with this plan. This discussion of processes will be followed by a presentation of how these relate to erosion processes and rates on the reclaimed site, and to the current problems with complying with stipulations. Based on these discussions, a number of erosion control measures are proposed in a conceptual form for review and modification as needed for implementing these measures.

2.0 REVIEW OF EROSION CONTROL AND PROBLEMS

This section will first discuss the history of erosional problems on the site from a regulatory standpoint. We will review the relevant Act and Regulations from UDOGM, the current permit design, criteria for erosion and sediment control, and stipulations. An assessment of the value of land versus the previous cost and control measures used is presented to evaluate the effectiveness of past efforts. A statement of the objectives of the reclamation, revegetation and erosion control plans for the J.B. King Mine is provided. Finally, the need for the suggested actions for erosion and sediment control is summarized.

2.1 History of Notices Of Violations

Notices Of Violation (NOVs) for erosion have been issued at the J.B. King Mine site on a regular basis in spite of repeated efforts to control rills and washing on site with feeder ditches and silt fences. In 1988 through 1989, a number of NOVs and Inspection Reports were conducted by the Utah Division of Oil, Gas, and Mining (UDOGM) on the J.B. King Mine site. The main issues were cattle disruption of revegetation efforts and erosion. A brief history of the NOVs and Inspection Reports as they relate to erosional problems for 1988 through 1989 is given below as an example of problems in one reclamation period:

INSPECTION REPORT - UDOGM 6/21/88 Main channel and feeder ditch completed, silt fences erected. Cattle grazing had taken place in spring and was adversely impacting revegetation success.

MEMORANDUM - UDOGM 7/5/88 Recommendations for revegetating recent disturbance caused by channel repair.

INSPECTION REPORT - UDOGM 3/7/89 Need to repair cattle impact on fences, settling along subsidence cracks.

INSPECTION REPORT - UDOGM 7/6/88 Stream channel repaired but minor erosion and washout evident in two locations. Silt fences functional but top fence/dam needs bank repair and silt fence #2 blown out. Bare areas from equipment operation in need of revegetation.

INSPECTION REPORT - UDOGM 9/29/88 Northeastern pond embankment needs attention. Top slope of reclaimed refuse pile questioned as to meeting requirements (by Mr. Orell who issued a TDN). Revegetation poor due to dry, hot weather.

LETTER - WATER, WASTE & LAND, INC. 10/19/88 Summary of reclamation items for discussion and recommendations by Dr. Bamberg and Mr. Strachan. Major reclamation issues include cracks in area above underground workings and gullies on topsoil stockpile.

LETTER - UDOGM 10/19/88 Division response to request for Ten-Day-Notice (Failure to cover portion of coal waste with best available material and revegetate) by Office of Surface Mining Reclamation & Enforcement. TDN is not valid because of permit approval.

INSPECTION REPORT - UDOGM 10/24/88 No new problems notices, however previous statements of repair for silt fences and revegetation still need addressing.

NOTICE OF VIOLATION - UDOGM 9/9/88 Failure to minimize erosion to the extent possible and failure to restore subsidence effected surface lands in accordance with the approved mining plan.

INSPECTION REPORT - UDOGM 11/7/88 Erosion control needed at several locations, silt fence repair or support to be done and re-establishment of contour furrow recommended. Reseeding of disturbed areas needed after site work done.

INSPECTION REPORT - UDOGM 12/5/88 All areas of previous concern have been taken care of, revegetation only remaining concern due to an increase in rabbit population.

INSPECTION REPORT - UDOGM 1/4/89 Cattle present on site, significant impact on entire reclamation area from grazing and trampling.

NOTICE OF VIOLATION - UDOGM 1/5/89 Failure to maintain necessary fences and proper management practices.

INSPECTION REPORT - UDOGM 2/1/89 Follow-up to NOV N89-32-1-1. Fences repaired but berms of contour ditches trampled by cattle will need repair.

LETTER - UDOGM 3/1/89 Sets up assessment conference in Salt Lake City on March 27, 1989.

INSPECTION NOTICE - UDOGM 3/5/89 Reports fence is intact and no cattle are present: requests repair of previous cattle impacts to silt fences, berms and contours.

On March 17, 1989 an informal conference was held and proposed actions were presented and accepted. This included Western States Mineral Corporation (WSMC) obtaining grazing rights to the site to exclude cattle, rerouting a local road off-site, and implementing a regular maintenance program with a local contractor to control erosional problems. Erosional control included additional silt fences and immediate response to new rill development with riprap and straw. These actions were carried out.

The main feeder ditch has been repeatedly damaged by severe summer thunderstorms. The ditch was built in 1985 and has required major repair due to severe thunderstorms in 1987 and 1989. When the resulting runoff from thunderstorms events during the months of July, August, and September 1991 again caused extensive damage to the main feeder ditch and the other erosional control systems at the mine site, WSMC wished to convene the UDOGM Informal Appeal process. They were misinformed that they must accept a written NOV to trigger the process. Three NOVs were issued:

NOTICE OF VIOLATION No. N91-35-6-1 UDOGM 11/07/91 Failure to comply with the terms and conditions of the permit. Failure to completely address and satisfy the requirements of stipulation R614-301-742.113 (TM) in a timely manner.

NOTICE OF VIOLATION No. N91-35-7-1 UDOGM 11/07/91 Failure to minimize erosion to the extent possible. Failure to minimize erosion off the refuse pile.

NOTICE OF VIOLATION No. N91-32-6-1 UDOGM 12/16/91 Failure to comply with the terms and conditions of the approved permit. Failure to implement and construct the main feeder ditch and the feeder ditch in accordance with the design criteria specified in the permit. This was issued after the Informal Appeal process was requested.

The Informal Hearing was held on February 11, 1992. This Erosion Control Plan is in response to the Hearing and presents the problems associated with erosion in the region of the reclaimed mine site and proposes modification of erosional control features and procedures as presented in the next section.

2.2 Review of Act, Regulations, Permit Design, Criteria, and Stipulations

The NOVs were issued for violation of UDOGM regulations R614-301-742.113 and R614-300-143.

2.2.1 Standards and Criteria for Erosion and Sedimentation

The current regulations have been interpreted by UDOGM to WSMC to mean no visible erosion, no off site sedimentation, no visible coal wastes, control erosion to the maximum extent possible, and construction of ditches to permit design specification.

2.2.2 Regulatory Requirements of R614

Controversy over the long-term plan for erosional control centers on the interpretation of the following four Utah R614 Coal Rules:

R614-301-357.100 "The period of extended responsibility for successful vegetation will begin after the last year of augmented seeding, fertilization, irrigation, or other work, excluding husbandry practices that are approved by the Division in accordance with paragraph R614-301-357.300."

R614-301-357.300 "The Division may approve selective husbandry practices, excluding augmented seeding, fertilization, or irrigation, without extending the period of responsibility for revegetation success and bond liability, if such practices can be expected to continue as part of the postmining land use or if discontinuance of the practices after the liability period expires will not reduce the probability of permanent revegetation success. Approved practices will be normal conservation practices within the region for unmined lands having land uses similar to the approved postmining land use of the disturbed area, including such practices as disease, pest, and vermin control; and any pruning, reseeding and/or transplanting specifically necessitated by such actions."

R614-301-742.113 "Minimize erosion to the extent possible."

R614-300-143 "The permittee will comply with the terms and conditions of the permit, all applicable performance standards and requirements of the State Program."

Also germane to this discussion are three definitions from Utah R614-100-200:

"**Land Use** means specific uses or management-related activities, rather than the vegetation or cover of the land. Land uses may be identified in combination when joint or seasonal uses occur and may include land used for support facilities that are an integral part of the use. Changes of land use from one of the following categories to another will be considered as a change to an alternative land use which is subject to approval by the Division."

"**Fish and Wildlife Habitat** - Land dedicated wholly or partially to the production, protection, or management of species of fish or wildlife."

"**Grazing Land** - Land used for grasslands and forest lands where the indigenous vegetation is actively managed for grazing, browsing, or occasional hay production."

"**Undeveloped Land or No Current Use or Land Management** - Land that is undeveloped or if previously developed, land that has been allowed to return to an undeveloped state or has been allowed to return to forest through natural succession."

"**Reclamation** means those actions taken to restore mined land as required by the R614 Rules to a postmining land use approved by the Division."

"**Previously Mined Area** means land previously mined on which there were no coal mining and reclamation operations subject to the standards of the Federal Act."

Using the above-reference rules and given definitions, the following facts are true in regard to the J.B. King property:

1. The J.B. King Mine is a "Previously Mined Area."
2. The J.B. King Mine "Post-mining Land Use" as well as it's pre-mining land use, is the same as the surrounding area - i.e., "Undeveloped Land or No Current Use or Land Management." Although the United States Department of the Interior, Bureau of Land Management, and the Utah State Land Board have granted grazing leases for this real estate, there is no "active management" of these leases. Therefore, the site cannot be classified either as "Fish and Wildlife Habitat," or as "Grazing Land" within the R614 definitions.
3. The J.B. King Mine and surrounding environs lies within climatological and geomorphologic regimes which are characterized by erosional landscapes sculpted by a repetitive drought-thunderstorm climatic cycle.

2.3 Value of Land, Previous Cost and Controls, Effectiveness

The J.B. King Mine site is approximately 30 acres of land categorized under the land use of grazing land and fish and wildlife habitat. WSMC will propose changing this to the Undeveloped Land or No Current Use or Land Management category after bond release, this will be the same as the surrounding area. The surrounding area has open range grazing on it but there is no active management or conservation of resources, the value of the land is estimated at less than $300 per acre.

WSMC has incurred substantial expenditures in the past at the J.B. King site for environmental/reclamation studies and projects, and continues to do so. Annual expenditures are reported in the table below.

J.B. King Mine Annual Reclamation Costs to Western States Minerals

1982	$ 98,625
1983	826,291
1984	679,258
1985	1,781
1986	148,039
1987	171,905
1988	27,934
1989	62,615
1990	15,468
1991 (as of 11/30)	16,631
TOTAL	$2,048,547

WSMC believes that the money currently and historically expended at the J.B. King Mine has not been particularly well spent, owing to the repetitive cycle of continuing repairs to the site's man-made erosion control structures induced by thunderstorm runoff. The total spent on J.B. King by WSMC as of November 30, 1991 was approximately $68,285 per acre.

2.4 Objectives of Reclamation, Revegetation and Erosion Control at This Specific Site

The main objective of the reclamation, revegetation and erosion control plan is to return the J.B. King Mine site to as natural a state as feasible given the history of mining on the site, and the environment of low vegetative cover, local geomorphic processes, and severe summer thunderstorms. To achieve this, it is necessary to restore "normal" local geomorphologic process of erosion by allowing some rilling and gullying and by changing the main and feeder ditches to accommodate the severe rainstorms and subsequent heavy runoff. Paramount to this is the control and minimization of the impacts while the land is under the bond period. Results of this erosion control plan will be monitored to insure the objectives are reached before the end of the bond period.

2.5 Need for Suggested Actions for Erosion/Sediment Control

The regulations and requirements on the J.B. King Mine imposed by UDOGM are impossible to meet for avoidance of NOVs and final bond release given the nature of the environment in Dog Valley Wash in Utah. In order to meet the requirements of no visible erosion, no off site sedimentation, no visible coal wastes, and construction of ditches to design specification, constant monitoring and maintenance of the site is required. The site cannot reach a steady environmental state while under artificial control. The proposed action to allow erosion to occur and to redesign the main and feeder ditches would allow the site to establish natural drainage patterns which would stabilize and eventually no longer require monitoring and maintenance.

The amount of money expended, $2,048,547 over a ten year period, and the issuing of continuous NOVs means current methods of reclamation are ineffective given the interpretation of the present rules and regulations, and the nature of erosion processes on the site and region.

The erosion control plan presented here is designed to control erosion and sedimentation rates to match those of the surrounding environment and to prevent undesirable effects on the downgradient environments. The regional environmental factors that control rates of erosion and sedimentation are fully explained in Section 3.0. Local rates will need to be determined through the monitoring of a local reference site for erosion.

3.0 GENERAL REGIONAL AND SPECIFIC SITE CHARACTERISTICS THAT INFLUENCE AND CONTROL EROSION

In this section, we will discuss the climatic factors and geomorphic processes on and around the J.B. King site related to geology and landform that influence and control rates of erosion and sedimentation from the natural land surfaces. We will further discuss land use and surface modifications that have affected rates of change in these erosion processes. Finally, we will apply these factors and modification both on and off site for estimating rates of erosion and related sedimentation.

3.1 Regional Characteristics

The J.B. King reclaimed site is located in the western Canyonlands section of the Colorado Plateau in central Utah on the western edge of the San Rafael Swell and the eastern edge of High Plateaus section. See Figure 1 for the location of the site in relationship to boundaries. This part of the Colorado Plateau is characterized by many high plateaus that are drained by the Green and Colorado Rivers. On the Colorado Plateau, the distinguishing features are elevated plateaus underlain by near-horizontal bedrock weathered into a stepped landscape with many cliffs and escarpments separated by wide gentle slopes as a result of differential weathering (Morrison 1991). In the Canyonland section, the easily eroded

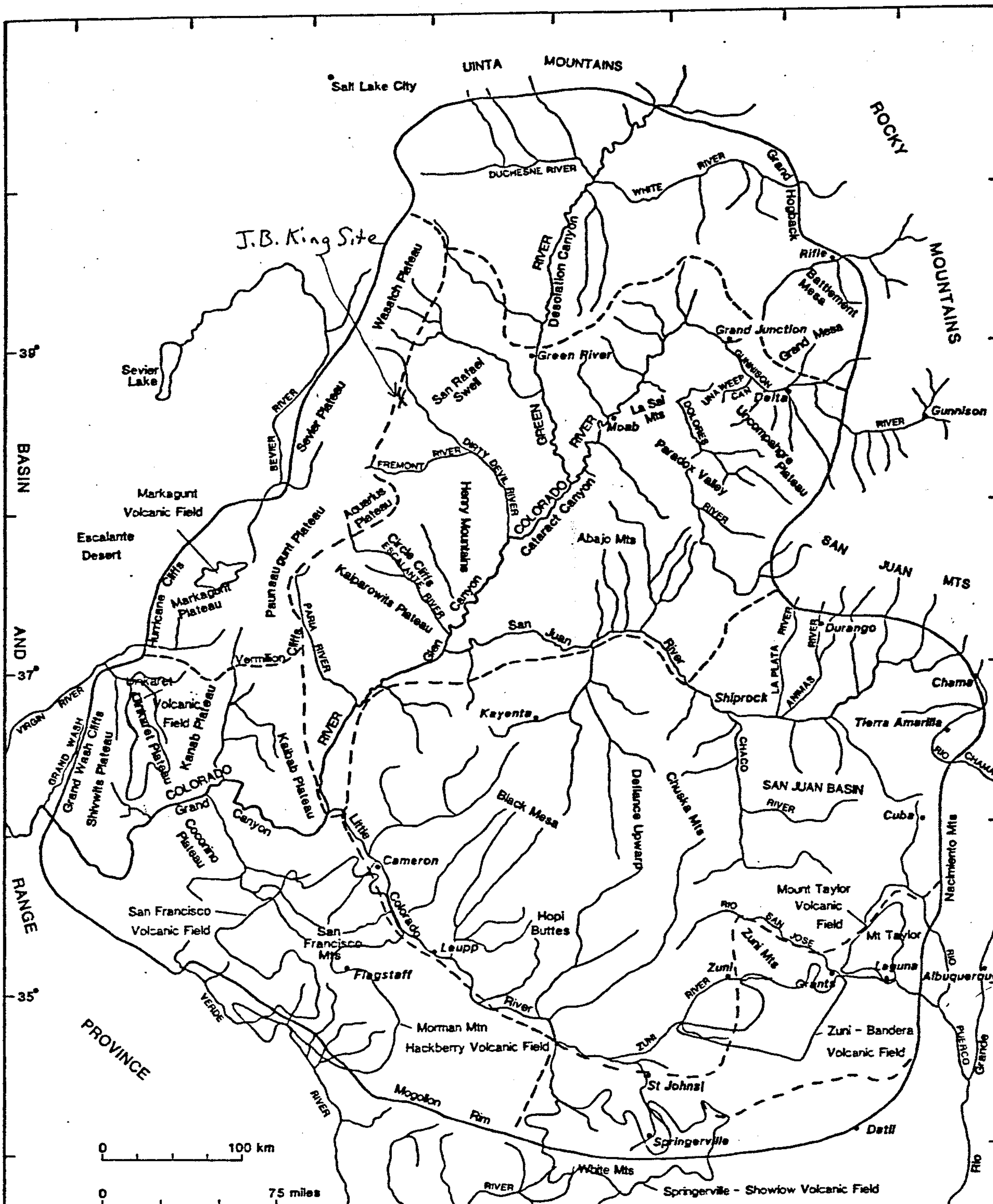

Figure 2. Detailed location map of the Colorado Plateau showing geographic features discussed in this chapter. Volcanic fields, largely Quaternary in age, are outlined in blue.

Figure 1 Detailed location map of the J.B. King Site in Relation to the Colorado Plateau

Cretaceous shales and sandstones are cut into canyons in flat-lying older strata. This area is well known historically from the journals of John Wesley Powell who in the late 1800s had classically documented the great significance of erosion in creating the topography and landforms of this area.

This intermountain region has a continental type climate with warm summers and cold winters and wide contrasts and fluctuations in temperature and moisture (Mabbutt 1977). The climate is semiarid with averages of 6 to 16 inches of annual precipitation and a range of 45 to 55° F average annual temperature in the region. The area is subject to "summer monsoon" type thunderstorms, and winter frontal storms as snow or rain. The region is noted for the intensity of the summer rainfall. Vegetation is upper Sonoran desert in the south, and in the central and northern section is a shrub-grassland at lower elevation grading into pinyon-juniper woodlands on intermediate areas with coniferous forests at higher elevations.

The major geomorphologic processes for landforms are mechanical weathering followed by mass movement by running water (Graf 1987; Biggar and Patten, pp 383-191 in Morrison 1991, Mabbutt 1977). Fluvial processes are active with the physiography of the region formed by a nearly continuous and long erosional history. The other major process is vertical incision of streams by slow, uneven headward erosion along randomly spaced tributaries. Rates of downcutting and headward erosion in fluvial systems are generally rapid and episodic. Entrenched rivers and deep canyons are common due to repeated uplift during the Pleistocene and Holocene epochs with stream incision and headward cutting. Downcutting rates for streams during periods in the last 200,000 years given in Morrison (1991, p 385) average from 45 to 3,400 meters per million years. Much of the sediment produced by mass wasting of landslides and mechanical weathering in source areas has been transported and result in aggradation of downstream valleys (Toy 1977, Graf 1987). Differential weathering of different strata has produced scarps that retreat by rockfall and slab-failure processes (Doehring 1977, Graf 1987, Oberland in Doehring 1977).

Several studies have dealt with recent erosion rates and patterns during the past 150 years (Graf 1987, Morrison 1991). The Quaternary historically has been a period of primarily cyclic erosional processes and, in 1830-80 during the first exploration period, the region had streams that were aggrading and choked with sediment. From 1880 through 1930 a new epicycle of erosional cutting produced modern arroyos that were larger than the paleochannels. "Large floods combined with poor land management may be the cause for severity of this period of arroyo incision as compared to the whole Holocene alluvial

From the desk of
Dianne R. Nielson

Note to file Re 12/31/91 letter: Matter handled informally through Division. Petition not timely Re administrative remedies

CERTIFIED

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MAIL

WESTERN
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CORPORATION

RETURN RECEIPT
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2.29

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record" (Biggar and Patten, in Morrison 1991). A partially stable period with some aggradation by floodplain alluviation occurred from early 1940 through 1980 (Graf, et al 1987, Chapter 8). Since 1980 there has been again an incision of the floodplains and increased erosion. Graf stresses the importance of the flood regimen, and how a succession of large floods results in channel instability and high sediment (increased erosion) yields.

The general regimen of the erosion processes and cycles has been studied on the Colorado Plateau specifically (Doehring 1977, Morrison 1991, Graf 1987) and in arid and semi-arid regions in general (Leopold et al 1964, Mabbutt 1977, Costa and Baker 1981). Other studies have dealt with the fluvial systems developed in semi-arid regions for erosion rates, sediment yields, and the related rill and gully formation (Barfield et al 1981, Melhorn et al 1975, Morisawa 1973, and Schumm 1977). Figure 2 is a generalized diagram of the annual sediment yield as a function of effective precipitation (Schumm 1977). This region of the Colorado Plateau has and effective precipitation of about 10 inches, which has the highest annual sediment yields of around 800 tons per squares mile. These studies stress the importance of erosion process and the denudation of an area subject to widespread erosion and sediment transport. The main temporal actions in the erosion cycle are:

- loosening or detachment of particles by weathering to produce sediment
- water detachment of particle by rain splash, impact or shear
- infiltration followed by runoff
- lateral movement by sheet erosion
- rill (< 8") and gully (> 8") formation
- sediment transport and downslope movement
- deposition in an aggradation zone

The delivery rate is equal to the yield of sediment production divided by the erosion rate. Unconsolidated sediment is subject to detachment and will be transported at the first opportunity.

The fluvial systems in the Colorado Plateau are in the degradation portion of the system particularly in the upper portion of the drainage areas. In the fluvial systems of Schumm (1977) most of the drainage basins are a Zone 1, the sediment production area in which the upstream controls are climate, deformation and land use of a fluvial system. Zone 2 is the transport area, and Zone 3 is the depositional sites. In the Zone 1 conditions are in a dynamic equilibrium with cyclic periods of erosion where geomorphic thresholds are unstable and often exceeded. Land use has altered some of the system

Figure 2 The Regional Topography of the J.B. King Mine Site

variables, particularly grazing of vegetation and some floodplain agriculture have reduced cover, and the hydrology of surface runoff by dams and sediment control structures. The alterations that have been locally significant are the highly disturbed areas such as roads or mining, or the widespread and diffuse uses as is the rangeland grazing by domestic livestock.

There are very few published rates for geomorphic processes of denudation, sediment yield and other parameters for the Colorado Plateau. Some of the rates are:

Denudation - .04"/year, .02"/yr, .6"/yr, .11"/storm, .44"/yr.

Sediment - 800 T/yr/acre, 12.5 T/acre/storm

Downcutting (river incision) - .005 to .02"/yr

Headward cutting - no rates published

These rates were not systematically derived in most of the studies, and were based on analysis of long term trends or indirect measurements or estimates.

3.2. Site Specific Characteristics and Factors Contributing to Erosion.

The J.B. King Mine is a reclaimed underground coal mine site located on the western edge of the San Rafael swell on the southern end of the Coal Cliffs along the eastern edge of the Dog Valley Wash at 6240 to 6375 feet elevation. See Figures 3 and 4 for the regional and site topography derived from USGS maps. The site forms a west and south-facing amphitheater with resistant sandstone cliffs around an eroded alcove formed on Mancos Shale which underlies the sandstone and contains the coal. The reclaimed site has about 30 acres with a covered refuse pile, a main drainage, open flats and slopes, and a barrow area.

3.2.1 Site Characteristics

The area and vicinity of the site has the typical continental climate and receives about 10 inches annual precipitation with intense summer thunderstorms. An intermittent drainage enters the site on the northeast from the sandstone slopes above and exits to the southwest where it joins the Dog Valley wash flowing to the northwest. This is a Zone 1 site where sediment is produced and eroded in a parallel drainage pattern controlled by resistant strata and different erosion rates. The area has fairly high and consistent rates of sediment production due to mechanical weathering of sandstone and dissolution of shale slopes.

The soils and ranges sites on the reclaimed mine and vicinity are in the Travessilla-Gerst badlands type

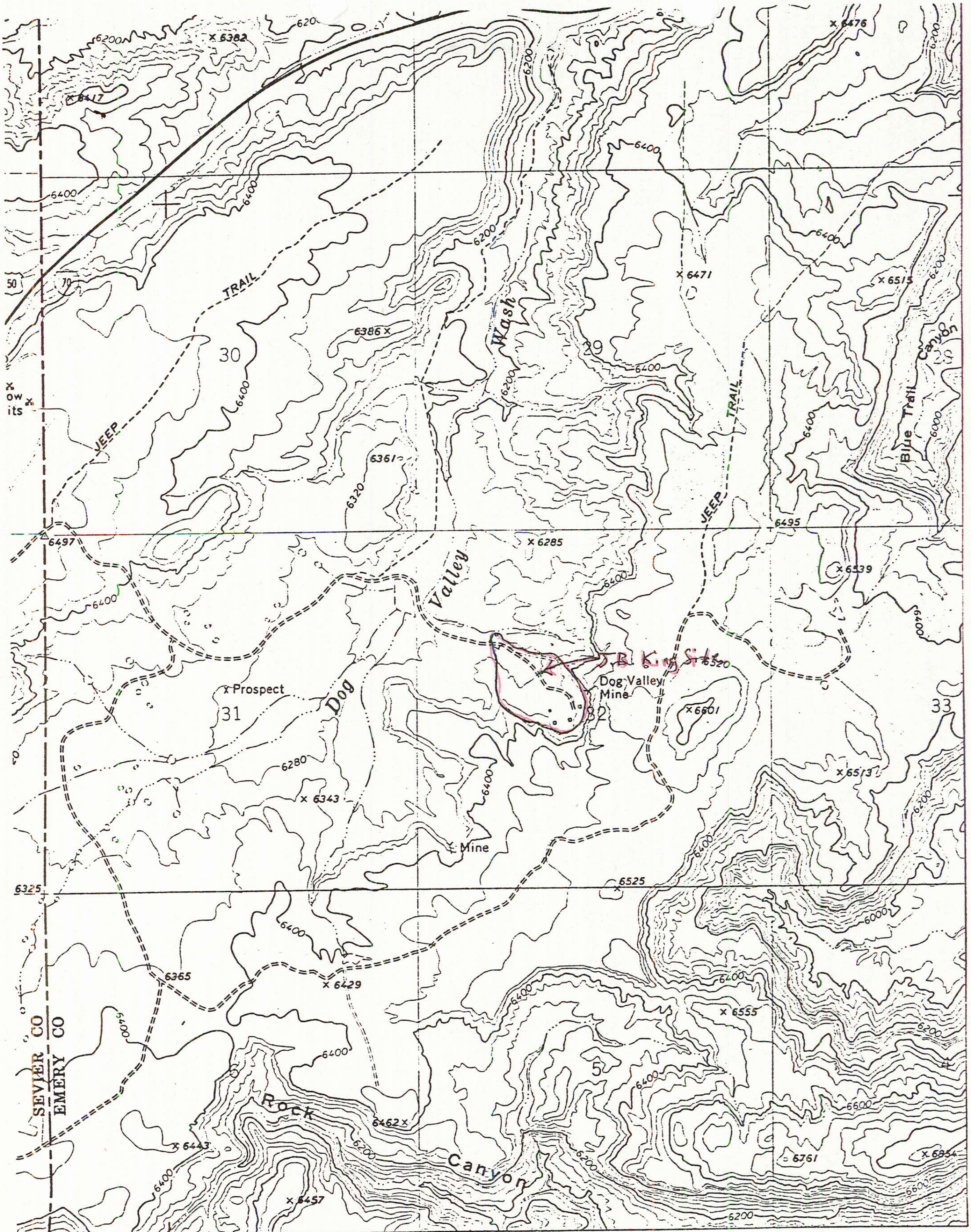


Figure 3 The USGS Topographic Map of the J.B. King Mine Site

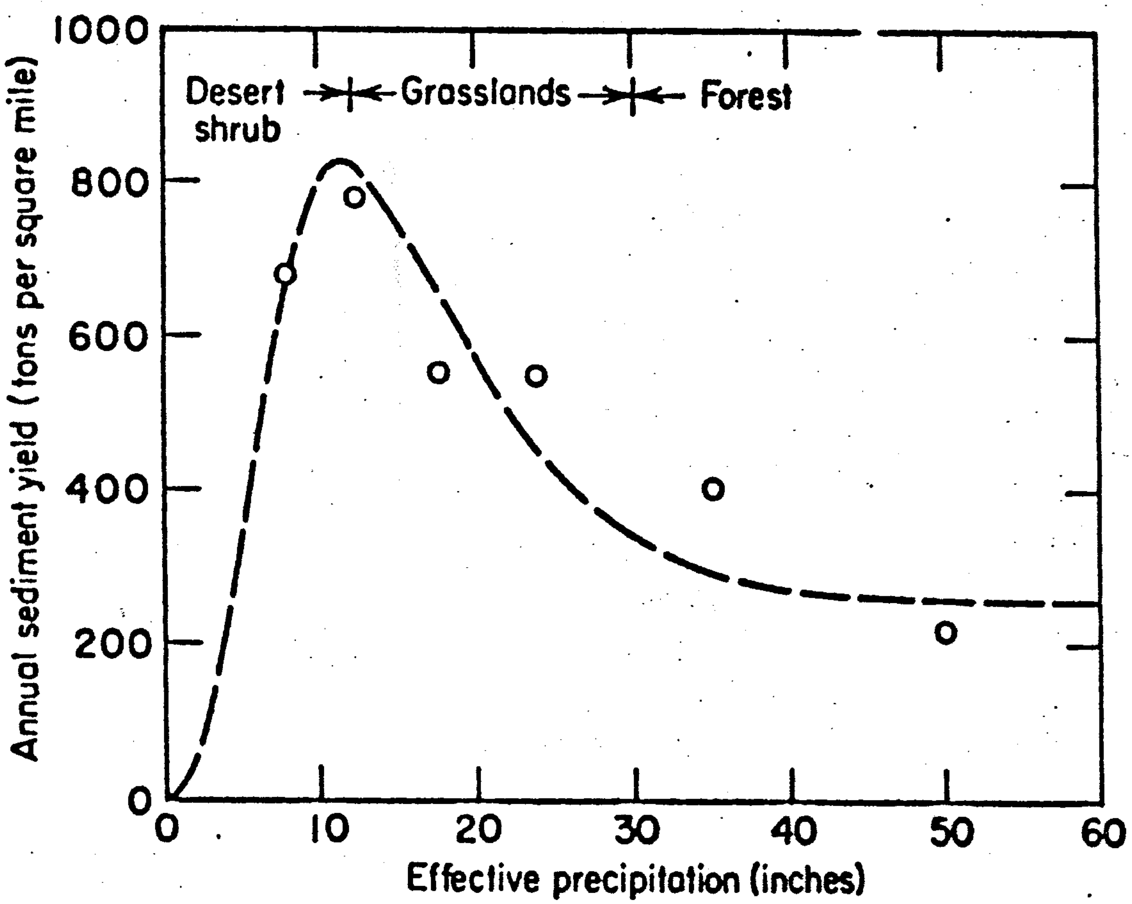


Figure 4 Sediment Yield as a Function of Effective Precipitation (Schumm, 1977)

according to the Soil Conservation Service (pers. comm., Leland Sasser, Soil Scientist, SCS, Price). This is considered a non-soil complex with shallow sandy material over bedrock on the sandstone flats and cliffs, and a clay loam on the Manchos Shale slopes. The erosion and weathering is too rapid for typical soil profiles to develop, and the soil is weathered bedrock materials with low vegetation cover. The alluvial slopes and bottoms below the cliffs and slopes has a variable non-defined colluvial or alluvial soils material with layers of coarse sand mixed with finer loams and clays. Vegetation on the lower flats and slopes is a grama-galleta grass with a larger shrub component on the shaley slopes. This grades into a scattered pinyon-juniper woodland on the sandstone outcrops mixed with shrublands on the sandy flats. Typical plant cover values are 8-10% on the shale slopes, and 18-20% on the colluvial/alluvial slopes and flats.

Numerous exposed coal seams outcrop in this portion of the Plateau in this area call "Coal Cliffs", and are a part of the natural environment. These coal seams vary in thickness but are generally exposed at the base of shale slopes and are easily erodible. Coal material is naturally part of the sediment production, and is transported and deposited in drainage and alluvial materials. Some local plant species are adapted to grow in this material and are common.

The area is grazed by cattle as winter rangeland except for the 30 acre reclaimed site which is fenced to exclude cattle. The grazing has been intense and increased erosion and runoff by reducing the sparse plant cover and loosening and breaking the soil surface by trampling. The last several years have had low rainfall and increased the effects of grazing by further reducing plant cover. The heavy summer thunderstorms produce large runoff that both erodes any loose sediment and increases the depths of rills and gullies. The constructed ditches across the site have received large volumes of water as runoff from the drainage above and outside the site boundaries. The thunderstorms produce splash erosion and sheet erosion on unprotected soil surfaces.

3.2.2 Factors Contributing to Erosion Control Problems on the Site

There are several contributing factors and conditions that have affected and controlled erosion both on and off site. These factors have increased or altered the already high rates of erosion and sedimentation due to natural geomorphologic and climatic conditions.

1. The recent drought has reduced vegetative growth and plant cover on and off the site.
2. Cattle grazing with no management during this drought period on the reclaimed site until 1989

and off site during the entire period has decreased plant cover and loosened soil surfaces.

3. The summer storms have consequently caused increased splash and sheet erosion, runoff, and the volume of water entering the site in the drainage control ditches.

4. The drought was interrupted in 1991 by a series of high intensity thunderstorms on and off the site. The drought increased the effectiveness of these storms to erode and move sediment.

There are other site conditions that have contributed to erosion and erosion control problems.

1. The site is located in a landform configuration with slopes, substrate conditions, and drainage that are naturally not in equilibrium for erosion processes, and mining and reclamation have increase instability.

2. The previous mining and reclamation activities left loose unconsolidated material on the site that is easily eroded and acts as a sediment source.

3. This unconsolidated material (refuse pile, and other flats and slopes) requires a period of time for armoring of loose surface and adjustment of microtopography for drainage into rill and gullies on smooth slopes and flats.

4. This has set up conditions for decreased infiltration and rapid runoff, large volume of flows, increased erosion and sedimentation potential, and formation of rills and gullies during summer thunderstorms.

The consequences of the site conditions for erosion control are the following:

1. Natural conditions and reclamation activities have resulted in instability of the slopes, surfaces and unconsolidated sediment on site. These conditions may not exceed natural conditions in natural surrounding environments.

2. Erosion on the site exceeds the interpretation of the requirements or regulations for erosion features, rill and gully formation, and design criteria.

3. Control of erosion to the stringent requirements of the regulations and permit stipulations and design is impossible or impractical under these conditions.

4. Mechanical control of erosion to the design criteria and stipulations cannot be achieved either in the short term, or during any normal period of liability.

5. Eventual termination, or failure to control or maintain, of mechanical control will cause greatly accelerated erosion and sedimentation. Consequences could be more disastrous than if normal erosion processes and landform adjustment for this region are allowed or promoted.

6. Downgradient effects in Dog Valley Wash may be increased erosion due to lack of sediment load occurring on site during control period on the reclaimed site. This would allow more downgradient erosion because of the artificially high sediment carrying capacity.

Recommendations for future erosion control based on the considerations listed above:

1. Alter erosion control procedures to allow adjustments to approximate natural conditions in the area for erosion and drainage patterns that must eventually be reestablished.
2. Establish the rates of erosion and landform conditions under natural conditions by monitoring on and off site by establishing an erosion reference area.
3. Evaluate the downgradient drainage in the Dog Valley Wash below the site for previous and present conditions and possible effects from sedimentation from the J.B. King site.
4. Reconstruct the upper portions of the drainage through the site for handling flows from off site.

4.0 PROPOSED EROSION CONTROL ACTIONS

The following proposed actions are presented as being applicable to the J.B. King reclaimed site based on site specific factors and the history of the site. All or some of the proposed control actions may be applicable, and the details of these actions will need further development. The following erosion control actions are proposed:

4.1 Set Up Erosion Control Plot as a Reference Area.

The local rates of erosion need to be determined for the J.B. King Mine site, little to no information on erosion rates exist in the literature and extrapolating this information would be inadequate. The erosion control reference plot would be the equivalent of the revegetation monitoring plots and would be set up to statistically sample erosion rates on a reference site located in a geomorphic and landform area similar to the site. This erosion control reference area will located be in the next drainage to the north along the western face of the escarpment in the vicinity of the revegetation reference control areas. Equivalent sample replicable gauges would be installed on the erosion reference area and on the site. The placement and number of measurements would be tested for statistical significance using appropriate procedures.

4.2 Reconstruct the Upper Parts of the Feeder Ditches.

The proposed actions are to reconstruct the upper parts of the feeder ditches and replace them with an excavated plunge pool or other energy dissipator. A conceptual plan with several cross section is provided as Attachment A. A channel armored with boulders and riprap would be constructed from the plunge pool to connect with the present channel, and the capacity and gradient of this channel would be adequate to handle the design flows. This construction would require the use of some heavy equipment. The disturbed surfaces would be kept to a minimum, then these surfaces would be hand seeded and mulched for revegetation.

4.3 Remove the Temporary Silt Control Structures.

The silt fences used to control sediment would be removed, and not replaced. Surfaces on the refuse pile and surrounding slopes would be allowed to develop a natural rill and gully erosion pattern, and develop natural armoring of rocks and competent soil crusts. The surfaces would be monitored for a period of years to follow the natural surface and erosion processes to insure that no hazards develop. Deep gullies in the refuse pile may be fixed, on an as needed basis, if determined to be eroding at an unacceptable rate, or exposing excessive amounts of coal refuse.

4.4 Monitor and Determine Sediment Conditions in Drainages On and Below the Site

Conditions of sediment rate and transport would be monitored in the drainages on the site including the main drainage and settling basin. The lower Dog Valley Wash where the drainage from the site joins the main area wide drainages would be evaluated for sensitive habitats such as wetlands or breeding habitats which may be impacted should sediment from the site reach these drainages. In the Dog Valley Wash, we would evaluate the present condition of soil and erosion surfaces, alluviation, and sediment for content of natural occurring coal or other soil parameters to establish some baseline conditions.

5.0 IMPLEMENTATION AND SCHEDULE

The above proposals for future actions could be implemented by WSMC during the summer and fall of 1992 with the concurrence of UDOGM. Details of the procedures and design would be completed during early summer, and the upper drainage ditches would be reconstructed during the summer followed by reseeding during fall. The erosion reference area and monitoring scheme would be developed and also in place by the fall of 1992.

ANNOTATED BIBLIOGRAPHY

Bibliography of sources of information for landform, geomorphic processes, erosion and sedimentation rates for reclaimed J.B. King Mine, Emery County, Utah. Chapters or papers designated of interest refer to the specific problems and erosional status on the J.B. King Mine.

Barfield, B.J., R.C. Warner, and C.T. Haan. 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press, Stillwater, Oklahoma. 603pp.

This book was written to assist engineers, reclamation specialists, government personnel, etc. in practical application. It contains tables, charts, etc. to help make practical design calculations, gives example problems, and suggestions to incorporate and integrate drainage, erosion, and sediment controls into mining activities. Chapter 5, Soil Erosion and Sediment Yield and Chapter 7, Drainage, Erosion and Sediment Controls provide relevant information and control techniques. The mechanics of water erosion, movement of sediment and amounts of sedimentation are discussed.

Coates, Donald R. and John D. Vitek. 1980. Thresholds in Geomorphology. George Allen & Unwin, Ltd., London. 498pp.

This book is a collection of manuscripts presented at the Ninth Annual Geomorphology Symposium held in Binghamton, New York on October 19-21, 1978 and also several additional papers on geomorphologic thresholds. Papers of interest include Schumm's on page 473 concerning the application of thresholds to the geomorphologic processes and the progression of erosion in high relief situations.

Costa, John E. and Victor R. Baker. 1981. Surficial Geology Building With the Earth. John Wiley & Sons, Ltd., New York. 498pp.

This is a geology textbook with an interdisciplinary approach for geologists and engineers. Chapter 7, Erosion of Surficial Deposits includes erosion processes and controls, sediment yield and sedimentation law.

Doehring, Donald. O. (ed.). 1977. Geomorphology in Arid Regions. Eighth Annual Geomorphology Symposium, Binghamton, New York. 272 pp.

The proceedings volume of the Eighth Annual Geomorphology Symposia Series held at the State University of New York at Binghamton on September 23-24, 1977. Somewhat relevant papers include Ian Campbell's "Sediment Origin and Sediment Load in a Semi-arid Drainage Basin," Steve Wells' "Geomorphic Controls of Alluvial Fan Deposition in the Sonoran Desert, Southwestern Arizona," and Oberlander's paper of sandstone scarps in southeastern Utah. The importance of rock types and structural geology for geomorphic processes and landforms is stressed.

Graf, William L. (ed). 1987. Geomorphic Systems of North America. The Geological Society of America, Inc., Boulder, Colorado. 643pp.

This book is divided into regional areas with an emphasis in the range and types of research development in each region. Chapter 8 covers the Colorado Plateau region for geomorphic processes of landform development, flood regimes, and erosional and depositional states. Other topics are hillslope erosion and

sandstone caps in forming the regions landforms.

Haan, C.T. and B.J. Barfield. 1978. Hydrology and Sedimentology of Surface Mined Lands. University of Kentucky, Lexington, Kentucky. 286pp.

This text presents a comprehensive treatment of methods for estimating the hydrologic and sedimentology changes brought about by surface mining and methods for altering these changes. Many tables, graphs, and charts required to make the design calculations are included. Chapter 5, Soil Erosion and Sediment Yield includes The Universal Soil Loss Equation.

Hails, John. R. (ed.). 1977. Applied Geomorphology. Elsevier North-Holland Inc., New York. 418 pp.

This book presents a perspective of the contribution of geomorphology to interdisciplinary studies and environmental management. Chapter 6 by R.U. Cooke, examines applied geomorphologic studies in deserts, and Chapter 8 and terrain classification.

Leopold, Luna B., M. Gordon Wolman, and John P. Miller. 1964. Fluvial Processes in Geomorphology. W.H. Freeman and Company, San Francisco, California. 522pp.

This book deals primarily with geomorphic processes associated with running water. Chapter 3, Climate and Denudational Processes and Chapter 10, Drainage Pattern Evolution (including Development of Rill Systems) are useful in helping to predict future erosional patterns. Emphasis in on mechanical weathering followed by mass movement by running water.

Mabbutt, Jack. A. 1977. Desert Landforms (An Introduction to Systematic Geomorphology; Vol 2). Australian National University Press, Canberra, Australia. 340 pp.

The emphasis of this book is on landforms rather than geomorphic processes, it covers a variety of desert landforms (piedmonts, sands, rivers, rock, etc.) and their characterization, origin, and evolution. There is discussion of upland weathering and erosion rates on hillslopes and the factors and processes that control these rates, including human intrusion and use.

Melhorn, Wilton N. and Ronald C. Flemal (eds.). 1975. Theories of Landform Development. Sixth Annual Geomorphology Symposium, Binghamton, New York. 306 pp.

The proceedings volume of the Sixth Annual Geomorphology Symposia Series held at Binghamton, New York on September 26-27, 1975. Relevant papers include Stanley Schumm's "Episodic Erosion: A Modification of the Geomorphic Cycle, "William Bull's "Landforms That Do Not Tend Toward a Steady State," John Hack's "Dynamic Equilibrium and Landscape Evolution," and Louis Peltier's "The Concept of Climatic Geomorphology." The emphasis of these papers in on the vastly different rates of action, and the rapid rates of lateral erosion by a stream at grade. Periods of activity alternate with repose in landscape form and processes.

Morisawa, Marie (ed). 1973. Fluvial Geomorphology. Fourth Annual Geomorphology Symposia Series, Binghamton, New York. 314pp.

The proceedings volume of the Fourth Annual Geomorphology Symposia Series held at Binghamton, New York on September 27-28, 1973. Relevant papers include Stanley Schumm's "Geomorphic Thresholds and Complex Response of Drainage Systems" and Irwin Novak's "Predicting Coarse Sediment Transport: The Hjulstrom Curve Revisited".

Morrison, Roger B. (ed). 1991. Quaternary Nonglacial Geology: Conterminous U.S. The Geological Society of America, Inc., Boulder, Colorado. 672pp.

This book reviews the Quaternary geology of the contiguous United States beyond it glacial limits, focusing chiefly on stratigraphy, not geomorphology. Chapter 13, Quaternary Geology of the Colorado Plateau specifically Norma Biggar and Peter C. Patton's article on the Canyonlands and High Plateaus Sections are of interest. This chapter summarizes the physiography, landform and geomorphic processes on the Colorado Plateau.

Rachocki, Andrzej. 1981. Alluvial Fans. John Wiley & Sons, Ltd., New York. 161pp.

This is a book the morphology and evolution of alluvial fans in varying climatic conditions and the braided distributary channels on alluvial fans. It reviews such fundamental matters as their origin, shape and dimensions, their sedimentological features, and the main concepts and events controlling their deposition and development.

Ritter, Dale F. 1978. Process Geomorphology. Wm. C. Brown Company Publishers, Dubuque, Iowa. 603pp.

This is a general text on geomorphology and covers the processes influencing land development and forms and some general types of land forms. Of interest is Chapter 4 on weathering and mass movement, and Chapter 5 "The Drainage Basin-Development, Morphometry, and Hydrology", particularly the subject of Basin Denudation.

Schumm, Stanley A. 1977. The Fluvial System. John Wiley & Sons, New York. 338pp.

This book considers the fluvial system and its components in such a way that the interaction of the components and the resulting degree of inherent instability of the system can be comprehended and related to some concerns of land managers, civil engineers, etc. The first few chapters dealing with general concepts, background material, and initial erosional processes creating headwaters may be of interest in non-fluvial systems. These concepts can be directly applies to the Colorado Plateau region for erosion and deposition systems.

Simons, Daryl B. and Fuat Senturk. 1976. Sediment Transport Technology. Water Resources Publications, Fort Collins, Colorado. 807pp.

This text presents the mechanics of flow and sediment transport in canals and rivers using fundamentals of fluid mechanics, geomorphology, hydraulics, erosion and sedimentation and river mechanics with emphasis on sediment technology. It is intended to serve as a teaching aid, a reference document and a guide for decision making relative to the sediment motion, scour and bed degradation. Relevant information includes properties of sediment, resistance to flow, and local scour in alluvial channels.

Toy, Terrence J. (ed.). 1977. Erosion: Research Techniques, Erodibility and Sediment Delivery. Publ. by Terrence J. Toy, Geo Abstracts Ltd., Norwich, England. 86 pp.

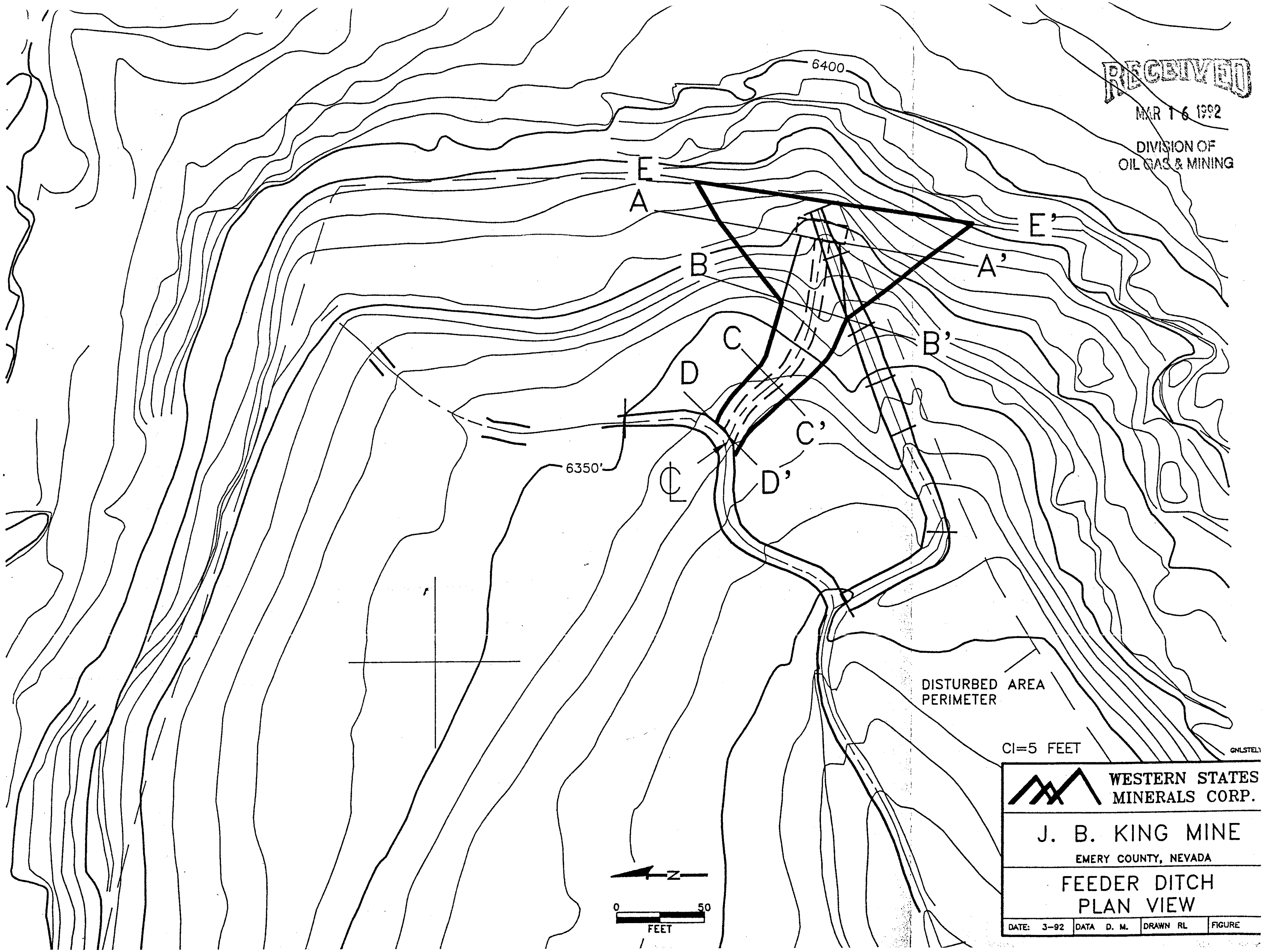
This text is an assemblage of papers on erosion. Topics include determination of runoff and sediment yield by rainfall simulation, mathematical modeling, soil erodibility, and some concepts of erosional processes and sediment yield in a semiarid environment. Cycles of erosion are discussed in relationship to type and intensity of storms, and in unconsolidated sediment.

Vanoni, Vito A. (ed). 1975. Sedimentation Engineering. American Society of Civil Engineers, New York, New York. 745pp.

This is basically a textbook on sediment engineering, it covers sediment problems involved in the development, use control and conservation of water and land resources. It deals with an understanding of the nature and scope of sedimentation problems, of methods for their investigation, and of practical approaches to their solutions. It is written assuming a knowledge of elementary fluid mechanics, calculus, and a general technical background. Rates or erosion under different soil management conditions are given.

ATTACHMENT A

Conceptual Drawings for Ditch Reconstruation



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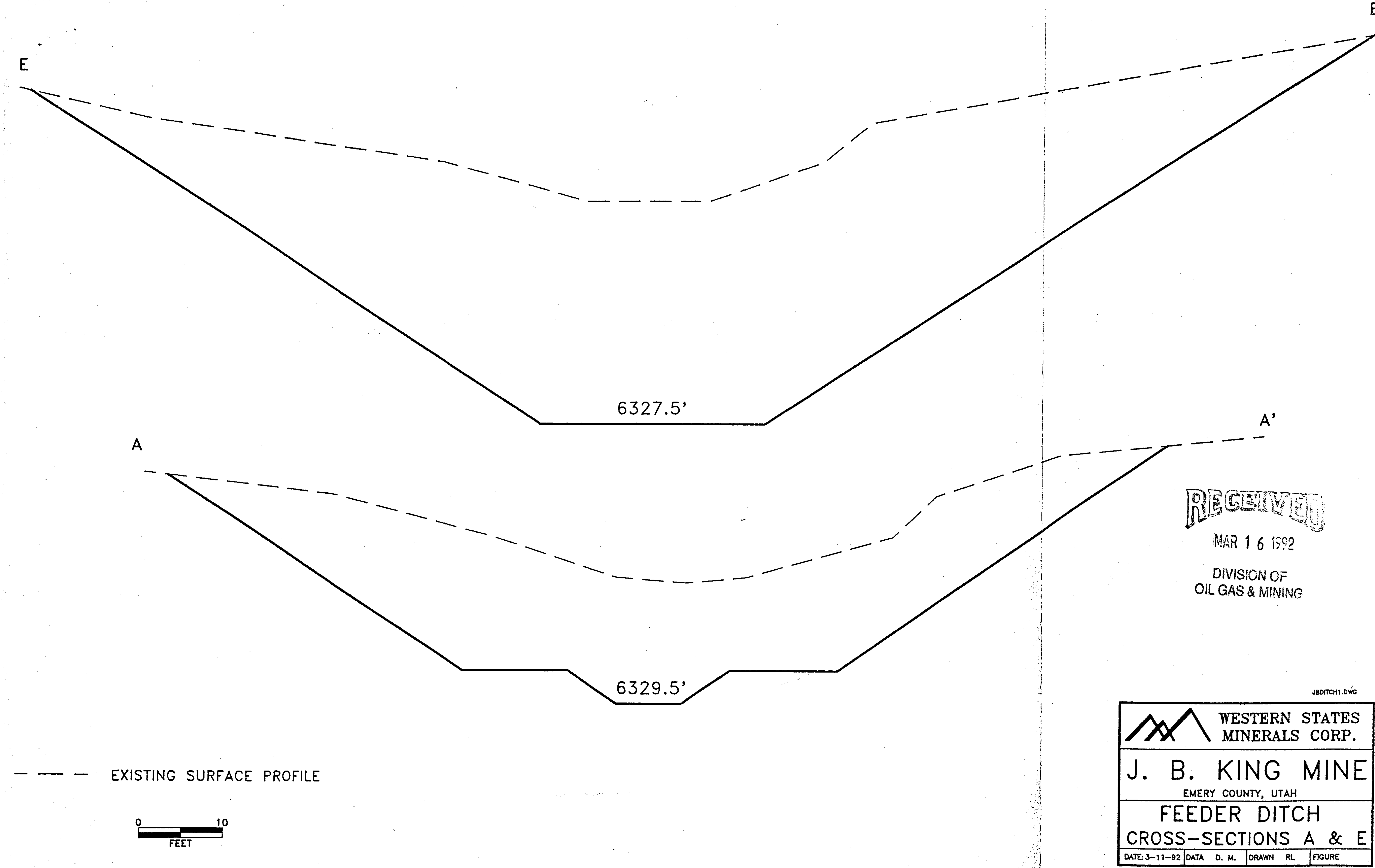
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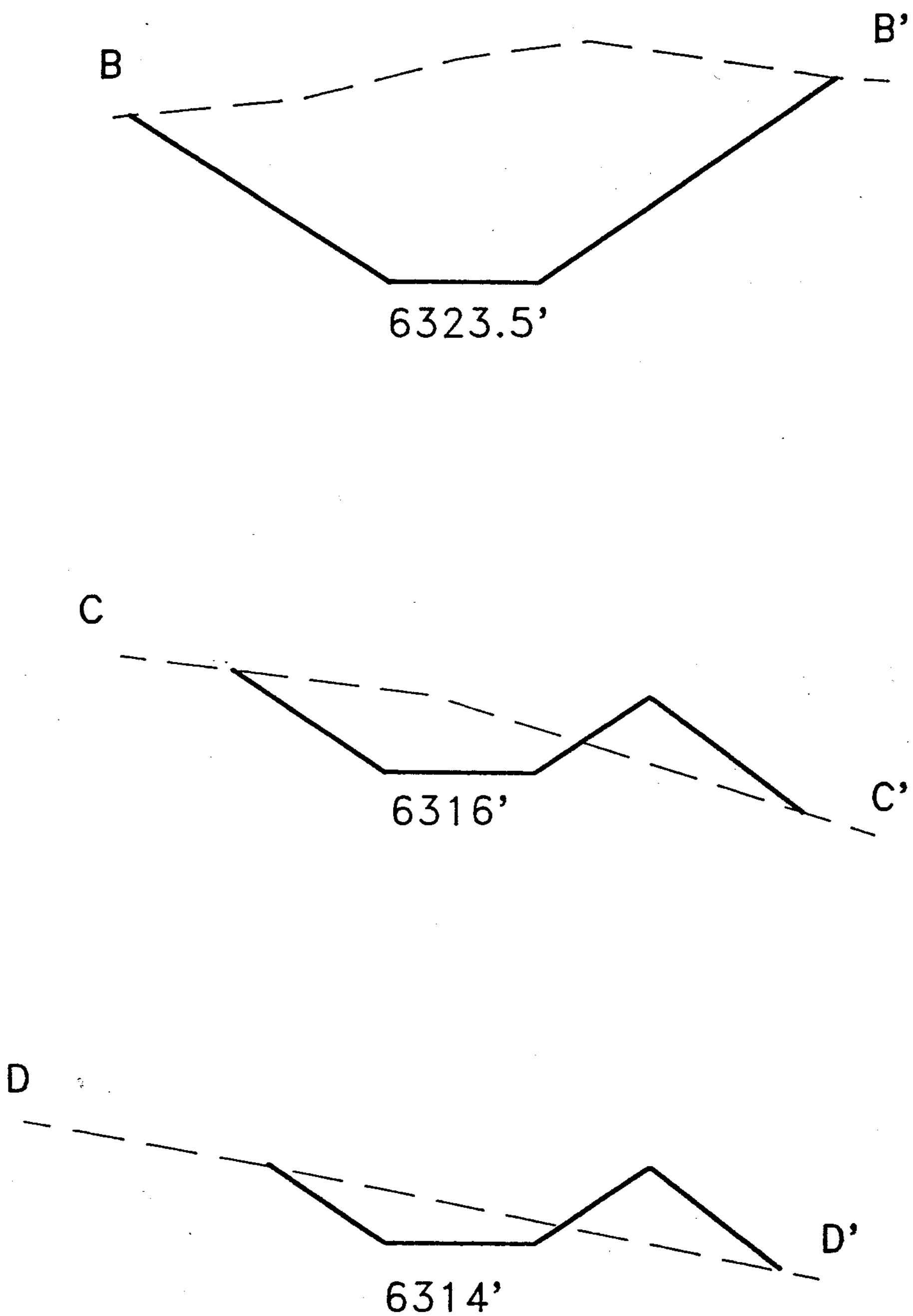

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