

Computer-Aided Visual Assessment in Mine Planning and Design¹

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Abstract: A computer modeling technique is described for evaluating the visual impact of a proposed surface mine located within the viewshed of a national park. A computer algorithm analyzes digitized USGS baseline topography and identifies areas subject to surface disturbance visible from the park. Preliminary mine and reclamation plan information is used to describe how the surface disturbances will be sequenced over time. Data from revegetation plots incorporated into the model account for disturbed areas that are returned to the viewscape. These quantitative results are displayed on a computer-generated three-dimensional perspective. The need for further work, including qualitative evaluation is discussed.

INTRODUCTION

Utah international Inc. is a major mineral development corporation that conducts surface and underground mining operations around the world. Our mineral products include copper, iron ore, uranium, and coal. Uranium is produced through a wholly-owned subsidiary. Our producing domestic coal mines are located in northwestern Colorado and in Four Corners, New Mexico. We are actively seeking opportunities to develop additional domestic coal reserves.

Utah holds leases and various agreements for 27,000 acres of coal in the Alton coal field of southern Utah. The extreme eastern end of the coal reserves lies within the viewshed of Yovimpa Point overlook of Bryce Canyon National Park. The distance from the overlook to the extreme eastern end of the mine area is about 5.0 miles. It is estimated that this view is enjoyed annually by up to 250,000 visitors to the Park, with spectacular vistas of up to 80 miles on some days.

As part of our environmental assessment, Utah developed baseline data of the normally considered physical and cultural factors, including the visual resource. Because this scenic resource is of unique value, careful consideration of the visual environment is being integrated into the planning and design of the proposed mine.

THE PROCESS

This paper describes our use of a computer technique developed by Comarc Design Systems to assess the project's visual impact on the viewshed of the Park. The assessment process included the following steps:

^{1/} Presented to the National Conference on Applied Techniques for Analysis and Management of the Visual Resource, Incline Village, Nevada, April 23-25, 1979.

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- Describe the landform alteration;
- Locate and quantify the visually sensitive areas; and
- Evaluate the results.

Landform Alteration Description

Visual impact should be assessed in the context of the process that is altering the landscape. Surface mining is a dynamic process where landform alteration continues from surface disturbance during mineral extraction through recontouring and revegetation, until the land has been returned to its condition prior to mining.^{5/} An important reclamation objective at the Kanab site is that the reclaimed landscape blends visually with its surroundings. A properly designed reclamation site that incorporates visual objectives during the planning process should present no long-term adverse visual impacts.

Quantify the Visual Impact

A. Technique Selection

There are several approaches to quantifying the visual impact including graphic analysis, photography, physical models, computers and combinations thereof. The computer was selected for this visual assessment because it provides:

- Rapid and accurate identification of visible mining areas;
- Ease in changing input data, such as mining area location and status;
- Rapid and accurate overlay of view cell data with other information;
- Display of analytical results in computer generated three-dimensional displays.

In summary, the planning team felt that the flexibility and quick response provided by the computer would provide a desirable planning tool.

B. Description of the Analytical Process

The steps involved in the computer visual assessment are:

1. Identification of the study area,
2. Digitization of topography,
3. Geometric analysis of visible areas,
4. Three-dimensional display of those areas.

1. Study Area

The study area included mining areas within the general viewshed of Yovimpa Point. It was selected based on the experience of those who had visited Yovimpa Point and by a qualitative examination of 1:24000 USGS topographic quadrangle maps.

2. Digitization

Digitized 40-foot contour intervals from a USGS base map provided a data bank for the view cell analysis and for later production of the computer-generated three dimensional displays. This data bank consists of 4-acre "view cells" with specified elevations.

3. Geometric Analysis

The algorithm used to determine whether an individual view cell could be seen from Yovimpa Point, depicted in figure 1, established a visual line-of-sight from this viewpoint to an individual view cell. If a landform is encountered along the sight line, i.e., if an object between the view cell and the observation point is above the line-of-sight, then the view cell is not visible.

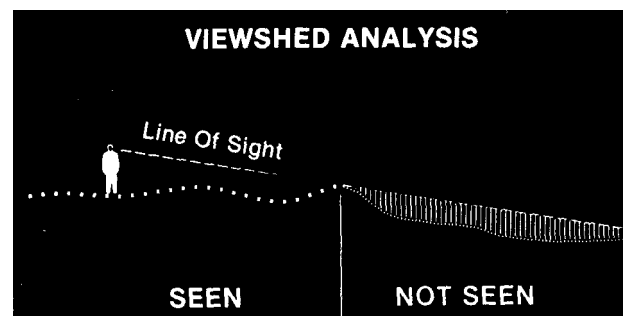


Figure 1--Visual line-of-sight algorithm used in computer model

^{5/} The authors recognize provisions in regulations pursuant to the Surface Mining Control and Reclamation Act of 1977 describing conditions for planning "alternative land uses."

A two-dimensional view cell map identifies individual grids within the viewshed of the Park that are seen from Yovimpa Point. The computer then compares these view cells with an overlay of the mining area and differentiates between the visible and non-visible portions of the proposed mine (fig. 2).

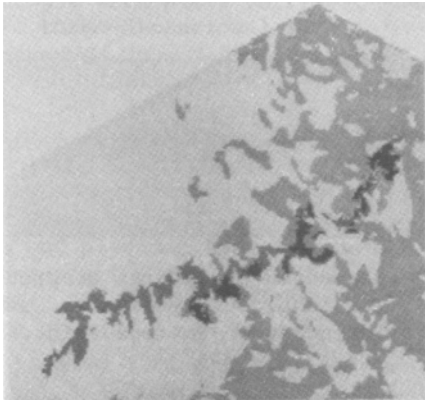


Figure 2--Two-dimensional viewcell map identifying surface-mined areas visible from Yovimpa Point (shown in black). Dark grey areas identify non-mining viewcells seen from Yovimpa Point.

4. Three-Dimensional Display

This information is then displayed on a three-dimensional plot which is produced from the same digitized topographic information used to identify visible mining areas. This is an important step because displaying the information in three-dimensional form more clearly communicates the analytical results.

During the initial phase of our study, technical limitations in the computer software did not allow for a three-dimensional plot of the study area as seen precisely from Yovimpa Point. Therefore, it was not possible to illustrate directly the visible mining areas as viewed by an observer standing on the Point.

As an alternative, the visible areas were overlaid onto a three-dimensional perspective prepared from a different vantage point. This 'birds-eye' view is several miles back from and above Yovimpa Point. The result shown in Figure 3, allows the viewer to observe the viewshed simultaneously from two different vantage points. This three-dimensional picture depicts a much broader vista at an exaggerated vertical scale to provide the viewer with a highlighted perspective emphasizing landscape features, while the overlaid view cells precisely identify those areas that would be seen if the viewer were standing on Yovimpa Point.

Evaluation

Until now, this study had accomplished two important objectives:

1. The areal extent and location of the visible surface disturbances had been quantified.
2. The analytical results had been displayed in three-dimensional form.

It became clear to the planning team, however, that a single perspective which simultaneously depicted views from two vantage points was not an easy concept to grasp. The landforms visible from the birds-eye view could be confused with the visible areas seen from Yovimpa Point identified on the overlays.

A second fundamental shortcoming of these initial results was that the study failed to incorporate the mining sequence into the analysis. The total potential surface disturbances during the entire life of the mine were depicted as though they would occur simultaneously.

To refine the study further, a preliminary mining schedule which specified mining sequences by blocks of coal seam units was incorporated into the model. Although this preliminary schedule does not contain the design detail needed for the final mine plan, it does provide a measure of the rate at which surface disturbance would proceed. Reclamation of these disturbed areas is an integral part of the mining sequence, and includes back-filling, recontouring, and revegetation. In keeping with experience at our other western coal mines, as well as with new requirements pursuant to the Surface Mining Control and Reclamation Act

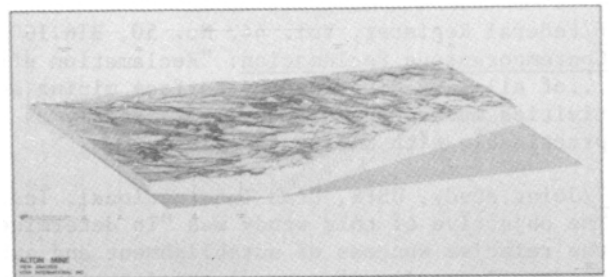


Figure 3--Viewcells mapped from Yovimpa Point overlaid on three-dimensional "birds-eye" perspective as seen from behind Yovimpa Point.

of 1977,^{6/} reclamation will proceed at a rate equal to the rate of surface disturbance. Test data acquired since 1975 at the site indicate that native species will be established within about three years of seedling.^{7/}

With this new information, it was possible to describe visually the location, areal extent, and time of surface disturbances visible from the Park, and to estimate when disturbed areas would be "returned to the viewscape" by reclamation. Because the mining sequence data are preliminary, time intervals of 5 years were selected.

While these efforts to integrate the mining sequence into the visual analysis were carried out, further attempts were made by Comarc Design Systems to overcome the technical difficulties encountered in producing a perspective as seen from Yovimpa Point.

In order for the computer algorithm to place the viewer directly on Yovimpa Point, it was necessary to slice off a portion of the study area (not including mining areas) directly in front of the view (fig. 4). The resulting perspective is shown in figure 5.

PHASE II RESULTS

For each five-year sequence, those visible areas in a state of active temporary surface disturbances are portrayed in three ways:

1. View cells are shown in two-dimensional form, for precise analysis;
2. View cells are overlaid on the birds-eye view perspective, for emphasis;
3. View cells are overlaid on a three-dimensional perspective as observed by a viewer standing on Yovimpa Point, for a precise display of the visual impact.

These preliminary results indicate that no surface disturbances will be visible during

^{6/} Federal Register, Vol. 44, No. 50, B16.100, Contemporaneous Reclamation: "Reclamation efforts ...of all land disturbed by surface mining activities must occur as contemporaneously as practicable with mining activities."

^{7/} Joint study, USFS, Utah International, Inc. The objective of this study was "To determine the relative success of establishment and subsequent longevity of several species...on top-soil...and overburden." While visual quality was not considered in the study, we use the results as a best available information source. Further evaluation may be required.

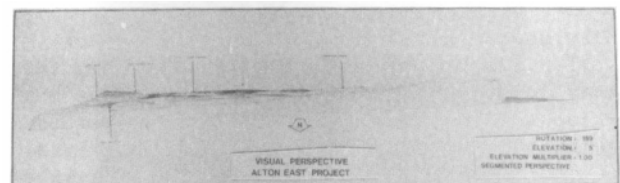


Figure 4--Segmented study area to produce three-dimensional perspective as seen by observer standing on Yovimpa Point.

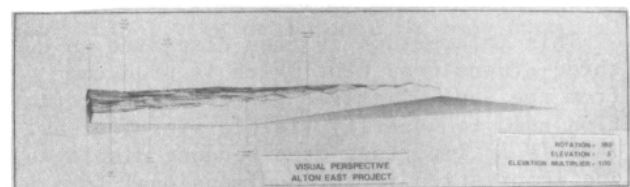


Figure 5--Three-dimensional perspective depicting view from Yovimpa Point

the first five years of mining from 1985-1990. Cyclical levels of visible disturbance will occur during the years 1990 to 2010. Surface disturbances will also occur during the later stages of the mining sequence in the eastern blocks during the years 2010 to 2020. Even at the later stages of mining, no more than 10% of the mining area under study would be subject to active surface disturbance within a given 5 year study period. Within 5 years after surface mining is complete, the reclaimed land will be fully returned to the viewscape. Examples of these results are illustrated in figures 6A, B, and C.

The second phase of this study has accomplished three important objectives:

1. It has integrated the mining and reclamation process into the visual analysis;
2. It has more accurately defined the visual impact by quantifying the location, areal extent, and timing of the disturbance;
3. It has accurately portrayed those impacts in three-dimensional form as observed from Yovimpa Point.

We conclude from these results that the computer is an effective and versatile tool for quantifying and displaying visual impact. As mine planning proceeds into more detailed studies, the established data bank will also provide our planning team with a useful tool for incorporating environmental concerns, especially the visual environment, into the planning process.

CONTINUING PROGRAM

These results are only the first step in Utah's total program to assess and preserve the visual environment. Other studies in progress include descriptive and quantitative classification using photointerpretation of the landforms in the viewshed beyond the mining area to establish a baseline visual environment. This study has identified landform alteration from range improvements and private farming.

Our ability to achieve visual design objectives will be measured by our performance. The efforts described in this paper, however, underline UII's commitment to include all important environmental values, including the visual environment into our mine planning and design.

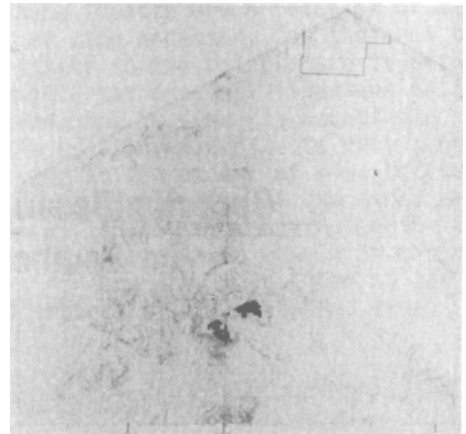


Figure 6a--Two-dimensional map depicting disturbed surface area visible from Yovimpa Point during the years 1990-1995.

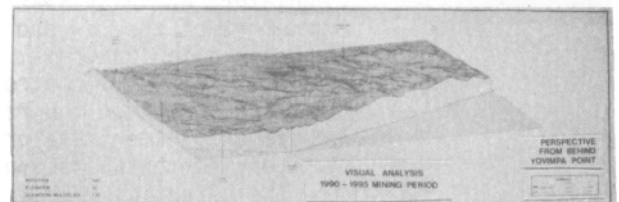


Figure 6b--Three-dimensional birds-eye view from behind Yovimpa Point depicting disturbed surface areas visible from Yovimpa Point during the years 1990-1995.

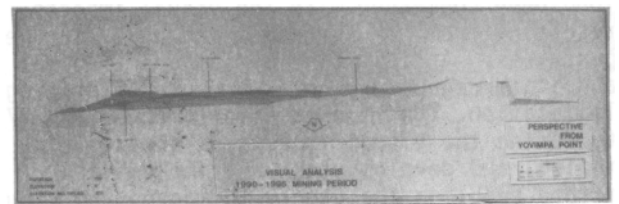


Figure 6c--Three-dimensional view from Yovimpa Point depicting disturbed surface areas visible from Yovimpa Point during the years 1990-1995