SITE SELECTION FOR ELECTRICAL RECEIVING STATIONS

by

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CHAPTER ONE

INTRODUCTION

INTROOUCTION

This country is currently facing a dilemma - how to locate the variety of development projects that are regionally needed, but which are objectionable to the public who must live near them. Examples of these types of development can be found almost everywhere and fall into a broad range of uses such as; power plants, airports, factories, low-income housing, prisons, power transmission lines, junkyards, sanitary landfills, highways, electrical substations, etc..

Perhaps the most important single variable to consider is the number of environmentally problematic facilities likely to be proposed. The following table shows U.S. Oepartment of Labor's projections of real output growth during the 1980's with high and low figures that generally depend on assumptions about the general state of the economy. Steel, petroleum refining, and copper are projected to grow at below the rate for the economy, paper at about average, and chemicals, aluminum, and electric utilities significantly faster than average. Of the sectors considered, electric utilities appear most likely to require large numbers of new domestic sites.

TA8LE 1. Projected Growth in Real Output, 1979-80

Sector	Project Growth (percentage change)
Total private sector	+29.5-49.0
Total manufacturing	+28.3-48.7
Steel	+17.0-37.5
Primary nonferrous metals	
Copper	+18.7-37.5
Aluminum	+36.3-5.77
Paper and paperboard	+24.2-39.3
Petroleum refining	-(15.8)-0.0
Chemicals	+40.6-55.3
Electric utilities	+42.2-61.1

Source: U.S. Oepartment of Labor, 8ureau of Labor Statistics, unpublished figures, April 1982.

THE IMPORTANCE OF THE STUDY

The immediate need for developing and expanding our electrical systems to meet increasing population levels has brought into focus the major critical facilities in producing energy. They are: power generation facilities, power transmission facilities, power transformation facilities (electrical receiving stations), and power distribution facilities.

Although each of these facilities is an integrated part of a total system, it is necessary to look at individual components so a detailed analysis, needed to effectively locate the facilities in specific sites, can be accomplished.

The environmental problems associated with electrical receiving stations tend to be point-or site-specific. By their very nature, transformation facilities are located in mostly urban settings and it is in these areas where the potential for altering the character of the neighborhood becomes the greatest and where the public becomes interested because the development is proposed in close proximity. It is in these urban settings where additional work in the development of a siting methodology is essential.

Unless legal requirements outline factors that must be addressed in the preliminary site selection of electrical receiving stations, all too often, only engineering factors (i.e. load center, proximity to transmission lines, etc.) economic constraints (i.e. cost of site) and political considerations (public opinion of utility company in condemnation suit), determine site locations for electrical receiving stations. Legal requirements vary by state and sometimes size of facility. For example, in the state of Kansas, for receiving stations and transmission lines below 161kv no formal environmental report need be done. Arizona, on the other hand, has well-defined requirements for supporting exhibits needed for a required certificate of environmental compatibility.

The most comprehensive appearance-mitigation programs throughout the electric utility industry have been in switchyards and substations. Appearance of these facilities has been receiving much consideration in the development of structural and electrical designs by many utilities. Color is being used to enhance the appearance of installations and to define the function of the electrical equipment. Landscaping and architectural fences have been effectively used. The objective is to design these facilities to be visually compatible with their surroundings.[1] The question posed becomes, "Can the different site characteristics be inventoried and compared for site compatibility in the selection process?"

There are numerous factors that are used in the site selection of electrical receiving stations (i.e. economic, engineering, political). In many urban settings there may be few substantial differences in land acquisition and engineering factors between various potential locations on which to justify site selection. All too often, the input from a detailed analysis of additional factors that determine the character of the site has not been utilized. Additional factors can include visual, acoustic and land use compatibility factors.

Can other factors besides economic, engineering and political considerations be utilized in the site selection process? Could the inclusion of additional factors give a more complete assessment of the impacts due to site development and reduce potential mitigation costs by proper site selection? Why not use an inventory of site characteristics in the site

1. U.S. Department of the Interior, U.S. Department of Agriculture, Environmental Criteria for Electrical Transmission Systems (Washington, D.C., U.S. Government Printing Office, Superintendent of Documents, 1970), p. 31.

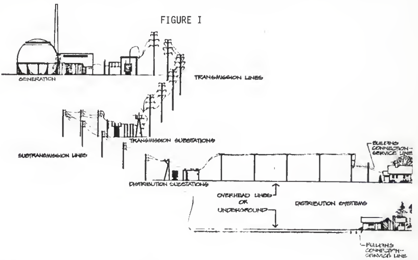
selection process to delineate potential site opportunities that can be used to lower the perceptual contrast of the development of the site?

The thrust of this research is then to develop a refined methodology for siting an electrical receiving station which could be used to differentiate often neglected site-specific characteristics. In order for one to begin to develop a methodology one has to be able to comprehend the purpose of an electrical receiving station, where it fits into the process of supplying energy and the various types of transmission substations to which an electrical receiving station belongs.

TYPICAL RECEIVING STATION

Within the overall electrical transmission and distribution system the electrical receiving station (transmission substation) is part of a larger system. The following figure, (Figure I) from a report by Johnson, Johnson and Roy (1970) delineates the various elements of a typical power

FIGURE I



William J. Johnson, Carl Johnson and Clarence Roy, *Transmission and Distribution Rights-of Way Selection and Development*, (Ann Arbor, Michigan for Consumer's Power Company, Jackson, Michigan, 1970), p. 1.

system. The publication published by the U.S. Department of Interior entitled, Environmental Criteria for Electrical Transmission Systems, gives the following general purposes for substations.

> The purpose of these facilities is to receive power, to transfer power from circuit to circuit, to protect circuits and equipment, to transform power to other voltage levels and to provide meters for billing system power scheduling and control and to monitor system performance. The installation often serves as a location for maintenance crew headquarters, warehouses and storage facilities.[2]

Johnson, Johnson and Roy in their 1969 publication Substation Site Selection and Development further describe the purposes of these facilities.

> The primary purpose of an electric distribution substation is to reduce the voltage of the bulk power source to a lower voltage for distribution to specific zones of the community. Installed in the basic substation are electrical equipment items such as transformers, voltage regulators, protective devices and switches. It also contains steel structures to terminate the subtransmission and distribution lines and also to support protective devices, switches and other smaller components which make up the substation.[3]

Normally the system is designed to minimize the duration of interruption and number of customers affected by an interruption due to a failure of a component such as a transformer, transmission line or distribution line. Contingencies such as the failure of one component in a system which forces a greater than normal load to be carried by the other components are normally planned for and incorporated into the substation design criteria.

Most substations do not require attendant personnel on a day-to-day basis. Operations including remote indication, control, and metering and methods of communications are provided so that the power systems can be monitored from a central point.

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2. Ibid., p. 31.

3. William J. Johnson, Carl Johnson and Clarence Roy, Substation Site Selection and Development, (Ann Arbor, Michigan, Johnson, Johnson and Roy, for Consumer's Power Company, Jackson, Michigan, 1969), p. 4.

Substations may be categorized as distribution substations, transmission substations, switching substations, or any combination thereof.

Distribution Substations

A distribution substation is a combination of switching, controlling and voltage stepdown equipment arranged to reduce subtransmission voltage to primary distribution voltage for distribution to residential, farm, commercial, and industrial loads.

Transmission Substations (Electrical Receiving Station)

A transmission substation is a combination of switching, controlling and voltage stepdown equipment arranged to reduce transmission voltage to subtransmission voltage for distribution of electrical energy to distribution substations. Transmission substations function as bulk power distribution centers, and their importance in the system often justifies bus and switching arrangements that are much more elaborate than distribution substations.

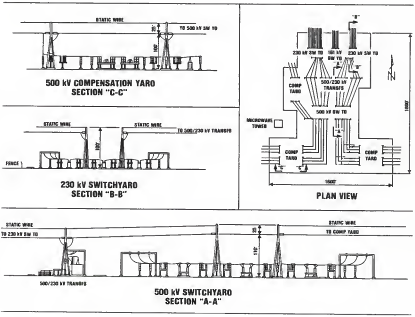
Switching Substations

A switching substation is a combination of switching and controlling equipment arranged to provide circuit protection and system switching flexibility.

In their basic breakdown, the components of an electrical receiving station consist of:

* Input lines
* Transformer
* Enclosure
* Service drive
* Regulator and recloser structure
* Output lines
* Guying structures for transmission lines

The following figure (Figure II) delineates the basic electrical components of a typical 500/230/161/69kv substation.



TYPICAL 500/230/161/69 kV SUBSTATION

FIGURE II

CHAPTER TWO

THE NEED FOR SITING PROCESS

RECENT LESSONS

The first and most common nature of siting conflict is caused by misjudgment of the attitude of the public. This area usually involves attitudes related to impacts on the natural and social factors. The ill-fated Panhandle Freeway in San Francisco as well as the Golden Gate Freeway are examples of the strength of public protest. Freeways are being opposed for various reasons, including concern for air, noise, visual pollution, growth inducement, neighborhood disruption and violation of scenic, recreational and historic areas. Similar results can be identified throughout the country, from New York's Westway (Interstate 478), Los Angeles' Century Freeway (I-105), and Interstate 95 in Boston as well as numerous minor highway proposals.

Electrical generating plants have been and are still opposed because of public concern for the environment. The Bodega Head plant in California, planned by Pacific Gas and Electric Company, faced wide opposition by the public including biological scientists. The discussion continued until a detailed geological study revealed an active earthquake fault nearby.

The Diablo Canyon plant in California met widespread opposition from the general public for numerous reasons during plant construction until additional studies were completed that discovered an earthquake fault less than three miles off the coast from the facility.

A second point of potential conflict is the frequent lack of consideration for environmental and social factors on an equal basis with economic and technical variables. Typically, few factors are given equal consideration in site selection; rather, they are assigned a degree of relative importance.

An additional point of conflict lies in the lack of information collected. The Bodega Head and Diablo Canyon cases delineate the difficulty in knowing everything about a site's geology and the consequences that occur as a result of inadequate environmental information.

Neglecting to disclose information can lead to problems, as was the case when the Florida jetport sponsors withheld information concerning their highway-widening needs. What is important and essential information should be decided by review agencies, the public, and, in the end, the courts rather than the project sponsors.

The final point of conflict occasionally arises when the siting methodology fails to involve all concerned interests in the site selection decision-making process. There have been enough experiences involving public and agency representatives in site selections, such as the Bureau of Land Management's scoping process, to show that public input can be utilized.

HISTORIC BACKGROUND

One of the earliest studies used to formulate guidelines in siting substations in the environment was the publication <u>Environmental Criteria for Electrical Transmission Systems</u>.

> The effective location of switchyards and substations requires careful consideration of the functional requirements of the facility and other factors understood and accepted by the utility industry, such as good access by road and rail and proximity to the load or generation station.
>
> Consideration of the following additional factors would do much to minimize the adverse environmental impact of the facilities:
>
> 1. Switchyards and substations should be located with consideration both for their basic function and for the preservation of public views of scenic, historic, natural and recreation areas, parks, monuments, etc..

2. The proposed location, layout, and design parameters should be coordinated with appropriate local planning agencies to assure maximum compatibility between the facilities and present and future land use.

3. The location should be coordinated with the needs of utilities delivering power into or receiving power from the station. This is particularly important in the development of the site's electrical layout to minimize costly, unsightly, transmission line crossovers and unnecessary duplication of facilities.

4. If possible, locations should avoid population areas, parks, scenic areas, wildlife refuges, hilltops and natural or man-made structures.

5. Locations near existing or proposed interstate or state primary highways should be avoided.

6. Where possible, substations should be located where they may be naturally or artificially screened.

7. Potential noise should be considered when the locations for high-voltage substations are being determined. The facilities should be located in areas where sound will not be resonated.

8. Multiple level, terraced substations may be used to minimize excavation and provide a facility that will blend effectively with sloping terrain.[4]

A report completed by Johnson, Johnson and Roy (1969) entitled, Substations, Site Selection and Development, dealt in a general way with all identified environmental problems created by substations. The report stated that functionally there are three requirements for substation location:

1. Geographically the location should be as close as possible to the center of electric power distribution load (demand) to be served. The future, as well as the present, distribution requirements should be considered. The determinants for current needs can be measured but future demands can only be determined by considering future growth projected by the plans of the community.

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4. U.S. Department of the Interior, U.S. Department of Agriculture, Environmental Criteria for Electrical Transmission Systems, (Washington, D.C., U.S. Government Printing Office, Superintendent of Documents, 1970), p. 31-32.

2. A factor which sometimes alters the center location is the necessity for the substation to be located near a high voltage transmission line or where right-of-way for a circuit to the high voltage transmission line is available.

3. The service requirements for substation equipment are such that convenient accessibility from a street or highway is important.[5]

The Western Systems Coordinating Council, Environmental Committee (1971) drafted general guidelines used to alleviate these same problems.

> Substations should be located with consideration for their basic function and for the protection and preservation of scenic, natural, historic, archeological and recreational values and, where possible, should avoid parks and monuments, wildlife refuges, and conspicious hilltops.
>
> When substations are located near interstate or state primary highways, the exposure of the facility to the public should be considered and adequate screening, landscaping or other aesthetic methods used to minimize the visual or physical impact on the landscape.
>
> Requirements for the selection and acquisition of optimal sites for major urban substations do not differ significantly from those applying generally to substations in other areas. However, the planning and construction of urban substations may be subject to more public involvement and require close cooperation and coordination with local planning and zoning commissions. It is essential that siting, design and construction of an urban station conform with the present and long-range objectives of local community planning. In order to gain public acceptance, site development must be compatible with existing and future land uses in the area.[6]

The Rural Electrification Administration (REA) states that two of the most critical factors influencing substation design are the substation location and siting.[7] Their list of 19 factors which need to be evaluated in relation to the selection of a substation site can be categorized into

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5. William J. Johnson, Carl Johnson and Clarence Roy, Substation Site Selection and Development, (Ann Arbor, Michigan, Johnson, Johnson and Roy, for Consumer's Power Company, Jackson, Michigan, 1969), p. 5.

6. Western Systems Coordinating Council, Environmental Committee, Environmental Guidelines, (Los Angeles, California, Western Systems Coordinating Council, 1971), p. 37.

7. Rural Electrification Administration, U.S. Department of Agriculture REA Bulletin 65-1, 1979, p. II-1 and II-2.

six broad categories: engineering criteria, geotechnical limitations, land use considerations, public/equipment safety, human awareness, cost, and ecological constraints. The factors as organized by categories, are as follows:

Engineering Criteria

1. location of present and future load center
2. location of existing and future sources of power
3. location of existing distribution lines

Geotechnical Limitations

1. soil resistivity
2. drainage and soil conditions
3. atmospheric conditions - salt and industrial contamination
4. general topographical features of site and immediately contagious area. Avoidance of earthquake fault lines, flood plains, wetlands and prime and unique farmlands.

Land Use Considerations

1. availability of suitable right-of-way and access to site by overhead or underground transmission and distribution circuits
2. alternate land use considerations
3. nearness to all-weather highway and railroad siding; accessibility to heavy equipment under all weather conditions
4. space for future as well as present use
5. land title limitations, zoning, and ordinance restrictions

Safety

1. public safety
2. security from theft, vandalism, damage, sabotage and vagaries of weather

Human Awareness

1. possible objections regarding appearance, noise, or electrical effects
2. possible objections regarding present and future impact on other private or public facilities

Cost

1. cost of earth removal, earth addition, and earthmoving
2. total cost including transmission and distribution lines with due consideration of environmental factors

Ecological Constraints

1. consideration of impact on rare and endangered species

A visual impact study conducted for the Northern States Power Company by Inter-Design, Inc. (1971), delineated visual criteria ratings for a number of substations. The sixteen criteria were judged against a three-level scale (positive, neutral, negative) which ranked the sites. The criteria are as follows:

1. Siting
2. Buffers (visual screening)
3. Topography Destruction
4. Vegetation Destruction
5. Scale Compatibility
6. Natural or Historic Features
7. Viewing (exposure of facility)
8. Arrangement (visual order)
9. Internal Elements (visual clarification)
10. Public Exposure (viewing from major circulation routes)
11. Visual By-Products

12. Lighting Levels
13. Creative Use of Color
14. Signage
15. Land Use Continuity
16. Day Visual Continuity

The study ultimately identified four problems encountered in siting a substation.

1. Location of facility in relation to public circulation
2. Resolution of facility edge conditions
3. Visual continuity of facility with surroundings
4. Facility arrangement[8]

A review of health, safety and general biological environmental effects of high voltage transmission lines was conducted by Dr. Sol. Michaelson (1979). The results of field and laboratory studies indicate that . . . "there are no demonstrable biological effects which may be hazardous to health or safety or to the general biological environment as a result of the presence of electric and magnetic fields from high voltage transmission lines."[9]

Noise is one of the most pervasive environmental problems. The Report to the President and Congress on Noise indicates that between 80-100 million people are bothered by environmental noise on a daily basis and approximately 40 million are adversely affected in terms of health.[10]

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8. InterDesign, Inc. Visual Study, (St. Paul, Minnesota, for Northern Power Company, 1971), p. 69.

9. Sol. M. Michaelson, 1979. Analysis of Studies Related to Biologic Effects and Health Implications of Exposure to Power Frequencies. The Environmental Professional, Volume 1, p. 217.

10. U.S. Environmental Protection Agency, Report to the President and Congress on Noise, December, 1971, (USGPO, 1972).

Relative to the occupational environment, hearing loss primarily due to noise is considered to be the leading occupational disability.[11]

The implicated health related effects due to noise include:

1. Permanent or temporary hearing loss;
2. Sleep interference;
3. Increased human annoyance;
4. Communication interference resulting in reduced worker efficiency;
5. Impairment of mental and creative types of work performance; and
6. Possible increase in usage of drugs like sleeping pills, as a method of adaptation to noise stress.[12]

Damage to physical objects is another important consideration. Many natural and man-made features in the environment have become increasingly vulnerable to an ever expanding technology, of which noise is a by-product. Damages associated with noise include:

1. Structural impairment
2. Property devaluation; and
3. Land use incompatibility.

This concern may be supported by considering the damages which are currently being sought by various plaintiffs for transportation noise, amounting to nearly $4 billion.[13]

The previous investigation in the historic background of various siting studies revealed some important facts. All of the studies (general or specific) seem to concentrate heavily on the investigation of environmental standards. Few siting methodologies seem to indicate the need for

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11. Clifford R. Bragdon, Noise Pollution: The Unquiet Crisis, University of Pennsylvania Press, Philadelphia, 1971.

12. Ibid., "Community Noise: A Status Report," paper presented at the 84th meeting of the Acoustical Society of America, Miami, Florida, November, 1972, p. 6.

13. Ibid., "Noise Control in Urban Planning," Journal of Urban Planning, and Development Division 99. No. 1, ASCE (1973).

a comprehensive organized approach to site selection or the need for a public information program whose importance we described in the first part of this chapter. The identification of well-defined goals for the entire site selection process including environmental standards seldom appeared as part of the process. A site selection process that utilizes all of these factors together seems a more appropriate solution.

THEORETICAL SITE SELECTION REQUIREMENTS

Public Information

It is a requirement that any siting process must be prepared for review by various government agencies and special interest groups. The most appropriate way to accomplish this is to include the public in the decision-making process through a clearly defined comprehensive site selection process. Attempts to neglect an open forum in site selection run the risk of protracted legal battles or worse, the disapproval of the project.

Organized Approach

Shortcuts based on trained, intuitive judgment or on formulas that "have worked in the past," should be avoided. The basis for each assumption and the process leading to each conclusion must be clearly defined. Problems of public understanding can be overcome by defining a logically sequenced and organized approach which explains goals, assumptions and key decisions.

According to Soderman and Stafford, the lack of programmed location decisions is caused by inexperience and the complex relationships that exist among factors.[14,15] Critical factors can change from one location to another. A decision may rest on relative costs, while others may be based entirely on qualitative factors.

Goal Identification

If an organization simply assumes that a certain type of facility in a certain location is desirable, then in all likelihood, the best results won't be achieved. A decision based on internally rational goals that ignores broader public-interest considerations can and will encourage public distrust. An effective siting process must possess well-defined goals in facility utilization as well as goals that the general public might determine to be important: air, water, compatibility of land uses, visual quality, noise levels and jobs.

Environmental Standards

The site-selection process must determine performance standards relating to the project's effects on the environment. As described in the previous section, one of the objectives of the process is to fulfill environmental goals by setting specific targets or performance standards. To avoid surprises in the cost of modifications to meet such standards, the standards should be identified early in the process. Costs attached to these modifications can be estimated and used in making decisions among alternatives as well as choosing the final site.

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14. S. Soderman, Industrial Location Planning: An Empirical Investigation of Company Approaches to the Problem of Locating New Plants, John Wiley & Sons, Inc., New York, 1975.

15. H. A. Stafford, Principles of Industrial Facility Location, Conway Publications, Inc., Atlanta, 1979.

Comprehensive Approach

A comprehensive approach requires knowledge of and experience in the way in which natural and social systems interact. The lack of comprehensiveness with respect to site-selection factors is often the result of inadequate attention to goals and standards. It is important not only to consider existing regulations and standards but to anticipate future changes that could influence the process.

Clear Presentation of Data

The site-selection process involves public review and must be documented in easily understood language to avoid hiding the siting decision behind technical jargon. A second reason for avoid technical jargon, if one is needed, is that the impact statement that will follow the siting decision is required by law to be written in lay language.

CHAPTER THREE

METHODOLOGY

SCOPE OF STUDY EFFORT

The purpose of the analysis is to develop a methodology that can be used to differentiate specific site characteristics by identifying and evaluating the potential impacts that might result from the construction, operation and maintenance of a proposed 230kV receiving station. The following figure (Figure III) details the tasks undertaken during the development and application of the siting methodology.

PROJECT DEFINITION

Project definition is an essential step in the site selection process. A complete understanding of all the elements and processes of the proposed facility is needed (i.e. space requirements, proximity to other facilities, performance standards, access to transportation.)

Definition of the project serves two purposes. It permits additional refinement of siting requirements and gives an understanding of potential effects on the environment that will enable the adverse effects to be minimized or avoided.

DETERMINE STUDY AREA

An important decision at this stage is the definition of the area of study. Limitation of the study area must be based on defensible economic, operational, political or other factors. Stafford, while analyzing case studies, found that private industry decision makers:

> rapidly and drastically transform the infinite complexities of the optimal location into a relatively simple, intellectually manageable, situation . . . Selection of an area of search, at the subnational, or, more commonly, the regional scale . . . involves the rather imprecise, and usually arbitrary or impressionistic delimitation of the specific area of search . . . The vast majority of the possible locations are never explicitly considered.[16]

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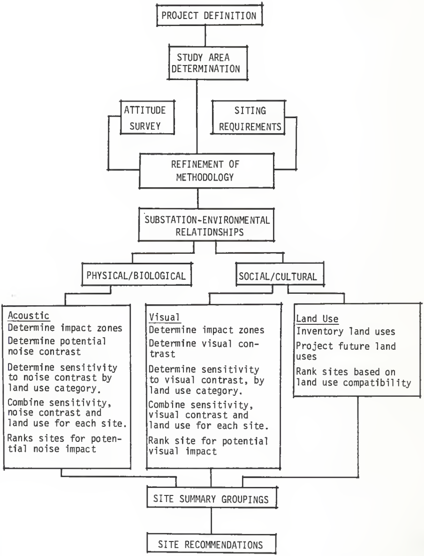
16. Ibid., p.11.

FIGURE III

SITING METHODOLOGY



Perhaps the clearest factors limiting the study area for an electrical utility company will be its jurisdiction and more specific load center, but in any case, sufficient area should be included so as not be preclude suitable sites outside the study area.

ATTITUDE SURVEY

Many aspects of human perception and sensitivity have been and are currently under study so that we may better understand the ways in which individuals perceive and respond to their environment. The existing body of literature does not adequately address the manner in which an electrical receiving station might influence the persons in close proximity to it. Thus for purposes of this study, it was useful to generate qualitative information which would identify any perceptions or responses unique to an electrical substation.

The procedure used for collecting specialized information about human perceptions of receiving stations involved sampling the attitudes of persons presently living near existing facilities. A detailed description of that qualitative survey effort is contained in Appendix A of this report.

Major conclusions reached from the survey results were the following:

Localized Effects

The location and operation of a 230kV receiving station are not likely to directly affect the lives or activities of people over a large area. A review of sensitive responses by proximity to the facilities indicates that persons living very close to a receiving station tended to develop a higher degree of sensitivity than persons who lived farther away or who experienced the facility less often due to intervening activities. These findings indicated that it is most efficient to locate new receiving stations by studying potential impacts only for people in the immediate vicinity of a proposed facility.

Visual Effects

Most persons questioned who responded in a sensitive manner stated that the visual perception of the facility was responsible for that sensitivity. The responses indicated that visual impacts are higher when a facility is viewed as a part of a residential neighborhood, or when no effort has been taken to effectively screen or otherwise mitigate the industrial character of a facility.

Noise Effects

Both the "hum" of transformers and the sharper noises associated with circuit breakers were noted as environmental effects around most of the receiving stations. Noise effects generally were noticed within an even more localized area than visual effects.

Land Use Incompatibility

Beyond such specific issues as noise, aesthetics and safety, some respondents felt that as a rule, 230kV receiving stations should not be placed in residential neighborhoods. In the location of future receiving stations, it thus appears useful to consider the overall compatibility of the facility with surrounding activities.

Adaptation

The major impacts of receiving stations on people are largely perceptual. Fortunately, most persons questioned in this study who lived near 230kV facilities did not appear to suffer adverse reactions to the facilities over the long term. Many of the "sensitive" responses were based on accounts of initial reactions to the facilities. Still, it is important to recognize potential short-term impacts and avoid or minimize them. Mitigation techniques, such as masking or screening the facility or providing a community improvement along with the facility, are useful for alleviating adverse response if somewhat incompatible locations must be chosen for receiving station development.

SITING REQUIREMENTS

This initial screening will focus on the physical, economic, social and legal factors that begin to identify the opportunities as well as constraints that are dictated by the proposed facility and the study area. Examples of some typical siting requirements might include:

* minimum acreage
* appropriate landform and geology
* proximity to existing transmission lines
* undeveloped land
* specific land ownership
* accesss to transportation
* avoidance of flood hazards

Critical siting requirements such as minimum acreage may be of such great importance to justify consideration or exclusion of certain areas regardless of environmental impact.

REFINEMENT OF METHODOLOGY

Findings of the survey were reviewed so that the details of a study approach could be developed. Three major points were reached as to the focus and strategy of the siting methodology:

1) Impacts associated with a 230kV receiving station are expected to be primary perceptual. It has been found that humans generally undergo some degree of adaptation to perceptual changes. However, it is still desirable to minimize a) the need to adapt to undesired change and b) the potential for even short-term adverse impacts;

2) Receiving stations are peceived visually and acoustically. The way to which individuals respond to those perceptions is related to the degree to which the facility contrasts with the surrounding environment;

3) In addition to site-specific evaluations of visual and acoustical perception, there is a need to establish more specific land use guidelines for siting electrical facilities within an urban setting. A land use compatibility analysis can accomplish this objective.

These three points provided starting points for development of methodologies to conduct visual, acoustical and land use compatibility analyses.

A system of rating and scoring sensitivities was developed for the visual and acoustical analyses. The critical factors incorporated in the system are the following:

1) type of activity (land use) affected;

2) type of effect (e.g., visual, or acoustical);

3) intensity of effect (e.g., the degree of contrast with the existing environment;

4) spatial area of impact;

5) anticipated perception or response of people (sensitivity).

SUBSTATION-ENVIRONMENTAL RELATIONSHIPS

The categories that comprised this investigation of substation-environmental relationships include one physical/biological component - acoustic, and two social/cultural components - visual and land use. The methodologies for these three components are briefly described below.

ACOUSTIC

This study was approached on a general level, with special field work held to a minimum. Basic sources of information included the maps of existing and future land use near the sites, sound level readings taken near an existing receiving station, the size and layout of a receiving station.

A first step was to describe noises anticipated from the construction and operation of the facility and to determine those likely to be significant. The levels of such sounds were then determined, as was a standard for identification of acceptable or unacceptable noise levels. Human sensitivity to noise in general was evaluated, followed by an evaluation of how likely people are to be sensitive in various land use categories and within various classes of background noise. An impact zone was identified for the area near each site and land uses inventoried within it. Final analysis examined the presence of sensitive land uses to the sites and some general measures that were available to reduce effects in those sites adjacent to sensitive land uses. A suitability rating was then made for each site.

VISUAL

To comprehensively describe the substation - visual relationships, the following steps were utilized:

Impact Zones

A conclusion of the survey report was that any adverse effects of receiving station are expected to be localized around the receiving station. A method for defining such a localized area was achieved through the development of visual impact zones. Distance and the degree of visibility were used as the primary factors in developing primary and secondary impact zones around each potential receiving station site. It is within these impact zones that land use categories have been inventoried and evaluated for potential visual sensitivities to receiving station placement. A detailed description of the method used in determining impact zones is contained in Chapter 4.

Visual Contrast

The visual change created by a receiving station can be measured by determining the contrast caused by that facility. This is accomplished by:

1. Describing each of the existing landscape features (vegetation, structures) in terms of the basic elements (form, line, color and texture) for each site. Other visual elements which were deemed relevant to the visual contrast analysis process were added.
2. Specifying discrete characteristics of the proposed receiving station's features that will be seen in terms of the basic elements (form, line, color and texture). To determine the degree of contrast for the proposed receiving station, compare the existing landscape to the proposed structural modification or addition to the urban landscape.
3. Assigning values that indicate degree of contrast - three for strong/high, two for moderate and one for weak/low - which

provides a relative indication of the strength of the contrast. The relative contrast values for each element are added to obtain a total contrast score for each receiving station site.

Sensitivity to Visual Contrast

Up to this point, the visual analysis has only involved the potential change which could occur to an existing environment if a receiving station were located there. As indicated earlier, there is a second component to the study of visual impact, i.e., the human response or sensitivity of the respondent.

It is assumed that people in close proximity to a receiving station are more sensitive than those at distant points where views of facilities are less dominant. It is also assumed that sensitivity diminishes as a function of the distance one moves away from the site and the amount of intervening visual clutter increases. The functions of distance and visibility as factors in sensitivity were described in the construction of visual impact zones.

An additional factor that was incorporated into the sensitivity analysis related human activity to the visual contrast of the proposed facility on an existing landscape. People may be very sensitive to the visual intrusion of a receiving station while they are entertaining in their backyard or recreating at a local park and less sensitive while at work. For the purposes of this study human activities are described by specific land use categories.

A matrix was developed which correlated: 1) the sensitivity of the various land uses with; 2) the visual contrast groupings (high to low); and 3) the potential visibility of the sites in the surrounding landscape (Impact Zones). A specific sensitivity rating for each land use within each impact zone for each visual contrast grouping was developed.

LAND USE

The land use study consists of two distinct parts - the land use inventory and the land use compatibility analysis.

Inventory

The land use inventory consisted of identifying and mapping all existing land uses surrounding the receiving station sites. This information was supplemented through the compilation of data regarding future land use in the study area.

The purpose of the land use inventory was to provide a data base for use in the analysis of each site. As such, it was necessary to compile the land use data in such a way as to maximize its utility to all aspects of the environmental analysis. For this reason, the land use information was collected and mapped within the boundaries of the impact zones established in the visual component of this study.

Existing land uses were generated based upon data collected from recent planning documents, aerial photography and on-site field investigation.

Future land use information was compiled in order to predict the manner in which currently vacant parcels of land might develop in the future. Information concerning future land use was compiled from various sources which included:

current zoning maps of the study area which provided information on types of land uses which could conceivably develop in the future;

site plans currently on file with the City of Phoenix Planning Department;

the City of Phoenix "Interim Plan to the Year 1985."

Based upon consideration of these informational sources, projections were made as to what types of future land uses might occur within the impact zones surrounding the candidate sites.

Land Use Compatibility

The Land Use Compatibility Analysis was conducted in order to assess the degree of compatibility that might be expected to exist between a 230kV receiving station and the pattern of land uses surrounding each of the sites.

Each site was rated as to whether construction of an electrical receiving station on site would result in a high, moderately high, moderately low, or low degree of compatibility with the surrounding pattern of land uses.

The ratings for each site were based upon consideration of four variables which are discussed below.

Existing Planning Departments

The City of Phoenix' conceptual plans for growth and development of the metropolitan area were reviewed in order to determine the intensity and types of land uses planned for the future in the areas surrounding the sites, and to determine whether or not construction of an electrical receiving station in these areas would be consistent with such plans.

Existing Land Use

The maps of existing land uses within the impact zones surrounding the sites were reviewed in order to document the types and distribution of land use activities that might be affected by construction of the facility.

Future Land Use

Future land use information was reviewed in order to predict the manner in which the areas surrounding the sites might develop and to identify the types of future land uses which might be affected by the receiving station.

General Compatibility Ratings

A set of general land use compatibility ratings was derived in order to illustrate the level of compatibility expected between an electrical receiving station and the types of land uses common to the study area. These ratings are based upon the functional nature of the different land use activities as well as the accepted principles of sound land use planning.

SUMMARY GROUPING

In order to integrate the findings of each of the respective resource studies, a summary grouping was developed to illustrate composite suitability ratings for each site. The sites were classified according to one of four suitability categories. These categories were established in response to the fact that the results of most studies indicated that four clearly defined groups of sites were identifiable.

CHAPTER FOUR

CASE STUDY

INTRODUCTION

The methodology discussed in Chapter 3 was applied to 13 separate sites in Phoenix, Arizona. The methodology was used in Phoenix due to the existing land use patterns which has allowed "leap frog" development and the present high growth rate of this sunbelt state that is causing blocks of vacant land to be developed.

ARIZONA SITING PROCEDURES

The Arizona Corporation Commission (ACC) administers policies on the rates and routes of public service corporations and common carriers. Three commissioners are elected for eight-year staggered terms on a statewide basis. The ACC has a very powerful legal mandate. Article XV of the state constitution describe ACC's range of activities:

> All corporations other than municipal engaged in carrying persons or property for hire, or in furnishing gas, oil or electricity for light, fuel, or power; or in furnishing water for irrigation, fire protection, or other public purposes, or in furnishing, for profit, hot or cold air or steam for heating or cooling puprposes; or in transmitting messages or furnishing public telegraph or telephone service, and all corporations other than municipal, operating as common carriers, shall be deemed public service corporations.[17]

ACC's fundamental legal authority is so extensive it has been labeled the fourth branch of Arizona state government.[18]

The utilities division, which is in charge of public utilities, is only one of six divisions. Electrical utilities are just part of the utilities devision's charge. Its authority also covers water, gas, telephone, fire, and radio communication. In all, 473 Arizona utilities come under ACC's jurisdiction.

In 1971, an 18-member Power Plant and Transmission Line Siting Committee (PP & TLSC) was established to review applications for power

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17. Arizona Constitution, Article XV, Sec. 2 (1974).

18. Bruce B. Mason and Heinz R. Hink, Constitutional Government in Arizona, 4th edition, Arizona State University, Tempe (1972), p. 192.

plants and transmission lines in order to determine their effect on the environment. The committee operates under ACC auspices, and once approval of a project is obtained from the siting committee, the corporation commission affirms the certificate of environment compatibility.

The Power Plant and Transmission Line Siting Committee's involvement in a siting decision begins when an electric company files an application and supporting exhibits for a certificate of environmental compatibility with the director of the ACC utilities division. The director, in turn refers the application and supporting information to the PP & TLSC chairman. Within ten days after receiving the application, the chairman gives public notice of hearing and submits copies of the application to the 18-member committee (Table 1).

TABLE 1

POWER PLANT AND TRANSMISSION LINE SITING COMMITTEE

Statutory Members

- State attorney general (chairman)
- State land commissioner
- Chairman, State Water Quality Control Council
- Director, Division of Air Pollution Control, State Board of Health
- Director, Game and Fish Dept.
- Executive director, State Water Commission
- Executive director, Office of Economic Planning and Development
- Chairman, Arizona Corporation Commission
- Chairman, Anthropology Dept, Univeristy of Arizona (director, Arizona State Museum)
- Director, State Parks Board
- Executive director, Arizona Atomic Energy Commission

TABLE 1 (cont.)

Appointed Members

(two-year terms appointed by ACC)

Two representatives of the public

Two representatives of incorporated cities and towns

Two representatives of counties

Registered landscape architect

The hearing date is between 30 and 60 days from the date of the public notice. The committee chairman schedules the hearing either in the vicinity of the proposed facility or at the state capital in Phoenix. Within 180 days, usually fewer, after the application is referred to PP & TLSC, written decision by a majority must approve or deny the application or impose reasonable conditions on a certificate of environmental compatibility. If the committee does not reach a decision with 180 days, then the applicant may proceed with construction.

Thirty to 60 days after the committee's decision, the corporation commission affirms and approves the certificate unless within 15 days after the decision some party requests a review of the record. Within 60 days after filing a review request, the commission reviews the record and confirms, modifies, or if PP & TLSC refused to approve the project, issues a certificate. Except for futher judicial review, the ACC decision is final.

PROJECT DEFINITION

The project to be sited in the case study was classified as a 230/69kV receiving station that will encompass an area equal to or larger than 400 feet by 700 feet or approximately 6.5 acres. The following figure (IV) illustrates a typical 230/69kV station.

FIGURE IV

TYPICAL 230/69 KV RECEIVING STATION

No attempt was made in the case study to further estimate locations of actual receiving station components within the sites, nor was there consideration given to the various component design options (i.e. high profile versus low profile). The case study involved a "typical" 230/69kV receiving station.

STUDY AREA

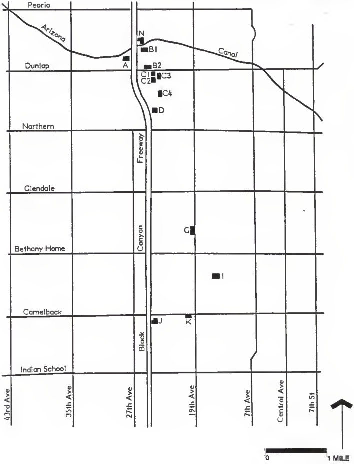
The study area boundaries were the general service area boundaries and specific load center for that particular area of Phoenix, Arizona (Figure V).

SITING REQUIREMENTS

During the development of the case study, suggestions and concerns were identified as to their use in the identification of siting opportunities. These criteria include:

FIGURE V

RECEIVING STATION SITE LOCATIONS



1. Site Size

   Equal to or larger than 400 feet by 700 feet

2. Land Ownership

   Private or public lands, except those belonging to school districts or city properties for park use

3. Land Use

   Vacant, with no plans filed; agricultural, with no plans filed; developed, but in disrepair.

4. Distance from Existing 69kV Substations

   Less than or equal to 1.0 miles

5. Physiography

   Level or levelable; outside of a wash channel

Thirteen potential stations, identified by letters in Figure V, passed the initial screening and were retained for the case study. The detailed environmental studies conducted on each of these sites are described in the following sections.

IDENTIFICATION OF POTENTIAL IMPACTS

An early effort in the study was the identification of the types of impacts anticipated to occur as a result of development of the facility.

A literature search was conducted to review previous investigations into the potential impacts associated with electrical receiving stations. This research provided no significant evidence that potential physical harm to persons or property was likely to result from siting the facility.

Health and safety hazards to the public were not anticipated to be significant due to the existence of protective standards and regulations which must be incorporated into the design of electrical facilities of this type. Thus, the likelihood of having accidents occur as a result of physical contact between individuals and a receiving station was minimal.

Displacement of persons and removal of existing structures were dismissed as potential impacts due to the stated intention to locate the proposed facility on an undeveloped parcel of land.

Considering the low level of impacts expected to result in regard to the factors just discussed, the primary impacts resulting from siting of the proposed facility was perceptual. The visual characteristics of the receiving station, noise generated by it, and its general compatibility with the surrounding human environment influenced the manner in which residents of the study area perceive the facility within their environment.

LAND USE STUDIES

The land use study consisted of two distinct parts - the land use inventory and the land use compatibility analysis.

Land Use Inventory

The land use inventory consisted of identifying and mapping all existing land uses surrounding the receiving station sites. This information was supplemented with data regarding future land use in the study area.

The purpose of the land use inventory was to provide a data base for use in the analysis of each site. As such it was necessary to compile the land use data in such a way as to maximize its utility to all aspects of the environmental analysis. For this reason, the land use information was collected and mapped within the boundaries of the impact zones established in the visual component of this study.

Existing Land Use

Existing land uses were generated based upon data collected from recent planning documents, current aerial photography and on-site field investigation.

Five major land use categories were used to describe the land uses in the study area: residential, commercial, industrial, agricultural and public/semi-public. The categories were chosen in an effort to differentiate among uses that might exhibit differing levels of sensitivity to electrical facilities. The industrial and agricultural categories are self explanatory, but further elaboration is necessary in regard to the residential, commercial and public/semi-public categories.

Residential

Traditionally, residential land uses are categorized according to density or housing type (single family, multi-family, etc.). For the purposes of this study, however, all residential land uses were treated alike. This decision was made on the basis of the results of the Attitude Survey (see Appendix A) which indicated that among individuals living in single family homes and those living in multi-family complexes, no appreciable differences existed in regard to the level of expressed sensitivity to an electrical receiving station. For this reason it was assumed that all residential land uses were characterized by the same level of sensitivity and in inventorying the land uses in the study area, no distinction was made between the various types of housing units in evidence.

Commercial

Commercial land uses within the study area were divided into two categories - "Commercial-Aesthetic Treatment" and "Commercial-No Aesthetic Treatment". The division was based upon the degree to which significant aesthetic considerations were manifested in the physical design of the particular establishments. It was assumed that a marked sensitivity toward the visual environment was implicitly expressed in the fact that certain commercial establishments have been designed to maximize visual amenities and the positive qualities of open space (aesthetic treatment) while others have not. It was assumed further that those establishments characterized by significant aesthetic treatment would exhibit a greater degree of sensitivity to the placement of an electrical receiving station than those establishments with no significant amenities.

In order to determine which commercial establishments had incorporated significant aesthetic considerations into their designs and which had not, a field investigation was conducted in which commercial establishments in the study area were evaluated in regard to the following set of design criteria:

Use of Vegetation
Diversity of Plant Materials
Water Features
Architectural Lighting
Benches
Open Space
Quality Building Materials
Aesthetic Signs
Well Maintained

Where these criteria were felt to be significantly expressed in the physical design of a particular establishment, that establishment was placed in the Commercial with Aesthetic Treatment category.

Public and Semi-Public

The Public and Semi-Public category is divided further into three more specific categories - Recreation, Transportation and Other Public and Semi-Public.

Recreation

This category is inclusive of all public parks in the study area which support either active or passive recreational activities.

Transportation

The land use categories utilized in this study are meant to be used as a tool for estimating the sensitivity of individuals involved in the particular land use activities. In this regard, the transportation corridors felt to be significant for purposes of analysis were those which served transient populations. Smaller collector streets or roads providing circulation within a local area were considered to be functions of the surrounding land use and were mapped as such. Only widely used thoroughfares such as freeways and major arterial streets were mapped under the transportation category.

Other Public and Semi-Public

Other public and semi-public uses include those areas commonly used by the public and those which provide a utilitarian service to the public. These uses are all institutional in character and include schools, churches, government buildings and public utility installations.

Land Use Breakdown

The following table (Table 3) illustrates for each site the amount of land within each visual impact zone that is devoted to each land use which was inventoried and mapped.

Future Land Use

Future land use information was compiled in order to predict the manner in which currently vacant parcels of land might develop in the future. Information concerning future land uses was compiled from various souces which included:

TABLE 3
ACREAGE BY LANO USE CATEGORY
AROUNO POTENTIAL RECEIVING STATION SITES

Site	Impact Zone	Residen-tial	Commercial		Industrial	Recreation		Trans-portation	Other Public & Semi-Public	Agri-culture	Un-developed
			Aesthetic	Non-Aesthetic		Active	Passive				
A	Primary			7.9				9.5	10.4		6.2
	Secondary	13.2	50.9	22.2				27.5	31.3	13.7	87.8
B_I	Primary								7.3	9.2	37.5
	Secondary	3.3	24.3	27.0	0.8			40.0	19.7	37.2	140.4
B_2	Primary	3.3						4.6		15.9	14.0
	Secondary	25.6	3.2	28.6				37.2	14.0	59.7	191.9
C_1	Primary	6.6						4.1		18.8	9.7
	Secondary	21.7						6.2	12.0	112.8	62.1
C_2	Primary	5.6						2.1		12.8	7.7
	Secondary	30.7						9.9	6.0	100.2	46.0
C_3	Primary							7.6		23.2	15.4
	Secondary	27.8		0.6		5.8		7.4	26.4	112.2	69.5
C_4	Primary	7.9				1.2		3.3		28.5	
	Secondary	36.5				49.8		8.5	22.7	85.7	27.1
O	Primary	5.1	1.5	2.1		4.8		7.5	1.5		7.0
	Secondary	30.4	4.4	2.7		51.5		15.7	3.3	4.4	15.7
G	Primary	7.9						3.1	0.8		
	Secondary	63.2				8.1	1.7	3.1	9.9		1.2
I	Primary	18.7									
	Secondary	68.4									
J	Primary	5.6		2.7				3.3			
	Secondary	32.5		16.6				16.6	4.6		
K	Primary	8.5	1.2	3.1				2.7	0.4		0.8
	Secondary	14.8	3.3	10.6				7.0	0.2		0.8
N	Primary		11.7	0.6				7.9	3.7		33.5
	Secondary	3.7	33.1	13.5				17.4	10.4	33.3	114.1

current zoning maps of the study area which provided information on the types of land uses which could conceivably develop in the future;

site plans currently on file with the City of Phoenix Planning Department;

the City of Phoenix "Interim Plan to the Year 1985".

Based upon consideration of these informational sources, projections were made as to what types of future land uses might occur within the impact zones surrounding the candidate sites.

Four categories of future land uses were mapped: residential, commercial, residential or commercial (in areas where no clear growth trends were identifiable); and transportation.

Land Use Compatibility Analysis

Overview

All land use activities have general attributes which stem from their respective functions, and these attributes have the potential for affecting adjacent land uses in either a positive, complementary manner or in a negative, potentially noxious fashion. As a consequence of the nature of their functional characteristics, certain land uses tend to be very compatible with one another, while others are not.

The land use compatibility analysis was conducted in order to assess the degree of compatibility that might be expected to exist between a 230kV receiving station and the pattern of land uses surrounding each of the sites.

Methodology

Each site was rated as to whether construction of an electrical receiving station on site would result in a high, moderately high, moderately low, or low degree of compatibility with the surrounding pattern of land uses.

The ratings for each site were based upon consideration of the variables which are discussed below.

Existing Land Use

The maps of existing land uses within the impact zone surrounding the sites were reviewed in order to document the types and distribution of land uses activities that might be affected by construction of the facility.

Future Land Use

Future land use information was reviewed in order to predict the manner in which the areas surrounding the sites might develop and to identify the types of future land uses which might be affected by the receiving station.

General Compatibility Ratings

A set of general land use compatibility ratings was derived in order to illustrate the level of compatibility expected between an electrical receiving station and the types of land uses common to the study area. These ratings are conceptually based upon the functional nature of the different land use activities as well as the accepted principles of sound land use planning.

The ratings appear in Table 4 and were used in conjunction with existing and future land use information in an effort to identify the degree to which the receiving station might conflict with the land uses surrounding the sites.

TABLE 4

GENERAL LAND USE COMPATIBILITY RATINGS

Land Use	Compatibility With Substation
Industrial	High
Commercial	Moderate
Institutional	Moderate
Agricultural	Moderate
Transportation	Moderate
Recreation	Low
Residential	Low

The City of Phoenix' conceptual plans for growth and development of the metropolitan area were reviewed in order to determine the intensity and types of land uses planned in the areas surrounding the sites, and to determine whether or not construction of an electrical receiving station in these areas would be consistent with such plans. Specific documents reviewed include the following:

The City of Phoenix' "Interim Plan for Phoenix to the Year 1985";

The Deer Valley Area Plan;

The City of Phoenix' "Land Use Plan 1990";

The U.S. Army Corps of Engineers' "Proposed Plan for Flood Control and Recreational Development".

Land Use Compatibility Results

The following table (Table 5) delineates the land use compatibility ratings and the rationale by site.

TABLE 5

LAND USE COMPATIBILITY RATINGS AND RATIONALE BY SITE

SITE	COMPATIBILITY	RATIONALE
A	High	Physically isolated within the land use pattern by the site boundaries - the Arizona Canal to the north, the Black Canyon Freeway to the east, the Deer Valley Water Treatment Plant to the west and Dunlap Avenue to the south.
		Physically isolated from residential districts.
		The site is adjacent to functionally similar land uses (the Arizona Canal and the Deer Valley Water Treatment Plant).
		From a land use planning perspective it would be desirable to locate the facility on this site, thereby clustering similar utility-oriented land uses and leaving other sites available for future development in keeping with city guidelines for future growth.
N	High	Site is zoned for light industrial uses.
		Physically isolated from existing and planned residential developments.
		Adjacent to functionally similar land uses (the Arizona Canal and an industrial park).
		Future land uses are likely to be industrial in the area surrounding the site.
		The proposed Cave Creek Park will be located east of the site - some portion of the land acquired for development of the substation can be devoted to recreational activities in conjunction with the proposed park.
B_1	High	Physically isolated from existing residential areas though adjacent to areas zoned for future residential development.
		Adjacent to functionally similar land uses (the Arizona Canal, an industrial park and an existing 69kV substation).

TABLE 5 (Continued)

SITE	COMPATIBILITY	RATIONALE
B_2	Moderately High	Physically isolated from dense residential areas though adjacent to an area of low density, agriculturally oriented residences to the south.
		Site lies within area expected to develop as a densely settled residential area.
		City of Phoenix discourages further development of non-residential uses along Dunlap Avenue.
C_1	Moderately High	Site is physically isolated from dense residential areas, though it lies immediately east of an area of low density agriculturally oriented residences.
		Though surrounding land is currently vacant to the north, south and east, this land is expected to develop in the future as a densely settled residential area.
		City of Phoenix discourages further development of non-residential uses along Dunlap Avenue.
C_3	Moderately High	Site is physically isolated from residential areas.
		Site lies in an area expected to develop in the future as a densely settled residential area.
		City of Phoenix discourages further development of non-residential uses along Dunlap Avenue.
C_2	Moderately Low	Site is immediately north of a densely settled residential area and east of a low density residential area.
		The site lies west and south of areas expected to develop in the future as a densely settled residential area.
J	Moderately Low	Commercial uses north of site are somewhat industrial in character (auto dealer) and are not strongly incompatible with receiving station.

TABLE 5 (Continued)

SITE	COMPATIBILITY	RATIONALE
J (cont.)	Moderately low	Dense residential development bounds site on two sides, however, and creates a functional incompatibility.
		Residential areas do not appear to be solid and transition to commercial uses could be expected.
K	Low	Area is intensively used for commercial purposes.
		Though not strongly incompatible with receiving station, its presence would preclude more intensive use of the land which would be more appropriate within the context of the area.
D	Low	Dense residential area to the north.
		Multi-family condominiums being built to the east.
		Golf course to the east.
		Aesthetically treated commercial area to the south.
I	Low	Area dominated by residential uses.
		New multi-family housing anticipated.
		Proposed freeway corridor runs through area.
G	Low	Area dominated by higher value residential uses in a very dense pattern.
C_4	Low	Dense residential west of site.
		New multi-family immediately to south.
		Golf course to south.

DEVELOPMENT OF VISUAL IMPACT ZONES

Introduction

Impact zones were developed to provide a basis for analyzing the degree to which a receiving station would impact upon the environment. A number of relationships have been defined and assumptions made in order to describe the human environment within the impact zones.

The relationships and assumptions are:

1. Impact zones vary with the physical characteristics of the urban landscape in which an installation occurs.
2. Impact zones are those areas in which a certain percentage of the height and width of a proposed facility may be seen from varying viewing distances. It is assumed that negligible visual, land use, economic or sociological impacts will occur outside of these zones.
3. Impact zones are the result of combining two essential pieces of information: the degree of visibility of a proposed facility in an existing environment; and the distance between a potential observer and a proposed facility.

Methodology

Determining the perceptibility of an object in a landscape is an interactive process in which both the object and setting characteristics play important roles. The sphere of visual influence of an electrical receiving substation in an urban setting is modified by the size, shape and location of existing structures, vegetation and topographic features. The size, shape and orientation of a receiving station are also important considerations.

The percent of visibility of a receiving station placed on each site was determined by the following steps:

1. A base map composed of City of Phoenix central file photos at a scale of 1:1200 was used to cover each site and its surrounding area.
2. A receiving station was placed on the site and assumed to cover most of the area of that site. It was assumed that the receiving station components started 50' in from the site boundary length and 25' in from the site boundary width. Using these measurements, plus the maximum height of the tallest receiving station component, a cuboid was placed in each site to represent the extreme limits of physical space that would be occupied by the receiving station.
3. Lines were projected from the widest corners of the proposed receiving station to the corners of existing structures surrounding the receiving station. This process revealed areas from which the receiving station would be one hundred percent visible, and partially visible areas from which the station would not be seen at all. One hundred percent visible may be defined as those areas from which the proposed receiving station would be totally seen; its entire width and height.
4. The screening capability of vegetative masses was determined using the same process described in Step 3.
5. The result was a map (see Figure VI) which depicts the area of visibility around a receiving station alternative site in terms of one hundred percent visibility, partial visibility and not seen.

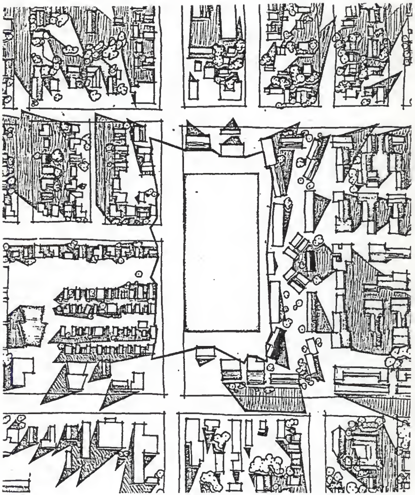


FIGURE VI

VISIBILITY OF A RECEIVING STATION AT A HYPOTHETICAL SITE

100% Visibility

Not Seen

Rest is partial visibility.

The sites located in densely urbanized areas quickly became "not seen" when the distance from the site increased because of the density of structures and vegetation occurring in surrounding neighborhoods. The apparent size of an object and the subsequent visual influence diminishes with distance. Therefore, it was necessary to establish a distance function to modify the substantial areas of visibility occurring around several of the receiving station site alternatives.

A mathematical model to establish distance zones thresholds, the trigonometric function relating angular height to receiving station height and distance from the facility was utilized in the following manner:

1. The first zone was established at a distance which represented the closest reasonable viewing distance to a potential receiving station on a candidate site. A 137' distance represented being on a sidewalk across a major arterial street from a receiving station. The threshold for this first distance zone was established at the point where the apparent angular height of the tower was reduced by one half. That point occurred 275' from the receiving station. Distance zones are illustrated in Figure VII.
2. In each of the subsequent distance zones, the apparent angular height of the proposed facility was reduced by one half as the boundary of each of the zones doubled its distance from the site. This relationship is illustrated in the top line of Table 6.

Results

A correlation between distance zones and percent of visibility was established to determine Impact Zones. This correlation is shown in Table 6.

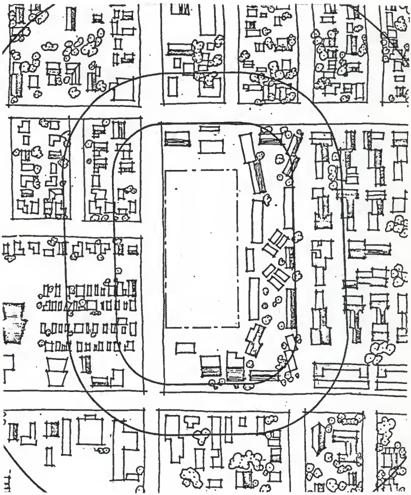


FIGURE VII

DISTANCE ZONES AROUND A HYPOTHETICAL RECEIVING STATION

TABLE 6

CORRELATION BETWEEN DISTANCE ZONES

AND VISIBILITY

Distance	275'	550'	1,100'	2,200'	4,400'
Angular Height	11.31^0	5.71^0	2.86^0	1.43^0	0.72^0
Visibility					
100%	Primary	Primary	Secondary	Secondary	-
Partially Visible	Primary	Secondary	Secondary	-	-

The determination of the threshold between primary and secondary impact zones was established through field testing at an existing receiving station site in Phoenix, and a literature search of research dealing with visual acuity.[19]

Information from the above sources suggests that visual acuity of the human eye diminishes by more than fifty percent within a 5^0 angle. Therefore, the hypothesis is that any seen structure with an angular height greater than 5^0 is a conspicuous and dominant element in the urban landscape. Examination of Table 6 reveals that a distance of approximately 550 feet from a proposed receiving station that is totally visible represents the 5^0 angular threshold. Therefore, that distance is the threshold of the primary impact zone. If the receiving station is only partially visible from a distance of 550 feet, it is less dominant, its angular height and width would be reduced and there would be less overall potential for visual impact. A receiving station only partially visible from viewing points at a 550 foot distance places the viewing point in the secondary impact zone.

19. Julian E. Hochberg, Perception, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 25.

The above discussion revealed that at a distance of 550' or closer, a receiving station's elements are larger than surrounding features and dominate the scene. With increased distance from the facility, its image size drops until a point is reached where its visual influence is less than or equal to any part of the urban landscape. This point is the outside boundary of the secondary impact zones. The secondary impact zone boundary for a one hundred percent visible receiving station was derived from research conducted by Jones and Jones, Seattle, Washington.[20] One of their conclusions was that "at the point at which the object can be perceived in a single glance or fixation of the eye is the threshold between high and medium relative visibility. We could predict this threshold to correspond to an image size of 1.0 to 1.5°, . . ."[21] In an urban landscape, there are many features of 1° in size. The eye will not fixate on the receiving station, but rather on some other more dominant feature in the nearground. It is still detectable, but not an obvious element. Inspection of Table 6 reveals that a distance of 2,220 feet can be estimated to be the outside boundary of the secondary impact zone for a receiving station which is totally visible. A partially visible receiving station would have a reduced angular height or width and implies a reduced overall visual impact. A receiving station, partially visible from viewing points at a distance of 2,200 feet was judged to have a negligible visual impact and those viewing areas were not included in the secondary impact zone.

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20. William G. E. Blair, Brian A. Gray, John A. Hebert and Grant R. Jones, Visual Impact of High Voltage Transmission Facilities in Northern Idaho and Northwestern Montana, for the Bonneville Power Administration, Jones & Jones, Seattle, 1976.

21. William G. E. Blair, Brian A. Gray, John F. Ady, Edward C. Driscoll, Jr., Measuring the Visibility of High Voltage Transmission Facilities in the Pacific Northwest, for the Bonneville Power Administration, Jones & Jones, Seattle, 1976, p. 32.

To summarize, the inference is that highly visible receiving stations are those that require scanning movements of the eye. As the receiving station image becomes smaller, other stimuli fill the eye. These other detailed inputs begin to compete for attention and impact is reduced. Table 6 correlates the distance zones and the percent of visibility of a receiving station to determine the thresholds for primary and secondary impact zones.

In the application and mapping of the visibility, distance zones and final impact zones, ground checks were performed. At this point, any minor modifications to the impact zone boundaries due to such considerations as orientation of buildings and characteristics of window placement, fences or other features were made. An example of the composite impact zone is shown in Figure VIII.

VISUAL CONTRAST ANALYSIS

Introduction

Visual impact in an urban area may be defined as a perceivable physical change to the urban landscape, that results in a negative human response. The definition breaks the study of visual impact into two basic parts; the first dealing with the perceived visual change and the second considering the resultant human response.

A change in the visual landscape is initiated by the perceptible addition and/or removal of elements in the landscape. With specific reference to electric power facilities, additions would include towers, the lines they support and stations for generation, transmission and distribution. Elements commonly removed by electrical installations may be vegetation, agricultural crops and occasionally buildings or other man-made structures. These all result in perceivable physical changes. The degree of

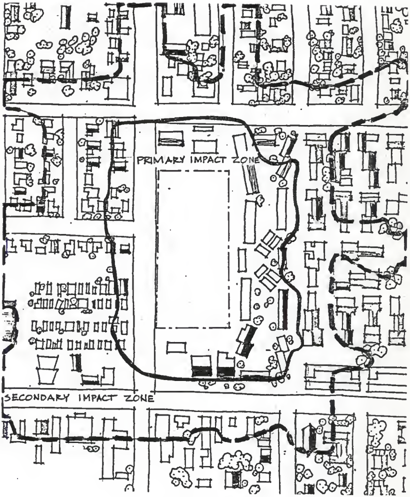

FIGURE VIII

COMPOSITE VISUAL IMPACT ZONES

change is not constant, but varies according to characteristics of both the installations and the landscape in which they occur.

Such changes, or even anticipation of them, can elicit human response. This degree of response is determined by the sensitivity of the respondent and is predicated on the values people place on their local visual landscape.

Background and Assumptions

Several approaches for predicting visual change have been developed in recent years by federal and state government agencies, universities and private interests. These methods have been designed to be utilized as part of a comprehensive environmental study and/or on a stand-alone basis. The Visual Absorption Capability (VAC) rating system of the U.S. Forest Service Visual Management System (VMS) and the Visual Resource Contrast (VRC) rating system of the U.S. Bureau of Land Management Visual Resource Management (VRM) system are two such methods for determining visual change.

The BLM VRC rating system was modified to meet the specific needs of this study, i.e., the introduction of an electrical receiving station into an urban area. For the remainder of this report, the modified BLM system will be referred to as the Visual Contrast Analysis process.

The purpose, basic philosophy and methodological descriptions of the visual contrast process is paraphrased and in some cases taken verbatim from the BLM Manual 8431.[22]

22. United States, Department of Interior, Bureau of Land Management, Manual 8431-Visual Resource Contrast Rating, no date.

Purpose

The purpose of the Visual Contrast Analysis process is:

to provide a measure by which the amount of change to an existing urban visual environment by the proposed receiving station can be determined; and

to indicate the visual features or elements of a proposed activity which need to be modified to reduce the amount of change to the surrounding environment.

Basic Philosophy

The degree to which a management activity (in this case the introduction of a receiving station) adversely impacts the visual quality of the landscape depends upon the amount of visual contrast that is created between the activity and the existing landscape character. The amount of contrast between a receiving station and the existing urban landscape can be measured by separating the landscape into its major features (vegetation and structures) and then predicting the magnitude of change in contrast to each of the basic elements (form, line, color and texture) for each of the features. Assessing the amount of contrast of a substation in this manner will indicate the severity of impact and serve as a guide in determining what is required to reduce or mitigate the contrast to acceptable levels.

Method

The visual change created by a receiving station can be measured by determining the contrast caused by that facility in each of the basic elements. This is accomplished by:

1. Describing each of the existing landscape features (vegetation, structures) in terms of the basic elements (form, line, color and texture) for each candidate site. Other visual elements which were deemed relevant to the visual contrast analysis process were

added. Table 7 defines the terms and provides a word list for describing the landscape.

2. Specifying discrete characteristics of the proposed receiving station's features that will be seen in terms of the basic elements (form, line, color and texture). To determine the degree of contrast for the proposed receiving station, compare the existing landscape to the proposed structural modification or addition to the urban landscape.
3. Assigning values that indicate degree of contrast - three for strong/high, two for moderate and one for weak/low - which provides a relative indication of the strength of the contrast. The relative contrast values for each element are added to obtain a total contrast score for each receiving station site.

This three step method was utilized to determine the relative visual contrast for each receiving station site. The results for each site are reported on individual worksheets. As indicated on the worksheets, structural features of the urban landscape take precedence over vegetation. Additional comments were added at the bottom of the worksheets as appropriate.

Application and Results of Visual Contrast Analysis

All sites were inventoried for their existing character. This procedure was accomplished by standing in the middle of a proposed site and noting on the worksheet the characteristics of the elements which occurred in the surrounding landscape. These descriptions utilized the standardized terminology developed for the study and defined in Table 7.

TABLE 7

DEFINITIONS AND TERMINOLOGY

Vegetation

A description of the degree of vegatative cover, specific types of vegetation and the overall form, line, color and texture created by vegetation patterns. Also, the description should consider the capability of existing vegetation to screen a proposed receiving station from view.

Structures

Form - The shape of the overall mass of the structures defined by lines, as opposed to the material of which it is composed. Describe the overall form in terms of: cubical, rounded, flat roofed, sloping, domed roofed, horizontal and/or cylindrical.

Line - An intersection of two planes. Single edges can indicate directional movement. Describe the lines that are created by structures as: horizontal, vertical, angular, peaked or rounded.

Color - A phenomenon of the spectral reflectance of light that enables one to differentiate otherwise identical objects, a hue. Describe the prevalent color or colors of the features in terms of the hue (red, brown, etc.), the intensity (bright, dull) and the value (purity).

Texture - The visual or tactile surface characteristics of individual structures or the clustering of a distant group of buildings and their spacing, in relation to the whole scene. Describe the texture of the structures as smooth, coarse, fine or rough and describe the distribution of light/dark over the surfaces.

Other elements that define visual characteristics of the landscape

Diversity - Land use diversity is a description of the number and relative areal distribution of land uses within view of the proposed activity.

Scale - The height of dominant elements and relative sizes of individual elements in the surrounding landscape defines scale.

Spatial Enclosure - The proportion of wall height to floor expanse, the nature of the enclosing walls and floors (hard, soft, complex), good proportion, clarity of form and degree of enclosure describe the relationship between vertical and horizontal elements.

Integrity -
(character) The degree to which individual elements join together to form a single, coherent, harmonious visual unit describes integrity. Unity or congruence describes the visual coherence and compositional integrity, the level of compositional harmony or visual intercompatibility of the individual elements which comprise the viewscape.

Other
Remarks - Additional comments which are relevant to the visual characteristics of a candidate site may be added here. These comments could describe long views or the location of existing electrical facilities.

As mentioned above, vegetation was described by its form, line, color and texture and also its screening capability. Long views and vistas, particularly to mountains and the proximity to existing transmission facilities were noted under Other Remarks.

Following the inventory, the proposed site was again inventoried, only with the discrete operational and physical characteristics of the receiving station in mind. A comparison of the existing landscape to the proposed structural modification or addition to the landscape was noted and assigned a relative contrast value for each of the elements. The contrast values were added to obtain a total contrast score for each receiving station site. Table 8 presents the results of the contrast rating process for each site.

As the worksheets in Table 9 depict, the actual contrast scores ranged from 11 to 20 within a theoretical range of 8 to 24. Sites which had the same contrast score or deviated from one another by only a few points were grouped together. Table 8, Visual Contrast Analysis Results, lists the groupings of the sites according to the relative degree of contrast each would display if a receiving station were located in that site.

TABLE 8

VISUAL CONTRAST ANALYSIS RESULTS

Potential for Visual Contrast	Sites
Highest	G, J
Moderate	C_2, C_4, D, I, K
Least	A, B_1, B_2, C_1, C_3, N

Human Sensitivity to Visual Contrast

Up to this point, the visual analysis has only been discussing the potential change which could occur to an existing environment if a receiving station were located there. As indicated in the Introduction, there is a second component to the study of visual impact, i.e., the human response or sensitivity of the respondent.

It is assumed that people in close proximity to a receiving station are more sensitive than those at distant points where views of facilities are less dominant. It is also assumed that sensitivity diminishes as a function of the distance one moves away from the site and the amount of intervening visual clutter increases. The functions of distance and visibility as factors in sensitivity were described in the construction of visual impact zones.

TABLE 9

VISUAL CONTRAST WORKSHEETS

STEP 1. Site Description (as it exists) · SITE: A

Vegetation (indicate degree of vegetative cover, types, form, line, color, texture, etc.)

Very little vegetation around site.
No screening opportunities with vegetation.

Structures

Form - Very blocky, cubical to the north (Metrocenter); horizontal rectangular to the south (Fed Mart); domed (amusement park along freeway).
Line - Horizontal (Fed Mart, canal, freeway); vertical lines of poles and elements of Metrocenter.
Color - Broad red band (along Fed Mart building); horizontal and white, concrete (of Metrocenter).
Texture - Coarse, buildings spread out; trucks in back of Fed Mart and cars at Denny's Restaurant.
Diversity - Moderate degree of diversity: commercial, canal, open and vacant, water treatment plant.
Scale - Very little to relate to human scale; large and coarse.
Spatial Enclosure - Little enclosure created by existing structures, to create a distance between structures.
Integrity - Very litte, no coherence or visual harmony among existing elements of the landscape.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Same form created by proposed receiving station, blocky, cubical.	1
Line - Horizontality and verticality of structural members of receiving station added to a low, flat landscape.	2
Color - Will add to diversity of colors, minimally; same basic colors, low, flat landscape already exist, browns, grays of various shades.	1
Texture - Coarseness of receiving station will not change texture of surrounding area.	1
Diversity - Will add to the diverseness of the area which is already used by utilities (canal and poles).	2
Scale - Will add to the lack of human scale.	1
Spatial Enclosure - The receiving station will fill the space defined by Fed Mart water treatment plant and the canal.	2
Integrity - Receiving station will not change the lack of existing visual harmony (which is low).	1
	11

TABLE 9 (Continued)

SITE: A

Other Remarks

- Generally an open site; Metrocenter and Fed Mart place some visual boundaries, but views open east and west.

- Good closeup views to mountains partially obstructed by 69kV pole line along canal.

- Canal has poles on both sides of it.

STEP 1. Site Description (as it exists) SITE: B_1 (along canal)

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

Scattered, low deciduous shrubs to the north across the canal; large deciduous trees to the east; no opportunity for screening.

Structures

Form - Not many forms in immediate vicinity of site, horizontal plain, rectangular shapes from existing substation and distant buildings.
Line - Vertical line from existing transmission poles; horizontal strengthened by existing conductors.
Color - Bright, light-colored metallic colors of conductors and house trailers, desert colors.
Texture - Generally open; coarseness created by existing receiving station and north to Corporate Center, fine-moderate throughout rest of area.
Diversity - Diverse at a distance from site (utilities, residential, trailer, industrial) but only agriculture in the immediate vicinity.
Scale - Very little scale definition provided by 69kV lines.
Spatial Enclosure - Few elements to define space, open site.
Integrity - Homogeneous around immediate site (largely agriculture), but to a lesser degree at a distance from the site boundaries.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Has similar form to blocky, long structures located at a distance from site.	1
Line - Adds vertical elements, but many transmission poles already close to site add horizontal elements above ground plain.	2
Color - Adds little additional color to area.	1
Texture - Coarse texture similar to existing.	1
Diversity - Adds to diversity, additional change over of agriculture uses to utility uses.	2
Scale - Very little at present, in scale with utility poles along canal.	1

STEP 2. SITE: B_1 (along canal)

Spatial Enclosure - Wide open site, does not help define any spaces. 1
Integrity - Change in visual harmony of agricultural activity to a utility use, existing utility elements in close proximity. 2

11

Other Remarks

- Very open site, good views to mountains are basically unobstructed.
- Small distributing station exists close to site, good transmission accessibility to 69kV line along canal.

STEP 1. Site Description (as it exists) SITE: B_2 (along Dunlap Road)

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

Old orchard, deciduous shrubs and trees along Dunlap on south side of street; vegetation distant to the east, almost nonexistent to the north and west; no opportunity to screen proposed receiving station.

Structures

Form - Some blackiness to the south, layer structures (Corporate Center and Metrocenter) cubical, blocky scattering of horizontal structures to the south and southeast.
Line - Mixture of horizontal and vertical; irregular.
Color - Mixed colors - Corporate Center brown and tan, Metrocenter tan, brighter colors to the west.
Texture - Somewhat coarse, large structures not pulled together, scattered about; texture modified by single family (finer).
Diversity - Somewhat diverse, agriculture, single family; commercial and office in the distance.
Scale - Closeness of single family homes add to the human scale, otherwise there is little to relate to.
Spatial Enclosure - Very little created, open on three sides.
Integrity - Very little, the many uses occurring nearby do not create visual unity.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Potential for the same type of form, but the existing structures are distant from the site. 2
Line - Adds strong statements of vertical and horizontal lines. 2
Color - Same colors as existing distributing station, other earth toned structures in distance. 1
Texture - Coarse texture similar to what is there. 1

STEP 2. SITE: B_2 (along Dunlap Road)

Diversity - Adds to diversity of area, agricultural use to utility.	2
Scale - Not much presently, but single family homes will be dominated by size of proposed receiving station.	2
Spatial Enclosure - Does not detract or help form spaces.	1
Integrity - Adds to an already disharmonious area.	1
	12

Other Remarks

- Heavy vehicular traffic along Dunlap.

- Some open views to mountains to the north and east.

- Existing transmission poles along canal and Dunlap Road.

STEP 1. Site Description (as it exists) SITE: C_1 (23rd Ave. and Townley)

Vegetation (indicate degree of vegetative cover, types, form, line, color, texture, etc.)

Old orchard to the west, other scattered deciduous trees around parameter of site.

Structures

Form - Square ends of trailers and rectangular structure of corporate center in distance; rectangular single family homes with sloping roofs.
Line - Somewhat horizontal, but not strong; vertical pole along Dunlap Road.
Color - Light white trailers in distance; multi-colored houses.
Texture - Not many structures to give texture, but mod-fine texture created by distant structures.
Diversity - Mostly vacant, some residential, agriculture.
Scale - Some residences to the west to create human scale.
Spatial Enclosure - Very little, open on three sides.
Integrity - Somewhat mixed, site contains refuse piles, agriculture and residential closs poles along Dunlap Road.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Form somewhat different, addition of blocky, cubical shapes.	2
Line - Somewhat changed, strong horizontal and vertical added.	2
Color - Minimal change in color.	1
Texture - Addition of a coarse texture into an area that does not have any existing structures.	2

STEP 2. SITE: C_1 (23rd Ave. and Townley)

Diversity - Adds a land use which is not well represented in the area.	2
Scale - Not much to compare change in scale to.	1
Spatial Enclosure - Does not help to create space, nor does it impinge on existing space.	1
Integrity - Visually inharmonious site, unity of site and surroundings slightly changed by receiving station.	1
	12

Other Remarks

- Distant view of mountains through poles and lines to the north and east.

- Very little to define this area visually other than it is rural, open, vacant, or farmland with some residential close by.

STEP 1. Site Description (as it exists) SITE: C_2 (Alice and 23rd Ave.)

Vegetation (indicate degree of vegetative cover, types, form, line, color, texture, etc.)

Old orchard to the west, other scattered, deciduous trees around parameter of site.

Structures

Form - Square ends of trailers and rectangular structures of corporate center in distance; rectangular single family homes with sloping roofs in close proximity.
Line - More horizontal houses to the south than C_1, fences to the west.
Color - Light white trailers in the distance; multi-colored houses in close proximity to the site.
Texture - Not many structures to give texture; moderately fine texture of residential area and distant structures.
Diversity - Closer to single family residential to the south and large acreage residential to the west.
Scale - Residential on two sides of site creates some scale.
Spatial Enclosure - Space defined by residential (and vegetation) on two sides of site.
Integrity - Somewhat mixed, site used as a refuse dumping area; agriculture and residential close by.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Addition of large, blocky, cubical shapes, some cylindrical shapes.	2
Line - Strong horizontal and vertical elements added.	2
Color - Minimal color change.	1

TABLE 9 (Continued)

STEP 2. SITE: C_2 (Alice and 23rd Ave.)

Texture - Addition of coarse elements to a finer textured area. 2
Diversity - Basically residential or vacant, agriculture across street adds to diversity of area. 2
Scale - Close to human scale because of residential land uses nearby; addition of receiving station which is not related to human scale. 2
Spatial Enclosure - Better defined than in C_1; receiving station fills space and removes it. 2
Integrity - Visually inharmonious site and surrounding area slightly changed by receiving station character. 1

14

Other Remarks

- Distant view to mountains to the north and east.

- In close proximity to residential land uses to the south and west.

STEP 1. Site Description (as it exists) SITE: C_3 (23rd Ave. and Dunlap)

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

Few scattered trees along irrigation ditch on west side of site. All of their vegetation is in the background and forms masses.

Structures

Form - Blocky, closest to site are single family residential, large blocky and horizontal in the distance (school and church).
Line - Horizontal; vertical poles on 2 sides of site.
Color - White of trailers, tan, light, white roofs.
Texture - Because of distance of the structures, the texture is moderate.
Diversity - Very little on actual site, agriculture, vacant; distance areas are developed.
Scale - No scale definition, tall poles.
Spatial Enclosure - All views are to distant features, blends into a visual whole.
Integrity

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Addition of a blocky, cubical form. 2
Line - Somewhat of a change, mostly vertical elements added, some poles horizontal. 2
Color - Minimal change to color. 1

TABLE 9 (Continued)

STEP 2. SITE: C_3 (23rd Ave. and Dunlap)

Texture - Coarse texture added to area.	2
Diversity - Add to diversity of an area which is not very diverse.	2
Scale - Detracts very little because very little scale defining elements exist.	1
Spatial Enclosure - Does not define space nor detract from the space.	1
Integrity - Distant views across agriculture or open space detracted from introduction of receiving station.	2
	13

Other Remarks

- All structures are at a good distance from the site.
- Good, clear views to mountains, only obstructions are structures along 19th Avenue and poles along Dunlap.
- Utility poles along the canal to the north are visible.

STEP 1. Site Description (as it exists) SITE: C_4 (Butler and 23rd Ave.)

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, ect.)

Large, deciduous trees at some distance to the east, mixture of deciduous and palms to the west, gold course (open), few trees, to the south, little opportunity for screening.

Structures

Form - Blocky, cubical, sloped roofed to the west, angular, rectangular to the south; rectangular and horizontal at distance to the east.
Line - Mostly horizontal, some vertical in light standards of school and utility poles.
Color - Mixed color of residential, all rather opaque, light (white, green, tan), interspersed with darker green of vegetation.
Texture - New structures will create moderate to fine light and dark patterns; single family and vegetation blends to a moderately fine texture; coarse in background.
Diversity - A fair amount of diversity among uses; single and multi-family, golf course, agriculture. Trailers and school in the background.
Scale - Basically low (human scale) however, utility poles and vegetation along west side add vertical height.
Spatial Enclosure - Some sense of enclosure from two sides (west and south), open to the north and east. A somewhat defined space.
Integrity - Somewhat mixed, extablished residential clashes with contemporary design of multi-family, agriculture and vacant being replaced by development.

TABLE 9 (Continued)

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Somewhat same shapes, i.e., blocky, cubical, but substation open, more defined (hard edges) and some cylindrical shapes.	2
Line - Greater degree of verticality added, transmission lines coming into receiving station at various angles.	2
Color - Add to diversity of existing colors; flat, non-metallic gray, brown of creosote wood poles, shiny aluminum of poles; minimal change.	1
Texture - Coarseness added to area, coarseness appears in the open spaces between members of receiving station.	2
Diversity - The area has a fair degree of existing diversity, more is added by putting area to a utility use.	2
Scale - Two story structures and utility poles create the same scale, however, most of area is human scale vs. size of structural members of receiving station.	2
Spatial Enclosure - Placement of a structure which is made up of separated members into a somewhat defined space does not help define space, but changes it.	2
Integrity - Established single family and new contemporary structures each have their own congruent character; receiving station character depreciates the visual integrity of these areas.	2
	15

Other Remarks

- Open to long views of the mountains to the north and east.

- Power lines along canal to north are visible, also other lines along Dunlap and 23rd Avenue.

STEP 1. Site Description (as it exists) SITE: D

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

Low (less than 20'), intermittent and widely spaced to the south, scattered palms (35') and massed deciduous trees to the north and a dense continuous line of deciduous trees and palms across freeway to the west.

Structures

Form - Blocky, cubical, low; sloping roofed.
Line - Strongly horizontal, angular, broken horizontal (some spaces between); vertical picked up in the architecture of the post office and new multi-family housing.

TABLE 9 (Continued)

STEP 1. SITE: D

Color - Muted, subdued, light white to some brown.
Texture - Fine (closely spaced houses) to the north; rest of area is coarse (spaced out buildings and dark/light spaces on facades).
Diversity - Single family, multi-family, public, commercial, freeway, diverse area.
Scale - Some two story structures, mostly low and horizontal.
Spatial Enclosure - Degree of horizontal to vertical is high, not a totally defined space.
Integrity - New buildings, clean lines, architectural style is contemporary, no overhead lines to the south; established single family residential and overhead lines to the north; new two story multi-residential at northeast corner, contemporary.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Form - Not much contrast, particularly with new structures, strong statements in form already exist.	1
Line - Major contrast in vertical elements which would be added.	3
Color - Addition of colors not present in area, metallic finishes.	2
Texture - Coarseness of receiving station elements contrasts with single family.	2
Diversity - Mixture of land uses already exists, addition of one more not a major event.	1
Scale - Elements of receiving station of larger mass than existing scale.	2
Spatial Enclosure - Receiving station fills and eliminates this moderately defined space.	2
Integrity - Entire site is not congruent, but separate pieces are; adding industrial structure to area that is architecturally designed.	3
	16

Other Remarks

- Area is diverse, semi-open, visible site; views to mountains in east are uninhibited, views to mountains through trees and electrical poles to the northeast.

- Residential area is homogeneous and the commercial area and post office are homogenous - together the entire site appears diverse.

STEP 1. Site Description (as it exists) SITE: G (19th Ave. and Maryland)

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

A fair amount of vegetation around the parameter of site; potential to screen views to site but they are low in height.

TABLE 9 (Continued)

STEP 1.

SITE: G (19th Ave. and Maryland)

Structures

Form - Rectangular with sloping roofs on three sides, definite cubes on the east side of site.
Line - Mostly horizontal, although broken by utility poles and vegetation; east side some vertical elements.
Color - Light, bright, white, cream to tan.
Texture - Medium to fine; although vegetation breaks up uniform textures, they themselves are moderate to fine.
Diversity - Little land use diversity; single family on three sides, multiple, P.U.D. on the east side.
Scale - Human scale, nothing over two stories, utility poles run around entire site.
Spatial Enclosure - Definite enclosed space, but walls are low and floor expanse is large.
Integrity - High level of integrity single family and P.U.D. is a unit.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Blocky, cubical forms added, slight similarity to existing forms.	2
Line - Adds more horizontal elements stronger vertical elements.	2
Color - Metallic added, darker tones.	2
Texture - Coarse texture added to a predominantly moderate to fine.	2
Diversity - Adds an element which is not similar to existing uses, the area around the site is not diverse.	3
Scale - Adding a non-human element into a human scaled environment.	2
Spatial Enclosure - The receiving station would fill and eliminate this well defined space.	3
Integrity - Adds change to a visually congruent area.	3
	19

Other Remarks

- Large office structures going up within two blocks, will have clear view into site.

- Views to mountains blocked or screened by existing structures and utility poles.

TABLE 9 (Continued)

STEP 1. Site Description (as it exists)   SITE: I

Vegetation (indicate degree of vegetative cover, types, form, line, color, texture, etc.)

On the site is a large grove of palms (10-30' high); around the site is a mixed patter of taller palms and deciduous, nothing to act as a visual screen to site.

Structures

Form - Very mixed, some rectangular, some cubical, cars parked around site are cubical, some angular roofs, some flat.
Line - Somewhat horizontal broken up by vegetation and a lot of utility poles.
Color - Light colored, earthy tone, cream, light olive.
Texture - Coarse and mixed, stationary cars are coarse.
Diversity - Land use is not all that diverse, generally single family or multi-family.
Scale - Land scale, nothing taller than two stories, vertical elements are utility poles and vegetation.
Spatial Enclosure - Not a well defined site.
Integrity - Little visual integrity, many visually disrupting elements.

STEP 2. Site Oescription, (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Would slightly change area.	1
Line - Additional vertical elements added.	2
Color - Darker color of substation elements would be inappropriate.	2
Texture - Diverse: fine to moderate to coarse.	1
Diversity - Existing land use diversity not great, would create change.	2
Scale - Longer scale of receiving station would dominate the area.	3
Spatial Enclosure - Would fill most of the site which is not a well defined enclosure.	2
Integrity - No visual integrity exists so there is little to change.	1
	14

Other Remarks

- The whole site is visually very incongruent, no housing or patterns emerging.

- Visually very disconnected surroundings, nothing to key on few (if any) regular patterns established. View to Squaw Peak filtered by utility poles; some partial views to central corridor high rises.

- Lot of building activity in poles.

TABLE 9 (Continued)

STEP 1. Site Description (as it exists) SITE: J

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

- Some verticality in the palm trees, mixed: shrub to palm trees.

- Some pine partially screening freeway.

- Vegetation is not well maintained.

Structures

Form - Cubical, blocky, rectangular; flat to sloping roofs.
Line - Horizontal, angular; vertical elements (light standards, flag poles).
Color - Light tones, bright.
Texture - Mixed: fine to moderate (west, south and east) in residential area; coarse north of site.
Diversity - Half of area is single family residential; mixed residential, commercial and freeway around remainder of site.
Scale - Low, one-story structures immediately around site, at a human scale.
Spatial Enclosure - Taller buildings to northwest somewhat closes area in; basically semi-open, few space defining elements.
Iintegrity - Mixed bag of residential, some degree of similar architectural style and condition, some maintenance required.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Rectangular, blockiness, same as around site.	2
Line - More emphasis on vertical elements.	2
Color - Flat gray, brightness of aluminum poles contrasts with existing colors.	2
Texture - Coarse, open, mass of large elements is a great change to area.	3
Diversity - Area fairly diverse, mostly residential, receiving station will add a new element to area.	2
Scale - Massiveness of substation, contrasts with scale of neighborhood.	3
Spatial Enclosure - Fills most of space.	2
Integrity - Character of commercial little affected, but residential would be.	2
	18

Other Remarks

- Flat, open site ringed by variety of land uses (single family through multi-family, freeway and auto dealerships), single family homes homogeneous shape, size, maintenance.

TABLE 9 (Continued)

Other Remarks SITE: J

- Some limited viewing to mountains, however, views are disrupted by existing 69kV transmission line and light standards in car dealerships yards.

STEP 1. Site Description (as it exists) SITE: K

Vegetation (indicate degree of vegetative cover, types, form line, color, texture, etc.)

Hedge row of shrubs bording the apartments to the south, some taller trees in hedge row.

Scattered in other direction, nothing on site itself.

Structures

Form - Rectangular (apartments to the south, buildings to the east) flat roofed; cubical sloping roofs to the north, also rectangular trailers north; large blocky structure to west.
Line - Horizontal buildings and fences, minor verticality of building to west.
Color - Light tan, earth tones of apartment and buildings, brighter colors north and east.
Texture - Coarse textures (dark inside doorways, lighter outside) rest of site is coarse.
Diversity - Area quite diverse (apartments, trailers, single family, commercial, transportation).
Scale - Somewhat in a human scale, nothing over two stories within close proximity to.
Spatial Enclosure - A definite, defined space, hard edges; totally enclosed except for gaps to the north.
Integrity - Very little integrity; many land uses, diverse area and character; some new structures, some older and not maintained.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Somewhat similar forms, scale difference.	2
Line - Addition of vertical lines will change, existing horizontal not strong.	2
Color - Diverse colors exist, adding more will cause little change.	1
Texture - Similar texture to what exists.	1
Diversity - Receiving station will fit into this diverse area.	1
Scale - Receiving station will dominate the existing human scale.	3
Spatial Enclosure - The space will be eliminated.	3

STEP 2. SITE: K

Integrity - Very little integrity exists, will create little change. $\frac{1}{14}$

Other Remarks

- Flat site ringed by a variety of land uses.
- Some limited views to Squaw Peak, telephone and power lines around site impact view to peak.

STEP 1. Site Description (as it exists) SITE: N

Very little vegetation.

Vegetation (indicate degree of vegyetative cover, types, form, line, color, texture, etc.)

Very little vegetation surrounds the site; low trees (20') located in corporate center parking lot, some low trees (palo verde) along canal and taller deciduous trees along Cave Creek.

Structures

Form - Cubical, blocky (corporate center); horizontal, blocky (Metrocenter and industrial area).
Line - Vertical utility poles along canal, horizontal conductors against sky, horizontal characters of Metrocenter.
Color - Light (Metrocenter); tan to browns of corporate center, desert colors.
Texture - Coarse (black glass and lighter structural members of corporate center), structures appear coarse in the landscape.
Diversity - Open vacant, some diversity (office, commercial, highway, proposed park).
Scale - Flat, open site, might relate to size of corporate center.
Spatial Enclosure - Not much of any enclosure, buildings are too distant to help define space.
Integrity - Area developing, natural character being superceded.

STEP 2. Site Description (proposed project on site and rate degree of change) 1 = low, 2 = mod., 3 = high

Structures

Form - Little change, size might be of the same proportion as the corporate center.	1
Line - Vertical elements added to landscape, strong vertical horizontal movements.	2
Color - Same basic colors.	1
Texture - Same texture, not much change.	1

TABLE 9 (Continued)

STEP 2. SITE: N

Diversity - The development which has occurred in the area is fairly homogeneous (office, commercial) addition of utility.	2
Scale - Little scaled elements, no change when something is added.	1
Spatial Enclosure - No existing spaces, no change.	1
Integrity - Another infringement on the "natural" setting, will create as much of a visual disturbance as other developments.	2
	11

Other Remarks

- Open site.
- Views through line along canal to South Mountain, unobstructed views to mountain in middle group and distant mountains to the north.

An additional factor that was incorporated into the sensitivity analysis related human activity to the visual contrast of the proposed facility on an existing landscape. People may be very sensitive to the visual intrusion of a receiving station while they are entertaining in their backyard or recreating at a local park and possibly less sensitive while at work. For the purposes of this study, human activities are described by specific land use categories.

A matrix was developed which correlated: 1) the sensitivity of the various land uses with; 2) the visual contrast groupings (high to low); and 3) the potential visibility of the sites in the surrounding landscape (Impact Zones). A specific sensitivity rating for each land use within each impact zone for each visual contrast grouping was developed.

The Visual Contrast/Sensitivity Matrix (Table 10) is the result. In general, residential, aesthetic commercial and recreational land uses were perceived as more sensitive to the visual intrusion of a receiving station than non-aesthetic commercial, industrial, agriculture and transportation land use categories.

TABLE 10

VISUAL CONTRAST/SENSITIVITY EVALUATION MATRIX

	Sites With Highest Potential for Visual Contrast		Sites With Moderate Potential for Visual Contrast		Sites With Least Potential for Visual Contrast	
	Primary Impact Zone	Secondary Impact Zone	Primary Impact Zone	Secondary Impact Zone	Primary Impact Zone	Secondary Impact Zone
Residential	H	MH	H	MH	MH	ML
Commercial-Aesthetic	MH	ML	MH	ML	ML	L
Commercial-Non Aesthetic	L	L	L	L	L	L
Industrial	L	L	L	L	L	L
Passive Recreation	MH	ML	MH	ML	ML	L
Active Recreation	ML	L	ML	L	ML	L
Transportation	ML	L	L	L	L	L
Other Public and Semi-Public	ML	L	ML	L	ML	L
Agriculture	ML	L	L	L	L	L

H - High
MH - Moderately High
ML - Moderately Low
L - Low

Visual Suitability Rating

A table was developed for the purpose of facilitating the assignment of a suitability rating for each site. The rating required two pieces of information: 1)the sensitivity levels, which were taken from the Visual Contrast/Sensitivity Evaluation Matrix (Table 10); and 2) the number of acres of each land use category in the primary and secondary impact zones around each site. This information is presented in Table 11. For purposes of clarification, the information in Table 11 is summarized in Table 12 and a suitability rating assigned to each receiving station site.

TABLE 11

ACRES AND VISUAL SENSITIVITY LEVELS OF LAND USE CATEGORIES

Land Use	Impact Zone	
	Primary	Secondary
	Acres - Sensitivity	Acres - Sensitivity
Site A		
Residential	-	-ML
Commercial-Aesthetic	-	50.9 - L
Commercial-Non-Aesthetic	7.9 - L	22.2 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	9.5 - L	27.5 - L
Other Public and Semi-Public	10.4 - ML	13.3 - L
Agriculture	-	13.7 - L
Site B_1		
Residential	-	3.3 - ML
Commercial-Aesthetic	-	24.3 - L
Commercial-Non-Aesthetic	-	27.0 - L
Industrial	-	0.8 - L
Passive Recreation	-	-
Active Recreation	-	-
Transportation	-	40.0 - L
Other Public and Semi-Public	7.3 - ML	19.7 - L
Agriculture	9.2 - L	37.2 - L

- Indicates that land use does not occur in impact zone.

TABLE 11 (Continued)

Land Use	Impact Zone	
	Primary	Secondary
	Acres - Sensitivity	Acres Sensitivity
Site B_2		
Residential	3.3 - MH	25.6 - ML
Commercial-Aesthetic	-	3.2 - L
Commercial-Non-Aesthetic	-	28.6 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	4.6 - L	37.2 - L
Other Public and Semi-Public	-	14.0 - L
Agriculture	15.9 - L	59.7 - L
Site C_1		
Residential	6.6 - MH	21.7 - ML
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	-	-
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	4.1 - L	6.2 - I
Other Public and Semi-Public	-	12.0 - L
Agriculture	18.8 - L	112.8 - L

TABLE 11 (Continued)

Land Use	Impact Zone: Primary Acres - Sensitivity	Impact Zone: Secondary Acres - Sensitivity
Site C_2		
Residential	5.6 - H	30.7 - MH
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	-	-
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	2.1 - L	9.9 - L
Other Public and Semi-Public	-	6.0 - L
Agriculture	12.8 - L	100.2 - L
Site C_3		
Residential	-	27.8 - ML
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	-	0.6 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	5.8 - L
Transportation	7.6 - L	7.4 - L
Other Public and Semi-Public	-	26.4 - L
Agriculture	23.2 - L	112.2 - L

TABLE 11 (Continued)

Land Use	Impact Zone: Primary Acres - Sensitivity	Impact Zone: Secondary Acres - Sensitivity
Site C_4		
Residential	7.9 - H	36.5 - MH
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	-	-
Industrial	-	-
Passive Recreation	-	-
Active Recreation	1.2 - ML	49.8 - L
Transportation	3.3 - L	8.5 - L
Other Public and Semi-Public	-	22.7 - L
Agriculture	28.5 - L	85.7 - L
Site D		
Residential	5.1 - H	30.4 - MH
Commercial-Aesthetic	1.5 - MH	4.4 - ML
Commercial-Non-Aesthetic	2.1 - L	2.7 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	4.8 - L	51.5 - L
Transportation	7.5 - L	15.7 - L
Other Public and Semi-Public	1.5 - ML	3.3 - L
Agriculture	-	4.4 - L

TABLE 11 (Continued)

Land Use	Impact Zone Primary Acres - Sensitivity	Impact Zone Secondary Acres - Sensitivity
Site G		
Residential	7.9 - H	63.2 - MH
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	-	-
Industrial	-	-
Passive Recreation	-	1.7 - ML
Active Recreation	-	8.1 - L
Transportation	3.1 - ML	3.1 - L
Other Public and Semi-Public	0.8 - ML	9.9 - L
Agriculture	-	-
Site I		
Residential	18.7 - H	68.4 - MH
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	-	-
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	-	-
Other Public and Semi-Public	-	-
Agriculture	-	-

TABLE 11 (Continued)

Land Use	Impact Zone Primary Acres - Sensitivity	Impact Zone Secondary Acres - Sensitivity
Site J		
Residential	5.6 - H	32.5 - MH
Commercial-Aesthetic	-	-
Commercial-Non-Aesthetic	2.7 - L	16.6 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	3.3 - ML	16.6 - L
Other Public and Semi-Public	-	4.6 - L
Site K		
Residential	8.5 - H	14.8 - MH
Commercial-Aesthetic	1.2 - MH	3.3 - ML
Commercial-Non-Aesthetic	3.1 - L	10.6 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	2.7 - L	7.0 - L
Other Public and Semi-Public	0.4 - ML	0.2 - L
Agriculture	-	-

TABLE 11 (Continued)

Land Use	Impact Zone Primary Acres - Sensitivity	Impact Zone Secondary Acres - Sensitivity
Site N		
Residential	-	3.7 - ML
Commercial-Aesthetic	11.7 - ML	33.1 - L
Commercial-Non-Aesthetic	0.6 - L	13.5 - L
Industrial	-	-
Passive Recreation	-	-
Active Recreation	-	-
Transportation	7.9 - L	17.4 - L
Other Public and Semi-Public	3.7 - ML	10.4 - L
Agriculture	-	33.3 - L

TABLE 12

VISUALLY SENSITIVE ACREAGE BY SITE,
WITH RESULTANT SUITABILITY RATINGS

	Sensitivity Level				
Site	High	Mod. High	Mod. Low	Low	Suitability Rating
A	-	-	23.6	163.0	Highest
B_1	-	-	10.6	158.2	Highest
B_2	-	3.3	25.6	163.2	Moderately High
C_1	-	6.6	21.7	153.9	Moderately High
C_2	5.6	30.7	-	131.0	Moderately Low
C_3	-	-	27.8	183.2	Highest
C_4	7.9	36.5	7.2	198.5	Moderately Low
D	5.1	31.9	10.7	87.2	Moderately Low
G	7.9	63.2	5.6	21.1	Lowest
I	18.7	68.4	-	-	Lowest
J	5.6	32.5	3.3	40.5	Moderately Low
K	8.5	16.0	3.7	23.6	Moderately Low
N	-	-	19.1	116.2	Highest

Results

Information generated for a single site becomes useful when similar information for all sites is compared to it. This is a relative comparison and does not explicitly depict absolute differences in the degree of visual impact from one site to the next. The last column of Table 12 illustrates the suitability rating assigned to each site.

Sites A, B_1, C_3 and N appear to be the most suitable sites for the receiving station. The visual impact zones around these sites are characterized as having no land uses of a high or moderately high sensitivity level. The existing land use activities are related to commercial, transportation and agricultural use. In addition, these sites have the least potential for visual contrast.

Two sites, B_2 and C_1, appear to have a moderately high level of suitability. Visual impact zones of both sites encompass only small areas of land uses with a moderately high sensitivity level (residential). Other land uses are of moderately low or low sensitivity. These sites also have the least potential for visual contrast.

Land uses around sites C_2, C_4, D, J and K all display some degree of high and moderately high sensitivity to the visual impact of a receiving station. The sensitive land uses include residential, commercial-aesthetic and a small amount of recreational acreage.

Finally, sites G and I are the least suitable sites for a receiving station. The land use surrounding these two sites is mostly residential which is considered very sensitive to the visual intrusion of a receiving station. The sites with the lowest potential visual impact are sites A, B_1, C_3 and N and are therefore the recommended sites for the receiving station based on this visual analysis process.

ACOUSTICAL ANALYSIS

Introduction

Among the phenomena attributable to the construction and operation of a 230kV receiving station is the generation of energy in the form of sound waves or "noise". During the construction phase this would include noise generated by earthmoving and material-handling equipment. During operation of the receiving station, two types of noises may be expected. One is the loud but infrequent "bang" of a circuit breaker as it interrupts a high voltage electrical circuit and the other is the continuous but low level "hum" of the transformers. The presence of these effects and the likely sensitivity of people to them are the reasons for this investigation.

Objectives

The objective of this study is to provide qualitative information about the context in which receiving station noises may occur in order to identify any differences among the sites being examined and thus to formulate recommendations relating to their relative sensitivity toward noise.

Approach

This study has been approached on a general level, with special fieldwork held to a minimum. Basic sources of information included the maps of existing and future land use near the sites, sound level readings taken near the existing Papago Buttes receiving station, the size and layout of a receiving station.

Methodology

A first step was to describe noises anticipated from the construction and operation of the facility and to determine those likely to be significant. The levels of such sounds were then determined, as was a standard for identification of acceptable or unacceptable noise levels. Human sensitivity to noise in general was evaluated, followed by an evaluation of how likely people are to be sensitive in various land use categories and within various classes of background noise. An impact zone was identified for the area near each site and land uses inventoried within it. Final analysis examined the presence of sensitive land uses to the sites and some general measures that were available to reduce effects in those sites adjacent to sensitive land uses. A suitability rating was then made for each site.

Types of Noise to be Anticipated

Three types of noise can be anticipated in conjunction with this project, namely the initial construction noises, the infrequent circuit breaker noise and the continuing transformer noise.

Construction Noises

While it would be remiss not to include a discussion of construction noises in this report, it can be concluded that such noises are not a consideration of major consequence based on the following rationale.

1. The noisiest of the construction equipment likely to be used, probably will not generate more than 80 decibels, which will attenuate in travel to about 60 or 65 decibels by the time it impinges upon adjacent property lines; such levels of sporadic sounds generated in construction work are rarely objectionable.
2. The very fact that construction is limited to a daytime activity appreciably reduces the possible sensitivity.
3. The short construction period assures people that any noises to which they might be sensitive if for long periods of time will be gone within a few weeks or months.

Circuit Breaker Noise

The noises produced by the tripping of receiving station circuit breakers are very loud but highly infrequent, perhaps on the order of two or three occurrences per year. Noises of such infrequency and short duration, while they tend to startle neighbors, are generally accepted as are such phenomena as claps of thunder, sonic booms or explosions. They are not of such amplitude as to be damaging, nor of sufficient duration as to be aggravating; they are, at the worst, annoying but their infrequency tends to make people less sensitive to them.

Transformer Noise

Electrical transformers set up a steady state uniform frequency noise, low in both output level and frequency. The NEMA sound ratings for 0 - 300 KVA transformers are 66 dB(A) for the self-cooled type and 70 dB (A) for the forced air type. This is a low frequency hum, predominating at 125 hertz, without pulsations, variations or modulations.

Sound level readings were taken at the Papago Buttes facility and they were found to be consistent with the National Electrical Manufacturers Association (NEMA) ratings. Specific examples of these readings were the 58 dB(A) level at the wire gate opening at midpoint of the east wall within twenty to thirty feet of a transformer and 46 dB(A) at midpoint of the wire fence at the west side, about 120 feet from the nearest transformer. Both readings indicate the degree of sound attenuation resultant from travel of the sound waves.

Determination of Property Line dB(A) Criterion

The most rigid governmental criterion with which any facility location might have to comply would be the HUD "Acceptable" property line noise limits for residential areas. In essence, this criterion stipulates that

45 dB(A) may not be exceeded more than two percent of the time. To achieve compliance with this standard, it would be necessary to have a 120 to 150 foot buffer zone between the nearest transformer unit and the property line. As is indicated by the readings reported in the previous paragraph, such a buffer zone is not only reasonable but actually is virtually in effect at the Papago Buttes facility.

Human Sensitivity to Noise

The following table, (Table 13) prepared by the Council on Environmental Quality, delineates the decibel scale as a measure of the energy level of sound. The scale is logarithmic, meaning that a level of 130 decibels is 10 times as great as one of 120 and 100 times as great as one of 110. In a quiet environment the sound level will be about 50 decibels or less, at 80 decibels the sound level becomes annoying.

It should be noted that the sound levels generated by this equipment are far below any ear damage levels, either of the immediate damage (approximately 140 dB(A)) or of the long range acceleration of presbycusis (90 decibels or more daily exposure). The transformer noise is also below the speech interference levels (approximately 70 decibels impingement). Thus, we are dealing strictly and solely with the psychological reaction to sound, the factor which supports the practical definition that "noise is simply unwanted sound."

At the other end of the decibel scale, it is to be noted that the 0-30 decibel range is primarily the instrumentation scale; few people can audibly detect sounds below 30 decibels. Rarely will a residence have an interior ambient noise level as low as 35 or 40 decibels; virtually all air conditioning equipment, most appliances such as refrigerators and fans, and even the person in the next bed snoring exceed such decibel levels. Thus, the 45 dBA property line criterion stipulated by HUD is, if anything,

Table 13. Weighted Sound Levels and Human Response

Decibel Level[a]	Representative Sources of Sound	Human Response to Sound Level
150		
140	Aircraft carrier deck jet flights	Painfully loud
130	Limit of amplified speech	
120	Jet takeoff at 200 feet	
	Discotheque	
	Auto horn at 3 feet	
110	Riveting machine	
	Jet takeoff at 2000 feet	
100	Shout at 0.5 feet	Very annoying
	New York subway station	Hearing damage (8 hours)
90	Heavy truck at 50 feet	
	Pneumatic drill at 50 feet	
80		Annoying
	Freight train at 50 feet	Telephone use difficult
70	Freeway traffic at 50 feet	
60	Air conditioning unit at 20 feet	Intrusive
	Light auto traffic at 50 feet	
50		Quiet
	Living room	
40	Bedroom	
	Library	
30	Soft whisper	Very quiet
20	Broadcasting studio	
10		Just audible
0		Threshold of hearing

Source. Council on Environmental Quality (1970) from Department of Transportation.[23]

[a] Weighted sound levels based on frequency response of human ear.

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23. Council on Environmental Quality (1970). Environmental Quality. United States Government, Washington, DC., p. 47.

excessively conservative in that it assumes only a five to ten decibel attenuation from the property line to the point of impingement at the residence, plus the actual structual attenuation of the building or portion thereof, itself. The criterion assures, therefore, that the extraneous sound will not produce sleep interference. By the same token, this level of extraneous sound will not be audible above normal daytime activity sounds within the residence.

In addition to the low sound level itself, the type of sound generated by the transformers is, in itself, of the innocuous type. It is, first of all, a low frequency sound (usually at about 125 hertz) and the human system has a greater tolerance and acceptance level of such sounds. Further, the continuous nature of this low frequency sound tends to have a more soporific than disturbing influence on the hearer. If this same sound were fluctuating or pulsating, it would be much more objectionable.

Determination of Noise Contrast/Background Noise

On the premise that the property line noise generated by the typical transformer facility will not exceed 45 dBA, it can be determined which type of adjacent land use would have the least and which would have the greatest, possibility of ever having this low level audible above the normal ambient noise level of that space. In this manner, the land use categories may be ranked as to sensitivity.

Industrial

There is no possibility whatsoever of the transformer noise level being heard above the normal 65-90 decibel noise levels generated within the average industrial plants. Although the transformer noise might be heard outdoors at the property line, even this possibility is remote because of the noise radiated by the various plant activities and this possibility becomes even more irrelevant when we consider that such outdoor spaces are normally storage or parking areas.

Commercial

Commercial office buildings, with their typical sealed construction and 60-70 decibel ambient interior levels, would likewise be immune to the transformer noise impinging upon these buildings. The same can be said about commercial shops, even the quietest of which will generate over fifty decibels of ambient interior noise. In both usages there is the rare possibility of the transformer noise impinging upon some outdoor walkways or parking areas, but such spaces are definitively of low environmental concern.

Recreational (Public/Park) Areas

While some such areas can maintain a bucolic ambience, the sounds of children romping in the distance, the activity noises of various sports, a single engine airplane passing overhead or even the chirping of birds, would normally introduce more disturbance than the steady low frequency hum of the low noise level transformer. There is a possibility of some occupants noting or even mentioning this transformer noise, but this would be infrequent.

Educational

The Papago Buttes facility flanks a recreational area on one side and an elementary school on another. Both usages appear to be totally compatible. The school building itself provides more than enough structural attenuation to preclude disturbance by the transformer noise and the normal noise level of playground activity overrides the transformer noise.

Residences Within 600 Feet of Freeways

The steady drone of traffic noise from a freeway will definitely mask the transformer noise for a distance not less than six hundred feet from the freeways. It would be highly unlikely that residents within this proximity would even be aware that the transformer emits noises, much less than it would be objectionable.

Residences With 300 Feet of Arterial Roads

The sporadic stop-and-go traffic noises incumbent with arterial roads would also be a much louder and more grievous aggravation to the residents within three hundred feet than would be the low frequency steady noise of the transformers. There is greater possibility, especially in the evening when the traffic noise is appreciably less, that the transformers could be heard, but it would be a rare person who would find this type of noise more objectionable than the adjacent traffic noise.

Residences Other Than Those in the Above Classifications

As discussed in the section on human sensitivity to noise, it would require a combination of low interior noise level, a particularly noise-conscious personality and a high acuity to low frequency sounds to bring about a complaint about the transformer noise. Such combinations are possible, however, and thus this sort of land use has the greatest, though remote, sensitivity to a grievance.

Land Use, Noise Sensitivity Rankings

As a summary of the above discussion, a ranking can be determined for these various land uses. With the lowest number being the least degree of sensitivity and the highest number being the greatest degree of sensitivity, the following scale is used to rank the noise of the land use.

1. Industrial
2. Commercial
3. Recreational
4. Educational
5. Residential Near Freeways
6. Residential Near Arterial Streets
7. Residential, All Others

Land Uses Adjacent to the Sites

Information concerning existing and future land uses adjacent to the sites was collected as part of the land use inventory.

Based on the possibility of a transformer being located within fifty feet of the proposed 400' by 700' site and the 150' buffer zone criterion discussed in "Determination of Property Line dB(A) Criterion," the area which potentially could be affected was determined to be a 100' wide zone adjacent to and surrounding each site. The land use maps were inspected to determine the land uses adjacent to each site and the results are displayed in Table 14. The land use sensitivity rankings developed in the last section are here used to characterize the expected sensitivities of uses adjacent to each site. Both present and future land uses are considered important in this analysis. Present adjacent land uses, of course, will receive the full effects of this facility and so need to be studied.

In some studies, the effects on future residents might be discounted, because of land use projection uncertainties and because of timing considerations. However, in this situation the facility is of a very long useful life (30 to 50 years) and development of vacant areas is likely to occur within five to ten years. Thus even the future uses will be affected for a long period of time.

Analysis

Following the tabulation of Table 14 it was inspected for significant patterns. Two sites were identified that had no sensitive land uses adjacent to them: Sites A and N. All of the others had sensitive land uses nearby. The land use maps for each site were then reviewed to determine if those inherent sensitivities could be reduced or eliminated by appropriate site selection or by other measures. The results of that analysis and this study are discussed below.

Results and Conclusions

As the rating scales are applied to the respective areas under study, two sites are seen as acoustically acceptable without reservations, both as their current bordering land uses and as to future uses contemplated. By the same application, one site is determined to be the most unacceptable from an acoustical standpoint inasmuch as there does not appear to be any feasible method of protecting neighboring land use from potential, although unlikely, excessive noise impingement.

All of the other sites are moderately acceptable, depending upon three sets of assumptions or mitigations. Two sites can be considered fully acceptable with simple assumption that no transformer unit will be located closer than 150 feet from any bordering residential property line. Five other sites can become fully acceptable if the size of the property purchased is assumed to be not less than 540 feet by 700 feet, with no transformer located closer than 150 feet from any bordering residential property line. The final three sites can be rendered acceptable if adequate sound barriers are designed and constructed at those property lines where the noise impingement is greater than the aforementioned 45 dBA criterion.

TABLE 14

ACOUSTICAL SENSITIVITIES OF LAND USES

Sites	Land Use Classification	Adjacent Land Use Categories* Direction From the Site: North	South	East	West
A	Existing	2	2	2	1
	Future	2	2	2	1
B_1	Existing	1,3	-	-	-
	Future	1,3	7	7	7
B_2	Existing	-	6	-	-
	Future	7	6	7	7
C_1	Existing	-	-	-	7
	Future	6	7	7	7
C_2	Existing	-	7	-	7
	Future	7	7	7	7
C_3	Existing	-	-	-	-
	Future	6	7	7	7
C_4	Existing	-	-	-	7
	Future	7	7	7	7
D	Existing	7	2	-	2
	Future	7	2	2	2
G	Existing	7	7	6	7
	Future	7	7	6	7
I	Existing	7	7	7	7
	Future	7	7	7	7
J	Existing	2	7	2,7	5
	Future	2	7	2,7	5
K	Existing	2,6	7	2	2
	Future	2,6	7	7	7
N	Existing	2	1,-	-	2,-
	Future	2	1,3	3	2

* Land use categories, from least sensitive to most sensitive:

- Vacant
1 Industrial
2 Commercial
3 Recreational
4 Educational
5 Residential Near Freeways
6 Residential Near Arterials
7 Residential, All Others

As shown in Table 15 and as described above, Sites A and N are fully acceptable as is. Sites D and J can be considered acceptable if the specific locations of transformers are stipulated, sites B_1, B_2, C_3 and C_4 and G can be rendered acceptable if adequate property is purchased and the locations of transformers are stipulated and sites C_1, C_2 and Site 1 can be rendered acceptable if adequate sound barriers are erected. While it is not the domain of this report to suggest mitigating conditions, it did seem appropriate and proper to distinguish among the three sets of situations which could render one moderately acceptable site more feasible than another. Site K has been designated as the most unacceptable in that none of the mitigating measures described above can be applied to adequately shield the two-story apartments south of this site.

TABLE 15

ACOUSTICAL SUITABILITY RATINGS BY SITE

Site	Suitability Rating
A	Highest
B_1	Moderate[2]
B_2	Moderate[2]
C_1	Moderate[3]
C_2	Moderate[3]
C_3	Moderate[3]
C_4	Moderate[2]
D	Moderate[1]
G	Moderate[2]
I	Moderate[3]
J	Moderate[1]
K	Lowest
N	Highest

Note: All of the "Moderate" sites would be considered unsuitable if a "worst case" situation occurs, that is, if the transformers were very near the adjacent sensitive residential areas. However, each can be made acceptable with the use of the following measures, according to the superscripts above.

1) The transformers are located at least 150 feet from existing or future residential uses;

2) Additional land is purchased to provide a buffer zone of at least 150 feet between the transformers and existing or future residential uses;

3) Sound attenuation barriers such as berms or walls are constructed between the transformers and adjacent residential uses.

SYNTHESIS OF FINDINGS: CASE STUDY

The following statements briefly summarizes each of the resource studies.

Land Use Study

This analysis was conducted in order to determine the degree to which the existing and proposed land uses surrounding each of the candidate sites would be compatible with the proposed receiving station. Ratings were developed to indicate which sites would be the most compatible and which would be the least. The higher the degree of compatibility, the more suitable a site was considered to be as a potential location for the facility. The sites in the northern portion of the study area were found to be more suitable than those to the south, largely due to the high density of existing land uses surrounding the southern sites. Sites A, N and B_1 were found to be the most suitable sites, while sites B_2, C_1 and C_3 have a moderately high suitability and sites C_2 and J a moderately low suitability. Sites C_1, D, G, I and K were found to be the least suitable sites from a land use compatibility perspective.

Visual Study

The purpose of the visual study was to determine, for each site, the degree to which the proposed facility would alter the existing visual environment. Ratings were developed to indicate which sites had the highest sensitivity to the visual changes. Sites G and I, surrounded by relatively homogeneous residential land uses, were found to be the most sensitive. Sites C_2, C_4, D, J and K were rated of moderately high sensitivity due basically to the proximity of substantial areas of adjacent residential land uses. Sites B_2 and C_1 had a moderately low sensitivity rating because of relatively large adjacent vacant areas, while sites A_1, B_1, C_3 and N were rated the lowest sensitivity and the highest visual suitability. These latter sites were given good ratings either because of their adjacency to non-sensitive land uses, their adjacency to presently vacant lands, or both.

Acoustical Study

The acoustical study was done in order to determine the anticipated sensitivity ratings of the sites to noise potentially generated by the proposed facilities. The pattern of residential land uses played a strong part in this analysis as it did in the visual study. Sites A and N were found to have the lowest sensitivity and highest suitability ratings because of the absence of adjacent sensitive residential areas. Site K on the other hand was rated the lowest suitability due to the proximity of a large number of multi-family residential units immediately adjacent to a narrow site. The other sites were rated as having moderate sensitivity and suitability due to their proximity to varying types of residential land uses.

Findings

The findings of each of the individual studies are summarized in the Site Evaluation and Comparison Matrix which appears as Figure IX. The shading shown in the matrix represent the relative suitability of each of the sites as a location for the proposed receiving station. The determination of a site's suitability was based upon the sensitivity ratings of individual resources at the particular site. An inverse relationship was established between "sensitivity" and "suitability". When the sensitivity rating of a particular resource was reported to be low at a certain site, the suitability of that site as a location for the receiving station was considered to be high. Conversely, when the sensitivity ratings of the resource was reported to be high, suitability was considered to be low.

Four relative suitability classifications were established: Highest, Moderately High, Moderately Low and Lowest. The four categories were established in response to the fact that the results of the visual and land use analyses indicated that four clearly defined groups of sites were identifiable. The resources of each site were evaluated and suitability classifications were assigned in regard to each of the environmental resources investigated. The shaded individual cells of the matrix represent the designated suitability classification.

SUMMARY GROUPING

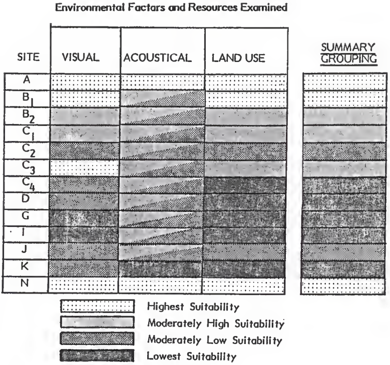
In order to integrate the findings of each of the respective resource studies, a summary grouping was developed to illustrate composite suitability ratings for each site. The sites were each classified according to one of the four suitability categories used in the individual resource studies - Highest, Moderately High, Moderately Low or Lowest. The results are displayed in the "Summary Grouping" column of the Site Evaluation and Comparison Matrix (Figure IX).

Of the three, visual and land use factors are seen to be of greatest significance in predicting site sensitivity ratings, and they are considered of equal importance. The acoustical effects are of less importance however, and affect a much smaller area.

Selection of the appropriate summary rating for each site was accomplished in the following manner. First, the ratings given to each site in the visual and land use analyses were reviewed. If they were the same, that rating was considered to dictate the summary rating. Of the remaining sites, those with the major factors rated of "moderately low" and "lowest" suitability were rated overall in the latter category. The rationale for this is that sites with major sensitivity ratings in either vis-

FIGURE IX

SITE EVALUATION AND COMPARISON MATRIX



ual or land use considerations are of lesser suitability for the siting of a receiving station. Efforts should be concentrated on the sites without such high sensitivity ratings.

The remaining site (C_3) has differing values for the visual and land use ratings. Since the ratings are adjacent, the rating from the acoustical study is used to resolve the difference in favor of the land use rating (moderately high).

TRANSMISSION ACCESSIBILITY

A final observation made prior to the development of recommendations for receiving station siting dealt with the ability to link potential receiving station sites with potential transmission line routes. This observation was made for the following reason. If any sites ranked as highly suitable were found to have nonviable or otherwise limited options for connecting the receiving station to transmission route opportunities, the suitability of such sites would be diminished and adjustments to the final ranking of sites would be necessary.

Three factors were considered in observing accessibility: level of urban development; variety of potential route opportunities; and proximity to identified route opportunities.

In general, the southern sites are surrounded by intensive urban development and are dependent on arterial streets as potential transmission corridors. Of the four southern sites, only site K is adjacent to a route opportunity.

Undeveloped and agricultural lands occur in the vicinity of the northern sites and two major types of transmission route opportunities, arterial streets and the Arizona Canal, are located in the area. Sites A, N, B_1, B_2

C_1 and C_3 are adjacent to one or the other of the route opportunities while sites C_2, C_4 and D are not.

Sites identified by the environmental studies as being either of "high suitability" or "moderately high suitability" are sites A, B_1, B_2, C_1, C_3 and N. All of those sites are in the northern portion of the study area and are adjacent to an identified route opportunity. Therefore, no significant constraints related to transmission access are anticipated and no modification of the summary grouping of suitable sites is proposed.

FINAL SITE RECOMMENDATIONS

Since the summary grouping represents the overall environmental evaluation of the candidate receiving station sites, that grouping is the basis for the following recommendations. Those sites that were found most suitable (A, N and B_1) are recommended.

CHAPTER FIVE

CONCLUSIONS

The actual impact of a 230kV receiving station upon the human environment can never be precisely predicted because of the dynamic nature of human attitudes, values and actions. The three analyses are submitted as a useful means of evaluating receiving station sites in regard to their relative potential as appropriate locations for a 230KV receiving station.

The detailed analysis of land use, visual and acoustic factors, can contribute important information to the site selection process of electrical receiving stations. The straight-forward approach described in this report and utilized in the case study has verified applicability to differentiate site characteristics in sufficient detail to make appropriate site selection decisions.

From the outset, it was recognized that the three factors - land use, visual and acoustic - would be highly interrelated due to the significant degree to which each of these characteristics is dependent upon the others. Within the densely developed urban setting, land use, visual or acoustic changes cannot be considered mutually exclusive of one another. Changes in one of these factors are reflected in changes in the others. The design of the methodology recognized this fact and the sharing of data among the three factors seemed to indicate that this was, in fact, true.

As discussed in Chapters One and Two, a vital aspect in the site selection process is the involvement of the public. Failure to include the public in decision-making has caused long delays in project schedules, if not a total rejection of the project. The methodology proposed in Chapter Three stressed the need for a public information program but did not define one for a number of reasons.

The first being that little information existed addressing the manner in which an electrical receiving station might influence the public within proximity of it. A qualitatively-conducted attitude survey which would identify any perceptions or responses unique to receiving stations was felt to be of better use in refining the receiving station - environmental relationships of a site selection process. In actuality, the attitude survey would be only a part of a well-defined public information program.

The second reason had to do with the status of potential land acquisition by the major electrical utilities in Phoenix, Arizona. Because many of the potential sites identified in the case study were potential sites for electrical receiving stations and some were involved in ongoing studies by the utility companies, an attempt at defining a public information program and implementing it in the case study area might have confused the public and jeopardized these ongoing studies. For much the same reasons, attitude surveys were conducted at existing receiving stations and no attempt was made to elicit responses from the public who lived near potential sites.

The third and final reason for not defining a new public information program was the existence of successful programs such as the one that the Bureau of Land Management utilizes in their scoping process.

As the case study proceeded, it became apparent that determining land use compatibility at the general level seemed appropriate. In attempting to define land use compatibility beyond this level and perhaps in different studies in which many of the components which define land uses (i.e. social, economic, aesthetic and political considerations) are dealt with in separate studies, a possibility exists for "double counting" impacts. One must remember that perhaps land use studies, which attempt to determine compatibility, should be conducted only at a general level and if more detailed information is needed, use a refined methodology of the social, economic, aesthetic and political components that determine a particular land use.

The utilization of visual, land use and acoustic elements in the case study indicates that a comprehensive methodology composed of all factors can be used effectively in a site selection process. In addition, there is nothing in the methodology that would limit its application exclusively to siting electrical receiving stations. The methodology and its application seem to indicate as well that similar sites have distinguishable site characteristics and the identification of those characteristics is limited only by the detail involved in the site selection screening process.

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APPENDIX

ATTITUDE SURVEY FOR 230kV RECEIVING STATIONS

ATTITUDE SURVEY FOR 230kV RECEIVING STATIONS

Introduction

The major objective was to identify the ways in which existing receiving stations located in the Phoenix metropolitan area are perceived by persons living near them. Although there are no known direct physical or economic impacts associated with the operation of these facilities, the survey effort was considered necessary so that people's perceptions of such facilities could be understood.

Methodology

The survey elicited information from persons potentially impacted by 230kV receiving stations as to the variables that should be studied in the siting of the proposed facility. Each respondent lived relatively close to an existing 230kV receiving station and potentially possessed information as to how such a facility could impact residential neighborhoods. The findings of this survey effort identified many of the variables and parameters incorporated into the analysis of perceived impacts.

Information to be generated by the survey was anticipated to be useful in describing several aspects of human sensitivity. An overriding objective was to structure the survey in an unbiased manner so that responses were not suggested by the nature of the questions. A copy of the questionnaire is included at the end of this appendix.

Tentative details of a sampling strategy were developed utilizing a pre-selected route within which various frequencies of sample points would be selected depending on proximity to the receiving station site. This method was developed so that differences in people's perception of the facilities could be evaluated in terms of distances from each receiving station. Criteria for zones were developed so that the interviewer could note adjacency and visibility factors. The zones to be used in coding each questionnaire were as follows:

Zone A - adjacent, or closest residence, to the facility;

Zone B - non-adjacent but with high potential for viewing the facility, or adjacent to a property in Zone A; and

Zone C - views of the facility predominantly or totally obscured, by intervening structures or vegetation, or apparent size diminished by distance.

It was anticipated that perceptions of the facilities would begin to fall off in Zone C and that the types of responses would likely vary among the three zones.

Persons living near the Sunnyslope receiving station were the first to be interviewed. Their responses indicated that perceptions of and sensitivities toward the facility fell off well within Zone C. Also, many persons surveyed in Zone A did not provide information that could be used to study receiving station impacts. These findings indicated that the routing strategy for selecting sample points was not necessary. Surveying in the vicinity of Papago Buttes receiving station was conducted in the nearest portions of the three distinct neighborhoods to the west, north and south. Patterns of sensitivity were obvious and intensities of perceived impact were low enough to forego additional sampling of more distant residents.

Residents living near the Mesa receiving station provided information very similar to that already obtained and sensitivities in Zone B were low enough in intensity to require no sampling in Zone C.

The last area surveyed was near the Anderson receiving station. The type of residential development in Zone C was different from that of Zones

A and B, and populations of Zone A and Zone B were very sparse. Therefore, more interviewing was conducted in Zone C than had been the case with the two previous areas surveyed.

Description of Survey Sites

Prior to identifying potential survey sites, neighborhoods surrounding the sites being investigated were described. A generalization of that information indicates that the sites are located in areas where housing values are reported by 1970 census data to be average for Phoenix. Some multiple-family housing units and mobile home subdivisions are mixed with predominantly single family residential units in these areas. Residents are predominantly Caucasian and the average family includes two to three people. The median ages of residents around these study sites is less than 27 years.

Existing 230kV receiving stations in the Phoenix area were located and examined for their comparability with the study sites. Five facilities were found to be in the vicinity of residential development. Those facilities are the Mesa, Papago Buttes, Anderson, Lincoln and Sunnyslope receiving stations.

Residential development around three of the facilities was found to be similar to areas around the study sites. Those were the Mesa, Papago Buttes and Sunnyslope facilities.

A substantially lower density of development exists around Anderson receiving station. However, the facility was constructed only seven years ago and as responses of persons living near a newer facility were desired, the Anderson receiving station was included in the surveying.

Lincoln receiving station was not included as a survey area. The facility is located in an area where housing value, length of residence, racial composition and median age are significantly different from the areas around the study sites. In addition, the Lincoln receiving station is adjacent to a complex of other switching and transmission facilities necessary to serve downtown Phoenix.

A brief description of four survey areas follows:

Mesa

The Salt River Project (SRP) Mesa receiving station is located in Mesa, northeast of the intersection of University and Stapley roads. The facility was constructed in the 1920s. Adjacent land uses to the west include vacant Salt River Project property and convenience shopping establishments. An industrial-type complex for Mesa Public Schools is located to the north. A right-of-way area for three rows of 230kV lattice towers is east of the receiving station and is being used as a golf course. To the south, the receiving station fronts on University Road and is faced by a church across the street. Some office/commercial establishments and apartments are also adjacent to University Road across from the facility.

Adjacent to all of the land uses just described are subdivisions of single family residences, generally built in the 1960s and assessed in the $30,000 to $65,000 range. The exceptions to this description of housing values are the homes just east of the golf course where the homes are assessed in the $20,000 to $37,000 range. (Maricopa County Assessor, M.A.S., April, 1983, Microfiche)

Papago Buttes

The Papago Buttes 230kV receiving station is located along the eastern side of the Arizona Cross Cut Canal, one quarter mile north of Thomas Road in Scottsdale. The facility was constructed in 1965 by SRP. Paiute Park, a grassy open area of approximately ten acres with picnic tables, a children's play area and two tennis courts, abuts the north and east sides of the facility. Adjacent to the park on the east is a neighborhood of one-story apartment complexes, ranging from four to ten units per building. The units adjacent to the park are oriented away from the park and the receiving station. Field research showed the apartments housing high percentages of college students and elderly persons.

North of Paiute Park is an elementary school. The park and the school, both public areas, serve to separate the adjacent neighborhood of single family homes from the receiving station by a quarter of a mile. This residential neighborhood to the north has homes built in the 1950s and assessed in the vicinity of $34,500 (Maricopa County Assessor, M.A.S., April, 1983).

A berm on either side of the Arizona Cross Cut Canal provides a physical barrier between the receiving station and the residential areas to the west. These residences are actually the closest homes to the facility, but the 230kV lines along the canal, feeding into the receiving station, not the station itself, are the major visible elements of the facility. Assessors records indicate an average value of $40,000 for homes in this area (Maricopa County Assessor, M.A.S., April 1983).

No residences are located between the receiving station and Thomas Road. This area contains vacant property and equipment storage for an existing utility company.

Anderson

The Anderson 230kV receiving station, owned and operated by Salt River Project, is the newest of the four substations included in the survey. It was constructed in 1972 along Baseline Road at Seventh Avenue in Phoenix. The adjacent area is primarily rural and agricultural. Two subdivisions with urban densities are within a quarter mile radius of the facility. Surveying was conducted in both the rural area and the subdivisions.

Most homes in the two subdivisons are oriented away from the substation or are obscured from it by intervening citrus groves or roadside commercial development. These subdivisions have higher non-white racial composition than most of Phoenix. Median family incomes are roughly average for the city. The homes were built in 1950s and 1960s and are generally assessed in the $20,000 to $27,000 range. (Maricopa County Assessor, M.A.S., April 1983)

Land use and neighborhood characteristics associated with this receiving station are somewhat different from the other sites surveyed. However, the facility was constructed in 1972 and provided an opportunity to survey people who have experienced the relatively recent addition of a receiving station to their neighborhood.

The more rural area closer to the substation is very sparsely populated. There is one small subdivision of twelve one-acre lots south of the substation, and a few additional large-lot and ranch-style residences along Baseline Road. These rural homes and ranches are assessed at varying values, from $20,000 to $77,000. They are often separated by fields, citrus groves or large lots. The population of this area is thus sparsely distributed.

Sunnyslope

The Sunnyslope 230kV facility is located two blocks north of Dunlap Avenue at 10th Street in Phoenix. It is bounded on the north by Mountain View Road and on the east by strip commercial development associated with Cave Creek Road which cuts diagonally through the Sunnyslope area. A large K-Mart discount center is located to the south and a neighborhood park to the west. The substation was constructed by Arizona Public Service Company in 1968.

Land use is relatively mixed within a quarter mile range of the receiving station. Commercial developments to the east and south range from automotive and machine repair shops to retail shopping and eating establishments. None of the adjacent establishments are oriented towards the facility. Farther to the east, behind the strip commercial area, is an older residential area of primarily single family dwellings averaging in the $14,000 to $16,000 range of assessed full value and constructed in the 1940s and 1950s (Maricopa County Assessor, M.A.S., April 1983).

North of the receiving station along Ninth, Tenth and Eleventh streets and Cinnabar Avenue is an area of slighly newer homes built in the 1950s. Assessors records indicate an average assessed full value of $22,000 to $23,000. West of the receiving station are areas of both older and newer residences. Single family homes ranging in assessed full value from $11,000 to $23,000 predominate, but apartment buildings and a mobile home park are also in this area.

Survey Results

Information collected in the survey effort was reviewed to identify those respondents who were sensitive to receiving stations and those who were not.

Eight persons (six percent of those surveyed) who were not found to be sensitive to receiving stations reported one or more positive features of the facilities, as shown below:

landscaping and fencing	-	3 responses
lights up neighborhood	-	2 responses

it is clean - 2 responses

limits development in area - 3 responses

park is adjacent - 2 responses

For purposes of this survey, the term "sensitive" refers to those persons who responded in any of the following ways:

* Negative statements about the facility or its location;
* Statements about changes to the environment brought about by the
* facility (unless changes were specifically noted as positive changes); or
* Statements indicating that an adaptation or acceptance of the facility had been experienced.

Forty-six percent of the 134 persons responding in the four survey sites were found to be sensitive to receiving stations. Those sensitive responses were compared against six factors:

housing type

ownership status

age of respondent

length of residence

proximity to receiving station

property value

This was done to determine whether any strong correlations between those factors and sensitive responses occurred. If correlations were found, that information could be evaluated for its usefulness in predicting sensitivity and locating the receiving station.

Housing Type

Table A-1 indicates that the sensitivity of persons interviewed who reside in single family dwellings did not differ substantially from those residing in apartments, townhouses or other multi-family units. Forty-five percent of single family unit respondents were classified as sensitive compared to fifty percent of the respondents living in multi-family units.

TABLE A-1
SENSITIVITY OF RESPONDENTS BY HOUSING TYPE
n = 134

Housing Type	Sensitive	Not Sensitive
Single Family Dwellings	45%	55%
Multi-Family Dwellings	50%	50%
Other	*	*

* Indicates less than ten sample points and no calculation of sensitivity.

Ownership Status

Similarly, residents of owner-occupied housing units who were surveyed exhibited no significantly greater or lesser potential for sensitivity than did respondents in rental units. Their respective sensitive levels were fifty percent and forty-four percent as shown in Table A-2.

TABLE A-2
SENSITIVITY OF RESPONDENTS BY OWNERSHIP STATUS
n = 127

Ownership Status	Sensitive	Not Sensitive
Owner Occupied	50%	50%
Renter Occupied	44%	56%

Age

Approximate ages of respondents were observed and recorded by the interviewers. An initial review of sensitivity levels for each age group as shown in Table A-3 reveals that sensitivity of persons interviewed increased with age. However, there is an extremely small difference between the forty-nine percent sensitivity of the 25 to 55 age group and the fifty-two percent sensitivity of the older than 55 age group.

TABLE A-3
SENSITIVITY OF RESPONDENTS BY AGE
n = 129

Age*	Sensitive	Not Sensitive
16 to 25	34%	66%
25 to 55	49%	51%
Older than 55	52%	48%

Length of Residence

Lengths of residence for survey respondents were categorized into three time groups: less than one year; one to five years; and more than five years. As Table A-4 indicates, no major differences in sensitivity were attributable to that factor. Slightly lower sensitivities among respondents who recently moved to their neighborhoods suggests that people moving into an area with an existing 230kV receiving station might notice it less and require less adaptation, than would residents who were established in the area prior to construction of the receiving station.

TABLE A-4
SENSITIVITY OF RESPONDENTS BY LENGTH OF RESIDENCE
n = 117

Length of Residence	Sensitive	Not Sensitive
Less than 1 year	46%	54%
1 to 5 years	52%	48%
More than 5 years	47%	53%

Proximity

Proximity to receiving stations was found to have a clear bearing on sensitivity. This was an expected result as persons living farther away from a receiving station are not likely to be as sensitive to its presence as are persons living nearby. As shown in Table A-5 sixty-one percent of the persons interviewed living with Zone A exhibited some degree of sensitivity to nearby receiving stations. Forty-two percent of the respondents in Zone B expressed sensitivity. However in Zone C, where views of receiving stations were predominantly or totally obstructed, only seventeen percent were sensitive.

TABLE A-5
SENSITIVITY OF RESPONDENTS BY PROXIMITY
n = 134

Distance/Visual Zone	Sensitive	Not Sensitive
A	61%	39%
B	42%	58%
C	17%	83%

Property Values

Relative property values assigned in the field were later substantiated through Maricopa County Assessor's records. A review of the survey data showed that persons living in higher value homes tended to provide more sensitive responses than did persons in lower value homes. This result is shown in Table A-6.

Property values were observed due to the suggestion by local government liaisons that impacts on property values were likely to be a significant impact of 230kV facilities. Only two persons interviewed suggested that property values were perceived to be adversely affected by a receiving station.

TABLE A-6
SENSITIVITY OF RESPONDENTS BY RELATIVE PROPERTY LINE
n = 131

Relative Property Value*	Sensitive	Not Sensitive
Lower	35%	65%
Moderate	44%	56%
Higher	70%	30%

* Relative values were assigned by interviewers and later substantiated through Maricopa County Assessor's data.

Summary of Findings

Table A-7 summarized the occurences of sensitivity by receiving station site. The lowest occurence of sensitivity was found around the Sunnyslope facility.

TABLE A-7
SENSITIVITY OF RESPONDENTS BY SUBSTATION
n = 134

Substation	Sensitive	Not Sensitive
Anderson	52%	48%
Mesa	52%	48%
Papago Buttes	50%	50%
Sunnyslope	26%	74%

Three factors are noted as relevant in the Sunnyslope receiving station's low sensitivity rating. As noted earlier, this facility was first of the four surveyed. Lacking previous indicators of sensitivity levels or patterns, interviews tended to conduct repetitive sampling in non-sensitive neighborhoods.

A second factor associated with the low sensitivity levels of the Sunnyslope receiving station is the facility's position in the local land use pattern. As explained in "Description of Survey Sites" Sunnyslope receiving station has significant commercial and light industrial development adjacent, and then intermittently, to the south and east. It thus becomes quite easy to perceive the facility as a part of the adjacent nonresidential activities taking place. Given the amount of traffic and other activity normally generated by commercial or industrial developments, this receiving station can be seen to serve as a relatively benign barrier between the residential areas north of the receiving station and the commercial activity occurring to the south and east along Dunlap Avenue and Cave Creek Road.

The third factor has to do with mitigation. A designed wall and some landscaping have been provided around the receiving station in all directions where there are residences. Several respondents indicated that such efforts are helpful in mitigating visual impacts.

The second lowest occurrence of sensitive responses occurred from residents living near Papago Buttes receiving station, which also has a designed wall on sides where more frequent viewing occurs. However, an area of higher sensitivity around this facility is to the west where the Cross Cut Canal and its associated berms acutally obscure those residences from a view of the receiving station.

A review of the locations of sensitive responses obtained near Mesa and Anderson receiving stations, reveals that a larger proportion of surveying in Zone C, and at greater distances from the facility, occurred near Anderson receiving station. This disparity is a result of the sparse population and more rural location associated with Anderson, as opposed to the consistently dense suburban development surrounding the Mesa facility. Accounting for these differences, it becomes clear that Anderson receiving station had the most frequent occurrences of sensitivity within Zones A and B of the four facilities studied. Many responses obtained from nearby residents indicated that the Anderson facility is still considered "new" and had not been fully accepted by the residences as a part of their environment. Anderson receiving station is the most recent of the four facilities studied.

The context and content of sensitive responses obtained through this survey were reviewed to determine what it is about 230kV receiving stations that triggers reaction. Table A-8 lists the types and frequencies of responses tabulated as sensitive.

TABLE A-8
NATURE OF SENSITIVITIES RECORDED

	No. of Responses	Percent of[a] Sensitive Responses
Aesthetic/Visual	25	40%
Noise	15	25%
TV/Radio Interference	12	19%
Negative Acceptance[b]	11	18%
Safety Hazard	8	13%
Land Use Incompatibility	6	10%
Other	12	19%

[a] Total exceeds 100% because some respondents named more than one perceived impact.

[b] Negative acceptance refers to those persons who did not define a precise characteristic or impact but who conditioned their response by statements of resignation (e.g. "what can I do about it anyway?")

Either aesthetic characteristics or simply a view of the facilities was most frequently stated as reasons for adverse response. In fifteen. cases, noises associated with receiving station operation were cited as factors that had been noticed.

Several respondents mentioned that they received poor television and radio signals and questioned their proximity to a receiving station as a pertinent factor.

Eleven respondents verbalized or otherwise indicated that they felt adversely towards having a receiving station in their neighborhood, but would not clearly state a negative reason. Instead, they would condition their remarks, explain the psychological trade-offs made, or otherwise indicate that they had become accustomed to or had adapted to the facility. These respondents are noted as having expressed "negative acceptance."

Some concern over safety hazards was expressed, although such remarks were often conditioned by statements suggesting that the respondent realized how very unlikely accidents related to receiving stations must be.

Six of the sensitive respondents stated that, although no real dangers or impacts were associated with them, receiving stations simply should not be placed in residential areas because they create incompatible development.

QUESTIONNAIRE

Before The Interview:

Substation name________	Housing Type SF Dup Multi
Substation zone________	Value low/________/high
% Visibility________	Vegetation sparse/________/dense
Time________	Maintenance low/________/high

****

(Interviewer introduces self and explains that he is conducting a survey to see what physical features people like and dislike about their neighborhoods.)

1. "How long have you lived in this neighborhood?"________

2. "What physical features in your neighborhood do you find attractive?"
____
____
____
____

3. "Looking around your neighborhood, are there any physical features you dislike?"________
____
____
____

(Explain to respondent that you are primarily interested in seeing whether he/she had strong feelings, positive or negative, about utility installations and since they have a major electrical facility nearby (or "in this part of town" - or because they did mention it in response to #2 or #3) you would like to ask them just a few questions about electrical facilities.)

(SKIP NEXT QUESTION IF SUBSTATION MENTIONED IN #3)
(SKIP NEXT QUESTION IF SUBSTATION IS CLEARLY OBVIOUS)

4. a. "Is there an electrical substation here?" ________
"Where?"________

(If "no" or "don't know", go to Question #7)
(Interviewer may continue on if respondent appears to be aware of the substation but has difficulty locating it. Use judgement.)

* If respondent doesn't know what "electrical substation" is, describe or define as "a fenced yard of electrical equipment," or something similar.

b. "Do you consider that a part of your neighborhood?" ________

5. a. (Choose one question, as appropriate, based on previous response:)
"What do you think of that situation?"
"I see there's an electrical substation (next door), what do you think of it?"

"What do you like about it?"
"What do you dislike about it?"

____
____
____
____

b. "Why?" "How often does that occur?" (Or other prompters as necessary to obtain a description of the impact.)

____
____
____
____

(If only negative responses are given ask the following:)

c. "Is there anything good about the situation?"

____
____
____
____

6. a. "Do you ever think about the substation?"______________

b. "How often do you think about it?"______________

c. "Do you ever talk to other people about it?"______________

____

(Shift to transmission lines. Something like: "The other component of electrical facilities that we're interested in studying are transmission lines. Not the smaller lines on wooden poles leading into houses, but high voltage lines on really tall poles like the ones coming into the substation we've been discussing . . .")

7. "There are high voltage transmission lines like ones coming into the substation in many parts of the area. For those lines on 100 foot poles, where do you think they fit in the best? - I'll give you choices."

Along a major, busy street?______________

Along a quieter, residential street?______________

Along a canal?______________

It doesn't matter.______________

None of the above.______________

Comments.______________
____
____

Finally, I need to ask you a few questions about your household in order to properly group your previous answers with other similar households.

8. "Are you renting this house, or do you own it?"____________________

9. "How many people live here?"____________________________________

"Is that more than one family?"__________________________________

"Additional Comments?"____

"Thank you"

****

After the interview, note:

Sex: M F
Race:
Age: 16-25 26-55 over 55

SITE SELECTION FOR
ELECTRICAL RECEIVING STATIONS

by

Terrence T. Smythe
B.L.A., Kansas State University, 1975

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE
Department of Landscape Architecture

KANSAS STATE UNIVERSITY
Manhattan, Kansas
1984

A dilemma facing this nation is the proper site selection of a variety of development projects that are regionally needed but locally unwanted. According to recent studies, electrical utilities appear most likely to require a large number of new domestic sites to meet demands caused by increasing population levels and shifts of concentrations.

Electrical receiving stations are an important element in producing energy. The environmental problems associated with electrical receiving stations tend to be point-or site-specific problems. By their very nature, the facilities are located in mostly urban settings, and it is in these urban areas where the potential for altering the character of the surroundings becomes the greatest.

There are numerous factors that are used in site selection of electrical receiving stations including economic, engineering and political ones. In many urban areas there may be few substantial differences to justify site selection in land acquisition and engineering factors between various potential locations. All too often, the input from a detailed analysis of additional factors (land use, visual, acoustic) that contribute to the character of the site, has not been utilized.

The purpose of the research is to develop a site selection methodology that can be used to differentiate specific site characteristics by identifying and evaluating the potential impacts that might result from the construction, operation and maintenance of an electrical receiving station.

A qualitatively-conducted attitude survey indicated that impacts associated with receiving stations are perceived visually and acoustically and the perceptions are related to the degree to which the facility contrasts with the surroundings. The attitude survey also showed a need to establish additional general guidelines for siting the facilities through the use of a land compatibility approach.

The methodology utilizing land use, visual and acoustic factors and described in Chapter Three can contribute important information to the site selection process. The straight-forward approach described and utilized in the case study (Chapter Four) has verified its ability to differentiate site characteristics in sufficient detail to make appropriate site selection decisions.