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DESIGN RECOMMENDATIONS FOR REST AREAS

by

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Research Report Number 442-4

Research Project 3-18-86-442
Design of Rest Area Comfort Stations

conducted for

Texas State Department of Highways and Public Transportation

in cooperation with the

U. S. Department of Transportation Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

November 1987

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE

The study of rest areas has been accomplished with the help of many persons in the State Department of Highways and Public Transportation (SDHPT), officials in highway departments in other states and in other agencies, and the staff of the Center for Transportation Research. In particular, E. W. (Bill) Wilson, Technical Advisor for the study, Robert Hays, and Gordon Turn of the Building Design Section of the SDHPT, have given generously of their time and have made many constructive suggestions. The valuable assistance of graduate research assistants W. T. Straughan, Brian A Rock, and Carl W. Scharfe is gratefully acknowledged. They helped to prepare the recommendations. The help of Rose Rung in typing this report is greatly appreciated.

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Joseph F. Malina, Jr.
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LIST OF REPORTS

Report 442-1, "Investigation of Rest Area Requirements," by W. T. Straughan, David W. Fowler, and Kirby W. Perry, October, 1988.

Report 442-2, "Evaluation of Energy Sources for Roadside Rest Areas," Brian A. Rock and Gary C. Vliet, December, 1986.

Report 442-3, "Water and Wastewater Systems at Highway Rest Areas," by Carl W. Scharfe and Joseph F. Malina, Jr., October, 1988.

ABSTRACT

Based on the findings presented in previous reports, recommended design procedures are presented. Recommendations include spacing, site requirements, example architectural designs, materials, mechanical systems, and operations and maintenance. Recommendations for energy sources, water systems, and wastewater systems are made.

SUMMARY

Based on an extensive study of needs, design recommendations are made for rest areas. Recommendations include spacing, example designs, materials, mechanical systems, and operations and maintenance. Recommendations for energy sources and water and wastewater systems are included. Examples of building designs and site layouts are included.

IMPLEMENTATION STATEMENT

The basic design of Texas highway rest areas was developed more than twenty years ago and is in need of updating to maintain parity with the rest area designs currently in use by other states. Operation and maintenance procedures are also in need of review as compared to the practices of other states.

A modern "state-of-the-art" rest area should be constructed, operated, and maintained in accordance with the recommendations of this report in a carefully selected location. This will function as a prototype model to prove the concept, and will at the same time allow optimization of all recommendations prior to the construction of future rest areas in other parts of the state.

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CHAPTER 1. INTRODUCTION

Rest areas are an important aspect of our highway system. The traveling public now expects to find them at regular intervals along the interstate highways. The Interstate Highway Act of 1956 provided the impetus for rest area growth although rest areas had been in exsistence for many years. Many states have developed large, attractive rest areas with spacious, well-maintained comfort stations. These states have used rest areas as "show places" for both in-state and out-of-state visitors.

This report provides recommendations based upon an investigation performed for the Texas Department of Highways and Public Transportation (SDHPT) to determine design requirements for rest areas. Many sources of information were used to develop the recommendations [1, 2, 3], which are based on

(1) visits with professionals involved in rest area design, operation, and maintenance from six states and visits to selected rest areas in those states,

(2) a telephone survey of representatives of 12 additional states,

(3) surveys of professionals with the Texas Department of Parks and Wildlife and visits to 13 state parks,

(4) an inspection tour of several U. S. Army Corps of Engineers public use areas,

(5) discussions with legal counsel with the SDHPT and the Attorney General's office concerning legal aspects of design criteria,

(6) an extensive literature review,

(7) a visit to a manufacturer of modular rest room facilities,

(8) letters received by the SDHPT concerning rest areas which were reviewed and summarized,

(9) two rest area surveys, which involved vehicle counts by time and type and interviews with rest area users,

(10) visits with maintenance personnel from SDHPT districts to determine problems and recommendations for improvements,

(11) visits to rest areas in Texas, and

(12) review of plans and specifications from other states which were reviewed.

From these sources of information recommendations are made for the design of rest areas. Special emphasis was given to design criteria to minimize vandalism.

Chapter 2 presents guidelines and recommendations for rest areas, with particular emphasis on comfort stations.

Chapter 3 presents recommendations for alternate energy sources.

Chapter 4 provides guidelines for waste water and water treatment.

CHAPTER 2. REST AREA GUIDELINES AND RECOMMENDATIONS

Specific recommendations and guidelines for the design, operation, and maintenance of highway roadside rest areas were developed after a detailed review of all drawings, plans, specifications, photographs, interview reports, and other materials, together with detailed discussions among Center for Transportation Research (CTR) personnel, SDHPT representatives, and others involved in this project. The best sources of information were the experiences and practices of other states. Texas, however, has unique requirements, and the recommendations made in this report attempt to recognize these needs.

2.1 GUIDELINES

a. Rest area spacing should be 50 to 60 miles, based on the experience of the majority of states surveyed and interviews with Texas travelers.

b. Overall design guidelines for determining the number of users should be based on current procedures recognized by many states, supplemented by data and experience in Texas.

c. The ideal site would be 20 to 30 acres, with 10 acres considered the absolute minimum for the successful perusal of the prototype. The site should be relatively square and should facilitate an attractive layout of all buildings, picnic shelters, and other facilities, with sufficient open spaces to prevent a feeling of crowding.

   Two recommendations mentioned by the other states deserve special mention.

   (1) Virtually all states reported that the major reason for excessive vandalism in rest areas near large metropolitan areas is not only their ready availability to large population segments but the large homosexual communities which typically exist in large cities. Without providing for 24-hour-a-day security in these rest areas, it is virtually impossible to eliminate this problem. For this reason, and the fact that similar commercial and public facilities are available nearby, consideration should be given to closing all rest areas adjacent to metropolitan areas.

   (2) It is essential that a buffer zone between the rest area and any nearby community be established and not be violated during the life of the rest area, to prevent problems with nearby residents. If the preferred rest area site is too close to a community to guarantee this buffer zone for 20 years, then steps should be taken to acquire the necessary surrounding land to maintain the buffer zone "inviolate."

2.2 PROTOTYPE REST AREA RECOMMENDATIONS

2.2.1 Lighting

a. Provide a high level of illumination in the parking areas, on the walkways to the restroom buildings around the outside of the building in the immediate vicinity, and inside the building.

   High pressure metal vapor lighting is recommended in all locations, not only because of its effectiveness, but because of its superior bulb life and low maintenance cost. An acceptable alternative would be fluorescent fixtures with vandal resistant covers in the men's and women's restrooms, or a combination of both.

b. Provide for strong natural lighting using skylights and clerestories.

2.2.2 Site and Ancilliary Facilities

a. Use concrete picnic tables and benches set on concrete pads.

b. Provide picnic shelters, charcoal boxes, and waste receptacles at all table locations.

c. Use concrete trash receptacles outside and inside the building.

d. Provide a utility sink, drinking fountain, and outdoor water spigot in conjunction with the restroom building.

e. Construct a separate gazebo-type structure for use as an information-communication center. Install telephones and provide for an informational display complete with a state highway map and description of nearby points of interest.

f. Use divided parking areas to provide separate parking areas for small vehicles, i.e., automobiles, pickup trucks, etc., and for large vehicles, i.e., all other trucks, buses, recreational vehicles, etc.

2.2.3 Restroom Building Design and Layout

a. The restroom building units should be essentially square or rectangular spaces with no recessed corners, and with a mechanical room between the men's and women's restroom. The men's and women's restrooms should have a vaulted (cathedral) ceiling to allow natural light in the rooms.

b. Construct dual men's and women's restroom units.

c. Provide an effective flow-through (low ingress - high egress) natural ventilation system supplemented with mechanical exhaust fans.

d. Provide solid core laminated plastic clad exterior doors in steel frames on all restroom entrances.
e. Provide a central forced air heating/cooling system to condition air in restroom units.

2.2.4 Plumbing Fixtures

a. Use wall-hung vitreous china toilets and urinals "back bolted" through the walls.
b. Use push button operated flush valves, with the valves mounted behind permanent construction.
c. Use vitreous china lavatories in conjunction with spring loaded faucets.
d. Provide central liquid soap dispensing, with a translucent tank to permit monitoring of the fluid level.
e. Use antitheft type toilet tissue holders (two per stall).
f. Use a compressed air hand dryer (without heating coils) in each restroom.
g. Provide a stainless steel sanitary napkin disposal unit in each toilet stall in the women's restroom.
h. Provide a toilet seat cover dispensing unit in every toilet stall in the rest area.
i. Use heavy duty glazed mirrors back-bolted through the wall in each restroom.

2.2.5 Interior Building Design and Specification

a. In all restrooms, use full height toilet partitions suspended 12 to 15 inches above the floor.
b. Use T304 or T316 stainless clad toilet partition panels and doors on all toilet partitions in all restrooms.
c. Use ceramic tile on the floors in all restrooms.
d. Use ceramic tile on all building walls in all restrooms to a height of 7 ft. 2 in.
e. Provide one or more 10-volt electrical outlets in all restrooms.

2.2.6 Operations and Maintenance

a. All rest area restrooms should be washed down with either a portable steam cleaning nozzle or high pressure hot (160° F or higher) water spray containing strong cleaning chemicals. This should be accomplished at least quarterly and more often if odors or visual accumulations of dirt or other residues that cannot be removed by normal cleaning means are apparent. The permanent installation of steam or hot water cleaning equipment is not recommended because (1) of the high cost per building (about $10,000) and (2) the portable systems can be used to clean the interior as well as the exterior, including sidewalks and picnic tables.
b. Establish the rest area maintenance organization to provide 24-hour-per-day, 7-day-per-week coverage; in most cases, a minimum of 16 hours per day, 7 days per week should be provided. Provide the attendants with uniforms, and make the wearing of the uniform mandatory at all times attendants are on duty.

2.3 EXAMPLE DESIGNS

Two examples of site plans are shown in Figs 2.1 and 2.2. Fig 2.1 is a 10-acre site and Fig 2.2 is a 20-acre site. The

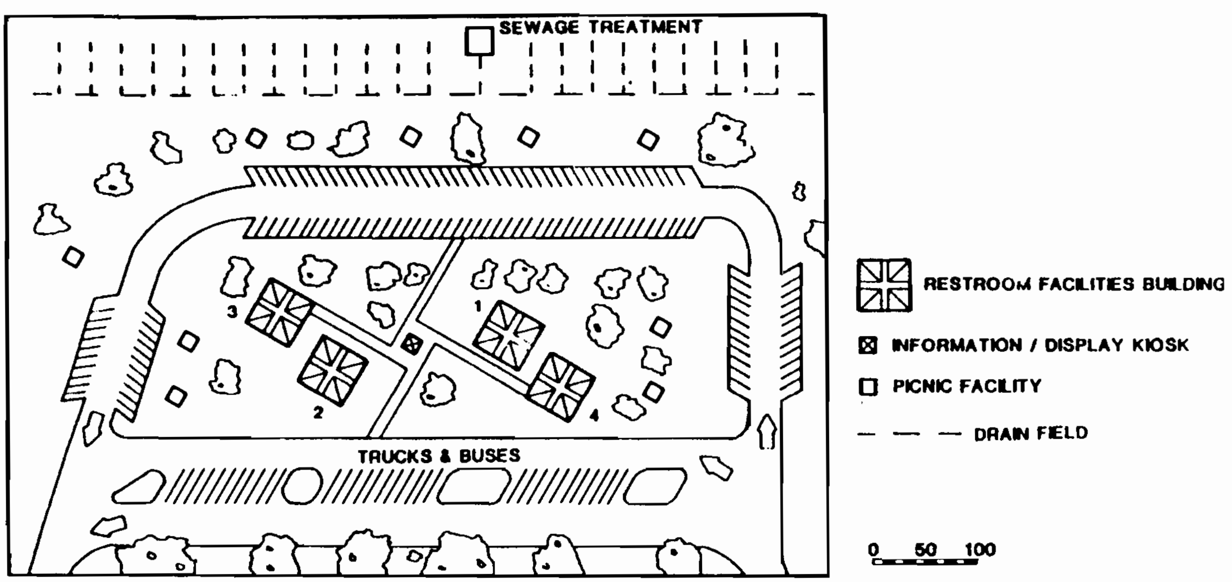

Fig 2.1. Ten-acre prototype site plan.

actual design for a specific site would have to be based on the features of that particular location. However, these examples indicate the separation of parking, the location of restrooms and picnic facilities, and the location of the sewage treatment facilities.

Figs 2.3 to 2.6 show a comfort station design which would serve 500,000 people per year. The facilities have dual men's and women's restrooms, well defined entrances and exits, escape routes in each unit, and a central maintenance and equipment room between units. A vaulted ceiling

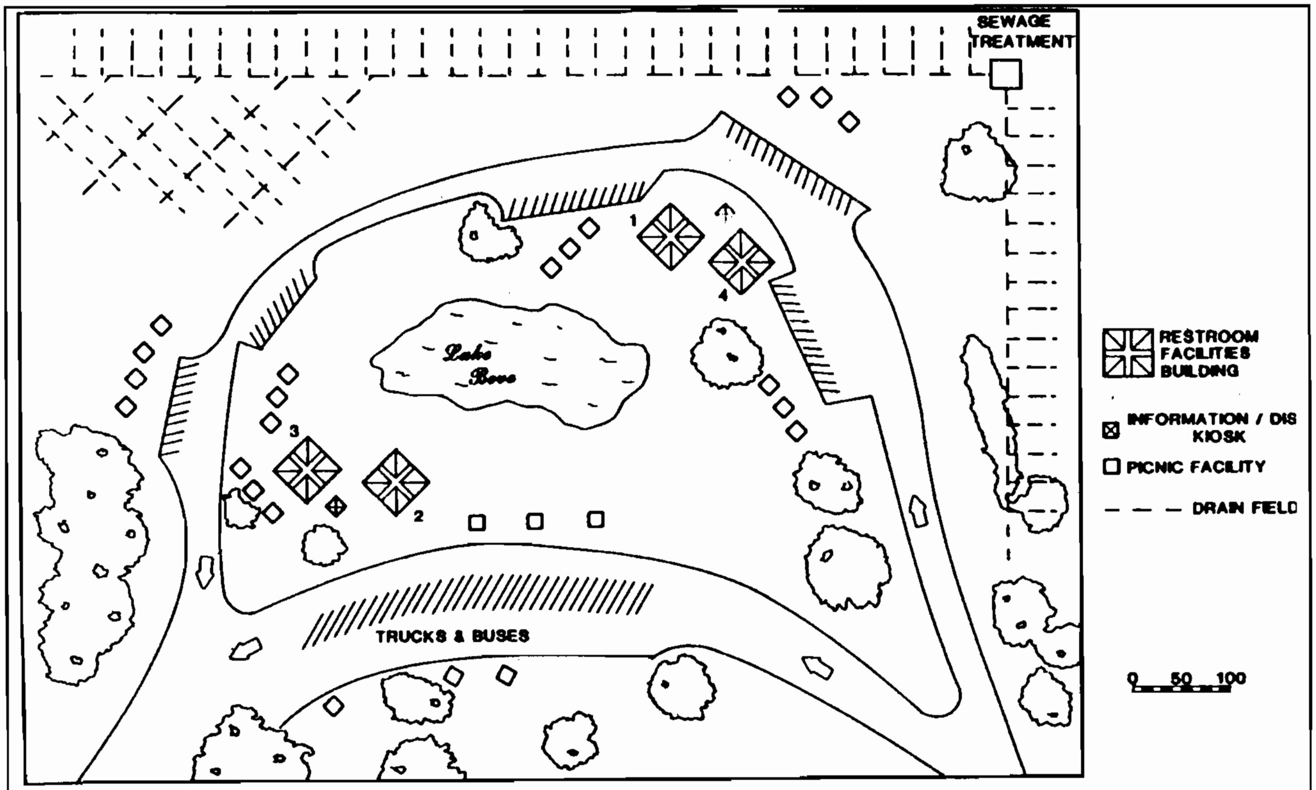

Fig 2.2. Twenty-acre prototype site plan.

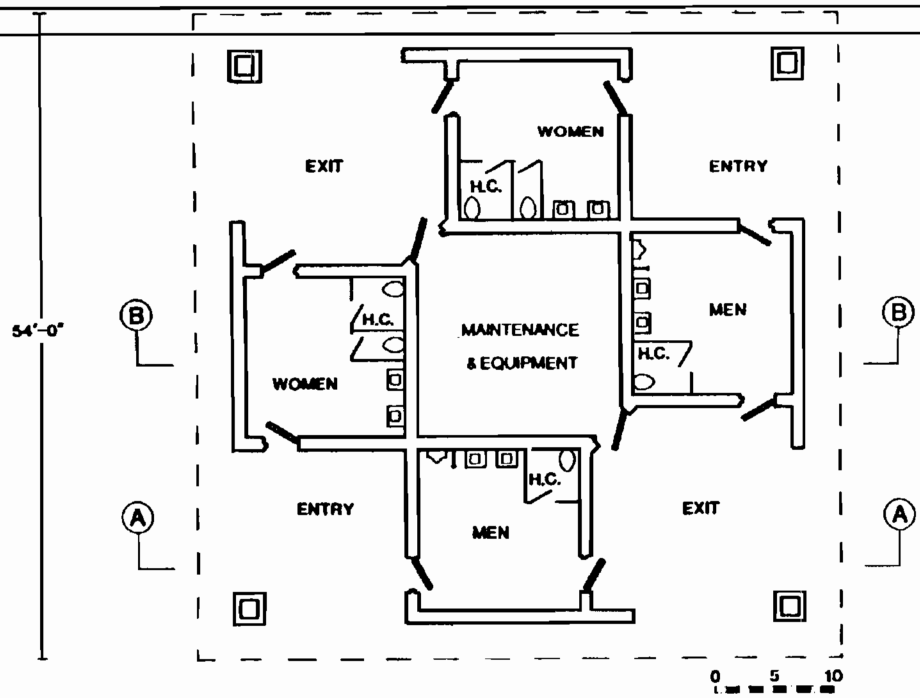

Fig 2.3. Prototype "A" — plan.

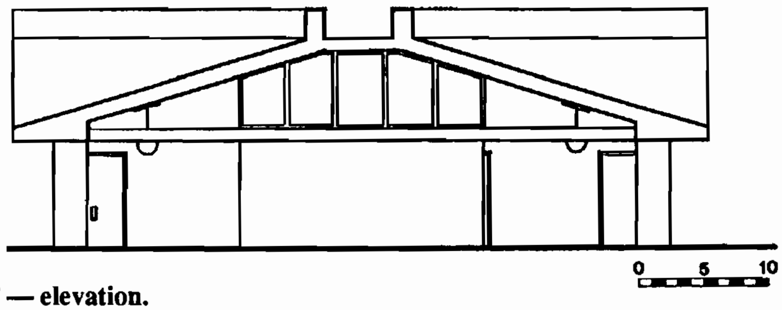

Fig 2.4. Prototype "A" — elevation.

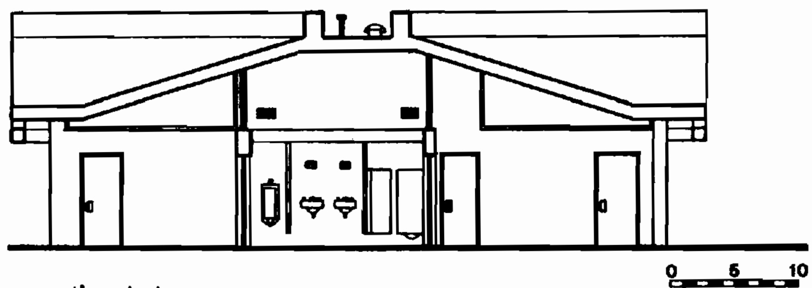

Fig 2.5. Prototype "A" — section A-A.

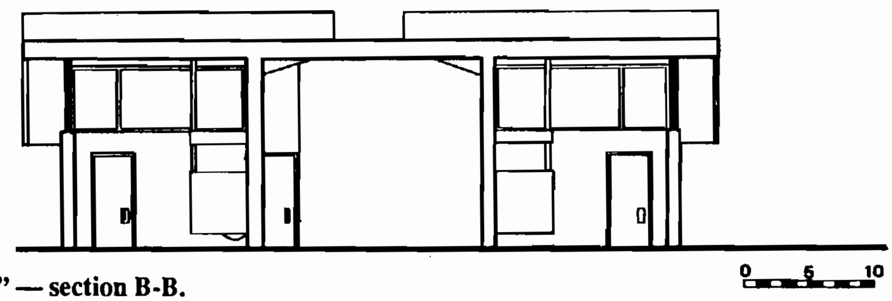

Fig 2.6. Prototype "A" — section B-B.

with clerestory lighting is used. A roof with a wide overhang covers the units.

Figs 2.7 to 2.10 indicate a comfort station which has larger restrooms, each with a pull down door in the center to provide separation during maintenance. This feature permits the units to remain open at all times. These units also have escape routes and no hidden corners. The stations also have a large overhang, natural lighting, and a central maintenance room.

Both prototypes can be used in multiple units, as shown on the site plans (Figs 2.1 and 2.2), with each unit capable of accommodating 500,000 people per year.

2.4 CONSTRUCTION OF PROTOTYPE REST AREAS

It is recommended that one or more prototype rest areas should be constructed to incorporate as many of these recommendations as possible. An evaluation team should be established, composed of CTR researchers and SDHPT Building Design Section and district personnel. Monthly inspections should be made initially, followed by inspections at less frequent intervals. In addition, the CTR research staff should conduct periodic surveys to establish numbers and types of users, and the opinions of users should determine the opinions of SDHPT maintenance personnel.

2.5 JOINT-USE FACILITIES

The concept of joint use facilities, in which private enterprise constructs rest areas in accordance with state guidelines, is being explored as a viable alternative in at least one other state. While a thorough study of this concept for use in Texas was beyond the scope of this study, it is recommended that this concept be investigated as a means of constructing rest areas at little cost to the state.

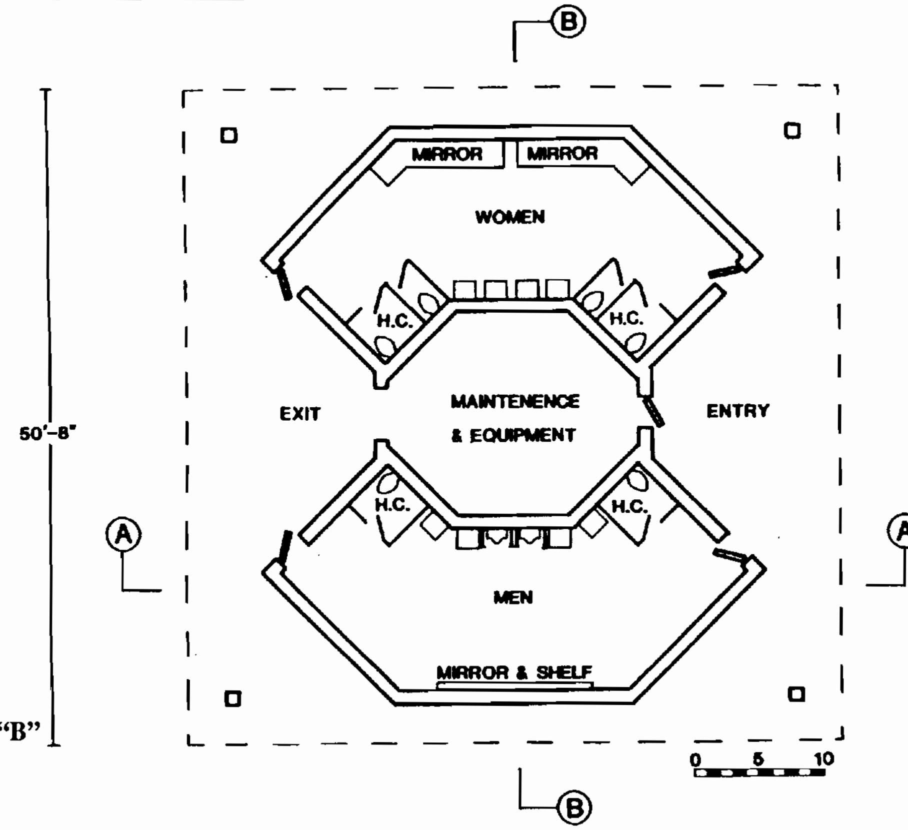

Fig 2.7. Prototype "B" — plan.

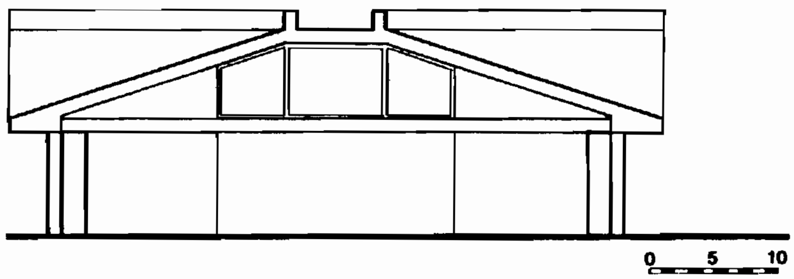

Fig 2.8. Prototype "B" — elevation.

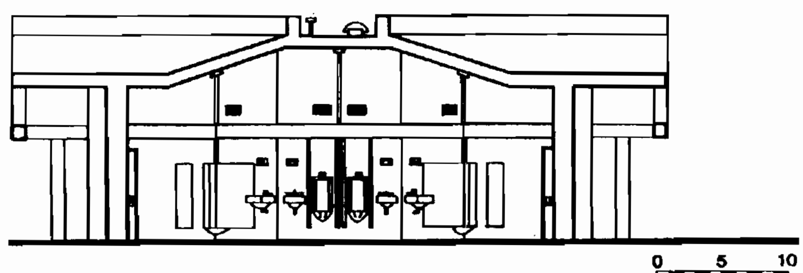

Fig 2.9. Prototype "B" — section A-A.

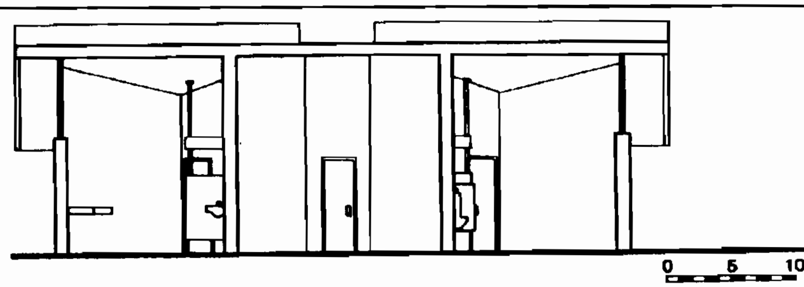

Fig 2.10. Prototype "B" — section B-B.

CHAPTER 3. RECOMMENDATION FOR ENERGY SOURCES FOR ROADSIDE REST AREAS

3.1 INTRODUCTION

Various methods for meeting the energy needs of roadside rest areas have been examined. Many energy sources, such as conventional, solar-thermal, photovoltaics, daylighting, wind, geothermal, and cogeneration exist and should be given consideration. With good design decisions, there is a potential for significant savings over the life of the rest area installation.

3.2 SUMMARY OF ENERGY SOURCES

Conservation should be the first concern addressed in the design since wasting energy increases the energy system's size and cost of energy. The building environment should be maintained at the minimum comfort level. This means a minimum acceptable temperature and humidity during heating periods, and a maximum acceptable temperature and humidity during cooling periods. Ventilation should be kept to a minimum acceptable level, and infiltration should be reduced. Equipment such as air-to-air heat exchangers should be utilized to reduce the energy loss associated with ventilation. To reduce infiltration, good construction practices should be followed, such as caulking all the joints in the building envelope and using vapor barriers.

Lighting equipment should be efficient and require low maintenance. For the interior of the building, metal vapor or fluorescent lighting is recommended over incandescent light sources. Other high efficiency point sources such as high pressure sodium luminaires would be difficult to control in interior applications, but they are recommended for exterior use.

For water and possibly space heating, solar-thermal flat-plate liquid-cooled sytems should be considered. For most locations, this type of system will be economical if it is properly designed and installed. Proven system configurations such as drain-back and antifreeze systems are recommended. Reducing the first costs is a key to making a solar-thermal system economically feasible. New personal computer-based codes such as F-Chart can rapidly evaluate the economics and the performance of a solar-thermal system.

Photovoltaics (PV) should be considered for low level and security lighting in isolated locations. For small applications, such as radio transmitters and traffic counters, photovoltaics should always be considered. As the cost of photovoltaic cells drop, PV systems will become economically feasible for a greater variety of applications. The program PV F-Chart is recommended for the economic and performance evaluation of a photovoltaic system.

The cogeneration of heat and electricity is currently feasible for locations where a low cost fuel source is available and should be considered. Wind and geothermal energies are very site specific and may find some limited application.

The main conclusion of this portion of the project is that the designer of future roadside rest areas should no longer assume that conventional energy sources are the only alternative. The designer needs to be aware of conservation measures and alternate energy sources and must be able to assess the economics of these options relative to conventional energy.

3.3 RECOMMENDATIONS

Future reserach on the renovation of existing rest area buildings would be beneficial. Since the State's current financial position may prohibit the construction of many new facilities, older locations will still need to be relied upon to provide service to the public. Making the buildings more energy-efficient and adding new services such as hot water and security lighting would extend the useful lifetimes of previously obsolete rest areas.

Joint-use facilities may increase the economic feasiblitity of a new rest area. Since the energy requirements for this type of construction would be greater, a larger opportunity for savings would exist with the use of alternate energy systems. Technologies such as the cogeneration of electricity and hot water, steam, or refrigeration would become more attractive. Research in this area would help to determine the merit of joint-use facilities over conventional rest areas.

CHAPTER 4. WATER AND WASTEWATER SYSTEMS AT HIGHWAY REST AREAS

4.1 INTRODUCTION

The majority of Texas highway rest areas were built in the 1960's. The water and wastewater systems at these rest areas reflect the technology available at that time. This report summarizes the "state-of-the-art" technologies for water and wastewater systems at highway rest areas in the United States. Methods for determining rest area water demands, wastewater flows, pump sizes, storage tank volumes, and fixture requirements were explored. Various wastewater systems used at rest areas in outside states were evaluated.

The two problems most frequently encountered in rest area water systems are inadequate water supply and/or water pressure. Water demand data for Texas rest areas are nonexistent and thus water meters need to be installed at all Texas rest areas. Meters should separate water usage in rest rooms from outside water demands at the rest area. For more immediate purposes, water demands can be estimated using the Zaltman method. Ideal water pressure at rest areas is 40 psi, with 20-to-60 psi being acceptable. Water system component sizing should be based on peak water demands.

Rest area wastewater systems best suited for Texas, in order of preference, are (1) evaporative ponds, (2) overflow ponds, (3) overland flow or spray irrigation, and (4) evapotranspiration beds. Failed septic systems can be renovated using the systems listed above during rest area high use periods. Land requirements for rest area wastewater disposal systems are a minimum of approximately 3 acres and can be upwards to 10 acres. Recreational vehicles and water saving toilets will increase concentrations of organic wastewater constituents delivered to wastewater systems and will require changes in the operation of the treatment systems, such as more frequent septic tank pumpout.

4.2 WATER TREATMENT SYSTEMS

Rest area water treatment systems must supply water of adequate quality and quantity. A municipal water supply is preferred, while well water sources should be utilized when a municipal supply is not possible.

The design of rest area water treatment systems requires knowledge of peak instantaneous, peak hourly, and peak daily water demands experienced at the rest area. Peak instantaneous demands are used to size piping to fixtures, peak hourly demands are used to size well pumps and determine storage requirements, and peak daily demands are used to determine the required capacity of the water systems.

As noted above, water usage data are not available for Texas rest areas, and so meters should be installed at all rest areas to start a data base. Water meters can provide valuable flow records for design and modification of future and existing water and wastewater systems at rest areas. Water meters should be installed in all new and existing rest areas. Meters should be installed in locations to measure instantaneous flow as well as the total accumulated flow. Water used for rest rooms should be measured separately from other uses, such as lawn sprinkling.

Estimates of water usage can be calculated and used for design if the following information is available: average daily highway traffic (ADT), the percentage of ADT stopping at the rest area, the percentage of those entering the rest area that use the rest rooms, and the water use per person or per vehicle. At present, peak instantaneous and peak hourly demands can be estimated using fixture methods, while peak daily demands can be estimated using traffic data.

Recreation vehicles will use approximately nine gallons of water per vehicle. Low flush toilets will use approximately one gallon per flush.

Disinfection with chlorine is required if well water, surface water, or storage facilities are used. Various chlorination systems are available and the chlorine demand will dictate the preferred system for a given application. Water softening using ion exchange (Zeolite) systems is required for water with hardness greater than 300 mg/L as $CaCO_3$.

4.3 WASTEWATER TREATMENT SYSTEMS

Rest area wastewater treatment systems should (1) be designed for low capital, operating, and maintenance costs, (2) have discharge and effluent that meets federal or state quality standards, (3) not pollute groundwaters, and (4) not cause unacceptable odors. Rest area wastewater is similar to domestic wastewater but has higher concentrations of carbonaceous oxygen demand and ammonium nitrogen. Wastewater flow rates can be estimated using traffic data and typically range from 4,000 to 8,000 gallons per day; peak demand can be two or three times larger than average flow rate. A minimum of three acres is required for rest area wastewater systems unless a package plant is used. Pond systems are favored for rest areas.

Geologic and soil studies should be conducted at the proposed rest area site, in addition to percolation tests. These studies will help determine the probable success of soil absorption, pond, land treatment, or evapotranspiration bed systems at rest areas. The geologic and soil studies should be a part of the rest area site feasibility study in order to combine waste treatment concerns with more routine highway and building construction concerns.

4.3.1 Ponds

Overflow and evaporative ponds are attractive treatment systems for rest areas. Evaporative ponds are favored especially where the annual evaporation rate exceeds the annual rainfall because they do not produce an effluent. Areas in west Texas are more suitable for evaporation ponds whereas rest areas in wetter east Texas may be able to use overflow ponds if effluent can be disposed of in a satisfactory manner. Pond surface area calculations can be based on evaporation rate excesses for overflow ponds. A minimum of three ponds in series is required for overflow pond systems. Ponds are flexible systems; if land is available the system can be expanded by building additional evaporative ponds. About three acres of land is required for pond treatment systems at rest areas. The minimum depth should be 3 to 6 feet depending on the geographic location.

Pond systems have low operation and maintenance requirements, consisting of mowing, dike and inlet and outlet inspection, and weed control. It has been estimated that two man-hours per week are required to maintain the system.

4.3.2 Septic Tanks

Septic tank/drain field systems have been used commonly at rest areas, with failures occurring in many instances. Failures of these systems are usually caused by tank undersizing and/or drain field clogging. Designing of these systems has usually been based on average daily flows and percolation rates. The design should consider the tradeoff between using peak daily flows and a higher tank cost compared to the lower tank cost at average flow rates. Drain field infiltration surface area also must be calculated, using the peak daily wastewater flow rate.

Alternate dosing and resting periods should be used in applying effluent to the drain field. Resting times need to be determined locally for the site, using soil moisture tests over various times of resting. It can be expected that sands will require about a month of rest and silts and clays several months or more.

Narrow trenches are recommended for the drain field system, bottom area and sidewall area can be used to design the field if the trenches are set up in series. If trenches are in parallel, bottom area alone should be used for design.

The use of overland flow or evapotranspiration beds for final disposal of septic tank effluent should be considered where drain fields have failed. Seasonal use of these systems during rest area high use periods is an option that should be fully explored. Approximately 4 to 6 acres of land are necessary for overland flow systems and evapotranspiration bed systems require 0.5 to 3 acres of land.

The United States Public Health Service Manual of Septic Tank Practices was published in 1967 and is still used today with slight modifications. Many of the guidelines have not been borne out by experience. Texas guidelines are very similar to those in the USPHS manual except for inclusion of alternate systems for percolation rates greater than 30 min/in. and the limit of daily waste flows to 5000 gallons for use of a septic tank/drain field system. Maintenance and operational costs for septic tank systems are small and can be considered negligible.

4.3.3 Package Plants

At present, package plants are one of the most frequently used types of waste treatment systems at rest areas. The major problem in designing the plants is correctly sizing the plant. Many extended aeration plants at rest areas are hydraulically overdesigned and organically underloaded. The performance is dependent on how well the sedimentation unit performs. Sedimentation problems include rising, bulking, and no-flocculent sludge settling.

Extended aeration package plants should be considered for use if (a) less than three acres of land is available at the rest area, (b) groundwater contamination is likely if pond or septic tank/drain field systems are used, or (c) discharge to a stream is the only means of final effluent disposal.

Modular package plants are recommended for use at rest areas so that design capacity is more closely achieved throughout the life of the treatment plant. Sufficient space should be provided at the site for the addition of modular units as needed.

Package plants can be expected to have higher operation and maintenance requirements than pond or septic tank/drain field systems. It is estimated that one man-hour per day will be needed for this system. The system is vulnerable to power shortages, which can cause system shutdown, so this is a disadvantage of the system.

Excess sludge disposal via drying beds, small ponds, holding tanks, or truck hauling is a necessary element of design.

4.3.4 Land Treatment

Land treatment systems are categorized as irrigation, rapid infiltration, or overland flow systems. Only spray irrigation and overland flow systems are being used at rest areas. Spray irrigation systems should have fixed distribution systems and have buffer strip areas to both hide the systems and trap aerosols. Overland flow systems can be used on impermeable soils such as clays and clayey loams. Overland flow-evapotranspiration fields can be added to failed septic tank/drain field systems and operated during summertime high flows to give the drain field a chance to aerate. High nitrogen uptake crops should be planted in spray or overland flow evapotranspiration fields. Canary grass and other plants should be investigated to find maximum plant uptake rates. These systems are capable of treating pond and package plant effluent but have not been recommended for septic tank effluent. Pollution of groundwaters has not occurred to any discernible amount due to spray irrigation or overland flow, and nitrate standards have been met. Both systems have demonstrated the ability to remove high percentages of BOD, nitrogen, phosphorus, and total organic carbon.

Land requirements for land treatment systems are controlled by hydraulic and nitrogen loadings, with the larger land area requirement being chosen. The wastewater application rates are determined from water balances made from climatic monthly summaries. Land requirements for these systems range from 2 to 10 acres and are sized according to hydraulic loadings.

Operation and maintenance requirements for these systems are low. Land treatment systems are usually automated so that pump maintenance and setting of dosing times are the main operation requirements. Harvesting of crop covers may be necessary, but this will probably take only a few man-hours per week.

4.3.5 Evapotranspiration (ET) Beds

Use of ET beds for rest area wastewater treatment systems is virtually nonexistent. The success of the system is dependent on the correct estimation of ET rates for the ET beds. ET rates can be correlated to pan evaporation rates for different effluent levels and crop covers.

The maintenance of a constant bed effluent level is necessary for proper cover crop growth and may require the use of pumps. Grasses may be less sensitive to bed effluent level fluctuations than trees. Treatment efficiencies of ET beds were not calculated in studies reviewed so that groundwater contamination risks from ET beds is not known. Additional performance data are required to establish effective design parameters and criteria. Maintenance and operation requirements of ET systems are expected to be between those for pond and septic tank/drain field systems.

4.3.6 Water Saving Recycle

Water saving toilets or water recycle systems should be considered if water shortages or high wastewater flows are a concern at the rest area. Water saving toilets are low cost systems that may solve water shortage problems with a minimum of change to the wastewater treatment system. Water recycle systems are favored if low flush toilets are already installed or are not desirable based on local experiences with the water saving toilets. Mineral oil systems are not recommended because they require a separate grey water system and have high overall costs and numerous maintenance problems.

4.4 RECREATIONAL VEHICLES

Recreational vehicles (RV) dump stations are not recommended at rest areas because they necessitate changes in the operation of the wastewater treatment system and they are prone to vandalism. Wastewater production from RVs will be approximately 16 to 21 gallons per vehicle. If RV stations are to be installed at rest areas, the RV wastes should be diluted before entering pond or package plant systems. If land absorption systems are used at the rest area, a separate RV wastewater treatment system should be used. RV wastes and water saving toilet wastes are similar in that both will increase the organic concentrations of wastewaters flowing to the treatment sytem. Therefore, design of these systems must take the increased concentration of wastewater constituents into account.

4.5 COSTS

Annual water and wastewater treatment costs should include both capital and operation costs. Cost indexing, although desirable, is a difficult task for rest area treatment systems because cost indexes are not available for small systems, with the exception of extended aeration package plants. Relative cost comparisons from two studies show that package plants are approximately two times more expensive than pond systems. Relative cost comparisons for package plants versus mineral oil recirculating are inconclusive so that the choice between using these systems depends more on other considerations. Based on one study it appears that overland flow-evapotranspiration systems may be less expensive than spray irrigation. The best way to estimate costs for rest area wastewater treatment systems is to consult local contractors and suppliers for capital cost estimates and to review operating and maintenance records at existing rest areas to estimate operation and maintenance costs for proposed rest area wastewater treatment systems.