

## SUSTAINABLE HOUSING FOR PARK RANGERS IN BIG BEND NATIONAL PARK, TEXAS

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### ABSTRACT

A team of graduate architecture students and faculty from the School of Architecture, at the University of Texas at Austin, under the direction of Associate Professor Michael Garrison, and the Department of Architecture, Texas Tech University, under the direction of Associate Professor Glenn Hill, have designed environmentally friendly "green" homes for park rangers in Big Bend National Park, Texas. With funding from the National Park Foundation and a construction commitment of 1.2 million dollars by the National Park Service, design teams in the joint project have developed permanent sustainable housing responsive to the hot-arid desert climate.

### INTRODUCTION

Big Bend National Park is located in southwest Texas where the Rio Grande River makes a U-turn and forms a "big bend." The region is typified by "islands of mountain ranges lying in a desert sea." Big Bend is also one of the most remote park areas in the lower 48 states. The isolated and rugged setting forces residents to face numerous day-to-day challenges and responsibilities in work conditions and family life.

Big Bend employees have long complained about the poor housing conditions in the park. Many employees live in outdated trailers. The trailers are beyond repair. The annual cost to maintain them exceeds their value. Occupants share their "homes" with scorpions, insects, and rodents and the cooling and heating systems do not work properly. All the dilapidated trailers need to be replaced with permanent sustainable housing structures.

The university design teams working with the National Park Service developed permanent sustainable housing designs appropriate to the desert climate of Big Bend to replace the temporary trailers. Design features include:

ramada shading porches, passive solar heating and cooling, high thermal mass construction, solar induced and cross ventilation, solar hot water heating, swamp coolers, low water use fixtures, low voltage and energy efficient lighting, energy efficient appliances and the use of sustainable and recycled content building materials. Construction documents for seven new homes were completed in June of 1995 and construction is scheduled to be complete by September 30, 1996.

### VERNACULAR ARCHITECTURE

The design process began with a survey of the local vernacular architecture. Most of the vernacular architecture in Texas' desert areas was built by pioneers who had traveled from Spain or Mexico. Houses in this area were typically constructed of Adobe. The desert inhabitants who chose to build with adobe quickly provided themselves with much-needed shelter from the climatic extremes of their environment, the thick walls of adobe mud slowed the penetration of outside temperatures and the day's heat did not reach the inside of the house until after dark, tempering the nighttime chill. Likewise the night's cold did not penetrate until the sun had already risen, allowing the interior of the house to remain cool despite the scorching temperatures outside. In this way the walls themselves provided air conditioning and heating, letting the inside environment remain within a more comfortable range of temperatures.

The Hispanic pioneer adobe houses were generally arranged in either a 'courtyard house' or 'ranch house' configuration. The courtyard house type was the more commonly employed of the two, and consisted of a string of one-story, flat-roofed rooms encircling a courtyard. Access to the house was gained through a roofed vestibule as deep as the living room. These houses usually had a limited number of windows and doors to bar the dust, heat, and painfully brilliant light of the outside environment from the interior spaces. For an added measure of protection, the windows were usually equipped with thick wooden shutters that could be closed against either daytime heat or night time cold. The courtyard arrangement itself yielded some

advantages in the desert climate. Its shaded, deep entrance stopped hot exterior air from penetrating into the house, while the enclosed courtyard, shaded by the house walls and usually containing a garden and fountain, provided a source of cool air and humidity for the rooms opening off it.

Ranch houses, by contrast, relied on cross-ventilation for their cooling breezes. These houses took the form of a long, straight chain of rooms with windows on both sides, surmounted by a pitched roof that extended to form front and back porches on the long faces of the house. This design had two major advantages. First, having the main body of the house only one room across created ideal conditions for cooling the house by cross-ventilation, and the air entering the rooms was already cooled by the porches' shade. A second advantage was that the porches automatically served as well ventilated circulation spaces, negating any need for enclosed, potentially stuffy hallways.



Fig. 1 Ramada at Fort Leaton, Texas

Another common desert vernacular building technique is to make the porch a shade "Ramada." A ramada, or shade trellis, was usually made of a dried indigenous cactus such as Ocotillo or river cane, and was utilized to dapple the harsh light and to keep the direct sun off the structure and its inhabitants.

## DESIGN PROCESS

To develop designs for housing in Big Bend National Park, the design team utilized the general principles of 'border style' desert Texas vernacular architecture, and attempted to minimize the visual impact of the development. Any views of the houses should not detract or compete with the pristine natural beauty of the surrounding park setting. The team's designs used natural earth-tone materials and low-pitched roofs, which along with xeriscaping and the rolling contours of the surrounding hills, minimize visual impact.

The site plan envisioned the development of three types of permanent family homes, a large 3-BR design, a smaller 3-BR design and a small 2-BR design. Each of the designs was formulated for size requirements and for the existing site features of the BBNP master plan. The designs were labeled by the shape configuration of their footprint and became known as the 3-BR H-House, 3-BR R-House, and 2-BR T-House.

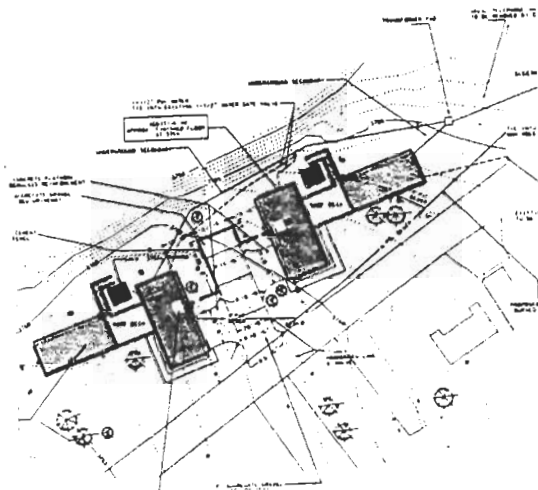


Fig. 2 T-House Site Plan

## T-HOUSE

The T-House was a result of the requirement of fitting the home along the narrow strip of land between a deep arroyo to the North and an existing road to the South. The grouping of the units into two provided the dual benefits of impacting a smaller portion of the land while

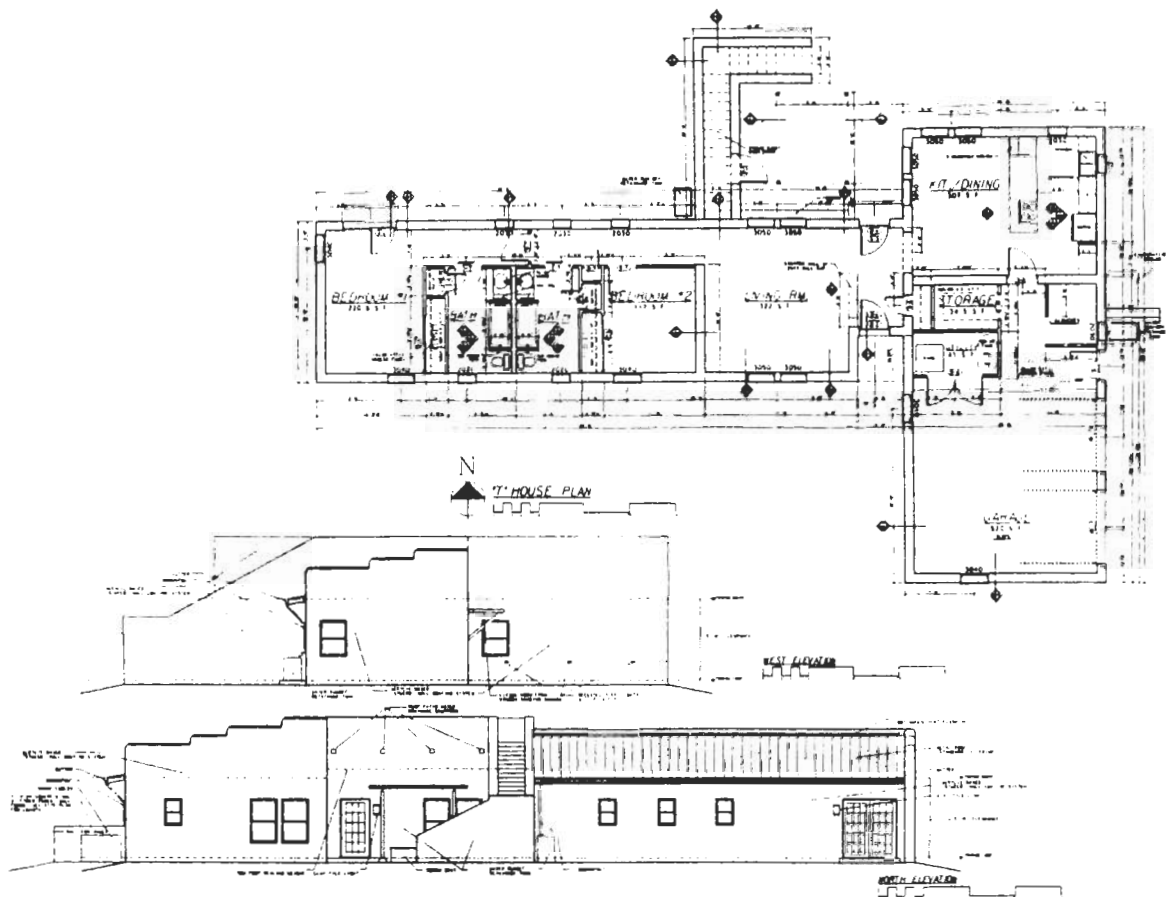


Fig. 3 T-House

giving rise to a structure for a larger group of units being planned to the south. This was incorporated to take full advantage of the site planning desired, optimizing views, solar orientation, proximity to surrounding dwellings and wildlife corridors, while maintaining the existing infrastructure.

The design of the house is simple, basically following the long line of its site constraint. This itself provides a benefit in that the unit is able to maximize the desirable north-south orientation and minimize east-west exposure. The kitchen and utility area are at one end, the private quarters are at the other, with the living area as the bridge. Off the living area to the north is an outdoor "room" created on two sides by the walls of the house, on the other two by a stairway leading to a roof terrace. These two outdoor areas, the lower with an overhead ramada

and the upper with a roof terrace, constitute the focal point of a house which is designed for outdoor living and appreciation. The outdoor rooms are small enough to be controlled yet give the promise of vast spaces inherent to Big Bend. The roof terrace, though simple, fulfills the function of providing a distant view of mountains and as a consequence, a broader perspective.

The interior of the house gives deference to the outdoors and nature, providing simple rectilinear rooms whose main adornment is the placement of windows. Stucco covers the load-bearing exterior mass walls, distinguishing them from the few interior "stramit" partitions. To emphasize the load-bearing nature of the exterior walls, the lighting scheme on the interior consists primarily of low voltage wall-washers, illuminating the stucco and providing soft indirect lighting. The 2-BR house is a frugal 1306 square feet.

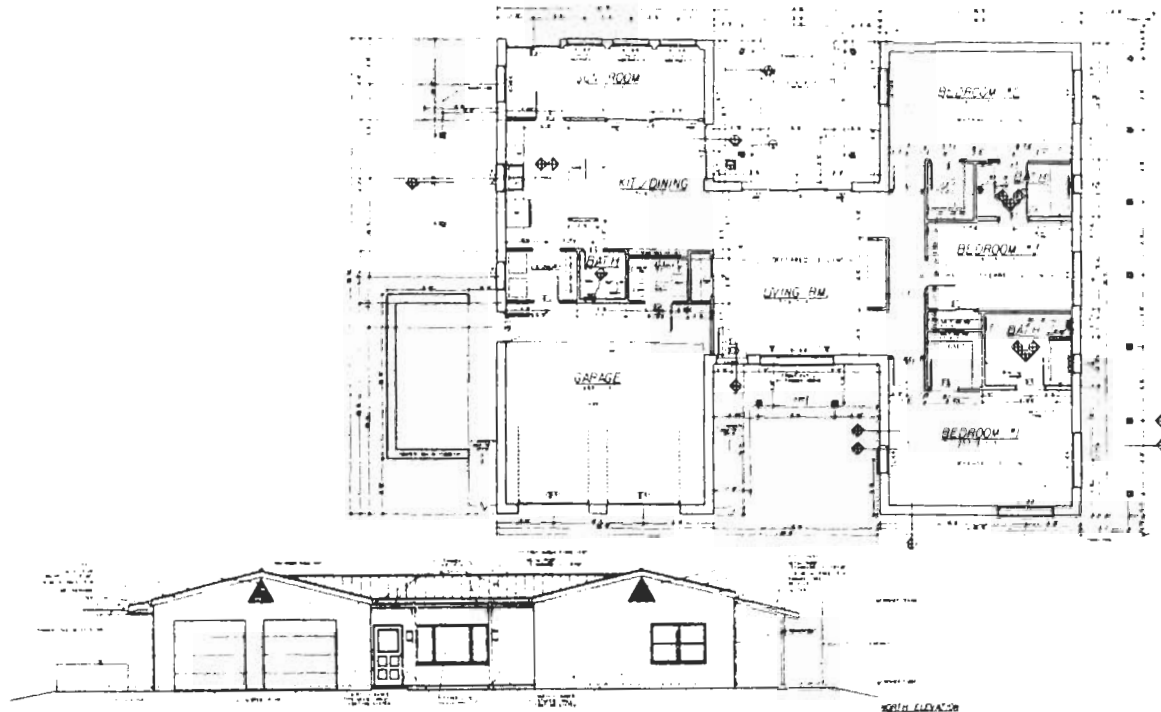


Fig. 3 H-House

### H-HOUSE

In the H-house, the Texas dog-trot courtyard plan configuration is designed to enhance natural ventilation. Dog-trot houses consist of at least two wings separated by a covered, walled passage, likened to a kennel run, which gave this housing type its name. The dog-trot passage channeled wind down its length, creating a shaded, ventilated room where residents would often eat and rest in more comfortable conditions. The front face of a dog-trot was usually oriented to the south to take advantage of southern breezes during the summer. The porch of the house faces south, with a long overhang that shades the house in summer while acting as a wind-scoop, helping to capture southerly breezes and to funnel them through the corridor.

The cooling effect of the natural cross ventilation is further enhanced if the dry hot air is first humidified by passing through a cool shaded courtyard before entering the house. The H-House configuration contains two courtyards both north and south of the living room that are formed by the protecting walls of the bedroom and utilitarian wings of the house. Rainwater collected from the roof of the house is channeled into these courtyards to create a micro climatic flora capable of humidifying breezes.

Other design features of the H-House include deep trellis/ramada overhangs to provide solar shading along the entire west facade, around the South facing courtyard, and in front of the East facing window over the kitchen sink. A large sunroom facing south next to the kitchen and dining room will provide additional winter heating and will allow the residents to plant a year-round 'critter'-free garden. A large pantry/utility room will connect the kitchen directly to a large enclosed garage. The garage will contain a mechanical room to house the equipment for a roof mounted solar hot water collector. A completely separate bedroom wing will enhance privacy. The plan layout uses an open plan living Room/Dining Room/Kitchen layout to enhance the informal living and increases the spacious atmosphere of the compact 3-BR house (1737 square feet).

The H-House uses a low angled 3 in 12 roof slope that combined with the H-House configuration, keeps the height of the roof low to the ground. The peak of the roof is only 13'-6" above the ground. The use of earth-tone exterior building materials and with adequate native xeriscaping, the design blends the house into its background setting.

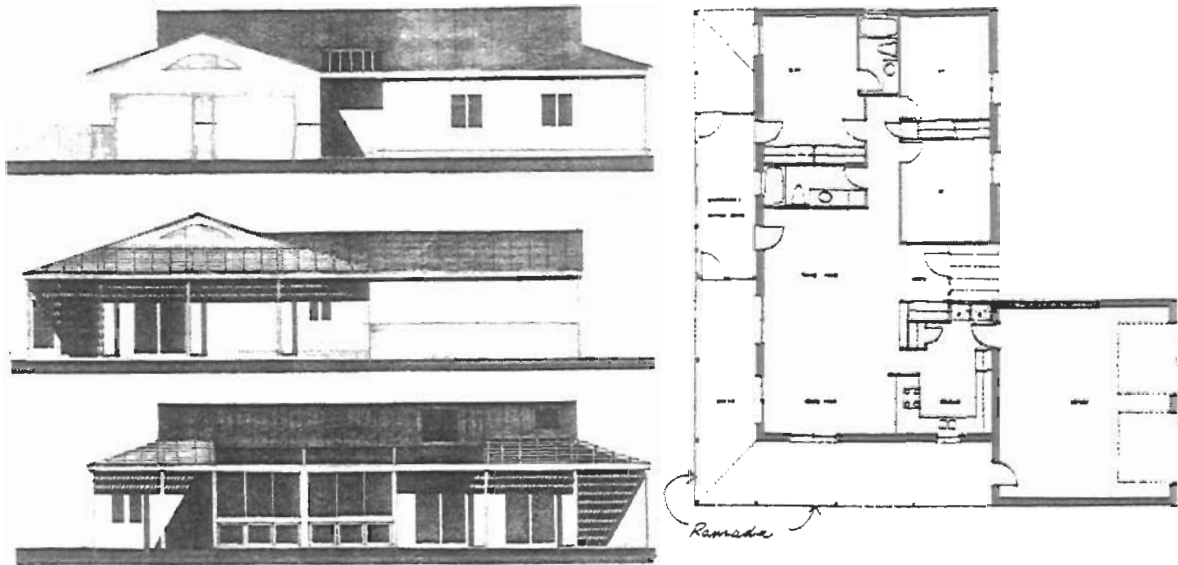


Fig. 5 R-House

### R-HOUSE

In the R-House, the rectilinear house shape takes advantage of solar geometry to reduce summer solar heat gain and to enhance winter heat gain. Due to the relative overhead path of the sun in summer and with a slight overhang on the southern facade the south elevation will receive very little direct solar insolation in comparison to the other building facades. Therefore elongating the southern facade and reducing the east/west facade for a given building area, will greatly reduce summer heat gain and enhance winter heat gain. If the abundance of window area, (shaded in summer) is also located on the southern facade the same beneficial geometry will result. Both of these solar geometry's are integrated into the design of the R-House. The house is a rectangle of 31 feet by 54 feet or a ratio of approximately 1:1.7. There are no windows located on the west facade. The north facade has only two small windows totaling 32 square feet, while the south and east facade, shaded by an 8 foot deep verandah contains 150 square feet of glazing (south) and 50 square feet of glazing (east). The total window area represents approximately 12% of the wall area, a relatively low but appropriate ratio for the Big Bend desert climate.

The large shaded 8-foot-deep verandah that covers the entire south and east elevations provides for an outdoor living space when evening conditions are ideal. The verandah includes a 20-foot long sunroom that adds

beneficial heating to the bathrooms and living-room areas in winter when it is normally too cold for comfort. In summer the sunroom is opened up by solar-induced ventilation so that the sunroom becomes part of the outdoors. The metal roof of the house has a continuous ridge vent augmented by two large-gable vents to enhance the even flow of ventilation through the attic space. The air stream is fed by a continuous soffit vent located at the ceiling of the cooler verandah porch. The attic ventilation, helps keep the ceiling temperature of the house cooler in summer. A solar collector for hot water heating is on the southern sloping roof of the house.

Other design features of the R-House include: a separate north entry vestibule and coat closet; a large kitchen pantry and utility area next to the kitchen; and an extra large enclosed garage. The large size of the garage provides extra storage and work spaces, and solar hot water heating equipment. Enclosed garages keep the javelinas and other BBNP wildlife from scavenging through belonging and provide protected storage. The kitchen, located next to the garage, has view angles to: the front entry, the garage entry, the back yard from a window over the sink, and to the living room/dining room across a snack bar. The open plan living room/dining room/kitchen layout suits the informal living lifestyles typical of the remote BBNP community and helps the small 3-BR house (1490 square feet) seem more spacious. The house will be accessible to persons with disabilities with an extra wide 4 foot hall and 3 foot wide doors on all rooms.

## CONSTRUCTION MATERIALS

As much as possible all the materials specified for construction are post-consumer or recovered materials and materials with a sustained useful lifetime to reduce maintenance, including:

1. Recycled steel-The content of cold rolled steel used for rebars, anchor bolts, roof decking and I beam is made up using over 66% recycled steel content. Light-gauge steels, such as appliance fronts, roofing and flashing, are made up of steel with up to 25% recycled steel content.

2. Fly-ash concrete is produced by substituting fly-ash for 20-30% of the portland cement used in normal concrete. This actually improves the performance and quality of the concrete by improving workability, reducing segregation and bleeding, and lowering the heat hydration.

3. Insulated Permanent Fiber Cement Wall Forms-"Faswall" use recycled mineralized wood waste along with portland cement to produce a CMU like unit that can be worked with normal wood working tools. The 9" thick form block bonds monolithically with a concrete and steel pour in the core creating high mass walls with an insulation R value of 12.

4. Alternatives to old growth wood, were specified Since wood does not weather well in the BBNP climate the exterior use of wood was minimized. In interior applications engineered wood products such as I-joists, laminated beams, parallel strand lumber, and linear strand or finger jointed lumber are all generally made with recycled or reconstituted waste wood. Trusses are constructed from wood obtained from fast growth trees that reduce dependence on old growth forests. Cellulose insulation is produced from recycled newsprint with borate for repelling insect infestation and for fire resistance.

5. Recycled glass tile is used for ceramic tile in bathrooms, kitchens and as a base molding. The tile contains 70% recycled glass.

6. Recycled plastics are used for piping, light fixtures, window profiles, exterior decking, weather-stripping, bathtubs, showers, counter tops and other products. Since most of the energy required to produce a plastic product goes into the production of feed stock materials, not the manufacturing process, plastic waste retains most of its original energy content. Thus, producing a plastic product from scrap plastic

instead of virgin resin saves approx. 85-90% of the energy otherwise used. A variety of recycled polymer PVC, HDPE, PS and PD products were specified. For example, the "Envirolon" carpet specified for the bedrooms is made from 100% PET recycled plastic.

7. Low VOC (volatile organic compounds) paints were specified for all painted finishes.

8. Low flow plumbing fixtures for water conservation were specified for shower, water-closet and faucets. Water conserving appliances were also specified. Gray water systems and Rainwater collection and cisterns were utilized for irrigation.

9. High SEER appliances were specified and all the houses will use liquid petroleum as the fuel source (range, solar assisted hot water, and furnace). LP is 1/3 the cost of electricity per BTU in Big Bend.

10. Energy-efficient low-voltage lighting, compact fluorescent, indirect full-spectrum bulbs with more lumens per watt were specified. Ceiling fans to facilitate air movement are located in almost every room to reduce cooling costs.

## CONCLUSION

The employees that preserve and protect our national parks for present and future generations are our most important resources. Without them the natural and cultural heritage we value as a nation will be endangered. These 'front line troops' deserve living conditions that support their efforts. The sustainable housing projects are especially appropriate to the Big Bend community, where protecting the environment is a community mission and can be a model for other sustainable development.

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