TERRA LAKE
AN EARTH SHELTERED COMMUNITY

ARCHITECTURAL THESIS MAY '84
DAVID D. CONKLIN
This book summarizes the work I have done in the past nine months. It attempts to give the reader an overview of my Thesis Project: the study of developing a sand and gravel pit into an Earth Sheltered Community. This project is prototypical and similar developments could be done on other mine-lands in the mid-west.

I have pursued my project with enthusiasm in hopes that some day in the future I can actually put my plans into effect and do this proposed development.
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At last the end of the thesis year is near. There have been highs and lows, insecurity and confidence. Through it all I continued with determination to succeed, to become an Architect, and to help build a better world. Thesis, as well as the preceding four years, has been a time of continual sacrifice and struggle.

Therefore, I would like to take this opportunity to thank those people who believed in me and provided continual support throughout my collegiate experience. First of all, I would like to thank my parents, Walter Dell and Rebecca Ann Conklin, for their love and support. I would also like to recognize my thesis professors, Stan Mendelssohn and Dan Woodfin, and also a special thanks to my thesis consultants Rod Underwood, Jeff Culp, Bruce Keiffer, Dave Ferguson, and Lee Smith for all of their invaluable help. I would also like to thank my classmates, who provided guidance in critical moments. Finally and most importantly, I would like to dedicate this book to my wife, Patty, for all of her love and support throughout all of this "madness"; Thank you for helping to keep my spirits up and keeping me from going totally insane.
Terra Lake, an earth sheltered community, seeks primarily to develop a sand and gravel pit with a pre-planned reclamation program into a year-round recreational community. It is to illustrate the potential gains one may achieve by planning for minelands later use, after excavation, in advance, so that unforeseen problems can be eliminated and the sites' potential can be more fully realized.

The community is composed of 250 condominiums, 60 duplex units, and a 12,000-s.f. clubhouse/community building and is on a 180 acre site with a 50 acre lake and a 40 acre forest/shelter belt. Topography varies up to 80 feet higher than lake level. Energy-conscious design strategies have been utilized to help produce a positive site microclimate and have also been used in the building designs.

The pedestrian and the automobile have been segregated to promote a stronger pedestrian path network to recreational activities throughout the site. Therefore, by making the automobile subordinate to the pedestrian while traveling from place to place on site the community is given a park like atmosphere and is more natural and aesthetically pleasing.
Introduction

This project is prototypical for future Sand and Gravel Pit reclamation (as well as other mine lands, i.e., open pit coal mines). It transforms unusable land into a community of terraced earth sheltered housing, organically designed with the landscape, and utilizes energy conscious design strategies.

The project involves three main ideologies: Land reclamation of mined land, integration of land and water recreational activities into the community, and energy conservation.

Land Reclamation of Mined Land

The sand and gravel industry is in a unique situation insofar as rehabilitation is concerned. It utilizes heavy earth moving equipment, and often has large volumes of material, unsuitable for processing, available for creating functional land forms. Since it is necessary to move this material in order to extract the desired resources, it becomes a matter of manipulating the equipment in a manner that will achieve the most desirable land areas.

Also, the location of the operation offers unique opportunities in land development. Not only are land values higher with numerous uses varying for a piece of land in the area in which operations exist, but the results of the excavation process may create interesting and unique features, such as large bodies of water that might not otherwise be available for development.

The availability of sand and gravel pit close to cities can make the depleted site, with early planning, suited for development. The need for the wise use of resources equally places the producer in the "land conversion business"; providing a dual or triple function for usable land (i.e., agriculture to mining to a relatively intense ultimate land use such as residential). As our cities grow there is an increasing need for land close to the city center and in the suburbs for development.

It is estimated that approximately 35,000 acres of land are being totally consumed annually in the commercial production of sand and gravel. The acreage of disturbed landscape which will occur as a result of future excavation operations by the industry is staggering, and indicates that immediate attention must be turned to procedures and techniques that can make the extracted areas attractive and useful parcels of real estate.

Integration of Land and Water Recreation

There is a need for outdoor recreation areas due to population growth, higher incomes, improving technology, and increasing cost of land close to urban centers. Millions of Americans spend not only part of their leisure, but a sizeable portion of their income on outdoor recreation. Since most people cannot afford to spend indiscriminately, the fact that a significant percentage of their income is spent on outdoor recreation is indicative of the relative importance of recreation planning.

Sand and gravel pits can be a desirable place for such activities for the following reasons:

1. Optimum Location
   Sand and gravel operations are generally located close to urban centers where the greatest demand for land exists for recreational sites and activities.
2. Desirable Site Features
The nature of sand and gravel sites and operations are conductive to the production of terminal physical site characteristics considered ideal for recreational activities, namely, topographic relief and water areas.

3. Alternative Use Sequence
In accordance with land wise management and progressive rehabilitation practices, recreational uses can occur on sand and gravel sites prior to, concurrent with, or subsequent to site excavations over the extended periods of operation which are characteristic of the industry.

4. Multiple Benefits
In consideration of conforming with typical zoning regulations and requirements, creating a positive public relation image, and realizing mutually advantageous economic returns, the development of sand and gravel sites for recreational uses should be of significant benefit to both industry and local public agencies.

5. Effectualization Procedures
The successful transformation of a sand and gravel site into a potentially valuable recreational resource is achieved through the application of a comprehensive and systematic planning process based on a thorough understanding of the characteristics of the area and the requirements of the people, including basic resource inventories and identification of alternative development possibilities.

The combination of housing and recreation opportunities is increasingly important to today's users. The reclamation of sand and gravel pits with proper planning can fulfill both of these needs.

Energy Conservation
The development of new communities and the design of housing within these communities are in a period of great transition because of significant changes that have occurred in recent years. As energy costs continue to rise, questions about future availability of energy from conventional sources of supply remain unanswered. Other natural resources, such as the supply of pure water, now appear limited as well. Moreover, some past development patterns have produced communities characterized by a generally poor quality of life as well as serious destruction of the natural environment.

Obviously, earth sheltering is not the only means of saving energy in housing - homes that appropriately use superinsulation, active solar, and/or passive solar can achieve energy performances similar to those of earth residences. Earth sheltered homes do have some additional advantages, however. For example, they are generally much quieter than conventional above ground houses because the earth surrounding them "dampens" noise from the outside. The masonry/concrete structure (concrete is the most commonly used structural material) is rot and vermin-proof and usually more fire retardant than materials used in conventional above-ground houses. Moreover, because these structures are below grade level, natural disasters such as tornadoes and severe storms have less effect on them. They also require less maintenance than conventional housing.

Earth sheltering makes good environmental sense too. By building into a hill or below the earth's surface, an attractive landscape or view can be preserved while allowing access to natural light. Furthermore, sites that may
have been unusable for conventional housing - for example, due to steep grade - may be successfully adapted for residential use through earth sheltering.

Another environmental plus associated with earth sheltering is the concept of working with nature as a part of the design plan. In fact, working with the site through design and landscaping so that the housing will blend into the surrounding environment is part and parcel of the overall concept of earth sheltered design. Thus, the lines and the forms of earth sheltered design tend to compliment and duplicate forms found in nature.

Earth sheltered housing is a natural choice for this site because of its ability to be placed on steep slopes. It is also a natural solution for energy conservation, and in conjunction with passive solar techniques requires little heating.

Earth sheltered techniques will be used in the community's design to blend architecture and landscape together, complementing each other. Passive solar and some active solar techniques will be used to obtain heating in the winter and to aid in cooling and natural ventilation in the summer (i.e. solar chimney effect and earth vent tubes).

A man-made water facility (a by-product of sand and gravel excavation) will be utilized for recreation and for its aesthetic properties, as well as, the positive micro-climate it can give. The lake will also be used as a geothermal heat sink. The bottom of a 50-30 feet deep lake will remain around 50-55 F, if it is of sufficient volume (approximately 3 to 5 acres of surface area with 25 ft. average depth), thus making it an excellent source for heat pumps (which provide the back-up heating and cooling for the homes).

An energy profile is provided later in this book to verify the energy efficiency of the homes.

In summary, the previous statements transfer into the following hypotheses:

1) If the reclamation of mineland is preplanned then the land can be more easily used for its pre-destined purpose. It will also ensure more thoughtful use of the natural features of the site as well as point out where new site features (such as a man-made lake) will be best placed.

2) The varied topography that excavated land provides will be attractive to earth sheltered housing which works well with hilly sites and also offers unique features to the flat lands of the midwest by providing excellent views overlooking man-made lakes. These features will also give the community a greater identity and cohesion.

3) By preplanning a excavation area for later use, a designer can more effectively use a wholistic energy-conscious design approach. Southern orientation of slopes can be placed as premium housing sites for increased solar gain. And the micro climate can be manipulated to give advantageous effects (such as wind protection and using lake effect cooling) also.

4) By reclaiming a sand and gravel pit for community development, recreational activities are more varied and readily obtained than conventional development.
5) With the cost of land increasing at a rapid pace, reclamation of minelands near urban centers is a necessity for developers. We cannot afford to waste land, as it is an ever dwindling natural resource already in short supply. It also makes much more sense to reclaim mineland than to develop our scarce natural land or farmlands that produce our food.

It is with these hypotheses in mind that I designed the community.
Objectives

-To create optimum environmental conditions for a community development.

-To achieve a strong, dynamic architectural concept that is symmetrical and grows from the landscape.

-To use energy conscious design to achieve climatic control and thus lower heating and cooling costs.

-To create a community with the atmosphere of vacation condominiums for year round living, offering a variety of recreational alternatives.

-To provide a housing design which integrates land and water as recreational elements.

-To demonstrate the prototypical concept of reclaiming sand and gravel pits for earth sheltered housing.

-To keep said housing competitive in respect to the market in its cost.
The following program attempts to define the problems encountered in the design of an earth-sheltered community using reclaimed mineland for it's site.

The program takes care to define users needs and the space requirements to meet those needs. It also states some of the particular problems encountered when developing an earth-sheltered community and how they can be best dealt with. There are five main issues being explored in trying to define the problems involved in this project.

1. Energy-Conscious Design Strategies
2. Land Reclamation of Mineland
3. Community Development
4. Year round condominiums with a 'Vacation' type spirit
5. Integration of land and water recreation into the community

All of these aspects strive to create the optimum environment for a strong, successful community.
This project is located in east-central Indiana, on the northeast side of Muncie, specifically on McGalliard Road just east of the By-Pass at the Shick Sand and Gravel Company.

The site was originally farmland. When it was profitable to mine the esker, or glacial deposit of gravel, excavation began. Mining was started at the northwestern corner of the site, just southeast of the forest, and worked its way to the middle, where it is presently. At the present rate of excavation, the site will be mined out in ten to fifteen years, after having mined some 2 million tons of sand and gravel.
As the project deals with land reclamation and energy conservation, an in-depth site analysis was done, including climatic and solar influences.

It was found that the best solar orientation was a range of zero to fifteen degrees east of due south. This information established the orientation of buildings for solar gain, which in turn affected the lakes configuration. The lake takes advantage of summer breezes to provide evaporative cooling for most of the site.
C-4: classification of soils for engineering purposes

<table>
<thead>
<tr>
<th>Group symbols</th>
<th>Typical names</th>
<th>Drainage characteristic</th>
<th>Frost heave potential</th>
<th>Volume change</th>
<th>Backfill potential</th>
<th>Suggested bearing capacity</th>
<th>Range (psf)</th>
<th>General suitability</th>
</tr>
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<tr>
<td>GW</td>
<td>well-graded gravels &amp; gravel-sand mixtures, little or no fines</td>
<td>excellent</td>
<td>low</td>
<td>low</td>
<td>best</td>
<td>6000 psf</td>
<td>1500 psf to 20 tons/ft²</td>
<td>good</td>
</tr>
<tr>
<td>✓ GP</td>
<td>poorly graded gravels &amp; gravel-sand mixtures, little or no fines</td>
<td>excellent</td>
<td>low</td>
<td>low</td>
<td>excellent</td>
<td>6000 psf</td>
<td>1500 psf to 20 tons/ft²</td>
<td>good</td>
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<tr>
<td>✓ GM</td>
<td>silty gravels, gravel-sand silt mixtures</td>
<td>good</td>
<td>medium</td>
<td>low</td>
<td>good</td>
<td>4000 psf</td>
<td>1500 psf to 20 tons/ft²</td>
<td>good</td>
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<tr>
<td>GC</td>
<td>clayey gravels, gravel-sand-clay mixtures</td>
<td>fair</td>
<td>medium</td>
<td>low</td>
<td>good</td>
<td>3500 psf</td>
<td>1500 psf to 10 tons/ft²</td>
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<td>well-graded sands &amp; gravelly sands, little or no fines</td>
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<td>low</td>
<td>low</td>
<td>good</td>
<td>5000 psf</td>
<td>1500 psf to 15 tons/ft²</td>
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<td>✓ SP</td>
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<td>good</td>
<td>low</td>
<td>low</td>
<td>good</td>
<td>4000 psf</td>
<td>1500 psf to 10 tons/ft²</td>
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<td>✓ SM</td>
<td>silty sands, sand-silt mixtures</td>
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<td>medium</td>
<td>low</td>
<td>fair</td>
<td>3500 psf</td>
<td>1500 psf to 5 tons/ft²</td>
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<td>SC</td>
<td>clayey sands, sand-clay mixtures</td>
<td>fair</td>
<td>medium</td>
<td>low</td>
<td>fair</td>
<td>3000 psf</td>
<td>1000 psf to 8000 psf</td>
<td>good</td>
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<td>ML</td>
<td>inorganic silts, very fine sands, rock flour, silty or clayey fine sands</td>
<td>fair</td>
<td>high</td>
<td>low</td>
<td>fair</td>
<td>2000 psf</td>
<td>1000 psf to 8000 psf</td>
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<td>CL</td>
<td>inorganic clays of low to medium plasticity, gravelly clays, sandy clays,</td>
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<td>medium</td>
<td>medium</td>
<td>fair</td>
<td>2000 psf</td>
<td>500 psf to 5000 psf</td>
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<tr>
<td></td>
<td>silty clays, lean clays</td>
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<td>MH</td>
<td>inorganic silts, mica-cecous or diatomaceous fine sands or silts,</td>
<td>poor</td>
<td>high</td>
<td>high</td>
<td>poor</td>
<td>1500 psf</td>
<td>500 psf to 4000 psf</td>
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<tr>
<td></td>
<td>elastic silts</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>CH</td>
<td>inorganic clays of medium to high plasticity</td>
<td>poor</td>
<td>medium</td>
<td>high</td>
<td>bad</td>
<td>1500 psf</td>
<td>500 psf to 4000 psf</td>
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<td>OL</td>
<td>organic silts and organic silty clays of low plasticity</td>
<td>poor</td>
<td>medium</td>
<td>medium</td>
<td>poor</td>
<td>400 psf or remove</td>
<td>generally remove soil</td>
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<td>OH</td>
<td>organic clays of medium to high plasticity</td>
<td>no good</td>
<td>medium</td>
<td>high</td>
<td>no good</td>
<td>remove</td>
<td></td>
<td>poor</td>
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<td>PT</td>
<td>peat, muck and other highly organic soils</td>
<td>no good</td>
<td>high</td>
<td>no good</td>
<td>remove</td>
<td>—</td>
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<td>MONTH</td>
<td>MEAN DAILY SOLAR INSOLATION</td>
<td>NORMAL DAILY TEMP °F</td>
<td>NORMAL TOTAL HEATING DEGREE DAYS</td>
<td>MEAN POSSIBLE SUNSHINE %</td>
<td>PREVAILING WINDS</td>
<td>MEAN RELATIVE HUMIDITY %</td>
<td>NORMAL TOTAL PRECIPITATION INCHES</td>
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<td>JAN</td>
<td>144 LAN 531 BTU 30°</td>
<td>1075</td>
<td>40</td>
<td>NW 12</td>
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<td>FEB</td>
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<td>925</td>
<td>45</td>
<td>W 12</td>
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<td>2-1/2&quot;</td>
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<td>MAR</td>
<td>316 LAN 1165 BTU 40°</td>
<td>800</td>
<td>50</td>
<td>NW 13</td>
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<td>APR</td>
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<td>400</td>
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<td>MAY</td>
<td>488 LAN 1799 BTU 63°</td>
<td>150</td>
<td>60</td>
<td>SW 11</td>
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<td>4&quot;- 8&quot;</td>
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<tr>
<td>JUNE</td>
<td>543 LAN 2002 BTU 73°</td>
<td>25</td>
<td>70</td>
<td>SW 9</td>
<td>70</td>
<td>4&quot;- 8&quot;</td>
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<td>JULY</td>
<td>541 LAN 1994 BTU 75°</td>
<td>0</td>
<td>70</td>
<td>SW 8</td>
<td>65</td>
<td>2&quot; 4&quot;</td>
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<tr>
<td>AUG</td>
<td>490 LAN 1806 BTU 75°</td>
<td>10</td>
<td>70</td>
<td>SW 8</td>
<td>70</td>
<td>3&quot;</td>
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<td>SEPT</td>
<td>405 LAN 1493 BTU 67°</td>
<td>75</td>
<td>70</td>
<td>SW 9</td>
<td>70</td>
<td>2&quot; 4&quot;</td>
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<td>OCT</td>
<td>293 LAN 1080 BTU 55°</td>
<td>300</td>
<td>60</td>
<td>SW 10</td>
<td>70</td>
<td>2&quot; 4&quot;</td>
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<td>NOV</td>
<td>177 LAN 653 BTU 43°</td>
<td>700</td>
<td>45</td>
<td>SW 12</td>
<td>75</td>
<td>3&quot;</td>
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<tr>
<td>DEC</td>
<td>132 LAN 486 BTU 33°</td>
<td>1025</td>
<td>40</td>
<td>SW 11</td>
<td>80</td>
<td>2-1/2&quot;</td>
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INDIANAPOLIS WEATHER DATA
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<th>Objectives</th>
<th>Temperate</th>
<th>Hot-Arid</th>
<th>Hot-Humid</th>
<th>Cold</th>
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<tr>
<td>Adaptations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position on slope</td>
<td>Middle-upper for radiation</td>
<td>Low for cool air flow</td>
<td>High for wind</td>
<td>Low for wind shelter</td>
</tr>
<tr>
<td>Orientation on slope</td>
<td>South to Southeast</td>
<td>East-southeast for P.M. shade.</td>
<td>South</td>
<td>South to Southeast</td>
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<tr>
<td>Relation to water</td>
<td>Close to water, but avoid coastal fog</td>
<td>On lee side of water</td>
<td>Near any water</td>
<td>Near large body of water.</td>
</tr>
<tr>
<td>Preferred winds</td>
<td>Avoid continental cold winds</td>
<td>Exposed to prevailing winds</td>
<td>Sheltered from north</td>
<td>Sheltered from North and West</td>
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<tr>
<td>Clustering</td>
<td>Around a common, sunny terrace</td>
<td>Along E-W axis, for shade</td>
<td>Open to wind</td>
<td>Around sun pockets</td>
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<tr>
<td>Building orientation</td>
<td>South to Southeast</td>
<td>South</td>
<td>South 5° toward prevailing wind</td>
<td>Southeast</td>
</tr>
<tr>
<td>Tree forms</td>
<td>Deciduous trees nearby on west. No evergreens near on south</td>
<td>Trees overhanging roof if possible</td>
<td>High canopy trees. Use deciduous trees near building. Evergreens for windbreaks</td>
<td>Deciduous trees near building. Evergreens for windbreaks</td>
</tr>
<tr>
<td>Road orientation</td>
<td>Crosswise to winter wind</td>
<td>Narrow; E-W axis</td>
<td>Broad channel, E-W axis</td>
<td>Crosswise to winter wind</td>
</tr>
<tr>
<td>Materials coloration</td>
<td>Medium</td>
<td>Light on exposed surfaces, dark to avoid reflection</td>
<td>Light, especially for roof</td>
<td>Medium to dark</td>
</tr>
</tbody>
</table>
1. User & User Activities

1.A. Singles
Couples
Families
Senior Citizens

B. Annual Salary: $18,000-$25,000 (12% of Muncie's population), which indicates units costing $75,000-$125,000 (1600-2400+ sq. ft.).

2.A. Access to Shopping
   -to grocery
   -to corner store (to be included in community)
   -to clothing store
   -to other specialty shops (i.e., Muncie Mall)

B. Access to Work
   a. access to highway and main thoroughfares
   b. close to workplace, near town center within 20-30 minutes drive

C. Recreational Activities
   a. water activities
      -boating
      -fishing
      -swimming
   b. Club House/Community Activities
      -party/reception areas (kitchenette)
      -sauna
      -hot tubs
      -weight lifting and other exercise equipment
      -billiards
      -meeting room
      -day care/preschool
      -racquet ball
   c. Other Outdoor Activities
      active: tennis frisbee
              basketball soccer
              football badminton
              volleyball horseshoes
      passive: gardening lounging
               picnic/barbeque
               strolling along lakeside

D. Occupation
   -most users will be employed in service occupations as there is an expected increase in this area (many of these will be professionals).

E. Education
   -most will have a college education (some may be working at the university). There are presently 11,000 college graduates in the Muncie area, or 9% of the population.

F. Ecology
   a. Many of the users may be more sensitive to their environment, having a greater appreciation of nature thus appreciating the gentle architecture of the development.
   b. Would appreciate a trail/path to stroll on along the lake and through the woods.
   c. A nature retreat/covered shelter secluded back in the woods for small picnic groups. Also, a separate place for meditation.
2. Activity Performance Requirements

A. Interior
   a. Comfortable, informal, organically planned condominiums, duplex units, and clubhouse/community building.
   b. Strong indoor/outdoor relationship.
   c. Low maintenance inside and out.
   d. Natural lighting preferred throughout.
   e. Natural materials emphasized.
   f. Natural ventilation.
   g. Good view of lake.
   h. Family housing units desire view of outside play area from kitchen.
   i. Exposed structural elements to give visual liveliness.
   j. Housing units should have the flavor of vacation homes, with many recreational opportunities.
   k. Sunspace/Greenhouse
   l. Energy Conservation
      -earth sheltered
      -passive solar techniques
      -solar chimney to aid ventilation
      -geothermal heat-pumps utilizing lake water

B. Exterior
   a. Dynamic geometric massing to buildings
   b. Organic Architecture
   c. Low maintenance inside and out
   d. Exposed structural materials for visual interest
   e. Pitched roof preferred or flat if deck space
   f. Housing units have exterior spaces for outdoor activities such as dining, lounging, children play area, close to a common green.
3. Space Performance Requirements

Elements for Housing

- Standard elements for housing

A. Entrance
1. Inviting front door, convenient to guest.
2. Comfortable entrance hall/greeting area with coat closet and guest bath convenient to kitchen, living, and private areas.
3. Kitchen door near entry and close to parking for bringing in groceries.
4. Various doors to decks and garden as appropriate.

B. Kitchen
1. Large kitchen with separate eating area.
2. Family social center.
3. Sunshine important.
4. Generous counterspace, work island, and cabinets.
5. Easy working layout/good refrigerator-stove-sink relationship.
7. Access to deck (or possibly covered outside eating area).
8. Phone in kitchen with a place to sit and take notes.

C. Dining area of Kitchen (or optional Dining Room)
1. Separate from kitchen work space, generous space for table.
2. Good natural lighting and more intimate lighting at night.
3. Place for both formal and informal activities.

D. Living Room
1. Spacious living room but not overpowering; cozy atmosphere—should feel comfortable alone in space.
2. Large fireplace with seating around it, providing focal point.
3. Should have good view of lake and woods.
4. Access to deck overlooking the lake preferred.

E. Study/Den (optional)
1. A library with a large desk, sofa, and comfortable reading chair.
2. Can be small but not confining.
3. A retreat place to get away from the noisy kids.

F. Bedrooms
1. Master: large with private bath, dressing area, sitting area with writing table, phone, two good size closets (possible hot tub adjacent to bedroom in separate defined area).
2. Other bedrooms(0,1,2) should have bathroom access. Rooms not large but comfortable with reading area or window seat.

G. Baths
1. Must be functional, convenient, well lighted, and have storage for towels, linens, and sundries.
2. Master bath should be larger with oversized tub or with hot tub and separate shower.

H. Utility Room
1. Will have a washer and dryer with a counter for clothes folding, and also a wash basin to soak things in.
2. Will have storage cabinets to store the following: cleaning supplies, a tool chest, broom and mop, bucket, vacuum cleaner, etc.
3. Have a door to the Mechanical Room in which is the electrical distribution panel, water heater, heat pump.

I. Sunspace/Greenhouse
1. Place to grow plants.
2. Sitting area.
3. Should have a good view.
4. Warm winter retreat.
5. Possibly double as an eating area.
6. Recreation space.

J. Stairs
1. Used to help promote better ventilation as well as circulation from floor to floor.
2. Also used as a massing element to help create a dynamic form for the unit.
3. Place to sit on a window seat and enjoy the view.

K. Decks
1. One for the master bedroom to go out and watch the sunset.
2. One off the living and kitchen area for lounging and outside dining.

L. Hobby Room (option)
1. Access from kitchen.
2. For additional storage space.
3. General purpose space to serve as whatever you want space

M. Storage
1. Very generous and as convenient as possible, "a space for everything and everything in it's place".
2. Woodbox for fireplace.
3. Clothes closet (2 in master bedroom and 2 in each of childrens).
4. Linen Closet.
5. Walk-in closet in master bedroom.

N. Other Considerations
1. If master bedroom is on same floor as childrens provide a buffer for privacy.
2. Adjacent bedrooms should be separated by closets or bath for increased noise control.
Elements for Clubhouse/Community Building

A. Lobby/Lounge
1. Main entrance to building onto this space.
2. Information desk.
3. Large fireplace as a focus to this spacious room with furniture arrangement around it.
4. Good view of lake.
5. Centrally located in building.
6. Access to deck and all other primary spaces in the building.

B. Bar and Grill
1. Seating for 50 patrons.
2. Good view.
3. Access to deck overlooking lake.

C. Cocktail Lounge
1. Located off from the bar.
2. Seating for 50 patrons.
3. More formal atmosphere.

D. Party/Reception Area
1. Room to have parties, receptions, banquets, dances, etc.
2. Seating for 100 people.
3. Doubles as a meeting hall.
4. Has movable partition to divid room in half for smaller groups and two simultaneous activities.
5. Has a kitchenette for food preparation.

E. Recreation Room
2. Billiards
3. Table tennis.
4. Video arcade - for kids, but adults can play too.
5. Natural lighting preferred

F. Exercise Room
1. Weight lifting equipment.
2. Mat area for aerobics.

G. Raquetball Courts
1. Two courts not necessarily in the community building, but may be integrated elsewhere in the community.
2. Spectator seating for 25 people.

H. Hot Tubs/Sauna
1. Adjacent to lockers and exercise room.

I. Lockers and Showers
1. To be used as beach house as well as for the other recreational functions, so it should be adjacent to the beach.

J. Corner Store
1. Open from 7a.m. to 9p.m. with "Village Pantry" type products and a 'mom & pop' flavor.
2. Will provide a work opportunity to empty nesters of the community.
3. Also will serve as a concession stand for the beach.

K. Day Care/Preschool Cooperative
1. Place to drop kids off (in good caring hands, your neighbors) for the day while your at work.
2. Requires nice exterior playground.
3. Natural light and ventilation.
4. Pleasant playful environment.
5. Could possibly be located in separate building near the community building.

L. Beach
1. Southern exposure.
2. Preferably in sheltered bay.
3. With lifeguard on duty.
4. Diving platform.
5. Round tables with umbrellas to give relief from the sun.

M. Basketball Courts (2)
1. Exterior.
2. Need not be located adjacent to the community building, can be integrated
elsewhere in the community.

N. Horse Shoes
1. Four or more areas integrated into the community.

O. Football/Soccer/Baseball Field
1. Combination recreation field for the whole community.
2. Central location is important.
<table>
<thead>
<tr>
<th></th>
<th>ESSENTIAL</th>
<th>IMPORTANT</th>
<th>DESIRABLE</th>
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<tbody>
<tr>
<td>1</td>
<td>ENTRY</td>
<td></td>
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<td>2</td>
<td>LIVING</td>
<td></td>
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<td>3</td>
<td>KITCHEN</td>
<td></td>
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<td>4</td>
<td>UTILITY ROOM</td>
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<td>5</td>
<td>MUD ROOM</td>
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<tr>
<td>6</td>
<td>GARAGE</td>
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<tr>
<td>7</td>
<td>BATH OR ½ BATH</td>
<td></td>
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<tr>
<td>8</td>
<td>MASTER BEDROOM</td>
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<td>9</td>
<td>MASTER BATH</td>
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<tr>
<td>10</td>
<td>CHILDREN'S B.R.</td>
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<tr>
<td>11</td>
<td>CHILDREN'S BATH</td>
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<td>12</td>
<td>SUNSPACE</td>
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<tr>
<td>13</td>
<td>SUNDECK</td>
<td></td>
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<tr>
<td>14</td>
<td>STUDY/DEN(OPTION)</td>
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<tr>
<td>15</td>
<td>HOBBY(OPTION)</td>
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<tr>
<td>16</td>
<td>VIEW</td>
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</tr>
<tr>
<td>17</td>
<td>NATURAL VENTILATION</td>
<td></td>
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<td>18</td>
<td>NATURAL LIGHT</td>
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<td>19</td>
<td>SOLAR GAIN</td>
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<td>20</td>
<td>QUIET</td>
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<td>PROGRAMMATIC NEEDS</td>
<td>USERS</td>
<td>II. ACTIVITY PERFORMANCE REQUIREMENTS (ACTIVITY CHARACTERISTICS)</td>
<td>III. SPACE PERFORMANCE REQUIREMENTS (SPACE CHARACTERISTICS AND SIGNIFICANT FEATURES)</td>
</tr>
<tr>
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<tr>
<td>Housing for singles</td>
<td></td>
<td>Interior Activities</td>
<td>Variations From Standard Elements</td>
</tr>
<tr>
<td>15% of all housing</td>
<td></td>
<td>-comfortable, informal, organically planned condominium on</td>
<td>-small condo-1600 s.f.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1, 1½, or 2 levels</td>
<td>-smaller, but functional kitchen bar,</td>
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<td></td>
<td></td>
<td>-strong indoor/outdoor relationship</td>
<td>pass through to dining</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-low maintenance; interior and exterior</td>
<td>-study/den is standard for this user,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-natural lighting preferred throughout</td>
<td>view preferred</td>
</tr>
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<td></td>
<td></td>
<td>-natural ventilation</td>
<td>-powder room to service entry level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-good view of lake</td>
<td>-option for hot tub adjacent to master bedroom</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-natural materials</td>
<td>-one guest bedroom-two bedrooms total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-sunspace/greenhouse</td>
<td>-hobby room is standard</td>
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<tr>
<td></td>
<td></td>
<td>Exterior Activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-outside deck for lounging</td>
<td></td>
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<td></td>
<td></td>
<td>-barbeques/outside dining</td>
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<td></td>
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<td>-garden</td>
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<td></td>
<td></td>
<td>recreation</td>
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<tr>
<td>PROGRAMMATIC NEEDS</td>
<td>USERS</td>
<td>II. ACTIVITY PERFORMANCE REQUIREMENTS (ACTIVITY CHARACTERISTICS)</td>
<td>III. SPACE PERFORMANCE REQUIREMENTS (SPACE CHARACTERISTICS AND SIGNIFICANT FEATURES)</td>
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<td>-------------------</td>
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<td>----------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Housing for families | ♦️ | Interior Activities  
- comfortable, informal, organically planned condominium/house  
- duplex unit on 1½ or 2 levels  
- strong indoor/outdoor relationship  
- low maintenance interior and exterior  
- natural lighting preferred throughout  
- natural ventilation  
- good view of lake  
- natural materials  
- sunspace/greenhouse  
Exterior Activities  
- outside deck for lounging  
- barbeques/outside dining  
- garden  
- recreation | Variations From Standard Elements  
- medium to large sized condominium  
- 2000-2400 s.f. 90%  
- or duplex unit of same size with more individualized feeling, more rural 10%  
- kitchen has bar/pass through to dining  
- study/den option, view preferred  
- powder room to service entry level  
- 1 to 2 children's bedrooms  
- hobby room is standard  
- larger sunspace/greenhouse because of larger unit  
- guest room optional |
II. ACTIVITY PERFORMANCE REQUIREMENTS (ACTIVITY CHARACTERISTICS)

**Housing for couples**
- Comfortable, informal, organically planned condominium on 1½ or 2 levels
- Strong indoor/outdoor relationship
- Low maintenance interior and exterior
- Natural lighting preferred throughout
- Natural ventilation
- Good view of lake
- Natural materials
- Sunspace/greenhouse

**Exterior Activities**
- Outside deck for lounging
- Barbecues/Outside dining
- Garden
- Recreation

III. SPACE PERFORMANCE REQUIREMENTS (SPACE CHARACTERISTICS AND SIGNIFICANT FEATURES)

Variations from Standard Elements
- Small to medium sized condominium, 1600-2000 s.f. 90%
- Or duplex unit of same size with more individualized feeling, more rural 10%
- Kitchen has bar/pass through to dining
- Study/den standard, view preferred
- Powder room to service entry level
- Option for hot tub adjacent to master bedroom
- One guest bedroom, two bedrooms total
- Hobby room is standard
Environmental Requirements

Most of these are stated previously in the space performance requirements. Some additional information is given here.

1) Natural Lighting-In earth sheltered housing, the penetration of natural light is important for two reasons. First, it is desirable in any design concerned with energy efficiency to allow as much solar radiation to reach the interior as possible, particularly since passive solar heat is basically free energy. Second, earth sheltered design is sometimes incorrectly related to the darkness of a basement and it is important to allow sunlight to enter spaces simply to create a brighter, more livable environment. It is necessary to consider the position of the sun at various times of the day, throughout the year, in order to take proper advantage of the light.

For skylighting, directional skylights oriented to the south are much more efficient than the typical flat or bubble type skylights, for these type lose great amounts of energy.

2) Natural Ventilation-In earth sheltered housing, natural ventilation is important for two reasons. First, it is desirable to help with cooling and thereby lowers energy costs. Steps should be taken in design to insure natural ventilation. It can be enhanced by using the greenhouse as a solar chimney in the summer, having the hot air rise out of exhaust vents at the top and allowing cool air to enter low inducing air flow throughout the house. Second, it allows in needed fresh air and flushes out stale odors and makes the occupants more comfortable.

3) Acoustics-One effect of earth sheltered homes, of positive note, is the great d ampening of sounds from the outside and of vibration from the surrounding earth mass. It should also be noted that due to this dampening, interior appliances or mechanical systems seem louder. These interior noises therefore need to be dampened, also.

4) Landscape Concerns-In Earth sheltered design, planting cannot be considered as a separate decorative feature. It is a critical component of the overall design which must be coordinated with all the other elements of the house, particularly the structural and water proofing systems.

5) Special Energy Considerations-
   A. Thermal Breaks
   Since many earth sheltered structures are likely to be built of concrete, the problem of heat loss through the concrete by conductance is a major one. This occurs when a concrete roof or wall is continuous from the inside to the outside of the house in order to form an overhang or retaining wall. This also occurs at skylight wells, parapet walls or any other situation where the concrete structure acts like a wick which allows the inside heat to bleed away to the outside. The solution is to provide a thermal break in the concrete such as a layer of styrofoam insulation which effectively separates the interior and exterior structures. Another possible solution is the use of separate structure and material for the exterior parts.
B. Thermal Shutters
These are to stop heat leaking from windows and other glazing at night. Generally of four types:
1. Dow Foam Board covered with wood or cloth which opens like a bi-fold door or slides into the wall.
2. Blow-in Foam Beads, mechanically blown in between two glasses.
3. Thermal Drapes made of insulative material with fabric covering.
4. Thermal Blinds, similar to typical venetian blinds but instead of being made of light metal, they are made of foam board with an extruded coating on them. They are superior to the above because one can control the degree of light coming in and still see out. If sun control is not needed they may simply be pulled up between the two panes of glass by a cord, like regular venetian blinds.
Some of the concerns of this area have been mentioned previously, there are a few more points to make, however.

1) **Impact of Energy-Conservation**
   There are two ways in which energy-conservation directly affects the overall configuration of an earth-sheltered home. These are the development of the compact plan geometry and the maximization of the earth mass around the structure. Passive solar heating also adds constraints (i.e., need for southern exposure and glazing to allow in solar gain but not let heat escape at night).

2) **Impact of Structural Systems**
   In any building, the structural system is a major shaping force of the overall design. This is of particular importance with earth-sheltered housing since the loads resulting from earth on the roof are substantial and must be designed appropriately. Terra Lake Condominiums have 3 feet of earth on their roofs, enough to provide various types of plants including shallow rooting trees (Silver Maples). This load is dealt with by using 2 feet deep steel bar joist every four feet on center (for illustration see structural axonometric in final design section).

3) **Function Interior Flexibility**
   See space performance requirements.

4) **Interior Circulation**
   See space relationship matrix and performance requirements.

5) **Building Codes**
   The major concerns that codes give to earth-sheltered design can be summarized as:
   A. Habitable rooms must have glazing areas greater than one-tenth of the floor area.
   B. Opening windows of at least one-twentieth of the floor area are required unless mechanical ventilation is provided.
   C. Sleeping rooms must have a window or door connecting directly to the outside. This particular rule is problematic for earth-sheltered design and can cause strange plan relationships. However, code variations have been granted for earth-sheltered residences in Minnesota that provide a fire egress path from the sleeping room to the exterior (must be less than 25 feet in length) and give natural ventilation and light to said sleeping rooms.

6) **Security**
   Gates will be provided at the two entrances to the community to give it a strong sense of identity. A neighborhood watch program will be used by residents to keep out intruders. All pathways and roads will be well lighted to discourage crime.

7) **Access**
   The entry is often the focal point for building designs but it has particular significance with earth-sheltered design since some people have negative associations with going underground and the entry can alleviate these misconceptions. An entry should be obvious to the visitor from the outside, and once entered should be light, spacious and not require an excessive number of steps to arrive at the main living level.
Most of these criteria are described previously, therefore I will just discuss the most important of these here.

- Site micro-climate manipulated for a more positive environment.
- A pedestrian path network is to be provided, segregated from the automobile, running to the various recreational features of the community (i.e., Clubhouse, beach, greenhouse commons, forest, sailing on the lake). This path shall be adequately lighted at night to ensure security.
- Access to the site is from McGalliard Road at both ends of the site and will have gates that will signify entry to the community welcoming residents and forbidding to trespassers.
- Common green areas are to be accessible from private patio areas to allow group interaction between residents.
- The site is to be extremely well landscaped and promote a strong feeling of nature in the community.
- Solar access is to be preserved.
- Trash dumpsters will be provided in a sub-space of the building's garages.
<table>
<thead>
<tr>
<th>I. For Housing</th>
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<tbody>
<tr>
<td>A. Living Room</td>
<td>240-320 s.f.</td>
</tr>
<tr>
<td>B. Kitchen w/eating area</td>
<td>240-288 s.f.</td>
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<tr>
<td>C. Study/Den(optional)</td>
<td>140-192 s.f.</td>
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<tr>
<td>D. Master Bedroom</td>
<td>180-224 s.f.</td>
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<tr>
<td>E. Child's Bedroom(0-2)</td>
<td>140-180 s.f.</td>
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<tr>
<td>F. Master Bath</td>
<td>120 s.f.</td>
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<tr>
<td>G. Children's Bath</td>
<td>60-96 s.f.</td>
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<tr>
<td>H. Powder Room(if nec.)</td>
<td>36-60 s.f.</td>
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<tr>
<td>I. Mud Room</td>
<td>36 s.f.</td>
</tr>
<tr>
<td>J. Utility</td>
<td>60-100 s.f.</td>
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<tr>
<td>K. Sunspace</td>
<td>200-240 s.f.</td>
</tr>
<tr>
<td>L. Deck Space</td>
<td>240 s.f.</td>
</tr>
<tr>
<td>M. Dining Room(opt.)</td>
<td>200-240 s.f.</td>
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</table>

  subtotal  max. 2400 s.f.

N. 3% Mechanical  

  total  max. 2472 s.f.

<table>
<thead>
<tr>
<th>II. For Clubhouse/Community Building Interior</th>
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</thead>
<tbody>
<tr>
<td>A. Lobby/Lounge</td>
<td>800-1000 s.f.</td>
</tr>
<tr>
<td>B. Bar &amp; Grill</td>
<td>600 s.f.</td>
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<tr>
<td>C. Cocktail Lounge</td>
<td>500 s.f.</td>
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<tr>
<td>D. Party/Reception Area</td>
<td>1200 s.f.</td>
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<tr>
<td>E. Recreation Room</td>
<td>2000 s.f.</td>
</tr>
<tr>
<td>F. Exercise Room</td>
<td>800 s.f.</td>
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<tr>
<td>G. Racquetball Courts(2)</td>
<td>1600 s.f.</td>
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<tr>
<td>H. Hot Tubs/Saunas(2 ea.)</td>
<td>600 s.f.</td>
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<tr>
<td>I. Lockers &amp; Showers</td>
<td>1200 s.f.</td>
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<tr>
<td>J. Corner Store</td>
<td>1800 s.f.</td>
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<tr>
<td>K. Day Care Center</td>
<td>800-1000 s.f.</td>
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</table>

  Sub-Total  max. 11,100 s.f.

L. Mechanical 3%  333 s.f.

Total Interior Space  11,433 s.f.

<table>
<thead>
<tr>
<th>Exterior</th>
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<tbody>
<tr>
<td>A. Beach</td>
<td>18000-24000 s.f.</td>
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<tr>
<td>B. Basketball Courts(2)</td>
<td>14400 s.f.</td>
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<tr>
<td>C. Horse Shoes(4)</td>
<td>4800 s.f.</td>
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<tr>
<td>D. Deck Space &amp; Terraces1800-2400 s.f.</td>
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<tr>
<td>E. Football/Soccer/Baseball Field</td>
<td>60000 s.f.</td>
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</table>

Total Exterior Space  105,600 s.f.
Design is a very personal and difficult process involving about 10% inspiration and about 90% perspiration. It is difficult to express what goes on in one's mind while in this process. It is a time of searching for answers and making difficult decisions.
The following is a brief description of the process I went through in my thesis design.

The first phase of the design involved gathering information about land reclamation, site analysis, energy-conscious site and housing design methods, and community and recreation planning (see appendix #1 for building type analysis).

From this information I began the preliminary design, exploring some organizational ideas and developing the site concepts on which to develop the master plan for the community. The site was designed to produce a positive micro-climate for the community, using lake-effect cooling in the summer and making south facing slopes for housing development thus gaining passive solar heating in the winter.

The next phase was schematic design, developing alternatives for evaluation as to which was best to proceed with. Site, building, and individual unit plans were designed with various alternatives (such as different structural and mechanical systems).

I then moved on to design development with the best of the alternatives developed. During this phase I began work on my research grant project, which was to develop guidelines for developing gravel pits into earth-sheltered communities. During the work on this I surveyed earth-sheltered housing in Minnesota and Wisconsin and talked to experts about my proposed guidelines and my thesis project and received valuable feedback (see appendix #2 for research paper). I also worked on a post-occupancy survey of energy-conscious homes in central Indiana which gave me important information as to the users wants and needs, and some problems they have had with their homes (see appendix #3 for summary of findings).

I then began the final phase and polished off the rough edges using the above information. In this final phase I tried to record some of the specific constructs that I had used (the result of which appears in appendix #4). I then arrived at the final solution.

Now, enough talk about how I went about it, the following pages show the project's development in sketches and drawings.
Developed specifically for mining/earth-sheltered housing design, this cyclic design process allows for the dynamics of time, and the coordination of mining with eventual housing development.
SECTION STUDIES

SUN POND 1A

SCALE: 1" = 40'

SECTION A-A

SECTION B-B

TOO TYPICAL SUBURBAN
NEEDS MORE TOPOGRAPHY CHANGES.
#2 UNDER PENS

[Diagram of a building with labels and annotations]
CONCEPT #1
CLUBHOUSE / COMMUNITY BUILDING AS A BRIDGE
CONCEPT #2
CLUBHOUSE/COMMUNITY BUILDING ON A POINT

WOODS

FAMILY

BEACH

SUMMER WINDS

NIC
CONCEPT #3
CLUBHOUSE/COMMUNITY BUILDING ON A ISLAND