

CARL AND MARY McDANIEL  
495 EAST COLLEGE STREET  
OBERLIN, OH 44074

# Trail Magic

## OUR GOAL:

The primary goal of Trail Magic is to create a home in which body, mind, and spirit will flourish and our lifestyle of simplicity and interdependent self-reliance will find expression as we live, work, and prosper among a community of kindred spirits.

## COST:

Pre-completion estimate of cost for house alone is about \$150 per square foot.

## ARCHITECTS:

### Schematic Design:

Donald Watson, FAIA  
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### Execution & Construction:

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## BUILDER:

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## three technical objectives:

- All energy from on-site sun •
- LEED™ Platinum<sup>1</sup> •
- Cost similar to quality, conventional construction •

*In striving to achieve these goals, many compromises are demanded, because the gods of energy, LEED™/green, construction, architecture, and economics agree on very little, at least at this point in time.*

## OUR SITE

1. Less than 1 mile from downtown Oberlin with easy access to a host of in-town amenities, as well as city water and sewer.
2. Four acres: mixed woods and field. Most ash trees were lumbered for flooring and shelving.
3. House located to orient long wall to true south for passive solar and close to road to preserve majority of site.
4. Landscape to be self-maintaining with native plantings and any necessary watering provided by on-site cistern or pond.
5. A walkout patio on the south side will have a microclimate that is sun exposed and wind protected, thereby extending the season of outdoor activity and plant growth.
6. Pond dug to provide fill for house site, geothermal heat source/sink, and fish for food.
7. Quarter-acre garden for food and an acre of native switch grass, a multi-use perennial grass with roots that sequester carbon.
8. Two derelict houses removed with 150 tons recycled (59%).
9. Existing gravel driveway extended to conserve resources.

## OUR HOUSE

Two-and-a-half stories with lower floor earth-bermed on three sides; 2,284 square feet.

**Ground Floor:** 2 bedrooms, full bath, family room, kitchenette, mechanical room, workroom, under-deck storage area. This floor was designed to accommodate guests.

**First Floor:** Living/dining room, kitchen, pantry, half bath, master bedroom, walk-in closet, full bath, deck.

**Half Floor:** Study or bedroom on north side, combined storage and loft area overlooking master bedroom.

**Stairwell:** Ventilation windows at high and low points are designed as a wind tower to provide a fully ventilated house in warm months. In winter, passive heat gain will migrate to top floor and be mechanically circulated throughout the house. The lower floor will create a summer refuge that is naturally cooler due to the thermal mass and earth berming. Adjustable shades provide a passive system to prevent overheating during the day and heat loss at night.

**Detached Barn:** Space for truck, car, and tractor with large, multi-purpose, second floor.

## ENERGY USE SUMMARY

It is estimated that Trail Magic will annually use 74 million BTU. First approximations indicate that 100% of this energy will be provided on site by the sun: passive solar gain from insolation, 40 million BTU; wood stove, 20 million BTU; PV panels, 11 million BTU; and solar hot-water heater, 3 million BTU.

**Note:** Over 50% of this energy results from passive solar design and the cost of passive solar features is about \$16,000 or less than 5% of construction when compared to conventional construction and with a payback of 5 to 10 years.



## CONSTRUCTION

- 1. Ground Floor:** Reddi-Wall insulated concrete forms with additional 2.5 inches of wet-spray cellulose insulation (half below ground, walls 13 inches thick,  $R = 35.5$ ) and 4 inches rigid insulation under cement floor ( $R = 20$ ).
- 2. First Floor:** Double, 2 x 4 wall with 1 inch spray foam air barrier and 10 inches wet-spray cellulose insulation (Walls: 12 inches thick,  $R = 47.5$ ). Double wall construction reduces “thermal bridging” (the movement of heat through wall), thereby increasing effective R-value.
- 3. Siding:** Prefinished fiber-cement “Hardi-board” siding and trim, used for its durability, fire resistance, and low maintenance.
- 4. Roof:** TJI rafters with 1 inch spray foam air barrier and 15 inches wet-spray cellulose insulation ( $R$ -value = 62.5); 24-gauge, standing-seam, steel roof with light color that meets Energy Star and LEED™ requirements for high heat reflectance.
- 5. Windows:** Loewen high performance windows—double- and triple-pane low-E argon with warm edge spacers. South windows tuned for solar gain.
- 6. Finishes:** Low volatile organic chemical paints, recycled ceramic tile, wood stove hearth made from reused granite cobblestones, local and on-site trees lumbered for flooring and shelving.
- 7. Framing Strategies:** Engineered rafters and joists are used in lieu of large dimensional lumber, which comes from old growth forests. Nothing larger than a 2 x 6 is used in construction. Advanced framing techniques are used which minimize amount of lumber needed without sacrificing structural integrity.
- 8. Airtight construction:** Use of spray foam air barrier, caulk and seal package, high quality windows, and results from a blower door test substantially reduce air infiltration, which is a significant factor in heating and cooling loads.

*Design and layout: Kelly Viancourt, photos: Carl McDaniel, text: Carl McDaniel, Donald Watson, Joseph Ferut, Mike Strehle, October 29, 2008.*

# CONSTRUCTION WASTE

1. 9,000 pounds of waste generated to date:  
Sheetrock: ~3,500 lbs. [all recycled on site by rototilling into soil]

Wood: ~3,500 lbs. [wood scrapes reused as wood stove kindling or for children's play blocks, OSB and TJI recycled off site as ground mulch, pressure treated wood to landfill]

Hardiboard: ~1,000 lbs. [crushed and used as base for driveway]

Cardboard: ~500 lbs. [recycled]

Plastic and other: ~500 lbs. [recycled]

2. Landfill: 270 lbs. [soiled paper and rags, non-recyclable plastic, etc.]

3. Reused and Recycled: 8,730 lbs.

**Note:** Total waste is expected to exceed 11,000 lbs. Greater than 90% of this waste

will be diverted from landfill by being reused, recycled, or sequestered on site (e.g., Reddi-Wall polystyrene and closed cell foam insulation put in ceiling; laminated support beams and mold resistant sheetrock were placed between studs of interior walls).

*Construction waste was weighed except for sheetrock. For sheetrock the weight was determined by estimating the area of waste and converting area to weight with a measured weight per area (1.4 lbs. per square foot of sheetrock). Interestingly, a rough calculation indicated that of the 12,800 lbs. of sheetrock used in the house, approximately 25 percent was waste.*



## LEED™

LEED™ Platinum requires 90 points, but because of a smaller than normal size for the number of bedrooms, Trail Magic needs only 84.5 points to be LEED™ Platinum.

Pre-completion estimates by the Trail Magic LEED™ team give Trail Magic between 95 and 125.5 points. The fees for LEED™ certification will be about \$2,000.

<sup>1</sup> LEED™ stands for Leadership in Energy and Environmental Design, a rating system developed by the U.S. Green Building Council to standardize and certify environmentally appropriate or "green" building construction.

*photo captions: (clockwise, from upper left) 1. Waste sheetrock in the house. 2. Sheetrock recycled as soil additive. 3. Sheetrock rototilled into soil. 4. OSB and TJI taken off site to be recycled into mulch.*

## WATER HEATING AND CONSERVATION

1. Evacuated-tube, solar, hot-water heater and 80-gallon storage tank with feed to on-demand electric tankless hot water heater with capacity of 2 gallons per minute. Over 50% of hot water energy cost is supplied by the sun, free after a 5-10 year payback period.
2. Low-flow shower heads (1.5 gpm), low-flow bathroom faucet

aerators (0.5 gpm), and low-flow toilets (dual flush, 1.6 and 0.8 g per flush) substantially reduce water use and the amount of hot water needed.

3. 1,875 gallon cistern filled from roof runoff for watering garden and plants with overflow to pond.

## INDOOR AIR QUALITY

1. Energy Recovery Ventilation (ERV) unit for fresh air is integrated with heat-pump and air circulation by a programmable timer. Air can be circulated within house, or with outside air, with and without heating/cooling provided by heat pump. The ERV allows for the in-

coming fresh air to be heated or cooled by exiting air.

2. Exhaust fans in bathrooms remove excessive moisture.
3. High quality filter on geothermal heat pump cleans air.
4. Central vacuum system reduces dust.

## ELECTRICAL

1. Electricity from 3.12 kilo Watt PV system with estimated annual production of 3,350 kWh and equivalent use: plug load, 1,800 kWh; heating and cooling, 500 kWh; air circulation, 300 kWh; hot water, 750 kWh. Oberlin Municipal Light and Power System has net metering that allows Trail Magic to feed excess electricity onto the grid or to take electricity from grid when needed. At this time Trail Magic does not have a battery backup system. If the grid

goes down, the PV system shuts down and does not supply power to the house.

2. Energy Star appliances throughout and icebox in kitchenette.
3. Compact fluorescent and LED lighting.
4. Day-lighting from window placement reduces need for electric lighting in daylight hours.

## HEATING AND COOLING

1. Pond geothermal heat exchange – 2 ton unit with 3 ton loop (5:1 efficiency ratio).
2. ERV (energy recovery ventilation) unit.
3. Passive solar gain via proper orientation, size and shading of windows.
4. Windows and stairwell placed for passive cooling and ventilation, the predominant cooling mode.
5. Airtight wood stove fueled by wood from site trees provides heat

on cold, cloudy days.

**Note:** Trail Magic has a “Cadillac” heating/cooling system that is not only highly efficient but also meets the highest level of occupant comfort, indoor air quality and health, mold elimination, and protection of interior furniture and construction materials. Design Strategy allows owners to heat and cool house passively and with wood stove, using mechanical systems only as needed.



*Left: The rear roof of the house, which faces south, is equipped with a 3.12 kilo Watt PV system and evacuated tube solar hot water. Right: North face with few windows.*

