Why did we take on this project?

Our interest – passion, really – for building, and building with a minimal footprint, motivated us to take it on.

It started out as a chance to improve our neighborhood with more owner-occupied homes, and to increase density as far as our local zoning intends, then add rental housing for students in the area who might not need to own cars (or drive very often) if they live this close to school.

It's been a chance to educate ourselves and share what we learned. We have researched materials, systems, building methods, efficient space design, and incorporated what we think we learned from the research and our experience into the design of these houses.

A recommended step in green building projects is an event known as an "eco-charrette", where you gather experts from many fields (energy, water, solar, materials, construction, architecture, etc.) to evaluate the options available to make the project green, and then prioritize. Our eco-charrette started with a very long list of possibilities, and we were ultimately unwilling to eliminate any of the green-building elements we identified. So, they're all in – and more.

We wanted to produce breakthrough homes when compared with standard new construction: where the costs of ownership (energy, water, maintenance) would be dramatically lower, where the indoor air quality would be much healthier, and where the time spent maintaining the house would be minimized. (Can you imagine cleaning two lengths of gutters on just one side of the house, and being done?)

Our advice?

It's not always easy to do, and it can be overwhelming at times. But very-green building is possible, it's a good idea, and it will prepare us for a future when water and energy may be far more expensive than they are now. Start small, and choose green options that will work for you. Every little bit counts.

Thoughts about energy sources

The biggest element of a house's environmental "footprint" is the energy it uses. It uses energy every day the building stands.

With these houses, our primary goal was first to conserve as much energy as possible, without using technology that would require the owner to have an engineering degree, and without compromising too far on what most of us expect in a functional home.

Second, for the energy we needed, we wanted to use sources that have as small as possible an impact on the world. PGE's alternative-power options allow us to minimize the impact of our electric energy. The most common fuel in homes, after electricity, is natural gas. It's still extremely popular for space heating and cooking, in spite of its enormous infrastructure, the security risks to that infrastructure, the environmental damage caused by exploration and production drilling, and its rapidly rising cost. Besides the publicly hailed "only carbon dioxide and water vapor", there are less-benign products of burning it: nitrogen oxides, carbon monoxide, methane, nitrous oxide, volatile organic compounds, trace amounts of sulfur dioxide, and particulates).

Thinking of "what sells" in spec homes, we thought of gas as a secondary heat source (a gas fireplace). Again, careful consideration drove us toward a wood-burning fireplace instead. The last bastion of natural gas, the kitchen cook-top, looked like it would survive our good intentions, and in spite of its threat to indoor air quality. But then we came across a better alternative: the electro-magnetic "induction" cook-top. This technology has proven itself in commercial kitchens and in European homes for many years; it's just now emerging in consumer-friendly, affordable cook-tops here in the US. It offers instant response, just like gas, but with 100% of the energy going into heating food (versus 35-40% for gas). It has zero indoor emissions, a smooth cooking surface that never gets hot, so it never has the baked-on residue that requires scrubbing. With this discovery, we completely eliminated natural gas.

Water heating is the other big residential energy hog. For these houses, we chose to heat the water with heat pump water heaters, which deliver between two and three *times* the hot water per unit of energy as conventional water heaters. Again, it's an electric load, not natural gas.

Having taken big steps to shrink our usage, and having chosen the greenest-possible energy source, we feel we've done almost everything we can. THEN…

We'll install as much photovoltaic (PV) capacity as we can afford on the roofs of these homes, which face south. We have the space and the inclination to head toward net-zero energy use, generating as much as we use over the course of a year.

Ultimately, rather than sacrificing or compromising, with these efforts we expect to be MORE comfortable, to be using BETTER appliances, living in a more ATTRACTIVE environment, and saving a LOT of money on utility bills.

What’s LEED?

The U.S. Green Building Council (USGBC) created “Leadership in Energy and Environmental Design” (LEED) for Homes rating system to transform mainstream residential building towards more ecologically responsible practices.

The rating system awards points in eight categories:

- Innovation and Design Process
- Location and Linkages
- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Awareness and Education

Each category considers several specific measures. Most measures have a prerequisite, or baseline you must meet; points are achieved by exceeding the baseline.

The level of performance (point total) advances in four tiers: Certified, Silver, Gold, and Platinum. These homes are striving for Platinum.

WHAT TO LOOK AT ON THE TOUR
TODAY

Please see posted signs for details about each of these items:

Friendlier concrete
(LEED – Materials & Resources 2.2)

Insulated slab

Radiant-floor heating

Local, FSC-certified lumber
(LEED - Materials & Resources 2.2)

Staggered studs/advanced framing
(LEED – Materials & Resources 1.2)

Density
(LEED – Sustainable Sites 6.1)

Location
(LEED – Location & Linkages 5.3)

Daylighting

WHAT TO LOOK FOR ON THE TOUR
NEXT YEAR

Please see posted signs for details about each of these items:

Super-efficient heat pump for space heating
(LEED – Energy & Atmosphere 6.0)

Heat pump hot-water heater for domestic hot water
(LEED – Energy & Atmosphere 7.3)

Efficient high-performance wood-burning fireplace
(LEED – Indoor Environmental Quality 2.2)

Salvaged materials

Efficient lighting
(LEED – Energy & Atmosphere 8.1; Energy Star)

Energy-efficient appliances
(LEED - Energy & Atmosphere 9.1; Energy Star)

Photovoltaic solar panels
(LEED - Energy & Atmosphere 10)

Fresh air/Indoor air quality
(LEED – Indoor Environmental Quality 4.2)

Sustainable windows
(LEED – Energy & Atmosphere 4.1; EnergyStar)

Rainwater storage tanks for potable water
(LEED – Water Efficiency 1.1)

Gray water system to recover reusable water
(LEED – Water Efficiency 1.2)

Low-flow fixtures
(LEED – Water efficiency 3.2)

Water-efficient appliances
(LEED – Energy & Atmosphere 9.0; Energy Star

Sustainable landscaping
(LEED – Sustainable Sites 2)

Friendlier concrete
(LEED – Materials & Resources 2.2)

The concrete mixed for the foundation, slab and stem walls in these two houses used 30-45% fly ash. Fly ash is what's left over from burning coal. It's a waste product from coal-burning power plants that can be used to replace up to 50% of the Portland cement that is used in making concrete. Fly ash replaces the energy-intensive Portland cement with a waste material that would otherwise be landfilled. Using fly ash requires a careful redesign of the concrete mix, but it produces a structurally stronger finished material. The only visible difference is a slightly darker color on the upper house floor.

Insulated slab

Beneath the concrete slab floors (but not under the garages) we used 10 inches of Perlite, a light volcanic rock "harvested" locally from eastern Oregon. Perlite is made by heating a certain kind of volcanic rock to 1600 degrees, when it pops like popcorn into an airy silica-based material that's ideal for insulation. The exterior of the foundation and stem walls are insulated with Styrofoam. These efforts will help conserve the energy used to keep the floors warmer in winter and cooler in summer.

[Photo: Perlite insulation]

HEATING:

Air-to-water heat pump for space heating
(LEED – Energy & Atmosphere 6.0)

We will use two-stage air-to-water electric heat pumps as the primary heat source for these homes. The second stage will let the heat pump operate efficiently to lower temperatures, letting us skip a back-up heat source. Typical heat pumps use inefficient electric-resistance heat for backup below about 35°. The system can also provide cooling on the hottest days with the use of fan-coils. This new heat pump is being developed initially for this project, but will soon be widely available here as an affordable, highly efficient, natural-gas-free alternative for heating and cooling.

Heat pump hot-water heater
(LEED – Energy & Atmosphere 7.3)

Domestic hot water will be heated by a separate “tank-top” heat pump. This will use between one-third and one-half the energy of a standard electric water heater.

[Photo: E-Tech Heat-Pump Hot Water Heater]

Speaking of hot water, one of the places we see energy disappearing, and water too, is when a faucet is located a long ways from the water heater. In our current house, we have one bathroom that’s 60 feet away from the water heater. It takes over 2 minutes to get the water to run hot, between 3 and 5 gallons. And within a half-hour of shutting it off, the water in the pipe has cooled enough that we have to start over again if we want more hot water in the bathroom.

In these houses, the bathrooms and laundry rooms are clustered close to the water heater. The kitchens are the longest runs, around 35 feet. For these, we are considering using spot-water heaters, which accelerates hot water when you signal (push button, motion sensor) that you want it. See www.gothotwater.com. Pretty cool!

Radiant-floor heating

These homes will be heated using water, warmed with a super-efficient heat pump and circulated through several separate zones through the concrete-slab floors on the ground floors, and through radiant panels and fan-coils on the upper floors. This is an efficient approach to heating a home: by heating objects (like people), radiant heat can keep you warm and comfortable when the air is much cooler, the way the sun feels warm outdoors even when it's below freezing.

Unlike forced air systems, radiant heat is silent, and doesn't stir up or distribute dust or allergens. The heated slab will provide all the heat for the ground floors, *and* most of the heat for the upper floors (except above the garages), where we will rely on radiant panels to provide space heating.

[Photo: Radiant floor PEX tubing installed before concrete was poured]

Efficient high-performance wood-burning fireplace
(LEED – Indoor Environmental Quality 2.2)

A clean-burning, efficient fireplace or wood stove (we're still deciding) will provide the "hearth" of the home and a backup heat source in case of a power outage. Burning wood in Oregon uses a local and renewable fuel, unlike natural gas. Burning wood releases only the carbon that the tree sequestered during its lifetime, and doesn't require the environmentally and socially destructive use of fossil fuels. We needed to take down a number of big-leaf maple trees here on the site; they will provide the first few cords of wood for our fireplaces.

Local, FSC-certified lumber
(LEED - Materials & Resources 2.2)

All the framing lumber, posts and beams are FSC (Forest Stewardship Council-certified) fir from Zena Timber near Salem and milled for this project by Kevin Kaster.

The glulam beams are FSC fir from Warm Springs assembled in Vancouver, WA.

FSC plywood is from Roseburg.

FSC hemlock tongue-and-groove car decking (used for upper-level floors, visible from below) is from John Belton's forest in Sandy.

What is FSC?

The Forest Stewardship Council (FSC) is a non-profit organization that encourages the responsible management of the world's forests. FSC sets high standards that ensure forestry practices are environmentally responsible, socially beneficial, and economically viable.

The Forest Stewardship Council certifies wood products harvested from well-managed forests. Certifiers verify that forests are managed according to environmental, economic and social-justice principles. Companies that sell FSC certified products must track their supply back to FSC certified sources (chain of custody).


[Photo: Some of our trees (and Katharine) on a visit to Zena's forest]

Salvaged materials

Materials were salvaged from the original house on the site, as far as possible, by the Rebuilding Center, and a number of individuals who recovered steel, appliances, pine paneling, roofing and other items, prior to demolition.

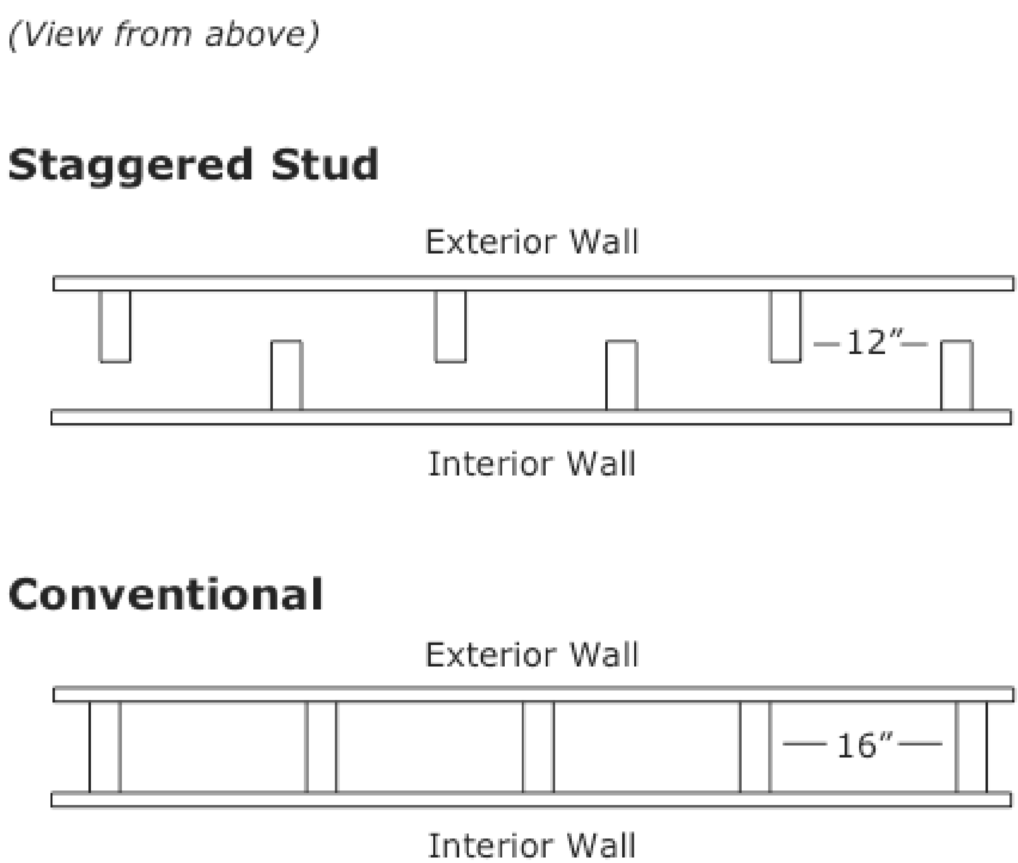
A 100-foot tall fir tree used to stand in the middle of the new driveway; Urban Timberworks salvaged the tree. Wood from the fir was milled into three-inch-thick stair treads for use in both houses.

Reclaimed maraschino cherry barrels, originally made from CVG fir, will be used for cabinets and trim.

Staggered studs/advanced framing
(LEED – Materials & Resources 1.2)

Reach into one of the exterior walls and snake your hand in and out of the studs. They're built using 2x8" plates and 2x4" studs placed every 24" on the interior and every 24" on the exterior walls, staggered so there's a stud every 12". (Standard code framing uses 2x6" studs 16" apart on a 6" plate.) Staggered stud framing eliminates "thermal bridging", where lumber that touches both interior and exterior walls forms a bridge for heat to escape from the house. You can see this when frost forms on roofs with stripes melted by thermal bridges. It also allows us to insulate the entire wall cavity rather than only stud bays, giving higher thermal performance (R-value) to the whole wall.

This approach also means that we don't have to drill through every stud to pull wire or plumbing. This method, also known as the "party wall", significantly improves sound insulation.



LIGHTING:

First, daylighting

In a house with effective daylighting, you rarely need to turn on the lights during the day. That saves energy. The size and placement of the windows provides light for most of what you need to do indoors.

Building code defines a minimum area of window for homes. There's a tradeoff: The more glass, the more heat the home will gain or lose through the windows, which from an energy-efficiency standpoint are holes in a bucket.

These homes will maximize the use of available daylight with their large windows, and having windows placed on at least two exterior walls of all the main rooms.

Efficient lighting

(LEED – Energy & Atmosphere 8.1; Energy Star)

Careful (or professional) lighting design can make the most of energy used to light a home. These homes will use a combination of compact-fluorescent (CFL), fluorescent tube, low-voltage halogen and LEDs for the different roles lighting plays in letting us see where we're going and what we're doing.

Some well-intentioned efficient-lighting specifications call for a minimum percentage of CFL fixtures. We've learned that CFLs are not always the most efficient lighting technology, when measured in terms of Watts per square foot (the standard efficiency measurement for commercial lighting). We hope to encourage performance-based standards for residential lighting in the future.

Energy-efficient appliances
(LEED - Energy & Atmosphere 9.1; Energy Star)

Refrigerators, dishwashers and clothes washers are rated by their efficiency by the US Department of Energy: to get Energy Star certification, they must be at least 15% more efficient than a comparable average (benchmark) appliance.

Manufacturers play interesting games to get Energy Star ratings, such as increasing the capacity of a washing machine or refrigerator to where it shows as the most efficient in a larger class, rather than less efficient in a smaller class. (This is behind the phenomenon where you may see big differences between refrigerators' "stated" versus "actual" capacity in places like Consumer Reports.)

Refrigerators specified for these houses will be rated close to 450 kW per year, which is as low as refrigerators get (that are both affordable and available).

Laundry-room door

We located an exterior door in the laundry room (on the upper house) so it would offer convenient access to clotheslines outdoors, to save the energy used to run the clothes dryer.

Photovoltaic (PV) solar panels
(LEED - Energy & Atmosphere 10)

Photovoltaic panels turn sunlight into electricity. These systems will be grid-tied: they capture electrical energy from sunlight. When they feed that energy back to the electric grid, our electric meter will run backwards. We intentionally sloped all of our roof area to the south to maximize the opportunity for placing as many PV panels on the roof as we can afford – now and in the future.

At this point, we're targeting 6kw of PV capacity on each house, meaning that at full power, the panels will generate 6 kW of electricity per hour (that would run one-hundred 60-Watt lightbulbs). We hope that this investment will allow us to generate as much electricity as we use, achieving something close to "net zero" energy use on an annual basis.

Fresh air/Indoor air quality
(LEED – Indoor Environmental Quality 4.2)

Early on, we chose to eliminate natural gas for heating the house or the hot water, but later eliminated it in the kitchens too, opting to use induction cooktops, which are super-efficient, super-sensitive and precisely controlled way to cook food. An energy-recovery ventilator (ERV) will exchange indoor with outdoor air. We're avoiding the use of VOCs and toxic materials throughout the house. What we bring into our houses on our shoes is the number one home pollutant, so walk-off mats and shoe storage benches will keep outdoor stuff outdoors.

Tight as they'll be, when they're buttoned up these homes will need a way to freshen the indoor air. We'll use ERVs (energy recovery ventilators) from Renew Aire, which will transfer over 80% of the indoor temperature to fresh incoming outdoor air.

Plumbing Fixtures – and Compromise

We're all used to chrome faucets and cast-iron sinks and tubs. But how often do we think about where they come from and what they're made of? We set out to keep things simple and very functional, with an eye to at least minimizing maintenance. But we didn't expect this to be so hard.

Talking with a friend a couple of weeks ago, when he learned we were looking at faucets, he said, "You're getting nickel, right?" Who knew about chrome – and how toxic it is during its manufacture? Check this:

> *"The electrical charge during the chrome plating process causes the hexavalent chromium to be emitted from the bath as an aerosol that, once emitted from the facility, can be inhaled and entrained inside the lungs."*
>
> *"The clear scientific consensus is that hexavalent chromium is an exceedingly dangerous carcinogen. EWG (Environmental Working Group) urges the (California Air Resources) Board to prioritize public health and set the most health- protective standard possible while moving towards the phase-out of this compound in decorative plating." (http://www.arb.ca.gov/regact/chrom06/fsor.pdf)*

It's toxic, and it's hard to contain, and it's ubiquitous. It seems reasonable to think that if we get chrome faucets made domestically, they would be expensive because of the cost of compliance with our environmental regulations. And if they're not expensive, they're likely made where the toxic emissions are being released into communities, into our atmosphere. So, what are the alternatives?

Turns out nickel plating is far less toxic. So, we're sourcing nickel-plated faucets. They're usually more expensive than chrome ones, by between 15 and 30%. That's our choice. They'll still last a long time.

Now, how about sinks and tubs? Cast iron, ceramic (fireclay – of which virtually all toilets are made), acrylic, fiberglass, solid-surface composites (like Corian), and stainless steel make up the choices we've seen. Cast iron, even porcelain-coated, is recyclable. But their manufacture is hugely energy-intensive. Fire-clay can be down-cycled (crushed and used in paving). Acrylic, fiberglass and solid-surface materials directly use petroleum products, and are recycled by crushing and using as fiber and filler in new fiberglass products. They come in more shapes and sizes (more accommodating 20" deep bathtubs, for example, compared to 16" for cast iron).

Ultimately, we chose fiberglass shower stalls because they're locally made, provide off the shelf components to fully enclose, and are easy to maintain (mildew-free, compared with tile, for example). But we also chose those deeper tubs, which will give us the opportunity to add decorative tile work in the most-visited ground-floor baths. We chose fireclay for bathroom sinks because they're extremely durable. We chose stainless for kitchen sinks because they are extremely durable, easy to clean, and like cast iron, can be recycled.

We never expected the challenge in specifying our choices for this mundane category, plumbing fixtures. Let's just say we learned a lot, and are OK with our compromises.

Sustainable windows

(LEED – Energy & Atmosphere 4.1; Energy Star)

Even though there are windows available with slightly better energy-saving performance, we chose to use Energy Star fiberglass windows as a more sustainable option for a number of reasons:

- Affordability: Windows can be a significant expense in a home, and these homes were intended to demonstrate that green homes can be affordable.
- Durability: They are entirely maintenance free, and do not require sealing, painting or staining initially or at any point in the future.
- Performance: Fiberglass is extremely strong and thermally stable, and a proven material for its durability, its ease of repair, and it can be painted any color (we won't paint them, to minimize maintenance).
- Fiberglass competes on price with vinyl windows. Unlike vinyl windows, these windows do not create toxic fumes when manufactured or when (if) they burn. Wood windows rarely use FSC wood, and the wood requires maintenance; aluminum-clad wood windows are possibly ideal, but are quite expensive by comparison.

Sustainable roof design

Many aspects of the roofs of these homes make them significantly more sustainable than typical roofs. They are designed to:

- Maximize south-facing area for solar energy collection
- Simplify construction and maintenance (just one gutter)
- Maximize rainwater capture using metal, which unlike other materials doesn't absorb any water into its surface; captures a drizzle as well as a downpour
- Reflect and dissipate radiant heat (bare metal is most efficient at this)
- Shade the roof, by raising the metal roofing with a ventilation space least two inches deep
- Minimize unused volume (no truss space or attic)
- Optimize thermal (insulation) performance
- Eliminate roof penetrations, which removes leaf-catching obstacles, opportunities for leaks to develop, obstacles to installing more solar energy collectors
- Last a long time.

WATER

Rainwater storage tanks for potable water
(LEED – Water Efficiency 1.1)

The standing-seam metal roofs will provide a smooth surface for collecting as much rainwater as possible – from drizzles to downpours – into 6,000 gallon cisterns at each house. The rainwater will be used for all potable water uses, filtered and sterilized on its way into the house.

Gray water system to recover reusable water
(LEED – Water Efficiency 1.2)

Initially, we wanted these houses will be plumbed to recover most of the water they use, known as "gray" water, from washing dishes, clothes and people, (but not from flushing toilets). This "used" water would be directed to a biological filter (a specially designed planter), and then (although it will be clean enough for the potable-water cisterns) it would be stored separately from the rainwater for re-use.

Pending permits, the collected gray water could be re-used for toilet flushing and washing clothes and irrigation while new plants are being established. After careful review of the economics, the homes will be plumbed with the option to allow the gray water to be captured, but we will not finish the systems at this time. The reason? We don't use enough water through those other uses to make it worth building now, and at this time, city water is too cheap (less than 1 cent/gallon).

Because the City's primary water source (glacier melt, in late summer and early fall) is diminishing, there may come a time when water is much more costly; when that happens, the homes will be prepared to recover and purify the gray water, with the addition of a tank and a valve. By the time that happens, regulations will likely be clear; to install a system today, we would be guessing about what would be required for regulatory compliance.

Low-flow fixtures
(LEED – Water efficiency 3.2)

Low-flow fixtures like dual-flush toilets, faucets and showerheads are a given. We will also be tightly enclosing the showers. (Did you ever wonder how much of your shower is to keep warm, versus washing yourself? An enclosed shower can eliminate the keeping-warm time.)

Water-efficient appliances
(LEED – Energy & Atmosphere 9.0; Energy Star

We will equip these houses with water-efficient appliances (dishwasher, clothes washer), motivated as much by getting the most out of our own captured and stored rainwater. Water-efficient appliances are as mainly about energy savings (reduced hot water use); we expect to wash most clothes with cold water.

SITE

Density
(LEED – Sustainable Sites 6.1)

We chose to divide the lot from R20 to R10 (20,000 square feet to 10,000 square feet), conforming to the maximum zoned density. Taking it further, we have designed accessory dwelling units into each home (permitted and built out in the upper house, an option in the lower house).

Location
(LEED – Location & Linkages 5.3)

Proximity to transit (TriMet buses #38 and 39), destinations such as Lewis & Clark College and Law School, Riverdale High School, Tryon Creek State Park, all within ¼ to ½ mile. TriMet buses stop over 125 times per day within a quarter mile of the site. The SW Terwilliger bike path is two blocks away, connecting to downtown via either Terwilliger or SW Barbur Boulevard.

Sustainable Landscaping
(LEED – Sustainable Sites 2)

The sites will be landscaped using native and drought-tolerant plants, and we intend to avoid planting lawn. We also plan to irrigate only until plants are established. The driveways and other outdoor areas, that might be conventionally paved, will use surface materials that allow rainwater to flow through, and plants (ground covers) to grow.

Typical home sites often dedicate one-third or more of their outside space to cars, space that's used by the cars passing through only a few seconds a day. On our upper house, the driveway space will be shared space, mostly planted with drive-over-able ground cover, and will look like a patio area. Reserved passage space will be only as wide as our car (6 feet including clearance). Areas along the driveway may see food or flower gardens. Very little of the driveway area will qualify as "hardscapes" – maybe none.

Roll credits…

Owners	Charlie Weiss & Katharine Lawrence
Architect	Kathy Kremer
Builder	Green Hammer Construction Stephen Auigier (owner) Alex Boetzel (project manager) and the crew: Rebecca, Annie, Bill (Ecologic Excavation), Joolz (Urban Timberworks), James (JR Arnold Construction), Jessica, Dean (NaDeans Custom Plumbing), Michael, Andrew, Jeff
Landscape design	Susan Latourette, CreativeScaping
Lighting design	Stephanie Cissna, Globe Lighting
Energy	Charlie Stephens Jonathan Cohen
HVAC	Jim McKillip, WESCOR
Financing	David Blackmon, Rose City Mortgage