

# The First Optimum Performance Home®

## site and foundation preparation part XV

Architectural Illustration By Ronald Devesa

Gary Reber



YOUR NEIGHBORS WILL BE  
**GREEN WITH ENVY.**



### synopsis

The project's concrete mixes use Portland Cement, Kryton's KIM admixture, Euclid Eucon A+ admixture, and 40 percent fly ash.

Waterproofing was one of the most important factors when dealing with the super saturated clay soils, which are prevalent at the building site.

A significant element in the proper functioning of the dedicated Optimum Performance Home Theatre is the insulated Spunstrand underground air-conditioning duct system that will deliver low-velocity ultra-quiet airflow circulation in the acoustically treated theatre.

The radiant floor portions of the five-inch thick suspended concrete slab and under-slab insulation will be encased at the perimeters with the EnergyEdge® eight-inch Frame Building Rail.

Under the slab, covering a granular mixture compacted over the soil, will be a Cosella-Dörken® DELTA®-MS UNDERSLAB waterproofing and vapor-retarder membrane designed for slabs on or below grade and a rigid Type II R-4 (per inch) 2-3/4-inch R-Control® Perform Guard EPS (expanded polystyrene) insulation from AFM Corporation.

### Introduction

After five years of design and plan development work, the first Optimum Performance Home® is now under construction.

This is the fifteenth article in the series documenting the design and construction of the first Optimum Performance Home. The project has been selected by the U.S. Green Building Council (USGBC) for inclusion in the national Leadership In Energy & Environmental Design (LEED®) for Homes pilot program, their new green build certification initiative, and the goal is Platinum certification.

The home is being built at The Sea Ranch, located in Sonoma County, along the Northern California coastline of the Pacific Ocean, approximately 110 miles north of San Francisco.

To document the day-to-day construction of the home, an iBeam Systems time-lapse construction camera is up and running. Visit <http://www.ultimatehomedesign.com> then click on the "Optimum Performance Home Build Cam" button.

Using iBeam's technology, our team is able to view a high-resolution photo archive of the entire project on a daily basis, including stunning 1920 x 1080p (progressive) high-definition time-lapse movies each month (see a standard-resolution version at [www.ultimatehomedesign.com](http://www.ultimatehomedesign.com)).

Photos are captured and automatically uploaded to iBeam's secure server every 15 minutes from 6:00 a.m. to 6:00 p.m. each day. They can be viewed through the directed link on the *Ultimate Home Design* Web site. Furthermore, the images can easily be e-mailed or printed to document job site conditions.



## YOU'LL JUST BE GREEN.

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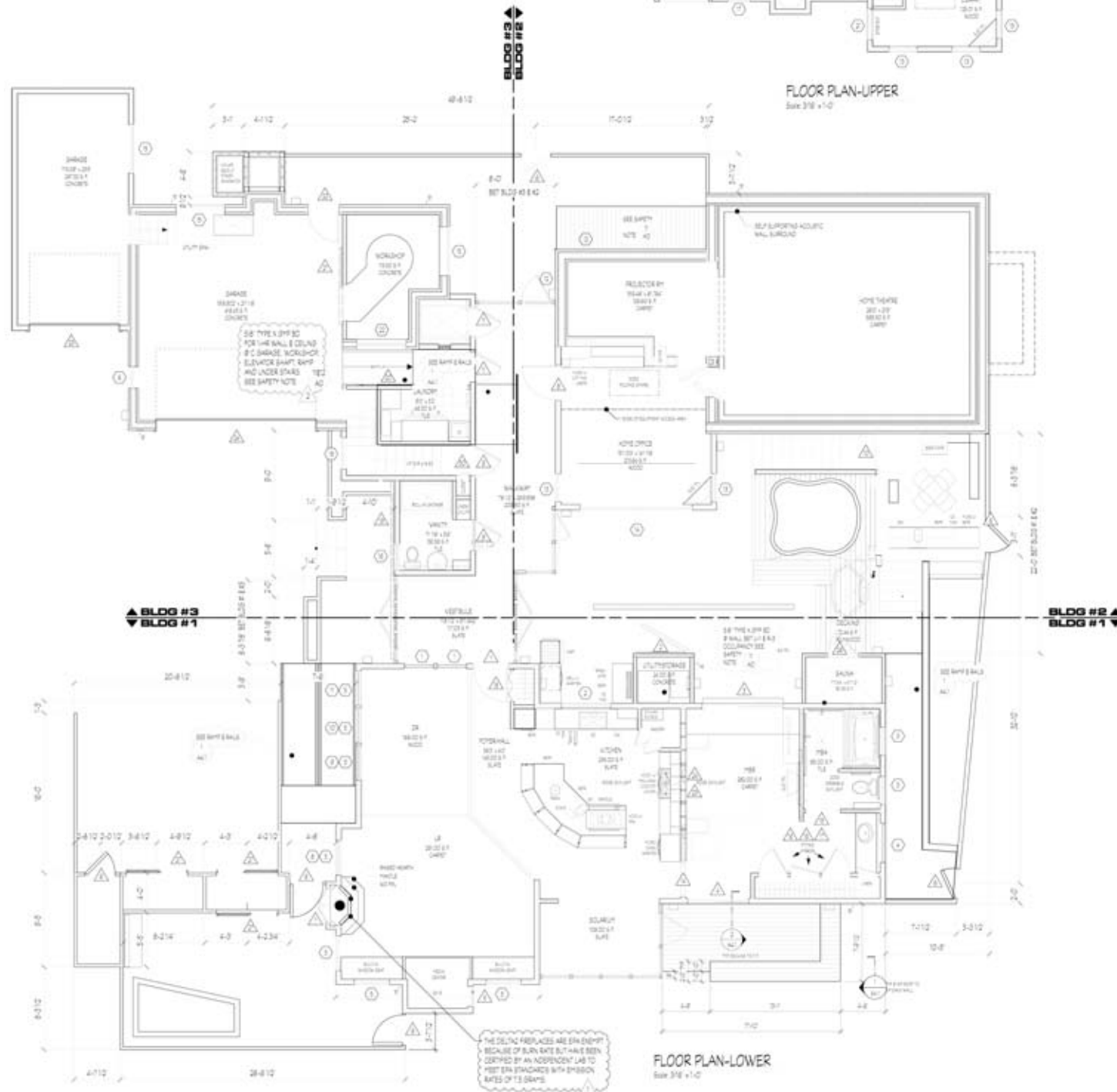
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# The First Optimum Performance Home® At The Sea Ranch



The Sea Ranch, Sonoma County, California  
Aerial Photo Courtesy Scott Simpson

At the conclusion, the entire construction photo archive will be featured as a 1080p high-definition time-lapse movie and will become part of a high-definition television program and educational documentary that Steve Michelson Productions and I are producing.

## Ultimate Home Design® Concept

The showcase project is exemplary of the "Ultimate Home Design®" concept, which integrates age-friendly universal design with the best sustainable building practices, while exerting minimal impact on the natural environment. Universal design is the inclusive, non-discriminatory design of products, buildings, environments, and urban infrastructure; as well as information technologies that are accessible to and useable by (almost) all. With respect to home design, the idea is to design and build homes that have no physical barriers, thus sustaining people of all ages and all capabilities in a functional, comfortable, and aesthetic lifestyle.

A building-science systems approach to home building is the cornerstone of the project, with emphasis on the relationship between the home's components and the envelope they create. Also paramount is good stewardship—proper regard and respect for the rights of neighboring homeowners and the surrounding natural setting, and resource efficiency. The goal is to optimize occupant health, comfort, and safety; maximize energy efficiency and structural durability; and minimize environmental impact. In addition, the aim is toward providing a nurturing home environment to support independent living and sustainable lifestyles.

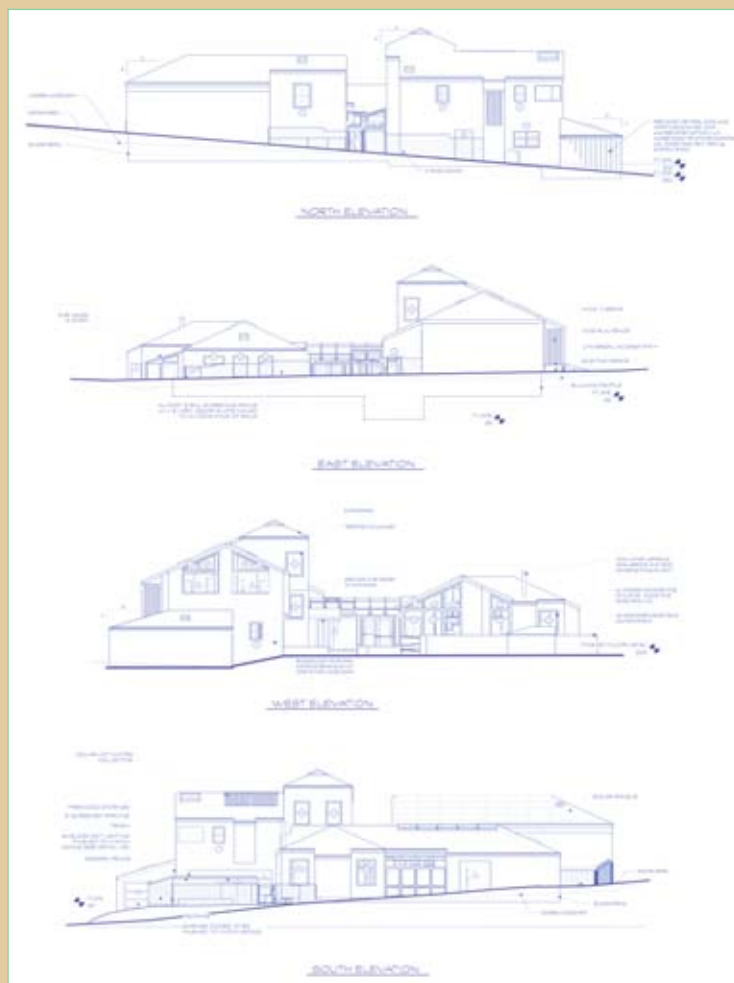
Part I of this case study series appeared in Issue 1, January/February 2006. The introductory article covered the project scope. Thereafter, each issue has contained a part of the continuing series by working through site planning and

preparation; Low-Impact Development (LID); further refinements to the site plan and drainage design; The Sea Ranch Design Committee-approved architectural/structural and grading/ drainage submittals with conditions that translated to clarifications on certain building components and material finishes; particular aspects of the home's mechanical plan; structural aspects of foundations, structural walls incorporating Insulating Concrete Forms (ICFs), and Structural Insulated Panels (SIPs), as well as roofing; the acoustical design of the dedicated Optimum Performance Home Theatre™ and rear-projection room; interior design approaches and materials; kitchen, bath, and home fixtures; universal design architecture; fire-risk mitigation; energy generation; and courtyard experience. "Breaking Ground" was the title of Part XIII, along with "Courtyard Experience." Part XIV covered the initial phases of "Site And Foundation Preparation."

Construction remains at the initial site grading, foundation, and mechanical, plumbing, electrical, and low-voltage infrastructure stages. This work is documented in the day-to-day time-lapse photography and archived photos on the Ultimate Home Design Web site.

Completion of the home is anticipated for December 2008. It is our intent to produce a high-definition documentary for educational use by the U.S. Green Building Council, the organization who created the LEED for Homes rating and certification program. Our presentation will reveal the step-by-step process for creating the first Optimum Performance Home—expected to be one of the highest rated, if not the highest, LEED for Homes Platinum residential home in the world!

**"The goal is to optimize occupant health, comfort, and safety; maximize energy efficiency and structural durability; and minimize environmental impact, as well as provide a nurturing home environment to support independent living and sustainable lifestyles."**



The elevations of the Optimum Performance Home at The Sea Ranch

## Construction Scheduling

Below is the breakdown of the initial site preparation and grading process and foundation work completed or under way. An outline will be provided in Part XVI for the next stage of construction relating to the completed below slab infrastructure and above the slab Amvic ICF and ThermaSAVE SIP walls and roofing.

### Pre-Construction Start Meetings

#### Site Work

- Clear Lot Vegetation
- Lay Out House Pad
- Install Curtain Drain Around Pad
- Excavate Optimum Performance Home Theatre, Alcove, Wine Cellar

#### Lay Out Footings

- Temporary Electrical Power
- Install iBeam Systems Time-Lapse Pro Construction Camera (See Part XIII)
- Install GetWireless and WildBlue Internet Transmission

- Activate Water Service
- Form Underground ICF Home Theatre, Alcove, and Wine Cellar Walls
- Verify Foundations' Site Placement/Inspection

- Rough Excavation Large Pond and Septic Trench to Designated Leech Field
- Install StormTech Infiltration Chambers (See Parts II, III, and IV)

#### Foundations

- Dig Initial Stage Foundation Footings and Install French Drain
- Pour First Stage Engineered Controlled Density Fill (CDF) Concrete with Portland Cement and Headwaters Resources Fly Ash (See Part VI)
- Set Forms, Tie Rebar Steel, Hold Downs and Anchor Bolts

- Pour Final Stage Foundation Footing Concrete with Portland Cement, Headwaters Resources Fly Ash, Kryton's KIM Admixture, and Euclid Eucon Admixture (See Part VI)

- Run Spunstrand Air-Conditioning Duct for Home Theatre (See Part V)
- Conduit Trenching for Uponor AQUAPEX Plumbing (See Part V and X)
- Run Armacell Insulated Uponor AQUAPEX Tubing

- Run Plumbing Waste
- Run Wardflex Flexible Corrugated Stainless Steel Fuel Gas Tubing
- Run Underground Water Line from Pond to the Boat Garage for Fire Hose Connection (See Part XI)

- Install Gravel Around Plumbing
- Run Plumbing Conduit and Supply
- Run Electrical and Low-Voltage Conduit
- Lay Out NuTone Central Vacuum System (See Parts IX and X)

- Finalize Underslab Infrastructure and Zurn Flo-Thru Trench Drain
- Underslab Inspection
- Place Gravel and Sand Underslab

- Install Cosella-Dörken DELTA-MS UNDER-SLAB
- Install AMF Corporation R-Control Perform Guard EPS Underslab Insulation
- Install EnergyEdge Insulated Form Around Perimeter of Slab
- Install AMF Corporation R-Control Perform Guard EPS Around Perimeter of Slab
- Prepare for In-Floor D-Box™ Technologies Custom Motion Platform In Home Theatre (See Part VII)
- Install Slab Rebar
- Install Uponor AQUAPEX Radiant Floor Tubing
- Pour Concrete Slab
- Treat Concrete Slab with Nisus Corporation Bora-Care Termite Barrier Pretreatment
- Waterproof Home Theatre, Alcove, and Wine Cellar Walls with Carlisle Coatings
- Backfill Foundation

#### Septic System

- Dig Septic Trench, Cut Road, Install Pipes, Backfill Trench, and Repair Road

The site preparation work is being done by Sonoma County Builders, Inc. under the direction of Noble and Loyal Davis. This company, based both in Santa Rosa and Point Arena, California, has had extensive experience in excavation for both residential and commercial/civic projects for over 35 years. They are very supportive of the project and sensitive to the environmental concerns and protections that are in place for the project. Prior to the start of their excavation work, the tall grasses were cut down by Steve Glaze (Steve Glaze Backhoe). This top layer of roots is being stockpiled along with the extensive mud excavated and allowed to form a "top soil" compost for later spreading back over the site, just prior to landscaping with indigenous vegetation and trees. John Feeney, our on-site supervising contractor and lead carpenter, and his carpenter team consisting of Ian Currie, Jerry Feeney, and Aaron Phillips are performing the foundation work. Sebastopol, California-based Weeks Drilling & Pump Company, under the direction of Chris Thompson, CEO, will drill the five 310-foot-deep geothermal bore holes after the foundation work is completed. Don Bartlett of Bartlett Mechanical Services will install the WaterFurnace® geothermal and complete the interface with the



Excavation of septic tank affluent transfer pipeline route



Affluent transfer pipeline crossing road; initial stage of pond excavation

### Stormwater Solutions EcoRain™ Tank Modules



• Underground modular water cistern tanks manufactured with 100 percent recycled plastic. The modular tanks can be used to create any size void space underground by just butting them to one another. A 40-millimeter thick membrane encases the tanks to hold the recycled water harvested from the roofs.



WaterFurnace system with the Spunstrand underground acoustically damped air-conditioning duct system. The Spunstrand system was constructed and installed by Jerry Feeney and John Feeney. Bill Wilson Environmental Planning and Design, LLC with Dylan Coleman, principal in Mt. Shasta, California-based Wonderwater, are responsible for the on-site water-management systems, including the pond and drains. Aqua Harvest International's Terry McMains, based in Rio Rancho, New Mexico, designed the site application of the EcoRain™ Stormwater Tank Modules underground water cistern manufactured by Stormwater Solutions, LLC.

Sonoma County Builders have completed the initial off-site septic system work, including digging the septic tank affluent transfer pipe line from the home site to The Sea Ranch-designated leech field, approximately 1,200 feet away; cutting the pavement across Timber Ridge Road east of the site, under which the septic pipe will transverse; installing the septic pipe in the trench; backfilling the trench; and repairing the surface of the road. During this procedure the excavator was careful to protect tree root systems, digging those areas of the trench by hand. Thus, all of the tree roots were preserved during the work, and the ground was restored.

### GetWireless And WildBlue™ Satellite Speed Internet®

In order to facilitate capturing the high-resolution images taken on-site by the iBeam Time-Lapse Pro Construction camera, an "always on" GetWireless AirLink Raven X EVDO V4221-VA and AirLink Dual-Band EVDO Antenna is being employed. This system provides the Ethernet Internet



iBeam Time-Lapse Pro Construction Camera Perspective

interface for the Verizon Wireless Broadband uplink service for the iBeam Systems time-lapse camera on the construction site.

A WildBlue™ Satellite Speed Internet® system developed by WildBlue Communications, Inc. and offered as part of EcoStar's DISH Network satellite services is being used on the site for Internet connectivity. The offer is provided separately under the EchoStar brand name, and sub-branded as "powered by WildBlue." The new WildBlue Enterprise Solutions™ satellite services system offers business-class broadband connectivity via state-of-the-art satellite technology, using a 26-inch satellite mini-dish equipped with both a transmitter and receiver for two-way satellite connectivity to the Internet. See Part XIII for a full description of the service.

### This Issue

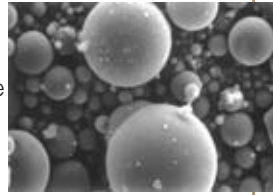
In this issue, the focus will be on the various construction elements related to site and foundation preparation.

The site's soil conditions (see Part XIV) resulted in extensive additional excavation work, including digging trenches around and within the perimeter of each building in the three-building compound. Deep trenches were necessary to reach the deeper laying bedrock. A specially engineered Controlled Density Fill (CDF) concrete mix was designed to fill the voids and provide a strong, stabilized surface upon which to support the foundation footings. CDF, also known as "flowable flow," is an engineered, controlled, concrete-fill material, which is self-placing, self-leveling, self-compacting, and non-settling. Our particular formula required a concrete mix consisting of equal amounts of Portland Cement and fly ash, water, and 3/8-inch aggregate and concrete sand. The so-called "two-sack mix" consisted of 188 pounds of Portland Cement per cubic yard in the



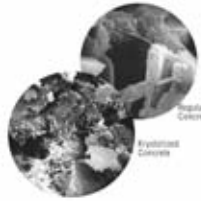
### Headwaters Resources

- Fly ash improves the performance of concrete foundations, making them stronger, more durable, and more resistant to chemical attack, while creating significant environmental benefits through stewardship of an abundant industrial resource. Because the tiny fly ash particles fill microscopic spaces in the concrete, and because less water is required, concrete using fly ash is denser and more durable. And concrete containing fly ash becomes even stronger over time compared to concrete made only with cement.



### Kryton's KIM® Admixture System

- KIM admixture renders hardened concrete impermeable to water penetration, reduces drying shrinkage, protects steel reinforcements from corrosion, and improves concrete durability. The advanced integral crystalline chemicals react with water and unhydrated cement particles to form millions of needle-like crystals to permanently block the pathways for water and waterborne contaminants.



### Euclid Eucon A+

- Euclid Chemical Company's Eucon A+ Type A admixture serves as a fast-setting, water-reducing, and plasticizing admixture for concrete that does not adversely affect concrete set times.



final concrete mix and an equal fly ash pound-weight. One sack of Portland Cement weighs 94 pounds. The mix design was formulated by Doug Yeggy at Headwaters Resources. Headwaters Resources is the source of the fly ash that will be used in the concrete mixes designed for the project. The Portland Cement Association and the California Portland Cement Company are the sources of the cement used in the project. Delivery of the Portland Cement and fly ash to the concrete production facility was handled by Conti Materials. The local concrete production facility is Bed Rock Products, based in Point Arena (and Gualala), California. Bed Rock Concrete Pumping is providing the concrete pumping service for the project.

Doug has designed two other concrete mixes for the project: standard foundation footing and the concrete to be poured into the Amvic ICFs, and the suspended slab-on-grade. These mixes use Portland Cement, Kryton's KIM admixture, Euclid Eucon A+ admixture, and 40 percent fly ash. The mix design for the standard foundation footings used 324 pounds of Portland Cement, 216 pounds of fly ash (40 percent), 11 pounds of KIM admixture, and 16 ounces of Eucon A+ admixture per cubic yard. The suspended slab-on-grade mix design will use, per cubic yard, 360 pounds of Portland Cement and 240 pounds of fly ash (40 percent), 11 pounds of KIM admixture, 18 ounces of Eucon A+ admixture, and FORTA® FERRO®. The Amvic ICF concrete mix design will use the mix design that was used for the standard foundation footings.

One of the unique features, which has caused quite a bit of frustration during the design phases of the Optimum Performance Home, is the naturally occurring subgrade water, which can be typical in California's coastal areas. Special design considerations were implemented to take an

otherwise user-unfriendly building site and making it part of the Optimum Performance Home's unique character.

Waterproofing was one of the most important factors when dealing with the super saturated clay soils, which are prevalent at the building site. The over-excavated-base rock-bearing foundation and the suspended slab footings are only the first part in a very detailed waterproofing system that uses the most advanced technologies to insure that moisture will stay outside of the building envelope where it belongs. Each individual part of the waterproofing system puts its own unique fingerprint on the other parts in the system and has had our suppliers and engineers working overtime to come up with solutions at every turned page of the plans or specification detail.

The most recent change has come in the concrete mix design for the suspended slab-on-grade. Originally designed at 5.50 sack with 30 percent fly ash replacement, as well as Kryton's KIM waterproofing admixture and Euclid's Eucon A+ water reducer (see Note 1), a change has been made to decrease the water-to-cement ratio down to a 0.45 water-to-cement ratio, which will help accommodate some of the design features of the DELTA MS UNDERSLAB waterproofing and vapor-retarding system—one of the more critical features of our Integrated Water Proofing System.

The reason for this change is as much due to the superior vapor-retarding capabilities of the DELTA product as it is to concrete's ability to be permeable. As discussed in an earlier article in this series, as concrete is being poured, water tends to collect on the surface as particles settle (also known as bleeding). The impermeable nature of vapor retarders in general has a couple of effects. They can decrease the amount of water that enters from beneath the slab and they hold water inside the barrier, which contributes to



### FORTA® FERRO®

- Forta Ferro is a copolymer/propylene fiber that is used to reduce plastic and hardened concrete shrinkage prior to the initial set, reduce hardened concrete shrinkage cracking, improve impact strength, and enhance concrete toughness and durability.

### Cosella-Dörken DELTA-MS UNDERSLAB



- DELTA-MS UNDERSLAB is a tough, impermeable vapor-retarding membrane that is placed on the earth or granular (adjective) prior to placing the concrete slab. The membrane provides a full capillary break and vapor retarder that prevents the upward migration of moisture through the capillaries that exist in all concrete.

### R-Control® Perform Guard EPS



- Rigid Type II R-4 (per inch) 2-3/4-inch R-Control® Perform Guard EPS (expanded polystyrene) insulation from AFM Corporation provides superior thermal mass for uniform heat transfer of slab-encased radiant floor systems. Photos courtesy of AFM Corp.

### Suspended Slab-On-Grade Compactive Strength 3,000 Pounds Per Square Inch (PSI) 56 Days (See Note 2)

Materials	Slab-On-Grade	Moisture Adjusted
Cement (Pounds)	360	360
Fly Ash (Pounds)	240	240
Water (Pounds)	270	196 Pounds (23.5 Gallons)
1 Inch x #4 CA (Pounds)	1,276	1,286 (6 Pounds)
3/8 Inch x #8 CA (Pounds)	400	402 (2 Pounds)
Concrete Sand (Pounds)	1,322	1,388 (66 Pounds)
Eucon A+ (Ounces Per Yard)	18	18
Target W/C Ratio	0.45	0.45
Kryton KIM	11 Pounds Per Yard	11 Pounds Per Yard
Slump + 1 Inch / - 2 Inch	4.0 Inch	See Note 1

**Note 1**—PLEASE NOTE! With higher volumes of fly ash in concrete mixes the slump will read differently than when conventional concrete is being delivered. The rule of thumb is to arrive on the project with meters reading a 2.5-inch slump if the concrete is ordered at a 4.0-inch slump. After first round, adjust accordingly.

**Note 2**—Mixes are designed to achieve 3,000 psi in 56 days when cylinders are cured in accordance with ASTM C31/C31M-08 Standard Practice for Making and Curing Concrete Test Specimens in the Field and tested in accordance to ASTM C39/C39M-05e1 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.



Pouring the concrete in a portion of the standard foundation footings





**Setting plumbing pass-through; finishing concrete pour; excavating guest parking**



**Forming wine cellar; concrete pour**



increased curing for the concrete. The only problem that may occur, and the reason for the decrease in the water-to-cement ratio to 0.45, is the additional bleed water that may have to come out through the top of the concrete, due to the vapor retarder's ability to keep the water out as well as in.

The waffle makeup of the DELTA MS UNDERSLAB product will allow areas for the water to go during initial placement, which will decrease the bleeding concerns. To further reduce the permeability of the concrete, and to insure additional protection in the very wet environment, we increased the percentage of fly ash (see Doug Yeggy's "High Volume Fly Ash—A Tool For The Concrete Designer's Toolbelt" in Part XIV), which reduces the water of convenience (water needed to place concrete) and the percentage of permeable voids, and is reflected by a

reduction in bleed water channels, which is the road that allows water to transfer through concrete.

Note 1—We were originally going to submit the 5.50 sack 30 percent fly ash mix and plead our case for the innovation point in the LEED point system. Consideration should have been made by the fact that 360 pounds of cement is the minimum amount that should be used in slab-on-grade concrete to facilitate placing and finishing in a timely manner without having to 1) increase the total cementitious content by one sack or more or 2) use chemical admixtures that would increase the cost of the concrete by as much or more than if we added the previously referred extra sack of cementitious material, and 3) incur greater costs by the contractor in man-hours needed to wait until the concrete was ready to be finish troweled. However, in looking at what was done to meet the LEED requirement for innovation, which is now met with our suspended slab-on-grade mix design, it does seem somewhat foolish that we did nothing more than increase the amount of fly ash by 10 percent over the original 5.50 sack 30 percent mix, which did not meet LEED requirements for an innovation point.

KIM admixture renders hardened concrete impermeable to water penetration, reduces drying shrinkage, protects steel rebar reinforcements from corrosion, and improves concrete durability. The advanced integral crystalline chemicals in the KIM admixture react with water and unhydrated Portland Cement particles to form millions of needle-like crystals to permanently block the pathways for water and waterborne contaminants.

Euclid Chemical Company's Eucon A+ Type A admixture serves as a fast-setting, water-reducing, and plasticizing admixture for concrete that does not adversely affect concrete set times.

The suspended slab-on-grade mix

design incorporates FORTA® FERRO®, an easy-to-finish, color-blended fiber, made of 100 percent virgin copolymer/propylene consisting of a twisted bundle non-fibrillating monofilament and a fibrillating network fiber, yielding a high-performance concrete reinforcement system. This fiber provides long-term concrete durability and increased impact resistance. FORTA FERRO is used to reduce plastic and hardened concrete shrinkage prior to the initial set, reduce hardened concrete shrinkage cracking, improve impact strength, and enhance concrete toughness and durability. This extra heavy-duty fiber offers maximum long-term durability, structural enhancements, and effective secondary/temperature crack control by incorporating a truly unique synergistic fiber system of long-length design. FORTA FERRO is non-corrosive, non-magnetic, and 100 percent alkali proof. The recommended dosage rate of FORTA FERRO is 3 to 30 pounds per cubic yard of concrete added directly to the concrete mixing system during, or after, the batching of the other ingredients and mixed at the time and speed recommended by the mixer manufacturer (usually four to five minutes).

The first-stage concrete pour provided the necessary compaction strength to support the final-stage concrete-footing pour, upon which will be suspended the concrete slab. The slab will be five inches thick. Under the slab, covering a granular mixture compacted over the soil, will be a Cosella-Dörken DELTA®-MS UNDERSLAB waterproofing and vapor-retarder membrane designed for slabs on or below grade and a rigid Type II R-4 (per inch) 2-3/4-inch R-Control® Perform Guard EPS (expanded polystyrene) insulation from AFM Corporation.

DELTA-MS UNDERSLAB is a tough, impermeable vapor-retarding membrane that is placed on the earth or granular surface prior to placing the



**Laying out Uponor AQUAPEX plumbing infrastructure under slab**



concrete. DELTA-MS UNDERSLAB prevents the early loss of hydrated water, thus producing a concrete that meets design strength and provides more even curing characteristics in concrete. The membrane offers a full-capillary break and vapor retarder that prevents the upward migration of moisture through the capillaries that exist in all concrete. Additionally DELTA-MS UNDERSLAB can act as a barrier to soil gases. This will provide a healthy and dry environment.

A 2-3/4-inch thick R-Control Perform Guard EPS will be placed over the DELTA-MS UNDERSLAB to provide superior thermal mass for uniform heat transfer of the WaterFurnace geothermal/heat pump heated water through the Uponor® 1/2-inch AQUAPEX® in-floor tubing encased in the five-inch-thick suspended concrete slab.

Prior to pouring the slab concrete, suspended over the final stage concrete footings, the Zurn® Flo-Thru trench drain that runs the full length of the courtyard will be installed. The modular Zurn molded-slop drain is designed for load-bearing strength, hydraulics, chemical resistance, and structural integrity.

A significant element in the proper functioning of the dedicated Optimum Performance Home Theatre is the insulated Spunstrand underground air-conditioning duct system that will deliver low-velocity ultra-quiet air-flow circulation in the acoustically treated theatre. The system is specially fabricated with duckboard and duct liner inserted into the energy-saving R-10 insulated Spunstrand ducts to hush background noise due to ventilation hum, self-generated air noise, and on/off ventilator switching.

Spunstrand manufactures green duct in the Pacific Northwest. The duct

### Spunstrand® Filament-Wound Fiberglass Underslab Duct

- Spunstrand HVAC duct is designed for direct burial applications and is manufactured using the filament-wound method to provide the greatest strength.



Laying out Spunstrand underground air-conditioning duct

maximizes clean air flow, eliminates rust and mold growth, and provides a more comfortable environment for building occupants.

As a member of the U.S. Green Building Council, the company has demonstrated how direct-bury, underslab duct eliminates concrete encasement, as well as extra soffit framing, Sheetrock®, and insulation because of improved energy efficiency. Round 19-3/4-, 18-3/4-, and 15-3/4-inch outside diameter (16-, 14-, and 12-inch interior diameter) green Spunstrand duct was specified for the Optimum Performance Home Theatre and rear-projection room air-conditioning application.

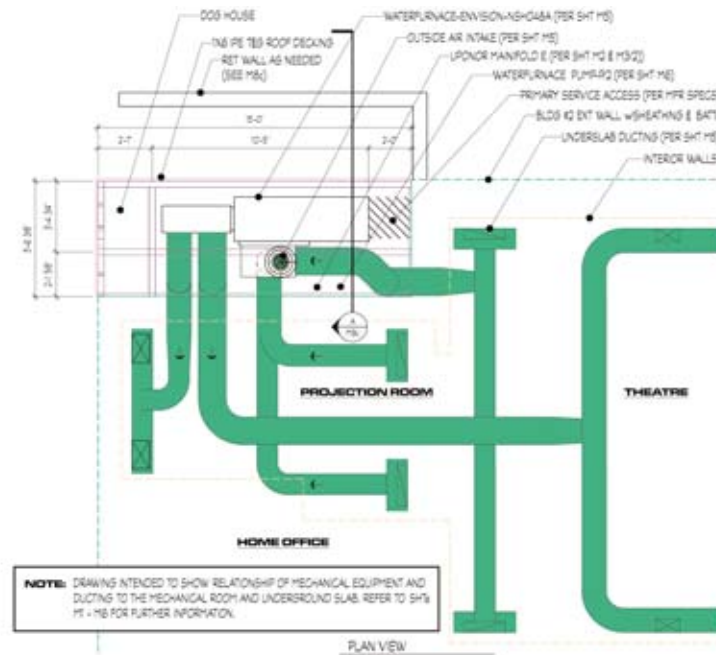
The Spunstrand duct system meets all aspects of the Uniform and International Mechanical Codes, carrying an ICBO (International Conference of Building Officials) approval to assure top-quality manufacturing for long-lasting duct, and achieves LEED rating points. Spunstrand fiberglass reinforced plastic duct (FRP) is rated Class 1 and code approved for direct underground burial. Spunstrand duct is manufactured using the filament-wound method, where continuous fiberglass strands are impregnated with resin and machine wound on a mandrel, which has first received a foil scrim kraft surface liner. Winding continues until the desired wall thickness is reached, and then the mandrel with the duct laminate is moved to a heated curing station where it is rotated until the resin is set. The approximate glass content of the filament-wound duct is 70 percent.

The internal surface liner provides the Class 1 rating for this product, while the fiberglass fibers furnish strength, dimensional stability, and temperature resistance. The type of resin is chosen to provide chemical and electrical resistance, color, finish hardness, and thermal properties.

The radiant floor portions of the five-inch-thick suspended concrete slab and under-slab insulation will be encased at the perimeters with the EnergyEdge® eight-inch Frame Building Rail (EE8fb). The PVC channel provides full-rigid insulation coverage from the top to bottom of an eight-inch slab edge to prevent radiant floor heat loss through the edges of the concrete slab. Below the EnergyEdge will be installed eight inches of two-inch-thick

R-Control Perform Guard EPS to satisfy California Title 24 insulation requirements for radiant floor slab edges.

Prior to the granular mixture fill, the placement of the DELTA-MS UNDERSLAB membrane, the R-Control Perform Guard EPS, and the Uponor AQUAPEX-encased suspended slab concrete pour, all the underground infrastructure for the home will be installed. This will include Uponor 1/2- and 3/4-inch red and blue pre-sleeved corrugated AQUAPEX tubing with outer Armacell® AP/Armaflex® pipe insulation, the NuTone® VX1000 central vacuum system, and the complex electrical and low-voltage wiring system encased in conduit. This work is underway and is expected to be completed by mid-June.



### EnergyEdge® Frame Building Rail



- The EnergyEdge Frame Building Rail (EE8fb) is designed to provide insulation at the radiant floor perimeters of the concrete slab. The PVC channel provides full-rigid insulation coverage from top to bottom of the slab edge to prevent radiant floor heat loss through the edges of the concrete slab.

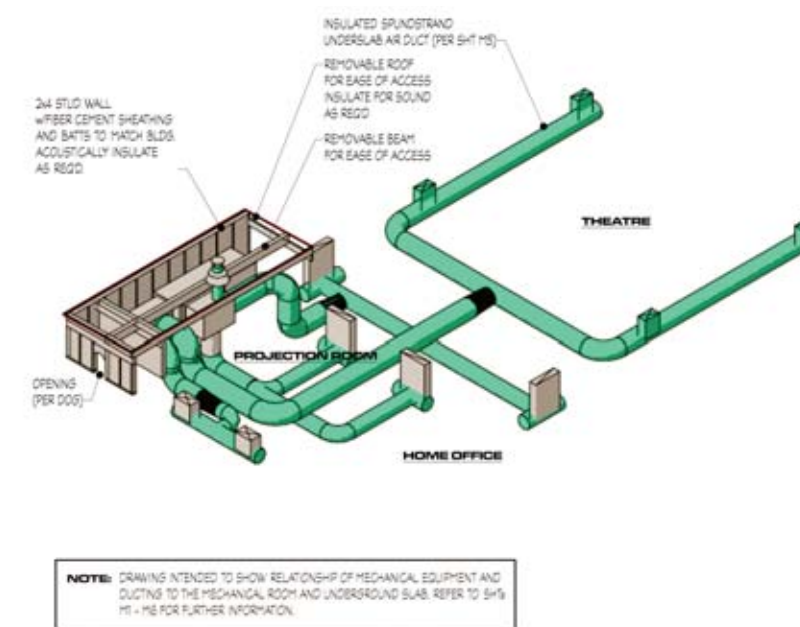


Forming wine cellar and retaining wall/planter

Uponor's red and blue high-density polyethylene (HDPE) corrugated pre-sleeved 1/2- and 3/4-inch AQUAPEX tubing provides protection for the installation in the soil and allows for easy removal and replacement of the tubing if required over time. In addition, the red and blue color-coded sleeves easily identify hot and cold water lines. PEX is a cross-linked polyethylene. PEX flexibility and strength at temperatures ranging from below freezing up to 200-degrees Fahrenheit makes it the ideal piping material for hot and cold water plumbing systems, trouble-free fire-sprinkler systems, and hydronic radiant floor-heating systems.

Armacell AP/Armaflex® pipe (tube) insulation will be wrapped over the Uponor AQUAPEX tubing to provide additional thermal insulation. The expanded closed-cell structure of AP/Armaflex pipe insulation makes it an efficient insulation for effectively reducing heat loss on the hot-water plumbing and heat gain on the cold-water plumbing systems. It is formaldehyde free, low VOCs, fiber free, dust free, and resists mold and mildew, and is made with Microban® antimicrobial product protection for added defense against mold on the insulation. When buried under the suspended slab, the pipe tubing will be channeled through crushed rock rather than through the soil to enhance long-term durability.

Jerry Moyles and his team at Mendocino Coast Plumbing are charged with the installation of the Uponor plumbing system and the



Wardflex® flexible corrugated stainless steel fuel gas tubing, which will supply propane to the KitchenAid® Architect Series® II dual-fuel 36-inch-wide range, the Wolf Range Company professional 36-inch-wide griddle, the Kohler® generator, and the Navien® tankless water heater.

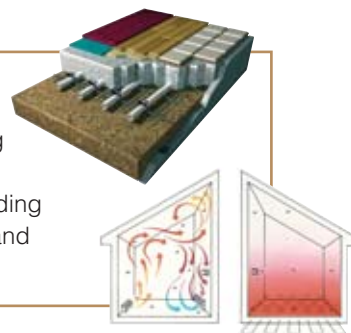
Wardflex corrugated stainless steel tubing (CSST) was selected, as it delivers more advantages over black steel pipe or ordinary CSST systems. Compared to either black steel pipe or other ordinary corrugated stainless steel tubing (CSST) systems, Wardflex delivers more performance and installation advantages. Using continuous flexible annular corrugated tubing made of 304 stainless steel, Wardflex installs without heavy carrying, threading, extensive measuring, or mess. The tubing is connected using special mechanical fittings. The continuous lengths and amazing flexibility of the fully annealed tubing greatly reduce the number of needed connections (and chances for leaks).

Roger Stevenson and his team at Stevenson Electric are charged with the complete installation of the elaborate and sophisticated electrical and low-voltage electronic systems infrastructure under the home and throughout the interior, including the extensive interfaces, fixtures, controls, and equipment and appliances powered by electricity.

Engineered Environments™ Randy Sterns, Brian Hodges, and Tim Johnson are consulting on the

### Uponor® Radiant Floors

- Warm water circulates under the floors throughout the Optimum Performance Home using Uponor's durable, flexible, and resilient cross-linked polyethylene AQUAPEX tubing, providing a comfortable, even heat without stirring up dust and pollutants.



### Uponor® Pre-Sleeved Corrugated AQUAPEX®

- Uponor® 1/2- and 3/4-inch red and blue high-density polyethylene (HDPE) pre-sleeved corrugated AQUAPEX® tubing is designed for durability and provides protection for installation in the soil and allows for easy removal over time.



### Armacell AP/Armaflex® Pipe Insulation

- The expanded closed-cell structure of Armacell AP/Armaflex pipe insulation makes it an efficient insulation for effectively reducing heat loss on the hot-water plumbing and heat gain on the cold-water plumbing systems.



### Wardflex® Flexible Fuel Gas Tubing

- Wardflex® is the gas piping system for the 21st Century with the highest overall-rated flow capacity in the industry. Wardflex is recognized as the "system of choice" by major gas utility companies.



### NuTone® Central Vacuum System

- A NuTone® Central Vacuum System will be featured in the home to help maintain healthy interior air quality. NuTone's central vacuum power units feature a space-saving sleek oval-shape design, internal sound suppression system, and a status light on the hose handle and power unit, which indicates when the VX™ unit's bag or canister is full and needs emptying.



### Bora-Care®

- Nisus Corporation's Bora-Care® is a primary termite barrier pre-treatment that creates a continuous barrier that termites cannot cross, eliminating their food source.



electronic systems design and installation of the home's low-voltage infrastructure and technologies.

Engineered Environments is recognized as one of the premiere residential electronic systems firms nationally, providing custom-integrated systems for discerning clientele who appreciate the benefits of properly applied new electronic technologies. Each year, the Custom Electronics Design & Installation Association (CEDIA) presents awards to winning entries submitted from its 3,000 members. The selection process is rigorous, with the judging panel made up of electronic systems contractors and American Society of Interior Designers (ASID) and American Institute of Architects (AIA) representatives. Engineered Environments' track record of winning top awards has spanned each of the past five years.

Stevenson Electric also will install the NuTone central vacuum system. The NuTone 1,040 watt cyclonic central vacuum power unit features HEPA-rated filtration, Microban protection, and Teflon antistick technology.

A three-inch filtered underground water line will be installed to serve as a surplus supply of water available from the pond. A standard 2-1/2-inch value red-painted standpipe hydrant with a male National Hose fire-thread fitting will be located at the driveway entrance at the front of the property, to which a fire hose can be connected.

Following the curing of the concrete slab, Nisus Corporation's Bora-Care® will be applied directly to the finished surface slab as a primary termite barrier pre-treatment. Bora-Care creates a continuous barrier that termites cannot cross and eliminates their food source.

The next installment in this series of case-study articles will cover the actual work being done to accomplish the tasks described, as well as the start of the above-slab Amvic ICF wall construction. In the meantime, photos will

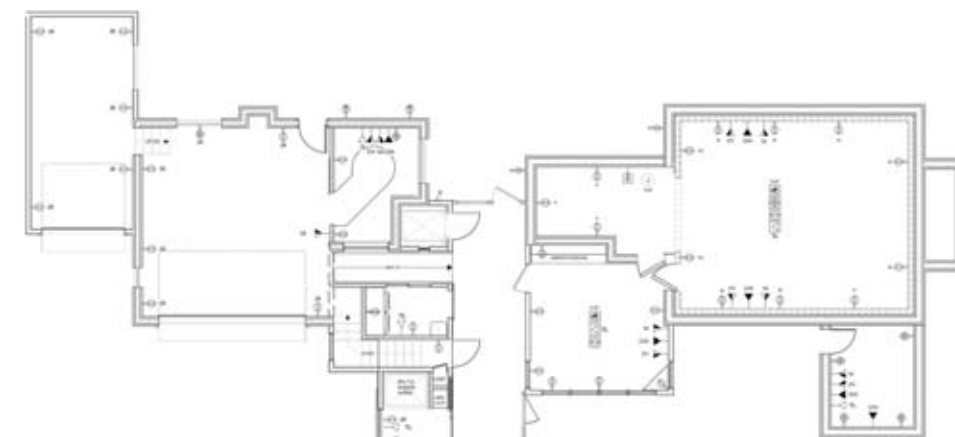


FLOOR PLAN - UPPER

ELECTRICAL SYMBOL LEGEND

○	120V/20A
○	120V/15A
○	120V/10A
○	120V/5A
○	240V/20A
○	240V/15A
○	240V/10A
○	240V/5A
○	120V/20A
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○	240V/20A
○	240V/15A
○	240V/10A
○	240V/5A

Electrical Plan (top);  
Low-voltage  
below-slab  
infrastructure plan  
(bottom)



FLOOR PLAN - LOWER



be posted on the *Ultimate Home Design* Web site ([www.ultimatehome.com/oph.php](http://www.ultimatehome.com/oph.php)), depicting progress in the construction of the first Optimum Performance Home.

### Design Concept

As previously noted in this series, the home design integrates all of the concepts advocated in *Ultimate Home Design*. The goal is to demonstrate how modern building products and methods can make life safer, more comfortable, and more enjoyable. The science of optimum performance homes concerns itself with building structures that use less energy, are quieter and more comfortable, have fewer problems with material degradation, provide clean air and water, and do less damage to the environment. As an integrated and holistic design, the house will serve as a permanent

residence that allows its occupants to age in place.

The high-performance building systems to be employed are designed to exceed California building code requirements and resist natural disasters more effectively than a code-minimum house, even with the new California code requirements that require use of non-combustible or fire ignition-resistant building materials. Constructed with stronger building materials and superior techniques, the home will be safer, allowing homeowners greater peace of mind. The

Optimum Performance Home qualifies for the Fortified...For Safer Living® program of the Institute for Business & Home Safety ([www.ibhs.org/business\\_protection](http://www.ibhs.org/business_protection)). This program specifies construction,





Zurn® Flo-Thru Trench Drain

• The modular Zurn® molded-slop Flo-Thru trench drain is designed for load-bearing strength, hydraulics, chemical resistance, and structural integrity.



design, and landscaping guidelines to increase a new home's resistance to natural disaster.

In addition, the home will meet the guidelines and qualifications for the U.S. Department of Environmental Protection's ENERGY STAR®, the EPA's (Environmental Protection Agency) WaterSense™, and the American Lung Association® Health House® programs. It also will meet the requirements of the National Association of Home Builders' (NAHB) National Green Building Standard, the Sustainable Buildings Industry Council (SBIC) Green Building Guidelines, and the "Green Points" program. Sonoma County and The Sea Ranch Association are now considering this program for adoption.

Furthermore, the home's design was the subject of a case study analysis presentation before the Custom Residential Architects Network (CRAN), Full Spectrum Practice Convention of the American Institute of Architects on October 20, 2007 in Chicago, Illinois.

The home is also a case study of the California Energy Commission in terms of energy-efficiency applications and an advanced water-saving plumbing plan.

Finally, the home is a national showcase for CEDIA, and is the subject of a series of articles on the design and installation of the electronic lifestyle components in the home. These articles are featured in CEDIA's *Electronic Lifestyles*® quarterly magazine.

**The Setting**

The Sea Ranch is an internationally renowned 5,000-acre environmentally protective residential development situated within a pastoral and forested coastal enclave and nature preserve approximately 110 miles north of San Francisco, California. This stunning development, now celebrating its 43rd anniversary, straddles a ten-mile stretch of Highway 1 along a uniquely beautiful rugged coastline, ending at

the northern tip of Sonoma County and the south bank of the Gualala River.

The Sea Ranch is widely regarded as a unique and remarkable residential development. During the 1960s and 1970s, The Sea Ranch was at the forefront of environmentally responsible development. It was conceived and designed by architects and landscape architects who wanted to provide a harmonious mixture of custom homes and pristine natural Northern California landscape in oceanfront, meadow, and forest environments. In fact, The Sea Ranch concept and its architecture are recognized in schools of architecture around the world, and it is frequently used for case studies in environmental and architectural design. The first condominium complex to be built on the southern coastal bluffs of The Sea Ranch is now a registered national architectural site.

Single-family development occupies approximately 2,500 acres without borderline fences or other visible delineation of property lines. The remaining acres are permanent green-scape commons with 45 miles of nature trails for walkers, bicyclists, and equestrians. Each home is custom designed by an architect/architectural designer following site-specific design guidelines and is situated off a private road network without curbs, sidewalks, or streetlights. The Sea Ranch is a very unique residential development woven into a tapestry of buildings and nature and committed to environmental preservation. The development includes 2,288 lots for single-family custom homes, with 529 remaining to be developed (1,735 already developed and 24 under construction).

The Sea Ranch is managed by The Sea Ranch Association, a Common Interest Development (CID) with an elected volunteer Board of Directors, and supported by numerous volunteer committees. All development on The Sea Ranch is subject to design review



Four perspective views of the Optimum Performance Home at The Sea Ranch

and the approval of a Board-appointed autonomous Design Committee. The Design Committee is presently comprised of architects and landscape architects, though it does not include anyone with experience in vegetation management or "green" sustainable building design. A legal set of Covenants, Conditions, and Restrictions (CC&Rs) govern the development and are designed to protect The Sea Ranch concept.

**The Home**

The Sea Ranch Design Committee imposes upon designers architectural building blocks derived from the original rural structures found on the northern California coast. Designers are expected to apply their creativity to render various arrangements and deviations to arrive at a custom solution that specifically responds to the site. Successful proposals submitted to the Design Committee address the issues of passive solar positioning, wind, glazing (window) layout, privacy between neighbors, vegetation protection, view preservation, topography and grade changes, roof slopes, appropriate exterior materials and finishes, and other exterior design considerations—all within the building and site design.

A focus of the Optimum Performance Home's design is to stand as a showcase for the "green" movement and demonstrate means of reducing a home's impact on the planet through the use of Low-Impact Development and environmentally responsible and sustainable building materials. It is hoped that the home will become a case study for a "Green Points Program" suited to the scale of The Sea Ranch.

The home's 3,272-square-foot living space (4,441-square-foot total building "footprint," including garages, covered walkways, courtyard, and decks) will be arranged in a three-building

compound using a well-sealed, well-insulated, super-tight building envelope that reduces temperature fluctuations and enhances overall energy efficiency. This arrangement provides for an alcove courtyard protected from the prevailing wind from the northwest. The home is designed with differing spatial experiences throughout to encourage exploration. The home will display innovative interior design and be furnished in a contemporary Frank Lloyd Wright style appropriate to its dimensions. The home design connects the indoors and the outdoors with covered walkways, a courtyard, decks, and a garden to expand livable space, without requiring heating or air conditioning. The home is designed in accordance with biophilic design principles with abundant and excellent use of natural light and natural indigenous landscaping planned. {For an in-depth analysis of the biophilic attributes of the home, please read "Biophilic Design," "Biophilic Design Attributes," and "The Interior Design Process, Part I: Synthesizing Sustainability, Universal Design, And Technology" authored by Julie Stewart-Pollack in Issue 3 (May/June 2006), Issue 4 (July/August 2006), and Issue 10 (July/August 2007), respectively.}

The main-floor living area is designed to accommodate the capabilities of all occupants without any challenging physical barriers, even for the elderly and disabled. The home design features a ground-level open plan for the living room, dining room, master bedroom suite, and spacious kitchen with solarium, exhibition cooktops, and home management system.

The second building in the compound is designed to accommodate a large state-of-the-art Optimum Performance Home Theatre with integrated rear-screen projection room and a home office.

The third building will include a two-car and boat garage, workshop, main-level guest bathroom, and laundry room. The second level of this building will have two guest bedrooms, a bathroom, and a dedicated library/home theatre/surround music room distinguished by a high-tower feature. To insure universal access to this floor, the design provides for an Otis® Gen2 residential elevator.

The entrance and walkways that connect the three buildings and the solarium will be enclosed with insulated- and solar gain-reduced-tempered glass. There will be a seating area at the vestibule entrance to the home. The main entrance vestibule will serve as an oversized mudroom. The driveway, area around the garage, guest parking, and entrance to the home—as well as all paths—are designed in

accordance with The Sea Ranch guidelines governing exterior hard-surfaced paths. All such surfaces are pervious to virtually eliminate water runoff. The surface will be packed with decorative crushed rock to enhance the natural appearance of the home's setting. There also will be a dedicated equipment room off the courtyard, which accommodates the Uponor and WaterFurnace radiant-heating apparatus, TrendSetter® solar hot water storage tanks, Navien's 98 percent condensing on-demand propane-fired tankless water heater, and other equipment. The backup Kohler® generator is housed within a separate weather-resistant tower located off the north wall of the two-car garage and guest bedroom, within the fenced dog run. This tower is designed to optimize the northwest wind performance of the PacWind® Seahawk® vertical-axis Savarrius™ wind turbine disguised within (see Part XII, November/December, Issue 12).

The home site is nestled on an almost-acre parcel at the edge of a forested area of the southern section overlooking the Pacific Ocean, offering distant water views. Some of the home's features will include a Benissimo® slate-floor outdoor courtyard, two thick solid hardwood Ipé deck areas, in-ground Dimension One Spa® Amoré Bay hot tub, Finnello® Finnish sauna, and underground wine cellar. The orientation of the home on the site is designed to take advantage of natural lighting and passive solar heating and cooling. Good site and land planning will result in minimal land disturbance and preservation of natural features and environments.

Landscaping will consist of The Sea Ranch-approved indigenous vegetation with low-water requirements and unique water conservation features, including two ponds and a stream supported by rainwater catchment and captured runoff. Site grading has been specifically planned to enhance the project's placement in the watershed, and the design incorporates the principles of Low Impact Development to minimize runoff from impervious surfaces and mimic the natural hydrology in overall effect. The resultant water harvesting will then minimize the use of irrigation, and the increased infiltration and retention will passively support the native landscape. Additionally, a gray water system will be used for undersurface plant irrigation.

## Next

With site preparation and foundation construction well underway, this continuing series of articles will focus on the design elements as they pertain to each stage of construction as the project progresses, and will include coverage of the technologies and building systems and the materials used and applied to construct the first Optimum Performance Home. **UHD**

## The Author

Gary Reber is the President of Ultimate Home Design, Inc. and the founding Editor-In-Chief and Publisher of *Ultimate Home Design*®, The Optimum Performance Design & Build Resource For Environmentally Enhanced Lifestyle Living™. He is also President of WSR Publishing, Inc. which publishes *Widescreen Review*®, The Essential Home Theatre Resource™. His diverse background in several fields includes an undergraduate, graduate, and postgraduate university education in architecture, community planning, and economic development planning. For the past 15 years he has been an editor and publisher of magazines in the consumer electronics and architectural fields. Gary can be reached at 951 676 4914 or [gary@ultimatehomedesign.com](mailto:gary@ultimatehomedesign.com).

## Product And Contact Information

- AFM Corporation, R-Control, 211 River Ridge Circle, Suite 102A, Burnsville, Minnesota 55337, 952 474 0809, [www.r-control.com](http://www.r-control.com)
- Amvic, Inc., 501 McNicoll Avenue, Toronto Ontario Canada M2H 2E2, 416 410 5674, [www.amvicsystem.com](http://www.amvicsystem.com)
- Aqua Harvest International, 3628 Greystone Ridge Court, Rio Rancho, New Mexico 87124, 505 975 5008, [www.aquaharvestonline.com](http://www.aquaharvestonline.com)
- Armacell LLC, 7600 Oakwood Street Extension, Mebane, North Carolina 27302, 800 866 5638, [www.armacell.com](http://www.armacell.com)
- Bartlett Mechanical Services, 6755 Oak Street, Anderson, California 96007, 408 313 2486, [www.bartlettmechanical.com](http://www.bartlettmechanical.com)
- Bed Rock Concrete Pumping, P.O. Box 503, Point Arena, California 95468, 707 882 2637
- Bed Rock Products, Inc., 135 Hay Parkway, Point Arena, California 95468, 707 882 2323
- Bill Wilson Environmental Planning & Design, LLC, 71 Del Casa Drive, Mill Valley, California 94941, 415 383 2919, 805 689 7639
- Broan-NuTone, 926 West State Street, Hartford, Wisconsin 53027, 800 548 0790, [www.nutone.com](http://www.nutone.com)
- California Portland Cement Company, 2025 East Financial Way, Glendora, California 91741, 800 272 9119, [www.calportland.com](http://www.calportland.com)
- Conti Materials, P.O. Box 30248, Stockton, California 95213, 209 467 0626, [www.contimaterials.com](http://www.contimaterials.com)
- Cosella-Dörken Products, Inc., 4655 Delta Way, Beamsville, Ontario, Canada L0R 1B4, 905 563 3255, [www.cosella-dorcken.com](http://www.cosella-dorcken.com)
- EchoStar DISH Network, 9601 South Meridian Boulevard, Englewood, Colorado 80112, 888 825 2557, [www.dishnetwork.com](http://www.dishnetwork.com)
- Energy Edge, 7701 East Kellogg, Suite 722,

- Wichita, Kansas 67207, 316 618 1983, [www.energyedgeform.com](http://www.energyedgeform.com)
- Engineered Environments, 1250 Marina Village Parkway, Alameda, CA 94501, 510 521 7500, [www.engineeredenvironments.com](http://www.engineeredenvironments.com)
- Euclid Chemical Company, 19218 Redwood Road, Cleveland, Ohio 44110, 800 321 7628, [www.euclidchemical.com](http://www.euclidchemical.com)
- Feeney Construction, 14660 McCourtney Road, Grass Valley, California 95945, 530 477 7647, 707 884 9458
- FORTA Corporation, 100 Forta Drive, Grove City, Pennsylvania 16127-6399, 800 245 0306, [www.fortacorp.com](http://www.fortacorp.com)
- GetWireless LLC, 10901 Red Circle Drive, Suite 325, Minnetonka, Minnesota 55343, 800 990 9025, [www.getwirelessllc.com](http://www.getwirelessllc.com)
- Hacker Industries, Inc., 610 Newport Center Drive, Suite 250, Newport Beach, California 92660, 800 642 3455, [www.hackerindustries.com](http://www.hackerindustries.com)
- Headwaters Resources, 10653 South River Front Parkway, Suite 300, South Jordan, Utah 84095, 888 236 6236, [www.flyash.com](http://www.flyash.com)
- iBeam Systems, Inc., 280 North 8th Street, Suite 30, Boise, Idaho 83702, 800 403 0688, [www.ibeamsystems.com](http://www.ibeamsystems.com)
- Kryton Canada Corporation, 8280 Ross Street, Vancouver, B.C., Canada V5X 4C6, 604 324 8280, [www.kryton.com](http://www.kryton.com)
- Mendocino Coast Plumbing, P.O. Box 41, Manchester, California 95459, 707 882 2628, 707 353 2628.
- Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077, 847 966 6200, [www.cement.org](http://www.cement.org)
- Seepage Control, 7301 West Boston Street, Chandler, Arizona 85226, 800 214 9640, [www.seepagecontrol.com](http://www.seepagecontrol.com)
- Smart Drain, Drawer 2219, Columbia, Maryland 21045, 800 638 8582, [www.smartdrain.com](http://www.smartdrain.com)
- Sonoma County Builders, Inc., 6280 Old Redwood Highway, Santa Rosa, California 95403, 707 837 2997 / P.O. Box 244, Point Arena, California 95468, 707 684 9144
- Spunstrand Incorporated, 620 North Post Street, Post Falls, Idaho 83854, 208 665 7444, [www.spunstrand.com](http://www.spunstrand.com)
- Steve Glaze Backhoe, 2766 Parkview Drive, Lakeport, California 95453, 707 263 3055
- Steve Michelson Productions, Lobitos Creek Ranch, 2800 Lobitos Creek Road, Half Moon Bay, California 94019-2547, 650 726 2460, [www.lobitoscreekranch.com](http://www.lobitoscreekranch.com)
- Stevenson Electric, 1340 Highway 4, P.O. Box 2642, Arnold, California 95223, 209 768 2100
- StormTech, 20 Beaver Road, Suite 104, Wethersfield, Connecticut 06109, 888 892 2694,

- [www.stormtech.com](http://www.stormtech.com)
- Stormwater Solutions, LLC, 3940 Laurel Canyon Boulevard, Suite 856, Studio City, California 91604, 866 786 7690, [www.stormh2osolutions.com](http://www.stormh2osolutions.com)
- ThermaSAVE/IHSN, Inc, 4002 Helton Drive, Florence, Alabama 35630, 256 766 3378, [www.thermapanel.net](http://www.thermapanel.net)
- Uponor North America, 5925 148th Street West, Apple Valley, Minnesota 55254, 800 321 4739, [www.uponor-usa.com](http://www.uponor-usa.com)
- Wardflex, 2085 West Avenue 140th, San Leandro, California 94577, 415 971 1531
- WaterFurnace International, Inc., 9000 Conservation Way, Fort Wayne, Indiana 46809, 800 222 5667, [www.waterfurnace.com](http://www.waterfurnace.com), [www.stormh2osolutions.com](http://www.stormh2osolutions.com)
- Weeks Drilling & Pump Company, 6100 Highway 12, Sebastopol, California 95472, 707 823 3184, [www.weeksdrilling.com](http://www.weeksdrilling.com)
- WildBlue Communications, Inc., Greenwood Corporate Plaza, Building. 1, 5970 Greenwood Plaza Boulevard., Suite 300, Greenwood Village, Colorado 80111, 866 945 3258, [www.wildblue.com](http://www.wildblue.com)
- Wonderwater, P.O. Box 1510, Mt. Shasta, California 96067, 530 926 5050, 530 925 2586, [www.wonderwater.net](http://www.wonderwater.net)
- Zurn Flo-Thru Operation, 116 Molly Rex Lane, Mooresville, North Carolina 28117, 704 799 7087, [www.zurn.com](http://www.zurn.com)

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