# BOULDER COMMUNITY FOOTHILLS HOSPITAL

BOULDER, COLORADO

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From site planning to artwork, Boulder Community Foothills Hospital offers a nurturing environment that promotes healing and sets a benchmark for sustainable healthcare design. The 154,000-square-foot facility is complemented by a 67,000 square foot outpatient services building and sits on a 49-acre site. Master planned for 400,000 square feet, the campus will eventually occupy 17 acres. The remaining 32 acres have been dedicated to the City as permanent open space. With sustainability as a primary guiding design principle, the resulting building improves environmental quality and human health through thoughtful design and construction practices.

Boulder Community Foothills Hospital is designed to reduce stress and maximize patient comfort. Private rooms offer patients control over all aspects of their environment including room temperature, natural and electric lighting levels, nourishment, privacy and views. Large windows overlooking foothills, creeks and Cottonwood trees provide a connection to nature. All patients have the option for a guest to stay comfortably in their room overnight, emphasizing the value of family support in the healing process.

BOULDER ASSOCIATES

ARCHITECTS

## PROJECT INFORMATION

### Client

- Boulder Community Hospital

### Scope

- 221,000 s.f.

### First Patient

- August 2003

### Cost

- $52 million

### Architecture:

- Boulder Associates and OZ Architecture

### Interior Design:

- Boulder Associates and OZ Architecture

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Parents of infants in neo-natal intensive care are offered adjoining rooms, where they can be next to their children and participate in their care until the infant is ready to go home. Lighting in the NICU baby rooms provides several options. It can increase and decrease over the course of the day to help develop circadian rhythms, be set to approximate the conditions of the womb, or allow close examination. These and other provisions for a healthy and comfortable family-centered setting are expected to improve patient outcomes, reduce stays, and help to optimize use of the building.

Creating a sense of richness and community was an important design consideration that manifested itself in several ways. All of the artwork exhibited within the facility is that of a Boulder County artist. In addition to the professional work, an employee-crafted tile mural enlivens the wall of the surgery waiting area, strings of origami cranes made by local schoolchildren brighten the pediatric unit, and handmade quilts adorn the walls of the NICU and Pediatric Patient Rooms. "Camp Hestanove" greets the children with friendly porch-like entryways, hand-painted murals and twinkle-stars. "Hestanove" is the Cheyenne equivalent of "community," the tribe which historically called this area of the country their home.

Recognizing that the health of our citizens is indelibly tied to the health of our planet, the use of environmentally responsible materials was a high priority for the project. The face brick, sandstone and concrete which make up the facilities' façade and frame were all harvested and manufactured locally, as were the gypsum board wall panels. Even the flyash which was substituted for cement in the concrete was obtained from a local power plant. The building also utilized an extremely high percentage of recycled content materials. All adhesives, sealants, paints, coatings, stains, carpet, casework and insulation are low-emitting materials. Furthermore, sixty-four percent of all jobsite construction waste was recycled, and designated collection rooms within the building will continue to help keep recyclable materials out of the landfill.

## SUSTAINABLE HIGHLIGHTS

### Site

- 54% Water savings for irrigation
- Covered bus stop and bike racks
- Cool Roof
- Stormwater treatment
- Exemplary encouragement of alternative transportation

### Water

- Waterless urinals
- Electric eye faucets in public spaces
- Low-flow faucets in patient spaces

### Energy

- 30% Energy savings over ASHRAE
- Mansard overhangs and trellised walkways
- Window / VAV interlocks

### Materials

- 62% Construction waste recycled
- 16% Recycled content materials
- 52% Locally manufactured materials
- 30% Locally harvested materials
- Rapidly renewable linoleum flooring

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Capital investment in a central utility plant is rare for a project of this size, but energy efficiency concerns as well as plans for future build-out of the site drove the decision to install the plant. Analysis of the $1.3 million investment showed a payback period of 12 years, even if no other buildings are constructed. Careful planning resulted in a system that allows new medical buildings and mechanical units to be simply "plugged-in" without physically increasing the size of the plant or having to duplicate distribution. All occupied spaces have sufficient plumbing, medical gas and HVAC to meet continuing changes in healthcare requirements. Valves and dampers were placed to easily isolate areas for remodeling or repair. Minimizing replacement and/or restructuring of systems reduces operations and maintenance costs as well as disruption of service, downtime, and resource depletion.

Water is a precious resource in this semi-arid climate, yet it is often squandered. The Boulder Community Hospital site was designed to illustrate that low-water landscape design can be beautiful. By emphasizing the use of native and adapted plants, the design for the campus is expected to save 50 percent over typical Colorado irrigation water usage.

NICU Floor Plan

**Strategies Employed**

**Maintain site biodiversity:**

Studies showed no evidence of endangered species but the site has historically housed a sizeable prairie dog colony, an animal whose numbers have decreased by 98% since 1900. Other species dependant on prairie dogs and the habitat they create include the black-footed ferret, mountain plover, burrowing owl, ferruginous hawk, golden eagle, horned lark, deer mouse, and grasshopper mouse. The colony was carefully protected and separated from the hospital by a specially constructed double fence designed to keep the animals in the 32 acres of dedicated open space and off of the hospital grounds.

## SUSTAINABLE HIGHLIGHTS (CONT.)

### Indoor Environmental Quality

- Urea formaldehyde-free MDF casework
- 2-week building flush-out
- Low-VOC wood stains, paints and adhesives
- Formaldehyde-free insulation

### Additional Features:

- 100% of artwork from local artists

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**Reduce stormwater run-off:**

In an effort to reduce stormwater run-off, the building footprint was minimized by designing efficient circulation routes and by maximizing the number of stories wherever the program allowed. The small one-story portion was structured for future vertical expansion. Nominal parking, grass-pave fire lanes, and future parking decks will further minimize stormwater run-off, as well as heat island effect. All stormwater is treated to reduce contaminants prior to leaving the site via constructed wetland.

**Encourage alternative transportation:**

The project is located along several bus routes, and two new bus stops were provided for employees, patients, and visitors. Signed carpool spaces encourage employees to share a ride, and bike racks, showers and changing facilities encourage employees to bike or walk to work. The site is linked to an existing City of Boulder bike path located along Boulder Creek. Paved parking surfaces were reduced accordingly to 25 percent below City requirements, via deferred parking waiver.

**Reduce water usage:**

In addition to low water-use plantings, the project incorporates waterless urinals and electric eye faucets in public toilet rooms, and low-flow faucets in clinical areas.

## AWARDS

**American Institute of Architecture Colorado North Chapter Honor Award 2004**

**The Center for Health Design Medquest Communications LLC Contract Magazine – Healthcare Environment Awards Competition 2004**

**2004 Excellence in Design Award – Environmental Design + Construction Magazine**

**American Society of Healthcare Engineers: Vista Award for Sustainable Design**

**ASID Colorado 2004 Sustainable Design - Commercial**

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**Ensure good indoor air quality:**

Low-VOC and formaldehyde-free products were teamed with a construction air quality management plan and two-and-a-half week building flush-out period to provide enhanced indoor air quality for all who use this non-smoking facility. A minimum of 95 percent air filtration was provided throughout. Demand ventilation maintains $CO_2$ at acceptable levels in the building and will help identify any malfunctions of the system. All intakes are remote from vehicular traffic and optimized to mitigate re-circulation of contaminants. Positive building pressurization is used to eliminate infiltration. The air diffusion performance index was applied for maximum air mixing within occupied spaces. Central station double-wall air handlers with walk-in access promote routine disinfection of the cooling coil drain pan and other interior surfaces. Materials and ducts were protected from contamination during the construction process. SMACNA IAQ Guidelines for Occupied Buildings Under Construction, 1995, and ASHRAE 52.2-1999 were followed.

**Optimize energy performance:**

The central utility plant houses equipment that is significantly more energy efficient and less expensive to maintain than that required for a decentralized system, including variable speed high-efficiency chillers and high-efficiency part load low NOx boilers. Other energy-efficient features include:

- white Energy Star™ roofs with R-30 insulation
- shading devices
- low-E glazing
- revolving doors
- roller shades
- daylighting and daylight sensors
- occupancy sensors
- high-efficiency fans and fan motors
- variable speed pumps
- variable supply and return fan controls
- fans that operate at lower static pressure than req'd by ASHRAE
- outside air economizers
- demand ventilation with $CO_2$ detectors
- operable windows interlock to VAV system
- direct gas-fired dryers
- high ADPI (Air Diffusion Performance Index) devices
- high-efficiency lighting controls
- multiple lighting levels
- zoning of the mechanical system allowing for localized control

**Ensure actualization of design intent:**

The building was fully commissioned by a third party commissioning agent, and re-commissioned after one year in use.

The design of Boulder Community Foothills Hospital was an integrated team effort. Architects, urban planners, landscape architects, mechanical engineers, electrical engineers, energy consultants, facilities staff, administrators, and contractors were brought together weekly during the design process to suggest and review options and to make decisions as a team. User group representatives were assigned to assist with the design of each department, and neighborhood meetings and patient focus groups brought community input to the table. During this process interrelationships between systems and strategies were identified that worked together to improve the overall design.

Natural lighting, views, and wayfinding requirements in public spaces were elements that found common ground early on. Many large institutions suffer from poor circulation, compounded by years of additions and relocations within the building. A short circulation spine that provides waiting areas and access to each of the departments was developed to be the permanent major circulation vehicle within the hospital. It connects the hospital to the outpatient services building and is planned to extend with the addition of any future service lines or additional medical office space. Located on the western side of the building and wrapping three sides of an open-ended courtyard, this element provides continuous views of the nearby foothills. A secondary circulation path connecting the front lobby to the emergency department is located along a glazed walkway that faces the main parking lot and major arterial. Views to familiar landmarks allow local residents to easily orient themselves.

Mansard overhangs were originally conceived to enhance the aesthetics of the building. Further study optimized their size and opacity, allowing them to fully shade the third-story windows from the summer sun. When cost implications required a reduction of the mansards, those located on the south and west sides were retained. These two facades benefit most from solar shading and are also the most visible from major view angles.

Encouraging alternative transportation and reducing storm water run-off worked hand-in-hand. Accessibility to bus service, carpooling spaces and bike racks enabled a reduction in the number of parking spaces to 25 percent below the City requirement. This, in turn, reduced the amount of impermeable surface on the site, which reduced stormwater run-off by 25 percent for parking areas.

**Qualitative and Quantitative results**

Energy savings were determined utilizing DOE-2 software. The building was compared to a theoretical structure that minimally meets ASHRAE/IESNA Standard 90.1-1999 but was of the same building massing, orientation, and mechanical system. The structure was determined to use 28 percent less energy than the ASHRAE compliant baseline.

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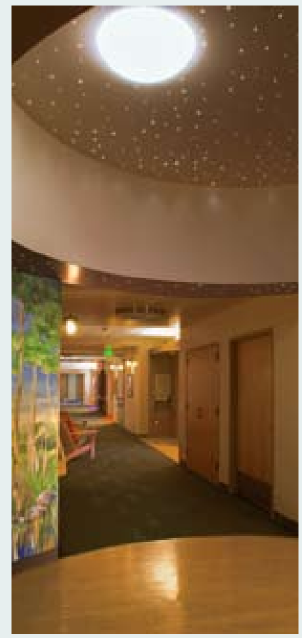
**Careful selection of equipment provided impressive operational savings:**

- Variable speed chillers will save 25 percent in annual chiller operating costs over constant speed chillers.

- Demand ventilation combined with an outside air economizer optimizes the maximum outdoor air capability while minimizing energy consumption. This provides more hours of increased ventilation with greater occupant comfort, without suffering an energy penalty. The local climate averages more than 4000 hours annually where low dry bulb and wet bulb conditions allow an airside economizer cycle, effectively providing "free cooling". A waterside economizer, or flat plate heat exchanger, also takes advantage of the local climatic wet bulb conditions.

- Variable speed pumping was used throughout for chilled water, condenser water, boiler feedwater and building heating hot water systems. Variable frequency drives were also used for building supply and return air fans, as well as for the cooling tower fans. These devices provide demand-driven energy consumption. With the extensive use of VFDs, energy consumed is equal to the required load, whereas traditional systems would consume the same fan or pump energy regardless of the demand. Energy-efficient variable speed pumps will provide a payback period of less than two years.
- Direct gas-fired dryers are 20 percent more efficient than steam dryers.

- Selected boilers reduce energy fuel consumption by 20 percent over standard boilers.



**Pollution reduction was also achieved:**

- Selected boilers and chillers have high efficiencies at all load conditions, providing a significant reduction in $CO_2$ production.

- A waterside economizer, or flat plate heat exchanger, reduces $CO_2$ production and chiller run time, translating to reduced chemical water treatment and water consumption at the cooling towers.

- High-efficiency partial load low-$NO_x$ boilers reduce annual $NO_x$ emissions by 70 percent, CO by 50 percent, and energy fuel consumption by 20 percent over standard boilers. This $NO_x$ level is 70 percent lower than standard boiler burner equipment.

- Variable supply and return fan controls reduce $CO_2$ emissions by 5.5 million lbs/year, $SO_2$ by 8.3 million gm/year and $NO_x$ by 8.1 million gm/year. They provide a payback period of less than 1 year.

**Providing for long equipment service life was another strategy:**

- Centralized equipment is constructed to last for over 25 years.
- Piping, insulation and ductwork materials are suitable for 50 years of service.
- All mechanical equipment can be readily serviced and maintained via full size stairways, encouraging improved and repeatable maintenance which in turn increases usable life.
- An acoustical report was completed by an acoustical engineer. All recommendations were followed with respect to the mechanical, plumbing and architectural systems and will help to improve the indoor environment for patients and staff alike. Selection of air devices with a high ADPI (air diffusion performance index) will also improve occupant comfort.
- Calculated for materials categorized in division 3-10 by the Construction Specifications Institute, the building contains a minimum aggregate weighted average of 16 percent post-consumer or 32 percent post-industrial recycled content material.
- Calculated similarly to above, 55% of all the building materials were manufactured locally, and 33% were both harvested and manufactured within a 500-mile radius.
- Careful documentation of construction waste removal on the site revealed that 64 percent of all jobsite construction waste was recycled.
- Analysis also showed that water consumption for irrigation was reduced by over 50 percent as compared to a typical design. Savings will be realized every year after two years, when plantings have had a chance to establish.

### Obstacles and Benefits

**Obstacles:**

Several obstacles were encountered during the design process which kept the team from more fully achieving their goals.

Three of these obstacles were the owner's non-profit status, the lack of incentives from the local utility, and low energy costs in Colorado. Attempts to incorporate photovoltaic panels on the project were derailed due to the inability to show any reasonable timeframe for payback on the system. Had a tax credit (as may be available to for-profit organizations) or utility incentive been available to offset the costs of the system, the payback period would have been significantly reduced. Higher energy costs would also have reduced the payback period.

Water rights issues severely impacted the ability to reuse water on the site. In Colorado, water rights are based on the doctrine of prior appropriation. Under this doctrine a property owner does not own water that rains, snows or flows across or adjacent to their property. Among other things, it is therefore illegal to harvest rainwater and store it for any purpose. Graywater use is also severely restricted, as water is provided by the utilities for one use only. Concerns surrounding infection control and evaporation severely affect policy. A special permit and/or water courts decree may be necessary in order to legally use rainwater or graywater for any purpose, including subsurface irrigation systems.

Another obstacle was upfront costs. The payback period and space required for ice storage made this type of system impractical. Solar hot water was studied and proven to be feasible for this project, however costs for providing this system and upgrading the structure to support it caused it to be ruled out. Surface parking was provided for phase one in lieu of structured parking due to financial impact. Structured parking is part of the master plan, and will eventually help to minimize stormwater run-off from the site.

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**Benefits:**

The owner and the project team have led by example with this project, and are encouraging others to build more sustainably. Marketing efforts have raised the awareness of the local as well as national and international community, and the project has become a benchmark for hospitals across the continent.

The new hospital will provide a healthier space for patients, visitors, and staff. Attributes provided by sustainable design efforts such as natural lighting and enhanced indoor air quality have helped to attract nursing staff during the current nationwide nursing shortage, and may reduce absenteeism and improve patient outcomes.

The facility is easier to maintain, remodel and expand. Service interruptions for repair, replacement or expansion should be reduced. Energy and water bills have been minimized, freeing up more capital for other uses.

Finally, Boulder Community Hospital is known as a good corporate citizen, and this project stands to raise their social capital within the community. The new hospital successfully reduced its impact on the environment and on future generations, and developed a roadmap for others to follow.

**Project Team:**

Owner: Boulder Community Hospital | Architects: OZ Architecture and Boulder Associates, Inc.

Energy/Sustainable Design Consultant: Architectural Energy Corporation | Landscape Architect: Civitas, Inc.

Interior Design: OZ Architecture, and Boulder Associates, Inc. | General Contractor: Gerald H. Phipps, Inc.

Mechanical/Plumbing Engineer: Shaffer Baucom Engineering and Consulting

Electrical Engineer: BCER Engineering, Inc. | Structural Engineer: Monroe Newell Engineers, Inc.

Civil Engineer: Drexel, Barrell & Co. | Commissioning: Farnsworth Group

**Boulder Associates**

Boulder, CO
Sacramento, CA
Orange County, CA

**contact us**
1.800.499.7796

**visit us**
boulderassociates.com