The Savings By Design program and the Energy Design Resources tools have helped the San Mateo Police Facility design team to design a building that will meet the City's goals for a LEED Silver rating and will provide long-term financial benefits to the City.

The recommended package of energy efficiency measures will reduce annual electricity use by 33% compared with the 2001 Title 24 base case. Annual gas usage is projected to be reduced by 16%, and peak period electricity demand is projected to be reduced by 38%.

POLICE FACILITY GOES FOR LEED SILVER

Achieving High Performance With Integrated Design And Energy Analysis Tools From Energy Design Resources

The City of San Mateo, California's existing Police Facility, which was built in 1960, needed more than an overhaul to bring it up to today's standards for security and performance. After determining that it would be insufficient to remodel the building, the City decided to build a new facility that would meet the requirements of the Police Department well into the future.

The new building had to meet high standards for security and be adaptable to changing functions. The City was also committed to meeting high standards for sustainability. In 2001, the County of San Mateo adopted a policy of using the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System® as its primary tool for rating the sustainability of its buildings. Since 2004, the City of San Mateo has required all city projects to achieve a LEED Silver rating.

The Policy Facility project is well on its way to achieving that goal thanks to an integrated design approach that encouraged close collaboration among key team members. The design team included City and Police Department staff, Leach Mounce Architects, energy consultants Green Building Studio, and mechanical/electrical/plumbing engineers Mazzetti and Associates. Many of the design team members had worked together before, which helped to ensure close and effective communication.

To evaluate design and energy efficiency options, the team used energy analysis tools, including eQUEST, that are provided by Energy Design Resources (EDR). EDR is the educational component of the Savings By Design (SBD) program, which provides services and incentives to help architects and building owners improve the energy performance of nonresidential new construction in California.

While plans for the Police Facility are still undergoing final construction documentation, the building is expected to easily exceed SBD program goals and LEED Silver requirements when constructed. The design includes energy efficiency features such as high efficiency heating, ventilation and air conditioning (HVAC) equipment, ample daylighting, high efficiency lighting with daylight-based lighting controls, natural ventilation, carbon monoxide (CO) sensor-controlled garage ventilation fans, and shading on the façade.

BUILDING DESIGN CHALLENGES

The project posed several unique challenges. The facility operates every day, around the clock. It is subject to all the security and privacy requirements of any police facility: it must provide defense against physical, chemical and biological threats, while allowing public access and maintaining an inviting, unthreatening appearance. It is designated as an *essential service facility* so must meet additional requirements for flood and seismic protection, and must be able to operate for extended periods without external power.

Often, the functional requirements of these highly secure facilities are perceived to be in conflict with energy efficiency. The requirement for privacy and security, for example, reduces the amount of vision glazing, and emergency requirements can contribute to oversizing of the mechanical plant.

However, from the beginning of the design process, the City, the Police Department and the architect were committed to building an innovative and efficient building through a team approach. The team took the programmatic challenges and converted them into opportunities for energy efficiency, using the energy analysis tools from Energy Design Resources.

To give everyone a shared reference point, the team produced memos and a draft report on achievable savings; "This allowed people to ask questions" says Al Okuma, the lead for sustainabiltiy on the project, "otherwise you can only assume that they understand."

THE INTEGRATED DESIGN APPROACH

The City was committed to hiring a design team that would be involved from the early stages of the project. Leach Mounce Architects was hired through a competitive process based on their expertise in designing public safety buildings. The firm also had a long history of integrating energy efficiency concepts into their building designs.

Early in 1999, almost six years before the final design, Leach Mounce began conducting a needs assessment to establish funding and performance criteria. Because planning began so far in advance, Leach Mounce was able to gain a thorough understanding of the site and the needs of the client and other stakeholders. This extended planning period helped them integrate green design practices in the City of San Mateo's building program.

Al Okuma, who led Leach Mounce's sustainability efforts on this project, believes that "communication all the way through the design process with all parties" is an essential success factor in sustainable building. Under his leadership, the design team set numerical energy savings targets for the building from the outset, laid out options for achieving them, and discussed them frequently with the City and other stakeholders. To give everyone a shared reference point, the team produced memos and a draft report on achievable savings. "This allowed people to ask questions," says Al Okuma, "otherwise you can only assume that they understand."

Leach Mounce Architects has designed over 60 police facilities. New concepts and innovations that they developed for past projects are put to work for new clients. These include daylighting strategies, ergonomically advanced work stations, graphic jail-control consoles, vehicle fuming tents, user-friendly booking facilities, and safety features. Leach Mounce advocates the use of natural light in their designs, and Al Okuma has considerable experience with hand calculations for daylighting and the design of daylit spaces. He also has personal experience with the tools available from EDR, through previous employment with Southern California Edison as a Savings By Design representative.

For this project, Leach Mounce added a new dimension to their design philosophy—that the building's ability to meet most of its lighting and ventilation needs from natural sources would be a benefit if the power supply were lost for a long time, such as following a major earthquake. This concept is an example of "hardening" an essential service facility that also enhances the working environment.

Green Building Studio was recruited by the architects for LEED and SBD's Whole Building Approach energy analysis. The company has extensive experience using tools such as DOE-2, eQUEST and EnergyPlus, and with lighting rendering software that can model the daylit appearance of interior spaces. They also conducted value-engineering studies to evaluate the cost effectiveness of the proposed measures; their ability to provide both these services streamlined the evaluation process.

The Savings By Design Program And Energy Design Resources

The City decided to participate in the Savings By Design program in part because it provides public recognition of the City's effort to create an energy-efficient building, and lends legitimacy to the achieved savings. Recognition helps demonstrate to the public that the City is a good steward of their tax dollars, and also assures Police Department employees that they're being given the best possible facility. The availability of design tools from Energy Design Resources was a benefit to the team.

Pat Bailey of Green Building Studio said "I often use the design guides for reference on technical content, and the case studies are very useful to educate clients and colleagues on energy efficiency measures."

PRELIMINARY DESIGN

Design a green building meeting the spirit of the LEED Green Building Rating System that would use environmentally friendly products, minimize energy consumption, and provide for recycling.

Drawing on the needs assessment of the facility and their previous experience with designing energy-efficient buildings, the design team developed a building program in September 2002. This laid the foundation for future energy efficiency measures incorporated into the design, and included several noteworthy goals:

- Design a green building meeting the spirit of the LEED Green Building Rating System that would use environmentally friendly products, minimize energy consumption, and provide for recycling.
- Consider a variety of energy conservation strategies, including:
  - Minimize windows at east and west exposures and shade south, east and west glazing.
  - Use appropriate thermo-glazing and insulation.
  - Minimize electric lighting, enhance space with natural daylighting, and use photocontrols where appropriate.
  - Use motion-activated light switches to turn off lights when spaces are not occupied.
  - Consider photovoltaic systems for generating electricity on-site.

Using the building program as a starting point, the architects established a preliminary design. Due to the City's requirement for LEED certification, the preliminary design exceeded the 2001 version of California's Energy Efficiency Standards for Nonresidential Buildings (Title 24). The preliminary design's energy efficiency features are summarized below.

Description	Base Case (Title 24 -2001)	Preliminary Design
Net Conditioned Area (Square-Feet)	43,262	
Roof Type	Concrete over metal pan	
Roof R-value	R-19	
Exterior Wall Type	Metal Framed	
Ext Wall R-value	R-11	R-19
Floor above Parking Garage (R-value)	R- 6.33	1.5" spray-on fireproofing with R-5.25
Window Type	Double Pane, Light Tint (non-north), Double Pane, Clear (north)	
U-Value (including frame)	0.81	0.77
Solar Heat Gain Coefficient (SHGC)	0.61 (north) 0.41 (non-north)	0.61 (north) 0.55 (non-north)
Visible Transmittance (Tvis)	0.50	0.57
Window Area (sq. ft.)	5,529 (20.3% window-wall ratio)	
Skylight Area (sq. ft.)	177	

Table 1. ARCHITECTURAL SYSTEM FEATURES

Description	Base Case (Title 24 -2001)	Preliminary Design
HVAC System Type	Packaged direct – expansion (DX), constant air volume	Packaged DX, variable air volume
Roof Top Units – Cooling Efficiency (energy efficiency ratio, or EER)	9.2 EER air-cooled	14 EER evaporative condensers units 1 and 2
Split Air Conditioning Units – Cooling Efficiency (EER)	10.3 EER	EER 12 units 1 and 2; EER 12.1 unit 3
Motor Efficiency	High efficiency	Premium efficiency

Table 2. HVAC SYSTEM FEATURES

ENERGY EFFICIENCY ANALYSIS USING EQUEST

While the preliminary design exceeded Title 24 requirements, the design team set its sights on a much higher level of energy efficiency. At least 15% better than code would qualify the project for SBD incentives, and roughly 30% better than code would qualify it for the LEED Silver rating.

Green Building Studio conducted extensive energy analyses of the building, with significant input from Leach Mounce. They used eQUEST, a sophisticated building energy analysis tool offered by Energy Design Resources that is capable of generating accurate analysis, yet has a simple user interface and involves an affordable level of effort.

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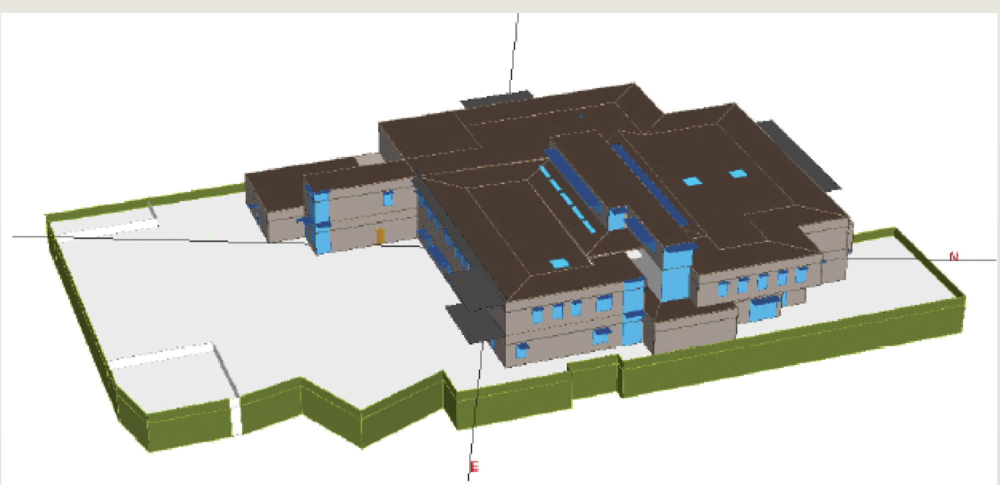

FIGURE 1: THREE-DIMENSIONAL VIEW OF THE EQUEST MODEL

The team initially considered 50 energy efficiency measures, and conducted detailed analysis on 20 of these. The measures included:

Added Insulation In The Roof And Floor

The design team considered upgrading the roof insulation to R-30 from R-19, or adding a radiant barrier to the R-19 roof. The eQUEST analysis showed that the additional savings from either measure would be negligible since the weather in San Mateo is mild, resulting in low heating and cooling needs.

For the floor the team investigated increasing the insulation to R-11 from R-5.25 between the garage ceiling and the first floor. Two alternatives were investigated—insulating the entire floor or insulating only the detention space and locker room. These measures resulted in natural gas heating savings, but small increases in electricity use because the insulation reduces the ability of the garage to act as a heat sink for the building during the summer. This measure was deemed to be not practical because constructability issues made it difficult to attach insulation to the underside of the floor.

A Cool Roof

A cool roof is a roof assembly that has a high solar reflectance to minimize the rate at which solar heat is absorbed, and a high emissivity so that absorbed heat can be radiated away from the roof once it does heat up.

Calculations showed that a cool roof would reduce cooling load but increase heating load, because the increased emissivity increases radiant heat loss in the winter. In terms of site Btus, the savings and losses approximately balance out, but because cooling is more expensive than heating, and because the cost of the cool roof was modest, the design team adopted the cool roof into the final design.

High Thermal Efficiency And High Visible Transmittance Glazing

Glazing was analyzed very early in the design process because it has complex effects on other building systems. The glazing had to satisfy aesthetic, security, privacy and energy performance criteria in addition to specific criteria for LEED accreditation and the health of indoor plants.

The team's design approach was to provide individual windows at offices and larger windows at open areas to maximize daylighting and views; energy use would be minimized by taking advantage of photocontrolled lighting.

For energy efficiency and comfort, the design team looked at windows with very low thermal conductance and solar heat gain, but high visible light transmittance. The team considered several commercially available windows, and selected a clear glass window with 0.70 visible light transmittance, 0.29 U-factor and 0.28 SHGC.

Lighting Efficiency

The high transmittance glazing made it possible to save lighting energy by using photocontrolled lighting. Dimming rather than switching controls were chosen because they were judged to save more energy and be more acceptable to office workers who might be annoyed by the frequent switching of lights. Savings were calculated in eQUEST based on window position, time of day, cloud cover and typical meteorological year weather files.

Occupancy sensors are most effective at saving energy in spaces that are vacant for significant lengths of time. The design team proposed that occupancy sensors be installed in private offices, storage areas, mechanical rooms, break rooms, restrooms, conference rooms and some corridors. There is currently no energy analysis software that calculates the effect of occupancy sensors, so the design team used the values given in the 2001 version of Title 24.

The design team also analyzed the effect of reducing lighting power density from 1.05 watts per square foot (W/sq.ft) to either 0.92 or 0.86 W/sq.ft. A lighting power density of 0.86 W/sq.ft proved cost effective and was included in the design.

High Efficiency Boilers For Space Heating

This alternative involved replacing the boiler in the preliminary design with a 93% efficient condensing boiler. The design team collected information from several manufacturers to show that boilers with this specification are commonly available and cost effective. This measure resulted in a 13% saving in heating energy, and was included in the final design.

Carbon Monoxide Sensor-Controlled Fans In The Garage

The underground garage requires ventilation fans to replace polluted air with fresh air. In many buildings these fans run continuously even when the garage is not being used, which wastes energy. The design team explored the option of connecting the fans to carbon monoxide (CO) sensors so that they run only when pollutant levels reach a threshold value. Based on the expected use of the facility, the team estimated that the fans would run for only six hours per day. This option was included in the final design.

The design team recommended a highly efficient scotopically enhanced (bluish-white light sources) fluorescent lighting system for the building. Lighting research suggests that the human eye perceives cooler temperature lighting (lamps rated at 5000ºK or greater, which tend to be bluish-white) to be brighter than standard warmer temperature lamps (3500ºK or less, which look yellow/orange) even if they have the same lumen and efficacy values.

The recommended lighting system (F32T8) also has high lumen output (3100+ lumens), excellent color rendering (85+ Color Rendering Index, or CRI), and long lamp life (24,000+ hour rating).

Operable Windows

In the previous Police Facility, the Chief of Police and her staff all had operable windows, and they preferred operable windows in the new building. This raised several issues, such as risks of intrusion and the concern that operable windows would compromise the HVAC system by letting cool air out in the summer and warm air out in the winter.

The design team looked at adding window sensors that would locally shut off supply air if a window was opened, or motorized windows that could close to conserve cool or warm air, but these were prohibitively expensive relative to the energy cost savings. However, by using eQUEST in conjunction with additional analysis, the energy consultant showed that the impact of uncontrolled operable windows was negligible because of San Mateo's mild climate.

Security concerns could be addressed by incorporating operable windows only on the second floor in areas where desk-based occupants would be located. However, after discussions with the Police Department, the design team recommended not to incorporate operable windows into the design because of security, operational and project requirements.

Data Center Backup Cooling

The data center required backup cooling capacity in case of emergency. Typically this means a fully redundant stand-alone cooling system for the data center. The design team chose instead to use redundant condensing units that tap into the building's HVAC system. If backup cooling were ever required, some of the capacity of the comfort cooling system would be diverted to the data center.

Photovoltaic Panels

At the request of the City, the design team investigated photovoltaic (PV) panels for on-site electricity generation. Two alternatives were analyzed: panels situated above view windows as shading devices, and panels as a stand-alone system on the roof. The City's decision about whether to adopt this measure depends on a number of factors beyond the cost-benefit analysis, and will be made later in the design process.

Energy Efficiency Packages

Green Building Studio knew there would be interactive effects among the different measures. For instance, the savings from daylight-linked lighting controls would be strongly influenced by the type of glazing chosen.

Based on their experience with previous projects, they took a two-stage approach to the energy modeling using eQUEST. First, they modeled each individual measure to identify which produced the greatest savings. Second, they defined three "packages" using combinations of the most successful measures **(see Table 3)**, and then modeled the effect of each package in detail to take account of interactions.

Measure	Package A	Package B	Package C
Roof — Cool roof	✓	✓	✓
Windows — Low-e glazing (0.38 SHGC, 70% VLT)	✓	✓	✓
Gallery Windows: Low-e glazing (0.38 SHGC, 70% VLT)	✓	✓	✓
Continuous dimming daylight controls	✓	✓	✓
Lighting: Reduce LPD and Occupancy Sensors	✓ (LPD=0.86)	✓ (LPD=0.86)	✓ (LPD=0.92)
HVAC: Condensing Boiler 93% efficiency	✓	✓	
HVAC: CO Sensors in Garage	✓	✓	✓
HVAC: Natural Ventilation of Gallery	✓		

Table 3. Energy Efficiency Packages Modeled in eQuest

BUILDING ENERGY SAVINGS

Using energy calculations and cost analyses, Green Building Studio made a final recommendation to adopt the measures in Package B (**see Table 3**). This package of measures reduces annual electricity use by 33% compared with the Title 24 base case. Annual gas use is reduced by 16%, and peak period electricity demand is reduced by 38%.

Although Package A would have delivered more savings, the option of natural ventilation in the central gallery space was deemed infeasible because it would require outside air intake at the ground floor, and the security and tightness requirements of the building preclude this.

All three measure packages are highly cost effective, according to a 25-year net present value (NPV) calculation conducted by Green Building Studio. The NPV calculation shows the amount of capital that would need to be invested at a commercial interest rate at the beginning of the project, to yield the same financial return as the energy efficiency measures, over a 25-year period (see Table 4).

Design Alternatives		Alt 21 Pkg A	Alt 22 Pkg B	Alt 23 Pkg C
Annual Savings Compared to Title 24	kW Savings	115	113	110
	kWh Savings	422,691	416,102	403,211
	Therm Savings	6,362	5,204	2,409
	Total Utility Cost Savings	$58,976	$56,937	$52,609
	T24 Compliance Margin	33.4%	32.4%	29.3%
Incremental measure cost *without* SBD incentive		$118,954	$108,954	$101,454
Incremental measure cost *with* SBD incentive		$37,780	$29,892	$28,651
25-year net present value of savings *without* SBD incentive		$2,396,359	$2,319,019	$2,179,421
25-year net present value of savings *with* SBD incentive		$2,476,893	$2,392,910	$2,252,223

Table 4. ENERGY SAVINGS FROM EACH MEASURE MODELED USING EQUEST

The recommended Package B provides the building with eight LEED points, helping the team in its quest for a LEED Silver rating.

LESSONS LEARNED

The design team had extensive experience with sustainable building design in general and with Energy Design Resources tools and resources in particular. This project served to refine an approach that they developed over previous projects.

Educate The Stakeholders

EDR's Design Briefs and Case Studies are useful for educating clients and other stakeholders and interested citizens, many of whom are unfamiliar with energy-efficient technologies and unaware of the benefits. These resources help to create a basis of shared knowledge and shared terminology that makes the development of the design much easier.

Green Building Studio also uses EDR Design Briefs and Case Studies when working with a new architect. According to Green Building Studio, because architects are called upon to be generalists, their knowledge in specific areas may need to be updated at the beginning of a project, and the EDR tools are an effective way to accomplish that.

Create A Schematic Energy Model

This was the first project in which the design team created a schematic energy model in the eQUEST Wizard, a simple tool that allows quick comparisons between design options. The team used eQUEST to assess and make preliminary decisions on energy efficiency opportunities at the schematic design stage. This is a very different approach from the standard practice of modeling energy efficiency measures only later in design development. Concurrent with the schematic whole-building energy modeling, the architectural, mechanical/electrical/plumbing (MEP) and facility staff developed early electrical, lighting and mechanical analyses. These were vetted by facilities staff for operational and maintenance efficiency and integrated into the eQUEST whole-building energy analysis.

Encourage Open Communication

The schematic energy model was an important communication tool because it functioned as a "straw man," encouraging people to ask questions and learn more about the design. It was used as a reference for energy efficiency targets (W/sq.ft) and the relative magnitude of savings from different measures considered throughout the design process.

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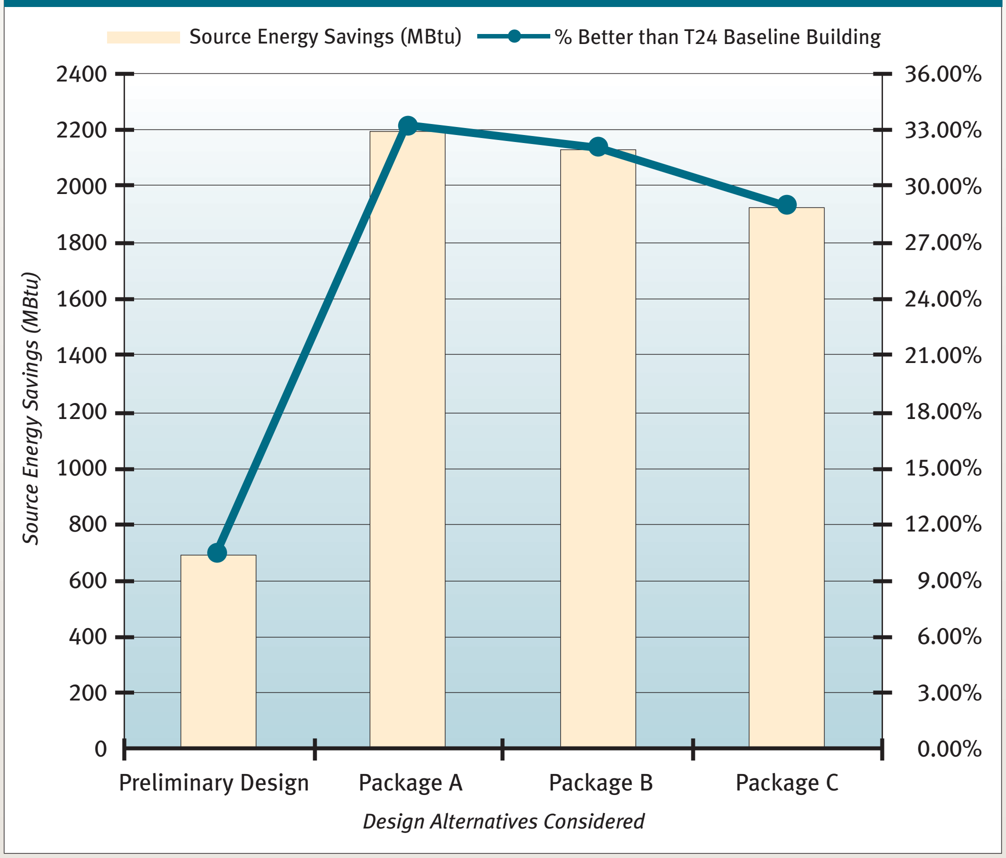
Build Trust

Trust between the client, architect and other consultants makes it easier to discuss energy efficiency goals. Often, designers are reluctant to quote energy savings figures early in the design process for fear that they will be held to those figures later on. In this project the client and stakeholders were aware from the beginning that energy modeling is approximate and that the values would be refined as the design process developed.

CONCLUSION

While the building remains to be constructed, the commitments and efforts of the City of San Mateo, Leach Mounce Architects, Green Building Studio, and Mazzetti and Associates have set the stage for the construction of a highly energy-efficient building. The Savings By Design program and the Energy Design Resources tools have helped the team to design a building that will meet the City's goals for a LEED Silver rating and will provide long-term financial benefits to the City.

ENERGY SAVINGS RELATIVE TO A CODE COMPLIANT TITLE 24 BUILDING



Based on the energy analysis conducted using eQUEST, Green Building Studio recommended Package B. This package of measures included a cool roof, high thermal efficiency windows, low installed lighting power density along with occupancy and daylight-based sensor controls, high efficiency condensing boiler for space heating and CO sensors in the underground garage.

Design team and stakeholders:

Leach Mounce Architects
Howard Leach,
AIA, CSI, Principal-In-Charge
Michael Smith,
AIA, Project Manager/Architect
Albert Okuma,
AIA, CSI, LEED AP, Architect

Green Building Studio
Patrick Bailey, *PE, Principal*
Marjorie Stein, *LEED AP, Analyst*

Mazzetti and Associates
Albert Ostroy, *PE, Mechanical Engineer*
Josef Repsch, *PE, Electrical Engineer*
Gene Joves, *P&FP Engineer*

City of San Mateo
Patty McHugh, *Project Manager*
Susan Manheimer, *Chief of Police*

Forell/Elsesser Engineeers
James Guthrie, *SE, Principal*

BFK Engineers
Roland Haga,
PE Civil Associate/Project Manager

Kathie Kottler Landscape Architect
Kathie Kottler, *Principal*

Hanscomb, Faithful & Gould
Zaif Ismail, *Estimator Associate*