

# FABRICATION + ADAPTATION:

A system for replacing elementary school portable  
classrooms throughout California

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## ABSTRACT:

Thirty percent of California public school facilities are made of portable buildings. Portable classrooms are uninspiring and inadequate spaces for learning, reflective of a cultural indifference for the education of California's youth. Children should be engaged and connected to learning from a young age to maximize their opportunities for success through the course of their lives. Portable classrooms are intended to be a fast and simple short-term solution to a growing population, but are almost always used long beyond their anticipated lifespan. Portable buildings are unresponsive to their site and climatic conditions, typically lined up in a row on the fringe of an existing school.

California needs a system of rapidly deployable but long-term classrooms to replace elementary school portables throughout the state. The classrooms are designed to foster a greater sense of community while maximizing the environmental conditions required for healthy learning spaces. The classrooms are able to respond to the variety of environmental conditions that occur throughout the state, as well as their local school infrastructure.

This thesis proposes to address the long overdue issue of replacing elementary school portable classrooms throughout the state of California by utilizing digital technology and prefabrication techniques to design classrooms that are adaptable to the diverse climates within the state. The classrooms will offer ample natural daylighting, cross-ventilation and other environmental strategies that are beneficial to learning. There are three classroom prototypes to show how the building form can respond to its climatic conditions, though the tectonics of the buildings remain the same. Two typical school site conditions represent strategies for replacing existing school portables relative to existing school layouts, and one condition depicts how the classroom unit could be used to create a new school entirely.

## CONTENTS:

1.	List of Figures .....	5
2.	Introduction .....	7
3.	Theoretical Framework .....	13
	a) Literature Review	
	b) Precedent Analysis	
	c) Summary	
4.	Design Methods .....	27
	a) Overview	
	b) Measures of Success	
5.	Program .....	30
	a) Program Goals	
	b) Limits + Delimits	
6.	Sites .....	34
	a) Hollister	
	b) Yucca Valley	
	c) Pollock Pines	
7.	Design .....	47
	a) Hollister	
	b) Yucca Valley	
	c) Pollock Pines	
8.	Conclusion .....	70

## LIST OF FIGURES:

1.	Existing portable classroom interior .....	8
2.	Existing portable classroom interior .....	8
3.	Existing portable classroom exterior .....	8
4.	Existing portable classroom exterior .....	8
5.	Existing portable classroom exterior .....	9
6.	Existing portable classroom interior .....	10
7.	Sea Ranch in Northern California .....	15
8.	Anderson Anderson Architecture's portable classroom .....	18
9.	Toyota Homes prefabricated house .....	19
10.	Sprout Space courtyard rendering .....	20
11.	Sprout Space classroom .....	21
12.	SEED Classroom exterior .....	22
13.	SEED Classroom interior .....	23
14.	Shigeru Ban Onagawa Atelier exterior .....	24
15.	Sheru Ban Onagawa Atelier interior .....	25
16.	Diagram of buildings encouraging interpersonal connections .....	27
17.	Diagram of connections between interior and exterior spaces .....	28
18.	Classroom program .....	30
19.	Diagram of classroom program adaptability .....	31
20.	Map of site locations .....	34
21.	Biome average temperatures .....	35
22.	Biome average precipitation .....	35
23.	Biome prevailing wind direction .....	35
24.	Biome classifications throughout the state .....	36
25.	Biome characteristics .....	37
26.	Hollister regional map .....	38
27.	Hollister landscape .....	39
28.	Hollister existing portable classroom relationship to existing school ...	40

29.	Hollister existing portable classrooms from field .....	40
30.	Yucca Valley landscape .....	41
31.	Yucca Valley regional map .....	42
32.	Yucca Valley existing school entry .....	43
33.	Yucca Valley playground and fields .....	43
34.	Pollock Pines landscape .....	44
35.	Pollock Pines regional map .....	45
36.	Diagram of module environmental response capabilities .....	47
37.	Module configurations .....	48
38.	Classroom general orientation strategy .....	49
39.	Tectonic concept .....	50
40.	Flat pack logic .....	51
41.	Classroom section .....	52
42.	Construction details .....	53
43.	Hollister location .....	54
44.	Hollister site plan and module configuration .....	55
45.	Hollister sectional perspective .....	56
46.	Floor plan of single cluster .....	57
47.	Hollister aerial perspective .....	58
48.	Perspective view of outdoor classroom amphitheater .....	59
49.	Yucca Valley location .....	60
50.	Yucca Valley site plan and module configuration .....	61
51.	Yucca Valley floor plan .....	62
52.	Yucca Valley sectional perspective .....	63
53.	Interior of Yucca Valley classroom .....	64
54.	Pollock Pines location .....	65
55.	Pollock Pines site plan and module configuration .....	66
56.	Pollock Pines floor plan .....	67
57.	Pollock Pines sectional perspective .....	68
58.	Perspective view of Pollock Pines classroom cluster .....	69
59.	Perspective view of shared courtyard concept .....	72

## INTRODUCTION:

*Recent research has confirmed what many educators have held as common sense—the quality of a school facility has an impact on student’s experiences and ultimately on their educational achievement. The research on school building conditions and student outcomes finds a consistent relationship between poor facilities and poor performance: when school facilities are clean, in good repair, and designed to support high academic standards, there will be higher student achievement, independent of student socio-economic status.*

*(Growth and Disparity, 2006, 3)*

One-third of California elementary school facilities are portable buildings. While portable buildings are perceived as a cost-effective solution to providing educational spaces for a quickly growing population, the long-term costs are high. Portable buildings are uninspiring and inadequate spaces for learning, reflective of a cultural indifference for the education of California’s youth. Children who are not engaged in and connected to the learning process from a young age have less opportunity for success through the course of their lives. Marginalized children often grow up to become disenfranchised adults, contributing to a cycle of future citizens that are disengaged from their community and fellow citizens.

Elementary school classrooms should be inspiring places for learning that students and teachers can be proud of. Classrooms should facilitate the learning process while offering a safe and healthy learning environment. California’s elementary school classrooms should encourage the many types of intelligences students have, rather than being generic stand-alone shells lined up in a row without any regard for their surroundings. Elementary schools with well designed, community oriented, inspiring, high quality, environmentally sound classrooms can positively influence learning and connectedness of students today, who can grow up to become engaged, collaborative, well-adjusted and educated adults of the future.

Teachers play a powerful but challenging role in the lives of California’s youth and deserve a healthy and comfortable workspace. Teachers should have spaces they feel proud of, that they can personalize and be comfortable in. Teaching is a more honorable profession than most, but the physical environments teachers inhabit are too often symbolic of a cultural disrespect for their social contribution. School buildings should offer dignity and a sense of pride



*figures 1, 2, 3 & 4 clockwise from top left: typical portable classroom conditions in California*



*figure 5: typical portable classroom condition and site placement strategy*

packing into dilapidated portable school buildings that have long surpassed their expected lifespan. School portables are a common short-term solution that most schools employ because they are cheaper than building new facilities. Schools built before 1989 were actually required to have at least 30 percent portable buildings in order to make construction more cost effective. Although the mandate for portable school buildings

to their inhabitants, displaying a clear physical message about the social value of what occurs inside.

California public elementary school facilities are in a state of disrepair, and lack adequate funding to renovate and build new ones. A growing population compounds the issue, with more and more students

was dismissed in 1989, California Public Schools still heavily relies on portable buildings to accommodate the growing number of students, rather than building new permanent facilities.

The intended maximum lifespan of a portable building is 10 years, provided it has been properly maintained, but California Public

Schools typically use portables for much longer than that. According to a 2005 study, 45 percent of California's portable public school buildings were over 10 years old (Environmental Health Conditions in California's Portable Classrooms, 2001). Many of the portables on elementary school campuses today remain from before the portable mandate was lifted in 1989. Schools either rent or buy the portable buildings, depending on their financial capabilities. While schools see value in having relocatable classrooms in order to provide temporary facilities for students, the classrooms are rarely ever moved or returned. The number of students attending California public elementary schools continues to grow, so schools rarely decrease in enrollment. Typically, the portables are installed on a school site and used longer than allowed, so the need for the buildings actually to be re-locatable is rare.

While the initial investment of buying portable school buildings is low, the impact of using them as a long-term solution is high. All



*figure 6: typical portable classroom interior*

portable school buildings are built to meet the current building code, but the quality of materials and construction is often lower than used for permanent construction in order to make them as inexpensive as possible. Thus, the materials break down quickly and require more maintenance and repair than school districts can give them. The energy required to heat and cool portable buildings is high, as they

usually have leaky but inoperable windows, no natural day lighting and loud but inefficient HVAC systems. The energy required to maintain portable buildings, like any other poorly constructed building, is high and results in a high operating cost that negates the initial purchase cost savings of the portable building. Other common issues reported with portable classrooms are poor indoor air quality, low lighting levels, stuffy air, musty smells, and noise. When compared to traditionally constructed classrooms, teachers reported more environmental issues despite the portable buildings often being newer. The prevalent use of carpet, dropped ceilings, and low-quality finish materials in portable buildings increases formaldehyde and volatile organic compound levels, which can result in unsafe air quality conditions.

California Public School's current ideological approach to facilities expansion is to apply long term what was intended as a short-term temporary solution. This policy, however, has evolved into a long-term environmental burden, as portable schools have become the cultural default to the need for more space.

Yet another major shortcoming of portable elementary school buildings is the quality of the space for learning. Portables are doublewide trailers designed and manufactured to be as affordable as

possible. What is the message this sends to the two million students who attend classes in these buildings every day? How does the physical environment reflect a society's cultural values? According to Denae Dorris' analysis of the environmental factors influencing educational facilities, the message that inadequate educational facilities sends to students is significant:

*[S]chool buildings and grounds ... reflect the cultural history, patterns of use, and deep-rooted values of the society particular to their location. Schools convey to students, teachers and the greater community a "hidden curriculum" about how learning is regarded, the place of education, and the role of children and youth in that society. As they change through construction and renovation across time and space, school buildings and grounds reflect particular shifts in these ideologies.*

*(Dorris 2011, 12)*

According to Dorris, all aspects of public schools' physicality is political and reflective of cultural values. School site, buildings, and grounds are a physical manifestation of society's changing feelings about education and the role of children within the politicized academic landscape.

Environments do not only affect students ability to learn, but have been shown to influence student behavior. "Related to its

impact on academic achievement, school facilities in disrepair and use of temporary buildings instead of permanent structures, have been correlated with an increase in student drop-out and absentee rates” (Patinella & Verdery 2010, 10). Thus, students who attend classes in better facilities are better students academically and behaviorally.

California is a large state that encompasses a wide range of climatic conditions, from the elevation of the Sierra Nevada Mountain Range in the north to the basins of the Mojave Desert in the south. Yet the portable classrooms deployed throughout the state are the same homogenous, rectangular, double-wide trailers that are not responsive to surrounding site and climatic conditions.

Because 30 percent of school facilities throughout the state are portables, any proposal for replacing re-locatable buildings has to be adaptable and easily modified to meet different environmental conditions. It is also critical that the buildings can be quickly and easily deployed. Schools typically allow on-site construction for the three months in summer when school is not in session, which is one of the major reasons for the overdependence on portable buildings in the first place. Portable classrooms are prefabricated off-site and quickly installed on campus in a couple of days. This thesis proposes to take

on the multiple problems associated with portable classrooms in the state of California.

The thesis needs to consider the advantages and disadvantages of prefabricated construction with respect to time-sensitive on-site construction. Prefabricated buildings or building components that can be quickly assembled on site are likely the best solution for replacing school portables.

The main concepts that this thesis explores are the factors that contribute to healthy spaces for learning and the ways that a repeatable prefabricated system can be altered to suit the diverse bioregions of California. Healthy spaces for learning include good environmental conditions, such as natural ventilation, daylighting, and acoustical control, but they can also undoubtedly benefit from other criteria, such as connection to the outdoors and shared community spaces. The literature analysis in the following chapter will offer a rigorous outline of the factors affecting spaces for learning. The literature analysis will also review methods of designing facilities that are responsive to site and climatic region, with additional information on the history of prefabricated and rapidly deployable building types.

## THEORETICAL FRAMEWORK:

This chapter includes a literature review, a precedent analysis, and the conclusions derived from both that inform the theoretical framework for this project. The review of literature covers the environmental factors that contribute to healthy spaces for learning, focusing on children and elementary schools. It also analyzes the variety of methods used to design buildings that are site responsive and connected to their local climate. Finally it explores the history of prefabricated buildings and basics of rapidly deployable building types.

### LITERATURE REVIEW

Understanding the factors related to healthy spaces for learning is a critical component of research for this thesis proposal. In her article researching the validity of the federal guidelines for Effective Learning Environments Assessment (ELEA), L. Denae Dorris determined that the critical factors affecting learning environment quality are school ethos, personalization, collaboration, environmental conditions, versatility and flexibility, and community. The conceptual framework for Doris's

study was to examine the factors affecting school facilities that are not typically considered before construction. Most school building assessments focus on cost, energy efficiency, and related engineering factors. While such factors undoubtedly need to be considered, her study examines the less tangible, but quantifiable needs of a changing academic environment in order to highlight their value.

School ethos is the culture, values, and rules of a school. Physical environments are related to school ethos because they are a representation of school values and priorities. Schools that value the importance of social interaction, for example, would prioritize public spaces that foster interaction. Personalization is the idea that the learning process is personal and is a process, rather than a product. Healthy school spaces foster a variety of spatial alternatives to support individualized learning processes.

Collaboration is another critical component of education. Schools should encourage teamwork based learning, as "...strong, positive, collaborative cultures have powerful effects on many features

of schools” (Deal & Peterson 1999, 7). Social engagement greatly affects learning environment quality. Spaces that discourage talking and interaction also discourage learning. Schools should focus on incorporating “socially catalytic” spaces for students and teachers to engage. Similarly, Doris determined that community is another critical component affecting students’ ability to learn. She found that school campuses that foster a greater sense of community have more civic engagement than those outside of the school system, connecting and unifying people of all ages. A sense of student belonging through a visible civic support system offers many benefits to schools.

Improved school facilities can create stronger community involvement because more people will want to use the spaces for activities outside of school. It has been determined that “[m]odernized school facilities can boost morale among students, teachers and school staff, as well as the community at large. Attractive, functional buildings can be used for neighborhood events and services to build stronger communities” (Patinella & Verdery 2010, 14).

Environmental conditions greatly impact learning as well. Noise and low lighting levels have been proven to affect negatively learning space quality, decreasing the ability of students to focus while

increasing their blood pressure (Dorris 2011, 85). Thermal comfort and air quality are also environmental factors that have a great impact on ability to learn. A 1996 EPA study on classroom indoor air quality found that high levels of carbon dioxide in classrooms greatly affected students’ concentration, compromising their memory and ability to do calculations. The findings of this study are “...statistically significant and tend to confirm that with indoor air quality management, including source control and adequate ventilation, student performance can improve” (Wakefield 2002, 300).

Lighting also plays a significant role in student achievement. The Heschong Mahone Group conducted a study in 1991 of over 21,000 students across three states, controlled for socioeconomic status and “... discovered students with the most daylight in their classrooms progressed 20 percent faster than peers with less daylight. Through observation and scientific exploration, scientists discovered full spectrum light is needed to control critical bodily functions such as blood pressure, respiration, pulse, brain activity and biorhythms” (Schneider 2002, 6). Though full spectrum fluorescent lights exist, natural lighting has proven to be even more effective. Natural lighting is an important factor contributing to healthy spaces for learning.

Research has shown that acoustics and noise also impact learning environments. "... High noise levels cause stress. Noise levels influence verbal interaction, reading comprehension, blood pressure, and cognitive task success and may induce feelings of helplessness, inability to concentrate, and lack of extended application to learning tasks" (Schneider 2002, 7). Classrooms should be acoustically separated from outside noise in order to be more effective. Schools in cities might suffer from more traffic and ambient noise than their rural counterparts so urban facilities should be designed to minimize noise obstructions.



figure 7: Donlyn Lyndon's Sea Ranch in Northern California

Regionalism is the idea that architecture should be reflective of its site and location, rather than utilizing a one-size-fits-all reaction. A regional architecture can be realized in different ways, though the underlying concept of site and place actualization unites the various strategies. Donlyn Lyndon, one of the architects who designed the Sea Ranch in Northern California, is one of the key founders of architectural regionalism. He reflects on his approach to designing Sea Ranch by stating:

*We all were certain that the buildings should be designed to fit to their site; that they could and should be shaped by the environment in all its respects. Buildings could reach for welcome sun, deflect coastal winds, merge with the landscape of meadows, hedgerow and forest; they could be built directly, with materials that were also a part of the site. It was clear to us that they should speak of the place, rather than be obsessed with the time.*

(Lyndon 2009, 82)

According to Donlyn Lyndon, buildings should strive for a timelessness that can be found in the site and climate conditions, rather than relying on changing architectural trends.

Kenneth Frampton is another major contributor to the discussion of architectural regionalism and has written many articles and books on the subject. Frampton has theorized on the need for a critical regionalism in architecture, dismissing both modern and post-modern movements as being overly stylistic and unconnected to context. Frampton believes that:

*[M]ore than any other art form, building and architecture have an interactive relationship with nature. Nature is not only topography and site, but also climate and light to which architecture is ultimately responsive to a far greater degree than any other art. Built form is necessarily susceptible to an intense interaction with these elements and with time, in its cyclical aspects.*

*(Frampton 1987, 363)*

Thus, buildings have a great responsibility to reflect all of the subtle and not so subtle nuances of site and place, as “[t]he fundamental strategy of Critical Regionalism is to mediate the impact of universal civilization with the elements derived indirectly from the peculiarities of a particular

place” (Frampton 1987, 21). Architecture should be derived from the factors that make it unique, namely the place where it is located. Buildings need to consider environmental factors such as light, shade, seasons, weather patterns, users, nearby local vernacular, and more in order to be powerful, experiential spaces.

Regionalism is typically contradictory to the idea of prefabrication in architecture, though it does not have to be. Regionalism is a site specific approach to design, while prefabrication implies mass production, typically without much regard for the site and specific regional conditions. Designers in the United States and Europe have been interested in the idea of prefabricated buildings since the beginning of the Industrial Era. If buildings could be mass produced, so the thinking went, they could be of higher quality and cost less than a custom-designed version. If the building industry could adopt the successful industrialized assembly line tactics of the automobile and aeronautical industries, then people could have greater access to well designed buildings.

Kit homes were an architectural option at the turn of the century, spurred by the onset of industrialization. People could order a house from a catalogue and have all of the components delivered

to them for assembly. Sears, Roebuck, and Company was one of the first companies to offer this system of precut lumber systems for mass production. The kit house model was relatively successful due to its wide variety of housing options and the variety of financing options the company offered. When the Great Depression of the 1930s hit, however, Sears was forced to discontinue the kit house program (Smith 2010).

Post World War II was a notable era for American prefabricated buildings, housing in particular. The return of thousands of US veterans meant local jobs and housing were needed. And since the military factories were no longer producing military supplies, they shifted their focus to supplying housing and jobs for veterans.

The Lustron Corporation produced military airplanes during the war, but began to manufacture enameled steel homes to fill the growing need for housing. Employing the latest automobile metal sandwich technology (Smith 2010) the entirely prefabricated Lustron House simplified the building components to be assembled similar to those of an automobile. While the company managed to sell about 2,500 homes, the price was too high for most homebuyers and the Lustron Corporation had to close its doors in 1950 (Smith 2010).

Around this time real estate developer Joseph Eichler was building developments throughout California. He developed an on-site system of post and beam construction that simplified building and minimized waste, making his modern homes more affordable than standard conventional ones. A large part of his success, however, came from the scale of his developments. Costs were minimized because he was able to buy materials in bulk and create an on-site assembly line type of project delivery system (Smith 2010).

A resurgence of interest has occurred recently in the idea of prefabrication and its promise of less expensive, higher quality buildings for the masses. Even modern day attempts have resulted in failure, despite the intelligence of those running the business. One example is Northern California's Michelle Kauffman. While she was a leader and spokesperson for the 2008 green prefabrication movement, even her business was not able to survive the economic recession of 2009. While logical, history has proven that manufacturing prefabricated buildings is not as simple as these earlier designers assumed. The greatest architects in the world have not been able to figure out the formula for making prefabrication a success. What are the factors that make building prefabrication so difficult? Why have so many failed? Is



*figure 8: Anderson Anderson Architecture's relocatable classroom design for the state of Hawaii*

from an incremental transition from site based craft and assembly to offsite componentization of building elements, accompanied by a deeper analysis and understanding of social and economic forces outside of design and mechanics” (Smith 2010, 41). The Anderson brothers understand the

there a hybrid model of prefabrication or manufacturing that needs to be explored?

Mark and Peter Anderson of Anderson Anderson Architects, builders with extensive prefab experience, offer some answers.

According to the Anderson brothers, “[the firm has] come to believe that the most effective path to achieving the benefit of prefabrication comes

challenges facing prefabrication and the limitations that have historically prevented its success. Their recommendation for making prefabrication successful includes thinking about prefabricating parts of the building, rather than the entire thing.

One prefabricated building company model that is successful in Japan is Toyota Homes. The automaker has several divisions outside



*figure 9: one model of Japan's Toyota Homes prefabricated houses*

that was coined by Toyota the 1980s. Toyota has applied its manufacturing principals to the construction process, making a typically inefficient process standardized and factory controlled. Toyota is able to offer Japanese homebuyers very high quality prefabricated homes at a significantly lower price, with the option for customization. Clients can visit the different home models at the Toyota Homes center then specify their desired colors and finishes. Their home

of cars, one of them being prefabricated homes. Toyota created the concept of lean manufacturing, which studies the manufacturing process closely to minimize any waste and inefficiency. The ethos of lean manufacturing is “preserving value with less work,” a concept

will be produced to order, much like the experience of ordering a car.

According to the author of Prefab Architecture, Ryan Smith, prefabrication has the potential to be successful in the United States if a variety of financial and logistical conditions are met. Several conditions

that apply to this thesis study are as follows: prefabrication should be applied on a large enough scale to make construction less expensive, builders should be able to easily understand how the components fit together and are installed on site, and buildings should be customizable enough to allow personalization.

With these ideas about healthy buildings and prefabrication in mind, the review now turns to an analysis of precedents illustrating these dimensions.

### **PRECEDENT ANALYSIS**

While portable classroom design has been of higher interest in recent years, most of the available solutions focus primarily on methods of making the modules more environmentally friendly and meeting different LEED and Living Building

standards. Though developing a more environmentally friendly portable is important, the current solutions are surprisingly similar in their approach. All share a similar panelized fiber cement exterior



*figure 10: rendering of the interior space between a cluster of Sprout Space classrooms*



*figure 11: exterior view of the Sprout Space classroom*

and butterfly roof aesthetic. They embrace the stand-alone concept that current portable buildings employ, disregarding any response to the adjacent buildings, local environment and climate. Both the Sprout and SEED classrooms utilize the standard portable building model of being prefabricated offsite and shipped in on trailers.

### **Sprout Space Portable Classroom – Perkins + Will**

The Sprout Space Portable Classroom was the modular category winner of the Architecture for Humanity's 2009 Open Architecture Challenge to design the classroom of the future. Perkins + Will is a global architecture firm that specializes in educational facilities. They are now selling the Sprout Space Classroom as a

better solution to the school portable epidemic. The classroom spaces are carefully planned to allow smaller break out spaces and engage with the outdoors, allowing for the flexible learning spaces needed to engage with a range of students. The classrooms use photovoltaic cells, rainwater collection and storage, LED lighting, ample natural daylighting, environmentally friendly materials, and efficient mechanical systems to allow them to operate as net-zero energy buildings, with the eventual goal of being energy independent. The Perkins + Will Sprout facility is unique from the others because of the roll up doors that connect the interior and exterior of the building, creating a flexible indoor/outdoor space for learning. When clustered with other modules, the buildings can open up into the neighboring building to create a larger common space between the classrooms.

### **SEED Classroom – SEED Collaborative**

Seattle’s SEED Collaborative has designed a similar solution to the portable building problem. Like the Sprout Space model, it is a net-zero energy building and prioritizes environmentally friendly features. The interior of the portable, however, is a lot more raw and exposed than the Sprout model, with a unique living wall and



*figure 12: exterior of the SEED Classroom*



*figure 13: interior of the SEED Classroom*

composting toilet features. The SEED model thinks of the classroom as a living laboratory, and sections of the space are separated out to function as an actual lab to support learning. A notable key feature of the SEED Classroom is its anticipated lifespan of 100 years, being designed to last ten times as long as the average portable school

building. Though the SEED Classroom is reportedly designed for a 100-year lifespan, most non-structural building materials have a lifespan of much less than that. Thus, most of the components in the building will require regular replacement and maintenance in order for the building to endure 100 years. A longer lifespan is an ideal concept for California's schools, though minimal maintenance is also desirable. There has to be a tradeoff between priorities.

### **Onagawa Atelier – Shigeru Ban**

Pritzker prize winning Japanese Architect Shigeru Ban specializes in rapidly assembled and disassembled buildings, often disaster relief emergency housing. His trademark material is a structural paper tube coated in polyurethane to provide fireproofing



*figure 14: exterior view of the Onagawa Atelier*

and water protection. Ban's work is unwaveringly innovative, yet humanitarian, tied to an authentic appreciation for the human experience. The Onagawa Shipping Container Housing project was designed to be rapidly constructed emergency housing for those who lost their homes in the 2011 earthquake and tsunami. At the center of the housing project is a temporary atelier, or school, made of Ban's trademark structural paper tubes and clad with a translucent corrugated polycarbonate. The polycarbonate gives the interior a soft glow and ample natural light for learning. The interior of the space is left relatively unfinished with exposed wood and some gypsum wallboard. Ban designed all of the emergency housing and accessory buildings to have simple wall mounted wood storage systems as well, to provide practical spaces for living and learning.

Shigeru Ban's Onagawa Atelier stands out as the most humanist and innovative of the three case studies reviewed. However, it is an emergency facility and does not need to meet the challenging structural and building codes enforced in California. What Ban's model does offer is a school prototype that is truly unique from the others because it does not need to be shipped as a complete unit. It is a kit of architectural parts that are delivered to the site before being built.



figure 15: interior of the Onagawa Atelier

Hence, the ceiling can be higher. The assembly methods and materials are more transparent. There is a pureness and authenticity to the building that is inspirational, despite being made of paper and plastic.

## **SUMMARY**

This thesis proposal to replace thousands of school portable classrooms throughout the state of California requires an investigation of healthy spaces for learning, ways the buildings can be adapted to suit different climates, and construction methods that can be rapidly deployed. Studying the physical, emotional, and environmental factors related to healthy spaces for learning revealed that connectedness and student engagement is the greatest factor impacting student learning and achievement. It is also notable that environmental factors such as air quality, natural daylighting, and acoustics have a significant impact on students' ability to learn.

An analysis of regional architecture highlighted the architecture benefits from being responsive to its site and environment, taking advantage of the unique conditions specific to one particular place on earth to create rooted, authentic buildings.

The study and history of prefabricated buildings revealed many of the factors that have plagued building industry manufacturing in the past, as well as revealed the potential for prefabrication in the future, provided some criteria are met. The most notable criterion that can be applied to this thesis is that prefabricated buildings need to be applied on a large enough scale to make them cost-effective, they must be customizable and able to be personalized, and the tectonics should be clear and simple enough for most people to assemble. If not, too much time will be wasted on site, making prefabrication more complex than traditional site based building.

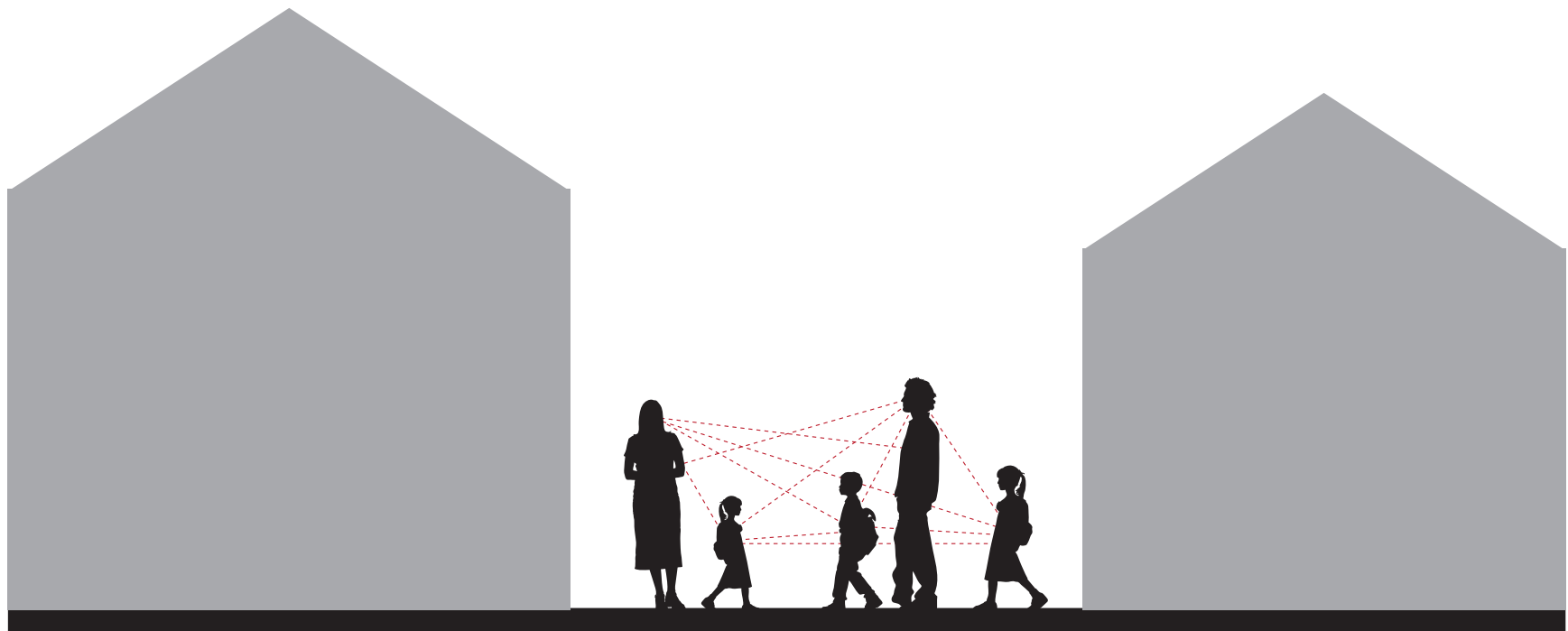
The combination of these factors; healthy spaces for learning, a regionally adaptable approach, and prefabrication, are critical to support the proposal to replace portable classrooms throughout the state of California. The proposed spaces should be designed to optimize elementary school student learning, be suitable to a diverse range of local climates throughout the state, and be able to be constructed in very little time. Successfully integrating these three design solutions can offer a viable solution to the problem of replacing school portable classrooms throughout California.

# METHODS:

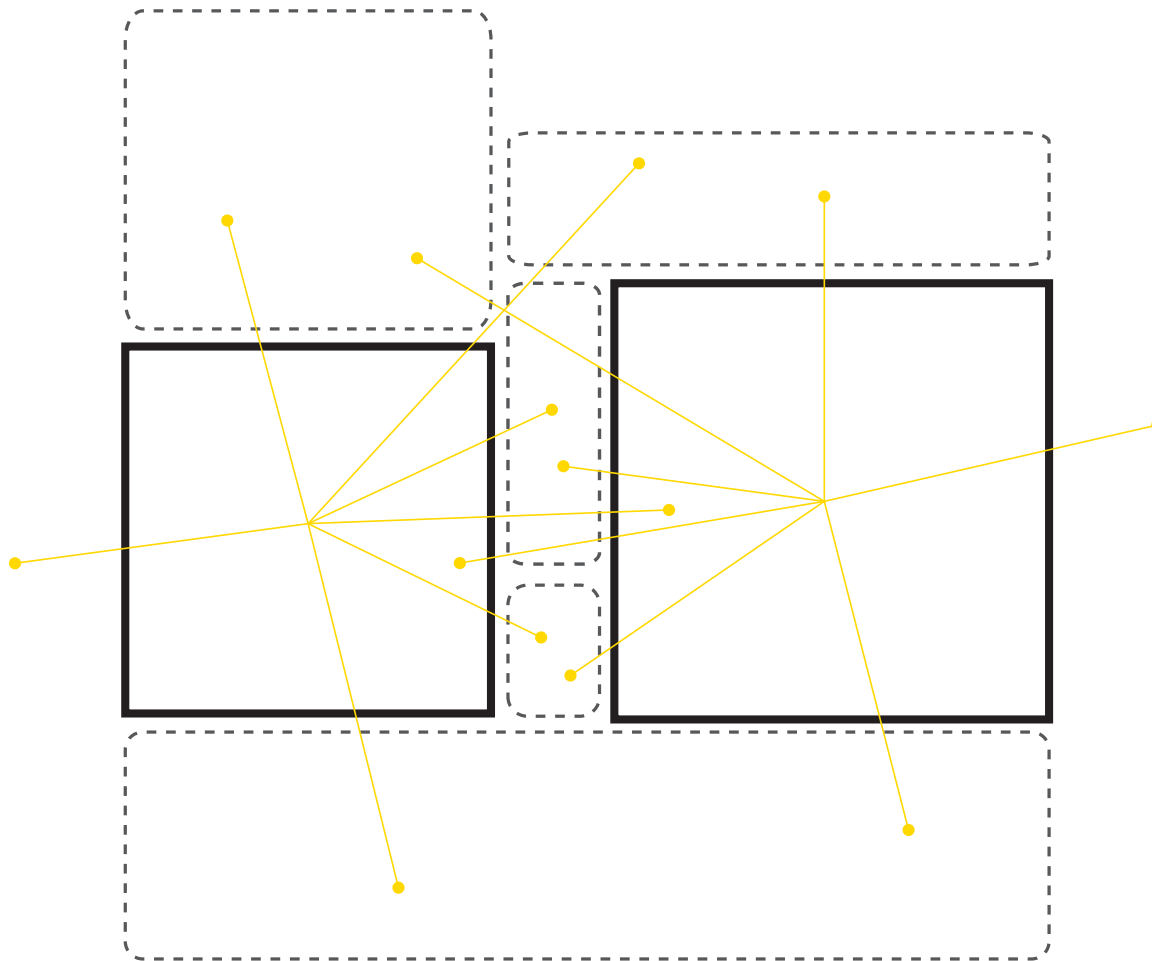
## OVERVIEW OF DESIGN METHODS

With its overtaxed, aging portable classrooms, the state of California needs a new approach to meeting the demands of its expanding public school system. The overarching goal of this thesis is to create a prototype for cost effective, rapidly deployable

but long-term classrooms to replace California public elementary school portables throughout the state. The classrooms should be designed to foster a greater sense of community while maximizing the environmental conditions required for healthy learning spaces.



*figure 16: diagram of buildings encouraging interpersonal connections*



*figure 17: diagram of connections between interior spaces and all of the surrounding areas*

Studies also show that basic environmental conditions such as natural daylighting, noise levels, and ventilation can contribute to enhanced learning outcomes (Environmental Health Conditions in California's Portable Classrooms 2004). Portable classrooms are shown to be less conducive learning spaces due to their detachment from the central school infrastructure and sub-par environmental conditions (Growth and Disparities 2006).

The design methodology implemented in this thesis focuses on the topics framed in the literature review - healthy spaces for learning, adaptable regionalism, and potential for simple construction and assembly. While many other factors were also carefully considered throughout the design process, these three were the design priorities guiding the decision making process.

## MEASURES OF SUCCESS

California's youth should have healthy classrooms that are conducive to learning. The replacement classrooms should establish a clear relationship to the rest of the school, each other, and the outdoors in order to foster a greater sense of community and connection to the outdoors. The benefits of replacing school portable buildings with inspiring, healthy places to learn are limitless. Happier, more connected and engaged young students results in better-adjusted adults that will only be beneficial to the future state of California. Investing in elementary school educational facilities now will reap a much wider return than what was invested.

A successful prototype needs to incorporate careful site planning strategies, in which the new buildings replacing the portables will tie into the existing school infrastructure while responding to a given site's environmental conditions so as to maximize natural daylighting, cross ventilation, and a connection to the outdoors. The prototype

also needs to be practical. Cost, durability, building lifespan, resource availability and duration of construction are all factors that need to be carefully considered. Finally, a successful prototype needs to connect to the central school infrastructure and to provide healthy and inspiring classrooms that properly enrich and support the learning process while being authentic to the people and place it serves.

# PROGRAM:

## PROGRAM GOALS

The project program is a repeatable prefabricated classroom module that can be clustered on site with site-specific infill that creates shared spaces for students and teachers. The recommended minimum size of a classroom for first through sixth grade is 960 square feet. The classrooms for this project are larger than the minimum at over 1,100 sf each to allow for more flexible learning spaces. The shared spaces range in size to suit different scales of human interaction – some smaller and more intimate, and others sized to suit groups more appropriately. Some are covered, but exterior and others will be fully enclosed. The fully enclosed areas will be appropriate places for teachers to gather and talk, or have one-on-one sessions with students. The larger outdoor shared spaces, some covered, some uncovered, will be dedicated to outdoor education, play and social interaction.

The thesis goal is to design three prototypes for school buildings that respond to the site geography, climate, and existing infrastructure in a simple and intuitive way. The proposed design

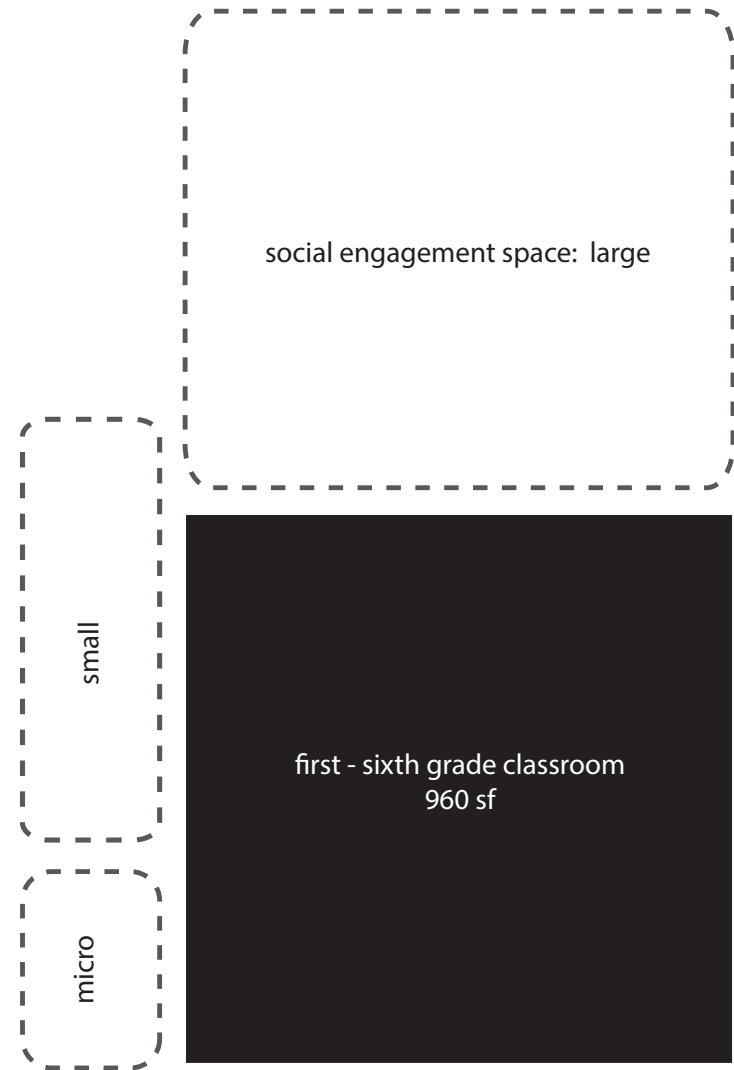
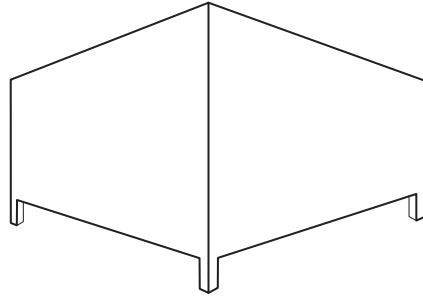
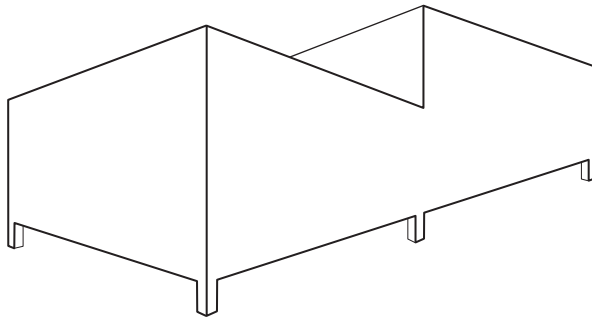


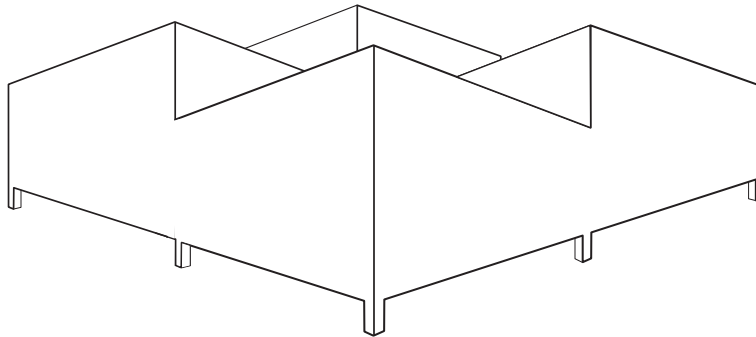
figure 18: diagram of classroom program



Single module:  $24' \times 24' = 576$  sf  
Small classroom (~10 students)  
Administration building  
Lab/art/music room



Double module:  $48' \times 24' = 1152$  sf  
Standard classroom (~30 students)



Quadruple module:  $72' \times 24' = 2304$  sf  
Extra large classroom  
Community room  
Library

*figure 19: diagram of classroom program scale and adaptability*

solution is a system of fabrication that can be slightly customized for each site through the use of digital technology, allowing the buildings to be manufactured offsite, or prefabricated, then quickly installed on school campuses. Schools need a system that can be rapidly deployed because they cannot have construction on site when school is in session, which would only allow for construction during the summer months. However, the design strategy is not to create a better version of a school portable model as it currently exists, but rather to design a long-term non-portable solution with a projected lifespan of 80 years.

The design goal for this project is to create a prefabricated system as an inexpensive and adaptable replacement for school portables throughout California. Another driving design goal is to integrate an inspiring dose of whimsy into the user experience, heightening spatial awareness and student engagement with their surroundings. Digital technology has the capability to customize an established system, and this project seeks to explore the potential for climactic, programmatic, and aesthetic customization within an established framework. While the design methodologies pertinent to varying climactic conditions will be carefully calculated, the aesthetic

methodology will be intuitive. The driving priorities behind design decisions are longevity, practicality, resource efficiency, and user experience.

The primary objective of this study is to determine what type of building system could be employed as an effective and inspiring learning space throughout the state of California. Using three sites represent the diverse climate zones of the state is intended to insure that the design strategy will be an appropriate solution for replacing portable school buildings throughout the state. There is not a one-size-fits-all solution.

#### **LIMITS + DELIMITS SUMMARY**

There are delimits and limits of this study. The delimits are personal constraints that I have determined based on my preferred areas of research and design. The factors this thesis will focus on are climate, site conditions, and land-use patterns. It also aims to carefully consider the elements of healthy learning environments, including collaborative learning arrangements in order to group the classroom units effectively. However, a wide variety of alternative factors could

be explored when designing for these site, the most notable being the populations the respective schools are serving. While designing for changing demographics is undoubtedly important, this thesis study considers demographics a delimit because the topic is expansive and would create too large of a project. Another delimit is politics. The California school system is already and overly political climate, so this study is not considering any political debates. Another delimit is the issue of the existing school facility design aesthetic. The permanent facilities of three schools represented are not beautiful, well maintained buildings, but this thesis will not address how they could be renovated or changed. The proposed design will respond to the existing facilities based on site and orientation, but not aesthetic conditions. Doing so is beyond the scope of this project.

A major limit of the study includes the two sites outside of my hometown. Since I have not visited Pollock Pines or Yucca Valley within the framework of this project, my perception of the sites is likely inaccurate. I have spent a lot of time in the Sierra Nevada mountains and some time in the California desert, so feel that I understand the climatic conditions to some degree, but have not experienced all of the seasonal variations that can only be understood by living in a location for a period of time. I also do not fully understand the contextual site conditions of the Pollock Pines and Indio sites like someone local would. Finally, limited information is available on California school facilities, so some shortcomings on site information resources are likely.

## SITES:

The state of California is large and encompasses a wide variety of biomes, ranging from the arid valleys of the Mojave Desert to the highland mountaintops of the Sierra Nevadas. To test the viability of the prototype, this thesis will target three California sites that represent the environmental range of the state, showing how well designed portable classrooms can be adapted to suit their climate. Selecting sites with differing climatic conditions heightens the possibility that the resulting design framework will lend itself to effective implementation throughout the entire state.

California is separated into four distinct biomes, which are defined by their climate and dominant vegetation. Biomes share similar climatic characteristic such as temperature, prevailing wind, and precipitation levels.



*figure 20: map of project site locations and biome classifications*

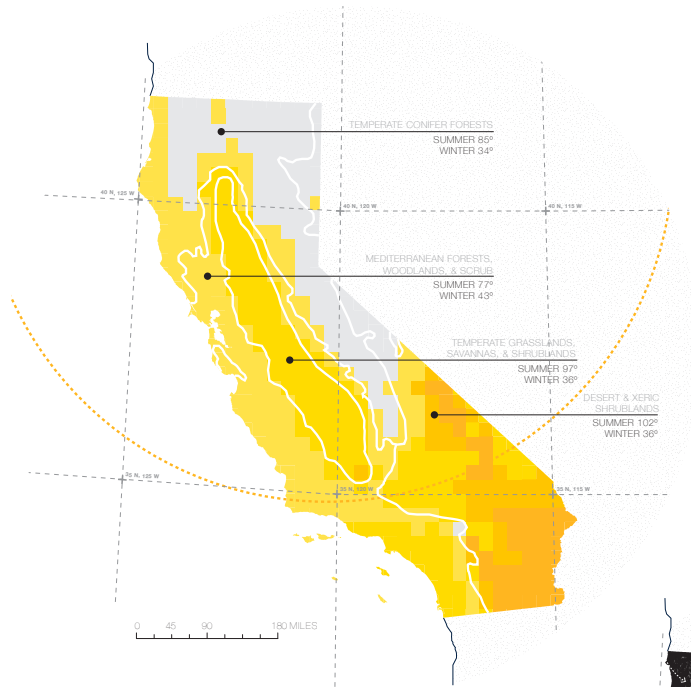


figure 21: biome average temperatures

figure 22: biome average precipitation levels

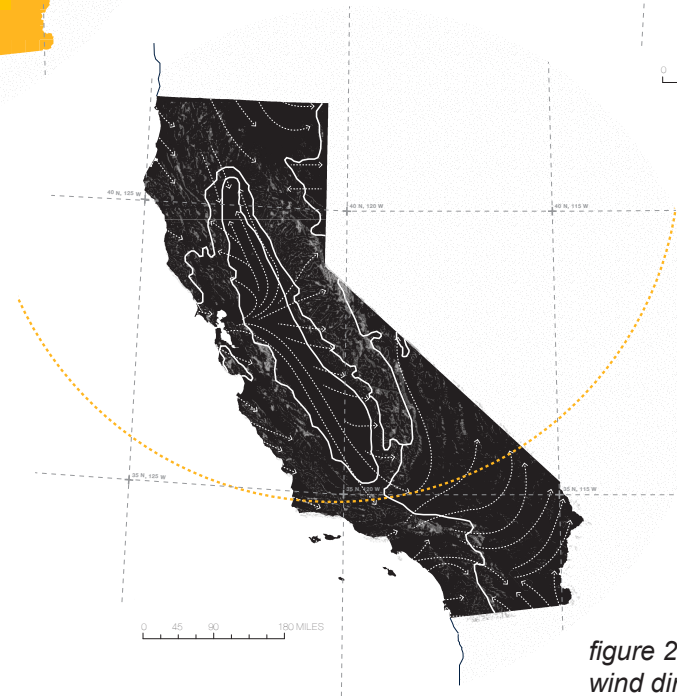
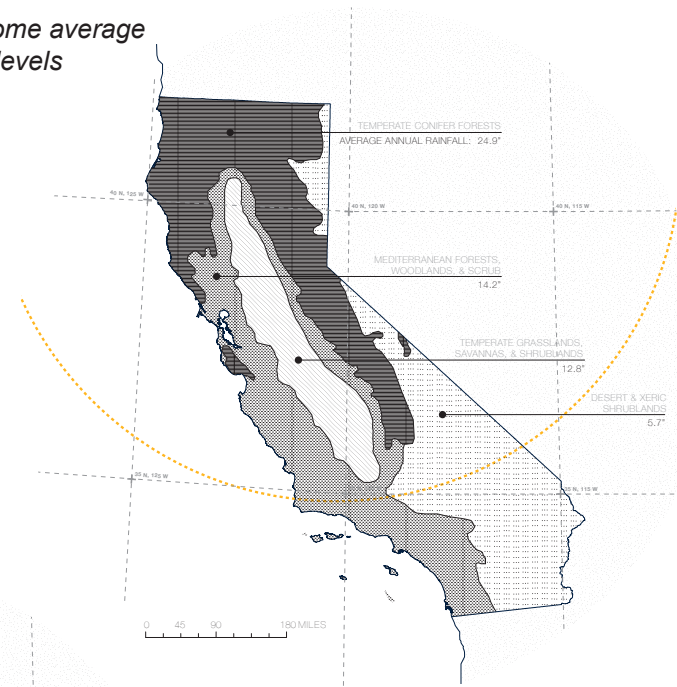


figure 23: biome prevailing wind directions

Because biome regions group climatically similar areas, this thesis proposes that the general site strategy and orientations used for each of the three sites can be replicated throughout their respective biome.

### HOLLISTER, CA

The first site is Hollister, California, which I am particularly connected to because it is my hometown. Hollister's school site of focus is R.O. Hardin Elementary School, which is located on the west side of town within a relatively suburban framework. The school has around 800 students who range from kindergarten to sixth grade. While R.O. Hardin School is located within the old, historic part of the town, the area immediately west is relatively undeveloped. The city waste pond is also located to the west of the project site, which gives the area a distinctive smell when the wind blows from the west. The school site



*figure 24: biome classifications throughout state*

itself is fairly large, with 43 classrooms condensed on a six-acre site. Twelve of the 43 classrooms are portable buildings. The grounds also include a gym, a playground with basketball courts, and a large open field with baseball fields.

Hollister is an agricultural community in the Central Coast region of the state with a population of about 35,000 residents. Hollister has a temperate climate with cool ocean air moderating warm summers and mild winters, making it an ideal zone for agriculture. The Central Coast has fertile soil ideal for growing produce, and is often referred to as the “salad bowl” of California due to the variety of produce it grows.

The design and program for the Hollister school site is a series of classrooms that respond to the Central Coast climate and is suited for children in first to sixth grades. The design proposal will replace the 12 portable classrooms on the current site to create more optimal conditions for community engagement, where the new structures relate to each other, the existing school facilities, and the rest of the site. The design solution will also allow for the proposed model to be implemented on a larger scale, in the event that populations continue to rise and the school continues to expand.



#### TEMPERATE CONIFER FORESTS

Temperate climate with warm summers and cool winters. Adequate rainfall to sustain a forest.



#### TEMPERATE GRASSLANDS, SAVANNAS, & SHRUBLANDS

Temperate, semi-arid climate with hot summers and cold winters. Predominant vegetation is grass and shrubs. Fertile soil with rich nutrients and minerals.



#### MEDITERRANEAN FORESTS, WOODLANDS, & SCRUB

Hot, dry summers and mild, wet winters. Tremendous plant, habitat and animal diversity. Prone to wildfires.



#### DESERT & XERIC SHRUBLANDS

Largest terrestrial biome in the world characterized by having a small amount of moisture. Evaporation exceeds rainfall. Poor soil quality. Rich flora diversity.

figure 25: biome characteristics



*figure 26: regional map of Hollister with the site noted in yellow*



*figure 27: Hollister's rural Central Coast landscape*

The Central Coast climate is mild, with annual average highs in the 70-degree region and lows in the 30s and 40s. While it does rain in the winter and spring months, the rest of the year is somewhat arid and dry. The design for the Central Coast school model will incorporate ample outdoor space to foster an enhanced relationship to the environment. The main classroom windows will be oriented to

the north, which offers the best natural diffuse daylight without glare. A rainwater collection system will be essential, as Hollister and the rest of California continuously suffer droughts. Outdoor classrooms will be incorporated, as the temperate Central Coast climate is ideal for year round outdoor education.



*figure 28 : R.O. Hardin's existing portable classrooms relationship to existing school on the left*



*figure 29 : view of R.O. Hardin's existing portable classrooms from the south*

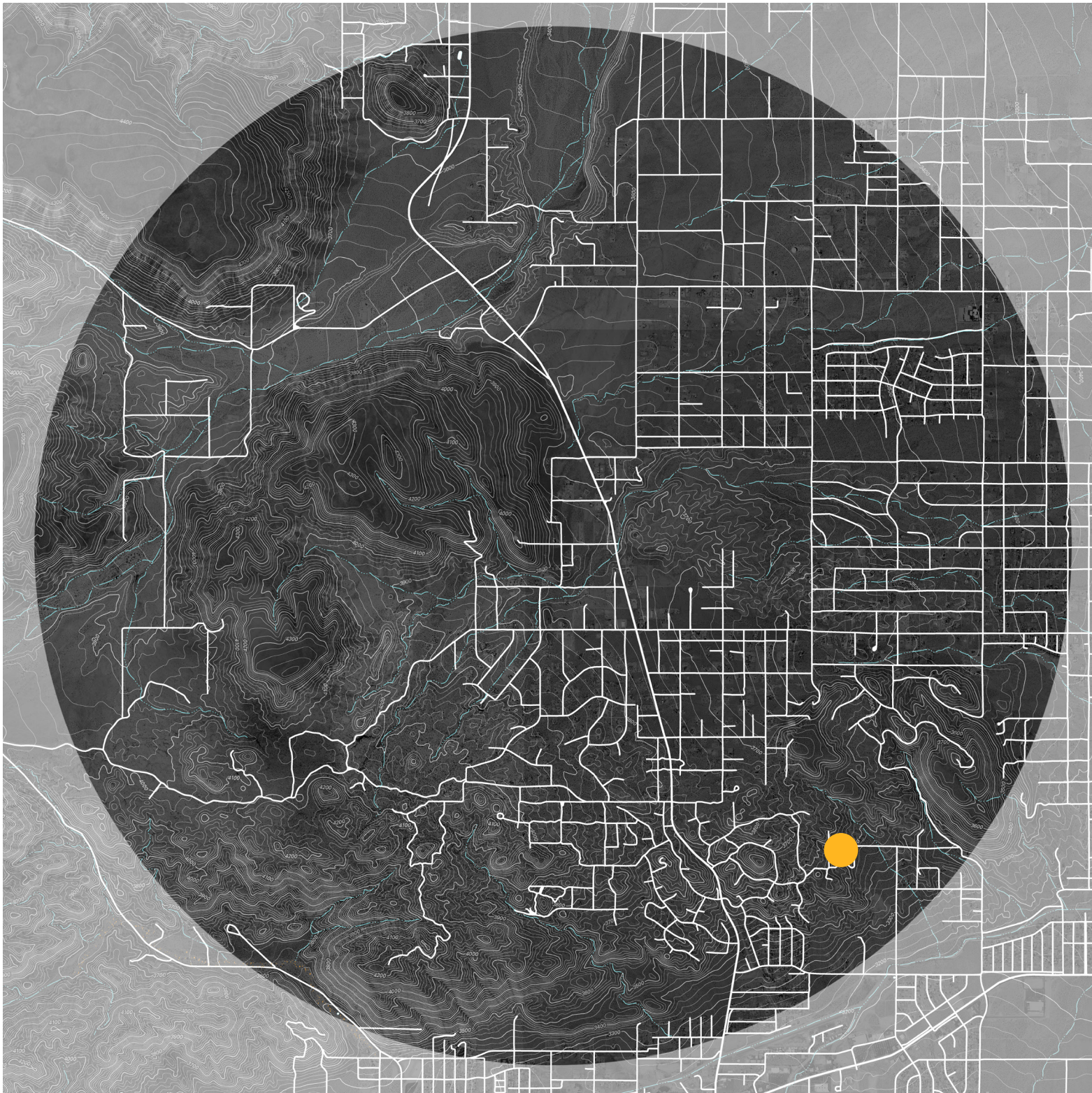


*figure 30: Yucca Valley's native desert landscape*

## **YUCCA VALLEY, CA**

The second site is Yucca Mesa Elementary School in Yucca Valley, CA. Yucca Mesa Elementary School is located in a rural part of Yucca Valley that is becoming rapidly urbanized, as the desert regions of California are growing more quickly than any other area. Yucca Valley has a growing population of about 20,000. The site is considered a high mountain desert and is located within the Mojave Desert, which

covers a significant portion of Southern California. The Mojave Desert encompasses high and very low elevations, including the Death Valley Basin that is the lowest point in the state. Yucca Valley is at an elevation of about 3000' above sea level, so is mountainous with significant topography. Winters are very cold with a couple of instances of snow, and summers are extremely hot.



*figure 31: regional map of Yucca Valley with the site noted in yellow*



*figure 32: main entry to Yucca Mesa Elementary School*



*figure 33: view of playground and fields at Yucca Mesa*

Yucca Mesa Elementary School was built in 1985 and includes 21 permanent and 9 portable classrooms. Other school facilities include a computer lab, a teacher work room, a library, a staff lounge and an outdoor amphitheater. There are about 430 students at the school, enrolled in kindergarten through sixth grade. The site is located in a rural part of Yucca Valley that is quickly becoming a sprawling suburban community.

The design and program strategy for Yuccan Mesa Elementary School is very similar to the Hollister R.O Hardin site, but will create a building that responds to a desert rather than to a mountainous or coastal climate. The school has nine portable classrooms, which will be replaced and re-oriented on the site in a way that optimizes the region's environmental conditions while creating a series of spaces for community engagement and connection in between them.

The Mojave Desert climate is hot, with very hot summers and cold winters. Thus, the outdoor spaces need to be covered in order to be useful in the warmer summer months. The roof and walls will also need considerable insulation to keep the interior spaces cool. Natural ventilation strategies will need to be maximized in order to be effective. The buildings themselves should be clustered together more closely

than the other models to create more shared shady areas and minimize heat gain from the scorching sun.

### **POLLOCK PINES, CA**

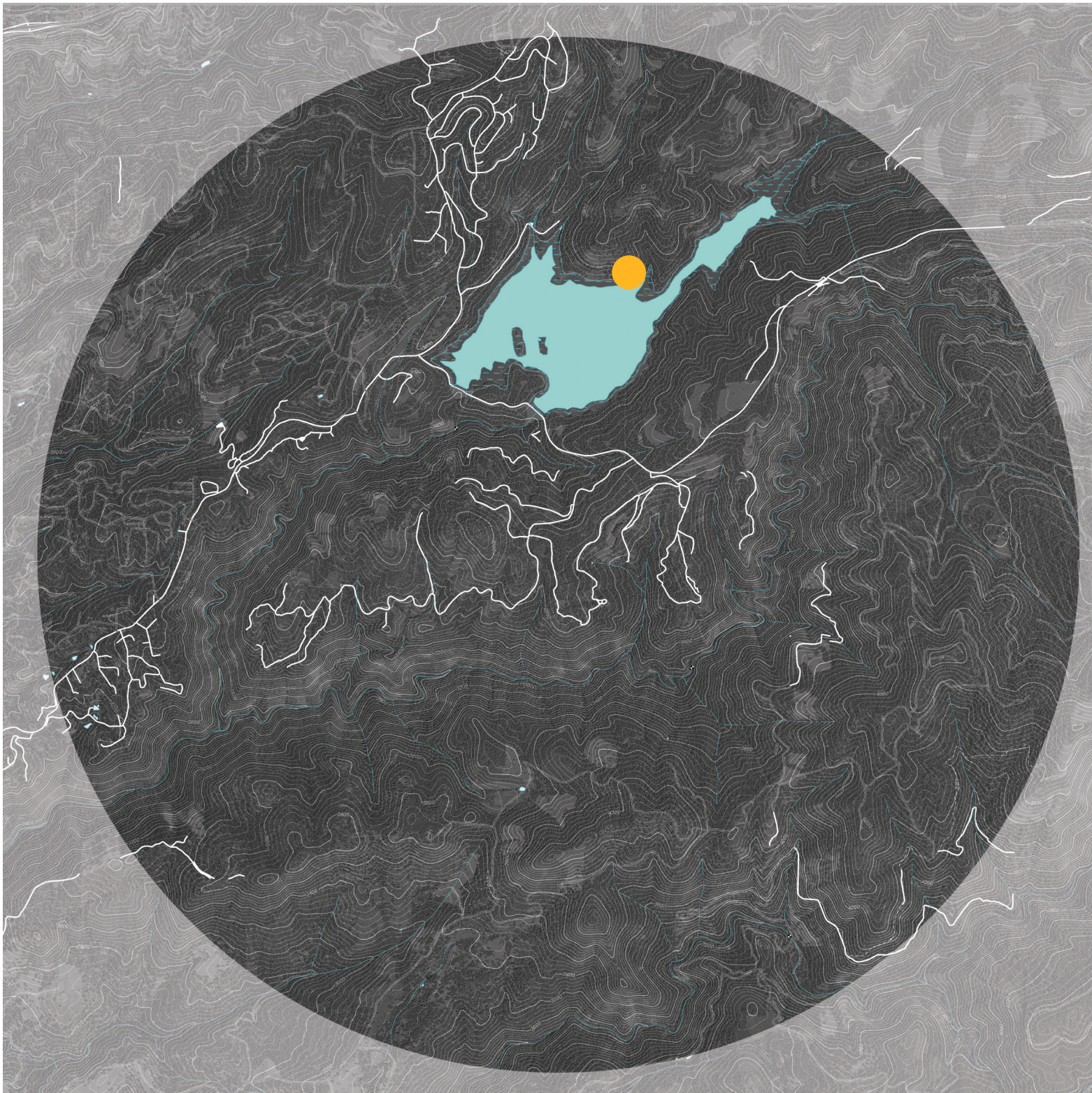
The third site does not include an existing school and is intended to show how the replacement portable classroom system could be implemented to create an entirely new school. The site is located in

Pollock Pines, California, which is part of El Dorado County on the lower west side of the Sierra Nevada mountain range. Pollock Pines has a population of around 7,000. The Sierra Nevada region is of the temperate conifer forest biome, which features warm summers and



*figure 34: Pollock Pines' Pine and Redwood forest*

very cold winters. The area receives an average of five feet of snow during the winter months with an average winter temperature of 37 degrees. Summers are warm and dry at an average of 91 degrees. Downtown Pollock Pines is located off of Interstate 90, which is the



*figure 35: regional map of Pollock Pines with the site noted in yellow*

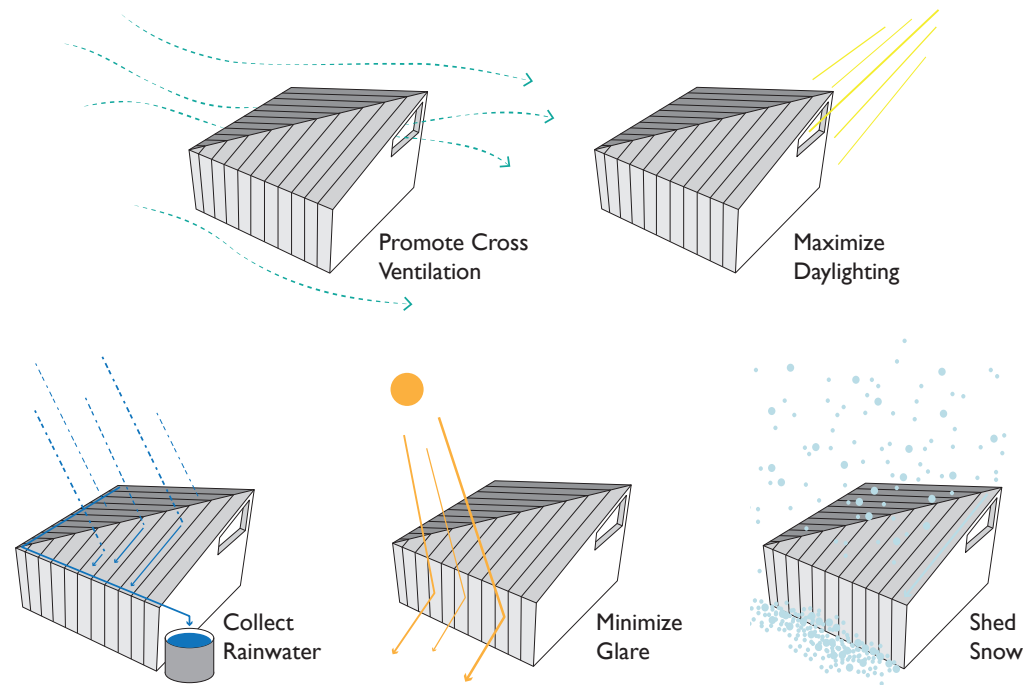
main road between Sacramento and South Lake Tahoe. This site is much more rural than the others and is located adjacent to Jenkinson Lake at the south eastern part of the county. The area east of the site is undeveloped forest land whose roads close down in the winter.

The proposed program for the new Pollock Pines Elementary School is two classrooms and one administration/general space to create a center for the new campus. The design goal is to create a building that responds to a mountainous Sierra Nevada climate and is suited for children in first through sixth grades. The school proposal will site the new classrooms in the most optimal orientations based on the natural surroundings and relationship to each other. The design solution will allow for future growth in the event that the school continues to grow over time.

The design objective for this site is to maximize natural daylighting inside of the buildings. Because the area surrounding the school is dense with tall pine and redwood trees, not a lot of natural light filters down to the site. Maximizing solar orientations will be key to the design. Another pressing design objective is to accommodate cold winters and snow loads, a condition that is not seen throughout the rest of California, by spacing the buildings further apart in order to capture more natural daylighting, and pitching the roof system to allow snow to fall off easily. The building roof and walls will also require considerable insulation due to the cold outside temperatures.

## DESIGN:

The design proposal for a replacement system for portable elementary school classrooms throughout California responds to three specific criteria – the design needs provide a healthy learning environment while being adaptable to a wide variety of climatic conditions and can be quickly constructed over the summer months that school is not in session. My literature review revealed that healthy spaces for learning include ample lighting, ample ventilation, good acoustics, adaptable interior spaces, a visual and physical connection to the outdoors, and spaces for community gathering and social interaction. The design proposal targets all of these points while offering a more energy efficient, attractive portable classroom replacement.



*figure 36: diagram of module environmental response capabilities*

The design process began by carefully crafting a dynamic architectural form capable of harnessing the ideal environmental attributes of different sites. The module form was carefully designed to respond to climatic conditions and does a variety of things. First, the roof pitch is angled at thirty percent to allow for easy rain and snow runoff. This is the ideal angle for simple snow removal as applicable to the Pollock Pines and Yucca Mesa sites. The design proposes rainwater collection tanks adjacent to each classroom. The collected rainwater can

be used to water school gardens lawns, and landscaping, while teaching children about the importance of conserving natural resources. A thirty percent slope also is the best angle for optimizing solar panels in California, so classrooms throughout the state could gather enough solar energy to operate off of the grid, potentially even creating excess energy that could be used to power the older existing classrooms. The module features a pitched roof creates high and low point inside of the building, promoting natural ventilation and maximizing diffuse daylighting through high clerestory windows. Because the standard classroom includes two modules, the forms can rotate and change relationships with each other to create a plethora of environmental response options.

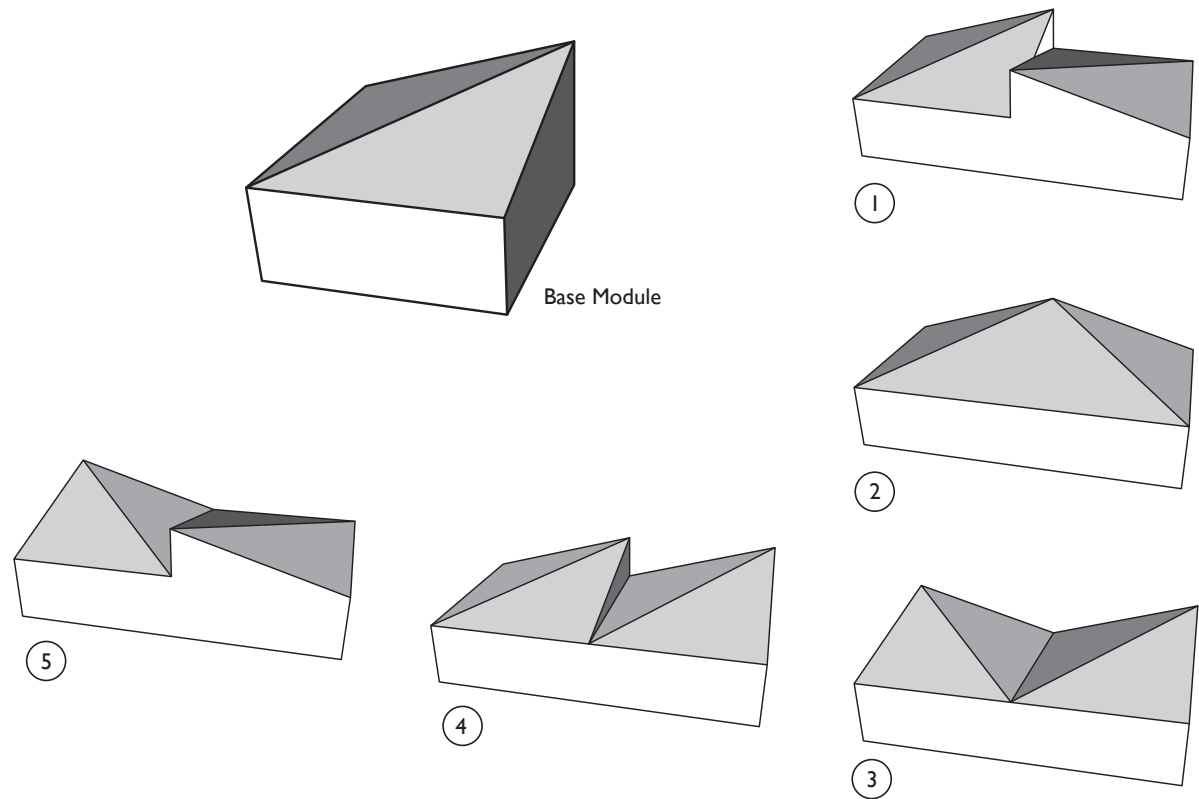
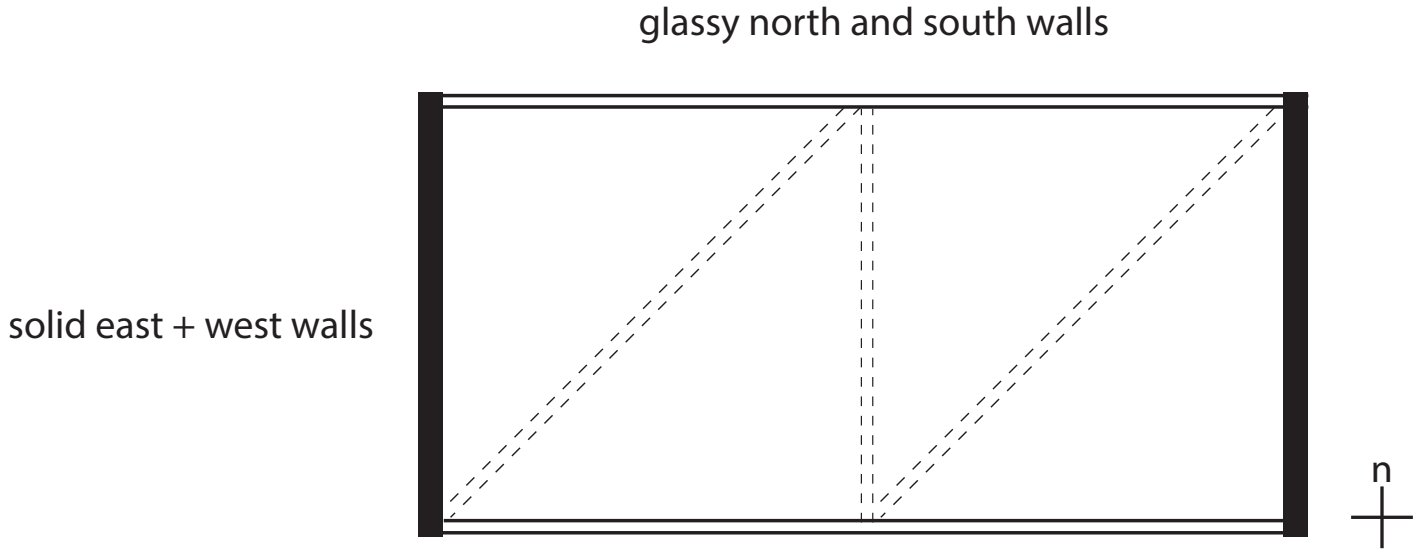


figure 37: module configurations

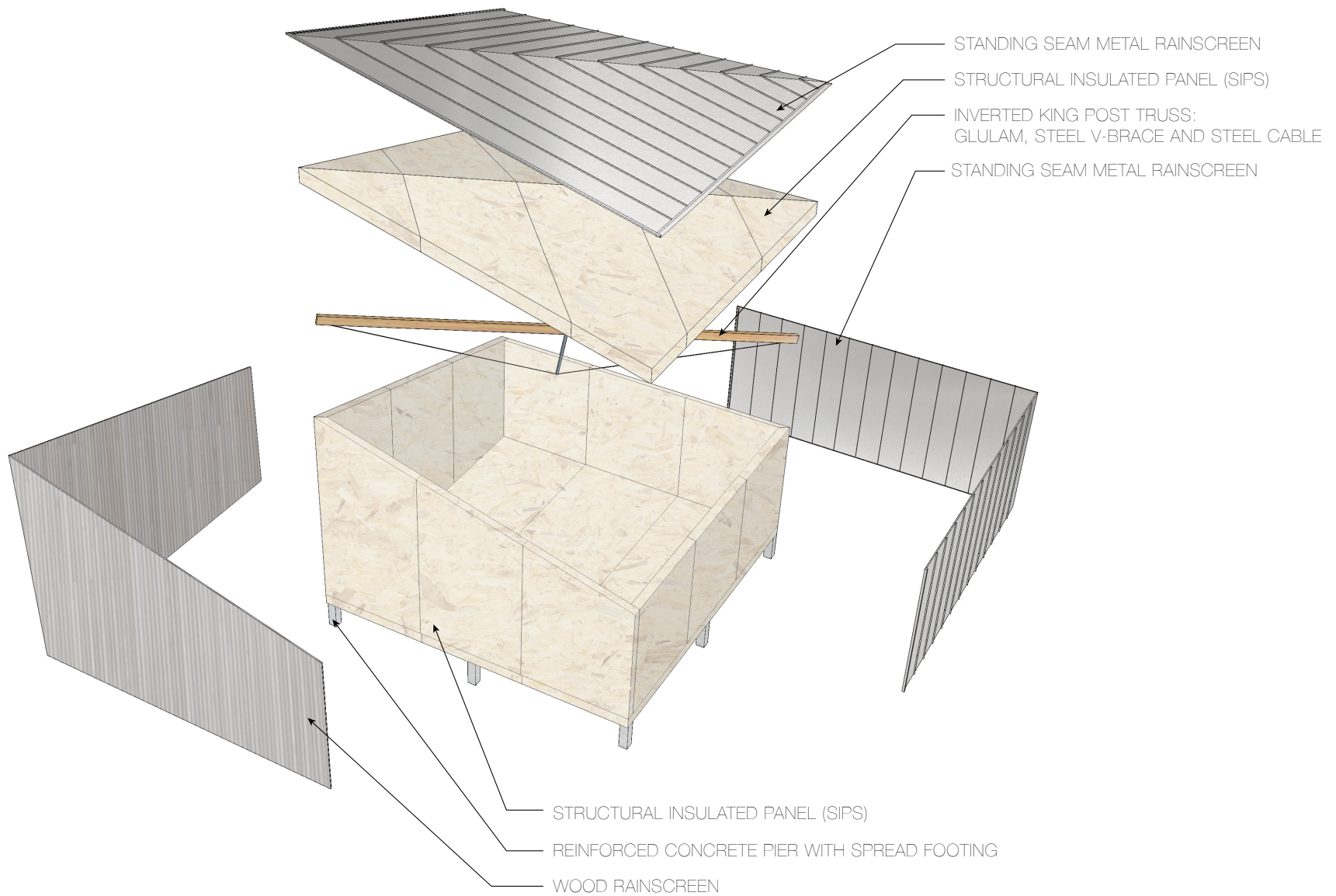
The module is also adaptable in scale. A single unit can be used as an administration space, a community room, lab, or shared computer room. If a larger space is needed, three or four modules can be easily combined. The modules interior walls can be removed or added as school needs change, allowing them to be dynamic and adaptable to ensure their longevity in a changing academic environment.



*figure 38: classroom general orientation strategy*

The general orientation strategy is to have the wide side of the classroom oriented to the north and south to maximize diffuse daylighting. The east and west walls are mostly solid with small rectangular windows for cross ventilation. The low side of the module should be oriented perpendicular to the direction of prevailing winds to maximize ventilation, as the cool air will enter at the low side of the building and the warm hot air will rise at the high point of the module and be released through high clerestory windows.

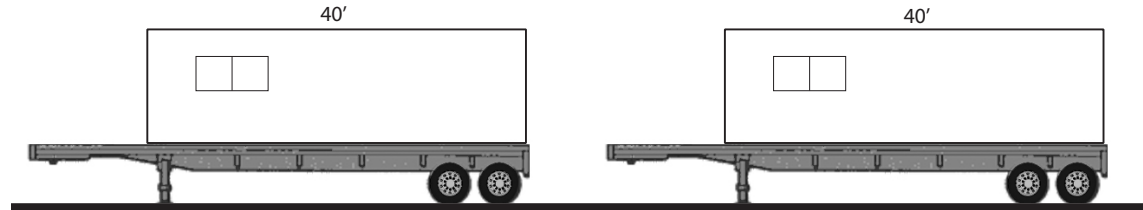
The structure is made of SIPs panels and clad in a metal and wood rain screen. The metal exterior is oriented to the south and west where the building is most prone to weathering. The wood rain screen wall with clerestory windows is oriented to the north for the best natural diffuse daylighting. The logic of using SIPs panels is that they can be fabricated off site and flat packed, reducing transportation costs and unnecessary travel complications. The existing portable classroom double-wide requires two full semi trips for a single classroom. The



*figure 39: tectonic concept*

SIPs panel solution can ship two full classrooms on one flat bed, so has one quarter of the travel footprint of current portable classrooms. Prior to the flat packed classrooms arriving at the site, concrete piers with spread footing would be cast to support the structures. The piers hold the classrooms up off the ground to minimize the impact on the site as well as minimize the amount of time and labor intensive site work required. The SIPs panels can then be delivered and easily assembled on site, then finished with building paper and a metal and wood rainscreen. Last, a raised deck is constructed on site between the classroom clusters, connecting all of the interior spaces to each other and providing opportunities for outdoor education.

Typical portable classroom:  
One classroom with two 40' trailer flatbed trips



Flat pack classroom:  
Two classrooms with one 70' trailer (max length) flatbed trip



figure 40: flat pack logic

The SIPs panels are structural, so are the primary structural system for the classrooms. As such, the most logical organizing principle for glazing and openings are punched openings in order to preserve the structural integrity of the system. The size limitations of SIPs panels informed the dimensions of the module, as the panels can be made in increments of two feet up to a maximum size of eight by 24 feet. The panels are a super simplified method of building, as all of the buildings

systems are integrated into the walls and coordinated in the factory, then plugged together on site. The panels have a high-density foam core with a hardy oriented strand board (OSB) shell. They are connected by an internal spline that is screwed into the neighboring

panel and fully sealed with internal sealant to create an airtight and highly energy efficient building envelope. The panels offer significant soundproofing benefits, energy savings, and a simple method of assembly, making them an ideal solution for portable classrooms.

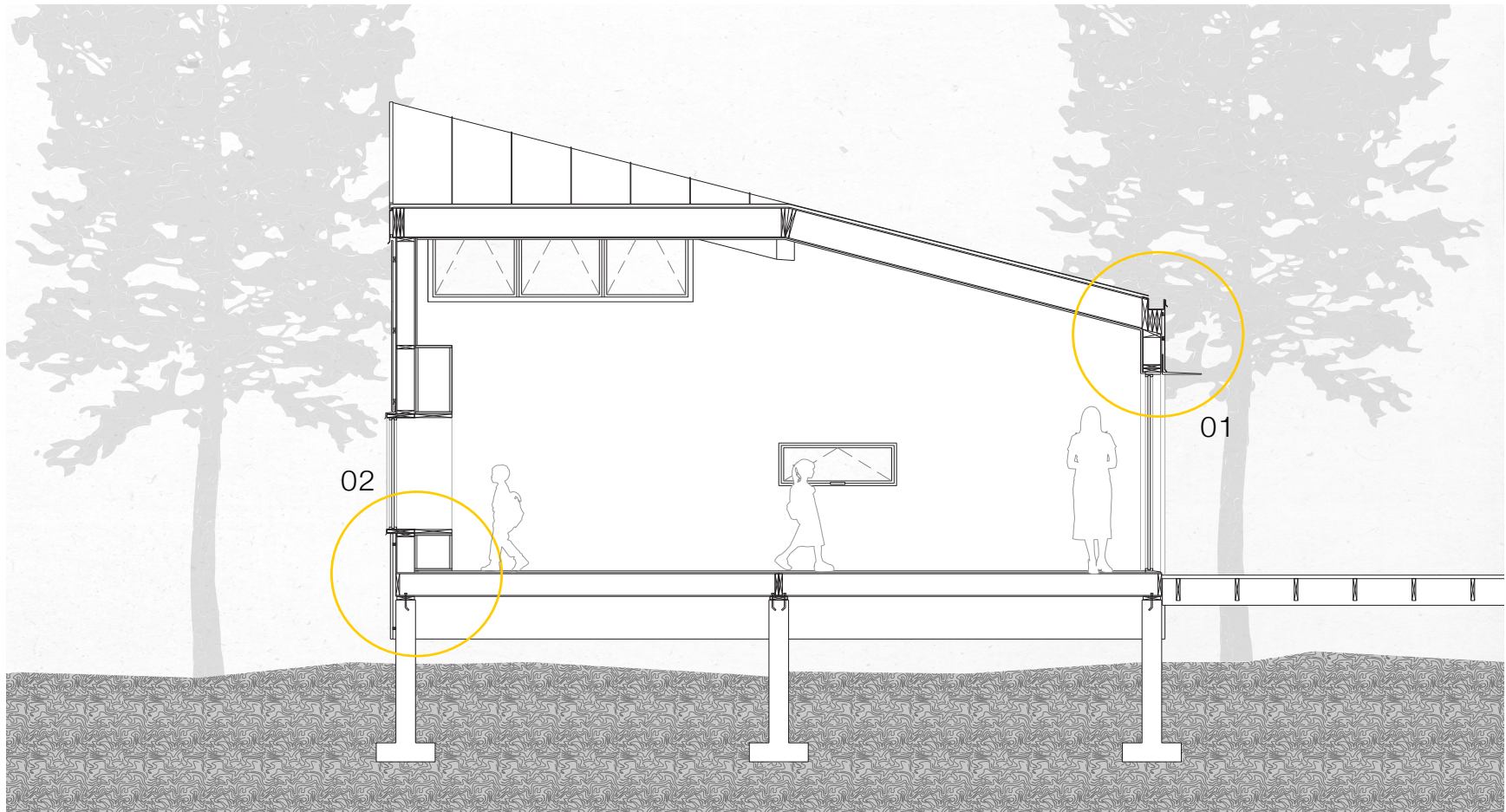
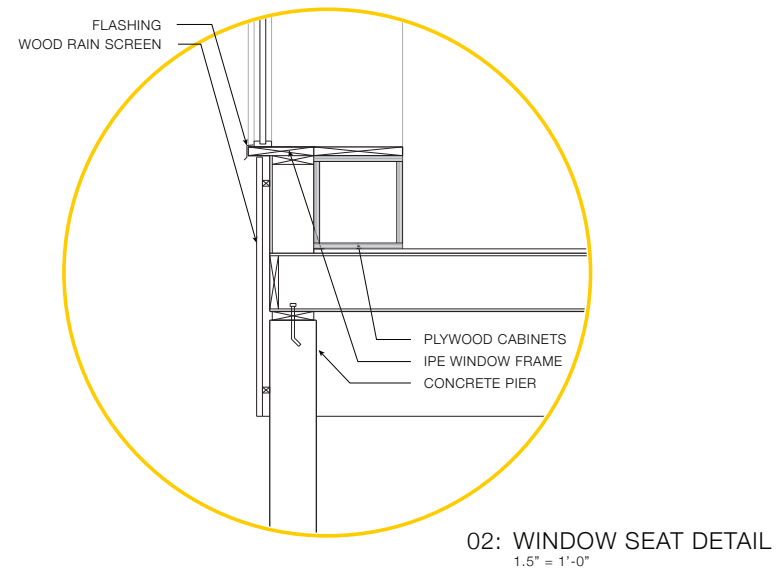
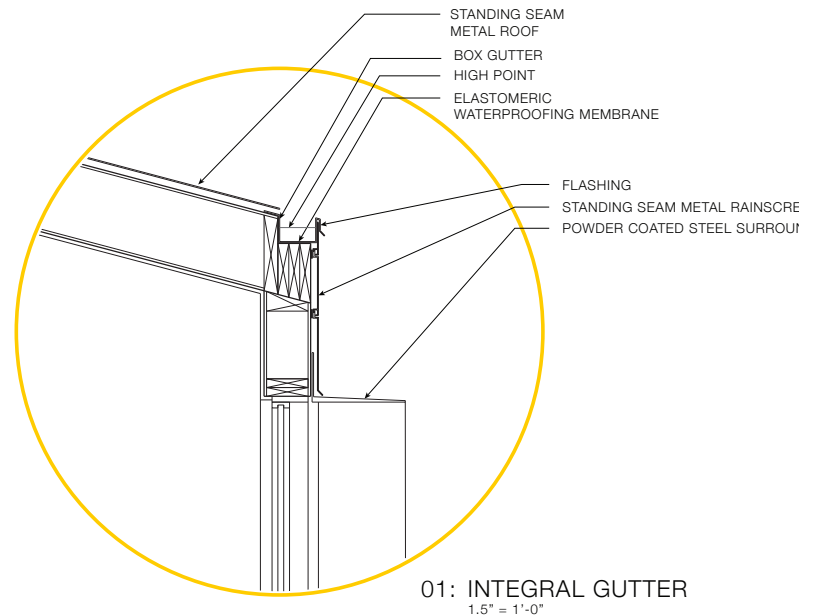
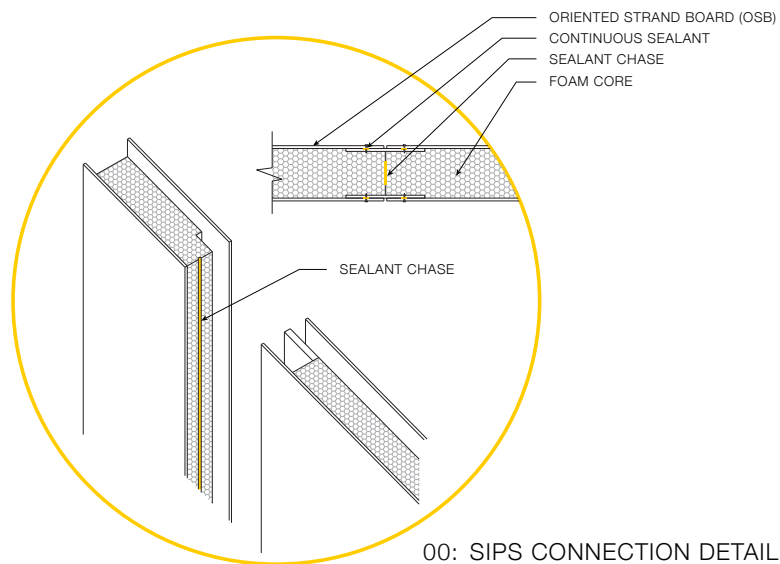


figure 41: classroom section



The classroom module offers a variety of child scale spatial experiences. The courtyard-oriented side of the classroom is glassy, open and public while the opposite side is more of a refuge. The walls are lined in storage cabinets, creating sitting nooks within the windows where students can read and work away from the group.

A critical design detail for the module is the integral gutter. The integral gutter allows the modules to be connected in a variety of ways while simplifying waterproofing issues.

figure 42:  
 construction details

## HOLLISTER, CA

Hollister's climate is characterized by hot, dry summers and mild winters. Mediterranean forest climates are ideal for agriculture and California's central coast produces the majority of the produce consumed in the United States. This area has dry, rolling foothills and lots of oak trees. The classroom modules are oriented eastward to maximize ventilation while capturing morning light and blocking glarish afternoon sunlight.

The school is located within a suburban community surrounded by agricultural land. The San Benito River runs along the southern part of the town. The existing school consists of three bars of classrooms. The outer two are bars are solely classrooms, and the central bar also houses classrooms as well as an administration office and a library. The gym is located on the west side of the site adjacent to the blacktop playing field and playground.

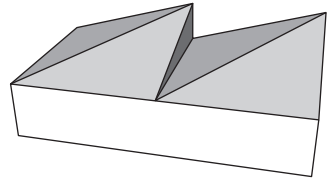
The proposed replacement of 12 portable classrooms is oriented to tie into the existing school and circulation patterns while creating clusters of common grades. First and second grades are located closest to the existing school so they can be more connected to



figure 43: Hollister location

the main school community. Fifth and sixth grades area located in the cluster furthest away, since the older students are more independent. The three clusters are courtyard-oriented spaces that connect to each other, the outdoor space in between, and the community beyond.

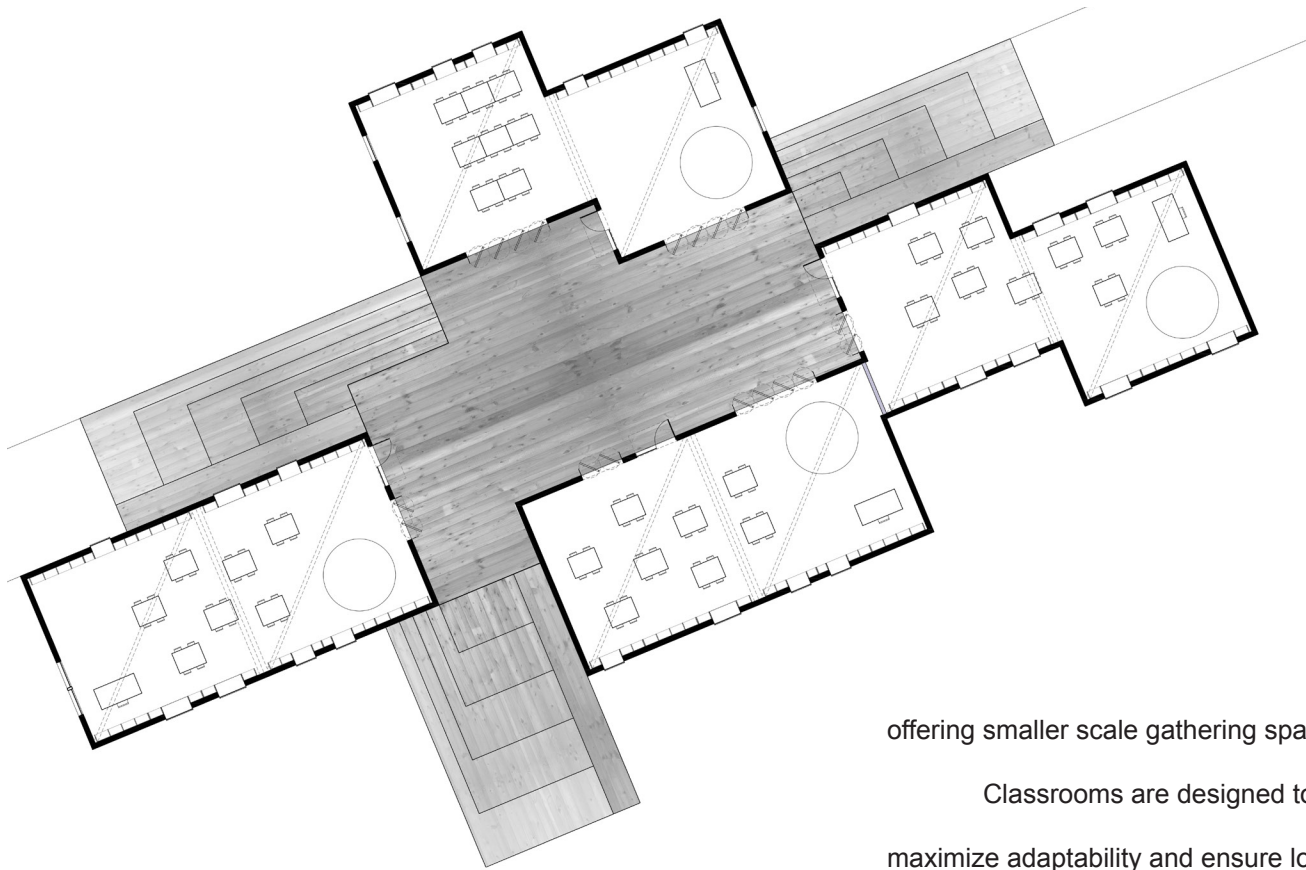
The low wall of the classroom module is oriented perpendicular to the prevailing wind direction to maximize natural ventilation.



*figure 44: Hollister site plan and module configuration*



*figure 45: Hollister  
sectional perspective*

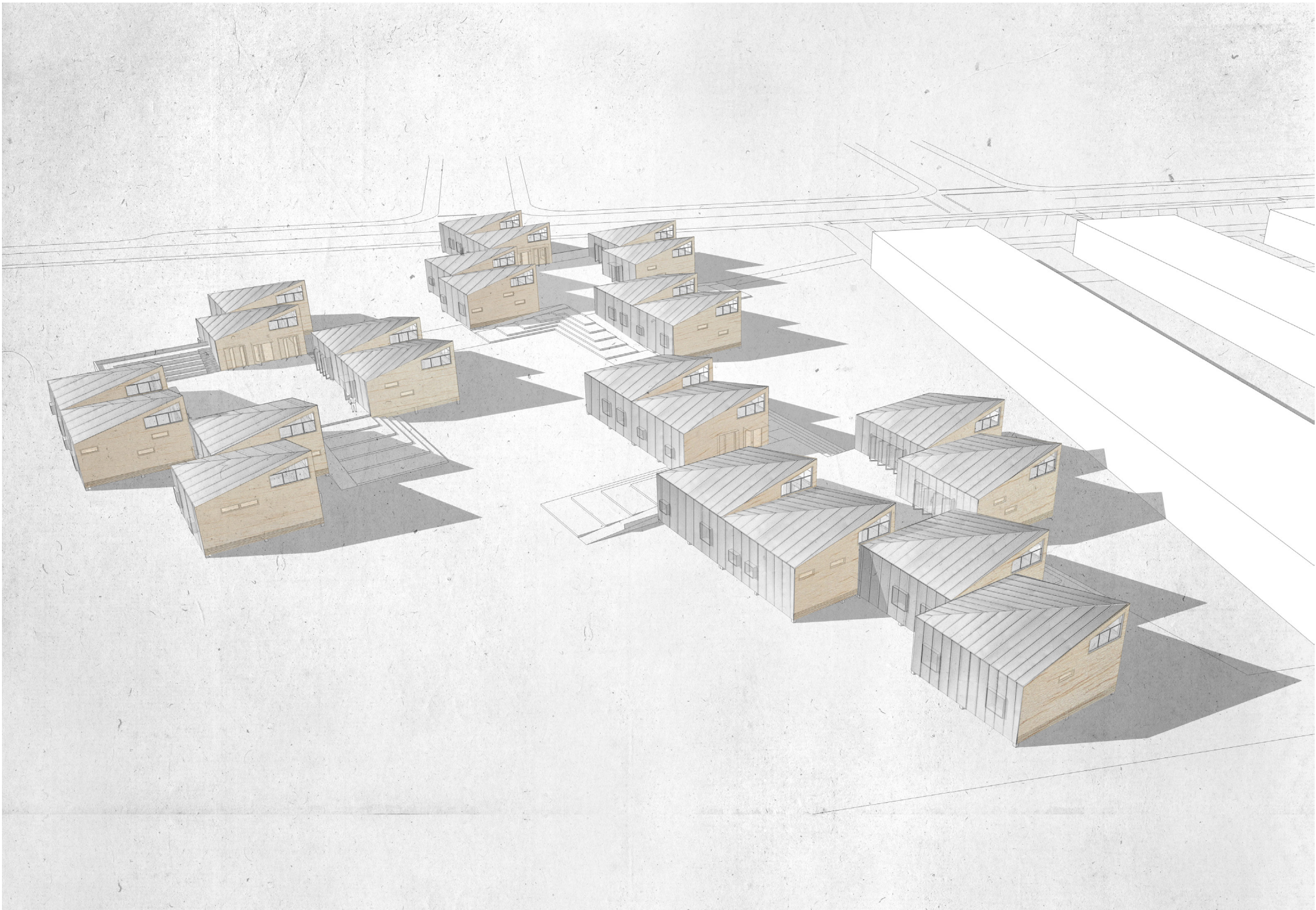


*figure 46: Floor plan of one cluster of classrooms*

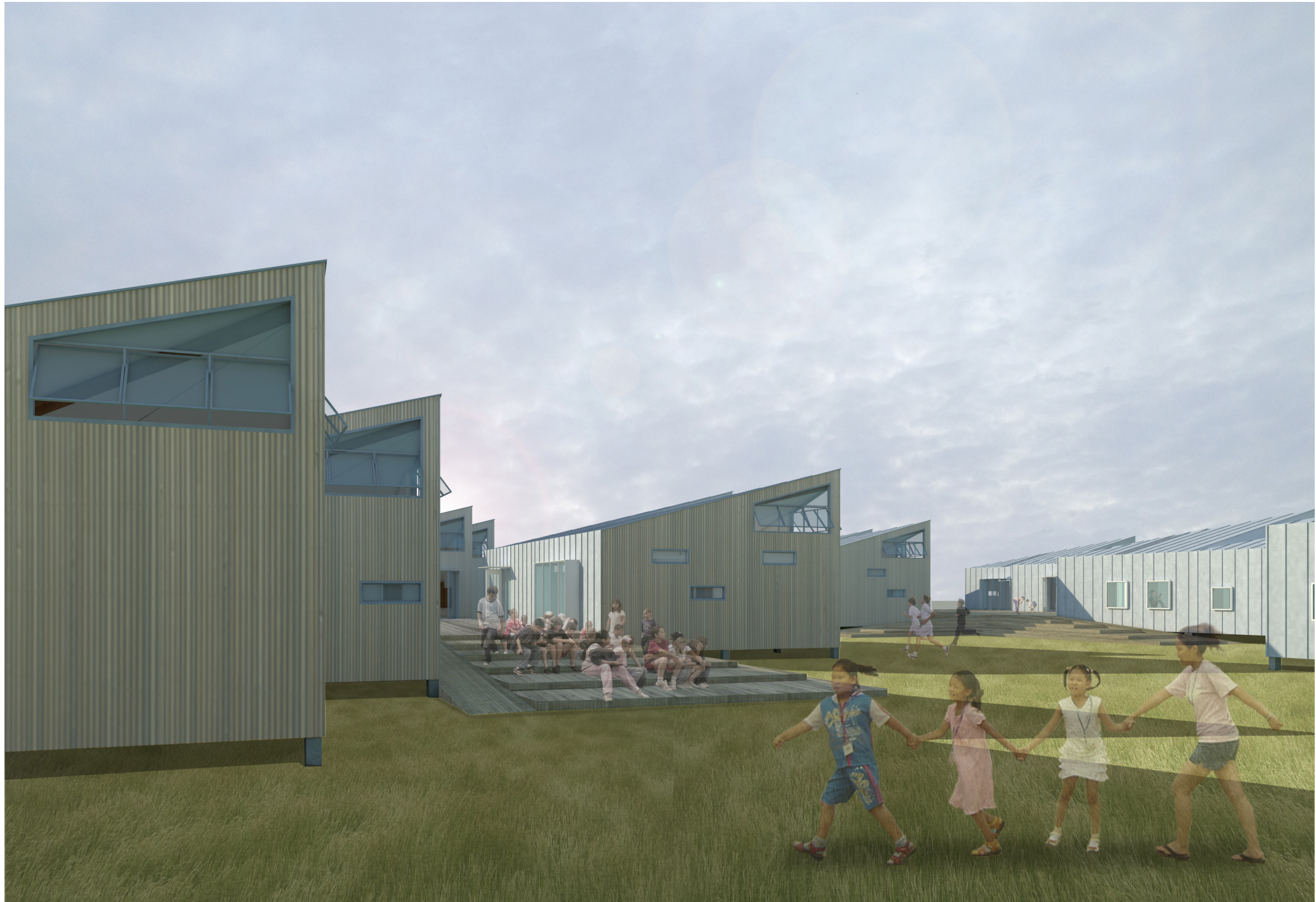
Classroom staggering further enhances ventilation when possible, though they can only stagger in one direction due to roof and rainwater collection constraints. The three clusters, or pods, frame a shared outdoor classroom/amphitheater space that can be used for larger group assemblies and recreational activities. Ramps and deep sitting steps between the groups encourage running and playing while also

offering smaller scale gathering spaces.

Classrooms are designed to be open shells for learning to maximize adaptability and ensure longevity. The modern classroom is an open flexible space that is more of a lab than a structured classroom. However, teachers will all arrange their classrooms differently, which the adaptable framework of the space encourages. The classroom spaces are designed to flow into a central shared courtyard space, giving teachers opportunities for outdoor education and stronger social ties between students in different classes. The



*figure 47: conceptual aerial perspective of Hollister portable replacement strategy*



*figure 48: perspective view into shared outdoor classroom amphitheater*

clusters have distinct color identities, further enhancing the sense of place and individual identity within each group.

### YUCCA VALLEY, CA

The next site is Yucca Valley of the desert and xeric shrubland biome. The desert biome features very hot, dry summers and very cold winters. The landscape reflects these extremes. There is very little precipitation, yet a wide variety of plant diversity. Yucca Mesa Elementary School is relatively rural with suburban neighborhoods quickly encroaching. The climate is very hot and dry, so the base classroom module is more defensive. The module clerestory windows are oriented inward to minimize solar gain from the south, east and west while capturing northern daylight. The clusters are tight so the courtyard spaces offer shade and protection from the elements.

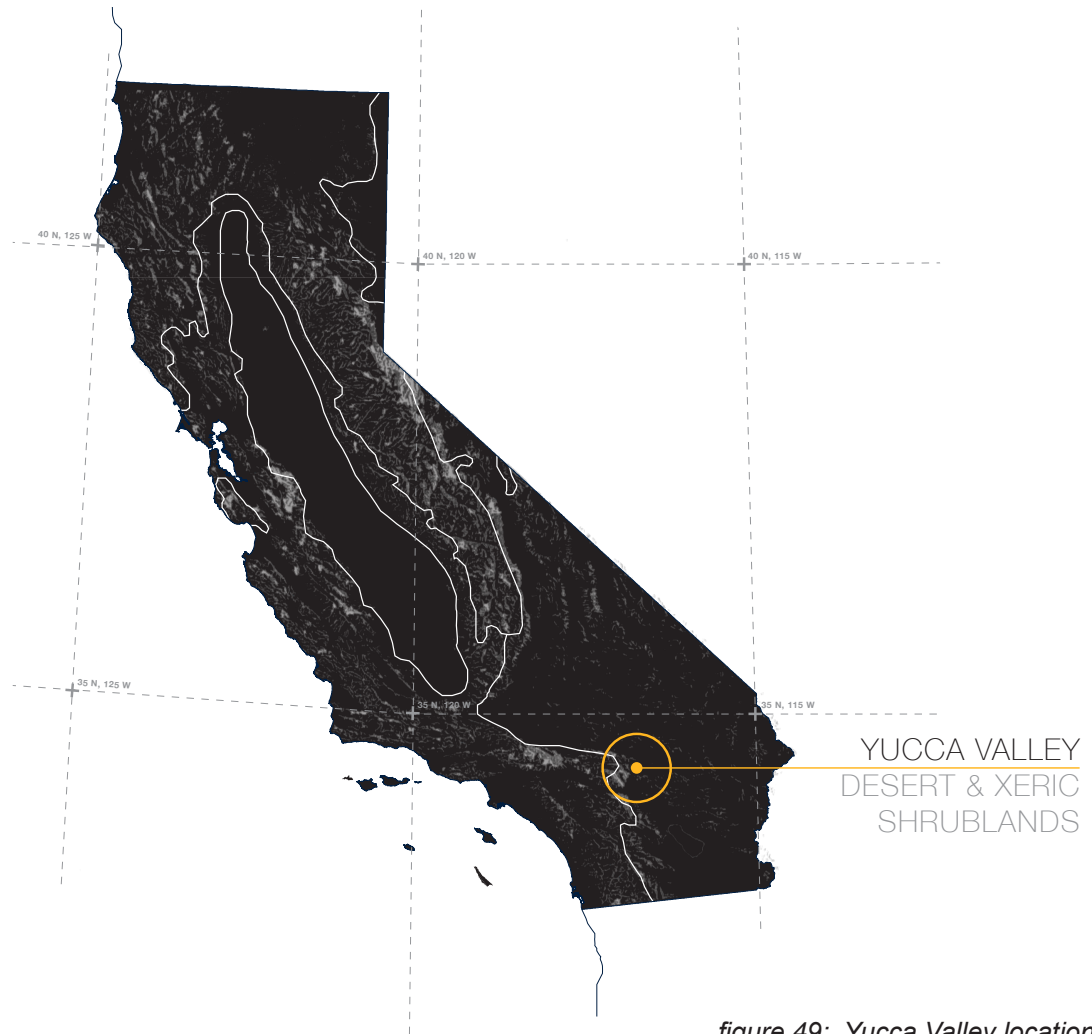
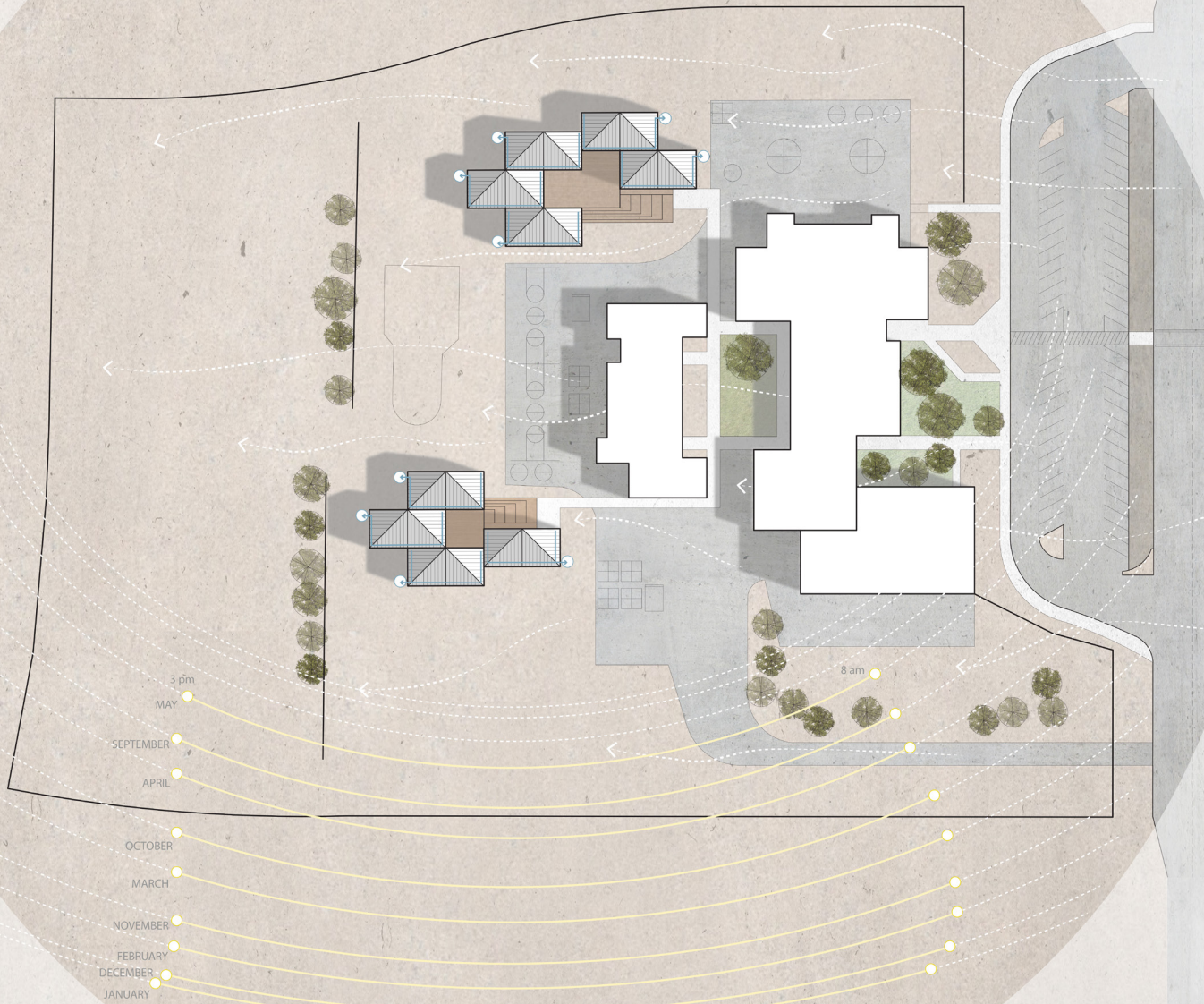


figure 49: Yucca Valley location



*figure 50: Yucca Valley site plan and module configuration*

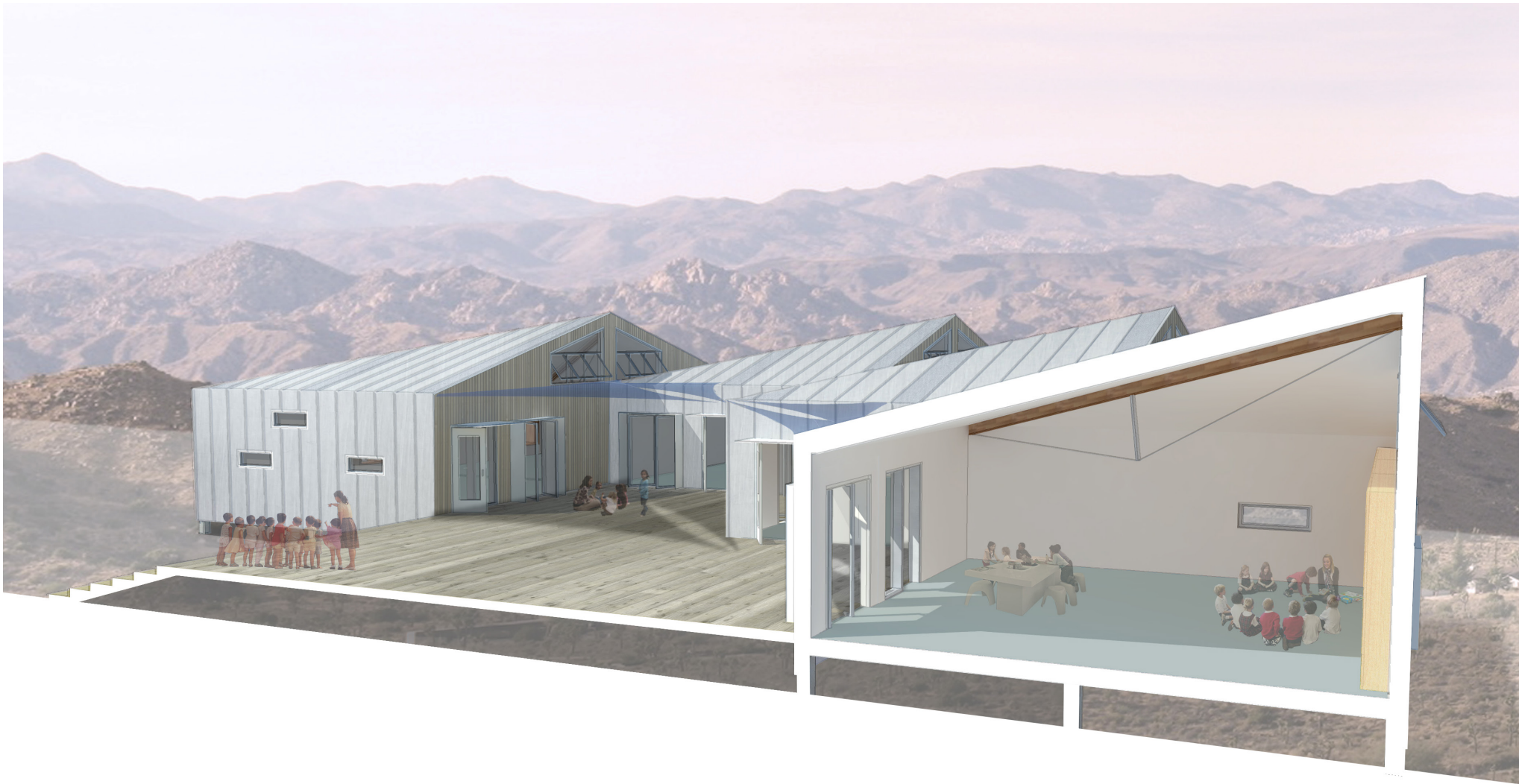


*figure 51: Yucca Valley floor plan*

The metal rain screen clads the east, south, and west walls because the sun is intense from every direction.

The replacement portable strategy for this location is to tie into the existing circulation patterns of the school. New pods can also be easily connected if the school continues to grow. The shared classroom walls can be removed or opened for more interior connectivity between

the classes. All of the classrooms flow into a central raised courtyard space. Shading devices overhang the courtyard space to make it more inhabitable in the summer and fall. The classroom interior has a high ceiling and ample natural daylight. Minimal inverted king post trusses support the angled SIPs roof panels.



*figure 52: Yucca Valley  
sectional perspective*



*figure 53: interior perspective of  
Yucca Valley classroom*

## POLLOCK PINES, CA

The third site is Pollock Pines of the conifer forest biome. Conifer forests feature cold winters and temperate summers with significant precipitation. Pollock Pines is heavily vegetated with pine trees. Again, this site does not have an existing school, but depicts how the system could be used to create a new school altogether. The site is very rural and adjacent to Jenkinson Lake – a reservoir used for fishing and boating. The area east of the site is undeveloped natural forest. The base module is oriented with the clerestory windows facing outward to maximize daylighting, since the climate is temperate and shady due to the density of trees.

The program for this site includes two classrooms and an administrative space. The courtyard space between the classrooms is large to prevent the buildings from shading each other. A larger raised deck allows for a depressed gathering space/outdoor classroom in the



figure 54: Pollock Pines location

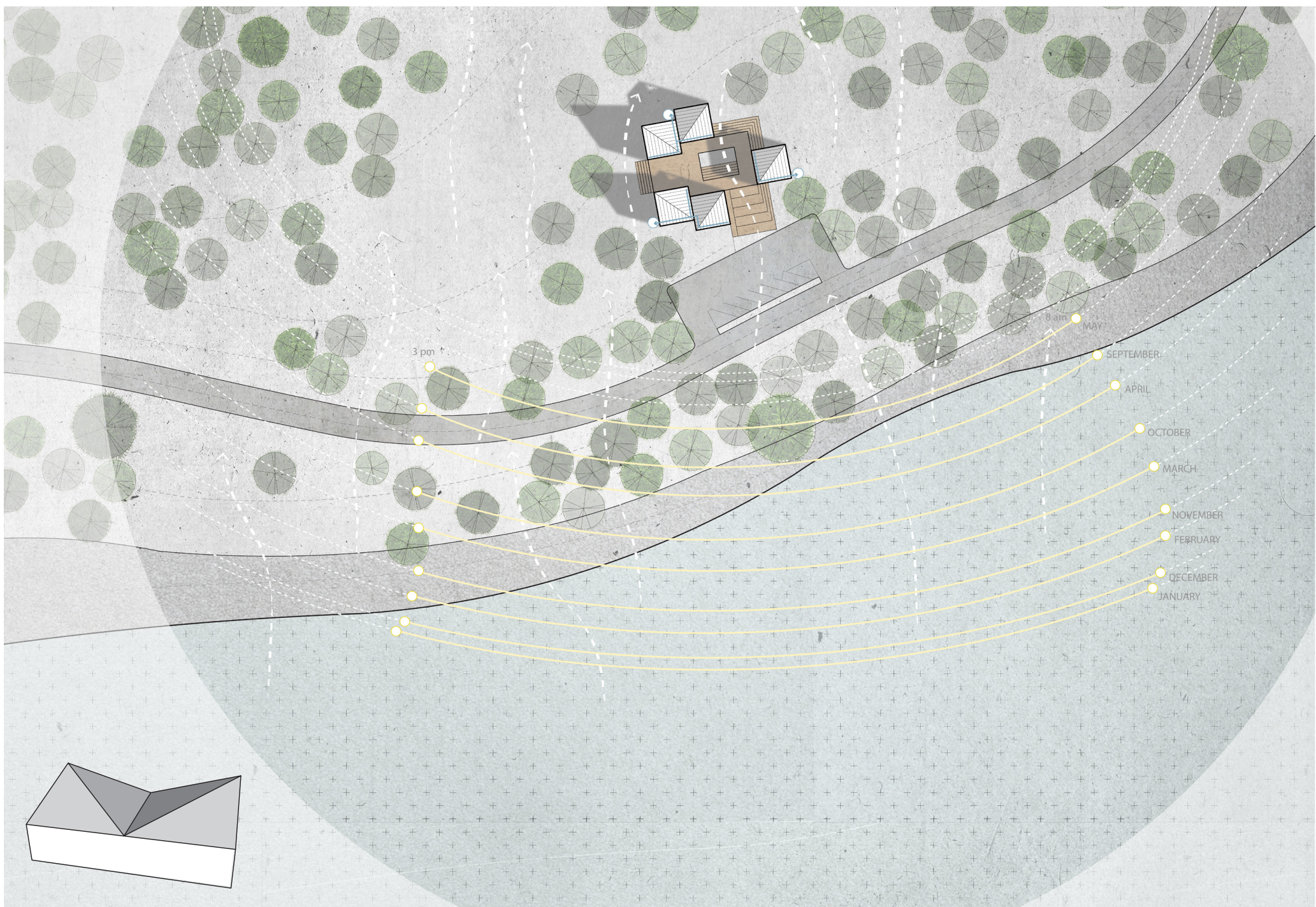


figure 55: Pollock Pines site plan and module configuration



middle of the courtyard. The raised deck around the gathering space also serves as a buffer from the wind and cold, allowing students to be outdoors more often. The raised decks connect the classroom spaces to each other as well as the forest beyond. The wood rainscreen covering the majority of the exterior façade ties into its natural surroundings.

*figure 56: Pollock Pines floor plan*



*figure 57: Pollock Pines  
sectional perspective*



*figure 58: perspective view of Pollock Pines classroom cluster*

## CONCLUSION:

This replacement system for portable classrooms throughout California aims to be a regionally adaptable, site responsive, easily constructed space for learning that could actually be implemented through the state. Schools should invest in long-term, well-designed solutions to the classroom shortage that has historically existed in California. This thesis proposes a simple single module as the solution, which is strategically rotated and reconfigured to optimize its specific environmental conditions. The simple module provides a framework that can create incredible diversity through repetition, creating great spatial richness when employed at different scales. The combination of mass production, quick construction, and site specific adaptability make this model a feasible option for replacing elementary school portables throughout California.

Modularity of building construction allows for a higher quality building envelope with future adaptability. Classrooms can be altered, moved, and changed as school needs change, which could happen on a day by day or a year by year basis. High quality windows, shading devices, and a tight SIPs panel building system work in collaboration

with specific site orientation strategies to realize a superior solution to the portable classroom epidemic. In turn, the buildings minimize energy waste, pollution, and greenhouse gas emissions while serving as environmental educators to the students that inhabit them. Factory production minimizes waste and a flat packed system minimizes the significant transportation footprint that most prefabricated buildings have. Significant economies are realized by utilizing a standardized module on such a large scale.

This system of replacement portable classrooms also focuses on creating healthy spaces for learning. Ample natural diffuse daylighting, ventilation, good acoustic isolation, adaptable interior spaces, a visual and physical connection to the outdoors, and opportunities for community interaction are the key factors related to healthy educational spaces and were all carefully considered when designing the replacement portable module. Studies have shown that feeling connected and invested in your school and surroundings is the most important factor influencing learning. The system is community oriented and offers a wide range of opportunities for social connections,

from the interior courtyard decks to the deep sitting steps that surround each cluster. Students and teachers that have a strong identity within their community feel more fulfilled, so classrooms and school campuses need to do more to foster social engagement.

The outdoor spaces that surround the classrooms also function as extensions to the classroom walls. Swiveling doors open up to the courtyard space and blur the line between indoors and outdoors in the relatively mild California climate. Classrooms can work outside together, rather than separately, or teachers can choose to focus more on outdoor education methodologies, which offer a variety of new learning experiences and opportunities for students.

In summary, it is possible for California's portable classroom infrastructure to be site responsive, community oriented, and provide environmentally superior spaces for learning. Portable classrooms can often be better than permanent classrooms if they are well designed. They can offer a simple, affordable, and thoughtful long-term solution to accommodate quickly growing populations. Children should have healthy, inspiring classrooms that engage them in the learning process and maximize their opportunities for learning throughout the course of their lives.



figure 59: perspective view of  
classroom shared courtyard concept



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