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Nature, daylight and sound: A sensible environment for the families, staff and patients of neonatal intensive care units

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Nature, Daylight and Sound: A Sensible Environment for the Families, Staff and Patients of Neonatal Intensive Care Units

by

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Dedication

To my husband Brandon, who has been incredibly understanding and supportive throughout this entire process, and to my mom Edith, dad Olger, and brother David for always believing in me.

Acknowledgments

To all my professors for the valuable knowledge they imparted in me. To my thesis committee, I am grateful for all your support and valuable advice. Thank you Jonathan and thank you Margie. Also, thank you to my Thesis Chair Dan Powers for always pushing me to do better. Finally, special thanks to Sheila for inspiring me to get started in this topic and for providing all your advice and knowledge.

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ABSTRACT

In healthcare environments, elements like nature, daylight and sound have been found to significantly influence the healing process of patients, by enhancing the quality of their recovery, shortening their hospital stay and consequently reducing hospital costs. For instance, it has been shown that exposure to nature triggers positive responses in people, daylight affects human psychology, and different sounds have varying behavioral effects on different groups of people. But, while these effects have been carefully studied in adult patients, leading to clear design standards, less is known about their impact on premature infants.

Interestingly, the care that many newborns receive in Neonatal Intensive Care Units provides countless benefits, but there are also many aspects of it that can cause stress to babies, staff and families. Exposure to continuous light, high levels of noise, separation from their mothers, minimal physical contact and painful procedures are all stressful factors that can have tremendous effects on a baby's recovery. So, while highly specialized treatments can greatly improve a newborn's medical condition, physical surroundings are rarely regarded as influential in his or her care.

This thesis exploration focuses on the design of a Women's and Infant's Medical Center prototype where the emphasis will be to promote well-being and healthy development through the physical environment. Attention will be given to the controversial effects of natural light on babies and its benefit will be determined through analysis of collected evidence. Equally, noise sources and methods to control it will be explored in order to minimize stress and discomfort in newborns. Finally, the importance of access to the natural environment will be studied, and even though this would normally not be directly associated with a baby's healing process, it could be an essential factor in the well-being of mothers and caregivers, which in turn will benefit the baby.

Through evidence, research, analysis and a prototype design various strategies will be developed to demonstrate how the proposed elements (access to nature, daylight, and noise control) could successfully be integrated into a NICU setting. The resulting environment should promote faster recovery and healthier development of babies, both directly and via their caregivers (parents and medical staff).

INTRODUCTION

Introduction

A neonate or a newborn is a baby that is still less than a month old. A full term baby is one that reaches 37-40 weeks of gestation and weighs between 2,500-4,000 grams. When a baby falls below these parameters, it is considered a “premature” infant that has not yet reached the level of fetal development that would generally allow life outside the womb. These babies require the care of Neonatal Intensive Care Units (NICU).

In NICUs, critically ill newborns and premature infants can be provided with constant nursing, complicated surgical procedures, respiratory support, and other intensive interventions they may require. They stay in a NICU until their organ systems can function properly on their own, which can range from one day to many months of observation and treatment.

Figure 1. Neonatal Intensive Care Unit baby and isolette/incubator

Currently, there is no single national standard or a consensus of what constitutes a NICU. Originally, in the 1950s NICUs were developed to provide advanced temperature management and feeding, isolation from infection risks, and access to highly specialized professionals, processes and equipment. Since then, some states have defined levels of care, while other states have informal or no systems for classification.

In summary, and based mainly on availability of specialized equipment and staff, the following are the primary NICU levels of care defined by the American Academy of Pediatrics:

Level I (Basic): This is a hospital nursery that can perform neonatal resuscitation, evaluate and provide care for healthy newborn infants and physiological stable near-term infants (35-37 gestational weeks), as well as stabilize newborn infants born before 35 weeks’ gestational age until they can be transferred to a facility that can provide the appropriate level of neonatal care.

Level II (Specialty): This is a hospital special care nursery that can provide care to ill infants born at more than 32 weeks' gestation and weighing more than 1,500 grams. These neonates are moderately ill with problems that are expected to resolve quickly and are not anticipated to need subspecialty services on an urgent basis.

Level III (Subspecialty): This is a hospital NICU that can provide continuous life support and comprehensive care for extremely high-risk, critically ill newborn infants. This level is further subdivided into three sub levels differentiated by the capability to provide advanced medical and surgical care.

In this thesis, the separation of patients and supporting medical staff by acuity levels will be taken into consideration when developing design strategies that will affect the recovery and/or well-being of premature infants. To that effect, the following critical stages of development, that are typical in premature infants between 27-40 gestational weeks, will be helpful in understanding crucial elements in a baby's environment that need to be addressed when designing a NICU:

24-29 gestational weeks

- Babies' eyes should be protected from light all the time. Premature babies' eyes don't have the reflex that protects them from bright light.
- Eyelids may still be fused shut.
- Babies may show stress signs if there is too much light. When their eyes open, they may have trouble keeping them closed tight and too much light can get in.
- Ears are totally formed for hearing, however, babies are still susceptible to any noise, thus soft speaking voices, especially from parents are ideal.

30-32 gestational weeks

- Eye protection from bright light is necessary.
- These babies see things best that are 8-10 inches away, so they may spend some time quietly looking around.
- They are able to shut their eyes tight.
- Ears are totally formed for hearing but loud noises may still cause stress.

33-36 gestational weeks

- Eye protection from bright light is still necessary.
- Eyes have an improving reflex to protect them from light, however, babies will only open their eyes if the lights are low.
- They start distinguishing people's faces.
- They still prefer soft sounds, loud ones cause them stress. They also start responding to the sound of their mother's voice.

37-40 gestational weeks

- Eye protection from direct light is necessary.
- They still prefer low lights, bright lights make them shut their eyes.
- Their vision is still not as clear as an adult.
- They can hear as well as an adult although loud noises still bother them. They even start enjoying soft music although just for short times.

PROBLEM STATEMENT

Problem Statement

"Infants are in a constant period of growth and development; and, their growth and behavior is in many respects different from that of adults" (Sauer 2002). The way their bodies react to different treatments and environments may sometimes be evident but are frequently immeasurable. Therefore, it seems necessary to point out the fact that research involving children of all ages is a constant concern.

For example, typical environmental conditions like those found in a newborn intensive care unit, which might not present harm to the adult, can have serious consequences for the developing infant (Sauer 2002). Consequently, it is imperative to re-evaluate the design of NICUs and focus attention on the physical environment with one same purpose in mind: to promote health, recovery, and well-being among critically ill newborns.

A recent and rapid growth in NICU population resulting from premature labor is also multiplying the demand for improved NICU facilities, and is causing great concern among doctors. In the United States, premature births occur in 8 percent to 10 percent of all pregnancies (National Institute of Health 2009). Although preterm labor can happen to any pregnant woman, researchers have identified some contributing factors that increase the risk for prematurity:

- Proliferation of modern fertility methods
- Multiple gestations
- Increase in unconventional and risky ages of expectant women
- Lack of or inadequate prenatal care
- Mother's history of substance abuse
- Other serious but foreseeable health conditions (e.g. diabetes, hypertension, cardiac and seizure disorders)

Despite the fact that doctors would prefer premature labor not to happen in the first place, recent medical advancements are allowing them to save a greater number of critically ill premature babies. Conversely, the special conditions that allow NICUs to reduce mortality in extreme premature infants may also be causing these babies to suffer some unforeseeable risks (Gravens Conference 2009). As a result, the extent to which a NICU's environment affects babies' recovery and the quality of their lives after they go home is presently a major topic of concern.

Figure 2. Present conditions in most NICUs

With many premature babies suffering from other disorders (cardiac, renal, lung and neurological) some time later in their lives, it is logical that NICU care is focusing its attention on other factors other than medicine that affect an infant's development and well-being during their hospital stay. That is why, "it is incumbent on clinicians and decision makers to understand the effects of the physical and developmental environment on the neonate and their families, as variations in these environments may lead to profound effects on a variety of physical and neuro developmental outcomes" (Gravens Conference 2009).

So, considering the positive effects that access to nature, daylight, and noise control could have in patients in a NICU, providing a stress-relieved, pleasant environment for patients' parents and medical staff could have similar valuable implications.

The idea that a parent's comfort and well-being is of parallel importance to his or her newborn is supported by evidence that reveals that a mother's interaction with her newborn is crucial for the baby's recovery. As a result, many hospitals are supporting family presence and participation, as they are considered additional caregivers of their infants.

Figure 3. Babies reaction to mother's touch. Courtesy of the National Institute of Health

Similarly, a focus on medical staff satisfaction can potentially translate into better and more effective healthcare for the patient (Gravens Conference 2009). This theory can be further enhanced by evidence that holds these elements (access to nature, daylight and noise control) not only greatly accountable for enhancing the quality of a patient's recovery, but also for shortening his or her hospital stay, and consequently reducing hospital costs.

Generally, the trend in NICU design, and healthcare for that matter, has been to architecturally standardize spatial and environmental conditions surrounding the patient. Babies were no exception to this rule, being submitted to open bay settings and group conditions. These crowded neonatal intensive care units are usually packed with nurses, equipment and lots of noise that affect the babies' stress levels. These effects are clearly noticeable in newborns' monitors that show how a lot of noise can agitate their fragile hearts.

In addition, these loud, crowded environments are also not particularly family friendly, and parents often do not feel comfortable about spending time there. Privacy, noise and infection control issues are all valid concerns surrounding these traditional open bay ward settings.

Figure 4. NICU open-bay setting

Fortunately, those types of units are being phased out, and individualized, controlled environments (single family rooms) are being favored in their place. State-of-the-art technologies now offer healthcare staff the opportunity to monitor patients from anywhere in the unit. Nurses can instantly connect with patients, receive medical alerts directly from the room, and even check if the infant is suffering from an acute or dangerous condition through telemetry. All of these technological advancements are providing more flexibility to the planning of these facilities, which can now be primarily targeted at fulfilling patients' needs and not just designed around the vasts amounts of medical equipment.

Figure 5. NICU Private room setting

Quiet, fully equipped private rooms for premature babies are now being preferred instead of one large room full of incubators. Although these type of settings are becoming more popular, they have not yet been established as a design standard. Some nurses and physicians are still concerned with the critical state of these patients and the fact that the required constant observation of these delicate patients might be jeopardized if there is a larger separation between them and medical staff.

However, further supporting evidence indicates that these babies' special circumstances warrant more individualized care. The subject of light, for example, affects different babies in varying situations distinctively. As pointed out earlier, a babies age and condition at birth reveals that light could be beneficial to some but not to others. So, the typical consensus that light exposure is beneficial to all babies is not accurate, nor is the opposite.

In summary, since healthcare providers are becoming aware of the importance of a baby's development beyond survival, and of certain elements that influence his or her well-being during their hospital stay, it is undeniable that changes are in order. As a result, the elements analyzed in this thesis will improve upon current NICU practices that place great emphasis on high tech equipment and surgical procedures and not on the physical environment.

PROJECT GOALS AND DESCRIPTION

Project Goals and Description

New technology is combining with old-fashioned common sense to create healthcare environments conducive to a rapid and soothing recovery. This thesis will address and analyze several influential aspects of a NICU setting that may ultimately transform its physical environment in order to promote faster recovery and improved developmental outcomes in ICU newborns.

Consequently, the final intent will be to provide a nurturing environment that optimizes babies' growth and development, encourages families to stay and participate in their care, and promotes staff wellness, productivity and satisfaction.

Figure 6. Newborn in a nurturing environment

Currently, there are several guidelines aiding the design of newborn intensive care units. Among the ones that will be valuable resources in the course of this project are The Recommended Standards for Newborn Intensive Care Unit Design 2007, American Academy of Pediatrics' (AAP) Guidelines for Perinatal Care, and the American Institute of Architects' (AIA) Guidelines for Construction of Hospital and Healthcare Facilities 2006.

The Recommended Standards were developed by committee chairman Dr. Robert D. White, (design chairman of the Annual Gravens Conference and director of the regional newborn program at Memorial Hospital in South Bend, Indiana) and a team of experts (healthcare, administrative, and design professionals). Dr. White states that these "standards provide guidance for designers and planning teams to apply the functional aspects of healthcare operations with sensitivity to the needs of infants, family and staff." While many of these standards are minimums, their intent is to optimize design within the constraints of available resources. According to Dr. White "this will help facilitate excellent healthcare for the infant in a setting that supports the central role of the family and the needs of the staff."

Dr. White also notes that “nurturing environments [should be] personal, controllable, and facilitate needs.” Interestingly, this description can vary depending on the user. For example, “for babies, this means rooms where their families are welcome, comfortable, and interactive. For families, this means rooms that become a second home for them at the time of their greatest need. And for staff, this means, a space that is comfortable and that they can call their own” (White 2008).

For this thesis project, these findings indicate that the development of various zones that satisfy all three groups (babies, families and staff) could be very beneficial. Evidence demonstrates that in low-stress settings babies get better faster. For example, lighting, noise protection, and temperature that emulates the dark, quiet warmth of the womb have shown to improve outcomes for many medically fragile babies.

Findings showing that patients seem to recover more rapidly when family members stay with them reveal the need of close physical contact between parent and child. Hence, many hospitals are striving to do all they can to encourage bonding between baby and parent. This topic will be expanded on further in the Research and Design Methods chapter.

The ultimate goal of this project is to provide the design of a prototypical plan-model that will attempt to serve as a catalyst for future improvement and development of other Women’s and Infant care facilities. Overall, elements like nature, daylight and noise control intend to improve the current environmental conditions that some premature newborns suffer in NICUs.

Figure 7. Importance of physical contact between baby and parent.

RESEARCH AND DESIGN METHODS

Research and Design Methods

In order to address primary issues, such as the impact of light, nature and sound in preterm babies, several study models will be developed. These models together with relevant diagrams will aid in providing information as to the morphologies of these elements. Further analysis could reveal different methods of how these elements could be manipulated to create a beneficial environment for newborns, families and staff.

Also, case studies of contemporary healthcare facilities will be crucial in reaching an understanding of current sociological issues as well as current medical practices. Moreover, information regarding existing healing methods and pertinent supporting evidence will be integrated into a single concept to ultimately reveal a new standard of care.

This thesis project will address several aspects of a NICU's physical environment that should ultimately lead to a faster and better quality developmental outcome in newborns. However, in order to implement these philosophies architecturally, first a general understanding of the magnitude and effect of these factors must be gained. The following is an exploration of general facts regarding these elements.

Influential Components of a Healing Environment

"In living organisms and vernacular buildings we see a variety of ways of successfully interacting with the environment" (Thomas and Garnham 2007).

Neonatal intensive care units are now being redesigned in the wake of growing evidence that the physical environment of the NICU has a profound impact on all who live and work there. Traditionally, healthcare design had been targeted at satisfying a general population. However, assessing the needs of hypothetical sub-populations could potentially translate into functional design variables that would benefit patients, parents and staff. In an environmentally sensitive NICU these variables would translate into optimum surroundings.

Coincidentally, a survey done by The Center for Health Design of Walnut Creek, California, and The Picker Institute in Boston showed that the environment makes a difference to patients when choosing a hospital.

Positive distractions, such as views or access to nature, presence of water features, plant and animal life, solitary and group seating availability and even something as simple as interactive art can facilitate or inhibit certain behavior and/or mood in people. Therefore, exposure to positive distractions in a hospital setting can be crucial for relaxation and stress relieving purposes.

The Recommended Standards for NICU Design 2007 also supports the need for positive distractions in a NICU setting by encouraging the addition of simple elements like fitness centers and access to music amongst other things. Each one of these positive distractions have proven to be successful in diverting people's attention away from stressful situations.

Figure 8. Nature park sketch, example of a positive distraction

Incidentally, it is worth pointing out that "human behavior can be conceptualized as a dynamic sequence of adjustments and readjustments to the physical and social environment" (Baum and Valins 1977). But, in the case of premature infants, whose physiologic, sensory and neurological systems are not yet mature, their adjustment to a new environment is much more difficult. Their early arrival often exposes them to chaotic surroundings, much different from the quiet, protective womb they have grown used to.

Fortunately, new technology is allowing advanced lighting, noise protection and temperature controls to be designed and controlled to simulate the comfort of the womb. So, premature, ill and high risk neonates still vulnerable to their surroundings can be comfortable and benefit from a positive and calm environment.

Patient stress can also decrease as a result of new technology. For instance, babies' stress levels that are usually disturbed by routine caretaking activities, such as taking blood samples, temperature monitoring, or minor surgeries can now be minimized. With the aid of new technology most procedures can be performed at the baby's incubator minimizing uncomfortable transportation processes.

In addition to technology however, other methods are emerging that provide enhanced nurturing care to babies. For instance, about twenty years ago, Dr. Heidi Als developed a formal model known today as The Neonatal Individualized Developmental care and Assessment Program (NIDCAP). Infants in this program are routinely assessed by caregivers and NIDCAP observers for stress cues that will direct the manner in which patient care activities are delivered. In other words, each baby is carefully observed so his or her care can be adjusted to best fit his or her needs and coping abilities.

In essence, the program's objective has been to provide an environment in which a premature infant's development can continue as normally as possible despite his or her early birth. Since this program's institution, the concept of developmental care in the NICU has gained increased acceptance.

Research into NIDCAP effects has shown that babies who are cared for using this care approach have fewer medical complications, shorter stays in the hospital, better weight gain, and fewer days on respirators. In addition, some early studies have indicated that these babies may also show more organized behavior and better development in their first year of life.

Daylight Exposure

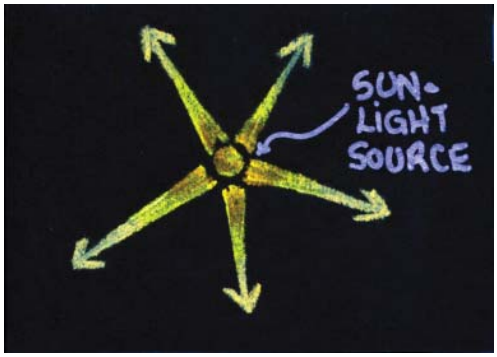


Figure 9. Sun light spreads uniformly throughout unobstructed paths.

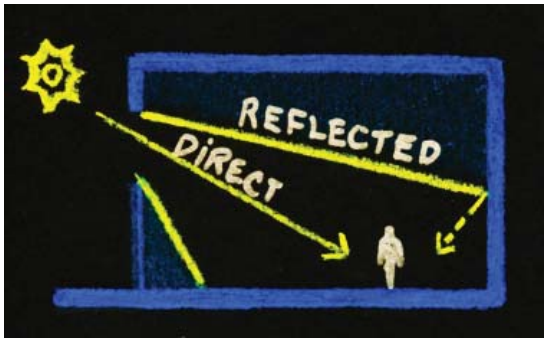


Figure 10. Sunlight: direct or reflected.

"Daylight inspires, invigorates and has a positive influence on the body and mind" (Koster 2004). "Natural light is one of the best antidepressant agents available, one that is more efficient than electric light. Sunlight provides a sense of time and connection with the outside world, a connection often needed by a person's biological clock" (Boubekri 2008).

Statistically, people spend the majority of their time indoors due to weather and the necessities of work. It is therefore of vital importance to design spaces that provide therapeutic light levels, preferably with daylight (Boubekri 2008).

A recent Turkish study investigated whether the lack of daylight in the work setting can be a predictor of job burnout of nurses who, as a group, generally have an above average risk for work stress and burnout. The concluding report indicated a strong relationship between outside darkness and the rate of medical errors (Alimoglu and Donmez 2005).

Fortunately, newly acquired knowledge supported by models and calculations aid in the design of optimum amounts of daylight that are suitable for any particular activity. A simple formula also facilitates the design of optimal daylight amounts in interior spaces. The formula establishes a ratio between the height of an exterior opening (H) and the distance (D) reached by the daylight penetrating the space. In other words, daylight will be at its optimal levels up to a maximum room depth distance of two times and a half the height of an exterior opening (H). Beyond this point daylight quality would be poor and not favorable for regular task performance.

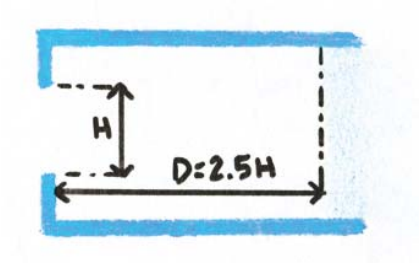


Figure 11. Formula to achieve optimal daylight amounts.

Regarding the nature of light and its role in perceiving our environment, University of Washington's architecture professor and lighting design expert Marietta S. Millet noted that "Light is not perceptible without form – even the diaphanous form of swirling smoke – is enough to reflect it. Conversely, form is not perceptible without light to reveal it, at least not to [human] vision, on which we rely to provide the majority of our information about our surroundings."

Therefore it is safe to assume that "daylight's primary function is to activate the visual world around us, so that we experience spaces, colors, emotions, etc. [Sadly], the knowledge of the dynamics of daylight and its effect on the user of a space has been slowly lost. Aesthetics and function are no longer directly related, thanks to the invention of electricity, which provided a much more constant and predictable source of light" (Steane 2004).

In low light conditions where there is little contrast, the fine grain of materials and color harmonies become more important. That is the case of Japanese architecture, in which the beauty of a room depends on a variation of shadows. Therefore, light and shade should be considered together, like light filtering through planes.

Additionally, as a constantly varying resource, in both quality and quantity, natural light has an advantage over all artificial sources, in that it changes with cloud cover and the time of day or season. Thus, good daylighting design requires a careful consideration of both the qualitative and the quantitative factors associated with it.

In NICU environments, earlier lighting levels were dictated by the needs of the staff while giving care with little known about the impact of direct lighting on the development of the infant or on circadian rhythms of either infants or caregivers (White 2004). However, recent studies indicate that newborn environments can benefit from a varying range of light levels. For example, cycled light can help regulate babies' biological rhythms better than a continuous illuminating source. Furthermore, spending some time duration in daylight helps infants learn the pattern of sleep, that is, sleeping during the night and being awake during the day.

Currently, bright light is still essential to perform medical procedures as well as being necessary to evaluate a baby's condition, such as his or her skin tone. Unfortunately, a balance has not been reached between the amounts of daylight babies can be safely exposed to and the illumination levels staff can be comfortable working in.

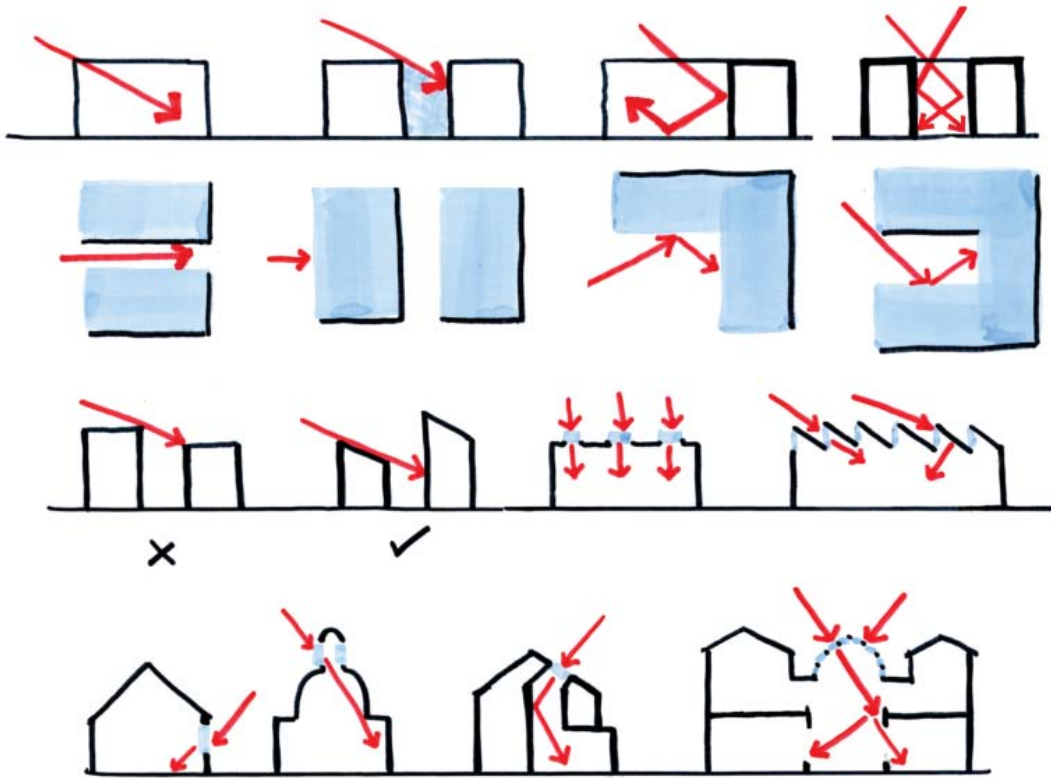


Figure 12. Light and shadow patterns; and possible sources of light.

The angle of the sun and the nature of the reflecting surfaces that the light strikes can affect people's perception of spaces and even their mood. Humans are sensitive to many different types of light, both inside and outside. Therefore, differences in spectral composition and intensity are equally important in a person's well-being since they help establish a specific sense of place.

Consequently, light can also be useful to ensure psychological well-being of staff and families. Evidence indicates that poor indoor lighting increases levels of stress in hospital workers, leading to compromised medical care. Similarly, families

exposed to better lighting conditions can have a greater positive psychological impact that could translate into better care for their babies.

Finally, evidence has shown that daylighting does not only help improve patient recovery rates, it also helps saving energy. Hence, it is important to stress building design where natural light is plentiful in the interior and not just around the perimeter. In the end, “strategies like these can help minimize concerns about the depletion of fossil fuels, global warming and other economical factors” (Boubekri 2008) in addition to providing healing benefits.

Noise Control

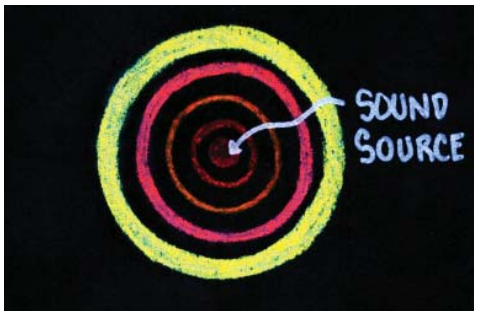


Figure 13. Sound spreading radially from source.

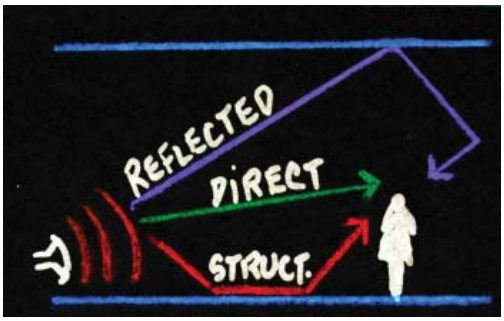


Figure 14. Sound path.

“We cannot see sound, and as a result the aural environment is not well understood … Characteristics such as loud or quiet, constant or variable, background or foreground are determined by architecture and establish the soundscape of our environment that in turn affects our perception of the architecture … The acoustic sequence of spaces, from public to private is important … we hear the architecture only because we activate it by the noise we introduce” (Steane 2004).

Sound is a very complex subject, and for the purposes of this research, a general understanding of its characteristics, behavior and morphologies is necessary. Noise and methods to control it will be a major focus of research and the design process. As a result, the following list includes elements that describe the characteristics of a noise source:

- Loudness
- Tonality (including frequency, perceived as pitch)
- On-off characteristics (abrupt or gradual)
- Repetition frequency (fast like an oscillator versus slow like a monitor alarm)
- Duration

Additionally, sound is only satisfactory to a receiver if the following characteristics are present (otherwise it becomes noise):

- privacy
- speech intelligibility
- freedom from intrusive noise and annoyance

“Obvious as it is, it may be worth noting that sound is not like light. Light is generated by sources built specifically for that purpose or by the sun and is fairly easy to direct and confine. Typically, sound and its sibling, vibration, are generated by people and by sources built for many different purposes located inside and outside the building. Sound and vibration are, therefore, difficult and sometimes costly to direct and confine” (Philbin 2004).

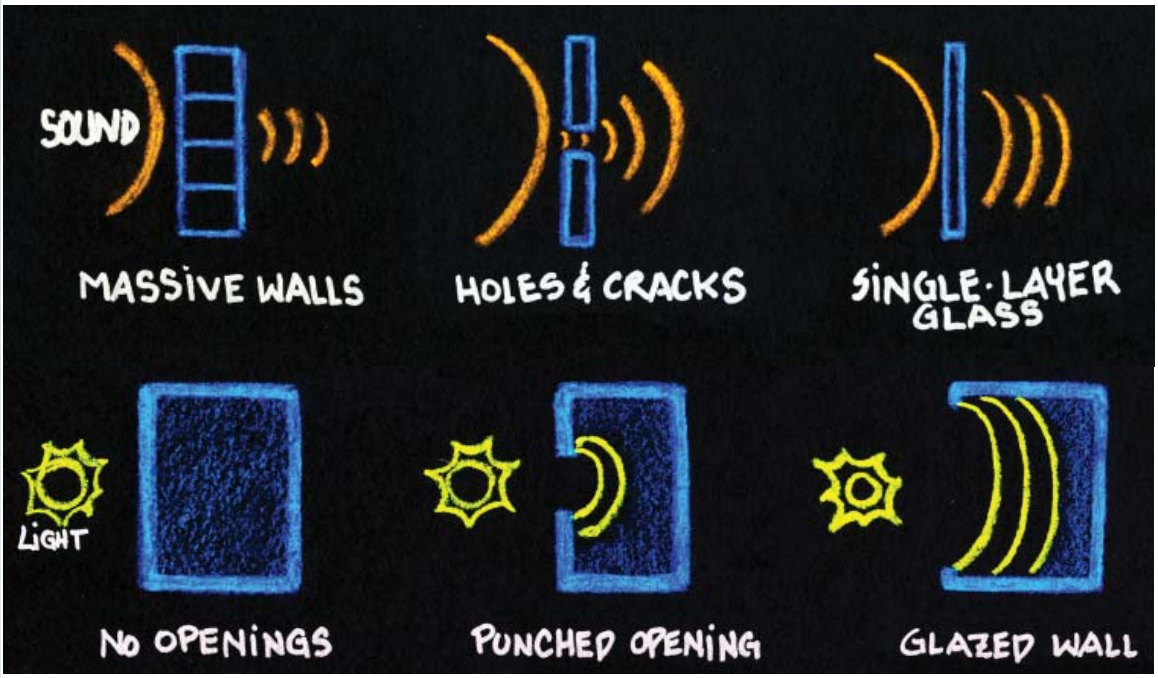


Figure 15. Sound vs light transmission

In addition, sound differs from light in that it can transfer across solid masses in the form of decreased intensity and vibration. Light, on the other hand, can only be transmitted through an opening or a visibly clear mass (i.e. glass) without any decrease in intensity. Light and sound are similar though in that both sound and light levels will weaken as distance from the source increases.

Figure 16. Sound vs light as they pass through a solid mass.

In a NICU environment, noise can originate from various interior and exterior sources. Interior noise is typically produced at heights of 3 feet to 6 feet above the ground, mainly attributable to loud medical equipment and staff/ visitor activities. The unit's layout, material surfaces and mechanical equipment are also factors influencing noise levels.

Exterior noise can also have a disturbing effect in interior areas of respite. Noise waves and vibration originating from street traffic, air traffic, wind, and external mechanical systems can penetrate partitions from the outside. Fortunately, knowledge about the movement of sound within a space can be utilized in planning the locations of rooms and activities served, the locations and types of walls, and the selection and placement of sound-absorbing surface materials.

For example, placing rooms with compatible activities adjacent to each other could isolate noisy activities away from quiet ones. This means that rooms or hallways with quiet activities, such as offices, consultation rooms, and sleep areas for infants, parents, and staff should be located adjacent to each other and other similar rooms in which noise intrusion must be avoided.

Noise may also affect adults' performance of tasks, attention, memory, speech communication, mental state, and physical wellbeing (Philbin 2004). So, a quiet NICU with separated care areas can also be beneficial to staff by improving mood, increasing concentration, better sleep, reducing illness, increasing personal calmness, and minimizing need to escape.

On the other hand, activities in a NICU produce many kinds of sound and many opportunities for incompatible room adjacencies. Therefore, reducing noise may entail spreading out noise sources. Safety problems posed by this increased space separation and extra walls within the unit may be quickly resolved by new reliable communications systems.

The characteristics of surfaces in a room (walls, floors, ceilings, furnishings) have an important effect on sound also. Hard, stiff and smooth surfaces like glass, plastic, plastered walls and vinyl tile over concrete reflect sound back into the room. On the contrary, thick, soft surfaces like carpets, fabric curtains and acoustical panels absorb sound by dissipating the energy (Philbin 2004).

In addition, wall and ceiling angles at about 90 degrees afford more opportunities for reflection since the sound bounces off of one wall and then bounces right back increasing reverberation time. In a perfectly reflective room sound would continue reverberating indefinitely allowing sound to build up in the space and creating conditions unsuitable for relaxing.

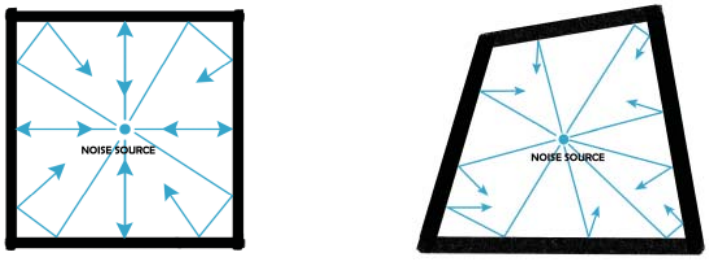


Figure 17. Perpendicular vs angled walls.

In many NICUs, alarm sources can be difficult to locate because the room is so reverberant that alarm sounds reflect many times before reaching the listener/ receiver, thereby acoustically camouflaging the original source. However, most of the early literature on nursery noise published by clinicians accepted the physical space as a given and urged the staff to make the nursery quiet by controlling themselves (Philbin 2004).

Loud noises are not only an annoyance to patients, families and staff but are also suspected to have potential long term effects in the normal growth and development of premature infants. Disrupting sound levels may affect their quality of sleep, auditory ability to attend, and their physiology. A study done in Sweden indicates that with reduced noise, improvements can be noticed in a patient's vital signs. Concurrently, other research shows that babies do best in an environment with soft sounds.

Although at this time there is no convincing evidence to support the addition of recorded sounds (music) for the purpose of improving infant development. Many reports have been unsuccessful at proving that music may be benign for hospitalized newborns (Philbin 2004). Reinforcing facts argue that before birth, babies are subject to high noise levels from their mother's bodies and may suffer the trauma of relatively quiet after birth. It has been reported that while babies are in the womb they learn of the world outside through sounds (voices, or music) and sometimes respond to the same sounds after birth (Steane 2004). This suggests that listening to similar recorded sounds could be favorable in helping babies relax and adjust to their new environments.

Finally, it is clear that each group (infants, parents and staff) has different receiver requirements, with the infants' being the most restrictive in terms of the effect of noise on disorganizing behavior and physiology as well as interfering with speech intelligibility. Therefore, if the infant space meets the infant's requirements for sleep, behavioral and physiologic stability, and attention, it will almost certainly meet the adult's requirements for speech communication, attention, rest, and accurate task performance.

Access to Nature

The Recommended Standards for NICU Design (2007) state that "when possible, views of nature shall be provided in at least one space that is accessible to all families and one space that is accessible to all staff. Other forms of positive distraction shall be provided for families in infant and family spaces, and for staff in staff spaces."

In most buildings, however, fewer building users have the privilege of connecting to the outside world. Access to the outside (through windows, etc.) gives users information on the time of day, seasonal changes in vegetation, weather and other forms of environmental data, which helps them maintain their biological cycles. This connection to the outside also provides "psychological relief, especially if the views are predominately of natural content rather than built spaces without nature" (Steane 2004).

Figure 18. Hospital with interior nature environment.

So far, research regarding nature and its effects on healthcare has been mainly experimental and has focused on demonstrating the relationship between exposure to green environments and well-being. A study published in the journal Science revealed that sick people seem to improve faster when their hospital wards have windows with views of natural scenery. This is logical since typically "windows allow diffuse daylight and sunlight inside a room while providing views to the outside, thereby adding a sense of openness, spaciousness, and orientation" (Boubekri 2008).

Most existing evidence on nature's health benefits is a result of laboratory experiments that exposed participants to photographic simulations of various types of natural environments, or controlled field studies that compared residents with a view of urban greenery to residents without such view. These experiments have demonstrated that mere exposure to views of nature can improve people's health and well-being by providing restoration from stress and mental fatigue.

In NICU settings the application of these findings can be very useful to provide comfortable, relaxing environments to the families and staff in care of delicate patients. However, despite the growing evidence that the natural world is an essential aspect of healthcare in human well-being, its importance is still being disregarded causing many healthcare settings to offer neither nurturing nor healing environments.

Sadly, many facilities tend to view green space more as a luxury good than as a basic necessity, and appear to overlook the potentially important effects of green space on health and well-being. For instance, in most parts of the world, the function of windows is solely to allow smoke to be vented out in case of fire and to provide escape routes for people in case of emergencies, rather than to bring in a certain level of daylight and nature views into the building (Boubekri 2008).

Essentially, “culturally appropriate positive distractions provide important psychological benefits to staff and families in a NICU. Looking out a window, viewing psychologically supportive art, or taking a stroll in a garden may help to reduce stress or increase productivity” (Recommended Standards for NICU Design 2007).

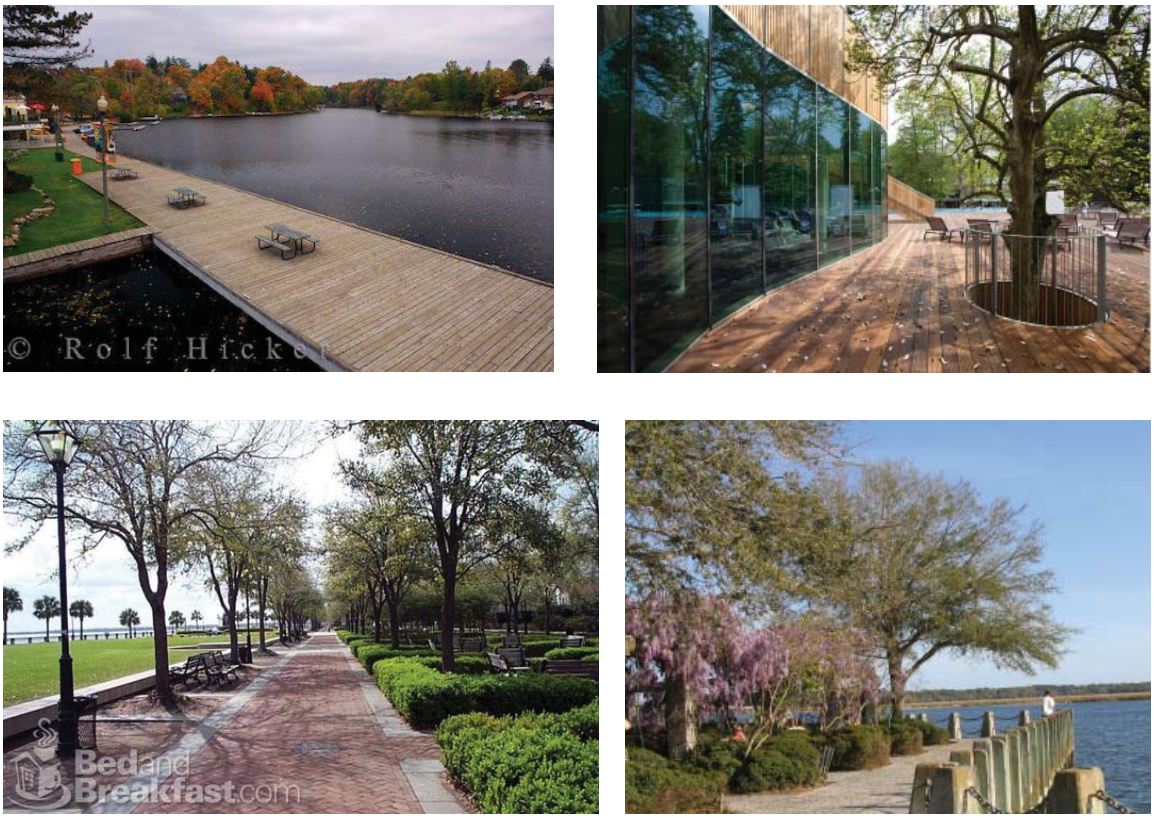


Figure 19. Graphic examples of proposed outdoor conditions.

Fortunately, as more is being revealed about how much the physical environment affects health outcomes and how it provides many health benefits to its occupants many design guidelines are being updated to include nature as an important design parameter.

For example, the 2006 Guidelines for Design and Construction of Hospitals and Health Care Facilities make many references to the environmental factors that contribute to patient, staff and family satisfaction, including daylighting and views of nature. These guidelines address the need for nature access by promoting the design of gardens or other controlled exterior space, accessible to building occupants.

Other guidelines such as the Green Guide for Health Care version 2.2 are also encouraging a connection to the natural world. They have included a special section within its content dedicated to the design of Outdoor Places of Respite. Here they prescribe that five percent of the net usable program area should be specifically programmed and with direct connection to the natural environment.

Figure 20. Sketch showing proximity to exterior nature environment.

In settings such as ICUs, the psychological health of its occupants (patients, families, and staff) who are often subject to high levels of stress is of great importance. Therefore, with the aid of positive distractions like nature settings, accessible either physically or visually, relaxation and well-being can be achieved. In the end, less fatigue and improved mood in NICU families and staff can have a positive effect in the care of delicate newborns.

Significance of Caregiver's Well-Being

Baby's Family

Family bond is increasingly becoming a greater priority in a baby's healing process. A study at New York University Hospital found that patients recover more rapidly when family members stay with them. Consequently, NICUs across the country are embracing a family-centered approach and establishing it as a standard of care (Gravens Conference 2009).

Family involvement throughout an infant's treatment has been shown to greatly benefit his or her overall recovery and developmental outcomes. Therefore, a comfortable environment to promote the patient's family well-being and comfort is of utmost importance. Fortunately, over the last ten years or so many NICUs have become much more parent friendly, encouraging them to participate in their babies medical care as much as possible.

Figure 21. Interaction between mother and baby

Coping with the intensive care experience can be less intimidating for parents if they are empowered by knowledge about what is happening to their newborn and can contribute in his or her recovery. That is why more and more facilities are encouraging rooming-in and early breastfeeding so the family can get to know the baby and can receive valuable guidance from staff during their hospital stay. Additionally, the baby's physical examinations can be performed alongside the mother to allow her to ask questions and allow the clinician to point out physical findings as well as provide anticipatory guidance.

Similarly, issues regarding privacy within a newborn intensive care unit should not be overlooked. Common NICU activities such as breastfeeding, kangaroo care (skin to skin contact between parent and child) and simply discussing a patient's medical condition can create uncomfortable situations if privacy from other patients or visitors has not been addressed in the design of the unit.

The baby's homecoming is just as stressful as the first days in intensive care for some parents, so facilitating the interaction of parent with the baby before leaving the hospital is crucial. Visiting their infant often, participating in his or her care, and consequently gaining knowledge on the caretaking process for their newborn outside the hospital should aid parents through this phase. In light of this, some hospitals are providing parents with a transitional rooming option that lets parents room-in with their baby for a day or two before bringing him or her home and while medical staff is only a few steps away for medical or emotional support.

The Institute for Family Centered Care (IFCC) assists hospitals nationwide in designing facilities to promote communication between families and their caregivers. This Institute also supports the design of useful amenities that make hospital stays more comfortable for parents, such as including family zones, resource centers, sleeping areas, laundry services, kitchens, and sibling play spaces.

Recognizing the importance of an optimal relaxing environment in the NICU will uncover the means to reduce parental stress and foster supportive communication among families and caregivers for the well-being of the patient.

Medical Staff

Figure 22. Interaction between medical staff, mother and baby

The dominant theme for the 2009 Gravens Conference on the Physical and Developmental Environment of the High Risk Infant was “Feelings Matter.” In other words, how a person feels (responds emotionally) about his or her job impacts how well the job is done, which can potentially translate into reduced medical errors. When people are upbeat and in a good mood, they perform better (Boubekri 2008). Thus, it is safe to affirm that providing adequate spaces conducive to a healthy work environment can benefit the caretaking staff as well as the patient.

In NICUs the medical team that care for each baby can consist of a large number of specialists, including neonatologists, medical residents, neonatal nurse practitioners, respiratory therapists, dieticians, physical therapists, pharmacists, lab technicians, social workers, developmentalists, and chaplains. Given the complexity of the care these staff members provide, it is crucial to ensure their satisfaction and comfort within their work environment.

The Recommended Standards for Newborn ICU Design address the significance of optimal staff conditions by requiring the use of daylight in all staff

and caring areas amongst other things. This requirement accomplishes two main concerns. It addresses the need for accurate assessment of a patient's condition, and it provides positive psychological stimulants for the benefit of everyday users.

Supporting evidence suggests that light affects mood and that mood influences or mediates the problem-solving process that people use at work (Boubekri 2008). So, negative stimulus resulting from a light deprived space can greatly impact a person's well-being. Furthermore, people who live and work in windowless environments or in places lacking adequate light may be at risk of having their internal clock continually disturbed (Boubekri 2008).

Consequently, stressful work environments in addition to daylight depravation can quickly generate fatigue, depression or other psychological disorders, which could in turn affect a person's work performance. That is why in order to provide the best care possible to patients, their caretakers health and well-being is imperative.

CASE STUDIES

The criteria used to select the following case studies are primarily encompassed in these four factors:

- Proximity and access to nature
- Use of daylight
- Functionality of spaces
- Significance of family and staff satisfaction

The case study selection includes three hospitals that have consistently ranked high in expert surveys ("Best Children's Hospitals," U.S. News & World Report) among nationwide facilities of similar specialty. In addition, these hospitals have also recently undergone major renovations in order to adopt current trends in NICU care.

Whenever possible, information regarding post-occupancy, comparing previous and current conditions, has been applied in the analysis of the various case studies. Additionally, data obtained from national ranking reports have also offered valuable insight as to the quality and outcomes of their practices.

Alternatively, a fourth case study is being presented because of its relevance to the subject of light and its significant architectural contribution. Even though this example involves a different building type, a chapel, its use of architectural (exterior skin) and non-architectural elements (daylight) to influence people's perception within the space, carries an inspirational significance worth exploring.

Case Study #1: Rainbow Babies and Children's Hospital

Overview

Located in Cleveland, Ohio, and a teaching affiliate of Case Western Reserve University School of Medicine, the renovated NICU space at Cleveland Clinic's Rainbow Babies and Children's Hospital was completed in April 2009 and grew from an 8,000 square feet into a 35,700 square feet, 40-bed unit.

The intent of the new unit's design was to balance the needs of medicine with the needs of the family. Rainbow achieved this by creating "…a critical-care environment that is more supportive of [the families'] emotional needs and decreases their stress level," according to Dr. Michele Walsh, Rainbow's NICU medical director. Dr. Walsh adds that "parents need to be there to emotionally connect with their children and be able to parent them later. When the architecture says otherwise, it's very hard to overcome that message."

Figure 23. Rainbow Babies' private NICU room courtesy of Rainbow Babies

At the recently completed unit, the new architecture fosters a better healing environment by reducing infant and family stress, and by promoting bonding. So, in keeping with evidence showing that sick infants do better in a calm, low-light conditions, the new unit replaced its old arrangement of as many as six infants in one room, with a new one of private patient rooms that offer individually controlled environments.

Another major focus of the space transformation was to emphasize the importance of family-centered-care. As a result, private newborn rooms now include bedside space and rooming accommodation for parents and siblings. Clearly, the hospital supports parent interaction and encourages them to remain active in the care of their baby 24 hours a day, if they so desire.

Additionally, each floor provides parents with the space and amenities necessary to take a break from the pressures of dealing with an ill child. Family lounges with washing machines, televisions, refrigerators, microwaves, beverage and snack machines offer them the necessary support to stay with their infant as long as possible.

Rainbow Babies and Children's hospital staff believe that premature babies do best in an environment with soft sounds, so, as an added feature, their NICU department is equipped with its own music therapist, who provides babies with soothing sounds as part of their treatment.

An unusual and remarkable fact about this facility is that Rainbow team members track the condition of their patients all the way into adolescence and beyond in order to detect lasting complications, such as asthma from a recovering damaged lung. Michele Walsh, the NICU's medical director pointed out that "it's not good enough to help [infants] survive,(the goal is) to help them live great lives."

Conclusion of Analysis

Post-occupancy reviews indicate that the transition into private patient rooms from the open pod unit design seems to have helped improve patient privacy. On the other hand, this increase in privacy has also caused patient rooms to be isolated from each other, which in turn has led to a diminished social interaction between patient families.

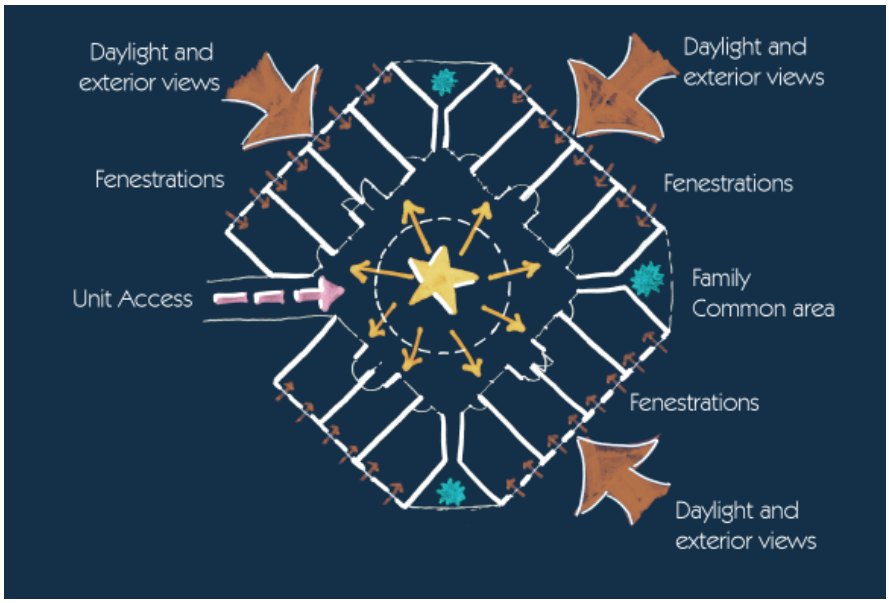


Figure 24. Floor plan diagram of NICU conditions at Rainbow Babies.

In spite of this, the introduction of individually controlled patient environments has also yielded positive results. For instance, improvement in specialized care was noticeably greater. In the old unit, groups of babies in an open-bay layout used to be subject to the stress of bright lights and loud noises. Now, each baby's environment (daylight, sound and temperature) can be individually controlled to suit his or her specific needs.

An additional positive result of the renovation was improved staff productivity. The unit's new core design allows better visibility from each centralized nurse stations into various patient rooms. With this new layout, nurses spend less time and energy walking long distances to check on a patient's condition.

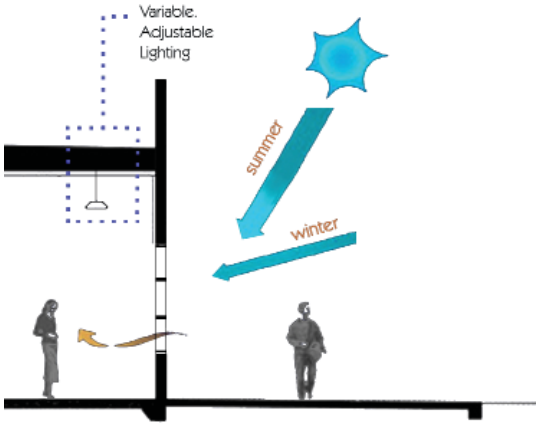


Figure 25. Section diagram of NICU conditions at Rainbow Babies.

Finally, variable lighting designed to resemble a mother's womb is an added feature in these critical environments. However, this innovative method of treatment combined with excessive sun exposure in some of the patient rooms impair its intended effects. In summary, care should be exercised to achieve a balance between various design features in order to successfully generate a healing environment.

Case Study #2: Emory Crawford Long Hospital Maternity Center

Overview

Located in midtown Atlanta, Georgia, this maternity center is owned and operated by Emory University. The newly constructed downtown hospital tower was completed in December 2002 and it includes a maternity center with eleven labor and delivery rooms, two cesarean rooms, twenty-four mother-baby suites, nurseries and twenty-four neonatal special care rooms. Women's services also include prenatal and postnatal education, bone density testing, mammography and obstetrics, and specialized care for high-risk pregnancies.

Figure 26. Emory hospital NICU bay, maternity suite and eleventh floor lobby.

The larger, state of the art special care unit was built with special attention being given to space for families, both at the bedside and in support areas. The redesigned NICU rooms are considerably larger and house one ventilator bed and infant per room, providing more privacy for family visits. With the addition of the private rooms, the NICU almost tripled in size from 3,800 square feet to 10,800 square feet. Staff have room to conduct infant care while families enjoy visiting in roomy, quiet spaces of their own. A family lounge with a four-bed unit for families to spend the night learning to care for their baby prior to discharge aids in the transition of the infant's homecoming.

In addition, given this facility's focus on family centered care, the maternity unit provides private rooms for routine births, where mother and baby are allowed to stay together. Furthermore, caretaking staff receives extensive training in the art of nurturing fragile NICU patients. This "nurturing" begins in the labor and delivery room and includes control of light, noise and temperature as well as gentle handling.

Conclusion of Analysis

The transition of staff and patients from the old open-bay space into the new renovated private room unit is worth noting. In the old unit, which had no private rooms, parents were many times elbow-to-elbow with staff. Since this facility encourages family unity, the interaction between parent and baby needed to be facilitated. By separating babies into their own individual spaces, fathers or other family members are now able to provide additional support and comfort to mother and baby without intruding in another patient's space. Clearly, the new unit's design is a successful model of the hospital's philosophy that family members can also be considered a vital part of the care team.

However, planning the new unit involved the allocation of additional square footage to allow space for private patient rooms and required circulation paths. The new spaces are comfortable and family friendly, but costly and difficult to maintain. For instance, the amount of required individualized equipment has multiplied. In addition, staff has to travel longer distances in order to reach patients.

Furthermore, post-occupancy reviews reveal that parents are satisfied with the increased privacy the individual patient rooms provide, but miss the constant attention and support of medical staff. New implemented technology still allows staff to monitor patients in private rooms from a central station without being immediately adjacent to the patient at all times.

Finally, daylight access is plentiful on the perimeter of the building thanks to its fully glazed facade. Unfortunately, this translucent feature does not offer a real connection with nature. The facility's urban location in midtown Atlanta may be greatly accountable for this deficiency. The building's translucency however, is very useful in the admission of sunlight.

Case Study #3: Winnie Palmer Hospital for Women and Babies

Overview

Figure 27. Winnie Palmer hospital's exterior courtesy of Winnie Palmer hospital

Located in Orlando, Florida and part of the Orlando Regional healthcare network, this 400,000 square-feet, 11-story addition was completed in 2006, and it includes 30 labor and delivery rooms, postpartum and high-risk antepartum units. The women's center provides care ranging from obstetrics and high risk births to gynecological services.

Winnie Palmer's new 40, 000 square-feet NICU addition increased the hospital's capacity to a total of 112 NICU beds, making it the fourth largest unit in the United States. Each year, more than 1,600 babies are admitted into this NICU. The unit is capable of providing level III care to premature, low birth weight and high-risk infants.

"Patient's comfort is the cornerstone upon which the hospital was built. [Therefore], special attention was placed on creating a soothing, healing environment with warm decor and natural ambiance" (Winnie Palmer hospital 2009). This hospital's soothing approach to healthcare also offers women many choices in childbirth, such as hydrotherapy or natural births.

Moreover, many of Winnie Palmer services are geared to pamper and revitalize women during their stay. As a result, the hospital offers upgradable packages that may include specialty linens, robes, gourmet menu selections, etc., all very similar to a chic-hotel.

Furthermore, the interior of the hospital is meant to be a sanctuary for women and their families. To that effect, patient rooms have 12 foot ceilings and floor to ceiling windows. This almost entirely glazed façade attempts to inspire serene, positive distractions, by letting the outdoors in through its transparent skin. Moreover, by locating patient beds facing the exterior windows and providing patients with a therapeutic view of the outdoors instead of corridors, an increased sense of privacy was achieved.

Figure 28. Winnie Palmer centralized nurse station and patient room views

All rooms except for those in the NICU are private. The NICU suites are semiprivate (4 babies per room). This setting was planned in order to enable nurses to view more than one patient at once and reducing walking distances between patients. Patient rooms have been arranged radially around a central nurse station.

Figure 29. Winnie Palmer NICU room courtesy of Winnie Palmer hospital

The nursing units are organized in three circular towers that surround the building's central core. On each floor three 10 to 12 bed modules radiate out from the core in a cloverleaf shape. The facility planners found this shape to be economical in terms of space, as it was believed to minimize corridor space and reduce the distance between patients and nurses.

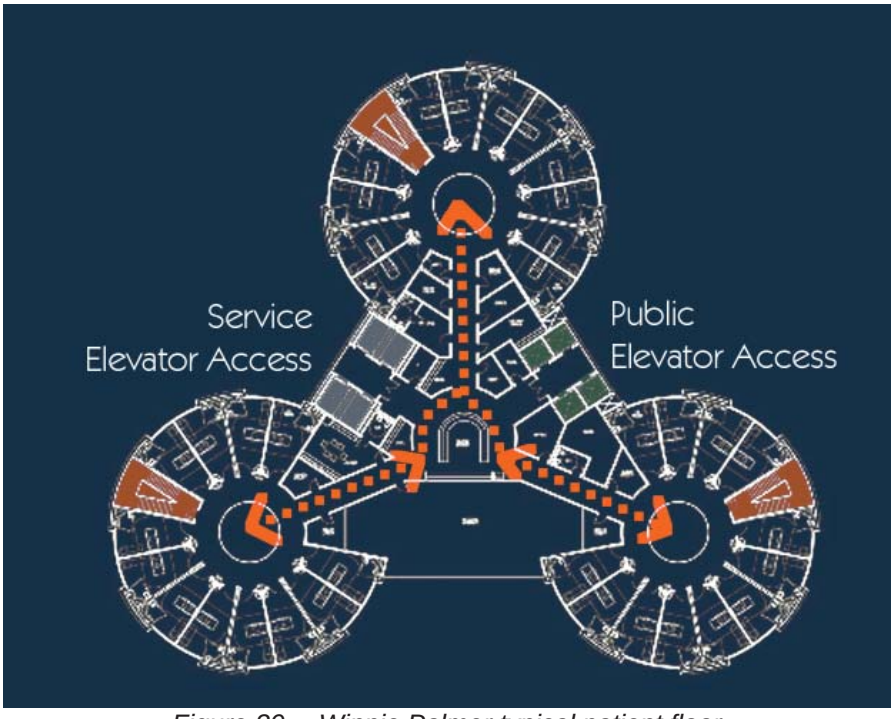


Figure 30. Winnie Palmer typical patient floor

The project's architect Jonathan Bailey, FAIA, RIBA, claims that a cloverleaf layout was prompted by the hospital's programming requirements and was not primarily an aesthetic solution. This design seems to have created a patient-centered environment that also provides a maximum, efficient layout in all areas of the hospital.

In addition, nature's influence is perceived through the addition of several balconies and a large outdoor patio named "Mother's Walk," which intent to provide necessary relief from stressful hospital conditions. The hospital's large terraces, multi-purpose rooms, and other amenities make it possible to accommodate a wide range of gatherings (visiting families, educational seminars, etc.) within the hospital.

Conclusion of Analysis

Figure 31. Winnie Palmer's NICU nurse station and occupied room.

The circular unit pod setting isolates each unit pod from each other, making it difficult for nurses to communicate or travel quickly from pod to pod. As a modular plan, this design is not successful in fostering staff collaboration between units. Social interaction between parents, and parents and staff within one unit did not seem to diminish in comparison to a completely open-bay setting. Consequently, NICU patient rooms are still lacking privacy due to the grouping of patients within one small space.

Access to nature is available visually from almost every location within the hospital. Floor to ceiling fenestrations provide outside views and ample daylight amounts. However, the amount of sunlight entering some patient rooms seems excessive considering this facility's location is Florida. Sun exposure control to shield from excessive heat and brightness can lead to added expenses.

Finally, despite the fact that physical outdoor access is limited to a few common areas throughout the hospital, the fully glazed façade allows a strong visual connection with nature from almost every room in the hospital.

Overview

Le Corbusier captures the essence of form and space in the following quote:

"Forms bathed in light … we look at things while walking around and the forms take on meaning. We receive a series of sensory shocks, one after the other, varying in emotion … the architectural sensation we experience stems from hundreds of different perceptions."

In the Chapel of Notre Dame Du Haut, the heavy materiality of the chapel's walls is emphasized by Le Corbusier's manipulation of daylight, which floods the interior space asymmetrically. Small openings mold daylight into varying levels, sizes and colors, reinforcing the sacred nature of the space. An additional light effect is produced by three towers that bring in indirect light. In the end, these varying light effects create additional layers of texture within the space. Light is unmistakably the originating and central concept of this design.

The natural surroundings however, provide the perfect backdrop for a peaceful sanctuary. Le Corbusier's architecture influences people's behavior as they come in contact with it. The carefully illuminated space and massive structure generate a sense of silence and humbleness.

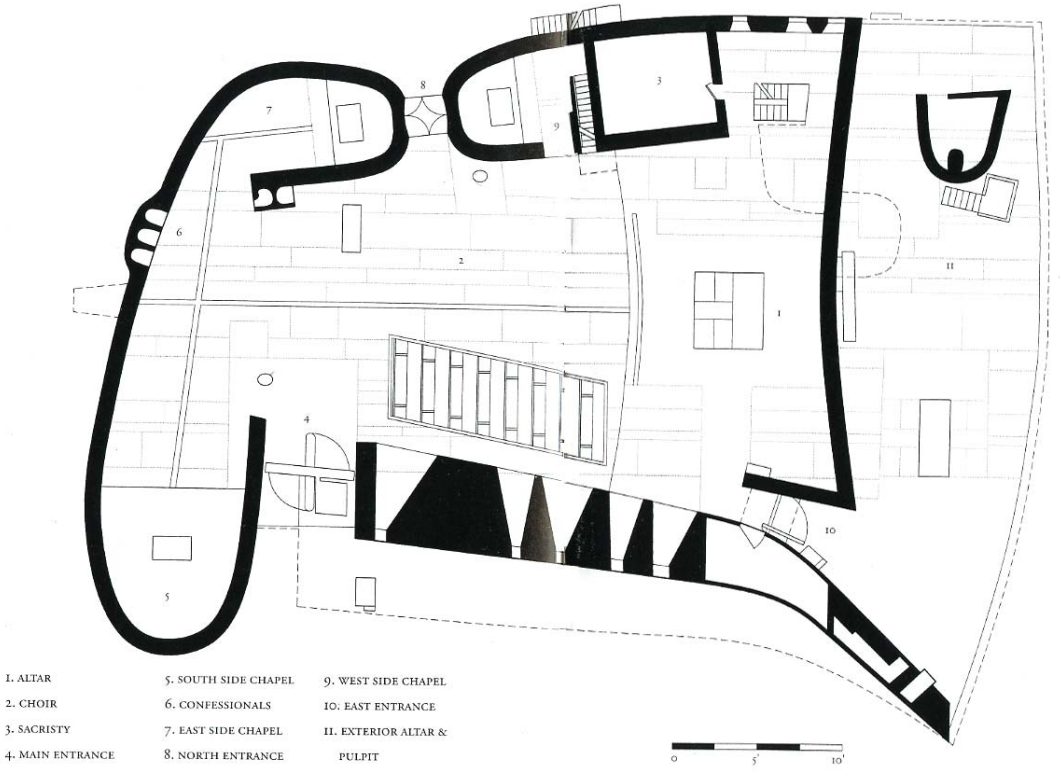


Figure 32. Notre Dame Du Haut floor plan

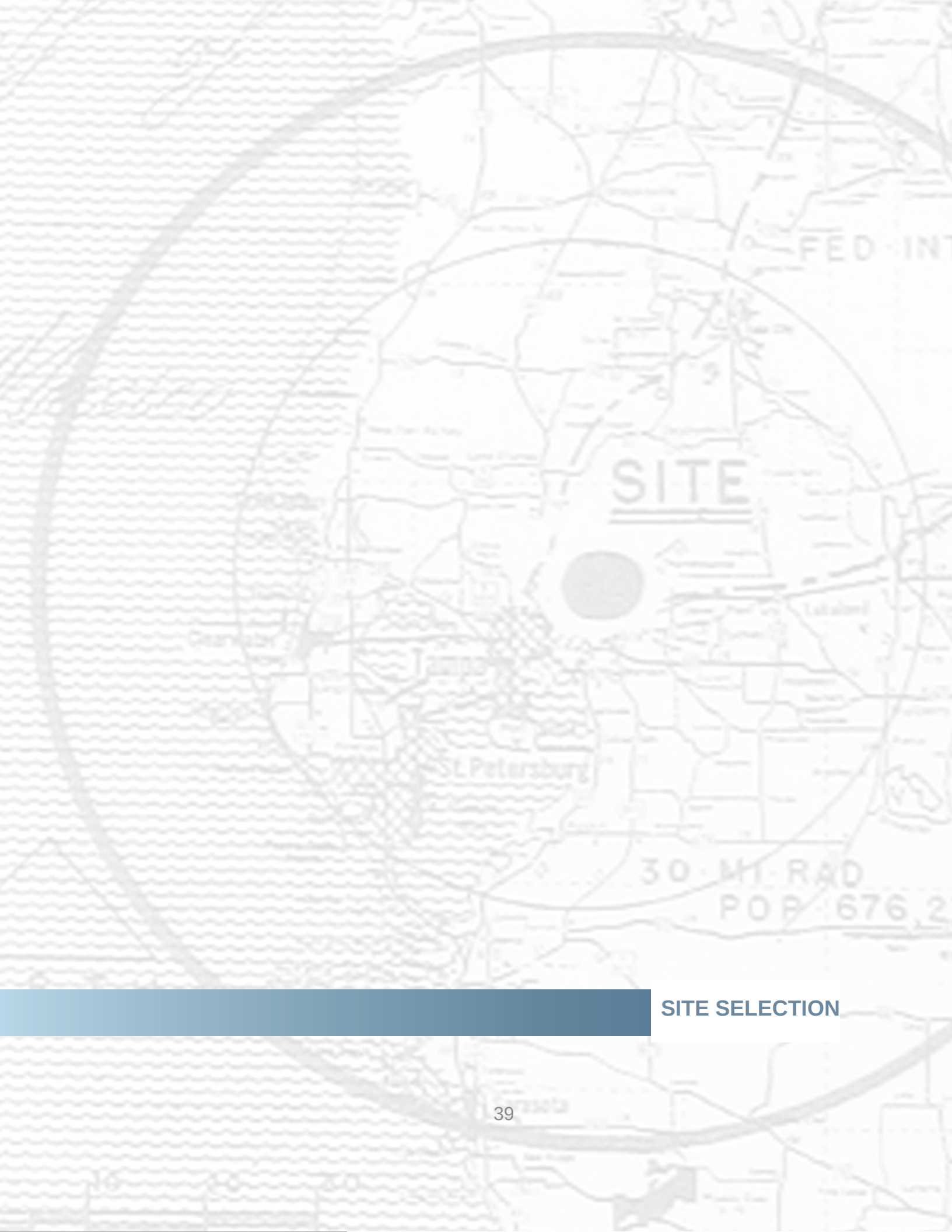
"The Chapel is a boldly expressive free-form structure in which the symbiotic association between the form and the interior natural light identifies the essence of the building … Light enters the space from multiple directions, bounding off richly textured surfaces and through colored glass that imparts spirituality" (Boubekri 2008).

Conclusion of Analysis

Clearly, a lot of this building's success lies in the architecture's successful interplay between structure, form and light. Nonetheless, the use of non-architectural elements like daylight trigger individual reactions towards the space. For example, the Chapel's simplistic interior is merely presented as the stage that brings about the interplay of light.

Figure 33. Notre Dame Du Haut light conditions

Although in Le Corbusier's example these varying light patterns render an assortment of conditions in a large enclosed area, their application in more individualized spaces, such as a newborn ICU can be very advantageous. For instance, light could be manipulated according to the level of specialized treatment necessary. Babies of varying conditions could be provided with spaces tailored to their individual needs.



SITE SELECTION

The University of South Florida - Tampa, Florida

All over the country, existing hospitals are turning to new ways of designing healthcare facilities based on recently acquired evidence. Most of these facilities are opting to replace their old units with new ones at their same locations. However, in order to better analyze this project's theory, and to test the concepts of an environment-oriented design, it is necessary to establish a location where the creation of a new, independent facility would be possible.

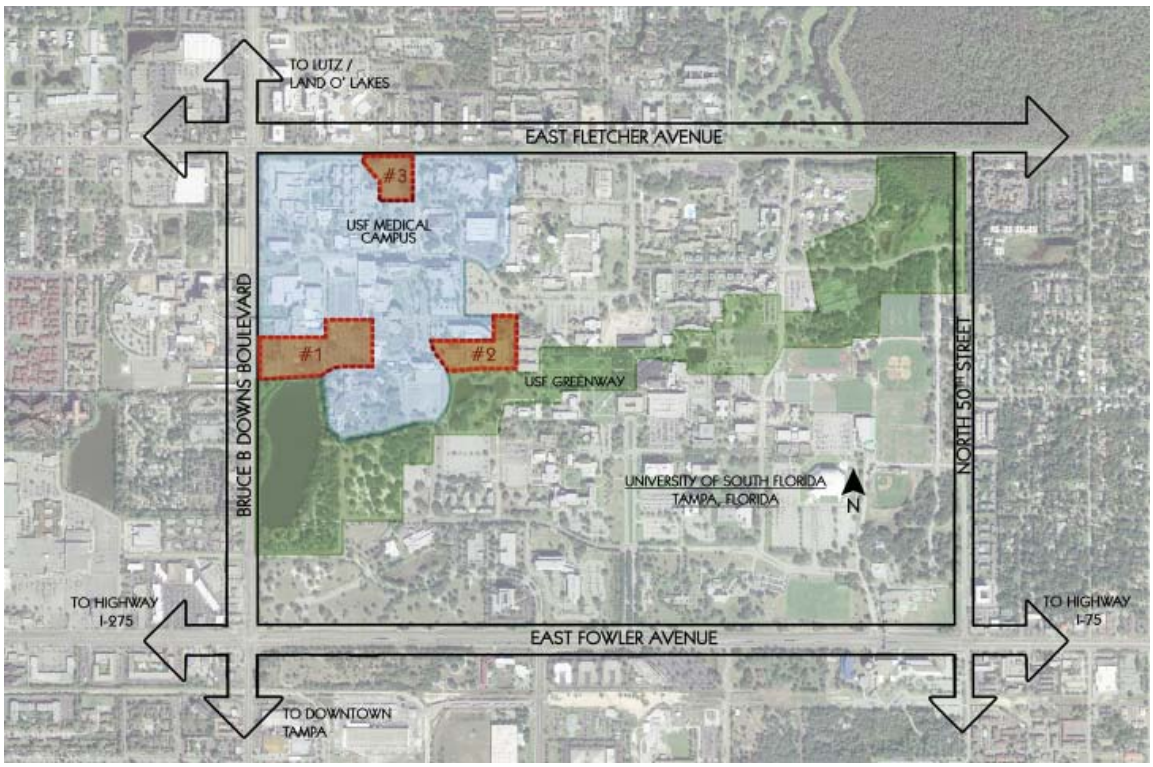


Figure 34. Proposed site locations within USF medical campus.

Nevertheless, proximity to other medical facilities remains a necessity in order to foster medical collaboration among various specialties. The University of South Florida's (USF) Medical Campus in Tampa, Florida possesses many of these qualities and the fact that it is a relatively new and developing campus suits the innovative nature of this project.

Subsequently, site selection within the campus boundaries was narrowed down to three options and was based on the following basic criteria:

- Access to nature
- Proximity to related / similar uses
- Road access to site

All three sites have similar topographical characteristics, that is, mostly flat land. Also, all locations have only been previously developed in the form of surface parking lots. Natural features such as lakes or ponds are mentioned individually within each category.

Alternate Site #1

Site number one is located south of the University of South Florida's College of Medicine. Its proximity to Bruce B. Downs Boulevard, a major road that connects North Tampa neighborhoods to downtown Tampa, provides great accessibility to and from the site.

The site is also adjacent to the USF Botanical Gardens and Lake Behnke, which presents opportunities of access to a vast nature environment. Although the area surrounding Lake Behnke would need some significant improvements in order to transcend into an outdoor sanctuary, several elements like the water views and already developed Gardens could be elemental in the design of a nature oriented facility.

Adjacency to the H. Lee Moffitt Cancer Center and the Shriners Hospital for Children enhance the potential for all of these facilities to establish this campus site as a destination for women's and children's health.

The total area available for development at this location is 10.2 acres. This calculation includes part of the USF College of Medicine's building that would need to be demolished.

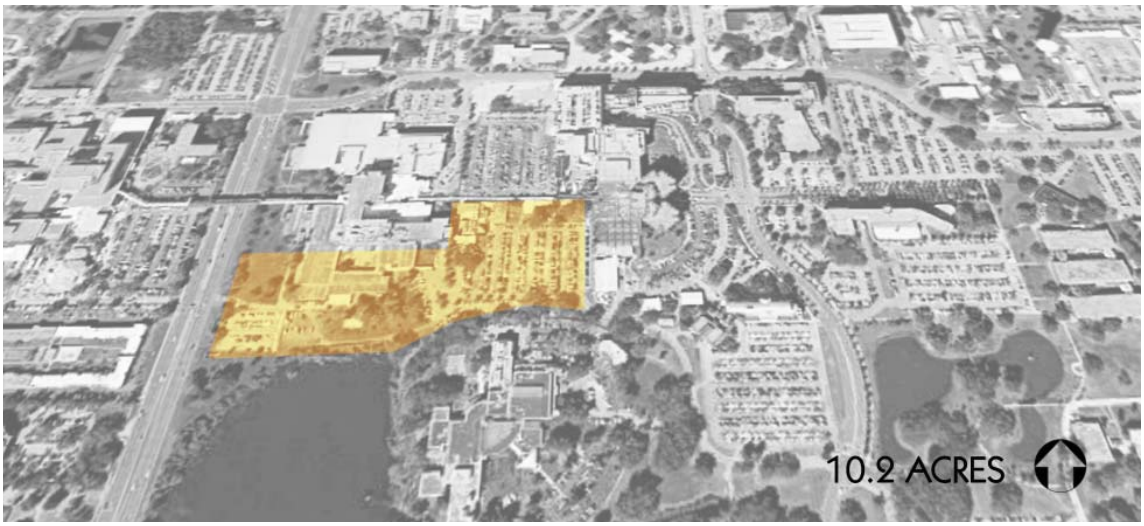


Figure 35. Alternate site location #1

Alternate Site #2

Site number two is located on an empty lot along Magnolia Drive and across the street (east) from the H. Lee Moffitt Cancer Center. This location provides more seclusion from major street traffic and noise than site number one. However, this means that accessibility to the site is slightly diminished as well. Vehicular traffic would have to use one of the on-campus roads to access the facility.

The site sits at the boundary between the USF medical center and the student campus. This information may suggest that increased flows of student pedestrian traffic along the exterior of the projected facility could be expected. Consequently, patients or visitors desiring a secluded serene environment may feel perturbed by constant passersby.

Exposure to positive distraction elements is possible through two small ponds. The water and surrounding minimal vegetation provide pleasant views and a good nature backdrop for the project.

The total area available for development at this location is 6.8 acres.

Figure 36. Alternate site location #2

Alternate Site #3

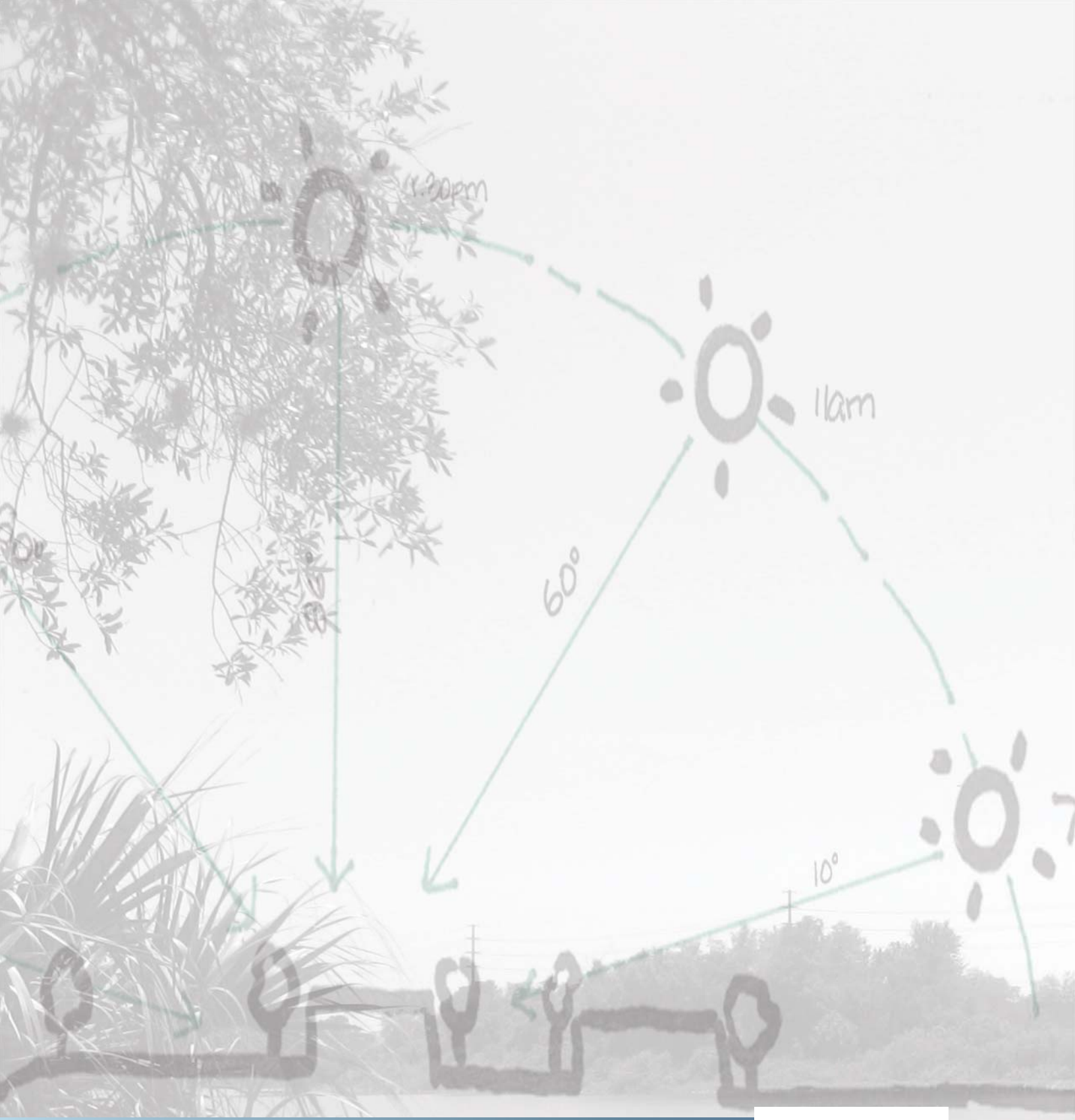
Site number three occupies a parking lot on the corner of Fletcher Avenue and Magnolia Drive across the street from the University Community Hospital (UCH). This location allows great visibility and accessibility from a major road into the site. However, street traffic and noise remain a concern.

In addition, this site does not offer existing pleasant views or access to any natural escapes. Extensive landscaping interventions would have to take place at ground level in order to provide building users with serene, relaxing surroundings.

The site's proximity to an existing large medical center, UCH, suggest the possibility of future collaboration between facilities and access to critical medical support resources.

The total area available for development at this location is 3.5 acres. The smaller surface area available means that the building would have to expand vertically to allow most of the ground surface to be utilized in the development of a natural oasis.

Figure 37. Alternate site location #3



SITE ANALYSIS

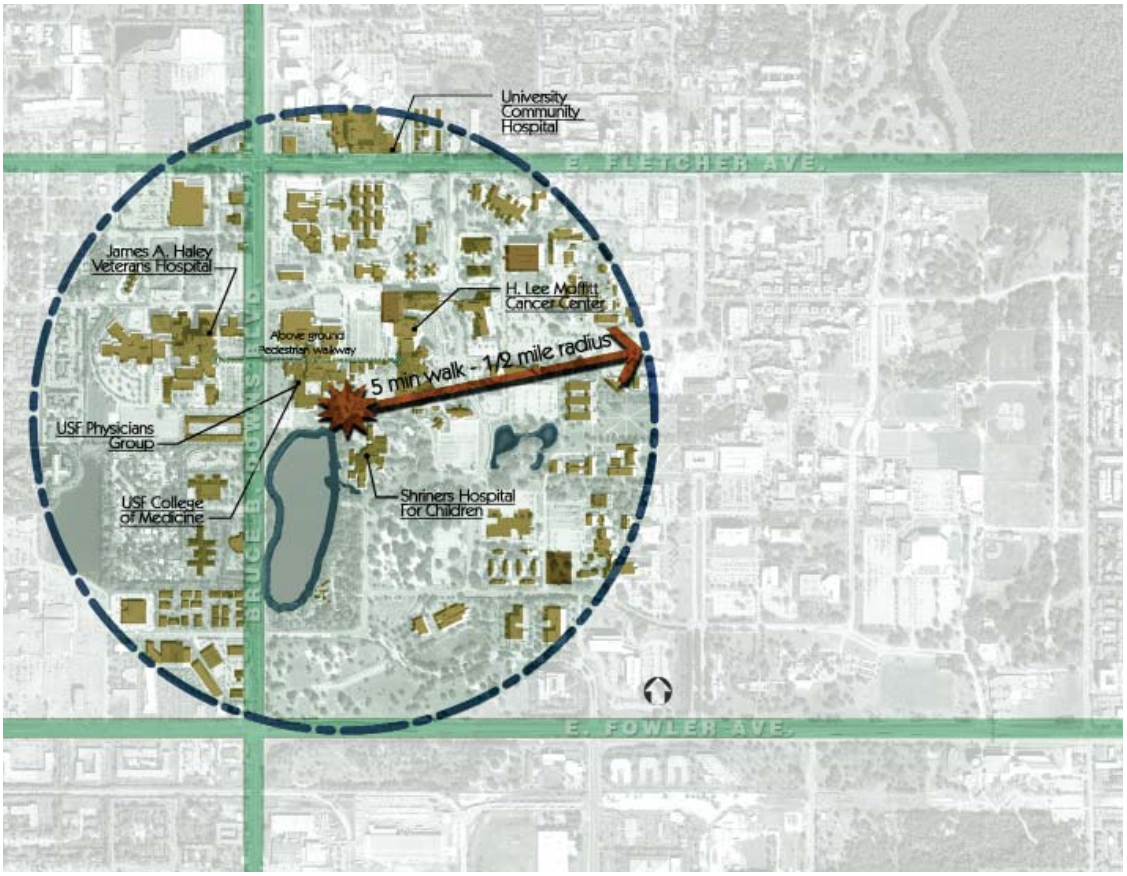


Figure 38. Major facilities within a half mile of the project site

The selected site is located within the University of South Florida's medical campus boundaries, and it is within walking distance to other medical facilities, including the H. Lee Moffitt Cancer Center to the east, the James A. Haley Veterans Hospital to the west, University Community Hospital to the north and the Shriners Hospital for Children to the south.

Climate information as well as the average amounts of daylight expected on or around the site are presented in Figure 39. In Tampa, the hottest temperatures can be felt during the months of July and August, where they can range between 74° to 90°F. August is also the rainiest month of the year, with an precipitation average close to 8 inches.

In contrast, the driest months are April and November with less than 2 inches of rain accumulation. This location is also very vulnerable to hurricane activity between the months of June and November. Curiously, August has the lowest average recorded wind speeds of the year (below 7 mph).

One of the major assets of the site is its large amount of sunlight, which is somewhat steady throughout the year. Mid-June averages the longest days with 15 hours of natural light in a day (6 am sunrise and 8.30 pm sunset). The shortest daylit dates can be found in December, with an average of 11 hours of sunlight (7 am sunrise and 6 pm sunset). Surprisingly, the spring months of April and May have the highest percentage (75%) of possible sunshine days; and rainy summer months August and September have the lowest percentage (61%).

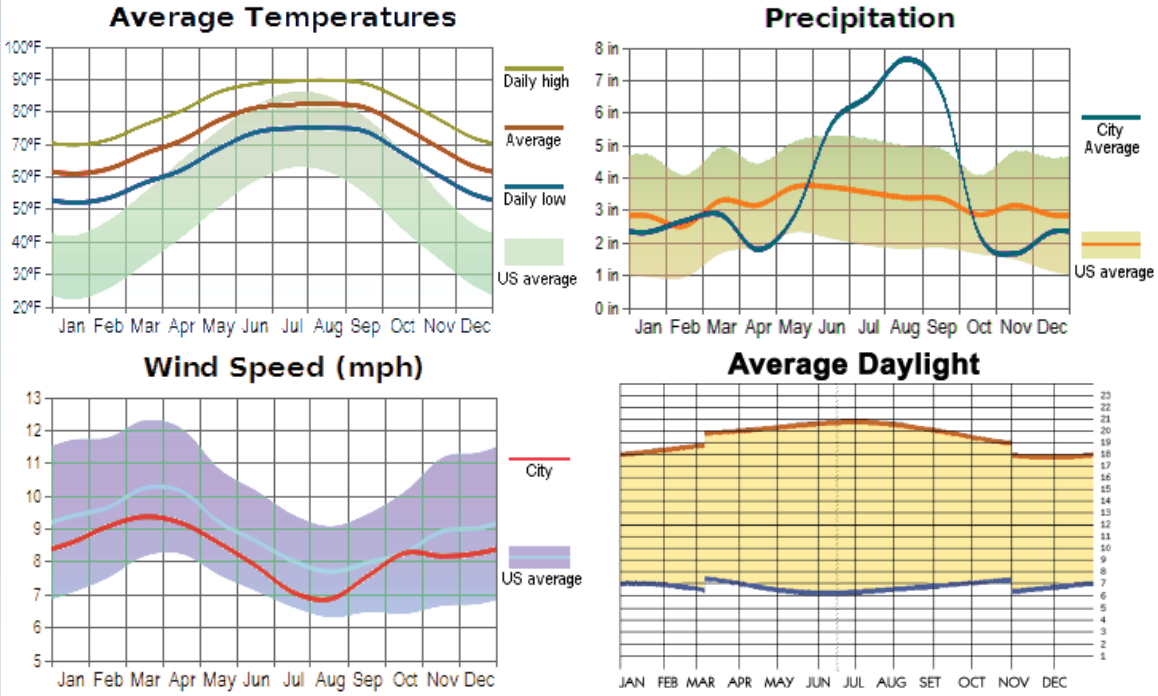


Figure 39. Typical climate conditions for Tampa, Florida courtesy of city-data.com

In summary, all of this information reveal the harsh climate conditions at this location, in this case high levels of heat (± 90°F) and humidity (± 78%) during the summer season (June thru September). These hot and humid conditions discourage people from spending time outside and opt for more comfortable, air-conditioned, indoor spaces. Therefore, in order to implement nature and daylight successfully in the design, these facts indicate that a combination of indoor and outdoor spaces would be ideal.

In most other northern locations a similar behavior is observed during opposing weather conditions. In the winter, when freezing temperatures render outdoor spaces unbearable people tend to spend the majority of time indoors. Regardless of the temperature, ample amounts of daylight and clear skies can help provide a pleasant indoor and outdoor environment throughout the year.

Site Accessibility

Access to the site is possible from several city arteries. The most direct route is through Bruce B. Downs Boulevard, where a future light rail stop is planned.

East-west routes that connect the site to major highways (I-75 and I-275) include Fowler and Fletcher Avenues.

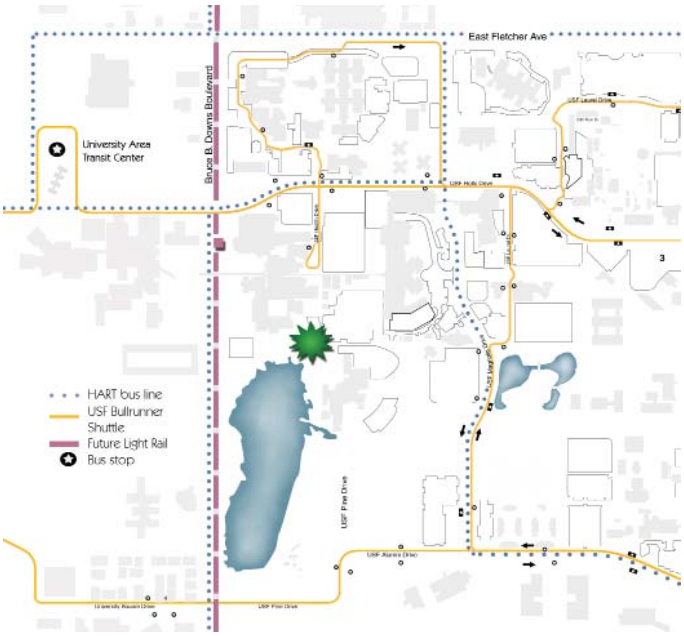


Figure 40. Public transportation routes.

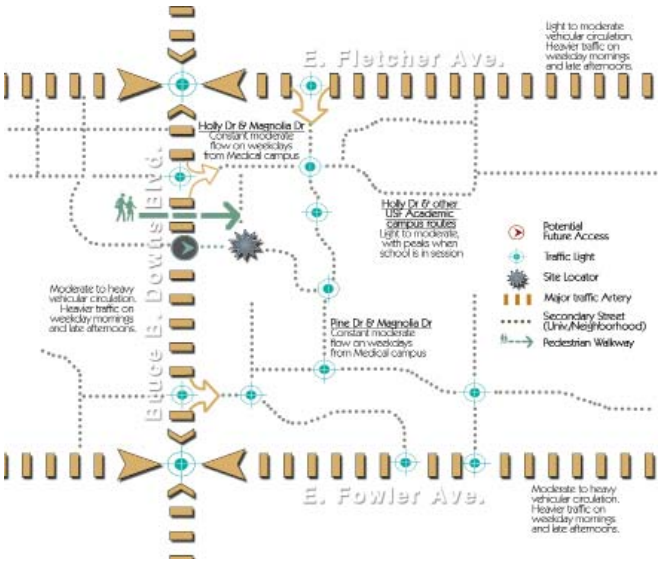
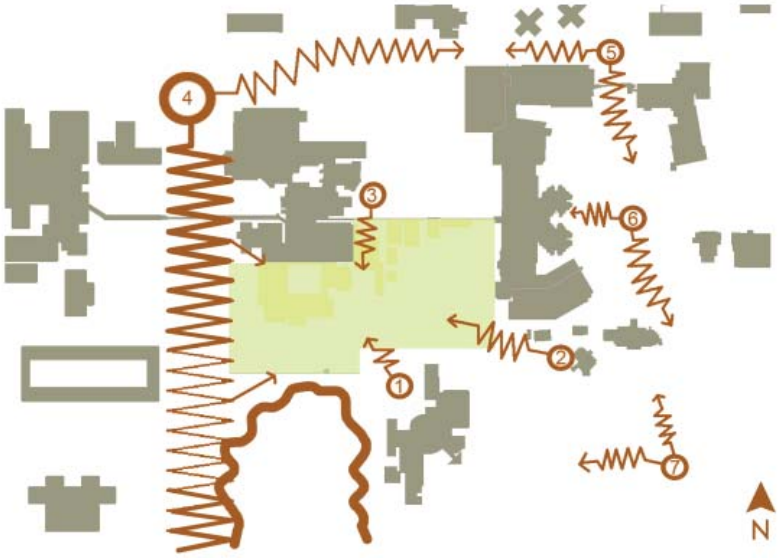


Figure 41. Major vehicular and pedestrian access to site.

Noise Sources

Noise originating from street traffic is a main concern on this site. Since this project's ultimate objective is patient well-being and improved recovery outcomes, it is important to address the type, amplitude and recurrence of stressful intrusions such as noise. Ideally, buffer elements will need to be implemented as well as set backs from the street to minimize noise intrusion.

On that point, the following figure identifies the most notable noise sources affecting the site. At a minimum, locating these sources will be useful when considering the appropriate methods to minimizing noise.



1. LIGHT noise from Shriners playground and employee parking lot during mornings and at end of workday.
2. LIGHT noise from Moffitt clinic playground and car drop-off area, during weekday business hours.
3. MODERATE noise from buses stopping and leaving at bus stop, during weekday school hours.
4. HEAVY constant noise from Bruce B Down Blvd. car traffic and from intersection with Holly Dr.
5. MODERATE noise at Holly Dr./Magnolia Dr. traffic light, during weekday business hours.
6. MODERATE noise at main entrance to Moffitt Cancer Center, during weekday business hours.
7. MODERATE noise at Medical Center Dr./Magnolia Dr. trafic light, during weekday business hours.

Figure 42. Noise sources surrounding the site.

Solar Conditions

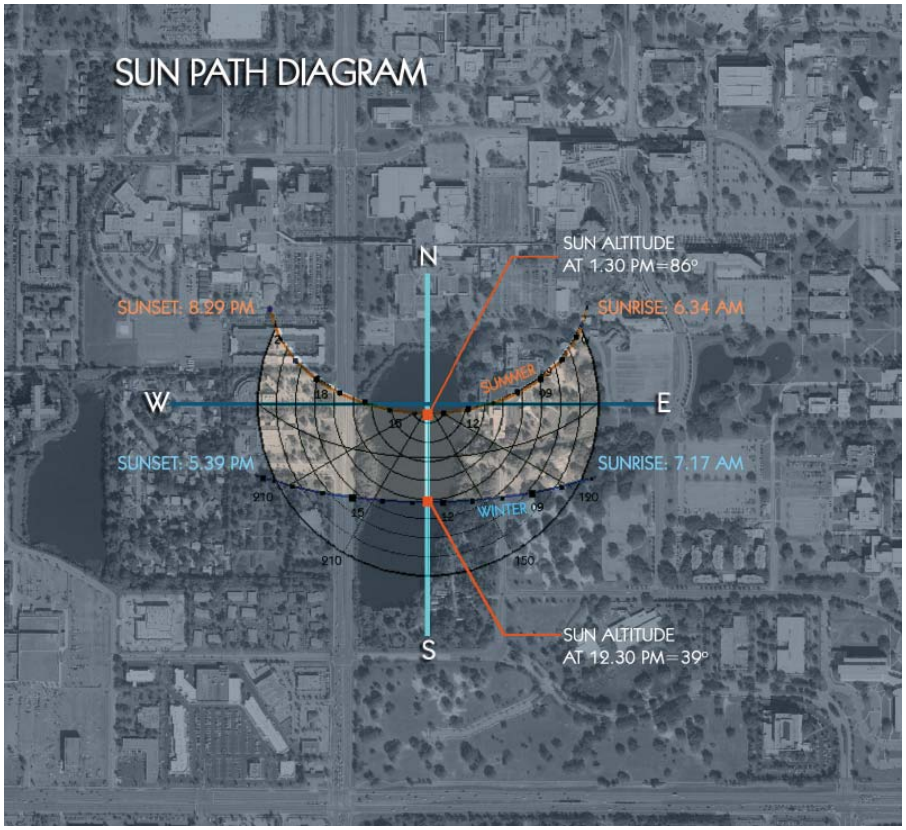


Figure 43. Sun path diagram

Earlier, climate diagrams indicated that this site's location is exposed to above average amounts of sunlight throughout the year. However, a study of the sun's path at different times of the year and of the day denotes areas within the site that receive the least and most sun exposure.

A variation in the sun's angle of incidence occurring as seasons change can also affect the amount of sun exposure. The differences are more evident at the peak of the winter and the summer seasons. For example, in the summer solstice, the sun will reach an altitude of 86° (in relationship to the earth's surface) at approximately 1.30 in the afternoon. Conversely, in the winter solstice, the sun will sit lower in the sky, reaching a maximum altitude of 39° at 12.30 in the afternoon.

This information indicates that throughout the year north areas receive the least amount of sun while south areas receive the most constant exposure. Therefore, measures to protect against excessive brightness and heat will have to be addressed in the design process. Also, existing tree coverage around the site is very low and scarce offering little or no relief from the sun.

Unfortunately, avoiding southern orientation in order to minimize the effects of the harsh southern sun would also diminish the project's contact with the main feature of the site, its nature environment.

The following diagrams present a straightforward interpretation of how the sun moves in relationship to the site. In addition, a simple diagram of the site's shadow patterns helps inform the design process further.

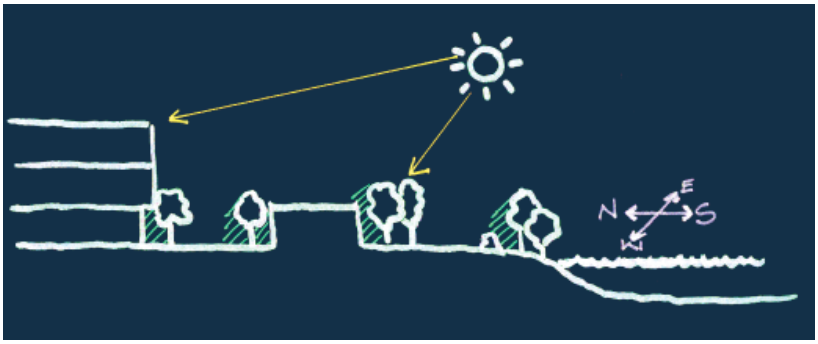


Figure 44. Shadows Pattern

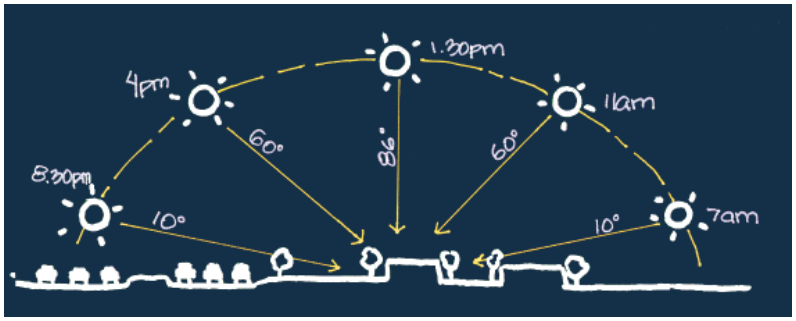


Figure 45. Section diagram of solar path during Summer season

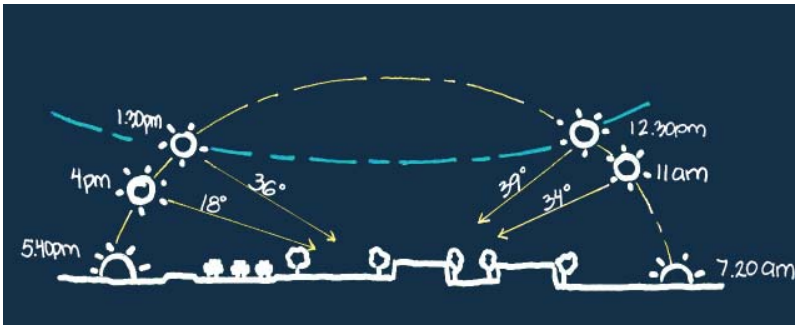


Figure 46. Section diagram of solar path during Winter season

In summary, a building orientation minimizing southern exposure would be ideal. But, since nature connection to the south is also a desirable attribute of the project, alternative sun control methods will have to be implemented in order to benefit from both elements.

Nature Access

Natural environment is provided by the adjacent University of South Florida's Botanical Gardens and Lake Behnke. The Gardens anchor the west end of a university planned greenway that stretches across the campus.

"The mission of the Botanical Gardens is to foster appreciation, understanding, and stewardship of our natural and cultural botanical heritage through living plant collections, displays, education, and research" (USF Botanical Gardens literature).

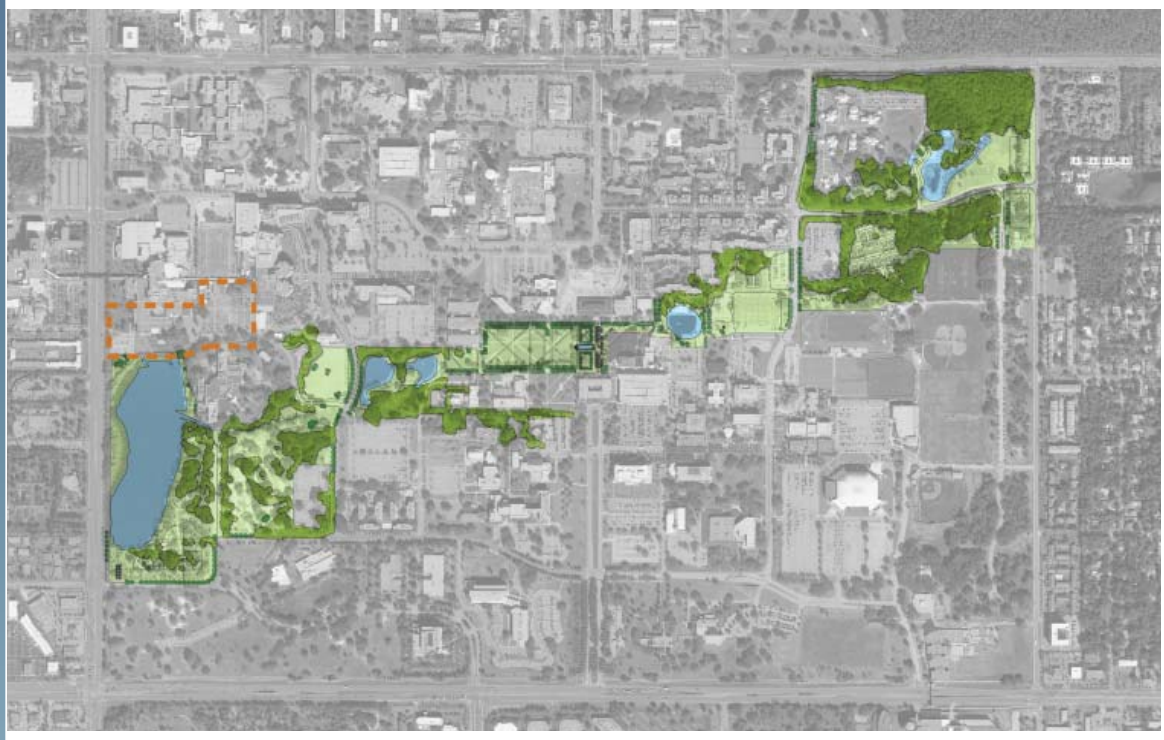


Figure 47. University of South Florida's proposed Greenway.

Visual and programmatic features of the project will be closely coordinated with the available landscape.

Figure 48. University of South Florida's Botanical Gardens

The site's land is property of the University of South Florida. The land itself is zoned for "major public/semi-public" uses, which permits the addition of a medical facility. Immediate context is comprised of university medical, office and classroom buildings. The rest of the surrounding area is largely comprised of residential, commercial and industrial uses as seen in the following figure.

Figure 49. City of Tampa's adopted land use for site's neighboring areas

Figure 50. Surrounding context: Shriners Hospital, USF College of Medicine and Children's Research Facility.

The following site plan diagram dissects the site into a visual set of elements. Views of the site have been categorized into excellent, mildly negative and negative views. In general, the findings reveal that the site surroundings are quite pleasant. The best quality views (vast vegetation and water views) are located on the southern portion of the site. The northeast areas of the site offer uninteresting views of the back of H. Lee Moffitt Cancer Center.

Figure 51. Quality of views from various areas within the site.

Figure 52. Views #1A and #1B, towards Lake Behnke.

Figure 53. View #2, towards USF College of Medicine.

Figure 54. View #3, towards existing parking lot.

Figure 55. View #4, towards Shriners Hospital for Children.

Figure 56. View #5, towards H. Lee Moffitt Cancer Center

Figure 57. View #6, towards Bruce B. Downs Blvd. and Lake Behnke.

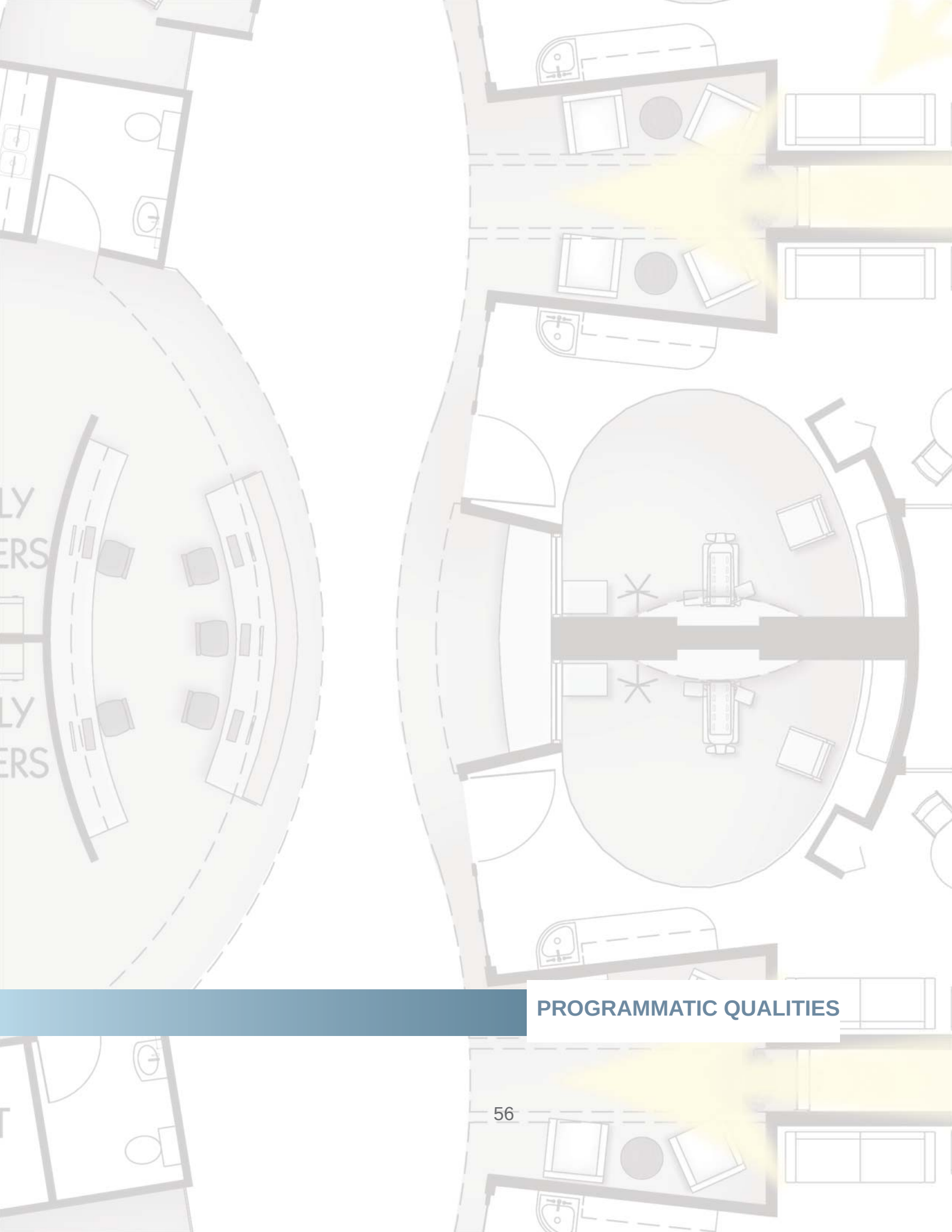
Figure 58. View #7, towards Bruce B. Downs Blvd.

Figure 59. View #8, from Botanical Gardens.

The USF College of Medicine

The University of South Florida's College of Medicine is directly adjacent to the proposed site. Although, the university's Facilities Department has plans for the college's renovation and expansion in the future, the particular aspects of designing such a facility will not become part of this thesis project. However, the possibility of establishing a connection and providing educational resources to members of the college will be considered.

Figure 60. Aerial view of the USF College of Medicine



PROGRAMMATIC QUALITIES

Programmatic Qualities

The programmatic objective of this thesis is to create a prototype model of a NICU based on a Women's and Infant's Medical Facility. To that extent, components (departments) of the overall proposed facility and their most appropriate adjacencies will be analyzed. For instance, areas like maternity suites, cesarean operating rooms and newborn ICUs need to have a strong correlation.

The women's services component, specifically maternity suites, will be crucial in improving the outcome of patient recovery. Labor and delivery wards located in the same hospital of newborn intensive care units have been shown to minimize separation anxiety between baby and mother.

Contact with nature will be maximized by giving priority to exterior views whenever possible. In order to achieve this, the relationship between departments within the hospital will be mostly linear expanding east to west. Psychologically, this constant connection with nature and daylight will promote building users' well-being.

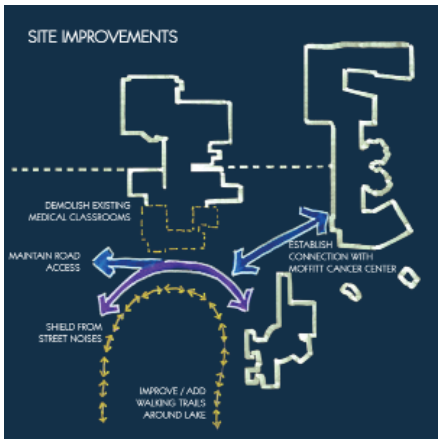


Figure 61. Context relationships diagram

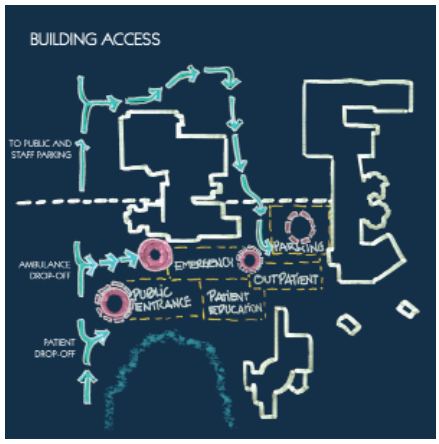


Figure 62. Adjacency diagram

As stated earlier, adjacency to exterior nature settings will be a necessary condition for most spaces. Interior and exterior courtyards exposed to nature elements would provide patients, families and staff relief from the sense of confinement from being inside.

Staff areas would specially benefit from the peaceful natural surroundings. These positive distractions could serve as indirect psychological stress relievers by helping take some of their focus away from work routines.

In the NICU, the connection with nature and daylight will vary. For instance, in spaces dedicated to patients, the approach will be more subtle. Since, premature infants' systems are more delicate than adults', direct exposure to exterior nature elements could be harmful. On the other hand, spaces dedicated to families or staff will see their exposure to daylight and nature maximized. In spite of this, direct physical contact with outdoor environments (through exterior terraces or balconies) will be avoided in order to minimize infection risks.

The program will also include spaces for educational activities like resource centers or training facilities for patients, parents and staff. These spaces will have access to the exterior, directly in the form of courtyards or indirectly, in the form of solariums.

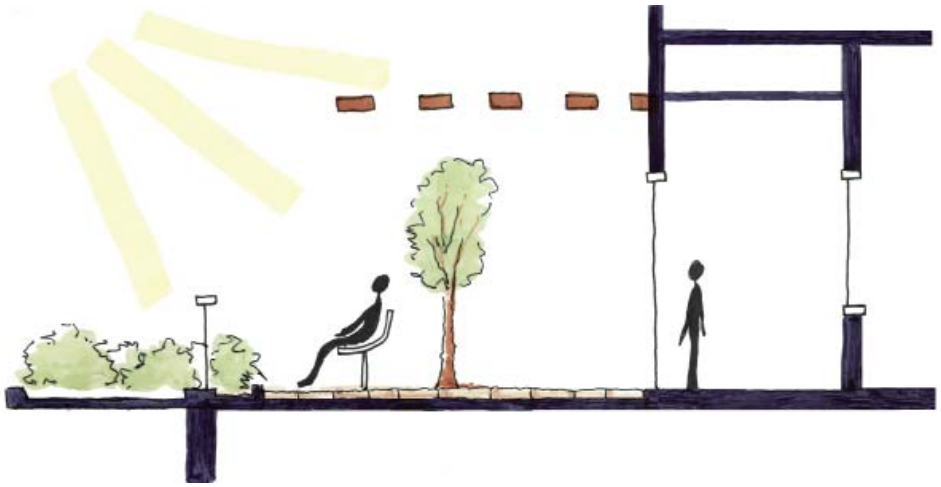


Figure 63. Sketch of exterior courtyard with access to nature.

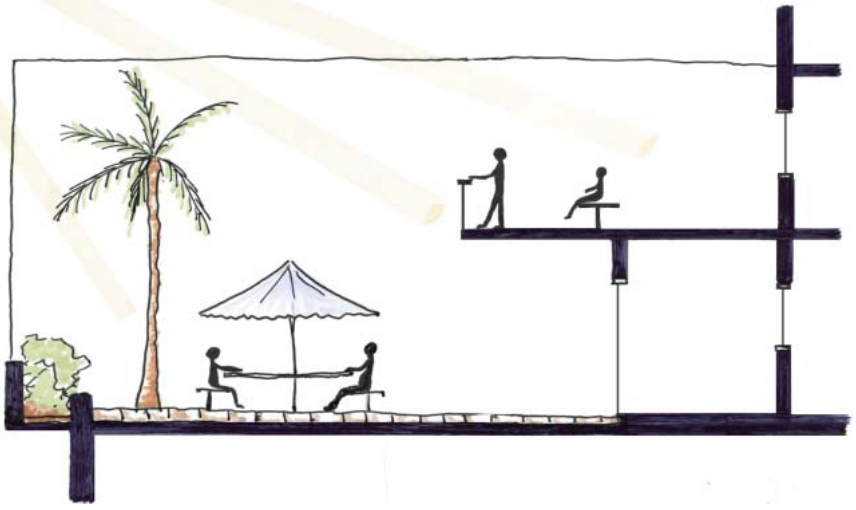


Figure 64. Sketch of interior courtyard with access to nature.

The main focus of the program will lie in the patient areas and their relationship with the proposed elements (nature, daylight and sound). As more hospitals are building the case for developmental care, the single patient room model of design has been gaining acceptance as a developmentally appropriate and family-centered solution (Smith, et al. 2004).

However, in this project, a combination of both single patient rooms and open-bay wards will be explored. Individualization of infant care areas will provide enhanced medical support to critically ill patients. Private patient rooms will allow specific treatments to be tailored to each patient and his or her environment. Furthermore, since most of these patients' delicate conditions warrant them a longer hospital stay, providing a comfortable environment for their parents or family members to stay and contribute in their care is a necessity.

Babies in need of observation but not in critical condition will benefit from treatment in the traditional open-bay setting. This layout will allow nurses to monitor several babies closely and attend to changes in babies' condition immediately.

Recent evidence shows that a downside to separated infant care areas (private patient rooms) is the loss of ongoing social contact and opportunities for meeting people. It may be helpful, therefore, to plan for alternative gathering locations throughout the NICU that would facilitate social interactions. Consequently, family lounges will be an essential part of the program. Such common areas can positively influence families experience at the hospital by increasing individual control over social contacts.

A variation of spaces will help minimize negative social interaction. In other words, parents may experience too many interactions at times when such contact is inappropriate or with others with whom interaction is unwanted. Therefore, if the opportunity for pleasant, casual interaction is provided by the setting, the discovery of common interests and the frequency of gratifying contact will be maximized. That is why the design of this prototype includes a combination of small meeting pockets and large common gathering areas. This mixture of formal and informal gathering spaces will facilitate casual encounters in a small or large scale.

These informal gathering areas will also act as connecting nodes between medical staff and patient's family. Family will be able to interact better with the medical team and contribute to the care of their infant. As a result, a family-centered care environment will be promoted.

In addition, since positive first impressions are essential in any space, the Recommended Standards of NICU Design 2007 indicate that the reception/ lobby area should contribute to and foster the concept that families are important members of their infant's health care team, and not just visitors. As an added feature, facilitating contact with staff also enhances security of infants in the NICU.

Similarly, including transitional family/patient suites in the program will allow parents to ease into the transition of going home by having the knowledge and help of medical staff within reach. These provisions will allow parents to start the role of primary caretakers of their babies more comfortably.


Figure 65. Hospital atrium and nature intervention examples.

Other spaces of focus in the program include physician and nurse lounges, alcoves in hallways with visual access to exterior, multi-purpose rooms for families and staff that can be used for meetings, consults or even exercising, meditation areas, children's playroom for siblings, and most importantly, patient spaces tailored to their particular acuity.

The type of spaces required in a facility such as this was derived from various sources that also offer formulas to calculate the required quantities and sizes of rooms. For example, the Guidelines for Perinatal Care indicate that a ratio involving the number of births, the average lengths of stay and the accepted occupancy levels in a specific facility will yield the number of patient rooms needed.

Quantity	Room Name	SF	Subtotal SF	Total SF
1	Main Lobby/ Reception area	400	400	
1	Offices (Security)	90	90	
1	Main Lobby waiting area	1,500	1,500	
3	Food Service (Restaurant/Café)	2,000	6,000	
1	Resource Center	600	600	
4	Classrooms	600	2,400	
1	Meditation room	400	400	
NA	Indoor Courtyards	1,000	1,000	
1	Gift shop	600	600	
6	Public Restrooms	50	300	
1	Other support (Storage & housekeeping)	280	280	
	Total Public Use Area			**13,570**

Figure 66. Breakdown of program areas-Part 1

Quantity	Room Name	SF	Subtotal SF	Total SF
1	Reception desk	200	200	
1	Visitor Waiting area	300	300	
24	Private Patient Rooms (NICU) (120 SF/bed)	400	9,600	
4	Patient open-bay unit (NICU) (6 beds per room)	1,400	5,600	
8	Family Sitting Lounge pockets	140	1,120	
2	Transitional Room / Overnight discharge	300	600	
2	Nurse stations	200	400	
4	Offices (Managers, Security, Consult)	90	360	
2	Physician Workroom	240	480	
1	Physician's Lounge	630	630	
2	Physician On-call rooms	200	400	
4	Med support areas (Medication, Nourish, Clean & Soiled Rms)	540	2,160	
2	Other support (Storage & housekeeping)	280	560	
1	Parent Multi-Purpose Center	840	840	
1	Conference room	840	840	
1	Meditation area	250	250	
1	Sibling's Playground	300	300	
1	Family Kitchen	300	300	
1	Family Laundry room	100	100	
2	Staff Lounge	850	1,700	
NA	Indoor/Outdoor Courtyards	2,800	2,800	
12	Public Restrooms	50	600	
	Total Newborn Intensive Care Unit			**30,140**
1	Lobby/ reception area	400	400	
1	Waiting area	600	600	
10	Exam Room/Triage	150	1,500	
3	Operating Rooms (C-Section) & support	750	2,250	
16	Prep/Recovery Bay	140	2,240	
28	Private Patient Rooms (Labor, Delivery & Post Partum)	520	14,560	
1	Lactation Support & Education	2,500	2,500	
	Indoor/Outdoor Courtyards	2,500	2,500	
1	Family Lounge / Kitchen	600	600	
1	Staff Lounge	600	600	
2	Nurse stations	200	400	
1	Physician Workroom	300	300	
1	Conference room	300	300	
2	Med support areas (Medication, Nourish, Clean & Soiled Rms)	540	1,080	
4	Other support (Storage & housekeeping)	280	1,120	
4	Public Restrooms	50	200	
8	Registration/Discharge desk	45	360	
	Total Labor and Delivery Suite			**31,510**
1	Lobby/ reception area	400	400	
1	Waiting area	600	600	
1	Resource Center	600	600	
10	Private Patient Rooms-Ante Partum	400	4,000	
1	Workout room	600	600	
1	Meditation area	400	400	
	Indoor/Outdoor Courtyards	1,500	1,500	
1	Family Lounge / Kitchen	600	600	
1	Staff Lounge	600	600	
1	Nurse stations	200	200	
1	Physician Workroom	260	260	
1	Conference room	200	200	
1	Med support areas (Medication, Nourish, Clean & Soiled Rms)	540	540	
2	Other support (Storage & housekeeping)	280	560	
2	Public Restrooms	50	100	
	Total Ante-Partum Suite			**11,160**

Figure 67. Breakdown of areas-Part 2

Quantity	Room Name	SF	Subtotal SF	Total SF
1	Reception area / Drop-off area	400	400	
8	Exam Rooms	150	1,200	
1	Nurse Station	200	200	
1	Physician Workroom	260	260	
1	Waiting area	400	400	
1	Med support areas (Medication, Nourish, Clean & Soiled Rms)	540	540	
1	Other support (Storage & housekeeping)	200	200	
2	Restrooms	50	100	
	Total Emergency Suite			**3,300**
1	Lobby/ reception area	400	400	
1	Waiting area	600	600	
1	Nurse Station	200	200	
6	Exam Rooms	150	900	
3	Operating Rooms (GYN)	600	1,800	
2	O.R. support areas (sterile, scrub space)	160	320	
10	Prep/Recovery Bay	140	1,400	
1	Pharmacy	800	800	
1	Conference room	200	200	
4	Offices (Manager, Security, Consult)	90	360	
1	Other support (Storage & housekeeping)	280	280	
6	Public Restrooms	50	300	
	Total OutpatientSuite			**7,560**
1	Lobby/ reception area	300	300	
4	Imaging Rooms (X-ray, scans, Ultra sounds)	400	1,600	
2	Exam Rooms	150	300	
2	Public Restrooms	50	100	
1	Physician Workroom	180	180	
1	Waiting area	400	400	
	Total Imaging Suite			**2,880**
2	Conference room	200	400	
6	Offices	90	540	
2	Physician Workroom	260	520	
1	Staff Lounge/ kitchen	600	600	
1	Staff Workout/ Exercise Room	600	600	
4	Physician on-call Rooms	300	1,200	
1	Physician Lounge with lockers & restrooms	2,000	2,000	
	Total Physician Suite			**5,860**
6	Mech/Elec/Telecom	250	1,500	
3	Circulation (Stairs/Elevators)	600	1,800	
1	Dock- supply receiving	600	600	
3	General Storage	600	1,800	
	Total Building Services Area			**5,700**
1	Outdoor Communal Gardens	45,000	45,000	
	(not included in building total area)			
1	Public Parking Garage (approx 290 spaces)	96,000	96,000	

Total Building Area	**98,110**

Figure 68. Breakdown of areas-Part 3

DESIGN PROPOSAL

Project Concept

"The design (of a NICU) should creatively reflect the vision and spirit of the infants, families and staff of the unit" (Recommended Standards for Newborn ICU Design 2007).

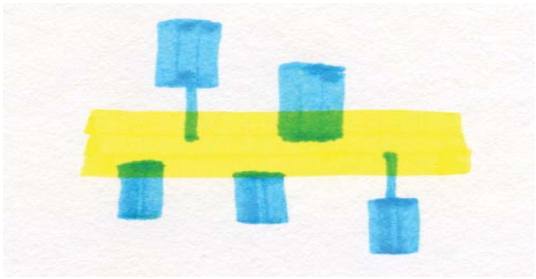


Figure 69. Overall project parti diagram..

As stated earlier in this document, this project's ultimate goal is to create a soothing and healing environment utilizing nature, daylight and sound as key components in its design. As a result, transparency plays an important role in the overall concept. Whenever possible translucent elements have been introduced to increase accessibility and connection to daylight and nature.

Moreover, as evident from the Mother and Baby circulation diagram, a path to recovery is clear. Therefore, an understanding of the relationship of the phases a baby and a mother go through while they stay at the hospital is vital to this design.

The moment a pregnant woman and her baby enter the facility, their path to recovery starts and it may end up taking unexpected turns for both of them. Mother could have a safe delivery, recover together with the baby and return promptly home, or they could both require specialty care after a high-risk delivery and stay longer at the hospital.

The project's concept is based on this notion of connectivity to a common element (the path) and the encounter of unexpected conditions (positive or negative). Similarly, the relationship of spaces at the proposed facility will mimic this sequence by establishing a core (linking path) and attaching the focus nodes (medical units or green pockets) to it. This creates opportunities for solid and void spaces throughout the mass.

This progression of spaces will be essential in establishing department adjacencies and overall building layout.

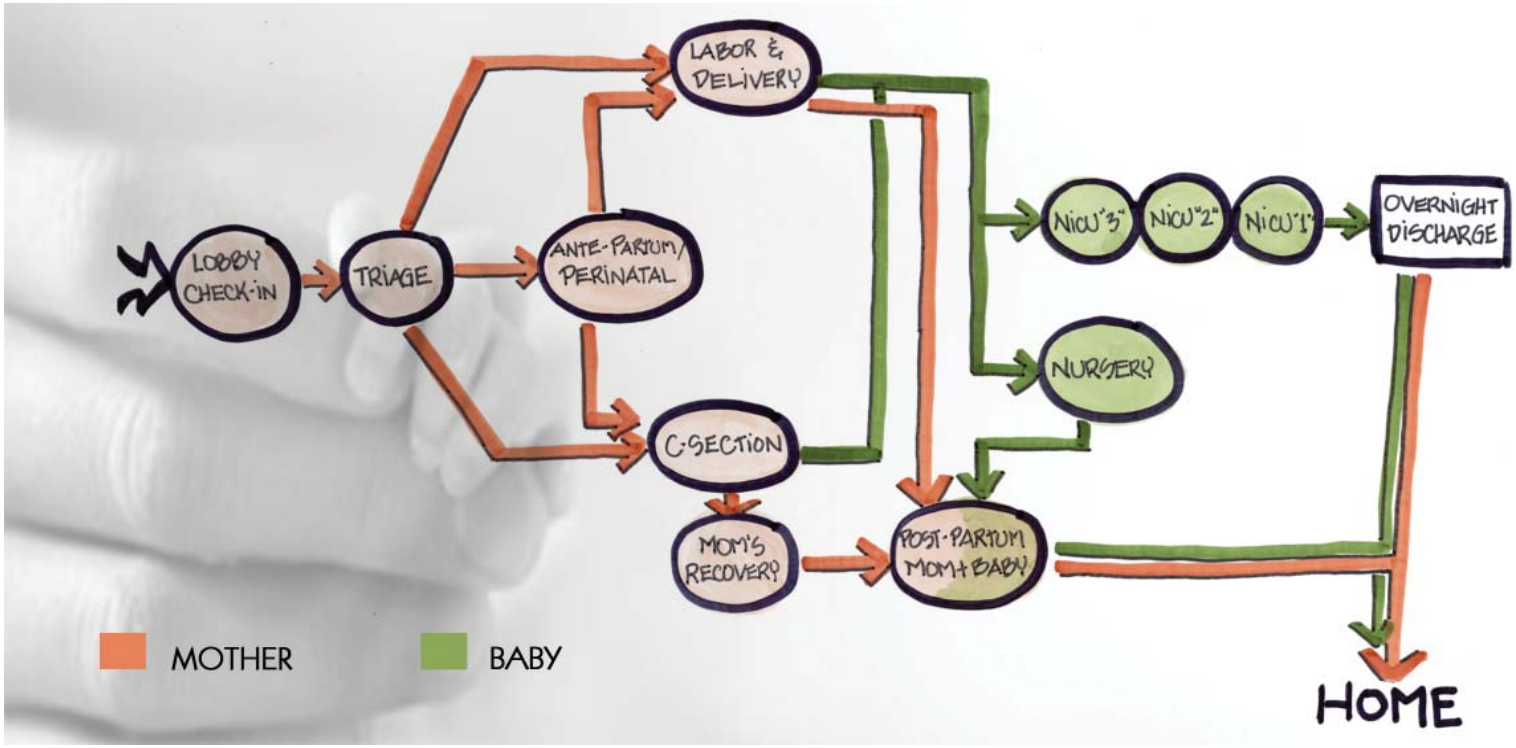


Figure 70. Mother and baby circulation diagram while in hospital.

As a result, the following diagrammatic models offer an exploration of building components and how they could relate to the site. In all cases, the west side of the building is emphasized by a heavier mass in comparison to the other components. This is meant to aid in the separation between noisy (street) and quiet services (medical facility).

Also, a main linear element connects all components or departments. This connection can be established in the form of horizontal circulation or a large atrium space. Red represents possible locations of the NICU and green represents vegetated areas such as exterior terraces or roof gardens.

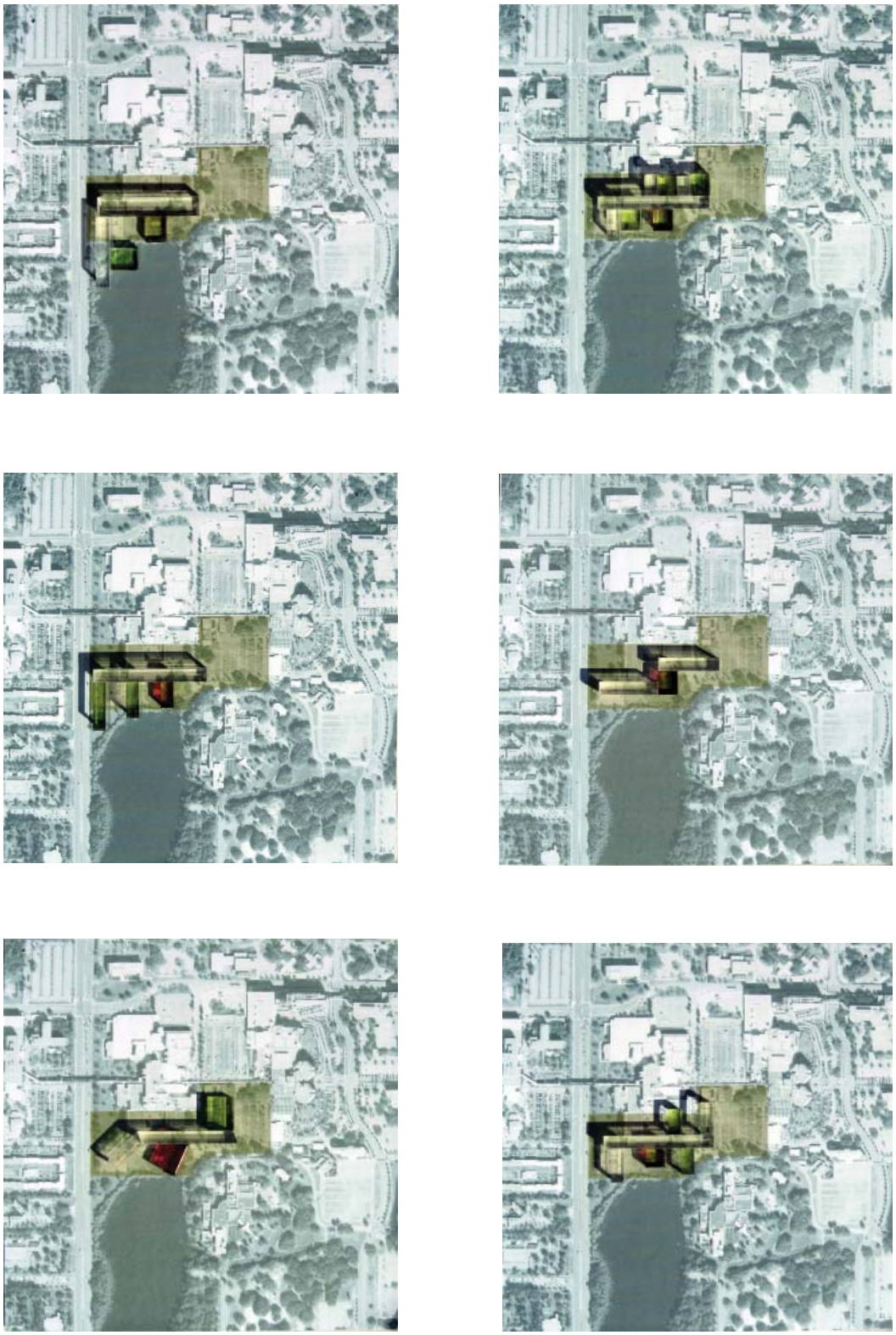


Figure 71. Diagrammatic layouts for proposed Maternity and Infant's Facility.

Proposed Scheme #1

This first scheme is a direct result of the site constraints. The existing surrounding context, composed of medical and educational facilities, establish the boundaries on the north south axis. These constraints translate into a linear east-west arrangement of the project components.

Also, from the previous analysis of solar conditions around the site, it was deduced that a building orientation with minimal exposure to east and west would be optimal.

Access to nature is also addressed in this scheme by maximizing the area that is exposed to the most nature views. In addition, interior and exterior courtyards could be included within the building, preferably adjacent to public areas like lounge rooms or family and staff gathering areas.

Figure 72. Sketchup diagram of Scheme 1, looking northwest.

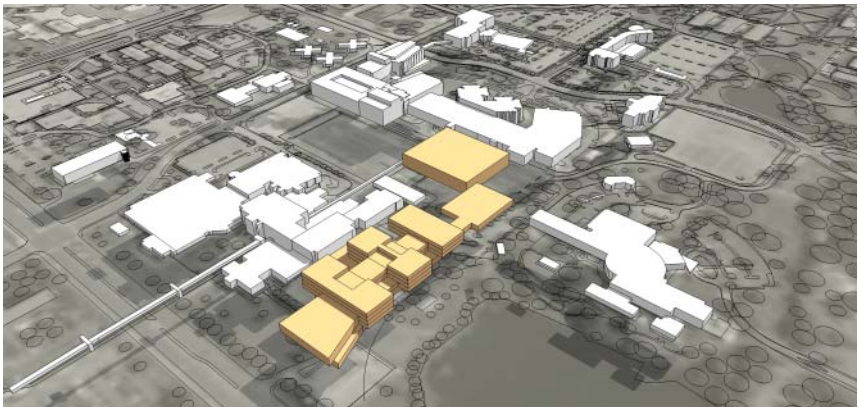


Figure 73. Sketchup diagram of Scheme 1, looking northeast.

Proposed Scheme #2

In this scheme the intent was to create a more organic form representative of the elements surrounding the site and including daylight, nature and sounds as design features.

Figure 74. Sketchup diagram of Scheme 2, looking north.

Figure 75. Sketchup diagram of Scheme 2, looking northeast.

In both schemes, the building footprint (including outdoor courtyards) utilizes most of the site's surface area. Building height is kept to a minimum (three to four stories tall) to allow closer contact to nature.

The final master plan shows the facility directly north of Lake Behnke. To maximize visual access to both the natural surroundings and daylight, all building units are arranged facing the lake.

Daylight and views of the outside are threaded throughout the facility. As visitors enter the facility, they will be greeted by vast amounts of daylight and expansive views of the lake.

Scattered throughout the facility, a mixture of healing gardens, meditation gardens, and rooftop terrace areas will be accessible to occupants.

Access to unfiltered sunlight will be provided in the form of solariums, balconies and terraces throughout the facility. In the NICU however, the critical nature of its patients requires that infection bourne agents be minimized. Therefore, all access to nature and daylight will be purely visual and not physically open.

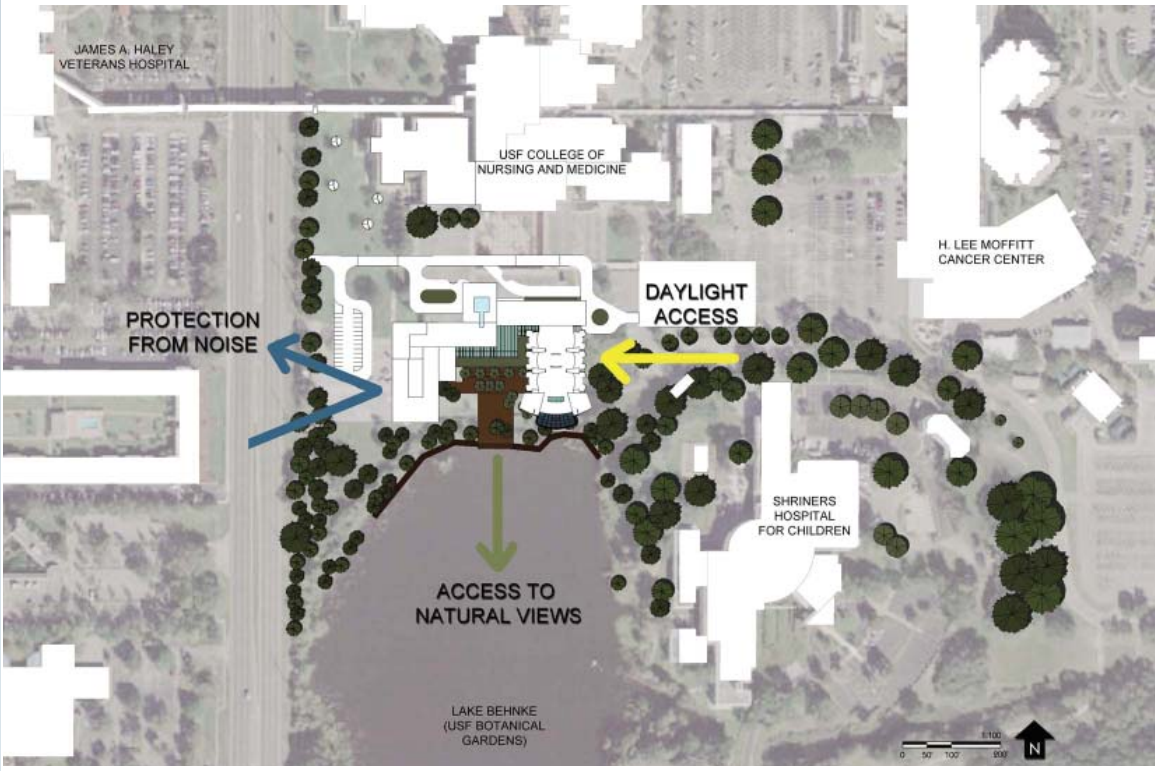


Figure 76. Site Plan and elements.

It is important for the neonatal intensive care unit to remain secluded from noise and other patient area traffic within and outside the hospital. This requirement is partly addressed by isolating the unit into its own hospital wing and locating it furthest from the main noisy street.

The maternity unit, as opposed to the nicu, houses less delicate functions, therefore, it is acceptable for this medical wing to act as second barrier between street noise and nicu. The primary noise barrier used throughout the site is achieved by the extensive use of vegetation.

The following diagrams show the location and relationship of various facility components.

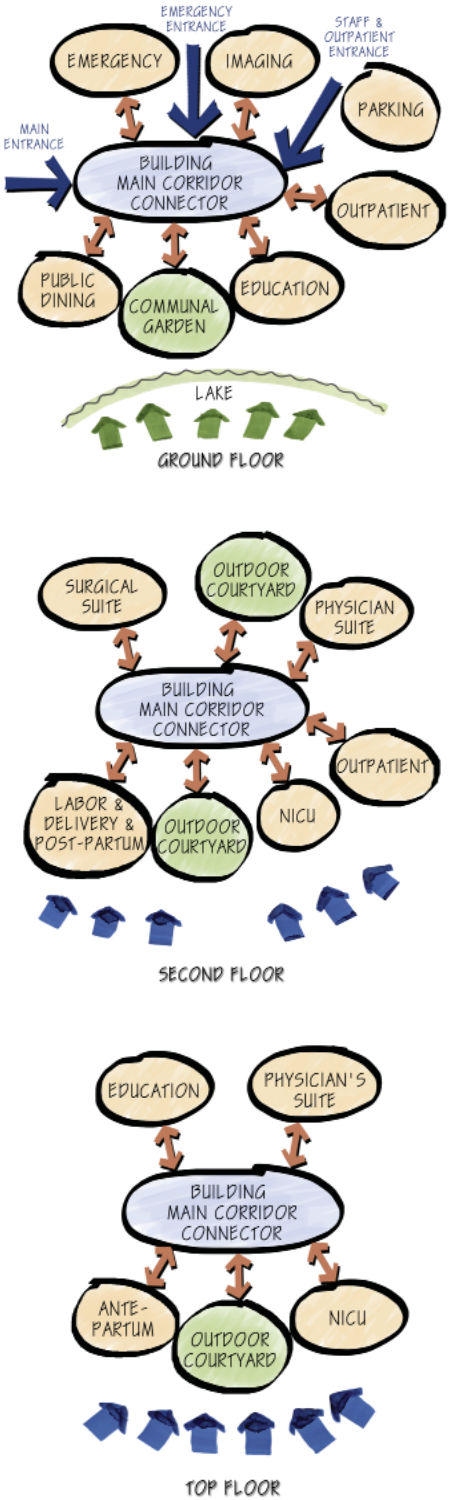


Figure 77. NICU's programmatic bubble diagrams.

The northern area has been dedicated for vehicular use as well as access into the facility. The proposed master plan locates the main entrance at the center of the facility, that way, travel distances for patients, staff, and visitors are diminished.

The southern part of the site is dedicated to pedestrians only. This area is to have jogging trails, paths and platforms over the water to make this outdoor experience a bit more relaxing to the building users.

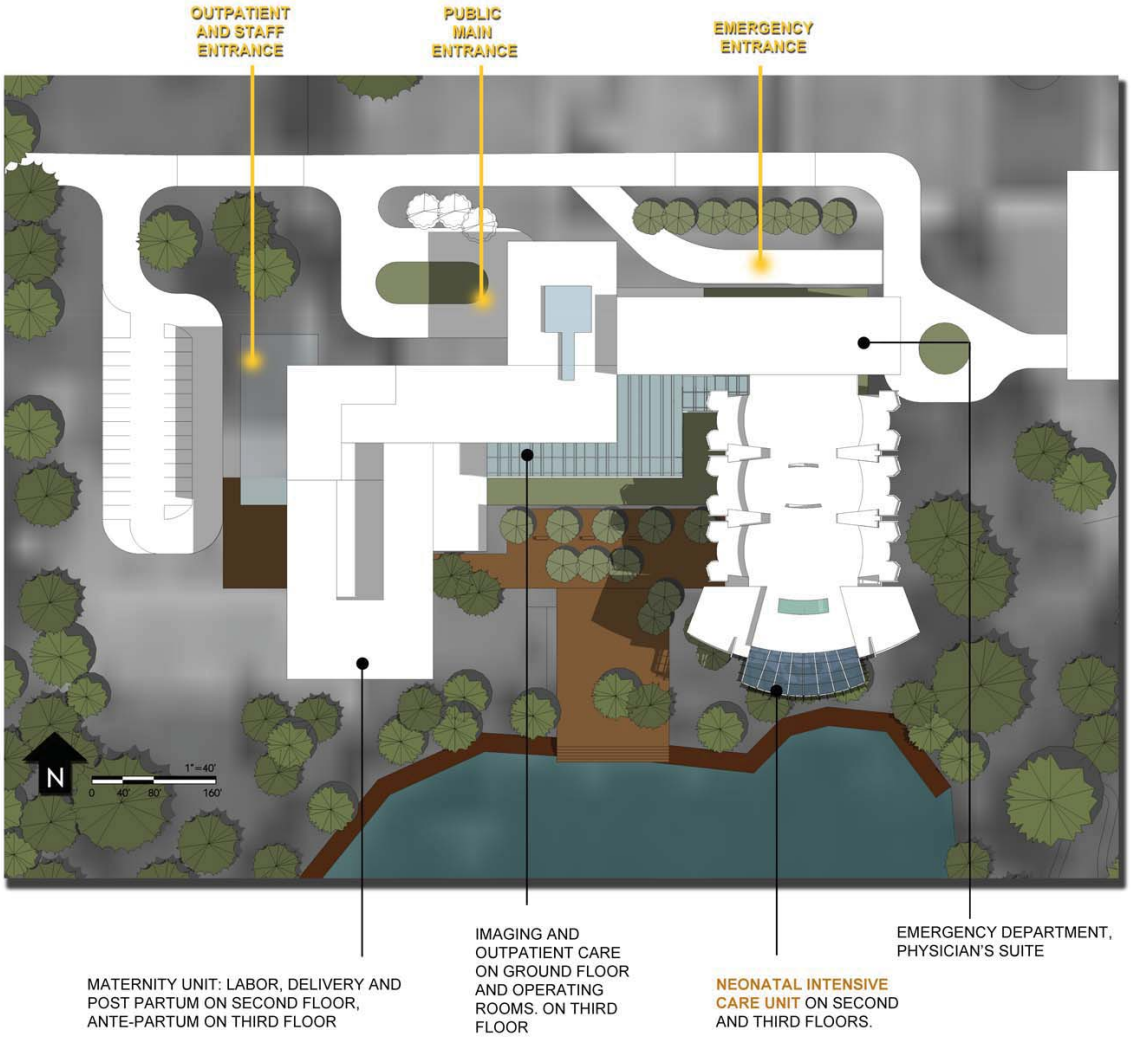
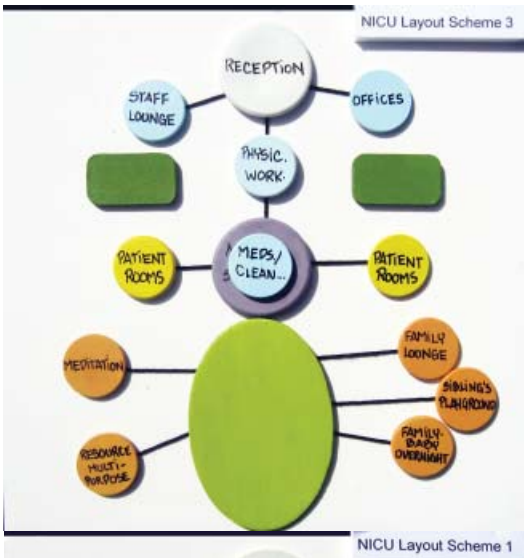
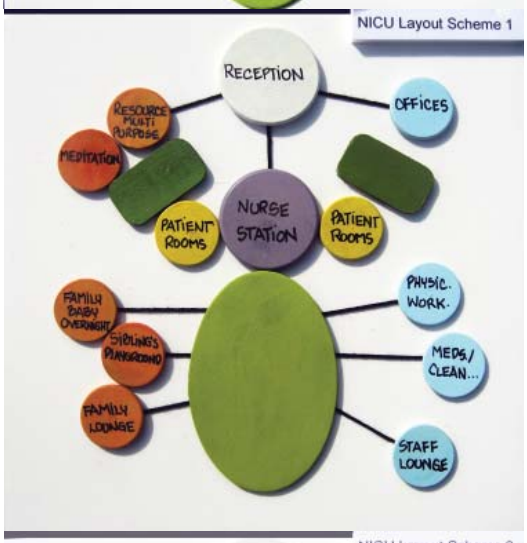


Figure 78. Proposed Site Plan

The Proposed NICU Prototype

The following programmatic schemes start exploring the relationship of various traditional components of a NICU and some of the proposed elements (nature and daylight). Several opportunities exist to intertwine small pockets of natural environment within the traditional aspects of this facility.





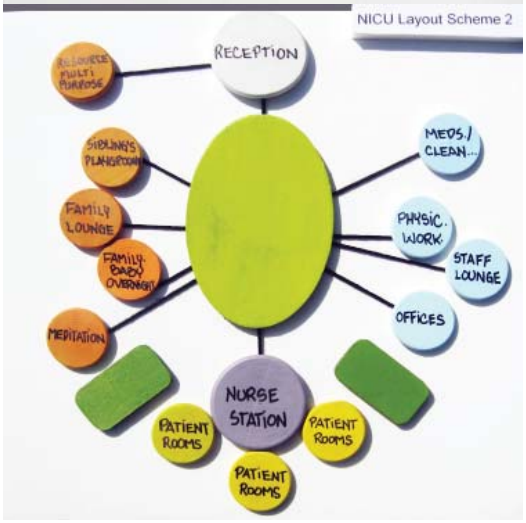


Figure 79. NICU's programmatic bubble diagrams.

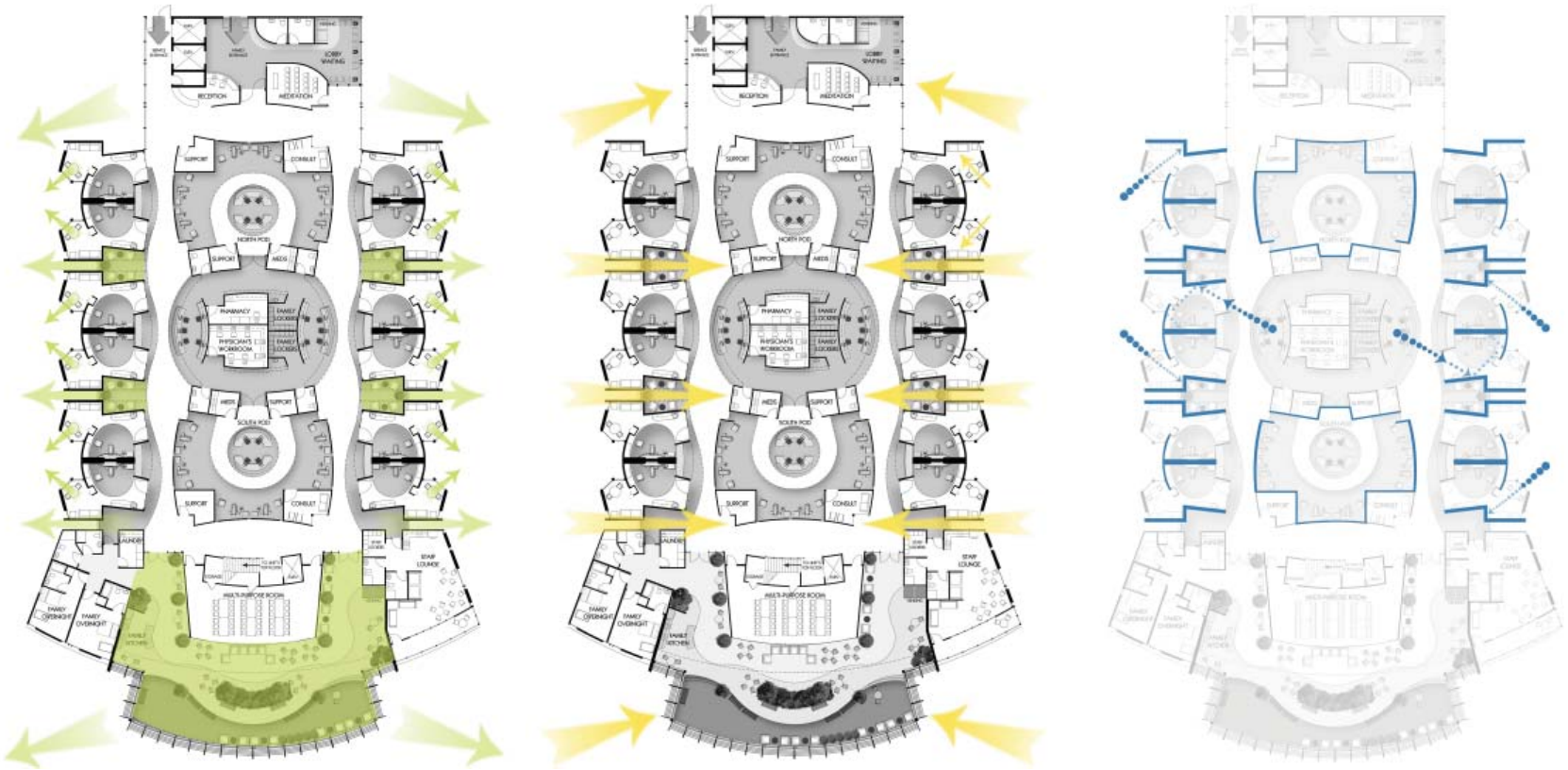


Figure 80. Nature, daylight and sound within the proposed NICU

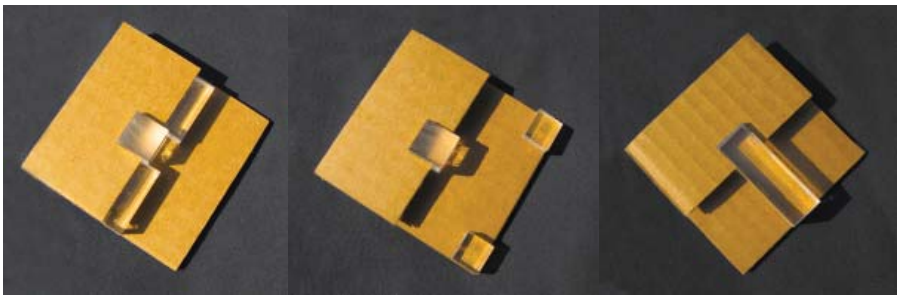


Figure 81. Relationship of solid vs. transparent spaces in NICU.

The following model shows how the private patient rooms divide family areas from patient areas without sacrificing visibility between parents and baby or to the outside.

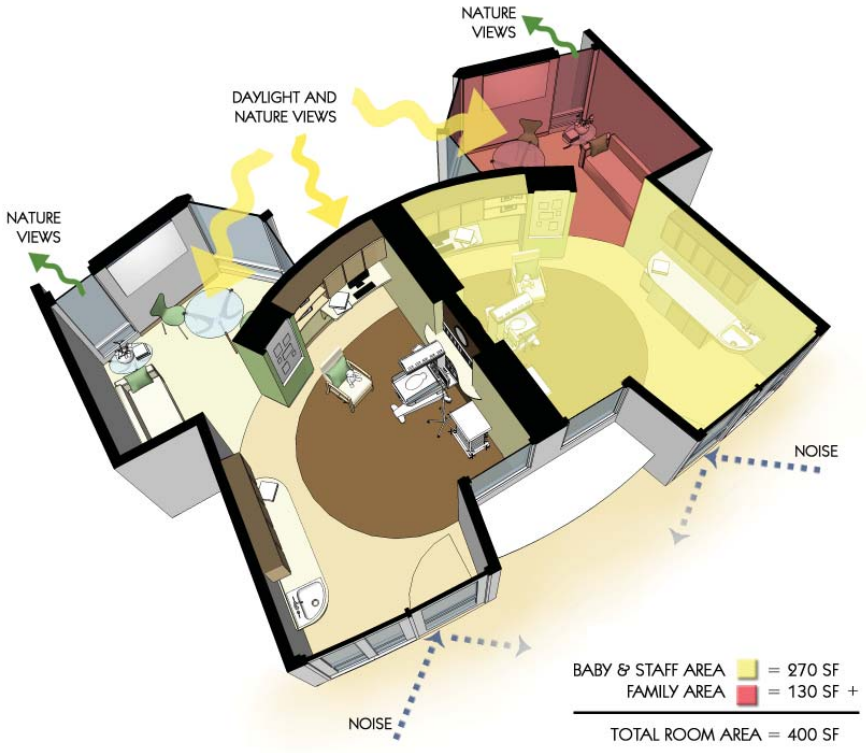


Figure 82. Single family room mirrored layout.

The family courtyard in the first floor provides space for family, staff and visitors to go for a walk, or sit down and read a favorite book while still remaining in close distance to their patient. The lounge pockets scattered throughout the unit as well as the family courtyard create opportunities for parents to turn to other parents in the NICU for comfort. In the end, spaces like these can provide a more restful environment that prepare parents and staff to better take care of their delicate patients.

The resulting prototype NICU is a two-story unit anchored on the north end by its connection to the main hospital and on the south end by its transparency towards a nature environment. As shown in Figure 80, the sitting lounges in between patient rooms pierce the floorplan letting more daylight in and providing views out.

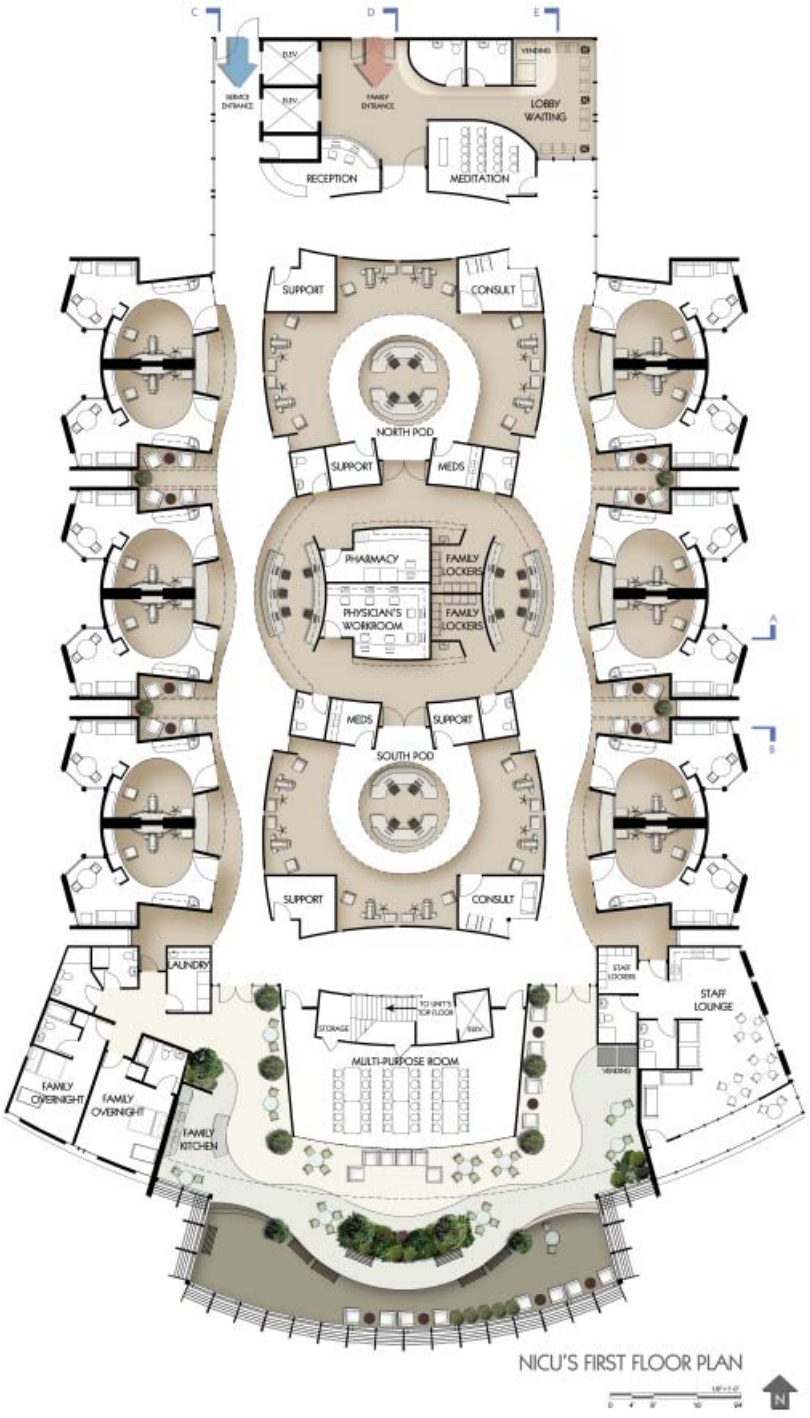


Figure 83. NICU's first floor plan

The second floor plan is almost identical to the first. This arrangement shows how the room modules can be replicated either in phases (pod units only, or private rooms only) to satisfy a specific target population.

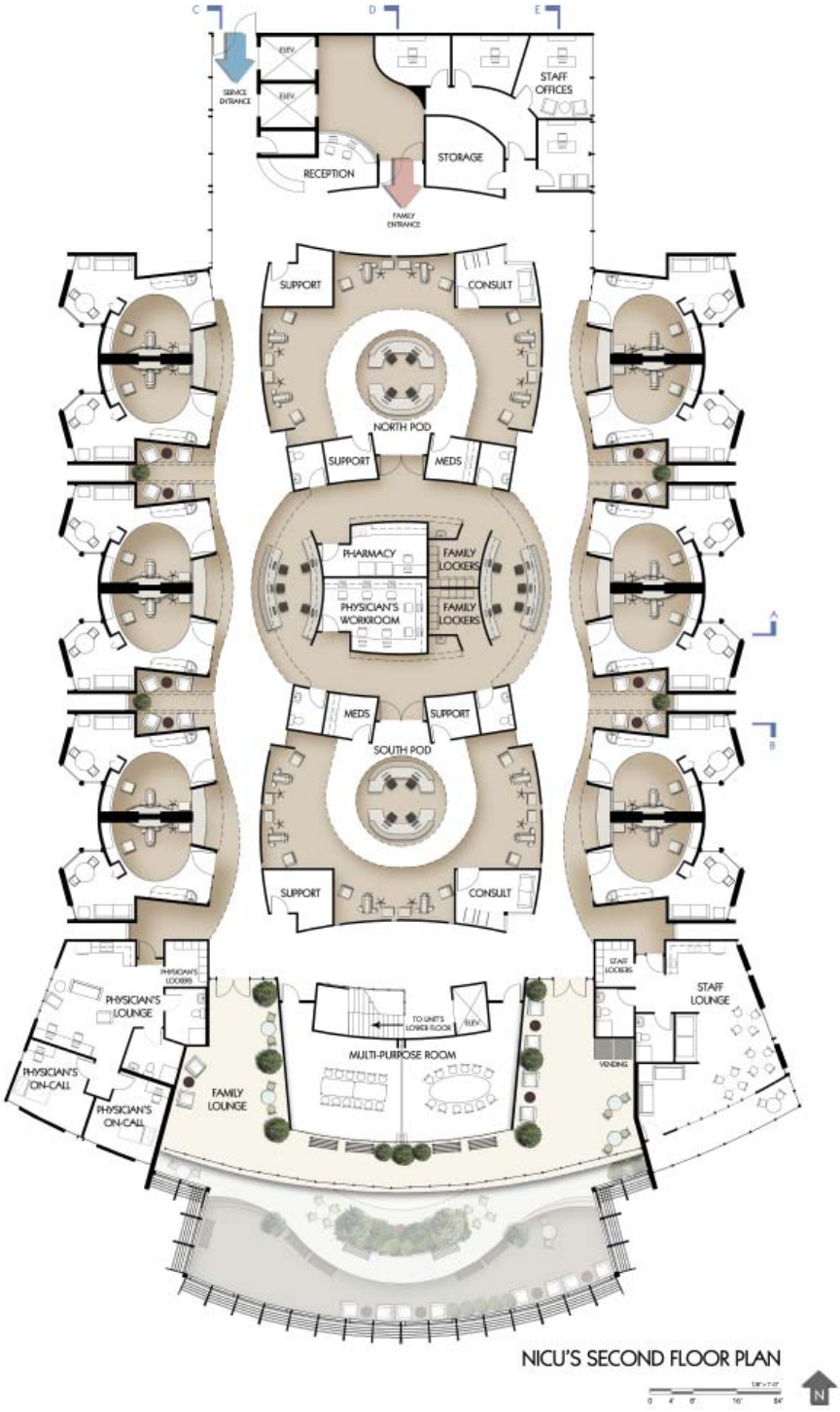


Figure 84. NICU's second floor plan

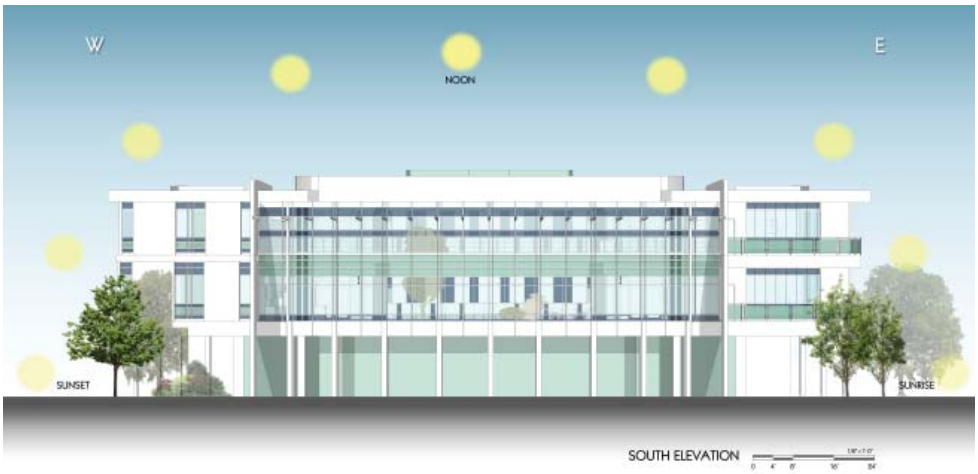


Figure 85. NICU's south elevation.

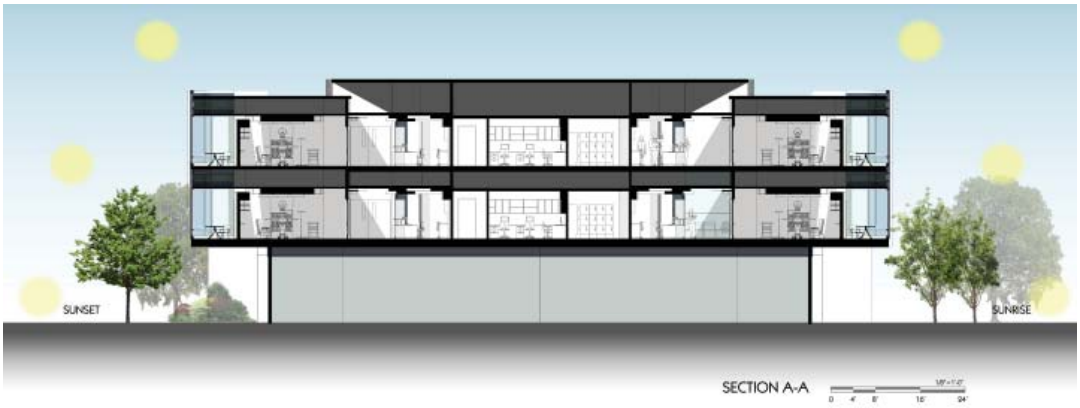


Figure 86. NICU's section A-A

Figure 87. NICU's section B-B

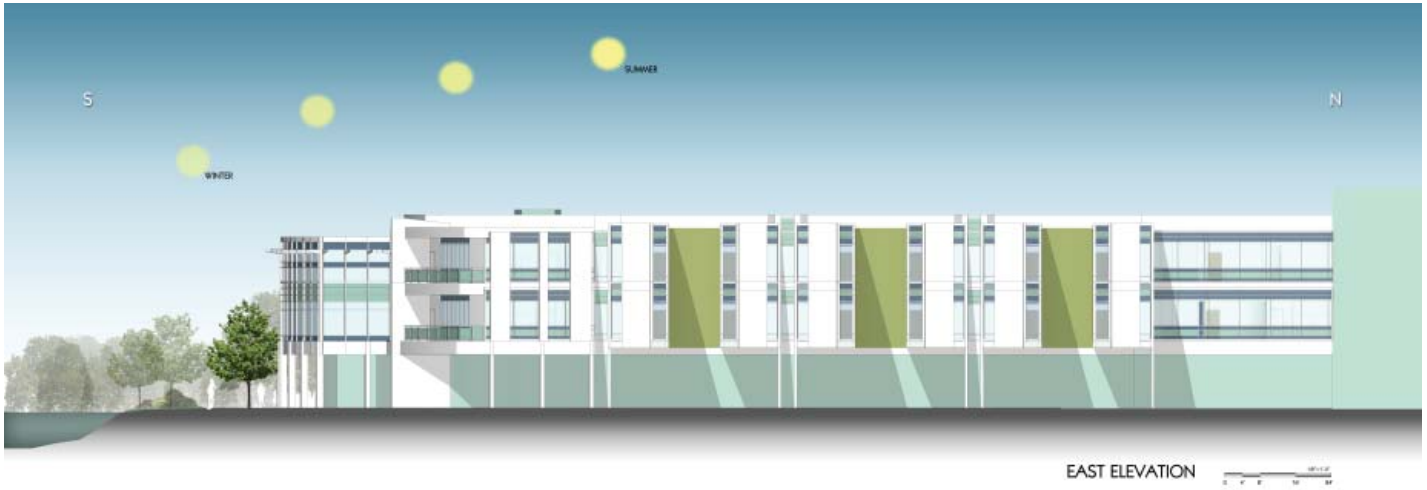


Figure 88. NICU's east elevation.

Figure 89. NICU's section D-D

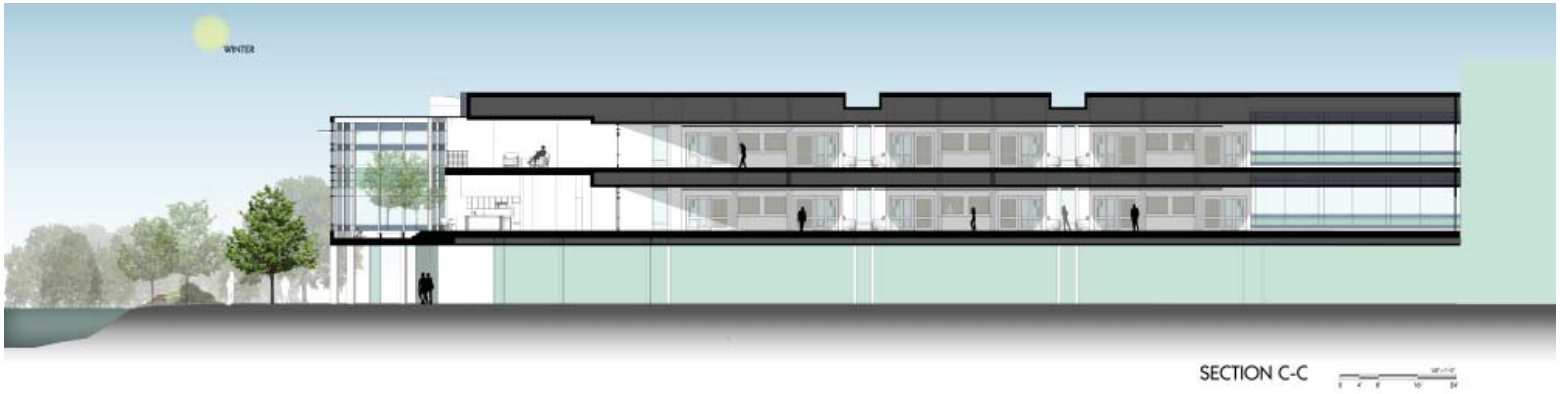


Figure 90. NICU's section C-C.

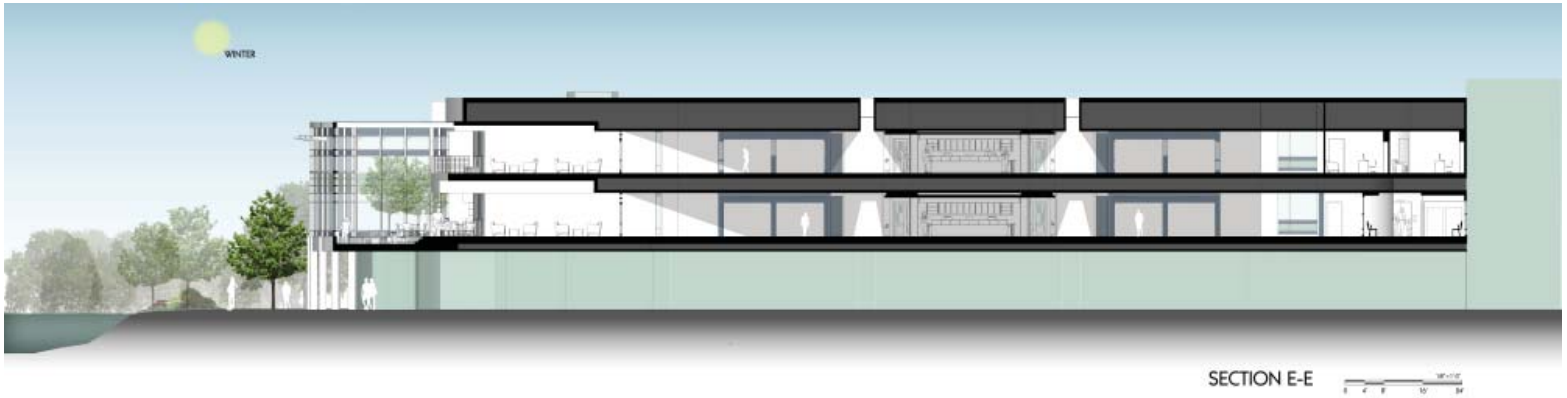


Figure 91. NICU's section E-E.

Figure 92. NICU's reception and lobby

Figure 93. NICU's nurse station

Figure 94. NICU's family sitting lounge and consult area.

Figure 95. NICU's open-ward pod.

Figure 96. NICU's single family room.

Figure 97. NICU's family courtyard

Figure 98. NICU's family courtyard

Figure 99. Final Presentation Day

The literature reviewed provided supporting evidence to the initial statement that the physical environment, specifically nature, daylight and sound, influence the healing process of premature babies. Several sources revealed that interaction with the natural world is a vital part of people's well-being, and that its effects can even be translated into positive task performance. Similarly, the effects of daylighting on a person's mood and health can translate into positive results.

In the end, the extensive research was applied in the creation of a final prototype. The resulting unit was successful at the planning level, where the proposed elements (nature, daylight and noise control) can be clearly seen interacting with the traditional components of a NICU. The natural world, daylighting and noise controls where successfully integrated into the proposed environment, proving that modern methods of care can be combined with a holistic approach to healing and achieve improved outcomes.

Additionally, the proposed patient room and open-bay pod combination setting was a successful approach to an on-going controversial argument regarding the benefits of one over the other. On one side, the proposed prototype provides long-term, individualized and comfortable rooming facilities to highly critical patients and their families. Besides, infection control and individualized treatments in an controllable environment can be very effective in the care of NICU infants.

On the other side, the open-bay pod setting, which is dedicated to providing care to less critical but in need of observation patients is the traditional model of care. In this setting, several patients are monitored at the same time, minimizing emergency response times.

In summary, the knowledge gained from this research suggests that the combination of these elements should enhance the quality and time of infant's recovery. Consequently, this information will be crucial in improving the design of healthcare facilities.

Finally, applied more broadly to society, this knowledge may change the way we approach public health and design environments for human use.

Figure 100. Final Presentation Day

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