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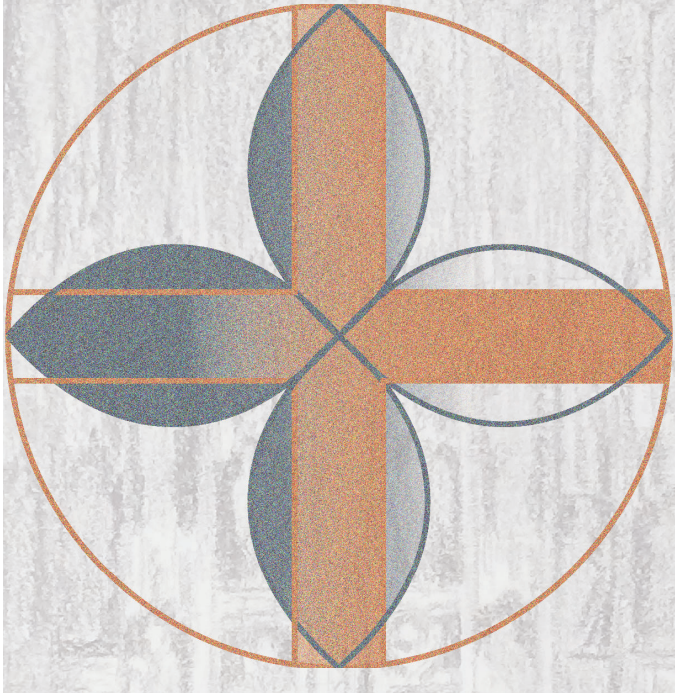

A HYBRID TYPOLOGY COMBINING WORSHIP AND EMERGENCY CARE FUNCTIONS FOR A SUSTAINABLE MODEL OF CHURCH BUILDING AND COMMUNITY RESILIENCE

BUILT ON THE ROCK

A HYBRID TYPOLOGY COMBINING WORSHIP AND EMERGENCY CARE FUNCTIONS FOR A SUSTAINABLE MODEL OF CHURCH BUILDING AND COMMUNITY RESILIENCE

A Design Thesis Submitted to the
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By
Philip Reim

In Partial Fulfillment of the
Requirements for the Degree of
Master of Architecture

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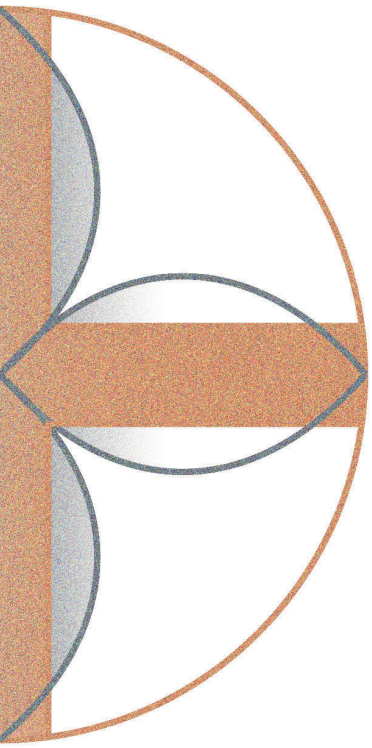
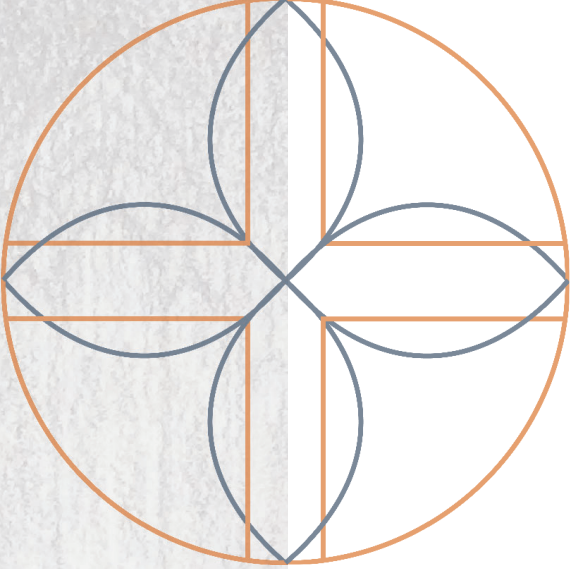


THESIS PROPOSAL



THESIS ABSTRACT

AND THE RAIN FELL, AND THE FLOODS CAME, AND THE WINDS BLEW AND BEAT ON THAT HOUSE, BUT IT DID NOT FALL, BECAUSE IT HAD BEEN ***FOUNDED ON THE ROCK.***

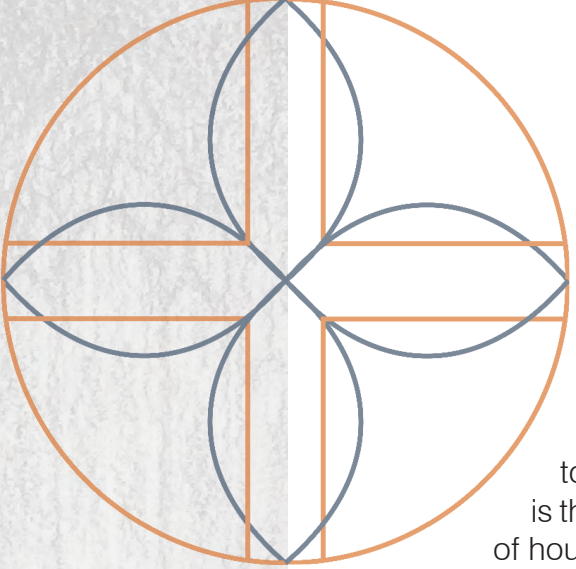
MATTHEW 7:25, ENGLISH STANDARD VERSION

American church buildings age, deteriorate, and vanish, their congregants dwindling and lacking the financial resources to build or maintain them.

Simultaneously, a global pandemic sheds light on shortcomings in emergency readiness, particularly related to emergency treatment capacities.

The two problems need not be addressed in isolation. The place where people take refuge in God can easily and logically become the place where they take refuge from disaster. This thesis will seek to address specific issues facing church congregations and emergency care centers through an innovative design solution drawing on the historic association of churches with disaster-related health care. The adaptive church building will be designed as a community asset, used normally by worshippers but converting to function as a sophisticated field hospital in times of increased need. As this mixing of typologies will benefit not only the faithful few but also local populations at large, charitable relief groups and non-government organizations will be incentivized to supplement the churches' own diminishing means of building and maintaining them.

THEORETICAL NARRATIVE



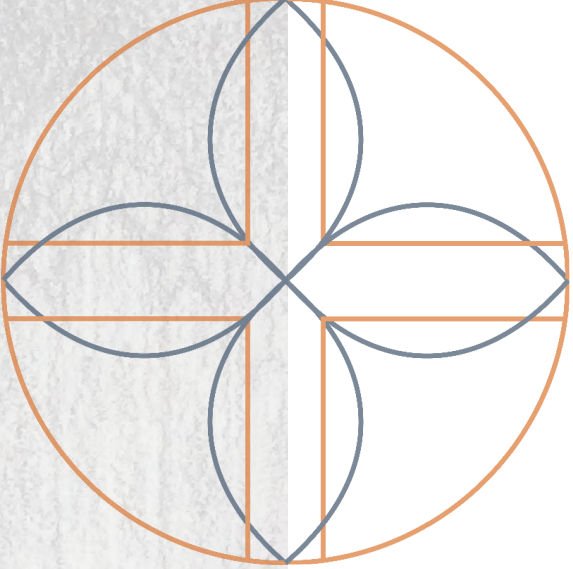
PREMISE I: Church buildings across the country age and fall into disrepair while their congregations, dwindling in numbers and finances, lack the resources to maintain them ("Church trends," 2017). Churches are vulnerable to economic shifts and instability. A recent example is the 2008 mortgage crisis, in the wake of which 20% of households decreased their giving to churches, and of those, 50% by half or more (Barna, 2008). In 2010 the Barna research group reported an average 7% financial decline across Protestant congregations, with 3% reducing facility budgets as a result. As diminishing attendance continues to hamper smaller parishes especially (Earls 2019), efforts to build, purchase, or maintain permanent facilities require more innovative approaches than member-generated revenue alone (Walton 2017).

PREMISE II: A recent viral pandemic has heightened awareness of healthcare capacities and their risk of overcrowding in emergencies. Even before the appearance of COVID-19, a 2008 survey of overcrowding in U.S. emergency departments (EDs) saw 91% of responding ED directors report overcrowding as a problem. More than half reported that overcrowding occurred several times per week, and 39% claimed it was a daily occurrence. One of the most significant causes of overcrowding was reported to be a simple lack of patient beds (Derlet et al., 2008). Although COVID-related overcrowding in the U.S. has so far generally fallen short of predictions, conservative estimates originally forecast that the healthcare system would need at least twice its current 95,000 critical care beds (Chopra et al., 2020). It is therefore reasonable to assume that, in the case of a more lethal future pandemic or a large-scale natural disaster of any kind, the U.S. healthcare system's patient capacity could become rapidly overwhelmed.

PREMISE III: Church buildings have an extensive precedent history of emergency medical function. One example is the adaptation of Tacoma's First Methodist to serve as a hospital during the 1918 Spanish flu pandemic (Sailor, 2020). In fact, the association of church institutions with health care goes back for centuries: medieval hospitals were usually managed in connection with monastic orders and attached to religious centers (Willmott et al., 2020). At the temporary conversion of New York's Cathedral of St. John the Divine into a COVID-19 field hospital, the church's dean remarked on the historic association of church and refuge (Stack, 2020).

In the modern era, churches are under-attended and healthcare centers are overdrawn; can a long-standing precedent of common interests come to the aid of both?

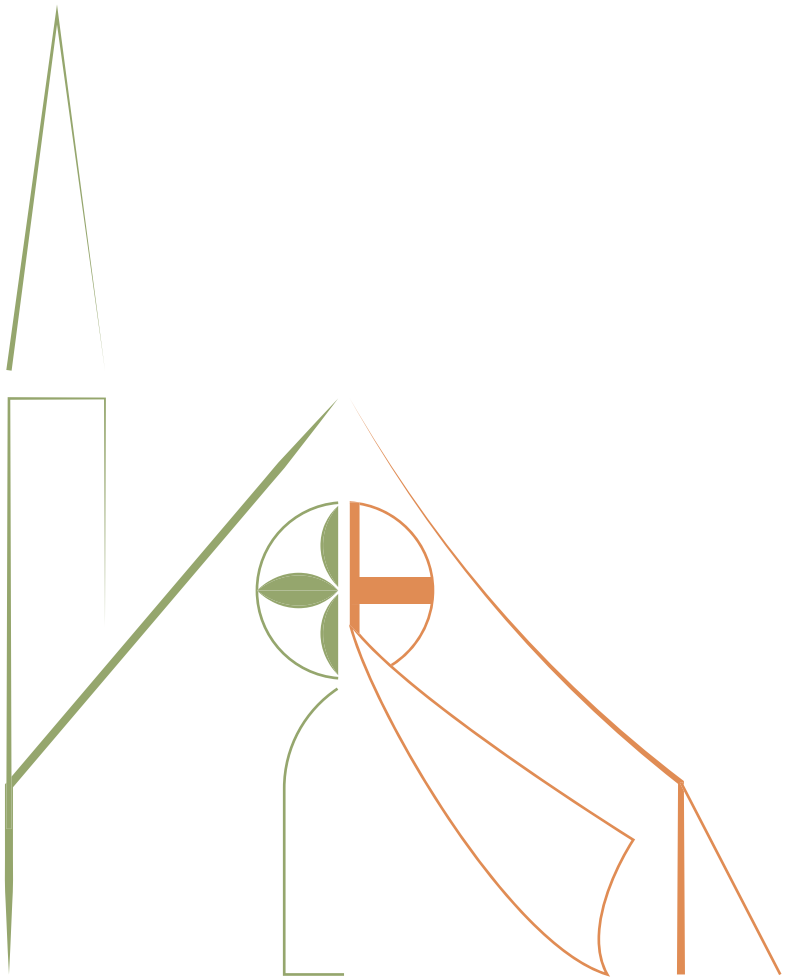
FINAL THEORETICAL PREMISE: The two issues discussed, namely the inability of church congregations to build or maintain facilities and the shortage of emergency healthcare capacity in the U.S., can be addressed in part through an innovative design solution. This thesis will propose a merged architectural typology of church and emergency treatment center. The representative building designed in this project will be intended to function regularly as a church, but with the ability to rapidly convert to a sophisticated field hospital in the event of a disaster requiring surge healthcare capacity. As a solution to churches' lack of funds, the proposed design method will include community-based financing through non-government organizations or disaster relief charity groups.



PROJECT TYPOLOGY

The theoretical premise of this thesis will be explored through a blend of church and refuge typologies. The design solution will be fully functional as a church building, including all typical service and auxiliary spaces and referring to traditional organization, geometry, and atmosphere. Concurrently, it will be flexible and equipped to rapidly convert its function to that of a field hospital or emergency shelter. Resilience and flexibility will be central to this aspect of the building, along with health conventions like increased ventilation and ease of sterilization.

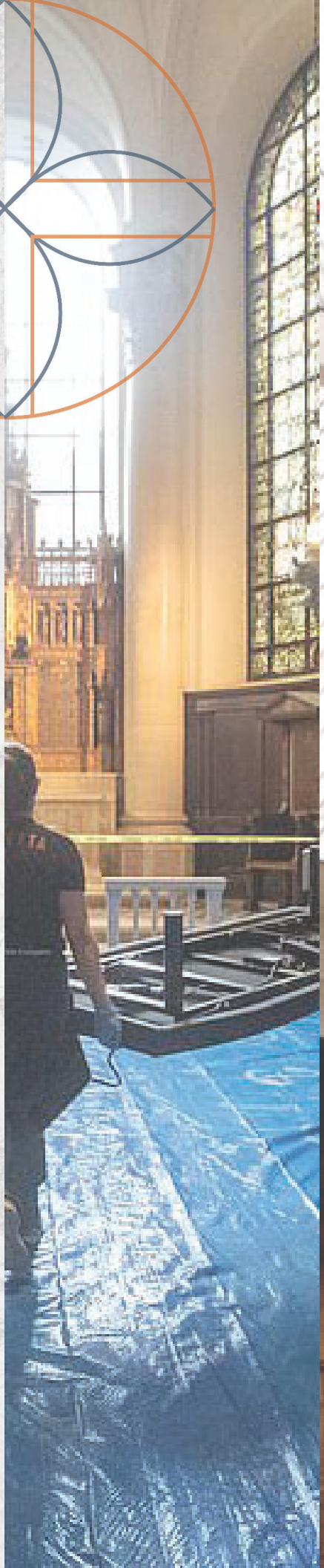
The emphasis on form and aesthetic common to church buildings will be checked by the field hospital's need for efficient function above all else. A need for symbolic, meaningful, and uplifting detail and proportion will compete with an inherent requirement for economy and utility. Ultimately the church will eschew extravagant decoration, and derive a fully meditative and worshipful air through only those means that its alternate tenant allows. Care center workers, their functional needs met, will find the converted church a healing environment preferable to the deployable shelters of their own design.



A DISCUSSION OF CHURCH ARCHITECTURE MUST INVOLVE A DISCUSSION OF RELIGION. YET THE CHURCH IS NOT ONLY THE HOME OF A RELIGIOUS CONGREGATION BUT, MORE THAN THAT, A BUILDING BELONGING TO SOCIETY AT LARGE. HENCE THE SECOND THESIS: A DISCUSSION OF RELIGION MUST, ESPECIALLY TODAY, INVOLVE A DISCUSSION OF SOCIETY AT LARGE.

R. GIESELMANN, CONTEMPORARY CHURCH ARCHITECTURE

PRECEDENT RESEARCH



Three case studies related to the church building typology provide background information in three central areas. A design proposal built on these examples will produce a unique typology: not a church that can be forced into a field hospital, or vice versa, but an efficient and malleable structure designed to be both.

VIABILITY: The proposed design will only be successful if the building not only functions as a church but also supports and enhances emergency conversion to medical use. The goal is not simply to allow emergency function in the church, but to expedite it and provide better opportunities for patient care.

LONGEVITY: The proposed design will require a significant up-front investment to be built, an investment that will only be justified if the building stands long enough to assist with the next disaster. Therefore the design must be resilient and include a long predicted life span, to maximize its utility as an emergency asset.

FLEXIBILITY: As emergency functions of the design will only be realized through a durable building, so the project will be most useful as a church if it acknowledges the possibility of repeatedly changing ownership. Can any Christian denomination move into the building and conduct worship comfortably? The design must be flexible and adaptable to future changes in liturgy and ritual.

CASE STUDY: FIELD HOSPITAL AT ST. JOHN THE DIVINE

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DUAL REFUGE

In April 2020, the Cathedral of St. John the Divine in New York underwent a rapid transformation to a COVID-19 surge field hospital. The adjustment is consistent with a long-running historical precedent: The church's Rev. Clifton Daniel III commented, "Traditionally, in earlier centuries, cathedrals were always used this way, like during the plague. So this is not outside the experience of being a cathedral, it is just new to us" (Stack, 2020).

The temporary repurposing used large portions of the cathedral interiors, dividing major functions between the 600-foot-long nave and the subterranean crypt. Because the field hospital at St. John the Divine was deployed in reaction to the most recent large-scale health emergency, it can be assumed to represent a sophisticated model of temporary surge facility design in an existing church building.

1 - Volunteers setting up patient beds in a chapel at St. John.
2 - Medical tent being erected in the cathedral nave.
3 - Samaritan's Purse supply trailer in front of the cathedral.

PROGRAMMATIC STRATEGY

The dean of the cathedral offered its use as a field hospital in March, around the time that COVID-19 began to accelerate in the U.S. It was not clear at the time whether the field hospital would receive COVID patients, or non-COVID patients in order to keep beds open at hospitals, and so the operating staff planned for the worst by designing for coronavirus treatment (Stack, 2020).

The nondenominational Christian organization Samaritan's Purse assisted with infrastructure and supplies for the field hospital, and the facility was staffed by personnel from the nearby Mt. Sinai Morningside Hospital (Stack, 2020).

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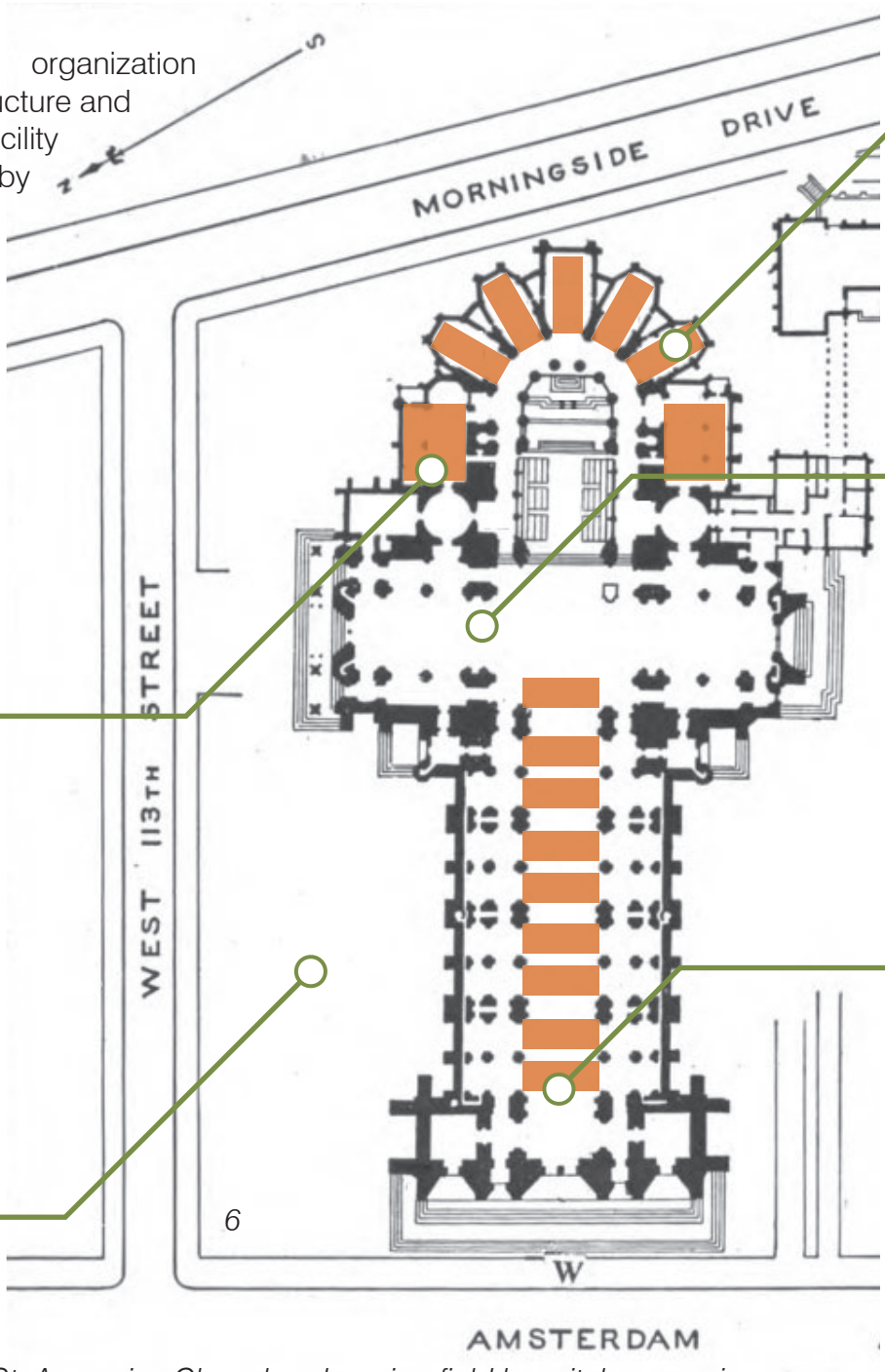

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4 - St. Ansgarius Chapel undergoing field hospital conversion.
5 - Packaged supplies delivered outside cathedral.
6 - Cathedral plan showing approximate patient bed layout.

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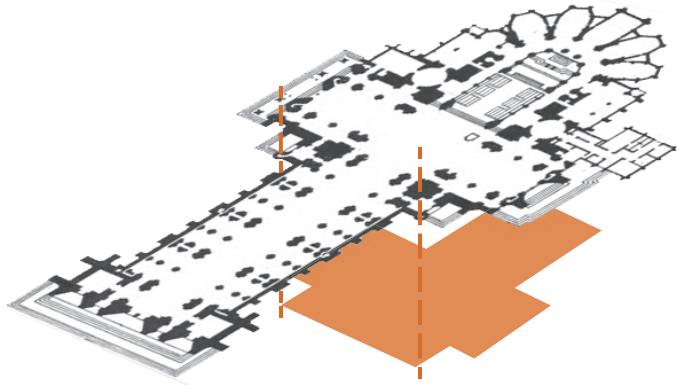
9

Volunteers installed four hundred patient beds in the church. Due to the highly contagious nature of the virus, staff recognized the need to keep patients relatively isolated so that pathogens could only spread within small groups. To this end Samaritan's Purse, who had previously constructed a COVID field hospital in Central Park, divided the 600-ft nave between nine climate-controlled medical tents filled with beds. These tents arrived at the church in compact packaging and were then rapidly constructed inside the building. Additionally, volunteers placed patient beds in the radiating chapels around the eastern apse (Lenthang, 2020).

With most of the church's ground plan devoted to patient care, the subterranean crypt became a storage and preparation space for medical personnel. The crypt is accessed via several tight winding stairways from the nave (Stack, 2020).

Should the field hospital begin receiving patients, the role of the church itself would be mainly limited to keeping the lights on and providing other basic utilities, according to the cathedral's director of facilities (Stack, 2020). Some logistical questions remained in April, related to needs like feeding and bathing patients (Stack, 2020).



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7 - Patient beds installed in St. Ambrose Chapel.
8 - Packaged medical tents awaiting deployment in the cathedral nave.
9 - Completed medical tent near west entrance.
10 - General schematic of cathedral crypt used for medical personnel.

11 - Respiratory unit setup.
12 - Interior of medical tent.
13 - Field hospital in Central Park.
14 - Medical tent inside cathedral.

SAMARITAN'S PURSE FIELD HOSPITAL

Shortly before installing the field hospital at St. John, the humanitarian organization responsible deployed a similar setup at Central Park. Again working in partnership with New York's Mount Sinai Health System, the complex was designed as a respiratory care unit specifically intended for COVID patients from Brooklyn and Queens hospitals. A team of 72 doctors, nurses, and other medical personnel staffed the unit, which contained 68 beds and 14 tents ("Field hospital," 2020).

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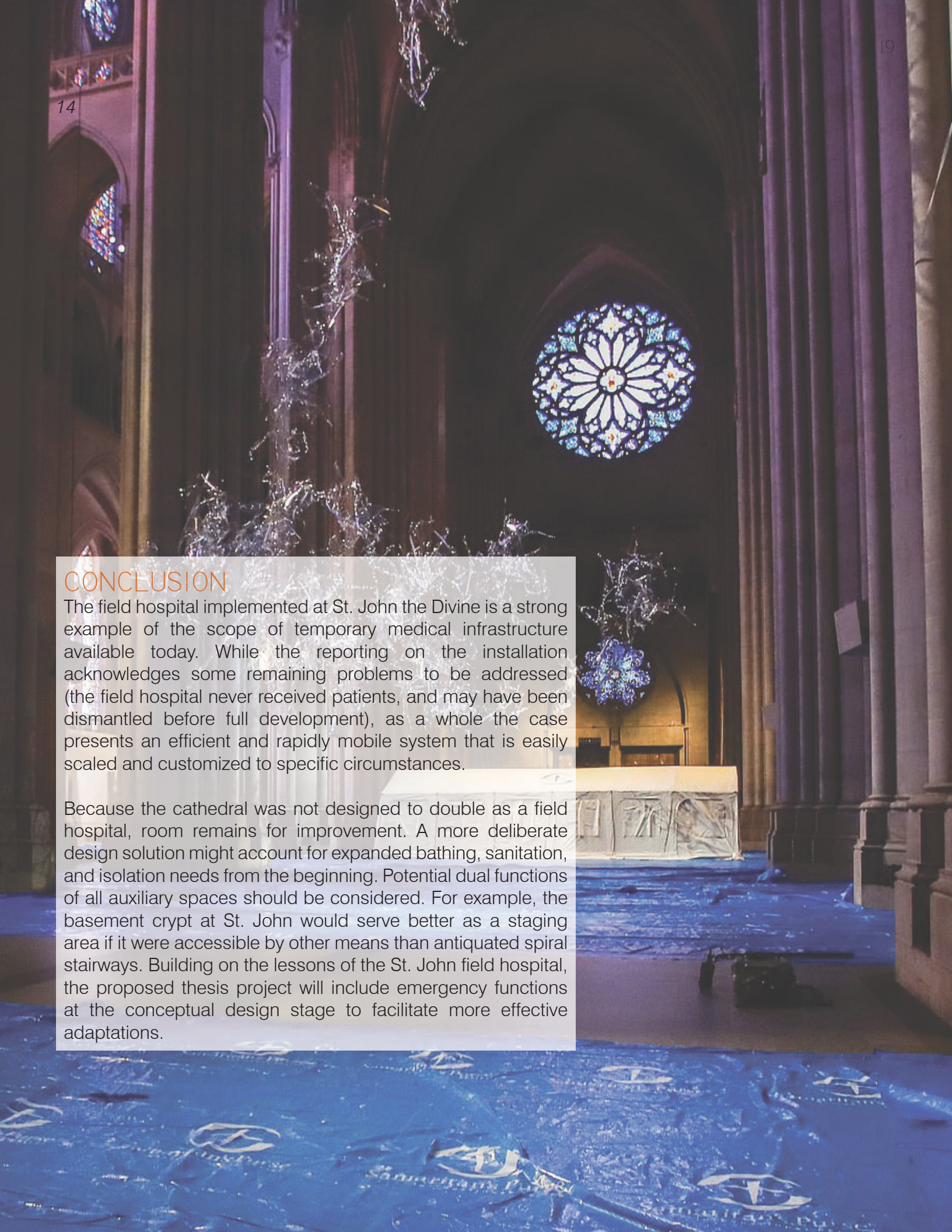


CONCLUSION

The field hospital implemented at St. John the Divine is a strong example of the scope of temporary medical infrastructure available today. While the reporting on the installation acknowledges some remaining problems to be addressed (the field hospital never received patients, and may have been dismantled before full development), as a whole the case presents an efficient and rapidly mobile system that is easily scaled and customized to specific circumstances.

Because the cathedral was not designed to double as a field hospital, room remains for improvement. A more deliberate design solution might account for expanded bathing, sanitation, and isolation needs from the beginning. Potential dual functions of all auxiliary spaces should be considered. For example, the basement crypt at St. John would serve better as a staging area if it were accessible by other means than antiquated spiral stairways. Building on the lessons of the St. John field hospital, the proposed thesis project will include emergency functions at the conceptual design stage to facilitate more effective adaptations.

CASE STUDY: CATHEDRAL OF OUR LADY OF THE ANGELS

RESILIENCE AS AESTHETIC

Construction began on this seat of the Los Angeles Archdiocese in 1996, after its predecessor was badly damaged by an earthquake ("Cathedral," 2014). Although the building's scale is likely greater than that of the proposed thesis project (the cathedral seats three thousand), and its intended function exclusively Roman Catholic, Rafael Moneo's work is a fine example of durability and resilience used to inform a comprehensive design.

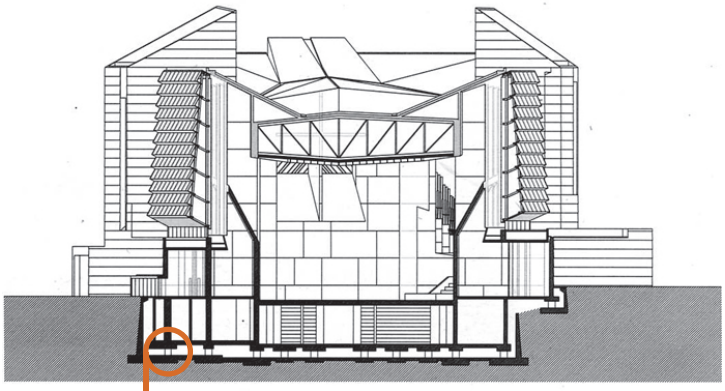
While debate continues on the relevance of traditional church architecture to modern religious design, the Cathedral of Our Lady of the Angels (OLA) offers a fairly tasteful contemporary reinterpretation of historic design elements.

15 - Concrete cross over chancel at OLA.

STRUCTURE

OLA is expected to stand for the next five hundred years. Nearly two hundred high-damping rubber and slider bearings provide seismic isolation. Load-bearing concrete walls, sized to resist earthquake forces, also become an impressive design element through sheer mass. Finally, a reinforced concrete diaphragm holds the entire structure together at the roof (Charleson & Guisasola, 2017).

In light of the earlier cathedral's fate, earthquake survivability was a key goal for the project. The building's jagged brutalist aesthetic results from the adoption of structural principles as architectural vocabulary.



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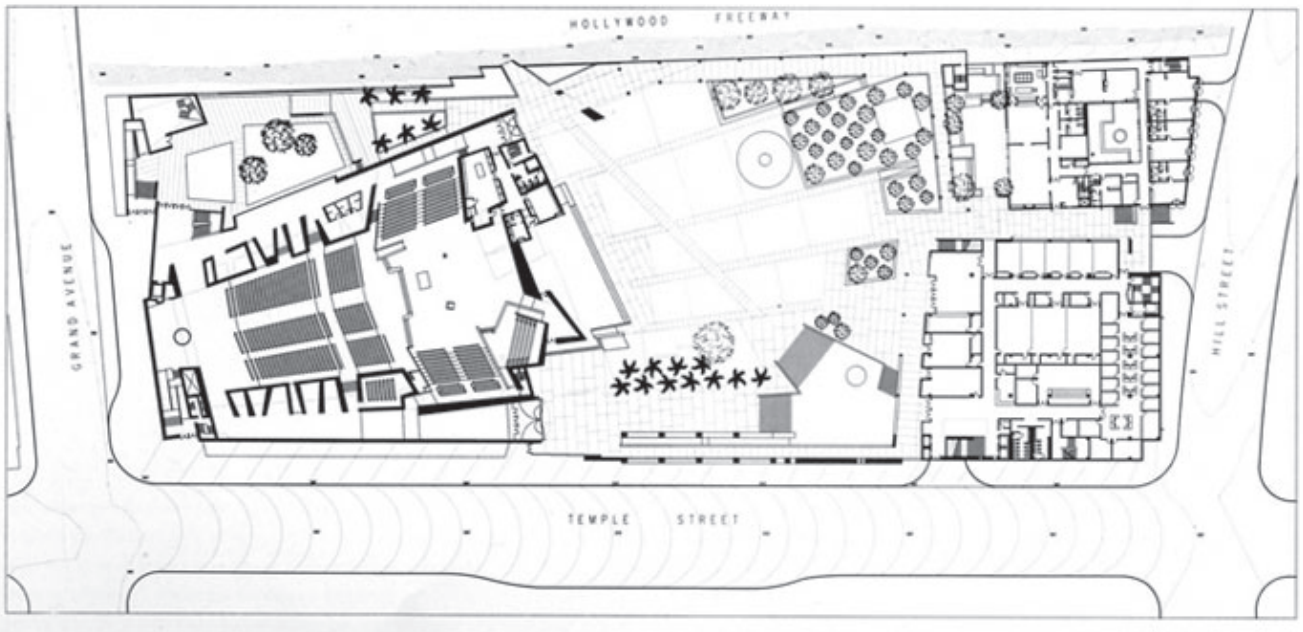
MASSING, PLAN, AND SECTION

In elevation and section the building form echoes the language of the plan, which contains almost no right angles. The shapes and colors of the exterior evoke regional adobe construction ("Cathedral," 2014).



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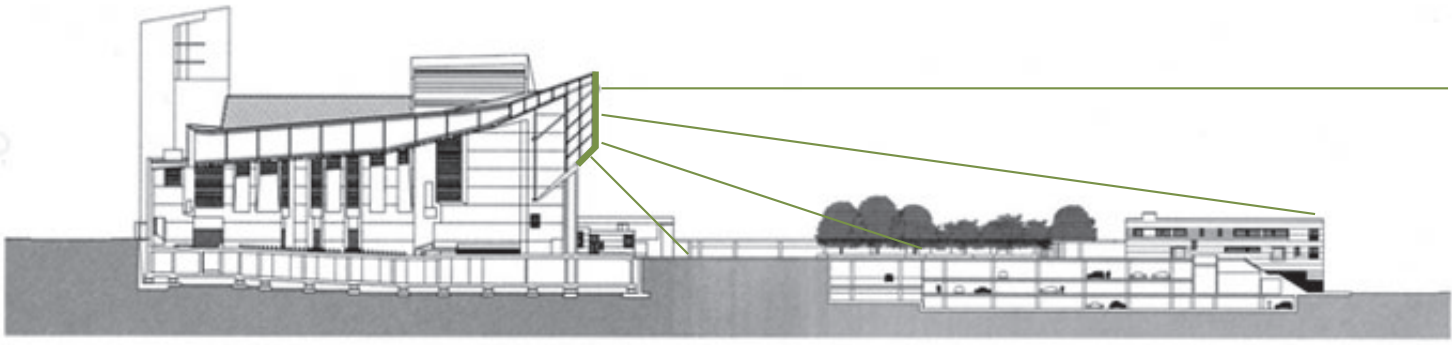


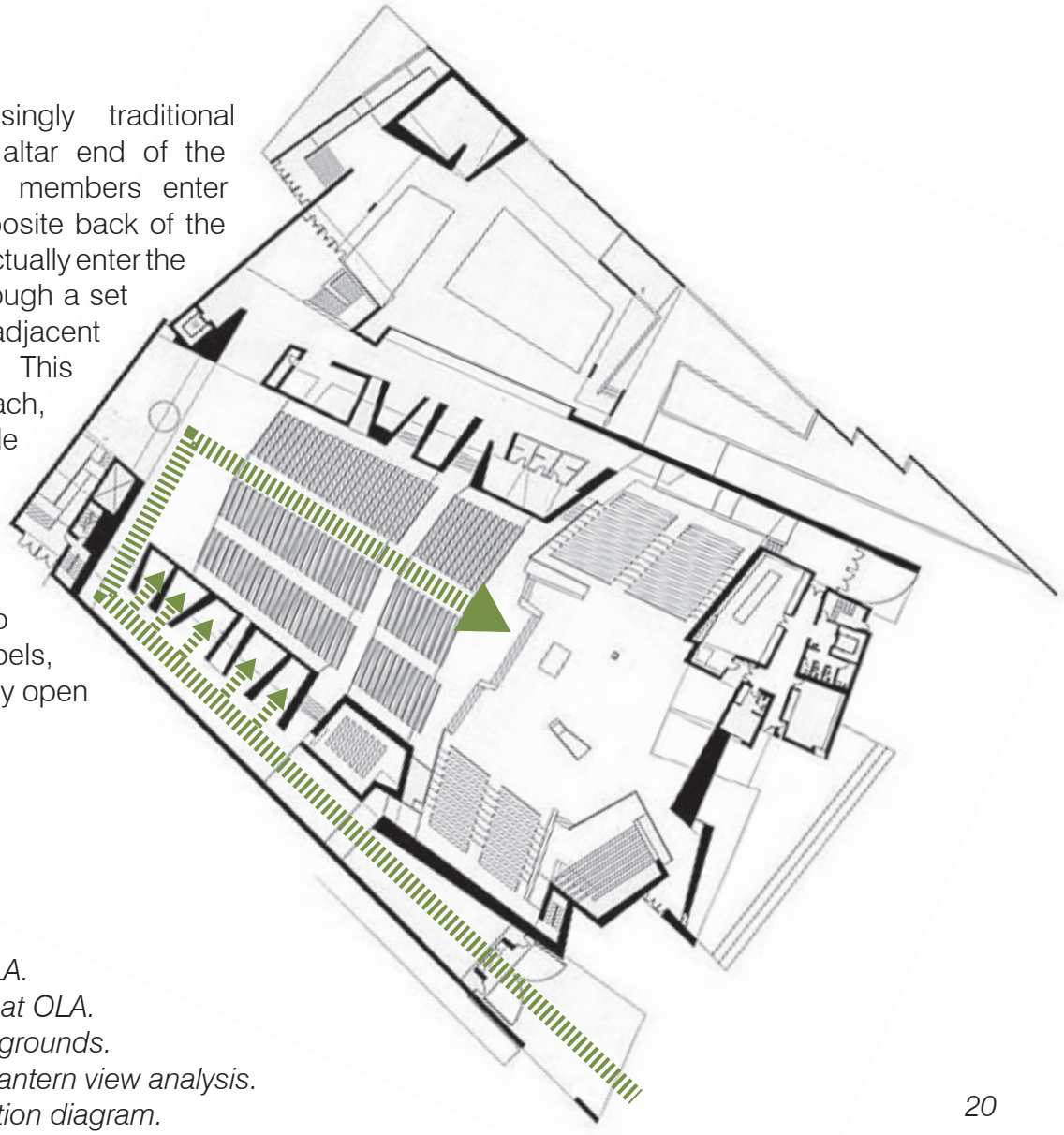
19

HIERARCHY

Worshippers approach the cathedral from the east, across an open plaza. The church raises a glazed lantern beaconlike over its eastern apse, visible from the pedestrian approach as well as from the highway nearby.

CIRCULATION

OLA follows a surprisingly traditional orientation on site. The altar end of the church faces east, and members enter the nave through the opposite back of the space. However, visitors actually enter the building much earlier, through a set of massive doors directly adjacent to the eastern apse. This added leg to the approach, a walk through a long aisle bordered with chapels, illustrates Moneo's design concept of a long earthly journey toward heaven. It also adds privacy to the chapels, which would conventionally open into the nave.



16 - Section drawing of OLA.
17 - Seismic isolator used at OLA.
18 - Site plan of cathedral grounds.
19 - Section drawing and lantern view analysis.
20 - Floor plan and circulation diagram.

20

NATURAL LIGHT

Light became a focus of the cathedral project as a metaphor for “the Light of God... revealed in salvation history, especially in and through Jesus Christ” (“Cathedral,” 2014). Despite the church’s contemporary air, Moneo described the windows in terms of restoring a sense of the “transcendental” (Moneo & Cortes, 2012). The cathedral’s large windows are technically mosaics of translucent alabaster. Direct sunlight does not enter the space through these windows; rather, the mineral admits a diffuse illumination, mitigating solar heat gain at the same time (“Cathedral,” 2014).

While the effect is impressive, it would be difficult to replicate without considerable expense. However, the technique raises the topic of alternatives to glass windows in church buildings. In a church building intended to serve emergency health functions and shelter from disaster, less fragile apertures using unconventional materials could be an advantage.

21

GEOMETRY

The cathedral maintains a relatively traditional plan schematic, with a repeated cruciform layout applied to the nave between flanking rows of chapels. The slight acute angle of the nave walls emphasizes the chancel and altar at the east end where, on the exterior, the iluminated lantern also invites visitors.

22

21 - Chancel and choir interior.
22 - Floor plan with liturgical cruciform overlay and radiating grid lines.
23 - Exterior view from adjacent highway.

CONCLUSION

While some designers of recent churches might find it necessary to rethink sacred architecture from nothing, OLA presents a successful adaptation of selected principles of traditional design to a wholly modern project. Traces of medieval design and thought are discernible, but do not clash with an overall contemporary aesthetic.

The cathedral also sets a useful precedent for resilience in church design. OLA features a structure intended for the earthquakes common to southern California, whereas the thesis project will be developed on the opposite coast, where hurricanes pose a greater threat. While the design decisions and executions will therefore differ from those seen here, the general approach of durability measures incorporated into architecture should be a guideing goal of the project.

CASE STUDY: UNITY TEMPLE

FLEXIBILITY FOR WORSHIP

Frank Lloyd Wright's Unity Temple, a church designed in 1905 for the Unitarian congregation of Oak Park near Chicago, is atypical among churches of the era. For that matter, the congregation was atypical as well: Rev. Jenkin Lloyd Jones, coincidentally Wright's uncle, advocated a liberal view of nondenominational religion which Wright conveyed in the Temple through divorce from traditional ecclesiastical architecture (Siry, 1996). Although this thesis is not intended specifically for liberal congregations, Unity Temple is a relevant case study in sacred architecture sufficiently vague to potentially house multiple church denominations over an extended life span.

The church is modestly sized, designed in precise scale to a congregation of four hundred. In recognition that a church's chief function is sacred, Wright planned the building in two volumes: the smaller multipurpose Unity House, devoted to the congregation's more secular functions, architecturally complements Unity Temple from the other end of the site (Siry, 1996).

24 - Unity Temple exterior and entry porch.

STRUCTURE

Load-bearing components are site-cast concrete, selected mainly for economy.

NATURAL LIGHT

Diffuse sunlight enters the worship space through high-set shaded clerestory windows and a translucent skylight.

MASSING

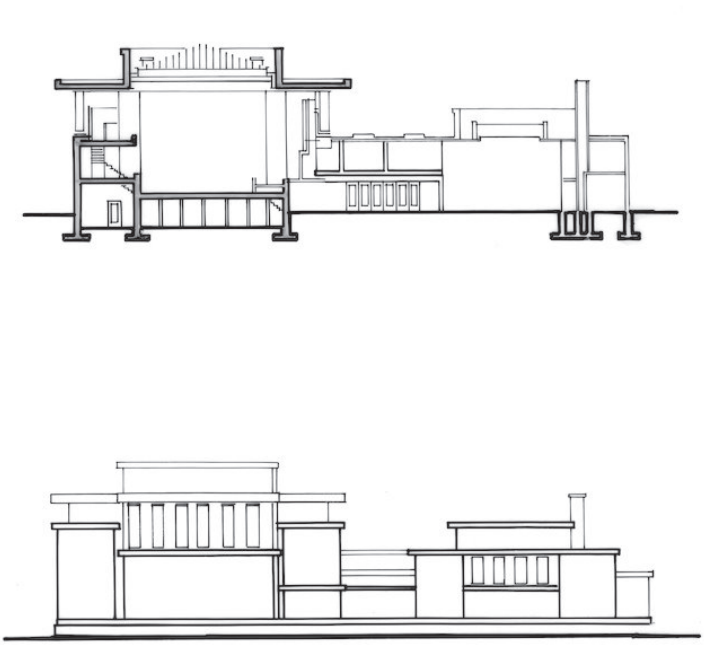
Two cubic volumes differentiate sacred functions (worship) from secular (other church functions). The visually dominant Unity Temple houses services, complemented by the subordinate Unity House.

HIERARCHY

Unity Temple intentionally eclipses Unity House, while maintaining architectural continuity through repeated elements.

GEOMETRY

By its consistent square geometry and notable lack of the traditional vertical emphasis, Unity Temple symbolizes the Unitarian belief in divinity at human scale.



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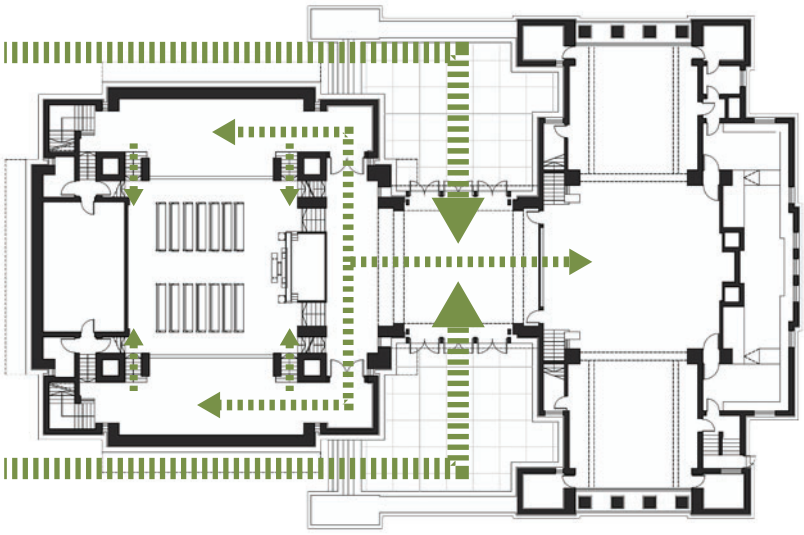
25 - Section, elevation, and plan drawings of Unity Temple.



26

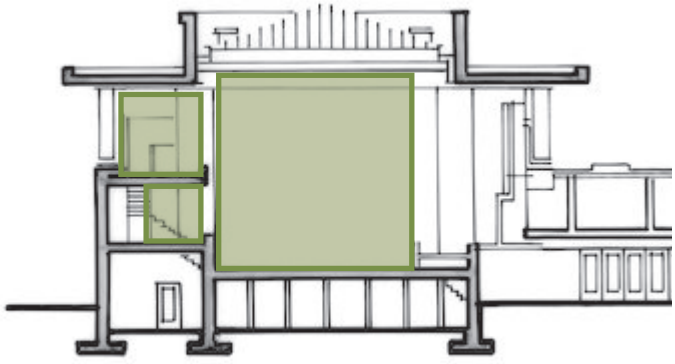
CIRCULATION

Members enter and exit the church near the pulpit, contrary to traditional liturgical orientation. More typically, congregants enter at the back of the nave and proceed toward the front. Here, a noisy street recommended an interior-facing church door, and the transitional space between Unity Temple and Unity House became an efficient central entry for each.

Strategic level changes and concealed stairways allow latecomers to take their seats in the auditorium without disturbing those already present. At the end of a service, the pastor is conveniently positioned to personally interact with his members as they file directly past the pulpit to exit the church (Siry, 1996).

PLAN, SECTION, AND SCALE

The Unitarian congregation and its minister Rev. Jenkin Lloyd Jones adhered to a theology of the divine being present in humanity, and not remote. The worship space at the Temple, therefore, is closely scaled to the congregation. In contrast to the lofty naves of medieval cathedrals, the Temple describes a snug cubic shell around its four hundred occupants.



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26 - Plan with circulation overlay.
27 - Section with scale overlay.

28

29

Wright actively avoided reference to traditional church architecture in his design for Unity Temple (Siry, 1996). Rather, in keeping with the Unitarian interest in world religions, the church is closer in form and detail to an ancient temple (Siry, 2009). Especially conspicuous is the lack of a spire or even a bell tower: the vertical emphasis of such an element would have clashed with the congregation's ideal that "God should not be sought in the sky but on earth among the children of men" (Rev. Rodney Johonnot, qtd. in Siry, 2009).

The significance of Unity Temple to the narrative of this thesis lies in its adaptibility to differences in denominational requirements. If a similar church building stood for a century and changed hands several times, as the proposed design should be expected to do, Lutheran and Baptist congregations would find it equally agreeable to their programmatic needs (or equally inconvenient, owing to the Temple's unconventionality).

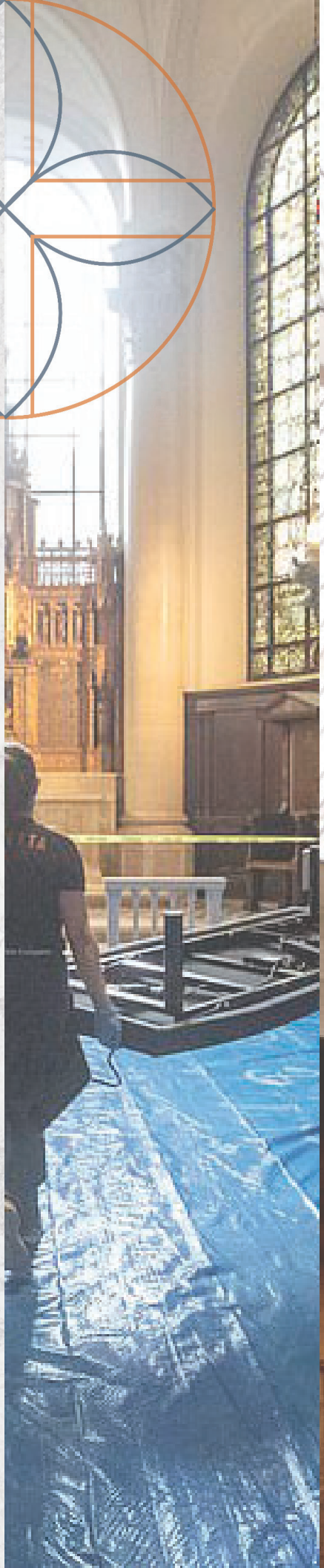
28 - Columned clerestory evoking ancient temples.
29 - Interior sanctuary, daylit by clerestory windows and skylight.
30 - Main entry, between Unity Temple and Unity House.

CONCLUSION

For best effect, the design proposed in this thesis should be adaptable with minimal changes to serve nearly any Christian, or at least Protestant, church community. A resilient church building might easily house multiple congregations over its life span, and its design should reflect as much.

Unity Temple, with a nearly total avoidance of denominationally specific symbolism, presents one approach to the design of a flexible space for worship. In addition, the design puts forward ideas of geometry, massing, and circulation that break from tradition in the interest of improved function.

TYPOLOGICAL SUMMARY



The hospital surge conversion of the Cathedral of St. John the Divine is a good overview of the programmatic needs of such a project. The case summarizes a possible approach to the problem, while also highlighting design challenges yet to be addressed. The Cathedral of Our Lady of the Angels presents a design response to a different kind of disaster, one that is preventative rather than reactive. The 500-year building's resilience is evident in its massive concrete piers and diaphragm, making durability the source of aesthetic. Finally, Unity Temple illustrates a flexible approach to sacred architecture. The building's almost vague lack of specific symbolism makes it adaptable to nearly any denomination that might inhabit it in the future.

The three examples are related: a building designed for future disaster should be resilient and long-lasting, and a building intended to last for ages should anticipate changes in ownership. The case study series, then, expands understanding of what will make a viable merging of church and shelter typologies. As a church building signifies refuge in God, a shelter communicates refuge from disaster, and both should do so functionally, consistently, and enduringly.

A theme of resiliency runs through all three cases: the old stones of St. John survive to serve a new purpose, the concrete bulk of Our Lady shores itself against earthquake, and Unity Temple remains open to changing needs.

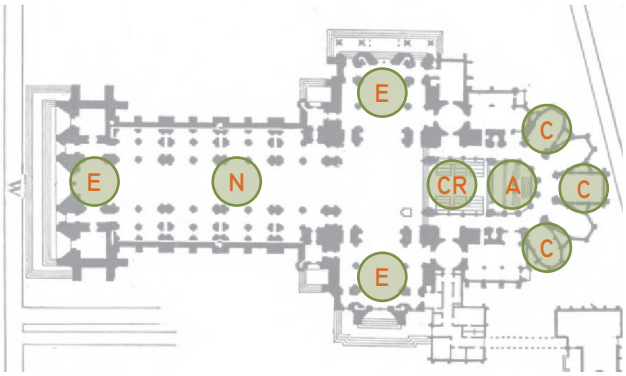
Important factors of each appear to be site-derived. At St. John, facilitators sought out the available space on the peripheries of the church grounds, and it can be assumed that some degree of efficient vehicular access led to the church's selection for altered use. Our Lady draws its fortress-like appearance from seismic risk, and its dyed-concrete aesthetic from local adobe construction. Important portions of Unity Temple, too, are responses to the site, including the interior entrance to the auditorium and the main entry placed in the link between building masses.

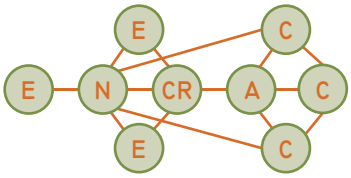
Additionally, Unity Temple is an obvious product of its immediate social context, with its avoidance of specific religious symbols in favor of a more vaguely spiritual air. In a different way, the St. John field hospital looks back to centuries of precedent, where churches took over medical functions as far back as the medieval plague.

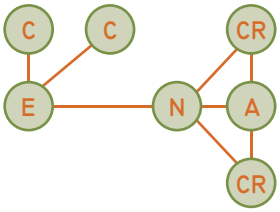
However, the three differ in their stances on traditional, symbolic sacred architecture and its relevance to contemporary churchgoing. Perhaps by default, St. John demonstrates that the use of historic form and detail is no inhibition to function; for worship services, it is likely an advantage. Unity Temple strongly argues the opposite, that houses for modern religion must also be modern, in this case through wholesale rejection of historic reference (yet it raises the question of what "modern religion" is, and how widespread. Non-Unitarians may very well prefer an architecture that hearkens to the faith of their fathers). Finally, Our Lady occupies the middle ground, with plan and form rooted in precedent but strikingly contemporary in execution.

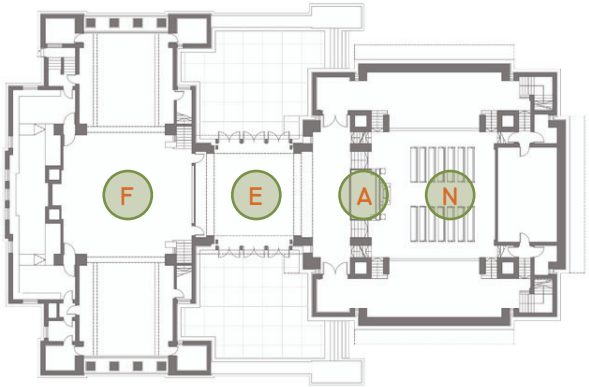
It should be expected, then, that the three churches should vary in parti. Each building is unique in its control of circulation and distance between spaces, yet some similarites do persist. All three are configured by a central axis. They all contain a progression from entry to nave to altar, though Unity slightly inverts this order and omits certain spaces more common to Catholic ritual. For that matter, the list of functional spaces will not be consistent across all examples: side and radiating chapels are not generally used in Protestant churches, which favor a multiuse Fellowship Hall.

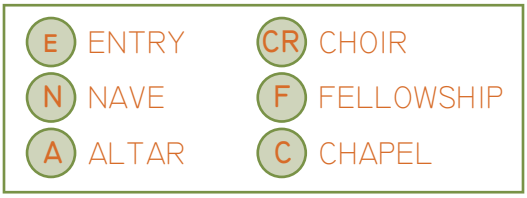
In summary, the selected case studies agree regarding the tangible concepts of plan construction, circulation, and organization. They offer differing opinions, however, on the more abstract topics of architectural symbolism and meaning. It can be concluded from the studies that a church should have an axial plan, but should that same church emphasize the vertical, drawing eyes heavenward, or be a grounded cube that invites introspection and belies transcendence?











31

31 - Parti analysis of case study church plans.

MAJOR PROJECT ELEMENTS

CHURCH-SIDE ELEMENTS

ALTAR

The focal point of the church, together with the chancel. Essential to some denominations for sacramental use.

CHANCEL

The venue for officiating services, as well as for the ceremonies of confirmation, marriage, and ordination.

SACRISTY

A preparation room for the officiant, containing vestments and other items used for services.

BAPTISMAL FONT

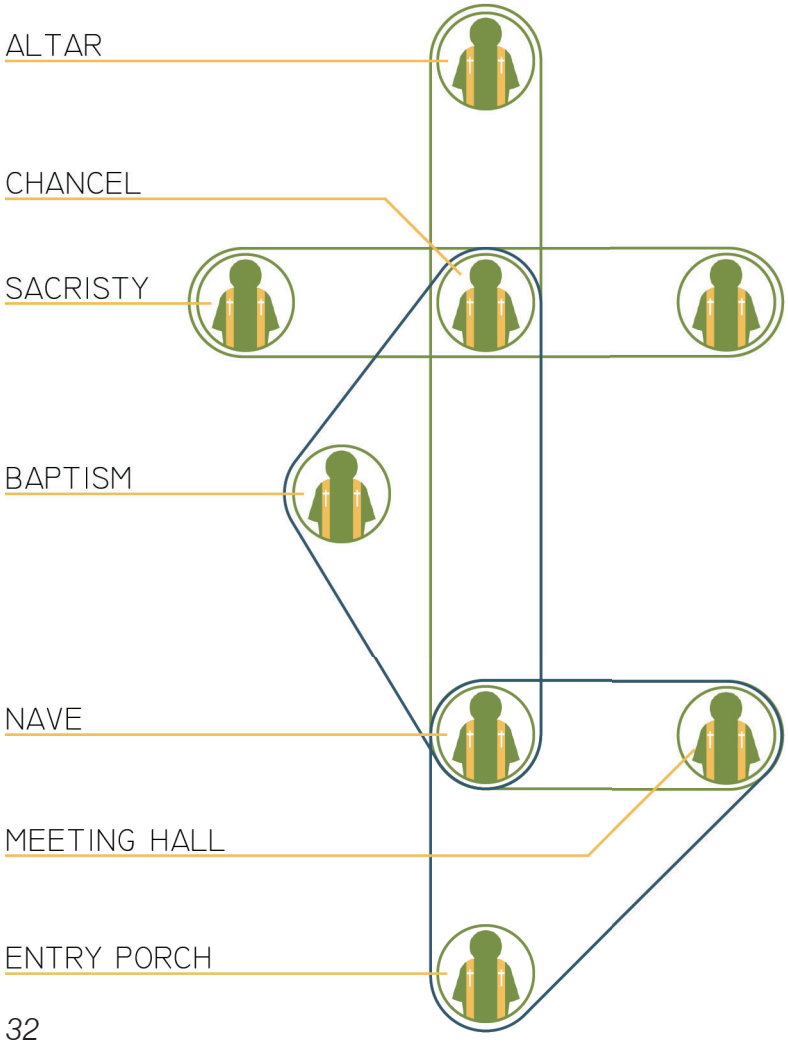
Provides for the rite whereby many members join the congregation shortly after birth.

NAVE

Contains seating for the congregation and accommodates procession to the chancel.

FELLOWSHIP HALL

Multipurpose area for church activities other than worship services, usually found in Protestant structures. Uses may include Sunday school, meals, or meetings.



32 - Venn diagram illustrating adjacency and circulation requirements for important church elements.

CARE-SIDE ELEMENTS

WAITING

Incoming patients must be accommodated until they can be received. In a pandemic scenario, they must also be kept separate.

TRIAGE

Patients move quickly through triage, where they are sorted to care areas or discharged without treatment.

PATIENT BEDS

A mass area of patient beds houses most of those being treated. Unless a pathogen is present, they can be kept relatively close together.

INTENSIVE CARE

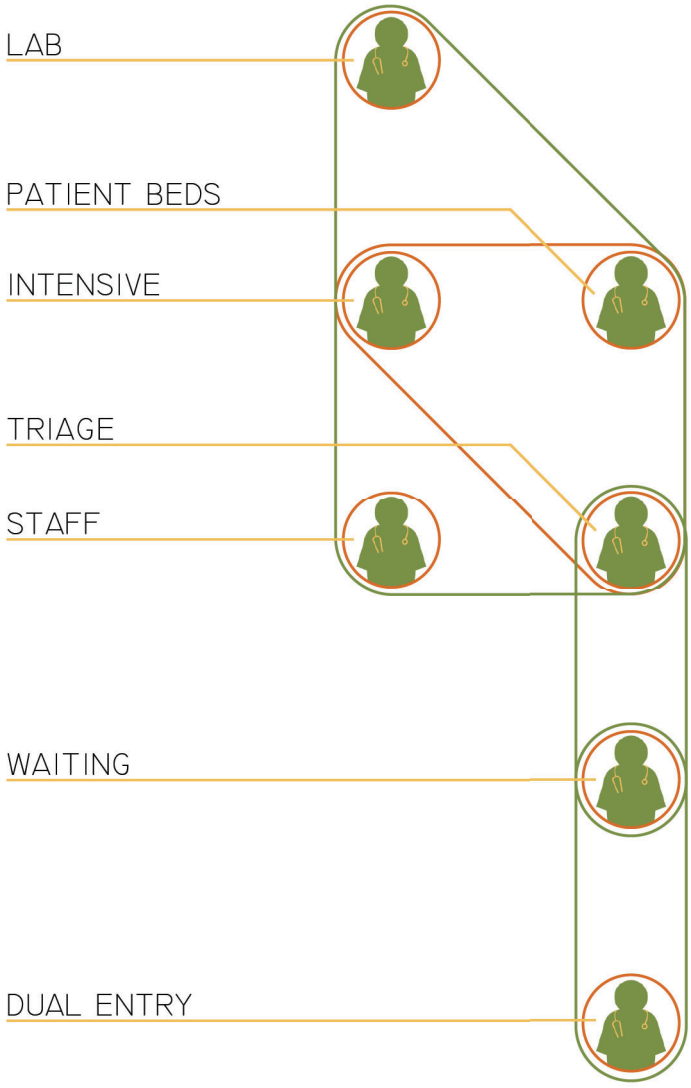
Patients requiring immediate or specialized care, or isolation from other patients, are closely monitored here.

DIAGNOSTIC LAB

Used in triage evaluations or for ongoing treatment. High-tech equipment brought from hospitals may be kept here.

RECEPTION

Depending on the nature of the emergency, both ambulances and ambulatory patients must be accommodated.



33

33 - Venn diagram illustrating adjacency and circulation requirements for important health-side elements.

FLEXIBILITY AND OVERLAP POTENTIAL

EFFICIENCY

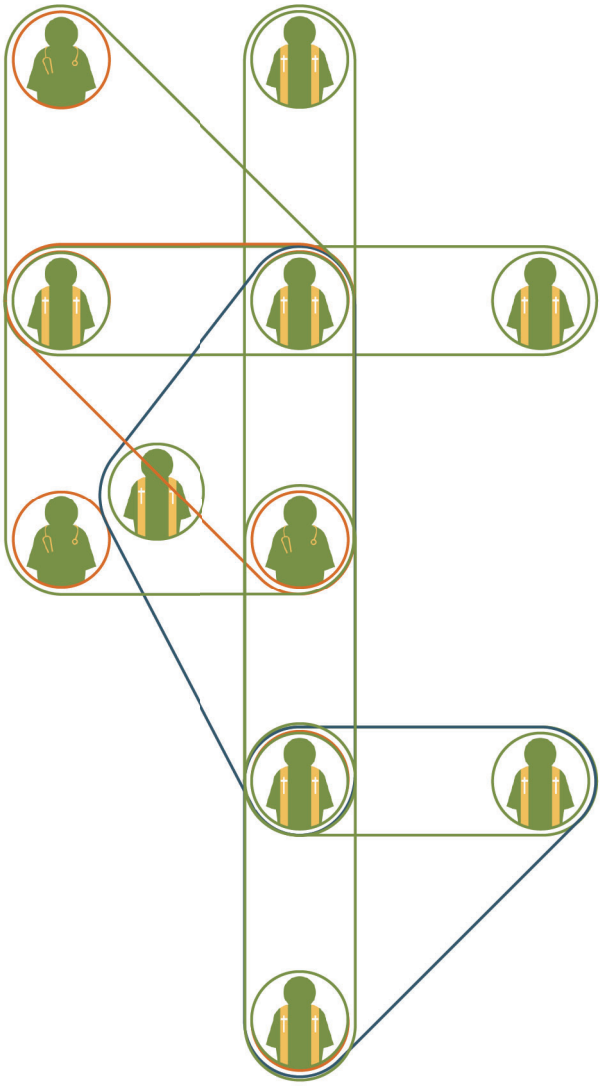
Analysis of program spaces and connections reveals potential for dual-use design elements. Building form will result from consideration of both functional programs and how the design can successfully serve both. Most spaces should be intended for conversion: for example, the nave where the congregation sits should be designed with removable seating, natural light, and ventilation to accommodate inpatient beds.

FLEXIBILITY

The best configuration of temporary healthcare facilities can change according the nature of the threat. In a viral pandemic, patient isolation must be possible, whereas sheer capacity could become a priority following a weather disaster. Finally, field healthcare technology will almost certainly change and advance over the next several decades. The building must be flexible and able to serve possible future needs.

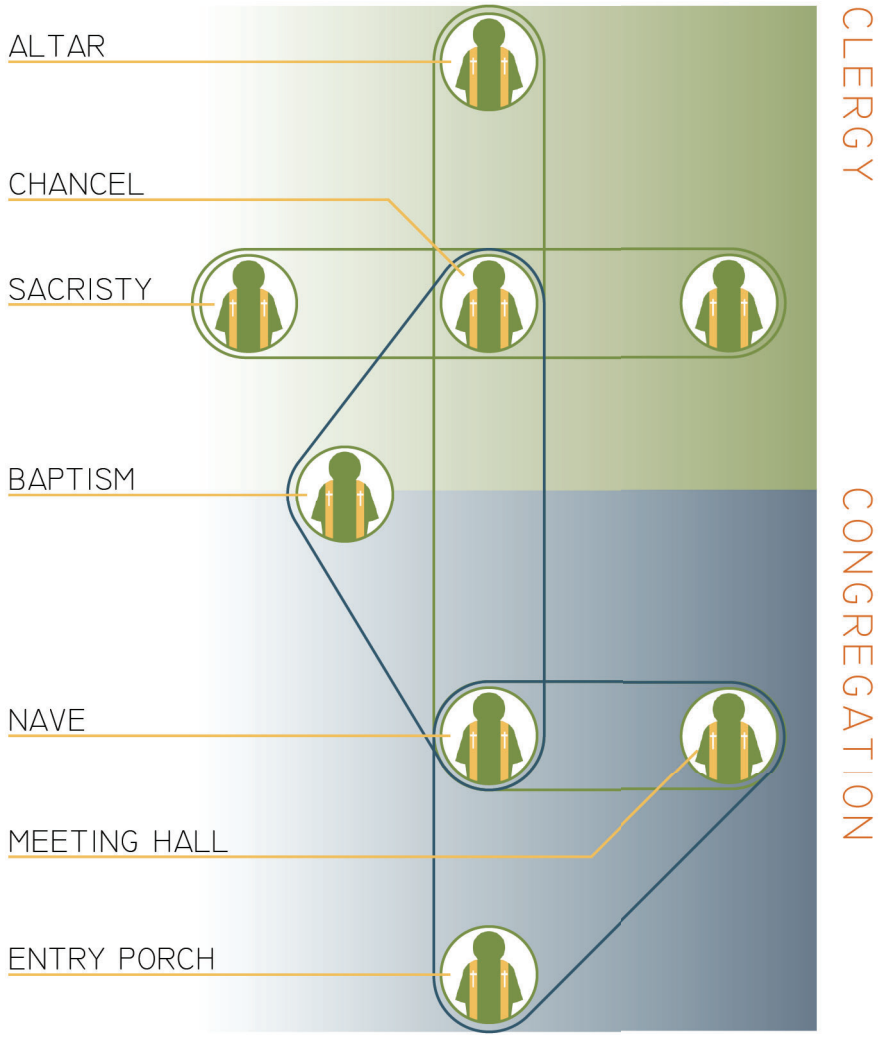
LONGEVITY

The building must be sufficiently resilient to justify the up-front cost of a disaster response facility that may not be needed for decades at a time. Concurrently, it must be able to survive a disaster itself. The safety and usefulness of the building cannot be compromised by whatever occurrence also necessitates its emergency conversion.



34

34 - Overlaid Venn diagrams for main church and care spaces, suggesting areas for multiuse design.



35 - Church Venn diagram overlaid with main areas of usage by occupant type.

CHURCH-SIDE USERS

USER GROUP I: CLERGY

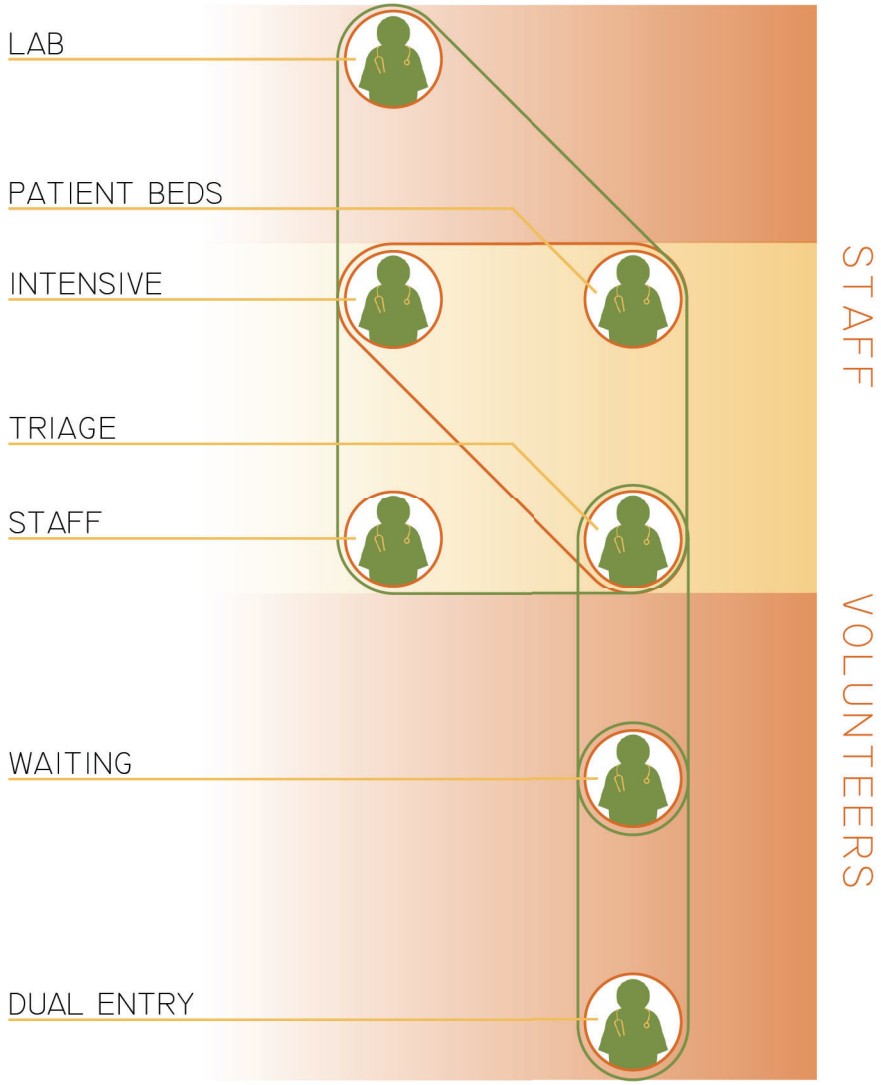
- 1 to 3 present at once
- Peak usage for Sunday or weekly services
- May include multiple groups in circulation

Although they comprise a relatively small proportion of the church community, clergymen contribute heavily to the list of programmatic spaces. Officiating a church service typically requires a pulpit, chancel, altar, sacristy, and other ritual demarcations.

USER GROUP II: CONGREGATION

- 250 to 400 present during service times
- Peak usage for Sunday or weekly services
- May include multiple groups in circulation

On a given worship day, churchgoers require little more than a nave furnished with pews and hymnals. However, they will over the building's life span periodically require accommodation for baptisms, funerals, weddings, communions, and other congregational functions.



36

36 - Healthcare Venn diagram overlaid with main areas of usage by occupant type.

HEALTHCARE-SIDE USERS

USER GROUP III: TRAINED EMERGENCY PERSONNEL

- May be relatively scarce
- Should be present at all times when in operation
- Function as operations leaders and organizers

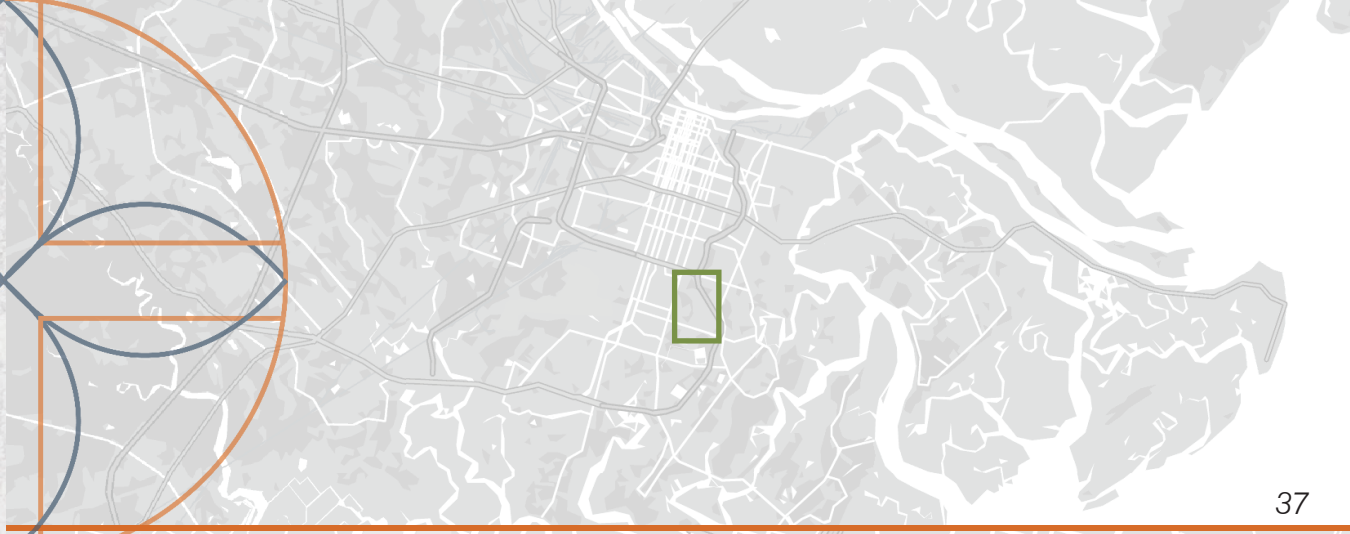
Medical doctors, surgeons, and other professionals should be regarded as a scarce operational resource. They possess technical knowledge and expertise that they administer with assistance from support staff and volunteers (“Planning,” 2020).

USER GROUP IV: EMERGENCY VOLUNTEERS AND SUPPORT STAFF

- Proportionally greater numbers
- Should be distributed to assist
- Versatile, with some relevant training but not qualified for all procedures

Support staff may include personnel from temporarily suspended healthcare departments, as well as federal health workers, trained volunteers, or even family members of patients (“Planning,” 2020).

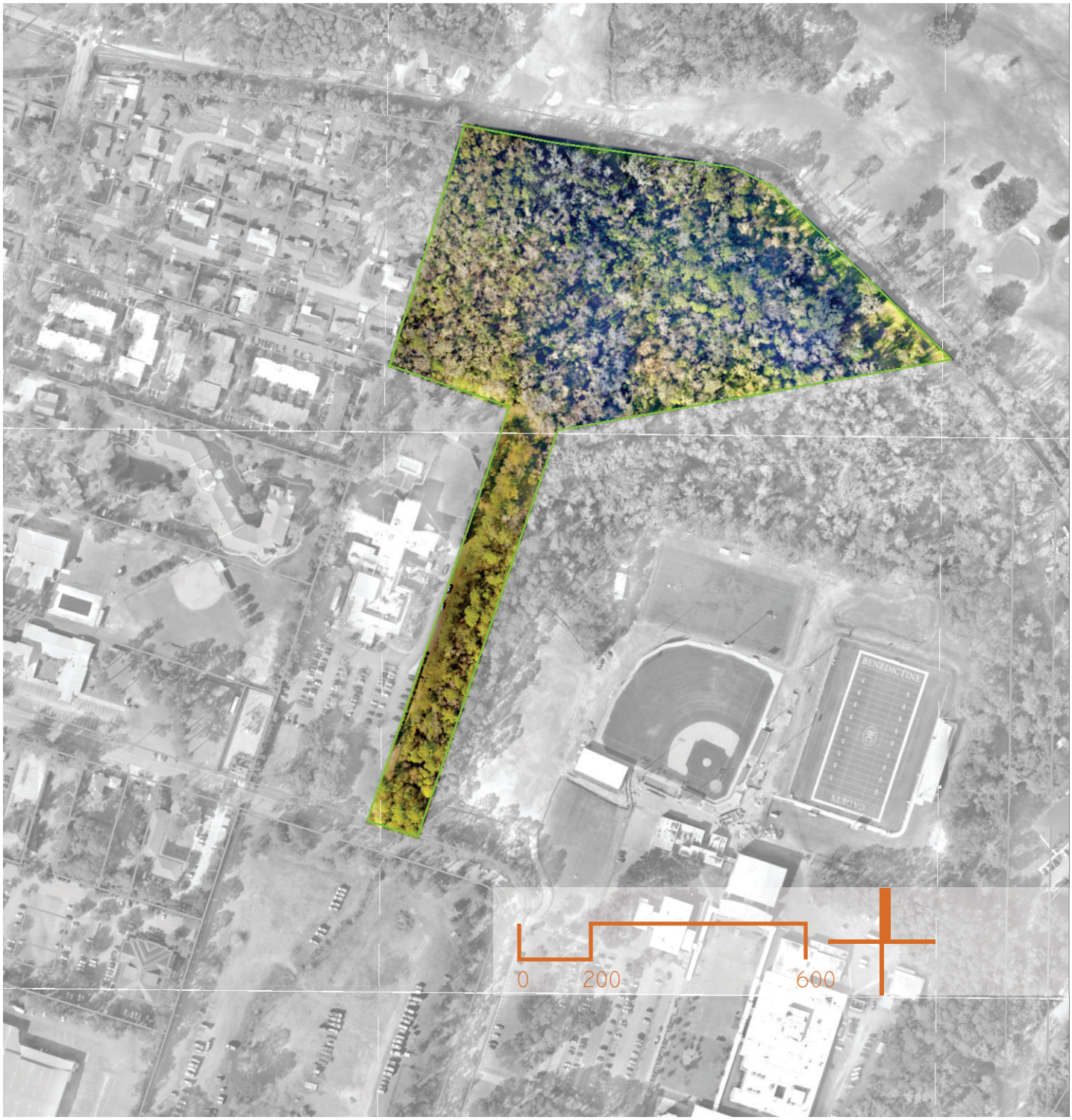
SITE INFORMATION

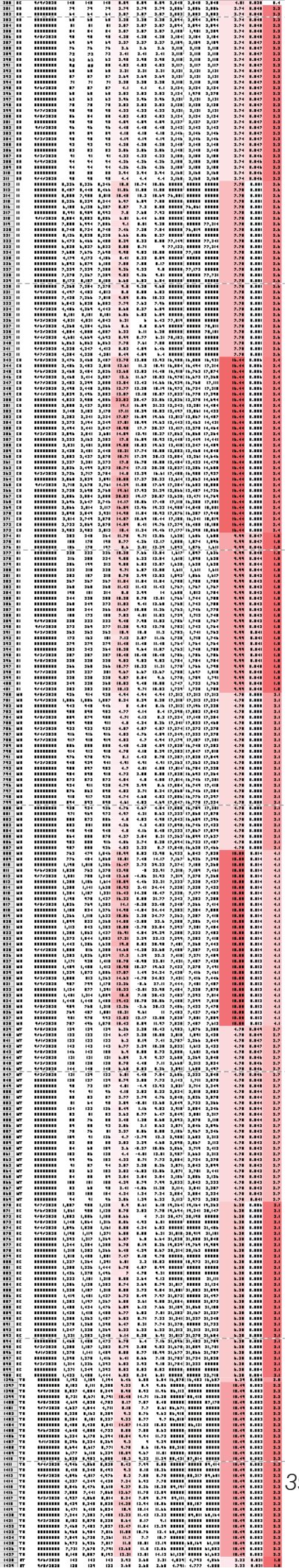


1160 CORNELL STREET
SAVANNAH, GEORGIA

37 - General location and orientation map of site.
38 - Scaled site plan with detailed context.

38





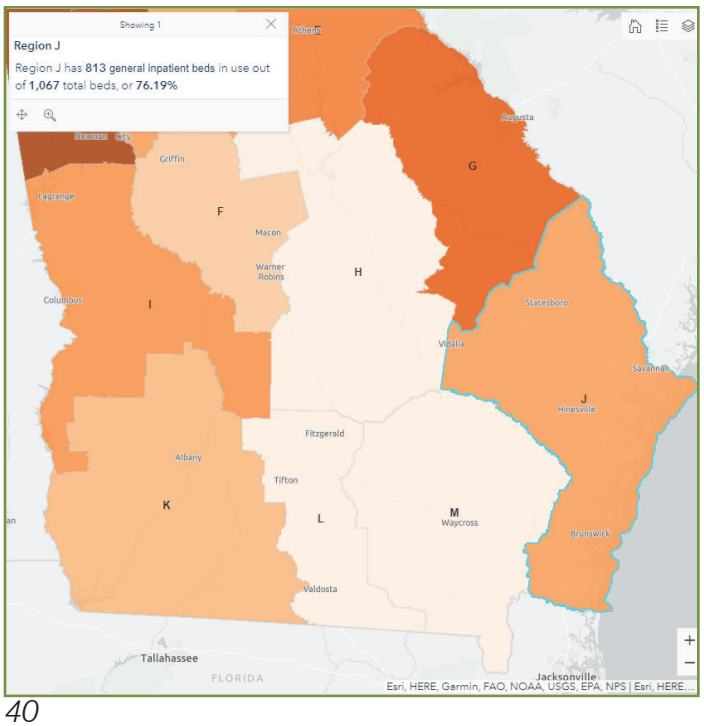
SITE SELECTION PROCESS

Research on the most logical site for this project attempted to identify areas of the U.S. most in need of additional emergency medical treatment capacity. Current data related to COVID-19 was especially valuable as a recent illustration of different states' and cities' abilities to house patients during a large-scale medical emergency.

CDC data from July 2020 identifies Florida, Georgia, Texas, Arizona, and Nevada as states where COVID-19 patients occupied the largest percentages of healthcare beds ("State representative estimates," 2020). The graphic at left analyses more detailed data from the Department of Health and Human Services ("Estimated inpatient beds," 2020). The three rightmost columns are formatted to shade entries by value on a red-white gradient, graphically ranking all fifty states by the following:

- Number of inpatient beds occupied by COVID-19 patients (highest numbers shaded red)
- Percentage of entire state's healthcare capacity comprised by one hospital bed (highest numbers shaded red)
- Total statewide hospital beds per one thousand population, according to most recent data (lowest numbers shaded red) ("Community hospital beds," 2017)

Those areas of the table containing the most red shading in the three rightmost columns represent the states least prepared, regarding healthcare capacity, for a pandemic response. Of the five capacity-depleted states identified by the CDC, Georgia lies at the intersection of high COVID-occupied beds (16.4%) and relatively few total beds available (2.4 per 1000 residents). Although each individual hospital bed accounts for only 0.5% of the state's total capacity, the statewide population is such that the ratio of beds to residents remains low.



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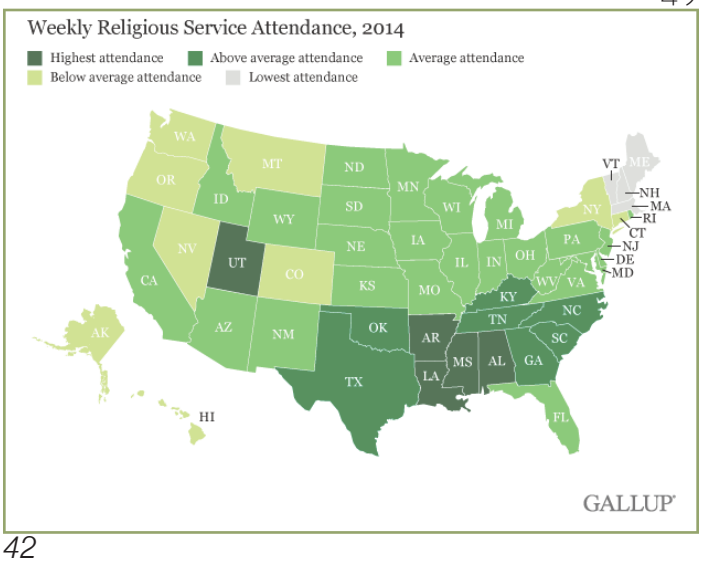
Region	Inpatient in Use	Inpatient % of Total	ICU Beds in Use	ICU % of Total	ED Beds in Use	ED % of Total
A	188	45	37	80	33	26
B	558	76	105	71	37	20
C	787	90	138	85	87	37
D	3540	75	924	79	567	55
E	411	71	67	96	70	49
F	1124	74	171	73	162	50
G	946	79	138	78	118	52
H	174	65	36	90	22	25
I	551	85	85	90	69	49
J	781	93	199	87	105	32
K	551	71	91	78	50	31
L	361	79	69	95	33	31
M	205	61	51	70	57	68
N	1110	96	204	90	174	62

41

39 - Opposite left: graphic analysis of hospital bed capacity and depletion due to COVID-19, by state.
40 - Above left: GIS map illustration of hospital bed use by region.
41 - Middle left: graphic analysis of data from above GIS map, severe depletions shaded red.
42 - Map illustration of church attendance by state.



42

Addressing the other aim of this project, a Gallup survey identified Georgia as having the eighth highest church attendance nationwide, with 39% of residents attending services at least once a week (Newport, 2015). While not rivalling the enthusiasm of Utah (51%) or Mississippi (47%), Georgia has enough churchgoers to justify the construction of new churches, more so than the evidently more secular New Hampshire (20%) and Vermont (17%).

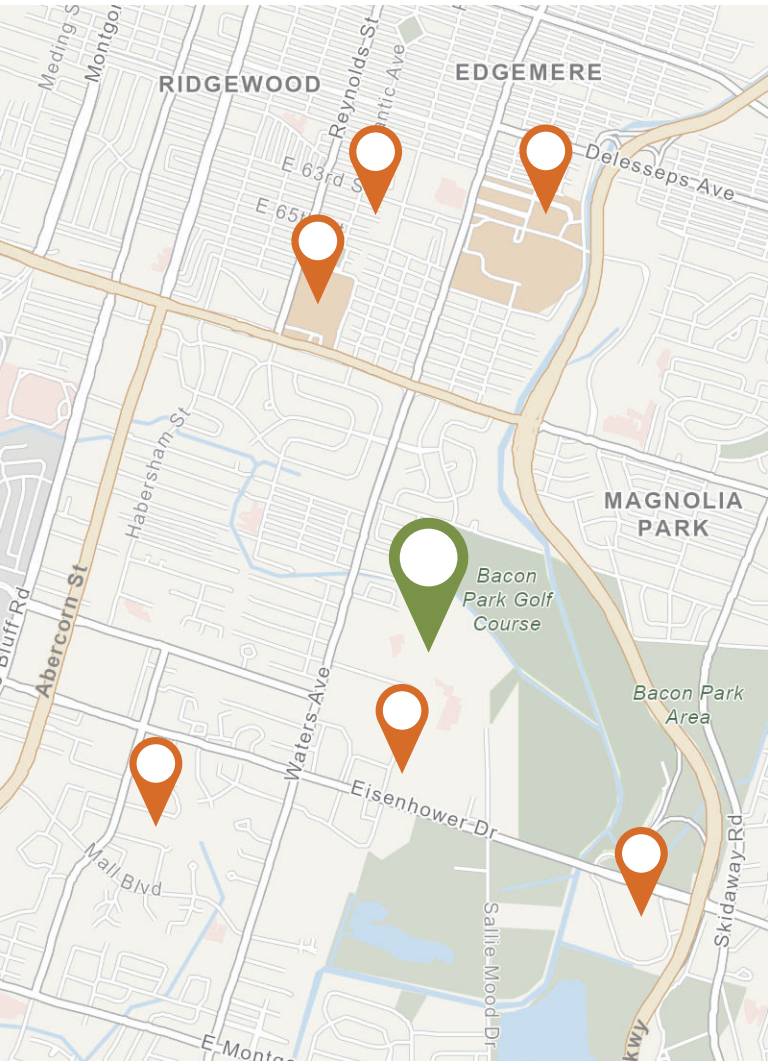
A GIS map published by the Georgia Department of Public Health compares regions of the state by hospital bed use. Although the most depleted areas are those around Atlanta, the capital was ignored as an important urban center likely to receive more media coverage and assistance during an emergency (Kapucu et al., 2014). The vicinity of Savannah was a more suitable location, having a fairly depleted healthcare capacity as well as being more susceptible to other emergencies, like hurricanes, that could require sudden expansions of emergency medical capacity.

The site is an undeveloped lot nearly equidistant from six hospitals and healthcare centers. In a disaster scenario threatening to overload any of these medical facilities, transfer of patients, staff, or equipment to a field hospital on the site will be relatively convenient.

In addition, much of the surrounding area is zoned for residential use. When the building is used as a church, as it will most often be, its location will offer short travel times for many potential attendees.

43 - Site location relative to six area hospitals.
44 - Extent of residential zoning around site.

43



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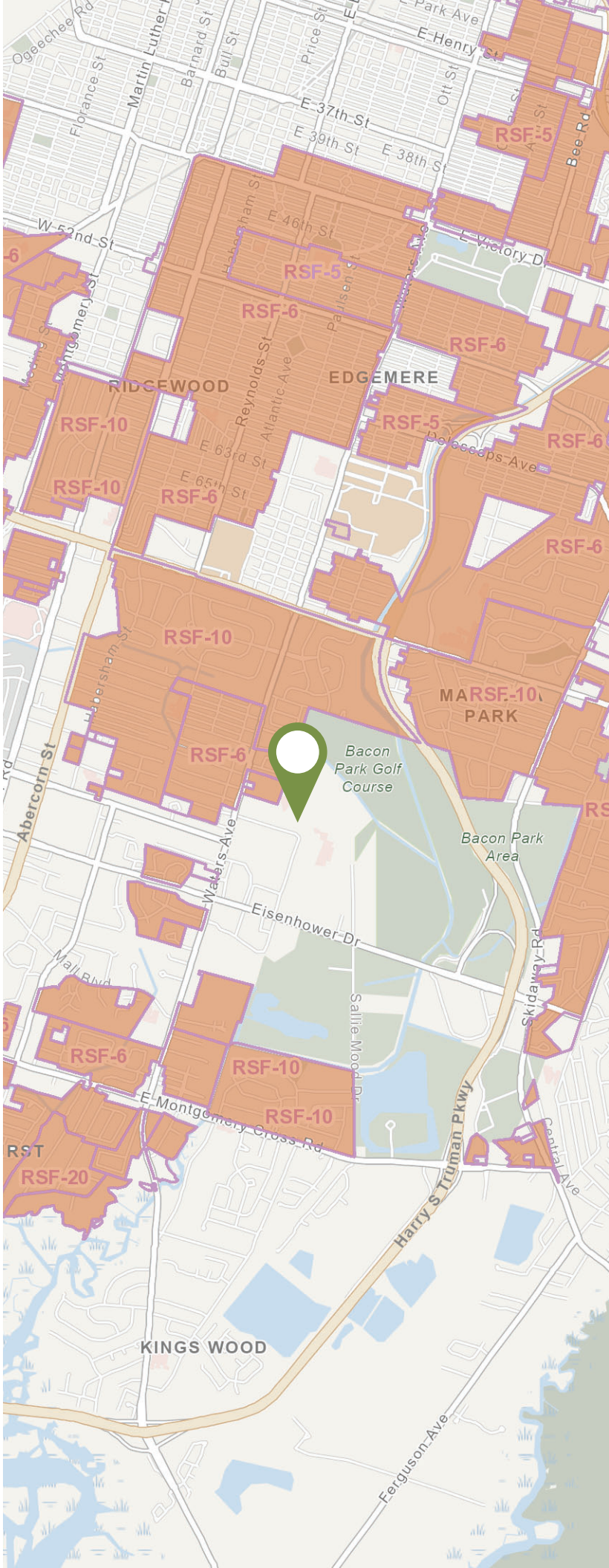
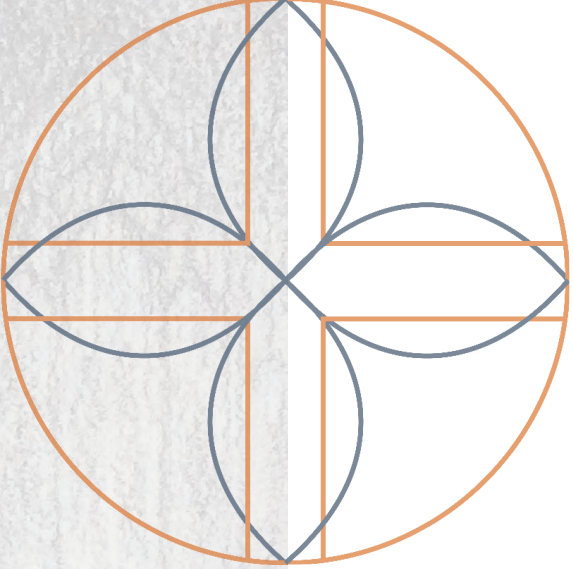


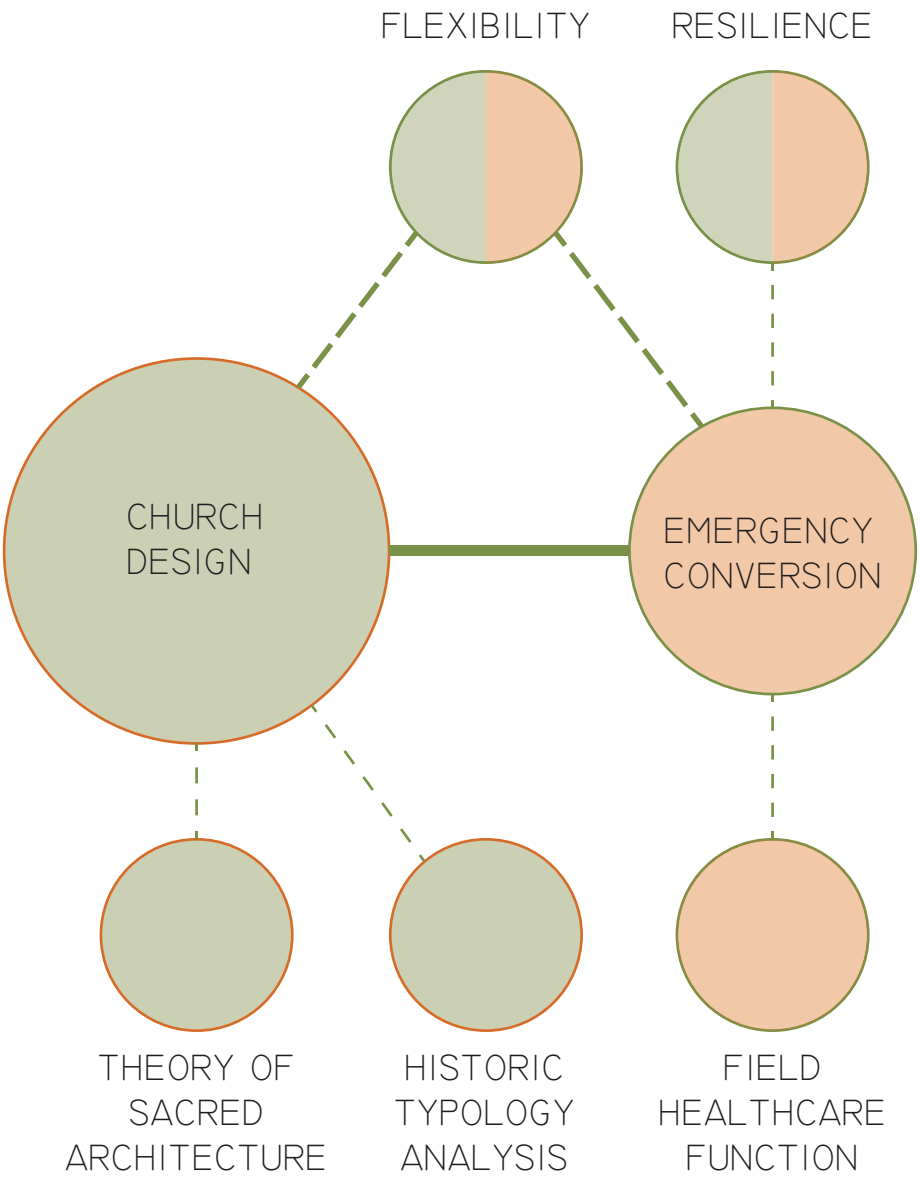


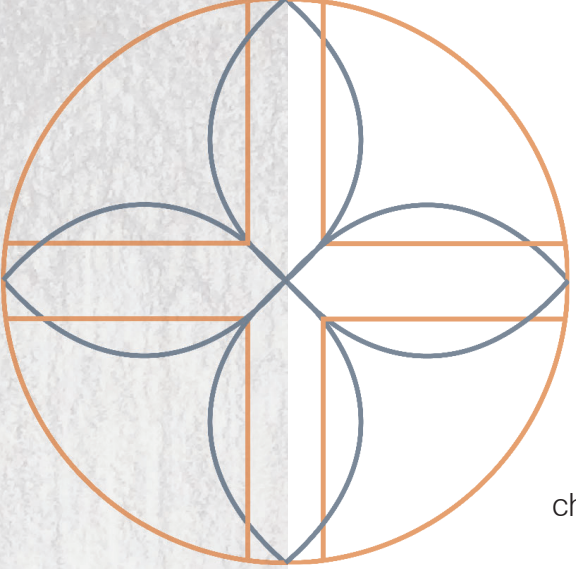
PROJECT EMPHASIS

This project will emphasize the design of a church building relevant to the landscape of sacred building difficulties facing twenty-first century congregations. While the ecclesiastical aspect of the design will be the project's continual focus, the design work shall be undertaken with the understanding that only through the viability of the concurrent shelter/refuge functions will the project be successful. Therefore, the value of designed spaces in the project as capable of serving both worship and emergency programs of use will be the central intended outcome.

Relevant to the sacred aspect of the project, design of the church spaces will be informed by research and analysis of traditional versus contemporary theory of sacred architecture, in the hope of maintaining consistency with precedent rather than duplicating it exactly.

The refuge side of the project will be guided by resilience and durability. Design challenges introduced by natural disasters, pathology, and sustainability will be researched and addressed.


FLEXIBILITY
RESILIENCE
CHURCH DESIGN
EMERGENCY CONVERSION
THEORY OF SACRED ARCHITECTURE
HISTORIC TYPOLOGY ANALYSIS
FIELD HEALTHCARE FUNCTION



GOALS OF THE THESIS PROJECT

In keeping with the project's emphasis on relevant contemporary church design, the thesis will address the typologies of worship and emergency buildings through the following overarching goals. The design's secondary function as emergency health care center will not be presented as a possible improvisation, but as a deliberate function of a flexibly designed church building.

GOAL 1: Develop a contemporary church building design that refers to traditional ecclesiastical architecture without imitating historic methods

GOAL 2: Incorporate resilient design strategies, especially related to extreme coastal weather and natural disasters.

GOAL 3: Maintain economy in materials, construction, and maintenance. Develop a successful space for worship without relying on an extravagance of design.

GOAL 4: Increase function, flexibility, and capacity in design areas related to emergency health care. Health care strategies will be incorporated from the beginning of the design, with the intent that it be an intentional and fully addressed design aspect.

GOAL 5: Demonstrate successful functioning of the design as both a as both a church and an emergency center. Both aspects will be clearly enhanced in comparison to alternative housing for them.

CONTRIBUTIONS OF THE THESIS PROJECT

The project will make additions to existing fields of research by synthesizing information and previous studies, and proposing a design in response to it. Informational benefits of the project will apply to three main categories: the academic, professional, and person.

ACADEMIC CONTRIBUTION

This thesis will produce a reference comparison between two dissimilar but historically related building typologies: the church and the emergency refuge. The project will be a contribution to any existing body of knowledge pertaining to blended building types, as well as a proposed methodology for exploring other combinations.

It will draw connections between specific aspects of church and healthcare buildings that enable or help facilitate typological combinations. The physical characteristics typical of both building types will support their integration.

If not a perfect solution to issues of church finance, the project will nonetheless encourage discussion of creative church stewardship in trying economic conditions. At the same time, the project will posit ideas about how communities can creatively provide for their future emergency needs.

PROFESSIONAL CONTRIBUTION

The project will provide an additional case study for church design in contemporary settings. It will also encourage discussion in professional design of the potential for extended building life through multiuse design.

Rather than convert an obsolete building through adaptive reuse, this thesis will advocate designing new buildings to serve alternative functions in the future. It will seek to identify specific areas of new building design that through conscious forward-thinking design can encourage future reuse rather than merely accommodate it.

The project will recommend consideration of innovative ways to serve communities in addition to serving clients, or vice versa, through designs that go beyond original programs of use.

PERSONAL CONTRIBUTION

Through this thesis project, I will enhance my own design process by building my background experience with innovative building efficiency and life span solutions. The design will provide me with a basis for new ways of thinking about building use and ways to improve versatility and utility into the future.

It will expand my knowledge base related to specific characteristics and technical aspects of church and refuge design and leave me with a beginning level of expertise for future projects in either category.

Finally, the project will widen my understanding of social issues related to congregational finance and emergency care capacity. As the thesis will demonstrate, both areas are relevant to architecture and will aid future solutions by contextualizing related design work.

PLAN FOR PROCEEDING

FUTURE RESEARCH

Development of the project will proceed with additional research focused on improving the following central areas of this proposal.

THEORETICAL PREMISE

1. Compare similar church denominations for potential focus and design basis.
2. Assess financial viability of selected church denominations.
3. Identify sources of community funding for church-shelter projects, such as non-government organizations or disaster relief groups.

PROJECT TYPOLOGY

1. Assess types of construction for use on the basis of economy, durability, sterility, and aesthetic.
2. Compile background research on deployable field hospitals, their requirements, and their use.

HISTORICAL CONTEXT

1. Collect precedents for the historic overlap of churches and disaster refuge.
2. Analyze traditional church architecture and evaluate its relevance in the context of modern programmatic requirements.

SITE ANALYSIS

1. Record detailed observations and site characteristics in person, as possible.
2. Predict necessary site interventions, their relative convenience, and their impact on neighboring sites.
3. Review any restrictions to building on the site, from zoning or site conditions.

PROGRAMMATIC REQUIREMENTS

1. Collect precedents for the historic overlap of churches and disaster refuge.
2. Analyze traditional church architecture and evaluate its relevance in the context of modern programmatic requirements.

RESEARCH AND DESIGN APPROACH

MIXED-METHOD RESEARCH DESIGN

1. Historical research
2. Case study analysis and quantitative research
3. Qualitative research
4. Grounded theory analysis

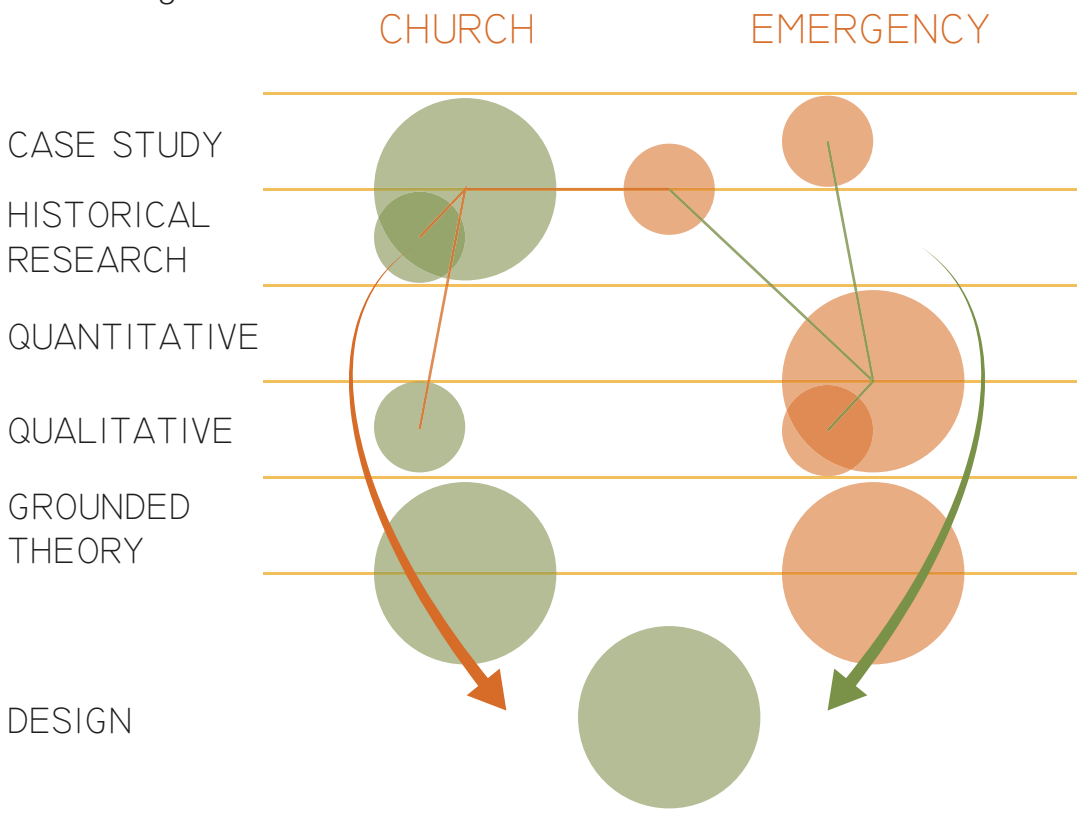
Research will continue using a mixed-method design with characteristics of a dominant-less dominant design. Grounded theory analysis of information will guide the research conclusions and subsequent design, drawing from historical research of the church typology, quantitative and qualitative case study analysis, and qualitative investigation of emergency health care.

Research related to the church typology will focus on case studies and historical research, compiling qualitative information on traditional ecclesiastical design and its relevance to modern architecture. Qualitative data will be drawn from published commentary and collected from serial case studies. Historical analysis will provide qualitative information related to eras of architectural thought.

The healthcare side of the project will be informed by quantitative details on necessary design components, accompanied by qualitative study of treatment function. Bed capacity, ventilation, lighting, and other technical aspects will be included mainly as quantitative data from archival search.

Finally, grounded theory analysis will synthesize the two aspects to direct a final unified design.

45



45 - Illustration of planned research methods for church and care project aspects.

DOCUMENTATION PLAN

The design process will be recorded and documented at intervals throughout the project, allotting the method of design a significance equal to the final product.

ITERATION

1. HAND SKETCHES, using physical drawing media.
2. ITERATIVE MODELS, using digital drafting programs.
3. ITERATIVE MODELS, using readily disposable materials.
4. DETAILED MODEL, using digital drafting software and modified continually.

PRESERVATION

1. DIGITAL CONVERSION of artifacts via scanning and photography.
2. AUTOMATED BACKUP of all files to Google Drive via Drive File Stream.

DISSEMINATION

1. ARCHIVAL STORAGE at North Dakota State University Institutional Repository.
2. LIMITED PUBLICATION in hard copy.

PRESENTATION

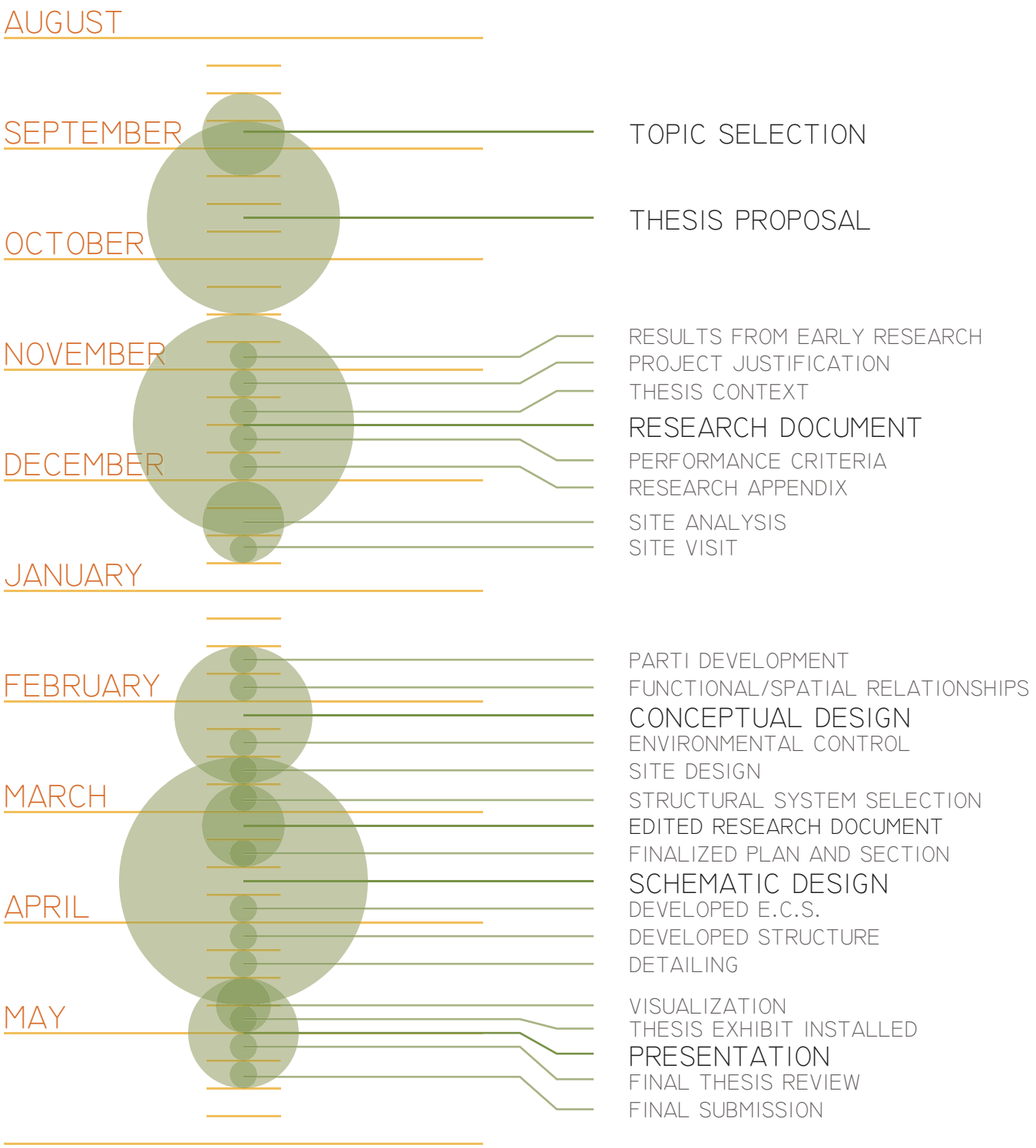
1. DIGITAL SLIDE SHOW presentation using PowerPoint or similar.
2. PRINTED DISPLAY BOARDS, large format.
3. DISPLAY MODEL in physical or digital format.
4. ORAL PRESENTATION to reviewing jury.

COMMUNICATION

1. DETAILED DIGITAL MODEL, refined continually during design development using Autodesk Revit and Rhinoceros 5.
2. TECHNICAL DRAWINGS, generated using Autodesk Revit.
3. INFORMATIONAL GRAPHICS, produced using Autodesk Revit, Rhinoceros 5, and Adobe Creative Suite.
4. CONCEPTUAL RENDERINGS, using Lumion 10 or TwinMotion and Adobe Creative Suite.

PROJECT SCHEDULE

The following general timeline organizes tasks and goals over the duration of the project time frame.



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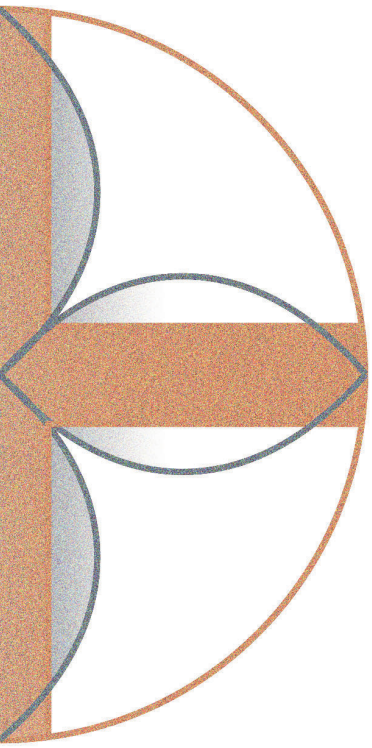
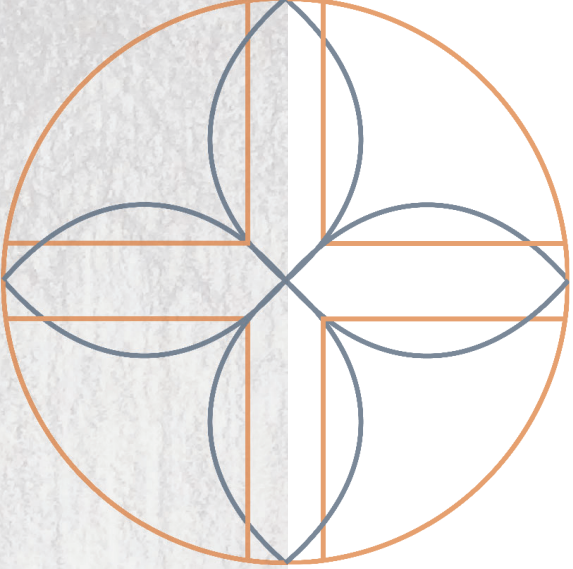
46 - Schedule for project completion.



THESIS RESEARCH



RESEARCH ON THE THEORETICAL PREMISE

CHURCH BUILDING IS... A PROBLEM GOVERNED BY HIGHER PRINCIPLES AND MORE ENDURING LAWS THAN OBTAIN IN ANY OTHER FORM OF THE GREAT ART OF BUILDING.

R. A. CRAM, CHURCH BUILDING

Research for this thesis is divided into two main areas: evaluation of historical and modern theories and trends in church architecture and their relation to functional requirements, and analysis of the design of temporary emergency medical facilities and field hospitals, primarily through case studies related to guidelines for permanent facilities.

Historical research of the church building typology consists of comparisons between antiquated and contemporary approaches to the design of sacred spaces. This research connects studies of older church buildings, traditional church design methods, and recent commentary and proposals for modernization. Historical study also includes examples of combined church and health typologies, most often epidemic field hospitals operated inside church buildings.

Research guiding the emergency health care side of the project focuses on qualitative data taken from field hospital case studies. Conceptual guidelines for the design and operation of temporary medical facilities is compounded with quantitative benchmarks and guidelines and compared to design practices for permanent medical facilities. The program of the proposed field hospital will derive from a grounded theory analysis of case studies as compared to published guidelines for general health care design.

In the end, logical argumentation demonstrates that a complete church building designed to support field hospital functions in regard to infrastructure, flexibility, resilience, and utility can adequately accommodate and even enhance the functions of both, comprising a potential solution to the noted issues.

RESEARCH SUMMARY

RESEARCH IMPLICATIONS ON CHURCH DESIGN

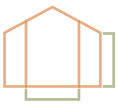
Central tenets of church design emerge consistently through review of literature on sacred architecture. While the form, aesthetic, and detailing of the church building have yet to be determined, certain typical elements are imperative.

First, the main part of the church, the area actually used for worship, must contain the architectural elements necessary for baptism (a font), confirmation and marriage (at least one chancel step), and communion (an altar; although not always directly used in Protestant services, the altar is nonetheless included). The altar and the chancel step require a chancel or sanctuary, separate from the nave where the congregation sits. There must be provision in the chancel for reading and speaking, such as a pulpit and/or lectern.

With a minimum program established, the literature is further condensed to provide a set of important design requirements. The goal of this stage is to help ensure a basic consistency with traditional church design regardless of overall style. These requirements will be used as performance criteria during the design of the project.

1: The nave seating should form a rectangular volume dimensioned approximately 1:3, if longitudinal, or square. The nave itself need not be rectangular in plan, as long as the extreme dimensions of the part used for seating follow either ratio.

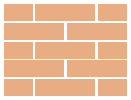
2: The nave must have either a low roof with wide side aisles, which will hold seating; or a high roof with narrow aisles, which will be used for circulation. The side aisles need not be defined by columns as is typical in traditional churches. The quantity and use of peripheral space are emphasized.



3: The walls of the nave must be higher than the width between the aisles.

4: Windows should be large, resembling “translucent walls” more than punched openings.

5: The chancel and altar must be the focal point of perspective, building, and sight lines throughout the nave.



6: False or imitation materials must be avoided.

Finally, the church must maintain the beauty and dignity due a house of God. Usually this evokes the great stone cathedrals, where an insistence on the very best materials, craftsmanship, and ornament achieves majesty. However, most of the reviewed works on the subject agree that the correct atmosphere is not best achieved through rote duplication of existing religious architectural styles. Apart from issues of spatial programming, certain laws of proportion and order such as those summarized previously appear to be almost sacrosanct whereas minor details like Gothic tracery and rib vaulting are not.

However, even if the six aforementioned points are met, a church can still fail to achieve the presence and feeling of a church. That final element, which involves scale and proportion and focus but is not exclusively any one of them, is difficult to quantify, and it is first and foremost that element that leads back to imitation of earlier successful designs.

Areas of finer detail, however, are more open to experimentation. Materials, furnishings, and decoration are more flexible in their execution; design guides such as *Church Building* stipulate only that such components be of high quality in recognition of the church's importance.

With elaborate wooden screens and decorative brass altar pieces not feasible for this project, more contemporary solutions will be required. A polished marble floor might be replaced with concrete or wood, ceiling joinery with finish grade plywood, murals and carvings with simple expressions of symbols and color, and so on.

The literature demonstrates clearly that elements of no historical style are essential to the "feel" of a church; a pre-Reformation parish church and a twentieth century brutalist chapel can share a common spiritual air. The goal of this review, in addition to selecting spaces for programming, is to distinguish those elements that give churches the timeless monumentality which sets them apart.

In summary, a study of relevant literature on the theory of sacred architecture separates those aspects of the typical church which are truly essential from those which may be revised for reasons of economy or style. The review yields a basic checklist for correct church function and atmosphere, also expressed in the project's finalized program.

RESEARCH IMPLICATIONS ON HEALTH CARE DESIGN

A review of published field hospital case studies, coastal building resilience guidelines, and supplementary resources on permanent health care facilities informs the interrelated design goals of durability and health care convertibility.

First, design recommendations for hurricane resistance are condensed from literature.

1: Building masses should be regular, without discontinuities. Adjoining masses of different size must be structurally separated.

2: Complex plans with reentrant corners (U, T, and cross-shaped plans, for example) should be avoided.

3: Shear walls and diaphragms should be incorporated to improve lateral resistance.

4: A 30° roof slope is optimal for wind resistance. Hip roofs are the most stable, but gable roofs still outperform single-slope structures.

5: Hurricane-ready design must address the Main Wind Force Resisting System (MWFRS), consisting of the foundation; floor supports; columns; roof rafters and trusses; and bracing, walls, and diaphragms.

6: A continuous load path must be established from wind load origins on the roof and walls to discharge at ground level.

Research relating to the field hospital function of the project refers to a number of documented field hospitals, in response to both viral and natural disaster emergencies. While specific requirements for patient care units, ventilation rates, etc., may change with the nature of the emergency, other field hospital functions like triage will be constant across all circumstances.

An airborne disease response such as the field hospitals built for COVID-19 should have patient bed units measuring at least 6.5'x6.5', with 12 air changes per hour. The literature suggests that these facilities can be naturally ventilated to achieve up to 40 ACH. A large COVID hospital employed a principle of "three zones and two passages" to keep contagious patients separated from staff. A much smaller operation also responding to the coronavirus allowed more intermingling with ventilation.

For non-disease emergencies such as hurricanes, field hospitals will provide mostly general care to patients, requiring less stringent isolation and containment measures. An 80-bed hurricane field hospital in Florida also highlighted the importance of communication infrastructure, volunteer staging, food and rest accommodations, and record-keeping in field care facilities.

Finally, the study includes resources on the design of permanent hospitals. A basic understanding of health care programming and facility operation from these sources completes the investigation of required services for temporary health care. For example, hospitals generally include in-house diagonstic labs. Although the lab is not mentioned in every field hospital study, it is included in this project's program as a provision for future circumstances. These sources also provide insight concerning circulation and care in patient areas, and how these areas can be most effectively configured in a flexible space.

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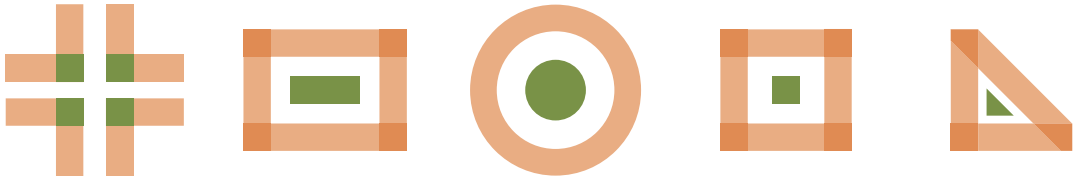


Ultimately, field hospital case studies and health care design guides contribute to the complete design program outlined under Performance Criteria. The study also provides starting points for the design of the temporary facility in this project, such as recommended layouts for patient beds and nursing stations. All of the field hospital and permanent hospital research contributes to the spatial program: the program is based primarily on field hospital case studies and supplemented with key spaces from permanent hospital design guides.

47 - Possible configurations for patient treatment areas as recommended in literature.

CONTEMPORARY CHURCH ARCHITECTURE

REINHARD GIESELMANN

Much of what is commonly associated with church architecture today is rooted in historical precedent, usually either the Gothic cathedrals of the Middle Ages or the Romanesque designs of the Renaissance. Theories of sacred architecture are therefore prone to clash with other building typologies, which are expected to change and modernize as they keep pace with technological and stylistic advances. *Contemporary Church Architecture* explores and attempts to rationalize the architecture of modern churches that deliberately break from the examples of history.

In an era of rapid technological improvement ("a time when everything must be arranged, regulated, insured," [8]), the relevance of any kind of traditional architecture can be questioned. After all, "religion is reflected in the unmeasurable, in the redundant" (8). Technology is presented as a major driver of the shift from traditional church design. Indeed, as modern society may even be said to worship technology the question might become "whether religion is necessary in the life of the technocratic society" (8).

IT CAN BE STATED THAT NONE OF THESE SYMBOLS [OF TRADITIONAL CHURCH ARCHITECTURE] HAS SURVIVED, AND THAT MAN'S QUEST FOR SYMBOLISM IS ALTOGETHER RECEDING. COMPARED WITH THOSE YEARS, IT SEEMS AS IF CONTEMPORARY CHURCH ARCHITECTURE IS BEGINNING FROM SCRATCH.

While the author concludes that religion itself is actually not obsolete, he elaborates on the recent shift in its tangible image. The emphasis of spaces for worship through monumental and symbolic architecture appears to be a thing of the past. That vanishing symbolism in churches does not refer only to allegorical depictions and sacred proportions: widely imitated Gothic elements such as the heavenward pointing tower, the meditatively lit nave, and the remote altar in the bright choir have become in their own right "symbols of the right faith" (10). In the modern era, however, "Man's quest for symbolism is altogether receding" (10),

The transition is not an easy one, for "to overcome the Gothic style means overcoming a mediaevally formalised faith" (12). When a church building breaks radically with tradition, exchanging the cruciform plan for a square column grid and ribbed vaulting for steel girders, the dissimilarity to its architectural forbears can be jarring. The extent of this dissonance is hard to quantify. After all, "even if you preached under a green linden-tree or willow, it would still be God's own abode and sanctuary, for God's Word reigns there. God's Word alone sanctifies the place and makes it His home and abode" (Martin Luther, qtd., 20). At the same time, however,

> Within the horizon of our associations, it was the Gothic style which achieved

> the greatest symbiosis of symbol and meaning. This may well be one of the most important reasons why, to us, the Gothic church still represents the embodiment of a Christian sacral building and its semantic standard. (24)

While pointed arches and a cruciform plan are not imperative to the use of a church (whereas elements like seating and an altar might be), symbolic elements are more relevant to a church than mere decoration is to other typologies. Recent architects have attempted not so much to do away with all symbolism and spiritual atmosphere, but more often to substitute for it. The understated brick, steel, and glass cube of Mies van der Rohe's 1952 IIT Chapel contains little decoration but "with its beautiful proportions and with its consistent use of the technical aids, [achieves] genuine monumentality (18). Le Corbusier's chapel at Ronchamp "signifies the final victory over the Gothic style" (18) and has left its mark on much of subsequent church design.

> Since Ronchamp, church architecture has known plastically shaped interiors with sentimental overtones… where a clear distinction between plan and elevation is no longer attempted. There are lighting effects where bright interiors are contrasted with darker parts of the room, occult twilight with radiant brightness. (18)

The end result of all this experimentation is that among many modern churches, the appearance of a church hardly remains (24). Concurrent is the increasing inclusion of more secular activities in building programs, producing multi-purpose interiors which can accommodate any of the congregation or community's activities (22). Yet the steady shift from the symbolic and conventionally sacred comes with a warning: should churches become so concerned with social and secular demands that the former competes with their spiritual foundations, they will lose their very reason for being. "Social activities alone can also be carried out by other benevolent institutions" (24). A church is not a social club, kitchen, or concert hall, and while it may on occasion have certain functions in common with them, it must not become one of them. Designers who aim to separate the church from those precedents which in many eyes make it fundamentally "churchlike" must take care that they do not remove the substance with the trappings.

The development of church architecture over time influences other areas of design, particularly related to the plan. Shorter naves better suited for sermon delivery have become popular in both Catholic and Protestant structures (14). Rectangular plans remain the most common, but all manner of variants have been attempted, in plan as well as in section and three-dimensional form (16). In general the altar has moved closer and closer to the congregation, participation in the sacrament gaining preference over involvement only as spectators (20). Flexibility is increasingly a concern, often to accommodate alternate uses within the church but sometimes in the form of a detached multipurpose space (22).

SUMMARY

Following the previously summarized discussion on the changing theory of church architecture, the book presents about fifty brief examples of modern reinterpretations. Without demanding a full case study analysis of any one project, the full set is a

sweeping cross section of successes and failures in adapting architectural traditions to more recent ideas and techniques. Most significantly, this sampling shows a clear contrast between churches that are largely true to Gothic concepts of space and order, with updates only to general aesthetics; and those whose designers attempted to reinvent the church typology itself. The former are recognizable sacred spaces, clearly intended for Christian worship, while the latter are not.

Whereas other resources like Cram's *Church Building* present near-comprehensive guides to traditional church design, *Contemporary Church Architecture* is a study in how far a place of worship can modernize without losing its design essence. Older books would insist that a longitudinal cruciform plan is the only choice, but counterexamples in this work demonstrate that the atmosphere of a church can indeed be preserved with a radial or square schematic. Other elements, like the altar as the focal point of the building, are simply non-negotiable.

Gieselmann's collection will therefore serve as a series of benchmarks for reference in the current project. It contains plentiful examples of church designs that pushed the boundaries of sacred architecture, yet firmly held on to the gestalt of sacred space. Because an authentic Gothic church is not feasible for this thesis, the design produced in this project will be a contemporary church. To ensure that it is viable as a church, however, it must remain on the conservative end of the spectrum in Contemporary Church Architecture, with those buildings whose architects rethought aesthetics without rethinking the church itself.

STONES OF WITNESS

COLIN CUNNINGHAM

The concise guide to the historical development of Anglican church architecture presents a counterpoint to *Contemporary Church Architecture*. According to the author's thesis, patterns of worship, rituals, and relationships actively shape church buildings over time (2); therefore every element of the historic church building has its role, and to strip away bits and pieces is to erase portions of the church itself. The church typology is a direct result of its history, and "what we see as we enter any church today is only the final coat, as it were, on a canvas that has been constantly repainted over many generations" (11).

While the examples surveyed in this book belong to the Church of England and not to any of the Protestant denominations common in the United States, the analysis of church use patterns provides a useful framework for thinking about the essential functions of a church building. Stones of Witness traces major architectural elements to the practice of seven Anglican sacraments. Here, for example, Protestant churches assign the term "sacrament" to only two of the seven, yet many parallels remain with the Anglican tradition.

1. Baptism: The basin of water used in baptism is often placed near the entrance of the church, symbolizing the beginning of the Christian journey and entry into the congregation (18-19).
2. Confirmation: "The rite in which baptised members of a congregation affirm their faith" (23) has left less of a mark on church architecture. It is practiced in Protestant churches, but not regarded as a sacrament. In Anglican churches it requires the bishop to lay his hands on the candidates as they kneel at the chancel step (24), making the slight elevation change at the front of the nave an element of ritual significance.
3. Communion: Denominational practices regarding the Lord's Supper vary widely, even between branches of Protestantism. In Anglican churches, where the Eucharist is more literally equated with sacrifice, the altar is pivotal (25). In Protestant churches the practice is different, but the altar remains present.
4. Marriage: Like confirmation, the ceremony is officiated at the chancel step. Historically the entry porch was involved as a venue for the exchange of marriage contracts, though this significance has weakened (38).
5. Ordination: Historically the formal induction into the clergy began at the main door, symbolizing the new priest's authority over the building, after which the candidate would ring the church bell (45). The process is less elaborate in Protestant churches and leaves no discernible mark on their architecture.
6. Penance and Extreme Unction: These are not practiced in Protestant churches, but the recorded subsequent approach to burial is more universal. "The church graveyard, as the gathering place of the dead of each community, is an important symbol of the way in which the present generation is a part of a continuity of faith" (58).

While the exploration of church architecture's ritual basis is not an exact template for the design of Christian churches in general, it sets forth an approach of distilling

church functions to their most basic architectural necessities. A water basin of almost any design will accommodate baptism. The addition of a single step between nave and chancel serves both confirmation and marriage. If the rudimentary programmatic requirements are met, many of the congregation's regular needs will be met.

The work traces other ubiquitous components of church buildings to their functional sources. The presence of a pulpit from which the minister addresses the congregation, for example, was rare in medieval churches (67) and gained acceptance only after the Reformation stressed the importance of intelligible Gospel preaching (63). Seating for the congregation, too, is a relatively recent innovation; a medieval church would have provided only a few movable benches for those who could not stand (68).

The use of symbolism is discussed and debated. Triangles and arrangements of three are common as representations of the Trinity (113). Other familiar examples often used in churches include the A and Ω (God's eternal nature), vine motifs (Christ as the vine), the Chi-Rho symbol (Greek abbreviation of Christ), and the fish (insignia of the early church) (114). Beyond these fundamental representations, a much wider array of symbolism refers to saints and church hierarchies (114). "However, it is… unlikely that any one congregation would have been able to understand more than a fraction of the symbols available" (114). Some iconography, such as the tooth-in-pincers of St. Apollonia (114), is obscure even to lifelong churchgoers, especially Protestant.

IT SEEMS IMPOSSIBLE FOR A RELIGION THAT DEALS WITH CONCEPTS OF ETERNITY TO ESCAPE FROM THE PAST.

To make the point moot, the Puritan sect later objected to "the whole arcane business of symbolism" and vandalized much of that found in English churches (114-115). Differing views on symbols persisted. The tower and spire, a medieval demonstration of man's aspiration toward heaven, was generally accepted (59), whereas organ music was not (76-77).

Recently, changing tastes in church architecture have become perhaps even more pronounced. After World War I, a general condemnation of Victorian excess led to greater simplicity in church buildings, whitewashing patterned walls and eliminating dim atmospheric lighting (198). After the Second World War, plans were rethought as new and rebuilt churches sprung up across Europe. As after the Protestant Reformation, the emphasis was on decreased remoteness and increased congregant participation (199). In our own time we see organ music giving way to praise bands, projection screens being hung from chancel arches, and moving chairs replacing pews (202). Though such a shift is nothing historically extraordinary, even younger church members may be apprehensive. As the author concludes,

> Perhaps the lesson is that… we will inevitably be faced with difficulties in using buildings designed for the liturgy of an earlier generation. Yet it is those very buildings that retain the priceless link with the communion of saints that stretches back to the earliest years of Christendom.

CHURCH BUILDING

RALPH CRAM

The oldest text included in this review is the work of an accomplished American church architect from the beginning of the twentieth century. *Church Building* insists on the Gothic style-- the English Perpendicular, in particular-- as the only legitimate architecture for churches, and virulently refutes all challengers. It is one thing for secular building styles to continually evolve and improve,

> but that the same qualities of trivial fashion and triumphant individualism should obtain in a portion of that Church which we hold to be changeless and stable, resting serene above the vacillations and vicissitudes of human society, is certainly a most unfortunate condition of things (4).

The author does not set forth any one medieval church as a template to be copied verbatim. The diligent design of church buildings consistent with their predecessors must be "art, not archaeology" (13). Rules for successful projects are many; the "certain fundamental laws of planning, composition, proportion, construction, and design, that are as old as the art of architecture itself" (87) are an enduring metric. Yet the ultimate crucible of sacred design, he posits, is "the test of what has been" (106).

ONE CAN WORSHIP GOD IN A BARN; BUT IT IS DENIED TO US TO BUILD FLIMSY WOODEN SHANTIES TO HIS GLORY, AND TO TRY TO DECEIVE HIM BY THE CHEAP ORNAMENT WHEREWITH WE HOODWINK OUR NEIGHBORS.

However, modern means and methods stand in the way of great stone works to rival Durham and Winchester. "Unless there can be a complete revolution in the whole system of building, it is hard to see how for the immediate future the architect can do much more than work in simple, standard forms" (298). Skilled labor is hard to find, and the most beautiful and long-lasting materials prohibitively expensive. The great challenge for modern designers is to preserve Gothic proportion and order without the aid of elaborate tracery and stone carving. "We cannot restore the externals of the Gothic style; but we can endeavor to re-create the underlying spirit, and lead it to express itself in the new forms we must impose on it" (22).

Sacred design has four foundational tenets (6-10). First, "a church is a house of God, a place of His earthly habitation, wrought in the fashion of heavenly things, a visible type of heaven itself" (6). If the finest media and constructions are not available, the designer must find another means of connecting the church to its divine antecedent. The church must also be a sacred space, set apart from the secular world. The goal is not isolation, but elevation; the author would certainly look down his nose at the

modern megachurch edging ever closer to mere entertainment. Third, the church requires an environment designed through its beauty and art to create "spiritual emotion," to "lift men's minds from secular things to spiritual, that their souls may be brought into harmony with God." Again, a church is not a meeting room or a social club, and should not have the appearance or atmosphere of either. The fourth priority of church design is "the arrangement of a building where a congregation may conveniently listen to the instruction of its spiritual leaders." This a church must accomplish, but not to the exclusion of the other three.

This framework reinforces a recurring observation: art and aesthetics are integral to the real function of a church building, much more so than for almost any other typology. It is not for seating capacity, nor acoustics, that congregations build and worship in churches. The stained glass and cavernous interiors of the great cathedrals are not wasteful ornamentation, but the builders' way of creating a space for approaching God.

When means are limited, however, "the little parish church of England is the most perfect type ever produced, and must therefore be for us a model in every way" (30). It is better to eschew ornament than to make do with cheap decoration. More important are the long rectangular plan (never square) and the continuous roof from end to end (22).

WE CANNOT RESTORE THE EXTERNALS OF THE GOTHIC STYLE; BUT WE CAN ENDEAVOR TO RE-CREATE THE UNDERLYING SPIRIT, AND LEAD IT TO EXPRESS ITSELF IN THE NEW FORMS WE MUST IMPOSE ON IT.

In addition to the perfect country church, other variations provide useful lessons. The larger "village church" was a project never completed, the ongoing work of succeeding generations, "not only the symbol of human unity: it was that unity, made up of all that lay within its control" (37). It is a far preferable approach, when immediate funds are limited, to build a little at a time rather than cheaply throw together an entire structure (43).

Church Building offers specific dimensions and proportions for ideal church plans. Some of these are based on structural limitations that are no longer relevant, while others respond to more relatively standard seating dimensions and circulation requirements. Some elements will not translate at all, such as the Anglican chancel in which the double-sided choir separates the altar from the nave (108). Yet the Episcopal leanings of the book do not exclude Protestant churches, in which the author notes a similar tendency toward Gothic architecture (312-314).

In summary, Church Building does not advocate any "new" style of church design. "Real art, real styles, do not so come into being. Each new thing is fathered by its antecedent, if it is legitimate" (332). The Gothic link must survive, however it translates from ornate stone to monumental concrete or layered wood. "Above all, let the spirit be that of the unchanging Church, the form alone that of the present day" (32).

SUMMARY

Church Building retains its relevance in an era in which fully traditional church architecture is rarely feasible. Especially for the current thesis project, an ornate structure of quarried stone is simply not financially viable. However, much of the book can be taken as guidelines for sacred architecture in general, outside the realm of the genuinely Gothic.

Ideal proportions and dimensions maintain their relevance. The width of a church nave should be approximately one third of its length, for example, and at most equivalent to its height. Recommendations like these will be invaluable for maintaining a "churchlike" atmosphere in a contemporary project. It may be too easy for a modern church architect, in the interest of efficiency, value, and flow, to abandon all those relatively inefficient components that make the historic church look and feel the part.

Other details translate easily to modern application, such as a change in elevation at the chancel, and again at the altar. Vertical space is crucial, even at the expense of other elements such as the tower, if need be. It is important to note here that such requirements, taken as a minimum, can nonetheless yield a product more typical of a gymnasium or convention center.

Therefore due attention must be paid to those aspects which are harder to quantify. Architecturally there is no one crucial element that gives a building the dignity and gravity of a house of God (the theological application of the term is more accommodating). The sacred aesthetic is qualitative, and perhaps highly subjective. There are clues, such as Cram's injunction against imitation materials and false construction. It is certainly relevant that he lists the practical housing of congregants as the last priority in church design: aesthetic and atmosphere, however they are validated, are far more relevant to the real function of a church than cosmetic decoration.

Church Building will serve as one of the chief guides for producing a design that is true to the historic precedent and sacred use of the church typology. Volumes have been published on the efficient and practical execution of such buildings, and are cited elsewhere, but they do not supersede the importance even today of centuries of precedent. The fundamental nature of church architecture is by now firmly established, and will be mainly expounded by this book as it pertains to the current project.

BUILDING TYPE BASICS FOR PLACES OF WORSHIP

NICHOLAS ROBERTS

Older publications on the proper design of church buildings may be irreplaceable guides regarding areas such as proportion, symbol, and detail, but concerning the more mundane but still important topics of parking, accessibility, and structure, only recent work will suffice.

Whereas the three books on church architecture previously cited are concerned mainly with the historical and symbolic significance of sacred design elements, Places of Worship gives an overarching survey of the bare functional requirements for the building type, and symbology rarely enters the discussion. The church entry is briefly described as a place to "meet one another before meeting God" (35), but of greater importance to the author is the adjacency of bathrooms, coat room, infant care, and ushers' storage (35). References such as the two preceding works will be sufficient for analysis of the chancel's theological significance; here emphasis is given to whether it can comfortably accommodate altar, pulpit, lectern, candles, and cross, and support liturgies, confirmations, weddings, and funerals (37-38).

The work is also relevant as a corroboration of concepts from the previous two sources. *Places of Worship* confirms that the long, narrow nave has become outdated in favor of a more participatory layout (41). The author gives the same reasoning in support of a baptismal font near the church door, but also summarizes alternative positionings common to different denominations (45).

Ancillary spaces are discussed in detail (51). Several are unique to Roman Catholic programming (Reservation of the Sacrament, Confession [48-50]), but many are applicable to Protestant structures. The complete list highlights opportunities for combining functions in multipurpose rooms, such as choir storage or practice, bride's room, Bible study, and child care.

The book includes a summary of public approval process (90), especially useful for a project intended to be at least partly community-financed. Relevant regulatory codes are mentioned, though these requirements may call for more up-to-date analysis. Considerations of economic, social, and environmental sustainability are also discussed, which may overlap with public approval and community impact.

Finally, the book gives an in-depth look at structural systems in the context of church design. It identifies key issues such as large central spaces of high volume and the need for structural diaphragms in floors and roofs, then discusses the capacities of different structure types to address the criteria. A separate chapter presents general strategies for mechanical design, giving special mention to considerations like drafts and noise. As both structural and mechanical systems will be central to this project, the information presented here will be a good beginning reference for comparison to the needs of emergency medical spaces.

SUMMARY

This work is most useful for the practical rules of thumb it provides for the spatial programming and design of a church. Also essential is the fact that, while other resources limit their discussion primarily to “church-specific” components like the nave, choir, and altar, this manual also covers the support spaces, sacristies, gathering areas, etc., that complement the use of the church proper without receiving the same level of ceremony.

The gathering space or narthex, omitted in the previous three works, is here discussed in detail. A place to assemble and converse before entering the church, it should feature informal seating and literature racks, as well as adjacencies with restrooms, study rooms, a small kitchen, and storage. Also, the gathering space should be sized with around 5 s.f. per worship seat in the church.

The more obvious church elements are also covered, but with a focus on basic practical requirements. The chancel (or sanctuary) must comfortably house altar, pulpit, lectern, candles, flowers, seating, and a cross.

The choir, sometimes omitted, should be sized based on seats spaced 2’ on center and rows 3’ apart. Ideal floor elevations and acoustical treatment are presented in plan and section, along with normal patterns of use and circulation.

Further auxiliary spaces are listed and their typical areas provided: 10x20 for a vesting sacristy, 8x10 for a work room, 30x30 for a Bible study classroom. Outside the building, one parking space should be provided for every 2.5 seats.

The space program and allocation tables draw heavily from this book. While older volumes are used as primary resources for decisions in more abstract areas like sacred geometry and symbols, this manual is a concise guide to the brass-tacks planning of a functional church design.

However, because the finished church must be able to convert into an equally effective field hospital, the recommended design standards may not necessarily be relevant. A space whose recommended area accommodates its church-side usage comfortably but cannot house the corresponding medical function must be adjusted to fit either one. Therefore this book is ultimately a starting point for collecting the design estimates that will later be used in conjunction with corresponding resources for health care.

THE POWER OF LIMITS

GYORGY DOCZI

Doczi's work documents the appearances of common mathematical ratios in nature, art, and architecture, across time and geography. The book is particularly concerned with four recurring proportions: the diatessaron, 3:4; diapente, 2:3; diapason, 1:2; and whole, 1:1 (8). These four arrangements order the components of ancient Greek vases (20), the plans and elevations of 4,000-year-old ziggurats (46), the segmented limbs of arthropods (57), and various constructions of pure theoretical geometry.

The four common proportions can be used exactly in architecture. A simple example is Vitruvius' ideal temple design in which the dimensions of walls, columns, and pedestal neatly describe 2:1, 3:4, and 3:5 (107). However, in buildings of increasing complexity and with consideration given to material tolerances, these perfect constructions are often not feasible. In fact, many of the documented illustrations, including examples both from architecture and the natural world, show that the real dimensions of component parts more often vary or alternate around a given "perfect" ratio, seldom landing directly on it. Plan components in the ziggurat of Ur sit arranged in the exact ratios of 0.68, 0.77, 0.76, 0.74, and 0.65, spiralling around the diatessaron proportion of 0.75 and the Golden Ratio, 0.62 (46). In this way the ideal ratios are present without the minute fracturing of standard measurements that exact representation would require.

WHEN WE LOOK DEEPLY INTO THE PATTERNS OF AN APPLE BLOSSOM... SOMETHING REVEALS ITSELF THAT IS INFINITELY GREATER THAN WE ARE AND YET PART OF US; THE LIMITLESS EMERGES FROM LIMITS.

In addition, not only the relation of one part to another is significant, but also the relation of both parts to a whole. A diapason ratio of 1:2 totals 3, which may in turn begin a larger ratio of 3:4 or 3:5. When the sum of all ratios defines a perfect 1:1, the construction is consistent from its smallest part to its whole.

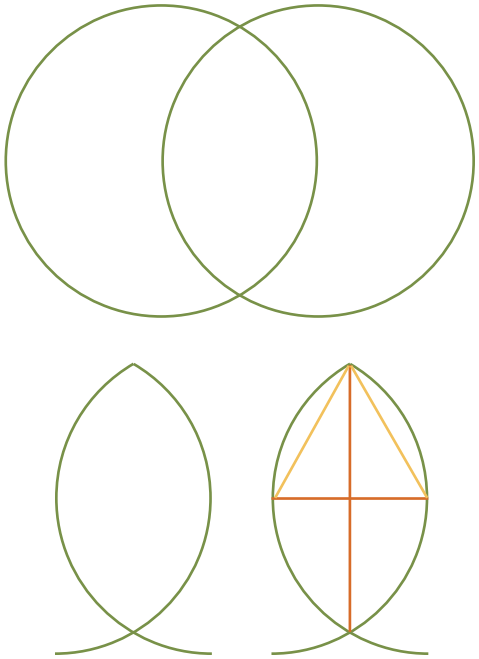
These two points are especially significant for the current project. First, the principle of adherence to a set of significant ratios provides a guiding ideal for the design of the entire building. While eschewing fully traditional Gothic decoration, the church can nonetheless be consistent with the medieval tradition of sacred proportions. Second, the wealth of precedents for approximate use of said proportions frees the design from strict mathematical outcomes to be executed in fractions of inches. According to the examples published by Doczi, a margin of material error is completely acceptable as long as the intended proportion remains evident.

SACRED GEOMETRY

ROBERT LAWLOR

Sacred Geometry: Philosophy and Practice provides further insight into the concept of ordering ratios, in a context more specifically relevant to church architecture. Of greatest interest is a section of the work exploring the geometric and theological significance of the vesica piscis construction.

The vesica, perhaps most familiar in the ubiquitous Christian fish emblem, is a construction of two identical overlapping circles whose centers lie on each other's edges. If the radius of each circle is equal to 1, then the vertical of the resulting solid is exactly √3. Bisected, the points of each half-vesica describe an equilateral triangle, reinforcing the relation of √3 to the Trinity. The diagonal of a unit cube also measures √3, linking the sacred shape to the basic unit of material creation. Additionally, the circles and constructed lines of the vesica can be used to construct an infinite range of circles and polygons, again making the shape a "seed" of the created world (31-34). Many images of Christ are framed with vesicas, perhaps for this very reason (34).



However, the problem remains of expressing the sacred ratio through material limitations. The irrational number √3 is infinite; buildings and dimensions are finite. Here Lawlor elaborates on Doczi's introduction of alternating ratios. The ancient mathematician Theon of Smyrna is credited for the pair of formulas that yields, for a given number, *a series of integers whose ratios revolve asymptotically around the number's exact square root.* Calculated for √2, this series is 1, 1, 2, 3, 5, 7, 12, 17, and on. The exact √2 is roughly 1.414; 1:1, 2:3, 5:7, and 12:17 alternate ever nearer this exact quotient, first lower, then higher, then lower, and always by a predictably diminishing margin. Thus *every rational integer in the sequence* is connected to the irrational √2, a series of buildable dimensions that represent the unbuildable (38-41). The finite journeys nearer the infinite: this same sequence, calculated instead for √3, will be a perfect metaphor for an earthly (material) journey toward God (the infinite 3), also providing a wholly buildable means of expressing that journey, numerically, in architecture.

IMPROVED BUILDING PRACTICES FOR HURRICANE AND EARTHQUAKE PRONE AREAS

RIMA TAHER

As a community resource meant to remain available long into the future, the hybrid church must be able to withstand environmental hazards specific to the area. As the southern Atlantic coast is vulnerable to hurricanes, high-speed storm winds and flooding will be the most relevant natural disasters for consideration in the design.

This report prepared for the Architecture for Humanity group is an overview of general design guidelines for natural disaster–ready buildings. Most of the information pertains to both hurricane and earthquake resilience, as both are associated with lateral loads. For this project, the recommended practices will be applied exclusively to hurricane-resistant design.

The most useful categories of information relate to building form, roof shape and slope, construction materials, and foundation systems. Quantitative and qualitative guidelines for each will establish a rough framework for design decisions. Most usefully, the report often presents options and alternative design responses, allowing freedom in evaluating the best solutions for the current project.

The document recommends that building forms be regular and unbroken, and that differing masses be separated structurally. This concept is well suited to church design, where simple massing geometries are common and where Cram's *Church Building* even advises a concise monumentality. Floor plans should also avoid tight corners: called reentrant corners, they require extra reinforcing or structural separation.

Roof diaphragms and shear walls are essential for transfering lateral wind loads across the entire building structure. Because exposed structure is frequently seen in churches, consideration of these requirements from an early design stage can lead to an engineering solution that aids the building's aesthetic.

Uniform roof shapes do the best job of resisting wind loads. To some extent the effectiveness of a roof is proportional to the number of planes: hip roofs perform best, followed by gable roofs, and single-slope roofs are to be avoided. A 30° roof slope is recommended. Additional modifications can be used to correct some vulnerabilities, such as openings at soffits and ridges to relieve wind pressure.

The general advice of this report will be followed in the project design to achieve a demonstrable level of disaster resilience appropriate to the site.

FEMA COASTAL CONSTRUCTION MANUAL, VOL. II

FEDERAL EMERGENCY MANAGEMENT AGENCY

Volume II of FEMA's Coastal Construction Manual is a detailed guide to the design of hurricane wind and flood–resistant structures. The information in the manual complements more simplified sources on coastal building, and though it is focused on detailed engineering procedures that exceed the scope of this project, general qualitative guidelines can be distilled.

The guide categorizes structural components into groups for overall recommendations. The main wind force resisting system (MWFRS) consists of the foundation, floor supports, columns, roof rafters, and bracing and diaphragms (8:52). This is the basis of a hurricane-ready design, followed by the components and cladding (C&C) category. Any part of the building exposed to environmental forces must be constructed to prevent its coming apart and creating airborne debris.

Through diagrams and force calculation tables the manual explains the configuration of a continual load path for simultaneous uplift and lateral resistance, and recommends specific details for design scenarios. The load path must transfer wind pressures from their origin on the building envelope to the foundation and ultimate discharge into the ground. The roof sheathing is considered the first area affected by negative loading during a storm, and it must transfer any load to the roof framing. The framing must transfer the negative load to the wall top plate, such that all three must be detailed to resist uplift. The series of transfers must continue in a similar manner down through intervening building components to the foundation.

This principle is especially relevant to church design, in which (1) large planar roof and wall components are common, and (2) visible structure is often used to illustrate the transfer of weight or loading. Exposed structural elements in this project could be used to express not only the direction of gravity loads, as is typical in Gothic architecture, but also to visualize the resistance to hurricane uplift on the envelope.

Although much of the content is too detailed and engineering-oriented to influence this project, the general advice of the book will be useful. It will provide elaboration on design aspects not covered by more cursory resources, and lead to an architectural design that further engineering analysis could conveniently complete.

ANALYSIS OF MEDICAL TREATMENT AT A FIELD HOSPITAL FOLLOWING HURRICANE ANDREW, 1992

ROY ALSON ET AL.

This 1992 report on the operations of a hurricane response field hospital provides a useful cross-section of the functional requirements on a non-COVID emergency medical facility. The paper summarizes the treatment of 1,539 total patients, including information on the most common complaints and the most significant challenges encountered by field hospital staff.

Among the report's most useful conclusions is the statement that medical personnel's primary function in a hurricane response effort will be to provide general care. This is consistent with patient admission records from Hurricane Frederic in 1979, when the number of patients with stings, gastrointestinal complaints, lacerations, and chainsaw wounds increased after the hurricane struck. Again, in 1985, Hurricane Elena caused an increase in patients presenting with insect stings, gastrointestinal disorders, lacerations, and chainsaw injuries. Less than a month later, 1,029 patients presenting at an emergency department contained only 484 with injuries caused by the storm.

Not all patients treated at a field hospital will necessarily have been injured by the necessitating event itself. Much of the demand for additional health care capacity in the studied event was a result of Hurricane Andrew's either shutting down or destroying local hospitals, clinics, and pharmacies. In addition, the statistics from previous hurricanes record many patients with conditions unrelated to the storms themselves, a large number of them having rather been injured during cleanup.

The response team mentioned in the study used an 80-bed self-contained field hospital, stored in a trailer and deployable within four hours. The functional spaces of the hospital are intended for setup in tents or vacant buildings. A team of 37 operated the field hospital, comprised of four physicians (one surgeon and three emergency physicians), one physician's assistant, four registered nurses, one psychologist, one pharmacist, 19 EMTs, six support personnel, and one preventative specialist. A robust communication network called the Incident Command System enabled coordination of ambulance movements, bed capacity, and volunteer allocation.

The report summarizes the following key conclusions from the analysis.

1. Support staff are essential to effective functioning, such that high-demand medical staff would be "paralyzed immediately" without them.
2. Local volunteers familiar with geography and local resources are also helpful.
3. All staff must be self-sustaining, especially with food, for the first 72 hours.
4. Consideration must be given to how patients and supplies will be transported to and from the field hospital.
5. At least one full-time staff member should be assigned to manage communications.
6. A designated support person should manage the allocation and coordination of volunteers. This will require a demarcated volunteer staging area.

ULTRA-RAPID DELIVERY OF SPECIALTY FIELD HOSPITALS TO COMBAT COVID-19

HANBIN LUO ET AL.

The hospital documented in this report is one of two hospitals constructed in less than two weeks to receive COVID-19 patients. It is an important distinction that unlike general field hospitals, like that used during Hurricane Andrew in the previous study, Leishenshan Hospital is a fully functioning facility fully equipped to treat severe symptoms.

The total construction area of the field hospital is about 860,000 sf, much larger than the current project. The compound is divided into a large medical treatment area, a separated living quarters for staff, and several smaller logistics areas containing supply warehouses, wastewater treatment, incineration, and ambulance decontamination.

The most useful portion of the case is the medical treatment complex, laid out according to what the authors term a “three zones and two passages” scheme. Patient rooms are located in the contaminated zones, which are linked by semi-contaminated zones. A clean zone sits at the entrance to the semi-contaminated zone. The “two passages” concept keeps patients and medical personnel separate: each group uses a different network of hallways and accesses patient rooms through different doors.

The hospital was constructed using modular container units of roughly 20’ x 10’ x 8.5’, factory-produced and installed on site with cranes. Each unit has a designated function, such as passage, patient room, bathroom, or isolation ward. Each patient room or isolation ward contains two beds and is served by half of a bathroom unit. The patient hallway, composed of passage units, runs along one exterior wall, and the personnel hallway accesses the other. Isolation wards feature additional measures such as two-way cabinets for safe exchange of food or materials. The entire layout is designed to allow efficient movement of both occupant groups with as little cross traffic as possible.

All patient bed units are negatively pressurized to prevent the airborne spread of pathogens out from infected patients’ rooms. Using Building Information Modeling (BIM) analysis of four ventilation and discharge systems, the study concludes that a ~15’ exhaust outlet elevation is sufficient to achieve a 10,000-fold dilution.

One of the most significant outcomes of the project is the dramatically reduced construction time (12 days) resulting from the use of BIM modeling to improve engineering efficiency and shorten development time. The BIM model allowed the designers to simulate flow and ventilation and resolve potential issues far in advance. The study even suggests that BIM will enable modification and continued use of the hospital after it is no longer needed for the COVID-19 pandemic.

A SAFE AND EFFICIENT, NATURALLY VENTILATED STRUCTURE FOR COVID-19 SURGE CAPACITY

NATASHA BAGDASARIAN ET AL.

This brief letter to the editor of the journal Infection Control & Hospital Epidemiology concisely presents a design for a rapidly deployable naturally ventilated COVID-19 surge field hospital. Despite the paper's brevity, it appears well-researched and documents one-time validation through a successful field operation treating 5,000 surge patients.

The facility was designed as an addition to an existing emergency department intended to relieve pressure on its capacity from incoming COVID patients. The facility, intended to be naturally ventilated in a similar manner to older tuberculosis wards, is open around its perimeter with a high canvas roof. The plan accommodates 20 patient bed cubicles dimensioned ~6' x 6', plus a resuscitation bay, radiology cubicle, and staff rest area. Later on, five modular cubicles were added to the total.

Patient bed cubicles were constructed of aluminum framing and PVC panels, closed on three sides and curtained on the fourth. The simple and modular design allows easy construction and replication without specific medical expertise. In addition, the shelter itself was constructed by a local tent contractor after being verified by an engineer. Due to the simplicity of the facility's design, it was erected in 17 hours and fully operational within 6 days.

Over four months, between February and May of 2020, the temporary facility received 5,004 patients, slightly more than half the number treated in the existing emergency facility in the same time. No breaches of infection control or COVID exposures were documented in the facility, and no transmission of COVID to staff or patients was observed in either the existing facility or the temporary extension.

Although natural ventilation is not often used in Western medical facilities, the report argues that while 12 air changes per hour (ACH) is typically the standard for airborne disease facilities, naturally ventilated spaces with high ceilings can achieve up to 40 ACH quite economically. Guidelines on severe acute respiratory infections published by the World Health Organization also recommend natural ventilation as a potential solution. Of course, the design was implemented in Singapore, where temperatures average 31-33°C (88-91°F); application of a similar method in the southern United States will require further comparison of the two climates.

HOSPITAL AND HEALTHCARE FACILITY DESIGN

RICHARD L. MILLER ET AL.

Although potentially somewhat dated (2002), this comprehensive guide to design considerations for healthcare buildings offers not only detailed lists of program spaces and their needs but also insight into each area's historical context. The background conveys an idea of why healthcare spaces should be designed as recommended. Concepts are explained through case studies, illustrating successful applications of modern healthcare design ideals.

There is much included in this book that does not directly relate to field hospital design, as the guide is intended more for permanent and complete hospital facilities. Two of the work's topics are of special interest: the patient care unit and the emergency unit. The previously referenced study of hurricane response field hospitals concludes that most of the work performed at such facilities will resemble general care, while the two appraisals of COVID-19 care centers advocate a design tailored to its specific circumstances. Therefore elements of both general and emergency care could be appropriate for this thesis; this work serves as a reference for comparing the two types and planning a concept that can serve either.

Related to emergency care, the book calls for helicopter access, triage, waiting, security, and staff spaces in addition to treatment areas, and others. Treatment rooms are sized under 240 s.f., for a variety of procedures. The content also bears on the configuration of spaces, suggesting the use of separate entries for ambulance and walk-in patients.

The goal of this portion of the literature review is not to generate a complete list of emergency facilities necessary for inclusion. Rather, programming information on emergency departments improves the understanding of what spaces may be required in a converted flexible church building.

The patient care unit is also presented in detail. Much of the information here matches descriptions in *Building Type Basics for Healthcare Facilities.* Recovery rooms must be arranged with particular consideration for sight lines and visibility for nurses and doctors. This will apply to the field hospital design as well, though temporary patient rooms will be less elaborate and technologically replete than those discussed in *Hospital and Healthcare Facility Design.* Sanitation is also an issue; in the current project individual washrooms attached to patient rooms will have to be replaced with a separated alternative.

The guidelines presented in *Hospital and Healthcare Facility Design* are evaluated as supplementary information for a better understanding of the facilities that field hospitals imitate. Without understanding these core issues, field hospital designs could be executed perfectly while missing chances to come nearer the ideal function, that of a permanent facility.

BUILDING TYPE BASICS FOR HEALTHCARE FACILITIES

RICHARD L. KOBUS ET AL.

This introduction to planning healthcare facilities serves as a counterpoint to *Hospital and Healthcare Facility Design*. While the first book explains the reasoning contributing to deliberate healthcare design, this work tends to focus on the details necessary for the actual design of such a facility. It organizes rough area guidelines and presents rules of thumb for effective plan layouts. Overall its emphasis is less on the goals of an effective design than on the basic requirements which the effective design must meet.

Of course, neither work applies directly to this thesis, as its intended outcome is not a fully functional permanent hospital. However, reference to the functional intents of permanent facilities remains a useful benchmark for the success of a less conventional design approach. The field hospital included in this thesis will not mirror permanent institutions exactly, but it will have much in common with them and will benefit from reference to these two works.

In the same way that *Building Type Basics for Places of Worship* provides concise and detailed recommendation for practical church design, its counterpart for healthcare facilities is a short survey of optimal design practices. One of the most important knowledge gaps that this book fills regards the patient care and observation rooms, and translates well to a field hospital application.

Distance-to-bed factor is a metric of an observation unit's efficiency. The sum of travel distances from a nurses' station to each patient room divided by the number of rooms, the factor reflects how effectively staff based at a central station can monitor and care for all patients in a unit. Based on this calculation, a number of compact module plans are established for use in an entire treatment wing.

Patient rooms, for both treatment and recovery, are the central space supported by the rest of a field hospital. They require adequate staff monitoring and must be configured for the occasion. If patients are being treated for a contagious disease, units must be isolated and perhaps even negatively pressurized. If patients instead present with injuries, efficiency of space becomes more important than containment. The recommendations in *Building Type Basics* apply neatly to the field hospital problem, where beds and nursing stations will have to be configured to efficiently fill a flexible church nave. The variety of plans and configurations offered in this volume are a solid basis for the development of a field hospital schematic.

LITERATURE SUMMARY

A series of commentaries and case studies published over 80 years forms the preceding survey of views on the correct design of church buildings. Prescribed schematics vary dramatically and are often at odds, requiring evaluation of all recommendations to select the most relevant. Where Cram's 1924 *Church Building* insists that Gothic is the only legitimate ecclesiastical style, Gieselmann and Roberts (1972 and 2004, respectively) embrace such modern concepts as square naves and open chancels.

While the current project cannot follow an archaeologically accurate Gothic style, it will aim to embody the same core design principles. This goal will follow six spatial and aesthetic tenets of church architecture as condensed from the literature. Beyond these quantifiable elements, great care must be taken to produce the correct atmosphere beyond mere functional competence; this becomes the seventh tenet that is emphasized in literature but hardly explained. Very likely, it can only be achieved in this project through ongoing comparison to existing churches and successful church designs. If a church meets all basic requirements but does not "feel" like a church, it is in danger of architecturally devolving to a convention center or meeting hall.

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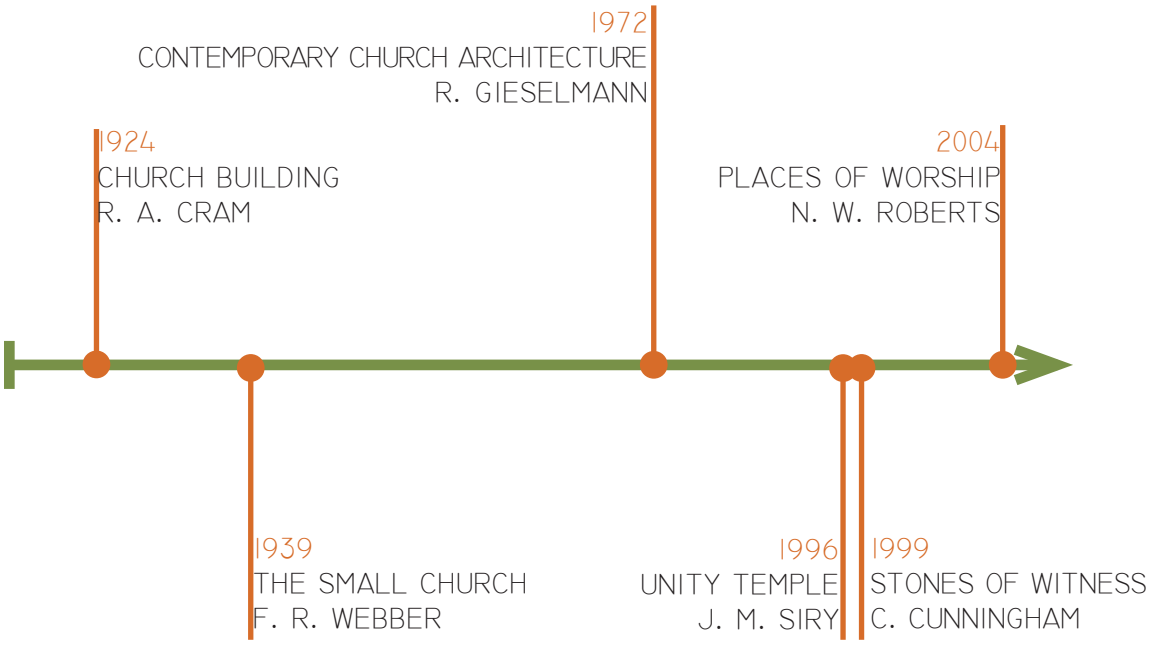

48 - Chronological distribution of architecture resources.
49 - Three overlapping fields study relating to healthcare design.

Literature informing the health care side of the current project falls into three general areas, focused on field hospital case studies, general health care design guidelines, and natural disaster resilience. Documentation of previously implemented field hospitals, in response to both COVID-19 and recent hurricanes, are the most informative for the current project. Guidelines for the design of permanent care facilities complement this information by providing a standard beyond that which has been merely improvised. Successful field hospitals show what has previously been possible; permanent hospitals demonstrate what is ideal.

Finally, the current project will also be designed to withstand the high winds and flood hazards common the hurricane-prone southern east coast. While much of the detailed engineering guidelines presented in FEMA's Coastal Construction Manual are far beyond the scope of this project, both that and other published guidelines provide enough familiarity with hurricane design issues to preliminarily plan a hurricane-resistant structure. All three literature topics overlap, with the goal of generating goals for emergency healthcare and disaster resilience that will then be combined with the conclusions of the church literature review.

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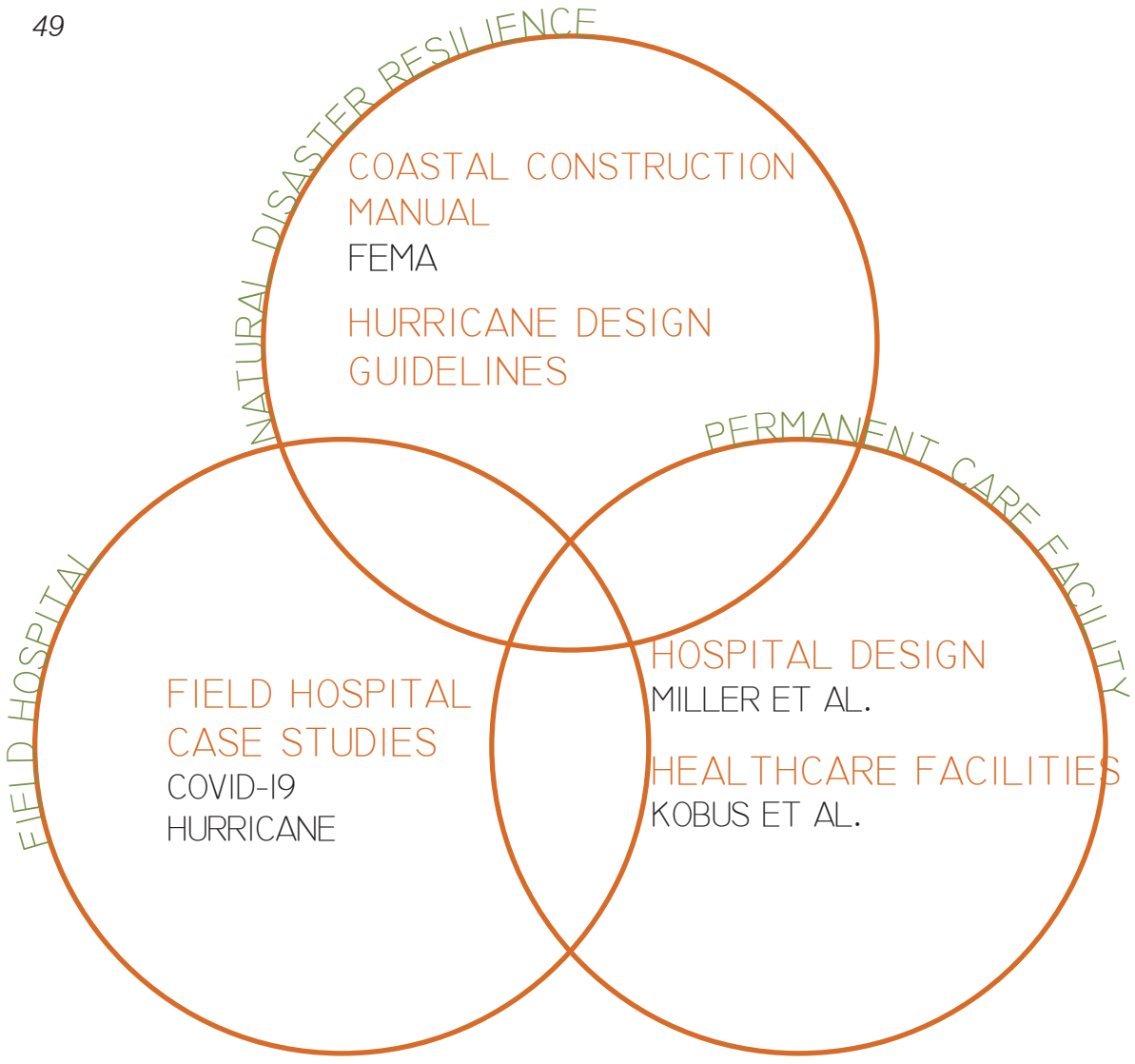


CHURCH SIDE RESEARCH IMPLICATIONS: The lists below summarize the main results of the literature review on the design of the church aspect of the project. The six style points mentioned in the research introduction form the basis of aesthetics for the church, generalized from the recommendations of multiple church design guides. The list of program spaces is a result of programming information from *Building Type Basics*, taken with the precedents included in *Church Building* and others.

DESIGN ELEMENTS

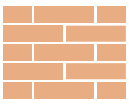
PROPORTION: First and foremost, the entire design must be guided by a series of integers generated from the sacred proportion of 1:√3.

SECTION: The nave must have either a low roof and wide aisles for pews, or a high roof and narrow aisles for circulation.

HEIGHT: Nave walls must be at least as high as the central volume is wide. This is a minimum, and the walls should actually be as high as feasible.

WINDOWS: Rather than appear as punched openings, windows should be large, appearing as translucent walls.

FOCUS: All lines of proportion, detail, and perspective should direct attention to the altar. The altar is the center and focus of the entire church space.



MATERIALS: Imitation materials should be shunned. Exposed concrete, wood, even steel are acceptable.

PROGRAM SPACES

NAVE: The main volume of the church, with seating for the congregation and containing the baptismal font.

CHANCEL: The separate area at the front of the church, containing the altar and pulpit; integrated with the nave in recent churches.

CHOIR: Auxiliary to the nave; also houses an organ or other instruments.

CHOIR ROOM: Used for music-related storage and/or robing.

GATHERING: A large space preceding the nave, an anteroom and crossroads for assembling.

BIBLE STUDY: The venue for supplementary spiritual activity; may serve as a multipurpose room.

SUNDAY SCHOOL: Corresponds to Bible Study, for children.

VESTING SACRISTY: Used by the clergy for storage and donning robes, if applicable.

WORK SACRISTY: An office or work room for clergy, adjoining the church.

KITCHEN

RESTROOMS

OFFICE

STORAGE

MECHANICAL

HEALTHCARE SIDE RESEARCH IMPLICATIONS: Disaster resilience is included as one aspect of the church's field hospital convertibility. Therefore another six foundational ideas derive from FEMA's *Coastal Construction Manual* and others. The program of spaces is informed primarily by the three field hospital case studies included in the literature review, and supplemented with isolated points from references like *Hospital and Healthcare Facility Design.*

DESIGN ELEMENTS

MASSING: Building masses should be simple and continuous, or separated at joints to resist wind or even flood loads.

PLAN: Reentrant corners should be avoided in the building plan, eliminating areas that may invite or concentrate strong winds.

SHEAR: Structural diaphragms and shear walls must be used to transmit wind loads across the building's entire structural system.

ROOF: A shallow pitch of 30° is ideal, without gables, overhangs, or soffits. Performance corresponds roughly to the extent of faceting.

MWFRS: The main wind force resisting system comprises the core structural elements that must be emphasized for hurricane resistance.

LOAD PATH: A continuous path must discharge wind loads to the ground.

PROGRAM SPACES

GENERAL CARE: Patient treatment and observation rooms.

ISOLATION/I.C.U.: Auxiliary to general care, for critical or contagious patients.

VOLUNTEER STAGING: A central area for organizing and directing volunteer staffers.

STAFF STAGING: A base of operations for trained medical staff operating the field hospital.

STAFF SLEEPING: Operating staff should be self-sustaining for 72 hours, requiring facilities for food and rest.

CAFETERIA

RECEPTION/TRIAGE: A zoned area for assessment, admittance, and discharge of incoming patients.

MORTUARY: An isolated room for temporary storage of the deceased.

COMMUNICATIONS: Some field hospitals have used dedicated communications networks requiring full time staffers.

LAUNDRY

RECORDS

RESTROOMS/SHOWERS

MECHANICAL

STORAGE

PROJECT JUSTIFICATION

This project is relevant to contemporary issues in two general directions. First, it addresses the gradual decline in the quality and availability of American church architecture. The financial disadvantages of many congregations around the country only perpetuate the problem, in turn further limiting those groups' prospects for expansion or future building projects. This project will introduce, if not a ready-made solution for these difficulties, a new way of thinking about the church building as a community asset deserving of community support.

Second, the project aims to resolve another issue that has recently received heightened attention, namely potential shortages of health care capacity for disaster or pandemic response. With a beginning design intent of future surge care conversion, the project will propose an opportunity for community investment in disaster preparedness.

Each aspect of the project adds relevance to the other. The potential for emergency function makes the church more useful to its entire community, and of interest even to those outside its congregation. Therefore, as an asset to resiliency, the project merits funding through community support or charitable organizations. At the same time, the project's routine function as a church increases the overall usefulness of the building. It is not exclusively a surge center, which might sit empty for most of the time and be used only occasionally, but rather a hybrid facility serving one group or another at any given time.

To best serve the function of an emergency resource, the project will be designed for resiliency, anticipating responses to natural disasters such as hurricanes as well as to health-related emergencies. The building is intended to require little maintenance under normal environmental conditions, limiting the extent of post-occupancy upkeep and proposing a method for similar resilient designs.

The project is well suited for development in a design thesis primarily for the blended building typology it will pursue. The church side of the project will be guided by an academic review of historical precedent and theory, while the surge care side will derive from case studies of current field hospital design and analysis of health care design principles. By pursuing both dissimilar aspects simultaneously, the project will provide an opportunity to go beyond previous studio experience in the development of an innovative architectural solution.

As program needs evolve, combined typologies may become more widely used, further increasing the relevance of this project. The work here undertaken will explore less conventional approaches to meeting client needs, and encourage discussion of similar opportunities in future projects.

IN MANY OF THESE CHURCHES, IT IS NOT ONLY THE SPIRITUAL-SPECULATIVE PURPOSE BUT ALSO THE AESTHETIC AMBITION WHICH HAS FADED. THEY TRY TO ESCAPE AESTHETIC CRITICISM AND WOULD LIKE, FIRST OF ALL, TO BE JUDGED BY POLITICAL AND SOCIAL CRITERIA... IT IS HERE THAT A FUTURE TASK OF CHURCH DESIGN BECOMES APPARENT - A TASK WHICH IS, AT THE SAME TIME, INCUMBENT ON FUTURE SOCIETY - TO FIND A NEW INTER-RELATION BETWEEN SOCIAL AND AESTHETIC EXPRESSIONS.

R. GIESELMANN, CONTEMPORARY CHURCH ARCHITECTURE

HISTORICAL CONTEXT AND NARRATIVE

The association of churches and health care institutions is not a recent concept: examples of variations on this idea can be found almost as far back as the first Christian churches themselves. In some cases, care for the sick was a routine feature of religious organizations, while in others it was a temporary measure in response to a heightened need. Many of the historical anecdotes differ regarding the level of association between church and hospital, the affiliations of medical staff, and the comprehensiveness of available care.

While isolated examples may be found even further back, the health care system is documented as a defining characteristic of the Christian monastic life as early as the fourth century AD (Crislip, 9). Monastic medicine had some traits in common with contemporary practice. These religious communities offered supervised inpatient care under doctors (Crislip, 10), and even professional nurses as early as the fourth century (Crislip, 16). Two general categories of monastic communities were deeply involved in medical care: lavra communities (named from the Greek word for “street”) allowed a level of individualism among their members under a minimal central authority, and coenobitic groups (from the Greek for “fellowship”) preferred strict authority accompanied by physical separation from the outside world (Crislip, 4-6).

While both orders sought to model Christian virtue in their treatment of the ailing, lavra and coenobitic approaches differed on several points. Coenobitic infirmaries were distinct architecturally and spatially from other monastic buildings, more to prevent disruption than the spread of contagions (Crislip, 12). It was in these designated infirmaries that the “inpatient care” equivalent would be administered to the sick. In lavra communities, medical care consisted of physicians’ visits to the individual cells of the sick rather than to a central building (Crislip, 13). In emergencies, however, lavra monks would turn to one of the only communal buildings in their compounds: the church. A severely ill brother could be housed in a converted sick room inside the church, a practice that eventually became so common that by the sixth century lavra churches were built with permanent connected infirmary rooms (Crislip, 13-14).

Monastic communities of the time included their own doctors, both lavra and coenobitic. Eventually, even the non-monastic public saw doctors, practicing monks themselves, as closely connected with coenobitic orders especially (Crislip, 14-15). Even nurses, as a trained order of health care workers who were neither doctors nor laymen, eventually emerged in monastic communities (Crislip 16). In coenobitic monasteries, already accustomed to hierarchical authority, elders had the role of overseeing treatment, providing clothing, medical instruments, and food while also serving as triage officers (Crislip, 17).

A focus on medical care continued to influence church communities into the ninth

century. The St. Gall Plan, an A.D. 830 design for an ideal monastic cloister, illustrates the central role of medicine in monastic orders. In the case of the Plan, it was likely also intended as a connection between the religious and secular worlds (Tschugguel).

The seminal Rule of St. Benedict gives guidelines for medical practice in monasteries: it prescribes that patients be given their own rooms and dedicated physicians, even stating that the urgency of caring for the sick outranks all else (Tschugguel). In the Plan, guesthouses and infirmaries are an architectural provision for these central duties. The medical wing even includes two bath houses for the ill, demonstrating the attention given to providing complete care (Tschugguel).

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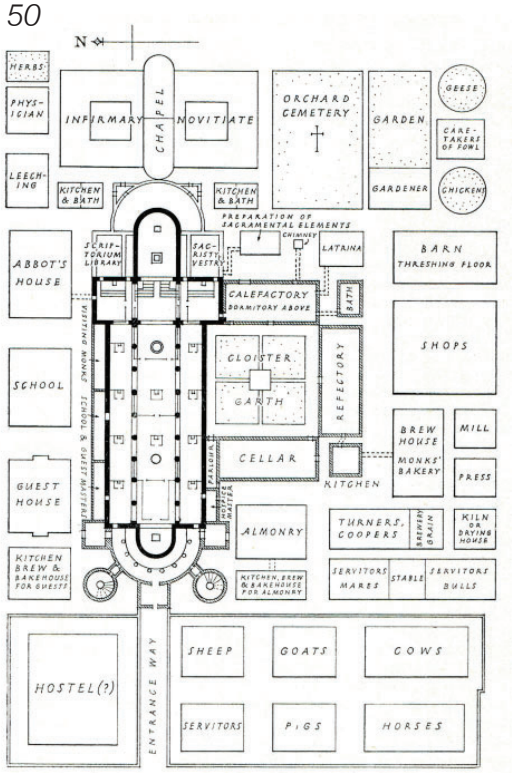

St. Gall's monastic garden also implies a focus on healing. A combination of supposed medicinal plants (rosemary, mint) with symbolic specimens (rose, lily) also shows the integration of secular healing methods with the monastery's Christianity (Tschugguel).

When the black death plagued Europe in the fourteenth century, churches were often involved in caring for the afflicted. Medieval hospitals were religious institutions, often run according to monastic principles and attached to religious houses (Willmott et al.). They came under increased pressure during health emergencies: St. Mary Spital, one such organization in London, was discovered through excavations to contain 175 mass graves (Willmott et al.).

This phenomenon extended to rural areas as well. The now-ruined Thornton Abbey, near Sheffield in the UK, was recently discovered to contain a similar plague grave holding at least 48 victims (Willmott et al.). The setting is appropriate, as the canons of Thornton ran a hospital on the abbey grounds, apparently converted from an earlier church (Huggon, 850). The story invites some consideration of the other services religious congregations can provide in the midst of health crises: with other institutions faltering under the plague, Thornton may have been the last facility for the dead and dying to receive a proper burial and hope for salvation (Willmott et al.). Although the circumstances prevented the ceremonies and individual burials that in medieval England comprised "a good death," (Willmott et al.) the church hospital and its monastic orderlies provided the next closest thing. The mass grave represents the struggling population looking to the hospital for spiritual aid (Huggon, 841).

Church and medicine remained interlinked into the sixteenth century, attested by the Italian physician Michele Savonarola's threefold prescription of diet, regimen, and piety (Huggon, 837). A secular fear of death was generally overruled by a fear of death unworthy of heaven, and therefore an "overwhelming majority" of physicians were also priests, emphasizing religion's role in healing (Huggon, 837). Medical devices of the day have been found at abbeys and priories across Britain (Huggon, 838).

Within a sweeping survey of medieval hospitals, around 70 were housed within

monasteries, and over two hundred were monastery dependents (Huggon, 846). Most hospitals, even secular, had canons, priests, or chaplains to serve their patients' spiritual needs (Huggon, 846). In some cases, church buildings were adapted to serve health care functions. A chapel at St. Bartholomew's in Bristol occasionally accommodated patients (Huggon, 847). Another hospital, St. Giles in Norwich was a converted parish church with cloister and infirmary added to the existing parish nave (Huggon, 850). Even in purpose-built secular facilities, medieval elements such as clean living, piety, and prayer remained central tenets (Huggon, 851).

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More recently, churches across the US underwent conversion to temporary field hospitals to treat Spanish flu victims in the 1918 epidemic. The Vestry (governing board) of Calvary Episcopal in Pittsburgh turned over the church's Parish House to U.S. Military authorities for use as a hospital for convalescing influenza patients (Smith). The congregation's priests stated that their hope was to free more hospital beds for serious patients by taking in the recovering, rather than to treat critical cases on site. In this case the hospital conversion did not include the church sanctuary itself, which was kept closed until reopening was allowed (Smith).

Nearby in Philadelphia, the archbishop temporarily gave over parish buildings for use as emergency hospitals, and recruited all priests, non-cloistered nuns, and other Catholics to support the effort ("Influenza pandemic"). Some of these laymen went to work at hospitals around the city, while others staffed the converted buildings in which they had previously worked ("Influenza pandemic").

Across the country, Tacoma's First Methodist Church was converted to an influenza hospital. The temporary arrangement continued for almost a month before it closed amid declining flu cases, afterward receiving "the most thorough fumigation ever given any place in Tacoma" before returning to normal use (Sailor).

Most recently, of course, a similar procedure took place at the Cathedral of St. John the Divine in New York City. Nine sophisticated medical tents and 400 patient beds occupied the Gothic nave in preparation for an influx of COVID-19 patients. The church compared the conversion to the role of cathedrals in plagues of the past, transforming into temporary infirmaries (Lenthang).

50 - Reproduction of the St. Gall Plan.
51 - Spanish flu field hospital at Calvary Episcopal Church.

HISTORICAL ANALYSIS

Western medicine has strong historical ties to church life, dating almost to the beginnings of both. Monasteries of the fourth century A.D. erected infirmaries to provide inpatient care, for monks and sometimes even for ailing members of the outside community. In some religious orders the church building itself was integral to these services, to the extent that infirmaries were even built as auxiliary rooms of the churches.

Monastic health care became a standard tenet of some orders, as exemplified by specific guidelines for medical practice in the Rule of St. Benedict. Elements of these requirements were considered important enough for accommodation in the architecture of typical monastic compounds.

Even as medicine gradually secularized, it remained associated with the church. Populations of believers turned to their churches for physical and spiritual care while the black plague swept Europe. Afterward, well into the sixteenth century, hundreds of medieval hospitals remained dependent on monasteries or even located inside them. The lines of separation remained blurred: secular hospitals staffed priests and chaplains, and several church buildings were converted, temporarily or permanently, to medical use.

Nearer modern times, the association weakened. The most notable examples from the last century are temporary conversions of churches, improvised hospitals set up in response to disaster. Though many religious medical institutions remain open, and the hospital chapel is a common sight, medical practice now seldom mixes with full-time churches.

In general, the parallel development of churches and medical facilities across history has followed a trend of increasing isolation. Where physicians and clerics were once but two roles of the same office, the two are now almost always separate. Though many hospitals and health care groups today retain religious affiliations, they do not approach the historic precedent of medical care offered totally within and by religious institutions. Finally, where church and monastic buildings were once built with the intent of serving health care function, either as needed or permanently, medical use of ecclesiastical structures today is usually something improvised only in times of extreme necessity.

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YEAR (A.D.)	EXTENT OF AFFILIATION	ROLES	DESIGN SUITABILITY
400-600	Infirmaries fully integrated in monasteries, though not always as distinct buildings.	Doctors, nurses, and overseers all members of the monastic community.	Coenobitical infirmaries designed for use vs. lavra in-cell visits and church repurposing.
800	St. Gall Plan designed to support health care functions within the the monastery compound.	Care likely provided by monastics.	St. Gall Plan laid out in compliance with medical directives in Rule of St. Benedict.
1300	Plague hospitals operated on church grounds by canons.	Care provided by monastic doctors and church figures.	Some hospitals, as at Thornton Abbey, adapted from existing church structures.
1500	Medicine gradually secularized, still influenced by church practice.	Some hospitals operated by churches, others with clergy present for spiritual work only.	Some hospitals adapted from church structures, others newly built as hospitals.
1918	Temporary facilities managed by non-church medical authorities.	Church figures tasked as nurses or orderlies, but not doctors.	Field hospital adaptations are only temporary and make the best of existing facilities.

52 - Historical research summary matrix.

CONCLUSIONS FROM HISTORICAL CONTEXT

As medical practice developed and grew into a specialized field, or category of fields, it is unsurprising that it should have gradually drifted from its background of close association with religious life. In many ways health care has improved throughout the transition, but one advantage especially relevant to emergency care has diminished.

During Europe's plague epidemic of the fourteenth century, churches and abbeys were a ready resource for simultaneous spiritual and medical care. This was perhaps the last significant instance of the two's close association. Later centuries would see disused church buildings converted entirely to hospitals, or secular hospitals retaining clergymen as staff, but little nearing the dual church and medical functions that had been commonplace in the preceding history.

The disadvantage of this transition is apparent in medical disaster responses. When churches lend their facilities to relieve strain on overburdened hospitals, the grateful medical staff is nonetheless forced to make the best use of structures that were not designed for health care functions. While the extra space for treating patients is of course appreciated, the church building is no longer synchronized with the functional requirements of modern medicine.

To reinvent modern medical practice as something integral to and dependent on the church is neither supported by the trend of history nor the intent of this thesis. However, by examining hospital programs and identifying opportunities for their re-integration into church buildings, this project will aim to restore an advantageous duality that has gradually disappeared.

SOCIAL CONTEXT

The basic social tenets of the problem addressed by this thesis have been explored through the project proposal. To summarize, a long period of gradually declining church involvement limits the financial solvency of existing congregations, hampering their abilities to build and maintain adequate venues for worship ("Church trends," 2017). For some, the usual reliance on offering revenue from church members is no longer sufficient for upkeep and building projects (Walton 2017).

The solution proposed in this thesis builds on the previously analyzed historical link between churches and healthcare centers, using an opportunity to address a lack of emergency medical care capacity (Derlet et al., 2008) as a catalyst to improve financial security and community investment in church buildings. Through a merging of the typologies of church and emergency care center, communities, charities, or even government agencies could be encouraged to financially support the construction and maintenance of modern church projects.

Potential sources for this financial investment are many. Non-government charitable organizations can offer grants to congregations based on criteria such as location, membership size, etc. ("Church grants," 2020). Numerous philanthropic organizations exist specifically to provide financial aid to Christian congregations. The Oldham Little Church Foundation, for example, offers grants to cover specific portions of building projects such as HVAC, lighting, or seating. The group makes these grants available exclusively to small Protestant congregations (Oldham).

Another organization, the Center for Congregations, offers 1:1 matching grants up to $15,000 for church projects and resources, including building projects (2020). Similar resources are available in the U.K., such as the National Churches Trust's Gateway Grant. Although the British government does not enforce the separation of church and state mandated in this country, the Trust is funded entirely by private donors without any government support.

Although the U.S. Constitution's First Amendment would seem to bar churches from receiving government aid, there may be exceptions that would allow public funding for church-care center projects. For example, in the 2017 case of Trinity Lutheran v. Comer, the Supreme Court ruled that the Free Exercise clause of the First Amendment prevents the exclusion of churches from otherwise secular aid programs. The Department of Health and Human Services confirms that "[religious] organizations may use government money only to support the non-religious social services that they provide" (2014). Government money might then be available for care center churches through programs such as FEMA's Building Resilient Infrastructure and Communities (BRIC) program, whose stated aim is to fund projects that "demonstrate innovative approaches to partnerships, such as shared funding mechanisms, and/or project design" (2020).

PHYSICAL CONTEXT

As discussed in the site selection rationale, the physical setting of the thesis project is uniquely situated to support both main aspects of its development. A Savannah worship directory lists 32 churches across the city ("Directory"); while the total number of churches is actually much higher, the directory sample is assumed to be representative of the whole. Protestant congregations are by far the most common, especially Baptist and nondenominational churches. Therefore, in anticipation of potential use by several congregations over the church building's life span, it should be designed to generally accommodate Protestant, rather than Roman Catholic or Episcopalian, liturgies.

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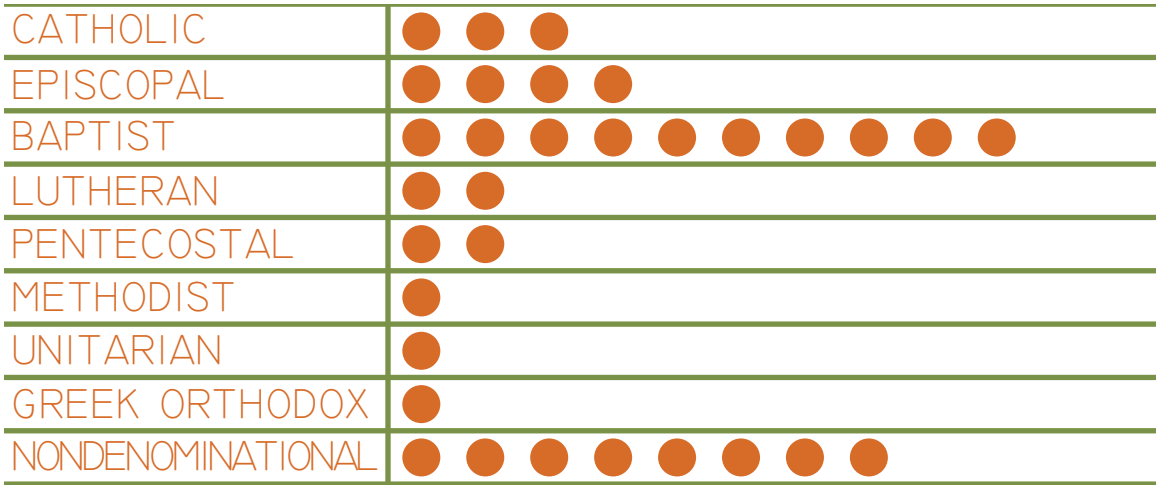
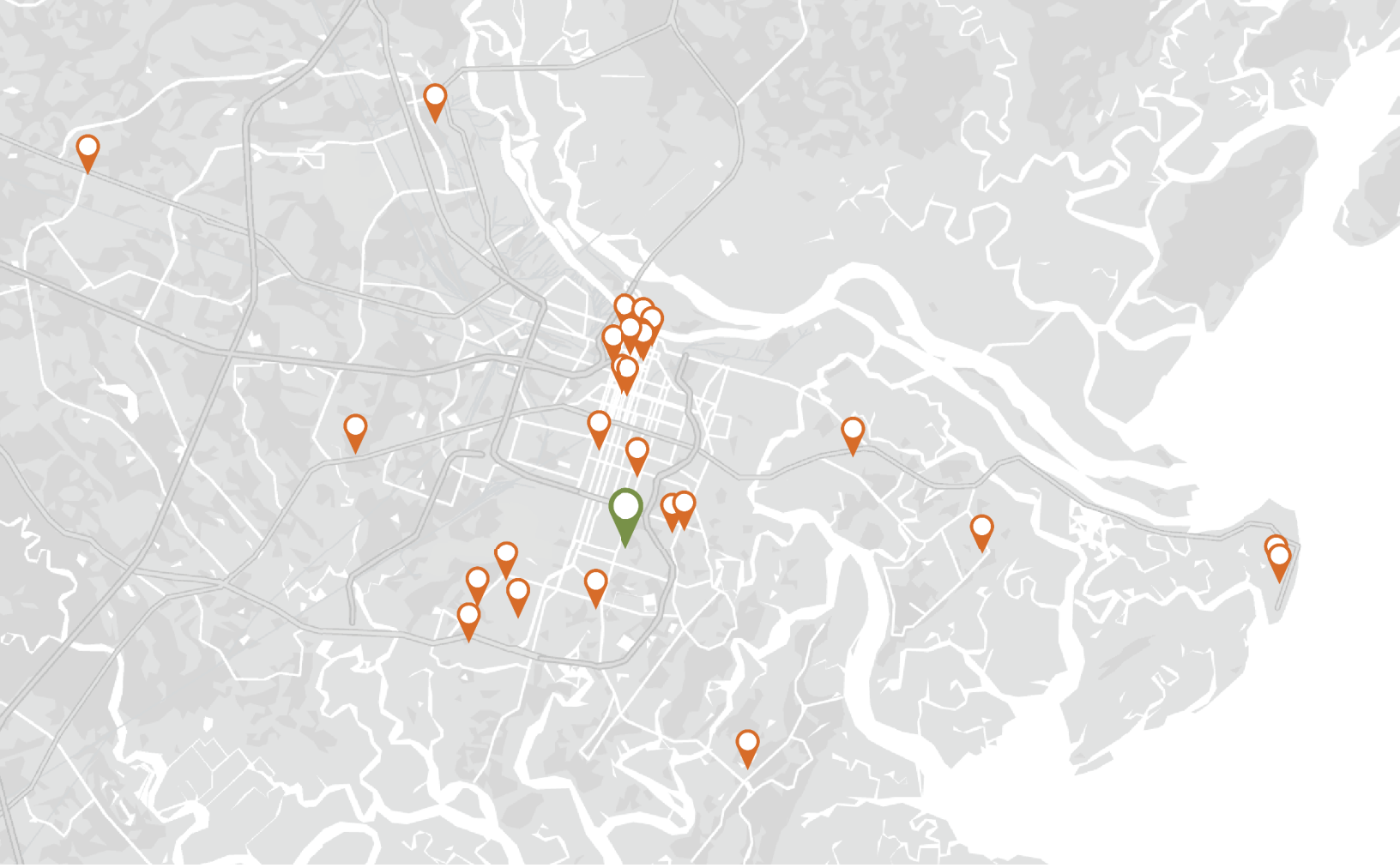
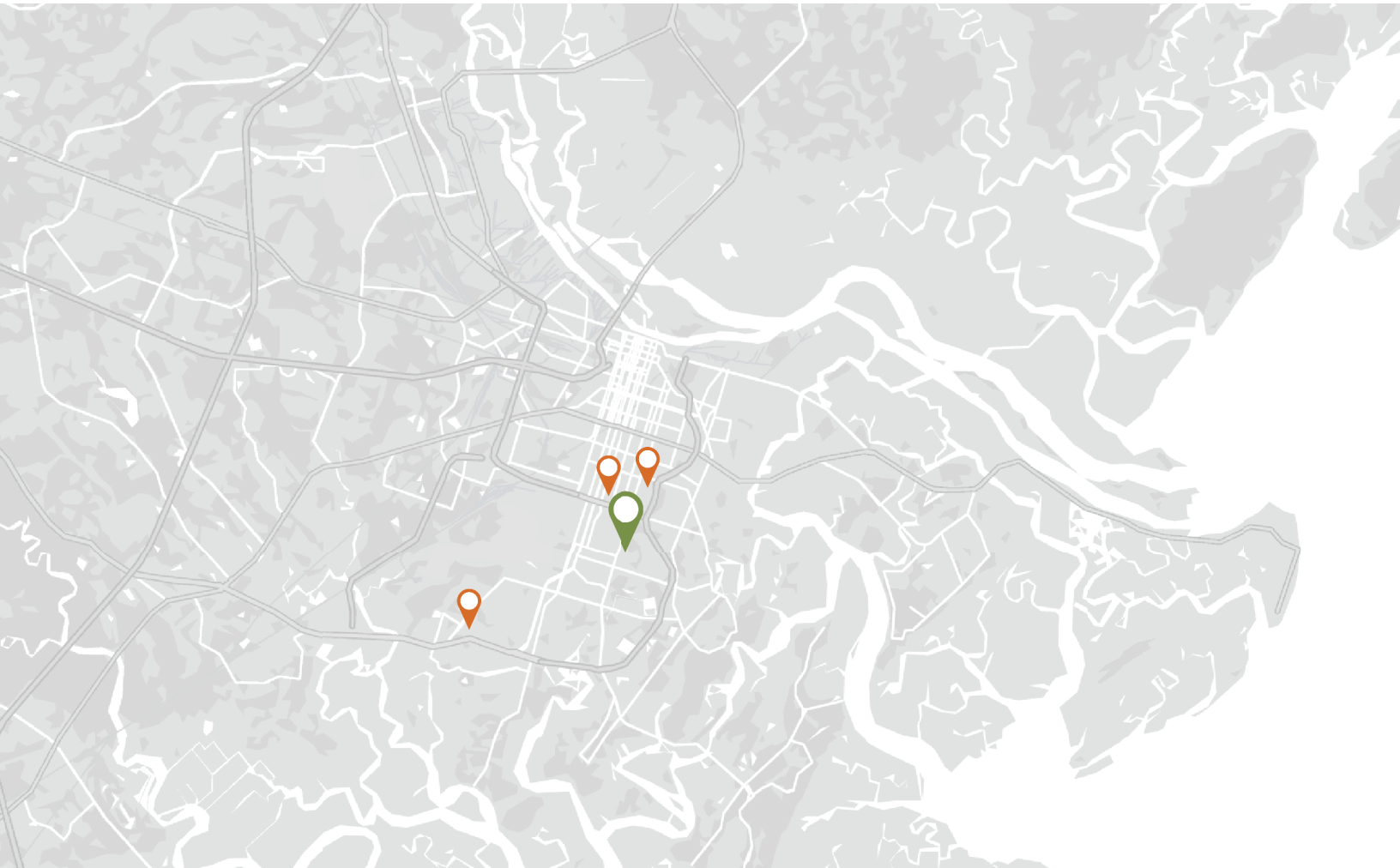


Savannah has three main hospitals (Savannah State, 2020), all of them near the thesis project site. Considering that the church field hospital would likely receive general care patients either to relieve pressure on hospitals or in lieu of them (Alson et al., 1993), the location responds to its context by allowing flexible configurations of patient movement between facilities. The project's context enables the design to efficiently receive patients for general care in the wake of a natural disaster, or for specialized care during an epidemic (Bagdasarian et al., 2020).

53 - Tally of Savannah churches by denomination.
54 - Church locations relative to project site.
55 - Hospital locations relative to project site.





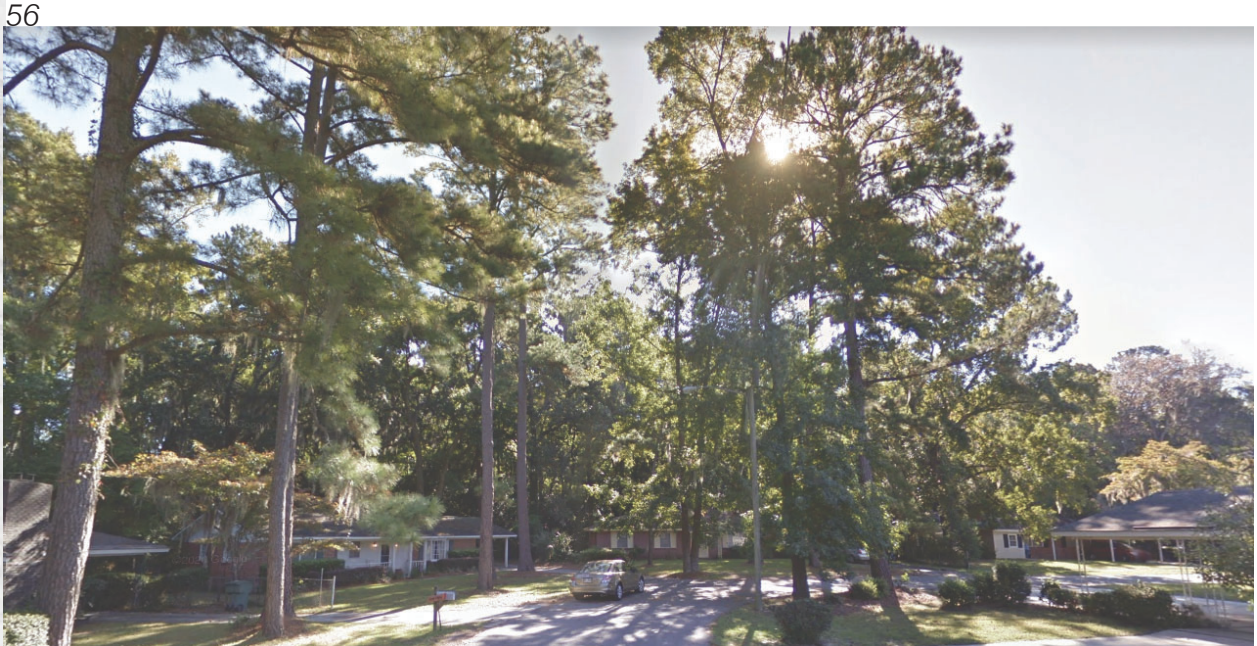
SITE ANALYSIS NARRATIVE

The sixteen-acre undeveloped site in the southern part of Savannah is fully overgrown and has been so for at least twenty-five years. Any new development on the parcel will apparently be the first, and so heavy clearing will be necessary. At the same time, the heavy forest covering the site provides an opportunity for environmental control of views, sunlight, and air movement. Any existing trees allowed to remain will natural screen or block all three, and so a conservative approach to tree removal will efficiently enhance the use of the site.

The north side of the parcel is defined by a river, and further separated from existing roads by a golf course on the opposite bank. Existing buildings and tracts of empty land isolate the east and west extents from vehicle circulation, leaving the narrow panhandle to the south as the only logical vehicle approach. This strip of land contains along one edge a steep drainage ditch or dry streambed that begins and ends off of the site. The ditch should remain intact to avoid runoff issues, leaving about 25' of continuous width in the panhandle for a long driveway.

Thus dictated by site constraints, the unconventional approach can become a substantial part of the church's enfilade, together with careful site clearing. A relatively long approach down a tree-lined drive may enhance a connotation of journeying or pilgrimage, especially coupled with the sight of a distant spire above the canopy. However, the aesthetic potential of such an approach must not supplant its functional requirements, especially as the same driveway will be used by ambulances and emergency vehicles under surge care use.

The roughly pentagonal bulk of the site proper is more uniform throughout, with only a gentle grade sloping down to the river on the north edge. Poor soil drainage dictates that the building sit as high as possible on the mild slope, but otherwise constraints



on this portion of the site are few. With the parcel's heavy blanket of old trees, any negative views out from the site will exist only as a result of careless intervention. Moreover, the entire north edge of the site borders the manicured lawns of the golf course, a further visual and acoustical buffer from the distant Truman Parkway. The river that also borders the site will likely even provide some masking sound, further insulating the building from unwanted noise.

As the lack of obstructions on site offers flexibility for development, consideration should be given to the design of the entire site. It must not only hold sufficient parking for churchgoers, but also configure effective circulation for emergency use, including ambulance routes and possibly helicopter landing.

The best use of the site will avoid clearing entire areas at once, rather planning ahead and retaining existing trees instead of adding new ones. The design must avoid the common shortcomings of the church floating islandlike in acres of paved parking. Building and landscaping should be integrated with the site, creating a pleasant environment without sacrificing efficient use and circulation.

With much of the surrounding area zoned for single-family residential use, and high-traffic roadways scarce, it is unlikely that nearby development will encroach on the site visually, acoustically, or regarding circulation, within the foreseeable future. In fact, the designated "local road" (the lowest category for annual average daily traffic) that connects the site to more prominent arterial roads appears more likely to hamper incoming emergency vehicles.

Visibility from outside the site is also a concern. If the building remains visually hemmed in by foliage, a tower or steeple can nonetheless signal the presence of a church and beckon worshippers. Barring that, the volume of the building itself can be arranged to surmount its context, lest this asset to the community become inadvertently concealed from the same. Visual prominence may be important for the building's emergency functions as well, in aiding emergency vehicles' navigation to the surge care site.

56 - View of site from the west.
57 - View of site from the south.

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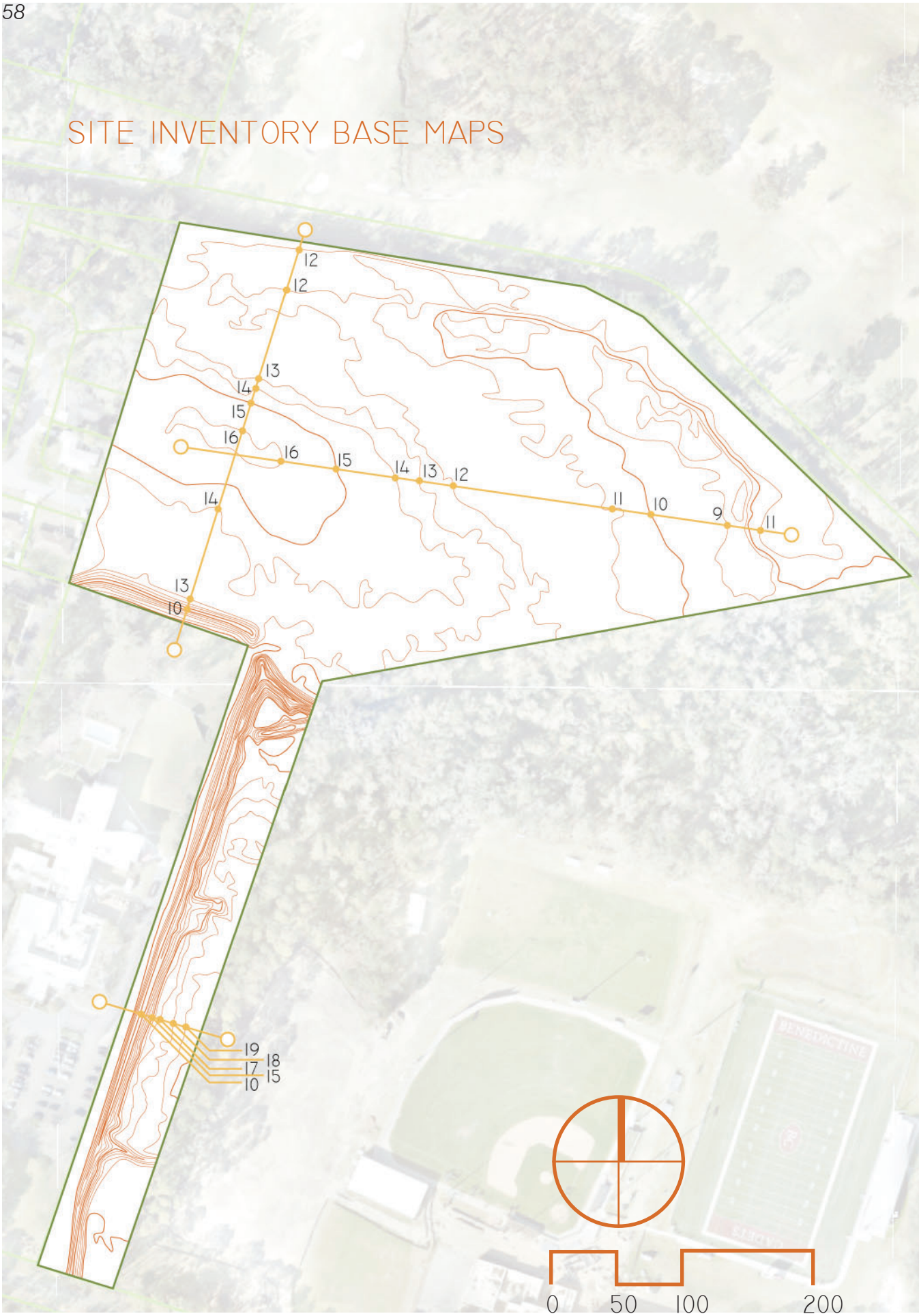
SITE INVENTORY BASE MAPS



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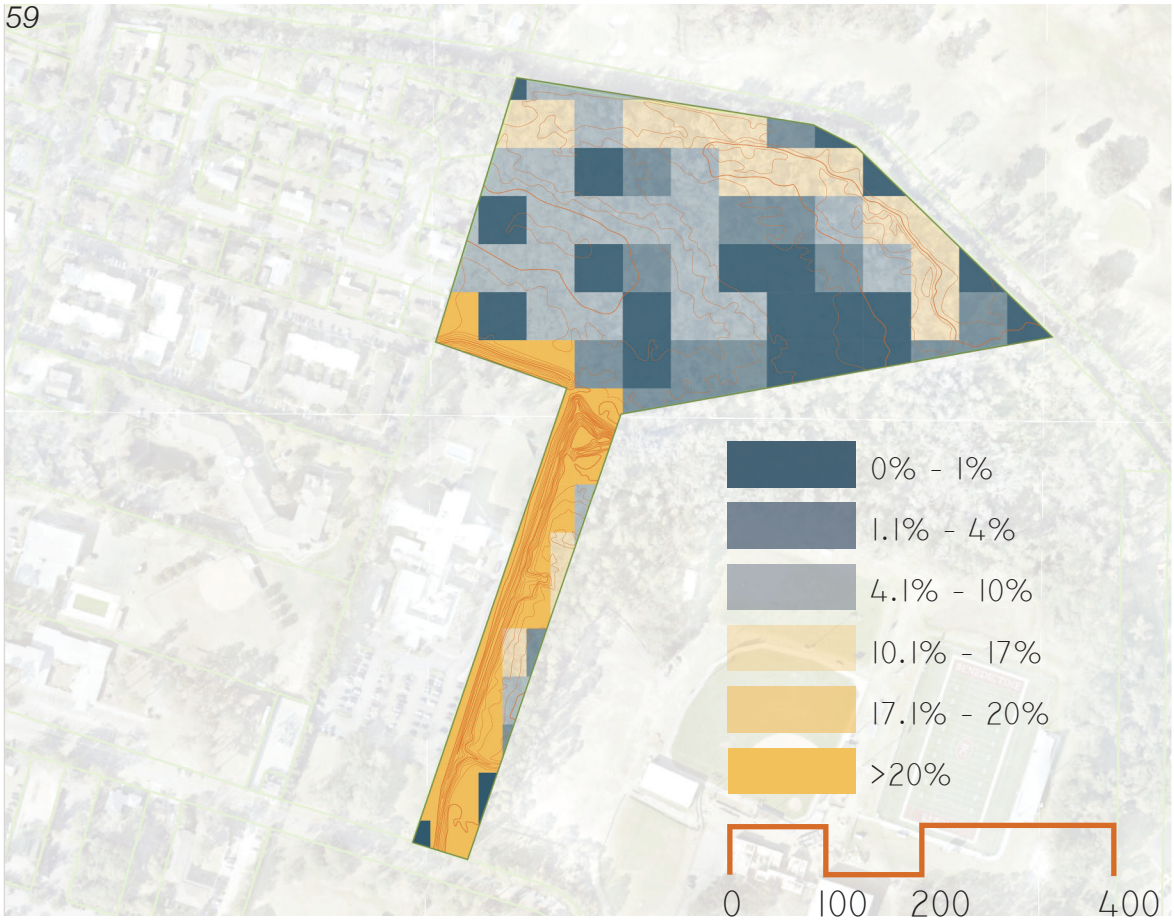

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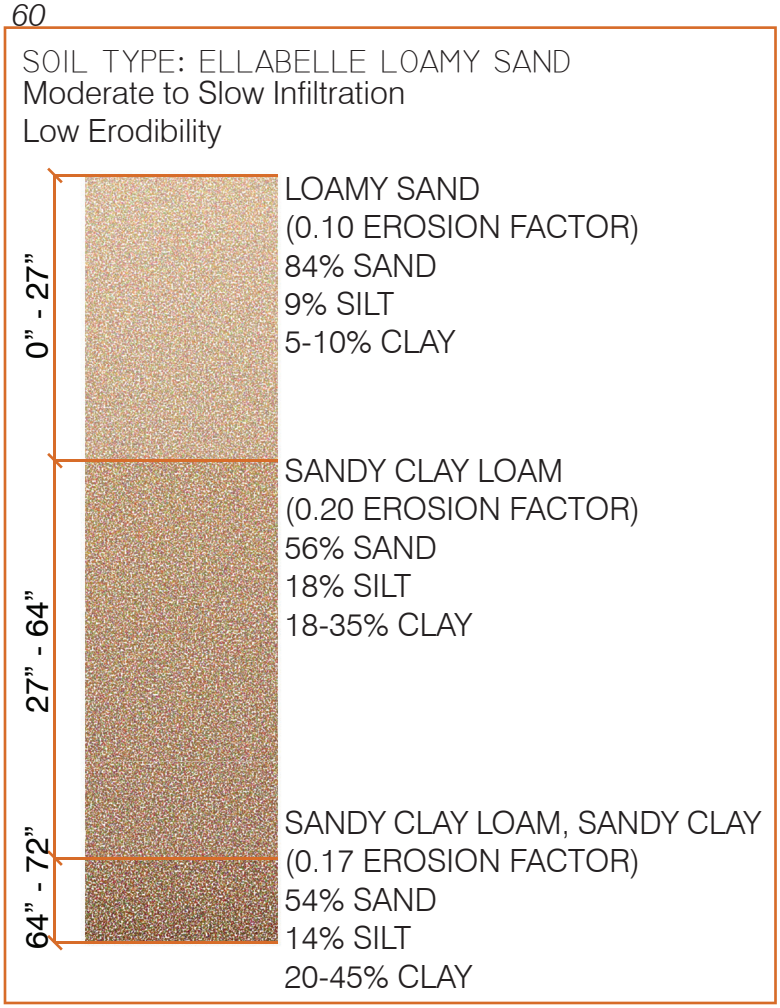

58 - Site topography and spot elevations.
59 - Site incremental slope analysis.
60 - Geological information to a 6' depth.

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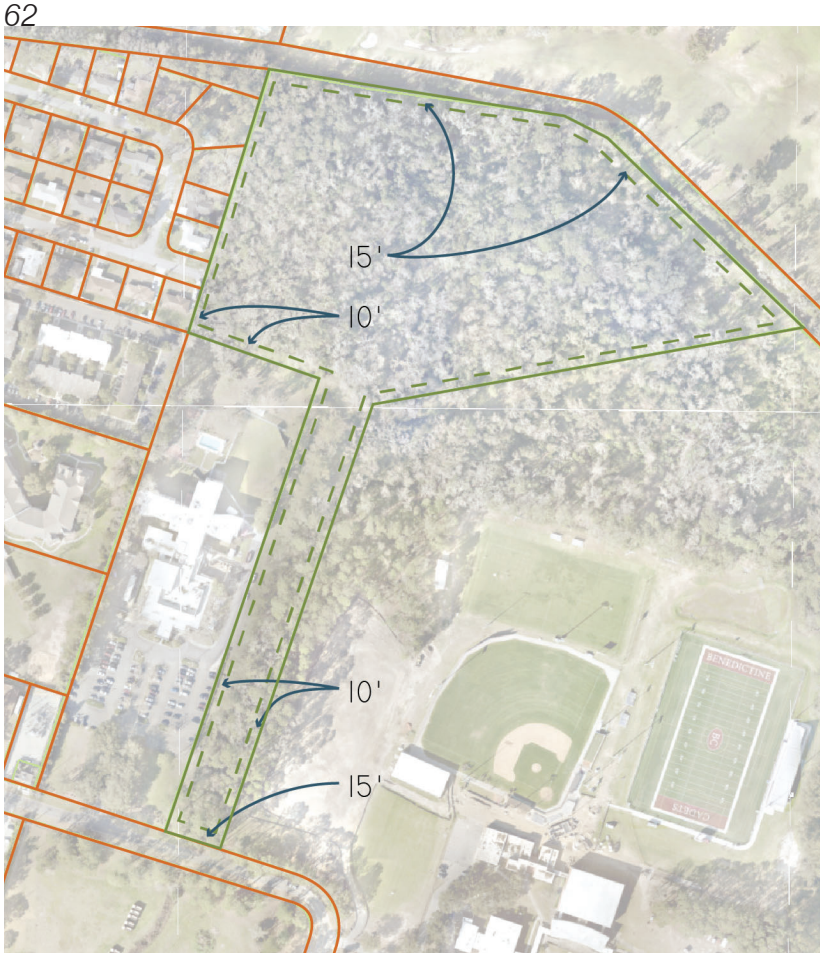

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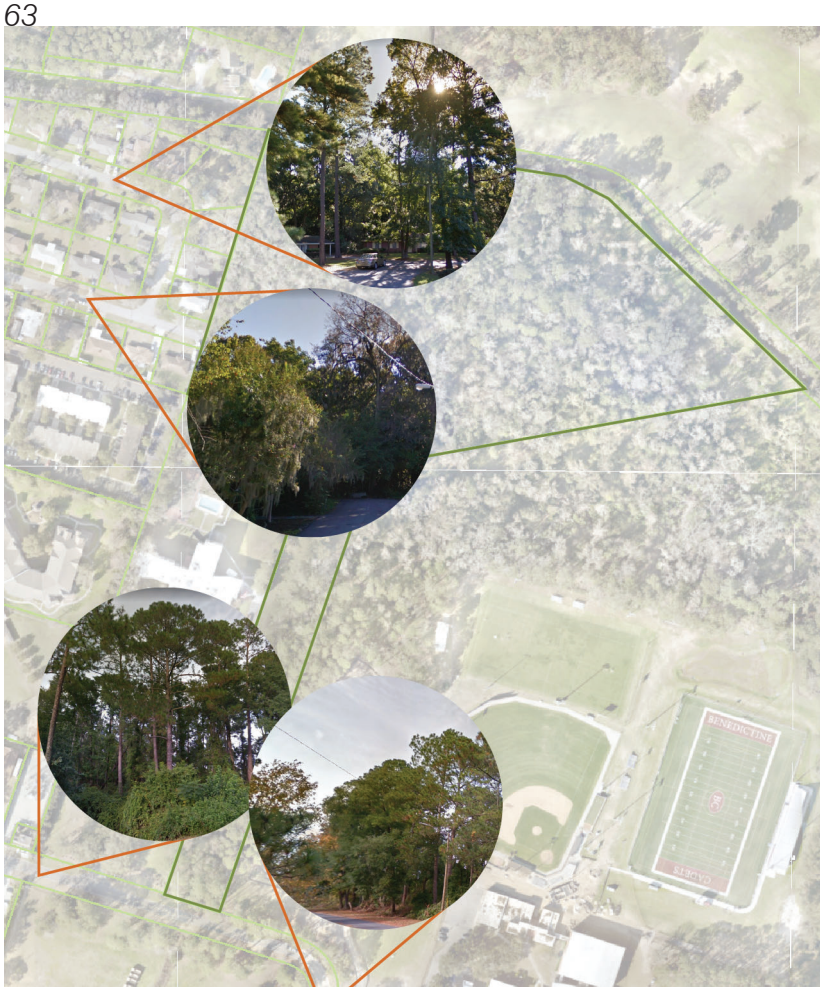

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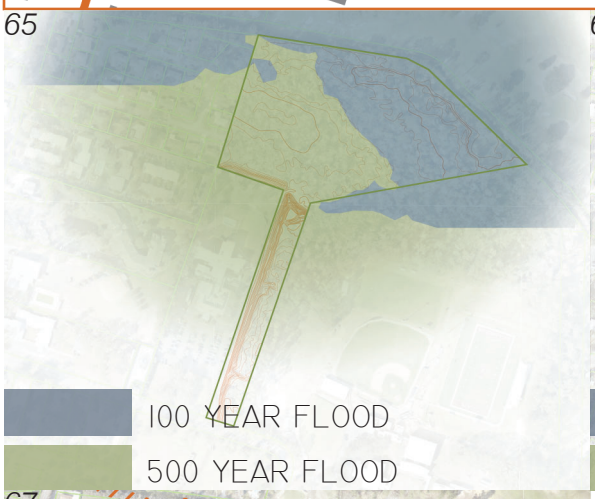

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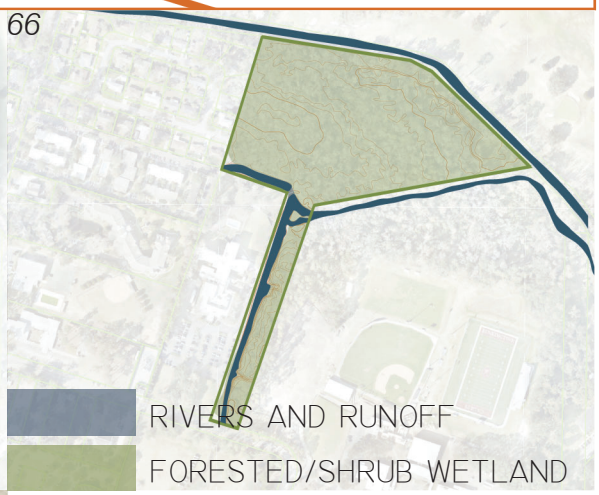

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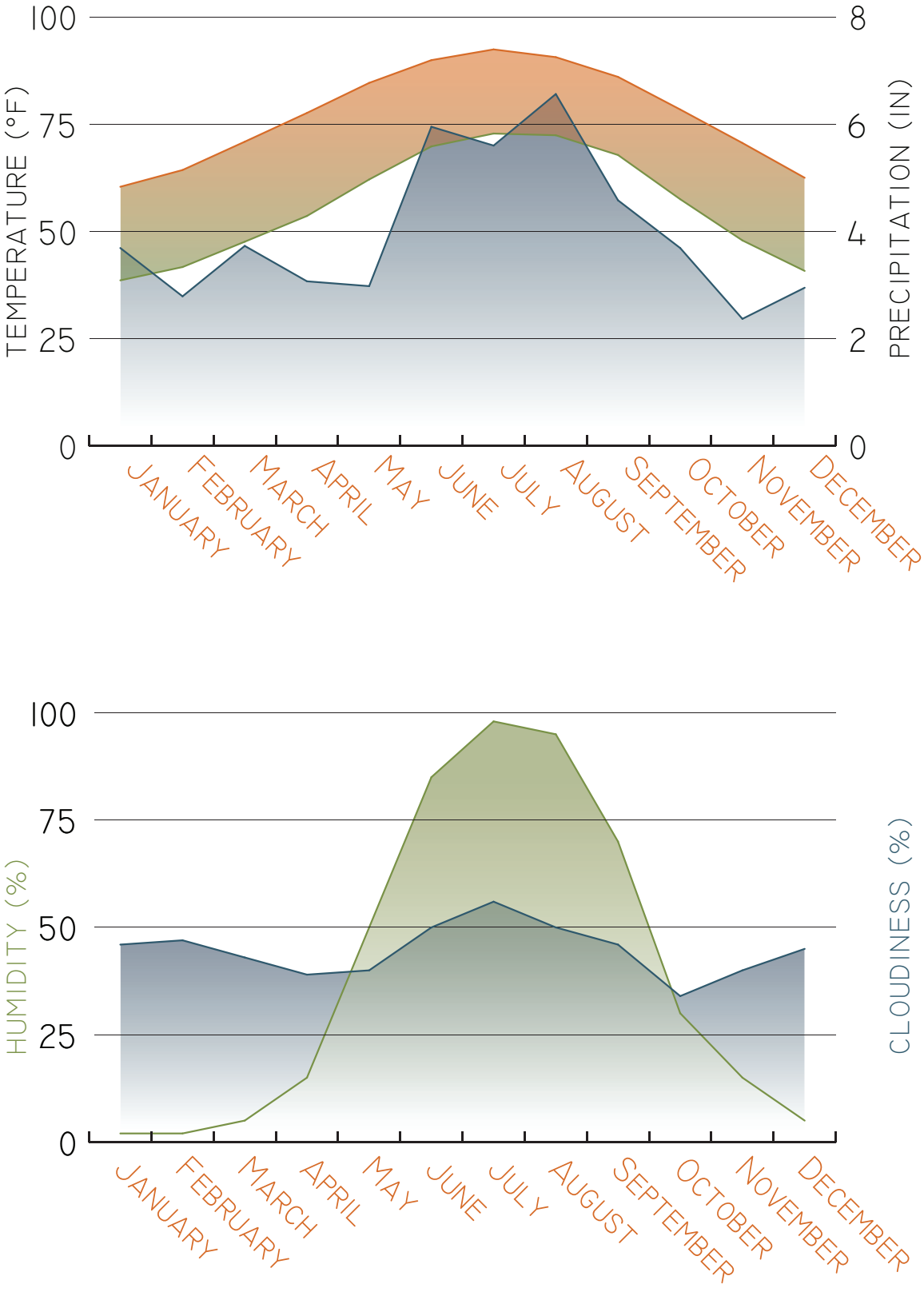
61 - 25-year aerial photos.
62 - Zoning setbacks.
63 - Views of site from surrounding streets.
64 - Surrounding building density and traffic.
65 - Flood zones.
66 - On-site water and ground cover.
67 - Forest extents.

68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100
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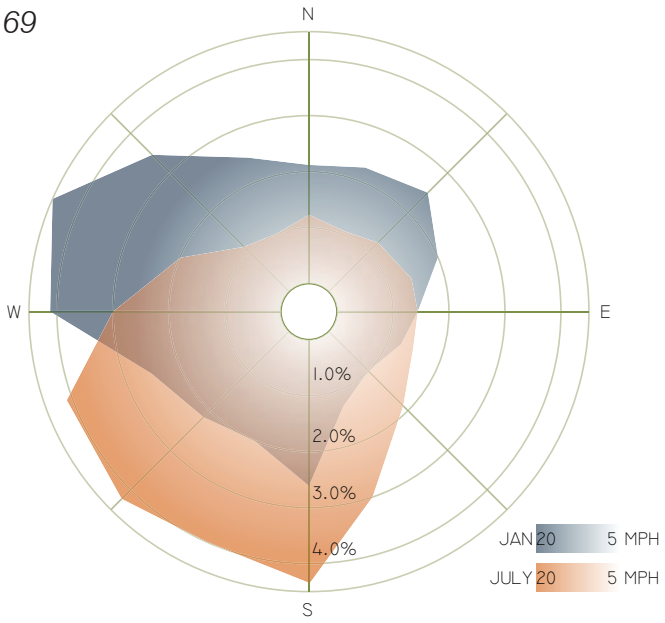
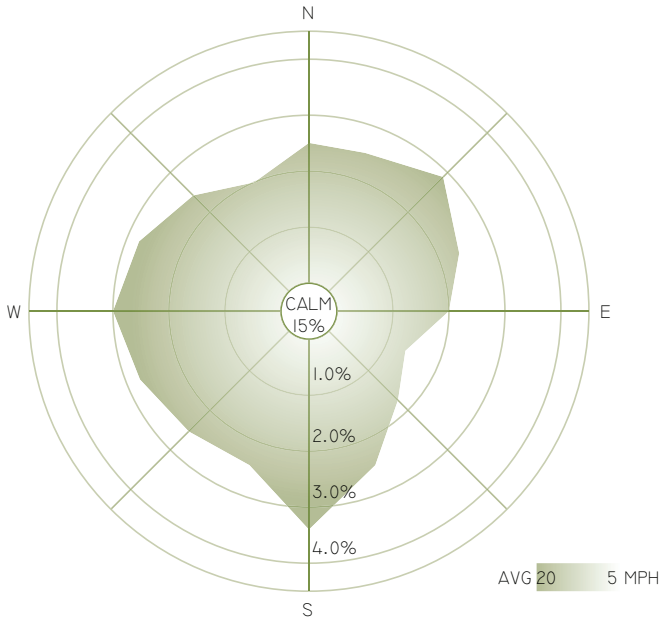
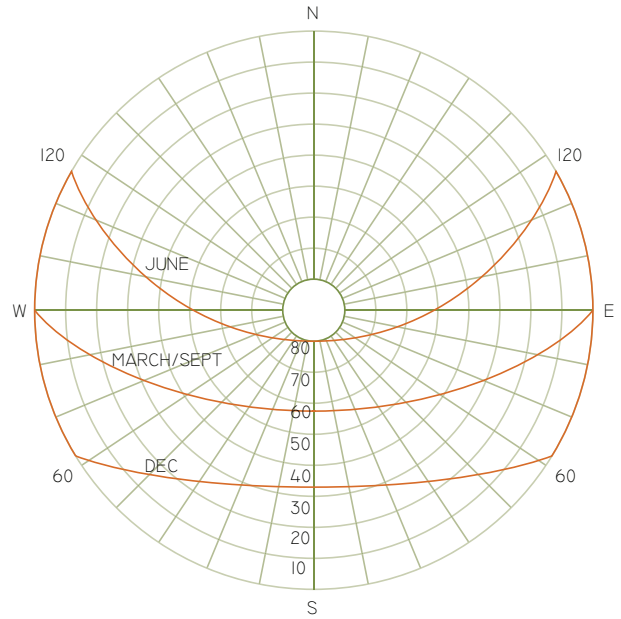






Typical of the southwest United States, Savannah's climate is very hot and humid in the summer. Rainfall and humidity drop in the winter, while temperatures remain above 50°. Wind patterns are mostly from the southeast, and not significantly obstructed by any major landforms or surrounding buildings.

While Savannah is not prone to hurricanes, the city is still considerably at risk (Swartz, 2018). Additionally, much of the site is located within the 100-year flood zone. Fortunately, the loamy sand that predominantly constitutes the soil is not prone to erosion. Infiltration is poor, however, and so specific siting of the building must take potential water hazards into account.

68 - Annual climate graphs for Savannah.
69 - Annual wind and solar charts for Savannah.

	PERFORMANCE MEASURE
SPACE ALLOCATION	Tabulate square footages of all functional spaces. Furnish all functional spaces with equipment and furniture needed for both church and surge use.
ENERGY CONSUMPTION	Calculate daylighting levels adequate for reading (church side) and medical treatment (surge side). Evaluate the viability of natural ventilation for surge use, as outlined in Bagdasarian et al.
ENVIRONMENTAL PERFORMANCE	Calculate correct artificial lighting levels and acoustical quality, and factor material cleanability. Complete preliminary sizing of mechanical equipment for healthcare ventilation.
BEHAVIORAL PERFORMANCE	Size room areas for church and surge occupant loads. Establish necessary circulation links for effective operation.

70 - Performance criteria matrix showing categories of performance and evaluation methods.

MEASURE SOURCE	PERFORMANCE ANALYSIS	PERFORMANCE JUDGMENT
Recommended room areas and proportions from published resources such as *Building Type Basics* and *Hospital and Healthcare Facility Design,* along with recommended functional space apportioning from *Problem Seeking.*	Compare room areas of final design to original space allocations. Fully furnish all functional spaces for church and surge uses to verify convertibility.	All room areas should vary from original allocations by less than 10%. However, the requirements of the sacred geometry parti supersede this requirement.
Daylighting aperture and plan and natural ventilation design guidelines from *Mechanical and Electrical Equipment for Buildings* (MEEB) and *Green Studio Handbook* (GSH).	Compare final designed efficiency components (daylighting and natural ventilation, if possible) with calculated minimums.	Daylighting and natural ventilation should accommodate minimums for church assembly. Medical use will require full artificial and mechanical environmental control.
Guidelines for artificial lighting design from MEEB, and acoustical guidelines from *Architectural Acoustics.* Material recommendations from healthcare design literature. MEEB and healthcare design literature recommendations for ventilation.	Compare artifical lighting capacity and acoustic system to calculated ideals. Verify main materials with lists of recommended cleanable materials for healthcare use.	Designed artificial lighting meets or exceeds calculated minimums. Acoustic system matches guidelines for church or auditorium building types. Materials selected are easily sterilized for health care use.
Room sizing guidelines from published resources such as *Building Type Basics*, and healthcare facility design literature establishing optimal functional circulation requirements.	Map circulation routes for both church and surge functions, denoting primary and secondary connections and isolations.	Primary and secondary connections and isolations meet optimal circulation intent.

	PERFORMANCE MEASURE
PSYCHOLOGICAL IMPACT	Establish a list of integral church elements and proportions from guides such as *Church Building*.
ENVIRONMENTAL IMPACT	Preserve as possible existing trees, grading, and waterways on and around the site.
CODE COMPLIANCE	Align egress, materials, and building components with local building code requirements.
COST	Apply the general cost estimating procedure outlined in *Problem Seeking* and adjust for inflation. Assuming a “Moderate” quality building with a 67/33% efficiency ratio, the method yields a total budget of $7,892,618.98.

MEASURE SOURCE	PERFORMANCE ANALYSIS	PERFORMANCE JUDGMENT
Church Building by R. A. Cram will be the basis of a criteria list, informed by other supplemental works such as *Contemporary Church Architecture.*	Identify inclusion of all essential church architectural elements in finished design.	Finished design contains the six major design elements identified in the literature review. The church design has the qualitative atmosphere of a church building and adheres fully to sacred geometry parti.
Existing site conditions as revealed through map and GIS analysis.	Compare post-intervention site conditions to pre-intervention vegetation, drainage, and waterways.	Existing site conditons, where not posing any hazard to development and where not allocated for programmatic modification, remain similar to their original state.
International Building Code (IBC) 2018, per local regulations.	Check components and systems of final design against IBC 2018 requirements.	Building components and systems comply with IBC 2018.
Simplified estimating method described in *Problem Seeking.*	Check qualitative categorization and efficiency ratio of final design against categorization assumed for cost estimating.	Qualitative categorization of final design is consistent with the categorization that was assumed when calculating the ~$8 million budget.

EXECUTIVE SUMMARY OF PERFORMANCE CRITERIA

Performance evaluation of the thesis project will revolve around the central point of verifying that the finished building will effectively serve both worship and emergency care functions. Each occupied space will be designed to serve at least two functions, with the exception of service spaces such as mechanical rooms and restrooms whose functions under either use will be identical.

Square footage allocations will derive from building efficiency ratios in the programming guide *Problem Seeking*, as well as from published references on church and healthcare design such as *Building Type Basics* and *Hospital and Healthcare Facility Design*. Precise area figures will comprise a convenient benchmark of building areas' ability to house dual usage patterns.

Environmental and energy analysis will investigate control systems especially relevant to church buildings and hospitals. Lighting, both natural and artificial, is crucial to both, and follow design methods prescribed in MEEB and GSH. Proper acoustical design is central to church buildings, and so will conform to recommendations in Egan's *Architectural Acoustics*. Finally, surge care use of the building will require a robust ventilation system. The potential for natural ventilation in line with Bagdasarian's study will be considered, but this area of design will focus on the sizing and configuration of a mechanical HVAC system capable of handling the increased load of healthcare use.

In addition to spatially accommodating program elements of both intended building functions, the project must provide effective circulation and allow practical patterns of use under both programs. Consideration of the programmatic concept of spatial relationships will establish two hierarchies of spatial connections, which can then be overlaid to establish a basic plan parti. The finished design will refer back to these spatial concepts derived from literature, as a benchmark of effective circulation.

Psychological impact will refer to the atmosphere of the church building, and whether it "feels" like a church. A checklist of basic architectural components from *Church Building* will serve as a metric, perhaps accompanied by qualitative surveys of other people's impressions.

The city of Savannah currently enforces the 2018 IBC and its companion codes for new construction. This project will comply with the general requirements therein, also taking into account the recommendations of the FEMA Coastal Construction Manual.

A rough cost estimate of $8 million follows the simplified estimation method outlined in *Problem Seeking*. To account for the age of the publication, the amount has been adjusted for inflation. Aspects of the finished design will be compared to the assumptions used in the estimating process; if the assumed conditions have remained consistent, the estimate will be assumed correct.

SPACE ALLOCATION AND INTERACTION

Area allocations are derived from the sizing of the nave (general care) to hold 250 seats (27 beds). Based on church case studies, one seat is assumed to require 6 s.f. of floor space, with the total area increased by 66% to allow room for circulation. This area is then divided by the recommended 42 s.f. per patient room, doubled to allow for circulation.

Many of the following allocations are proportional to the size of the nave (general care), save where a specific area is recommended in literature or where a constant size will suffice for a fixed number of occupants.

71

CHURCH	AREA (SF)	%	SURGE
NAVE (250 SEATS)	2400	23.1	GENERAL CARE (27 BEDS)
CHANCEL	600	5.8	
CHOIR / ORGAN	550	5.3	ISOLATION / I.C.U. (6 BEDS)
GATHERING / NARTHEX	1250	12.0	VOLUNTEER STAGING (500 SF)
			RECEPTION / TRIAGE (750 SF)
SUNDAY SCHOOL / CRY ROOM	450	4.3	STAFF STAGING
VESTING SACRISTY	200	1.9	MORTUARY
WORK SACRISTY	80	0.8	COMMUNICATIONS
CHOIR ROOM	275	2.6	STAFF SLEEPING
BIBLE STUDY	900	8.6	LAB / DIAGNOSTICS
KITCHEN	400	3.8	CAFETERIA
RESTROOMS	500	4.8	RESTROOMS / SHOWERS
	50	0.5	LAUNDRY
OFFICE	150	1.4	RECORDS
MECHANICAL	400	3.8	MECHANICAL
CIRCULATION	2050	19.7	STORAGE
STORAGE	155	1.5	STORAGE
TOTAL	10,410	100	TOTAL

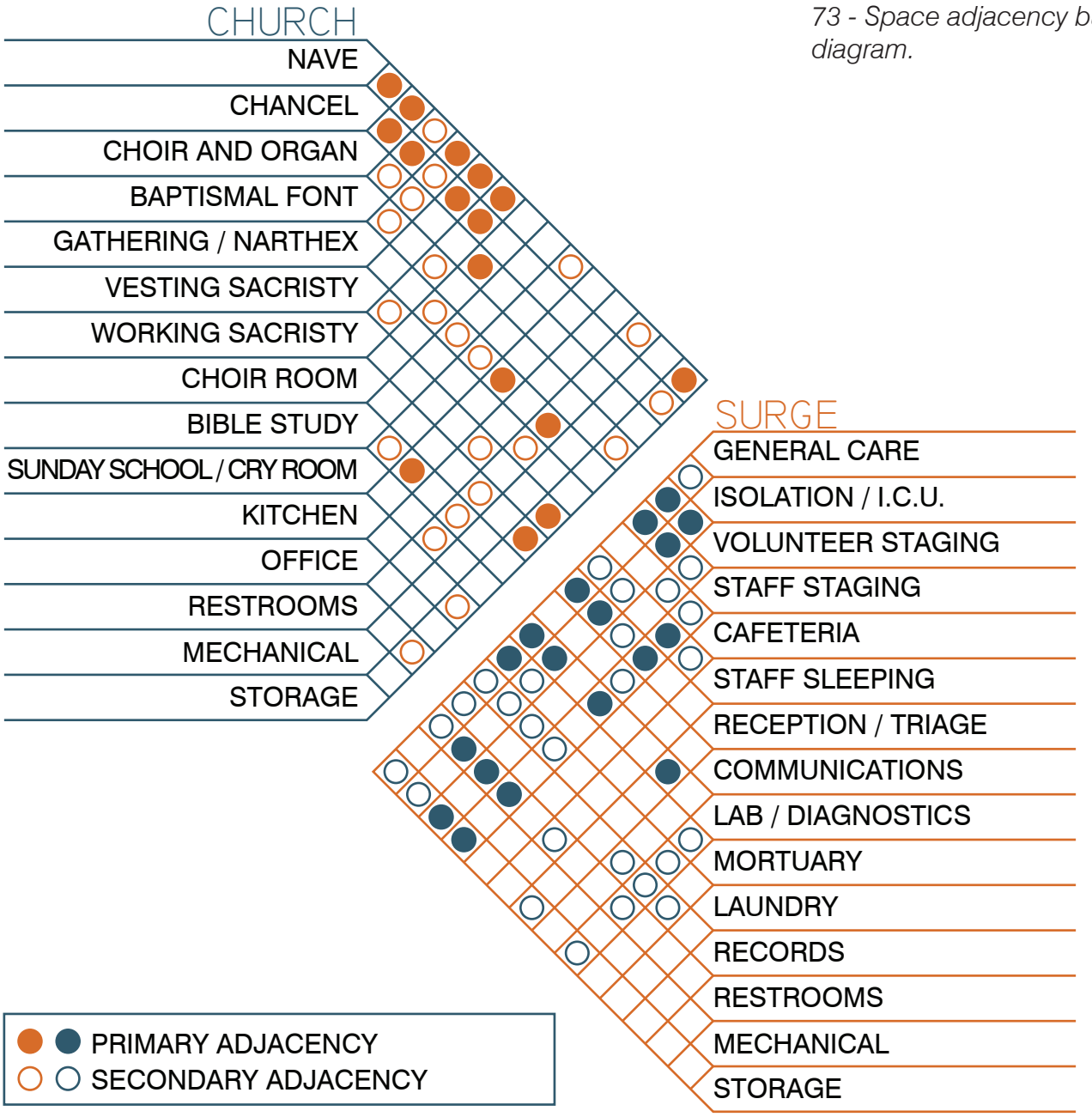
71 - Program and space allocation table.

The twin matrices below organize optimal connections between program spaces for both church and healthcare functions. A primary adjacency refers to a configuration in which one room is directly accessible from another, including via short hallways. A secondary adjacency may require passage through an intervening space or circulation area. If no adjacency is indicated, no specific spatial relationship is required.

The interaction diagram at right illustrates the same information in the form of a rough parti diagram. In this case, church and healthcare interactions are represented simultaneously. Restrooms and storage are omitted from the diagram, as both will likely be divided into multiple smaller units to better serve different program spaces, reduce travel distance, and facilitate utilization.

72

72 - Spatial interaction matrix.
73 - Space adjacency bubble diagram.



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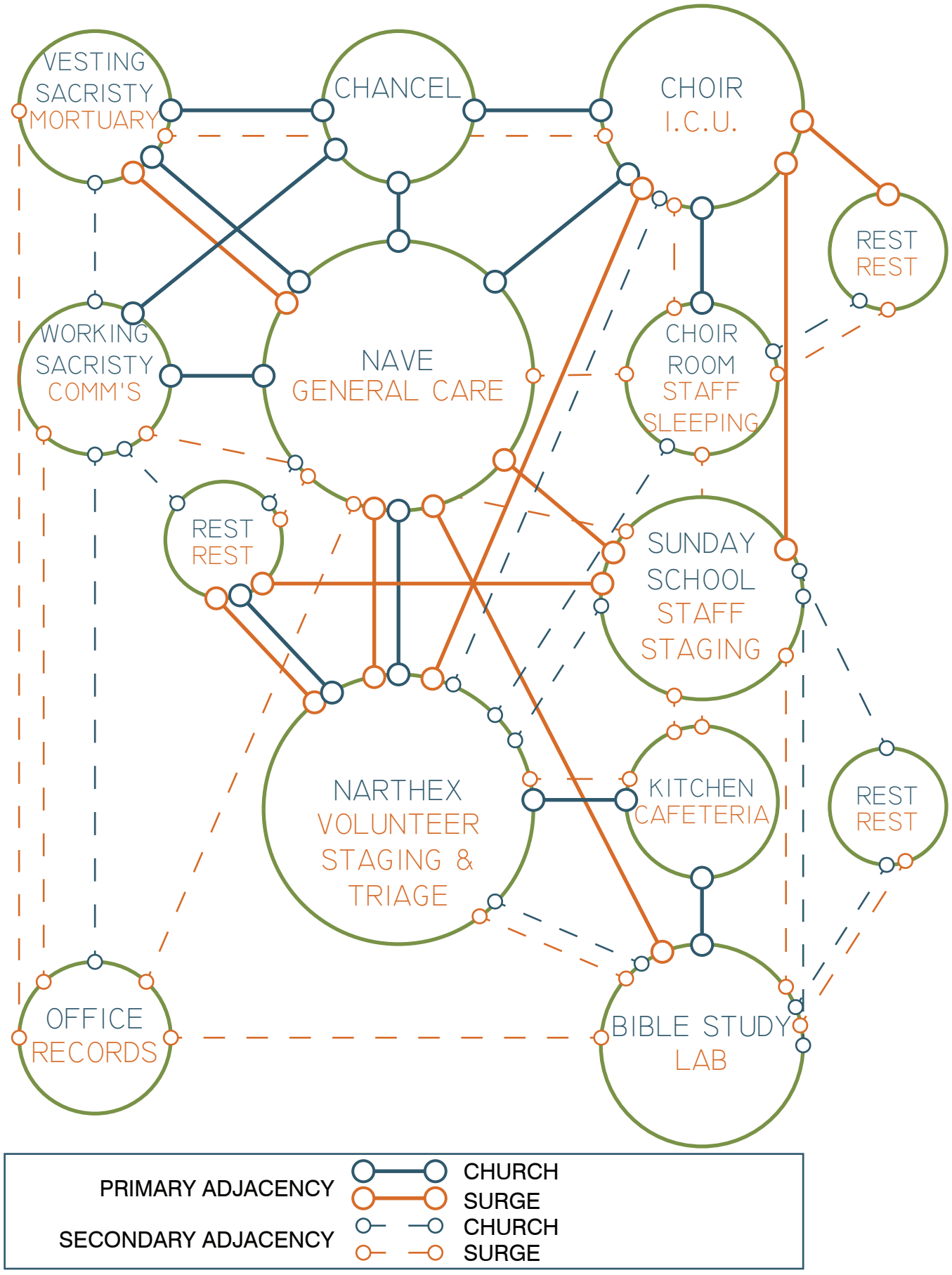
VESTING
SACRISTY
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CHOIR
I.C.U.
REST
REST
WORKING
SACRISTY
COMM'S
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GENERAL CARE
CHOIR
ROOM
STAFF
SLEEPING
REST
REST
SUNDAY
SCHOOL
STAFF
STAGING
NARTHEX
VOLUNTEER
STAGING &
TRIAGE
KITCHEN
CAFETERIA
REST
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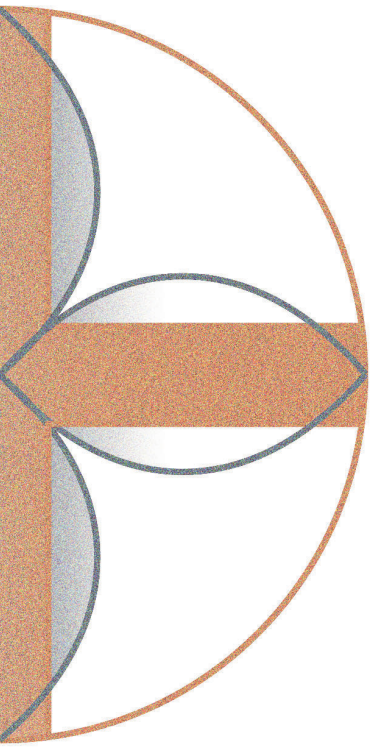
CHURCH
SURGE



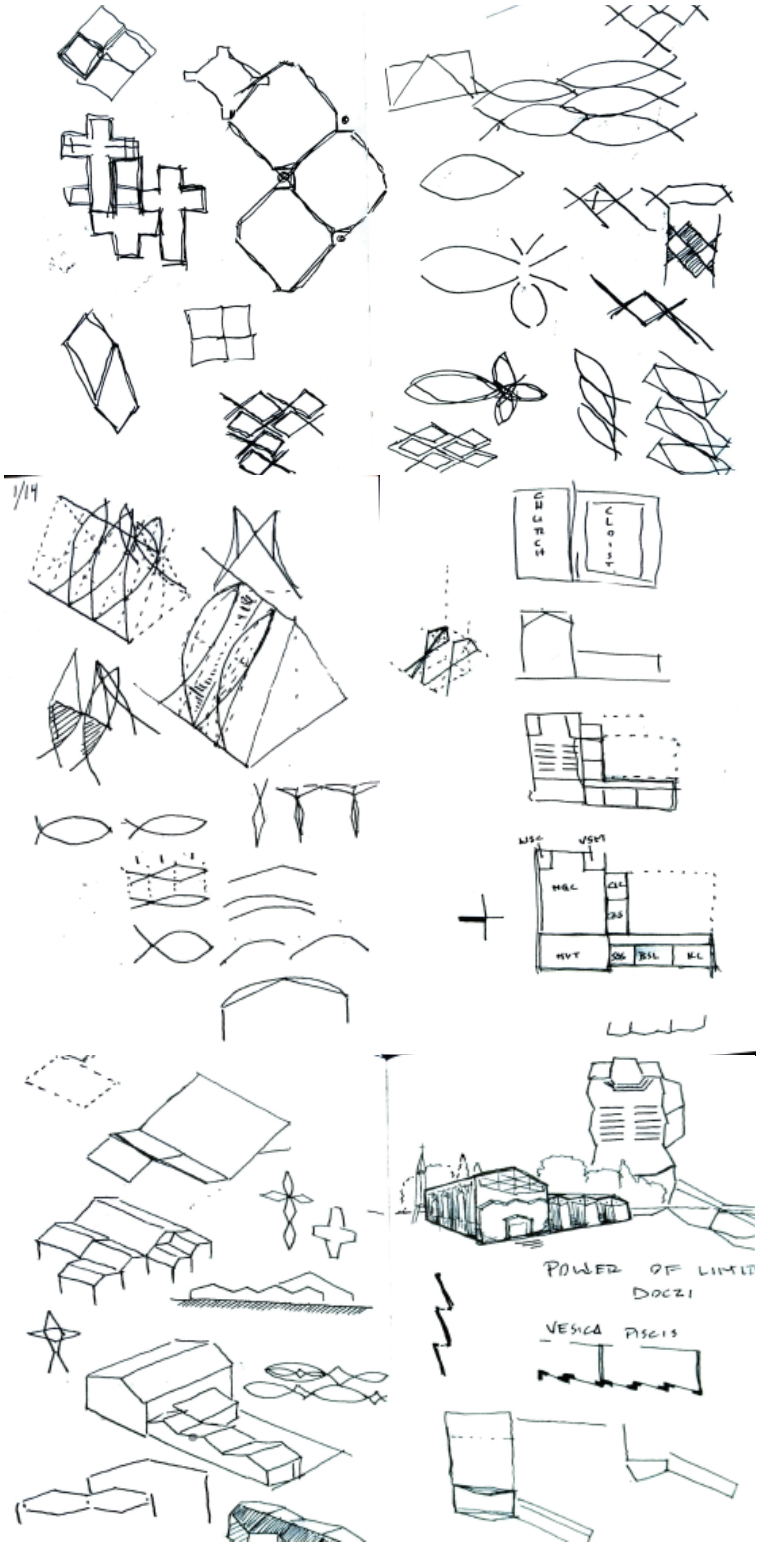
DESIGN SOLUTION

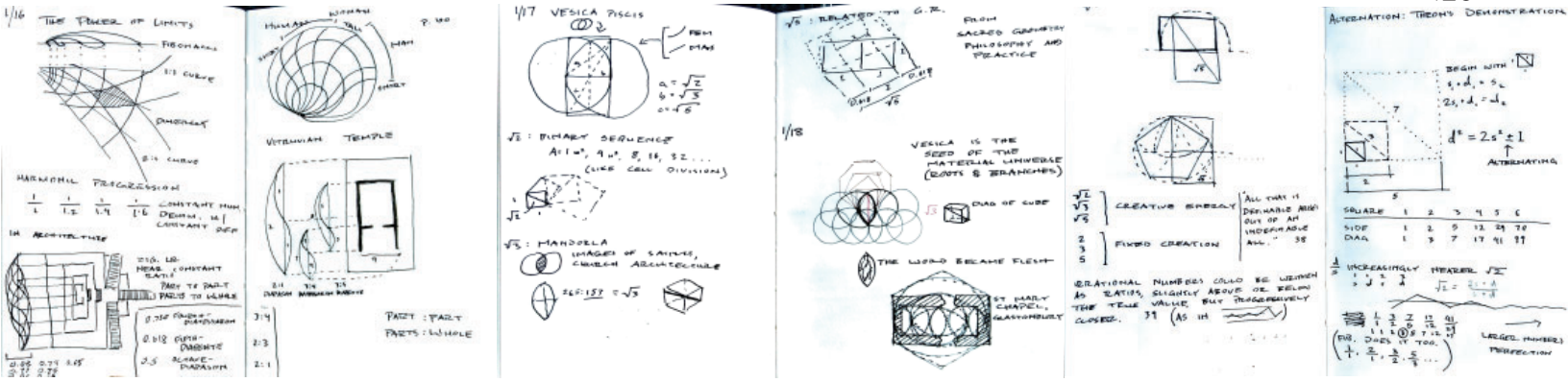
PROCESS DOCUMENTATION

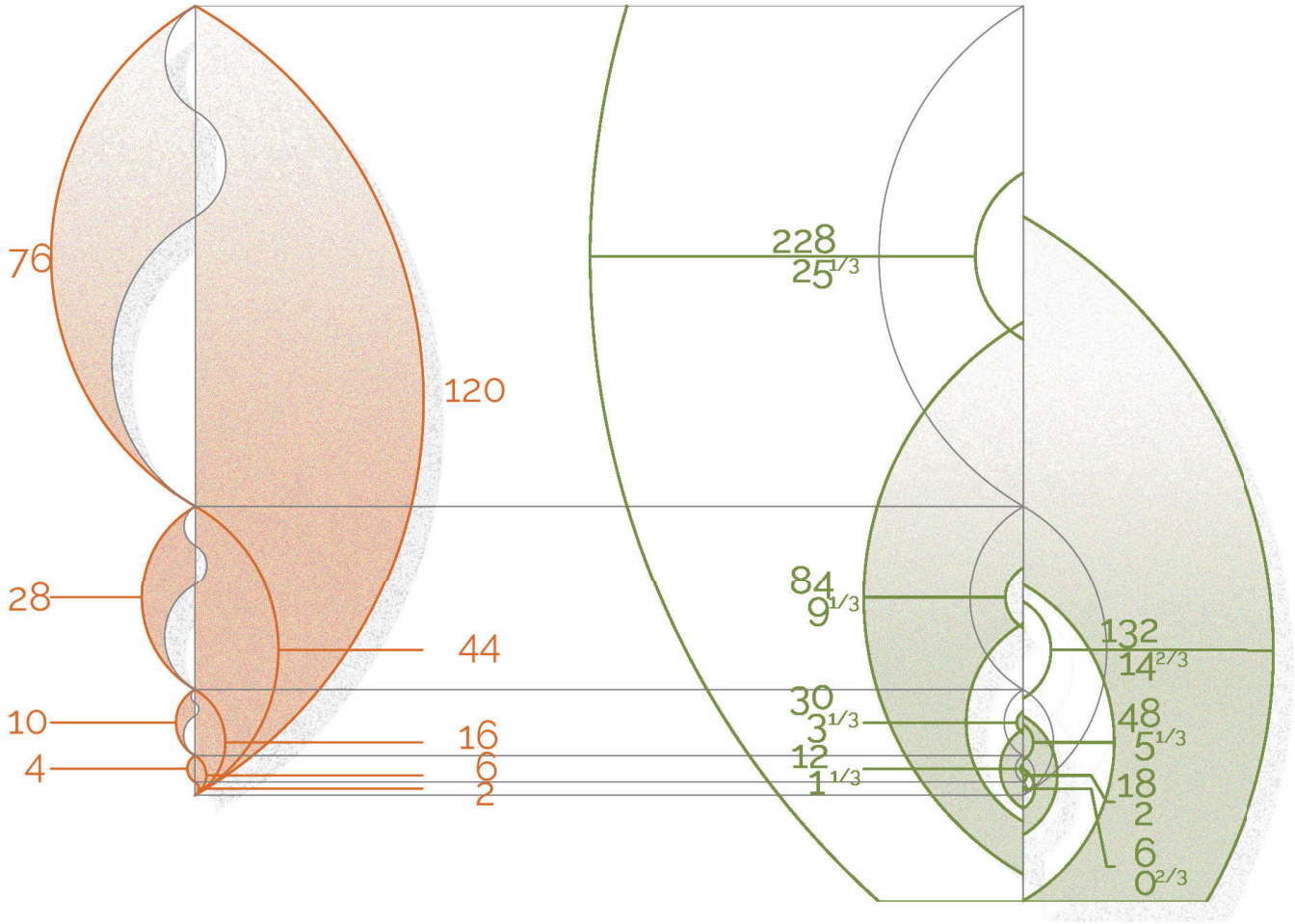
I. CONCEPT

Early explorations considered church symbols for use as repeating shapes and form drivers. This study led to the selection of the Vesica Piscis fish shape as the geometric basis for design.

Further investigation of sacred geometry and Vesica Piscis proportions, drawing primarily from Doczi's *Power of Limits* and Lawlor's *Sacred Geometry*, called for detailed mathematical study of the Vesica and its related constructions. With practical consideration of applicability to architectural design, this course of exploration resulted in the dual proportioning system used as the starting point for all future design work.




1/16
THE POWER OF LIMITS
FIBONACCI
1:1 CURVE
RHOMBUS
8:5 CHORD
HARMONIC PROGRESSION
CONSTANT NUM
CONSTANT DEP
IN ARCHITECTURE
VITRUVIAN TEMPLE
PART : PART
PARTS : WHOLE
1/17
VESICA PISCIS
PHI
PHI
PRIMARY SEQUENCE
(LIKE CELL DIVISIONS)
MANDORLA
IMAGES OF SAINTS,
CHURCH ARCHITECTURE
1/18
VESICA IS THE
SEED OF THE
MATERIAL UNIVERSE
(ROOTS & BRANCHES)
CUBE OF CUBE
THE WORD BECAME FLESH
ST MARY
CHAPEL,
GLASTONBURY
SACRED GEOMETRY
PHILOSOPHY AND
PRACTICE
CREATIVE ENERGY
FIXED CREATION
RATIONAL NUMBERS COULD BE WRITTEN
AS RATIOS, SLIGHTLY ABOVE OR BELOW
THE TRUE VALUE, BUT INCREASINGLY
CLOSER.
ALTERNATION: THEON'S DEMONSTRATION
BEGIN WITH
ALTERNATING
SQUARE
SIDE
DIAG
INCREASINGLY NEARER
LARGER NUMBERS
PERFECTION


76
120
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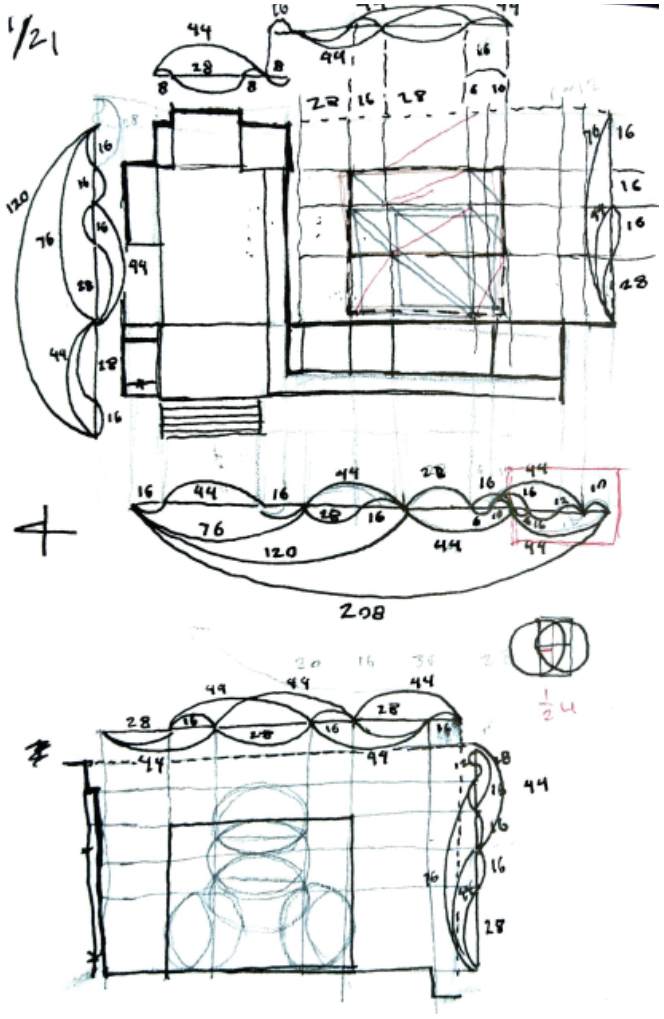
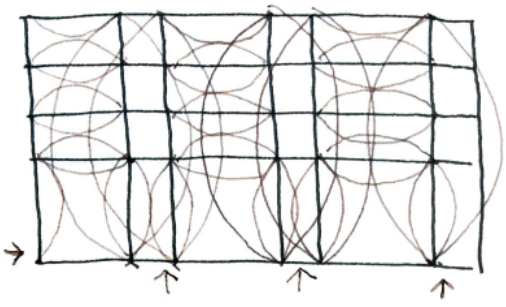
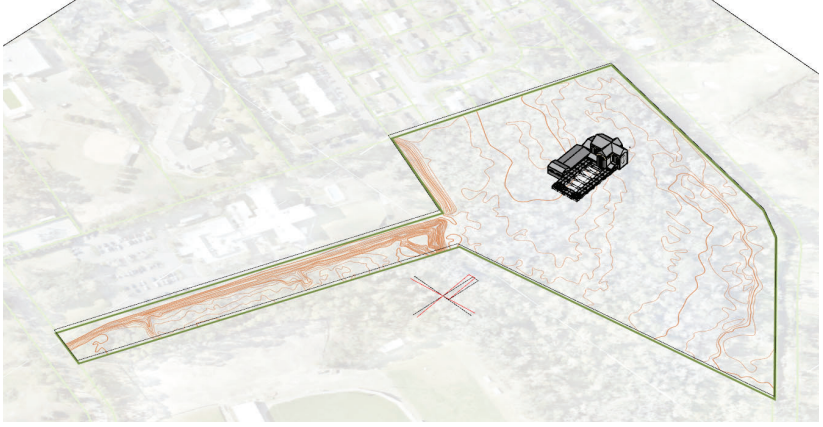
0 2/3

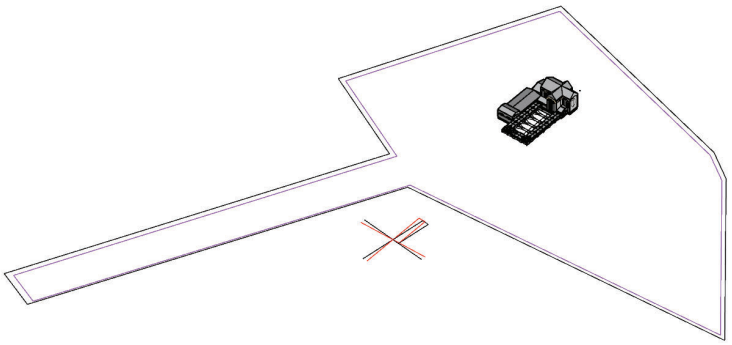


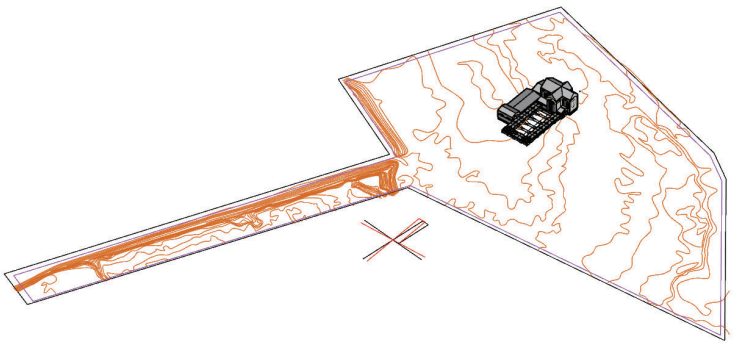
Application of the Vesica proportioning system continued in schematic plan development, with all dimensions derived from the Vesica integer series.

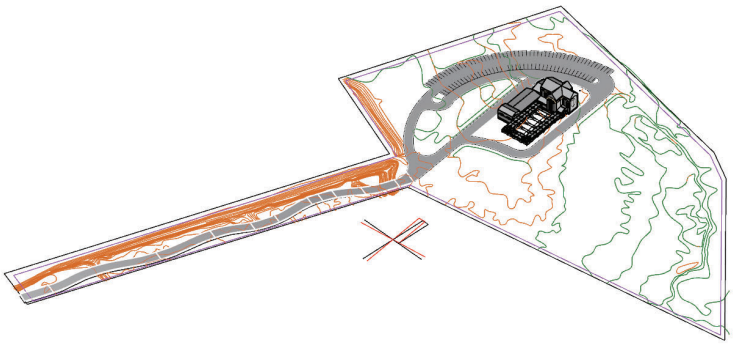
Proportional integers were arranged to dimension rooms that aligned as closely as possible with original area allocations. However, some square footage variance was acceptable in the interest of proportional conformity.

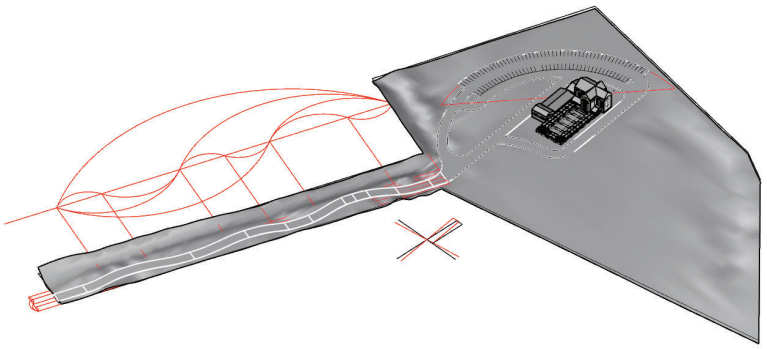








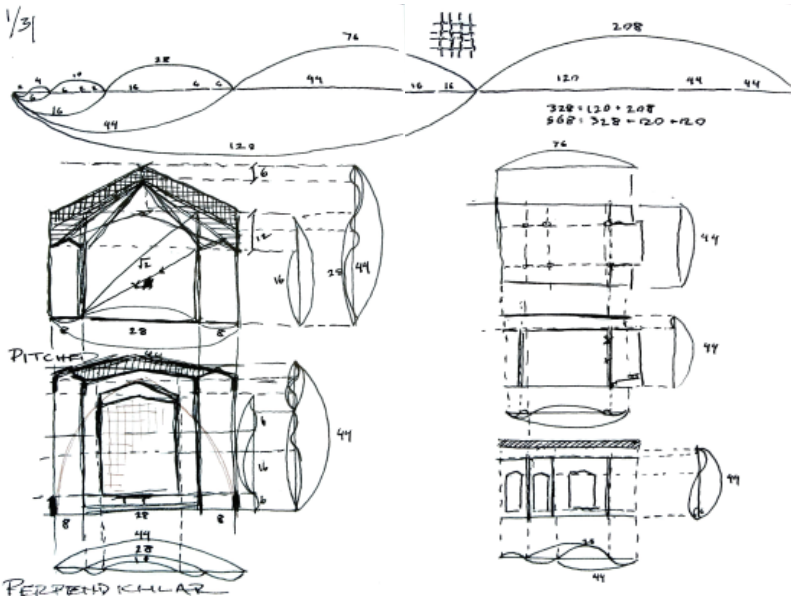


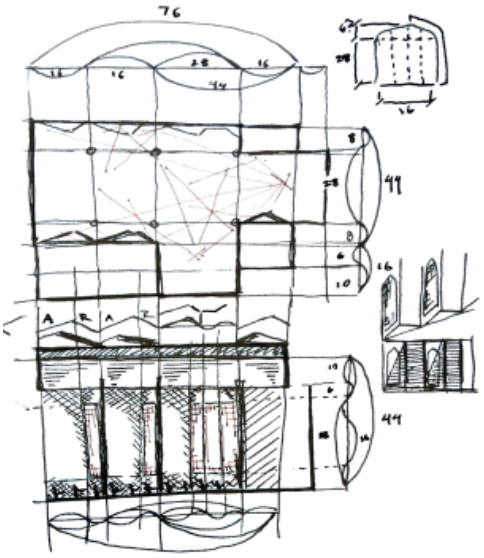


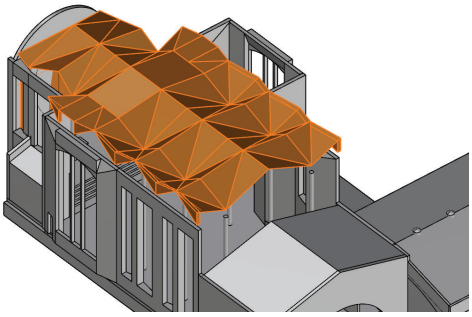
II. SITE DESIGN

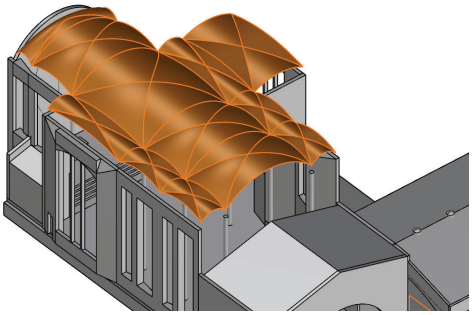
Building placement and circulation on the site primarily followed consideration of efficient movement for medical surge vehicle traffic. Based on rules of thumb for parking design, the site plan also required 100 vehicle stalls.

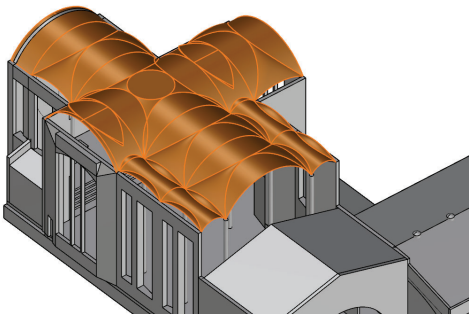
After investigation of existing topography and zoning setbacks, building placement and site access followed a further application of the Vesica modular system. This approach was in turn enabled by shifting the building plan slightly off axis to align with magnetic north in 2020, allowing more efficient use of site space.







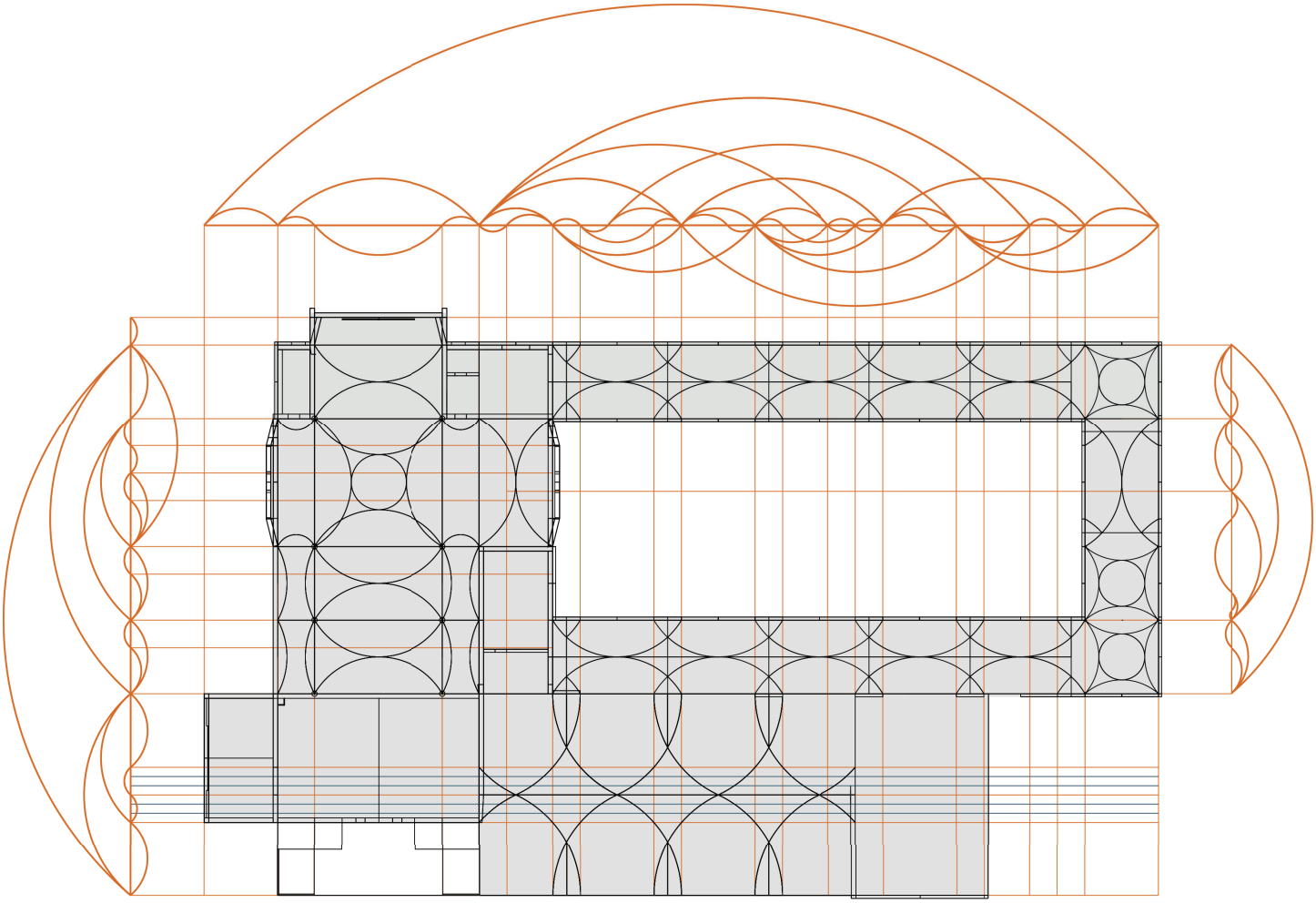




III. CONCEPT DEVELOPMENT AND STRUCTURE

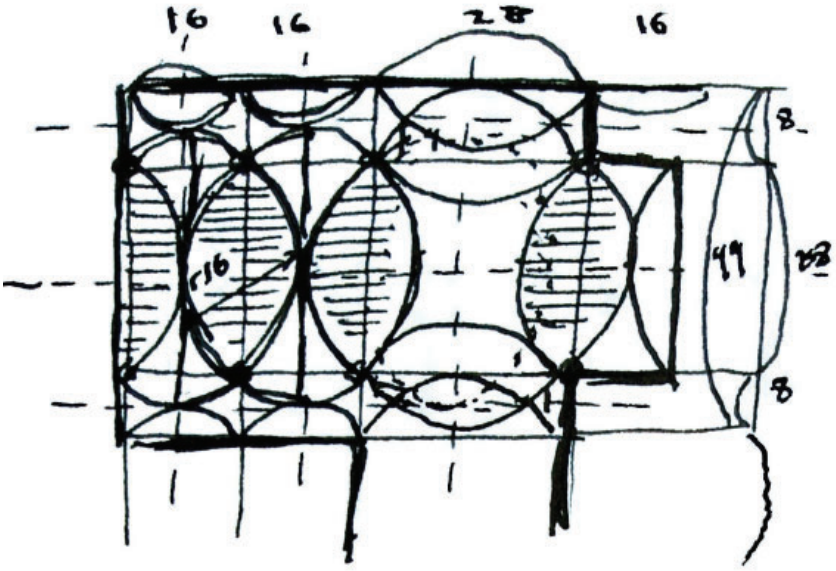
Design development in plan and section continued with further use of sacred geometry proportions. Iterations in this stage were largely concerned with the structural diaphragm vaults over the church proper and auxiliary wing, accounting for most of the building footprint.

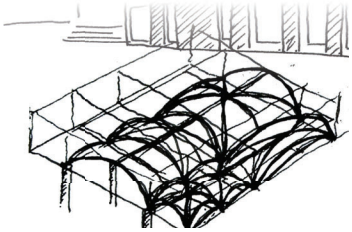
Design of the vaults followed multiple interpretations of the proportioning system, beginning with angular bays derived solely from numerical intervals and progressing to curvilinear vaults using literal Vesica segments. An advantage of the latter is found in the successful integration of not only Vesica-proportioned arcs but also of entire Vesica fish shapes in the vaulting plan. Eventually, vaulting in the church, auxiliary wing, and courtyard comprised a structural system proportionally compatible with the building in plan and section.

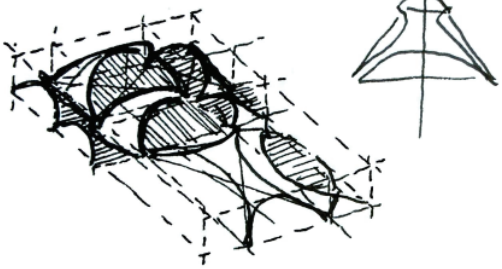


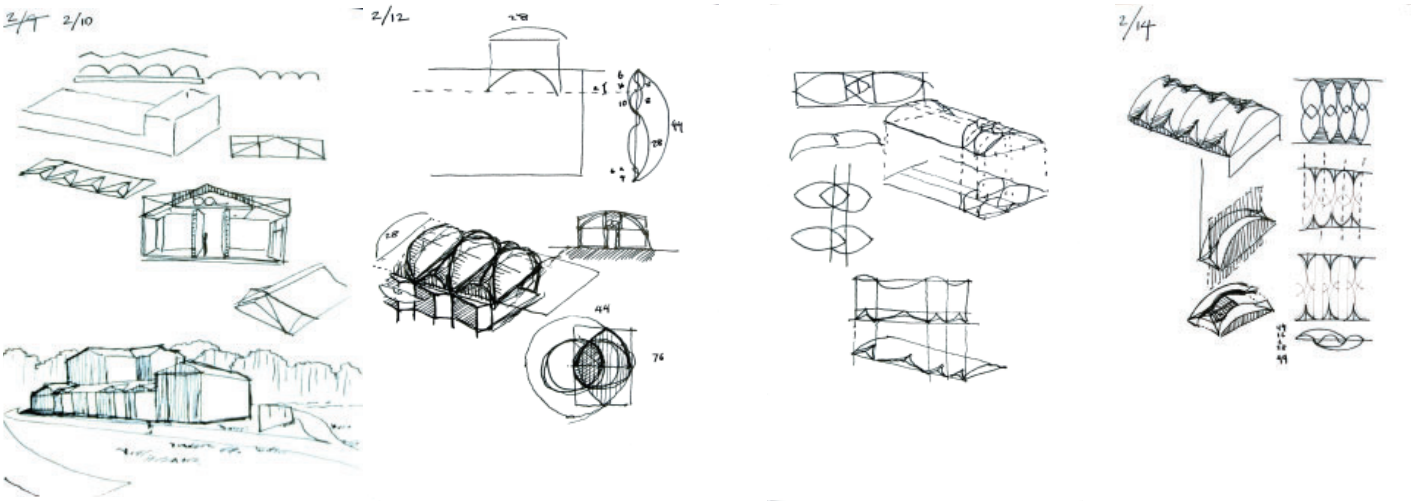
VAULTING PLAN

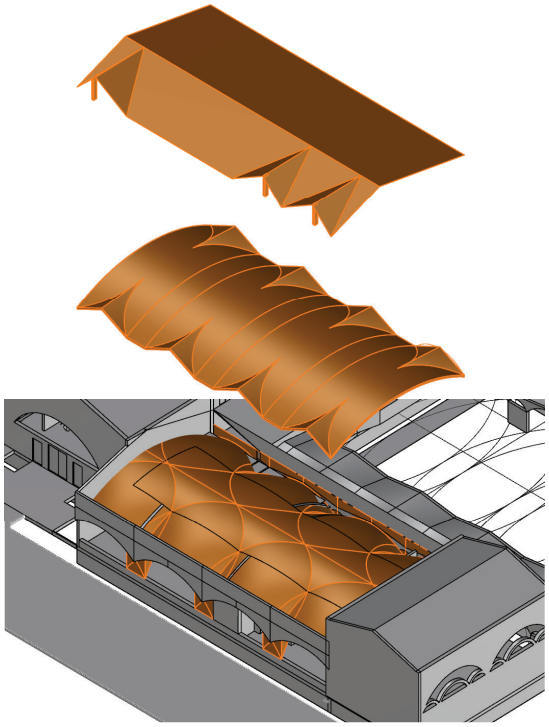
0 10 20 40





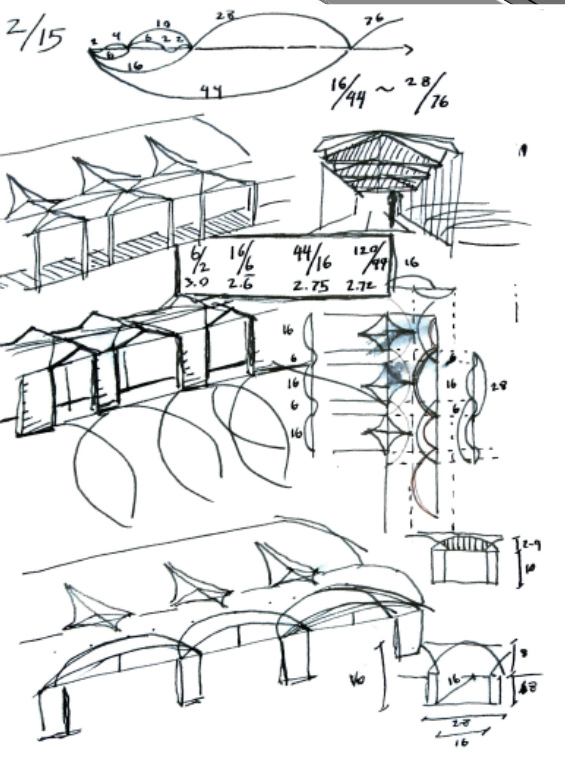


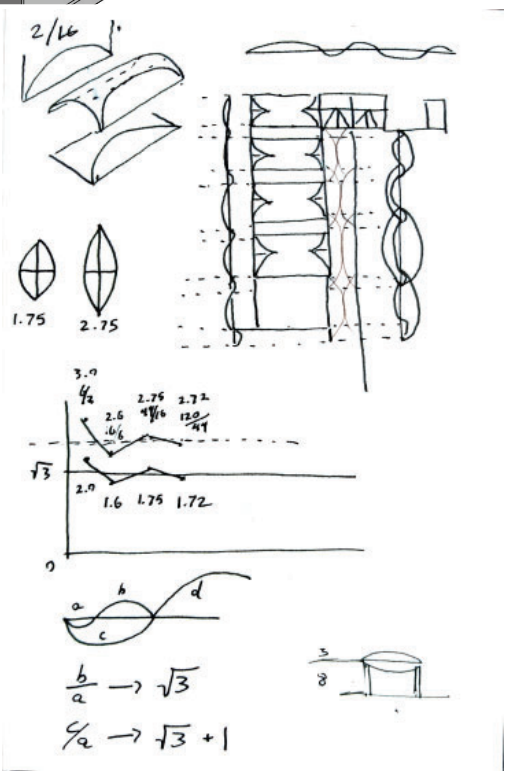


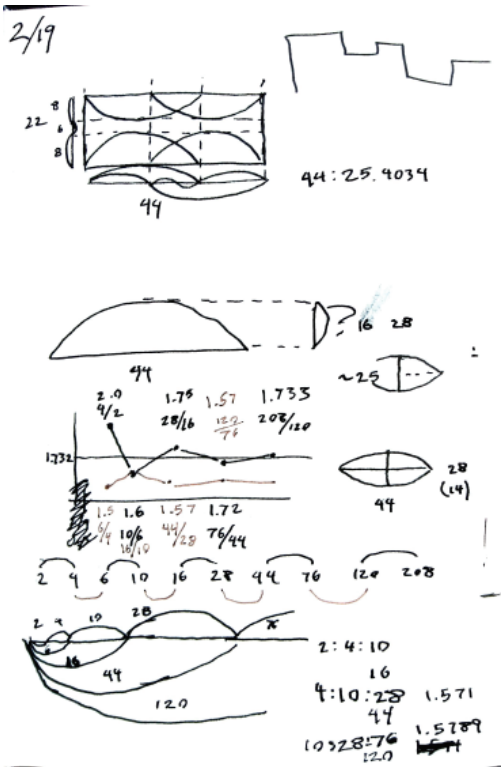


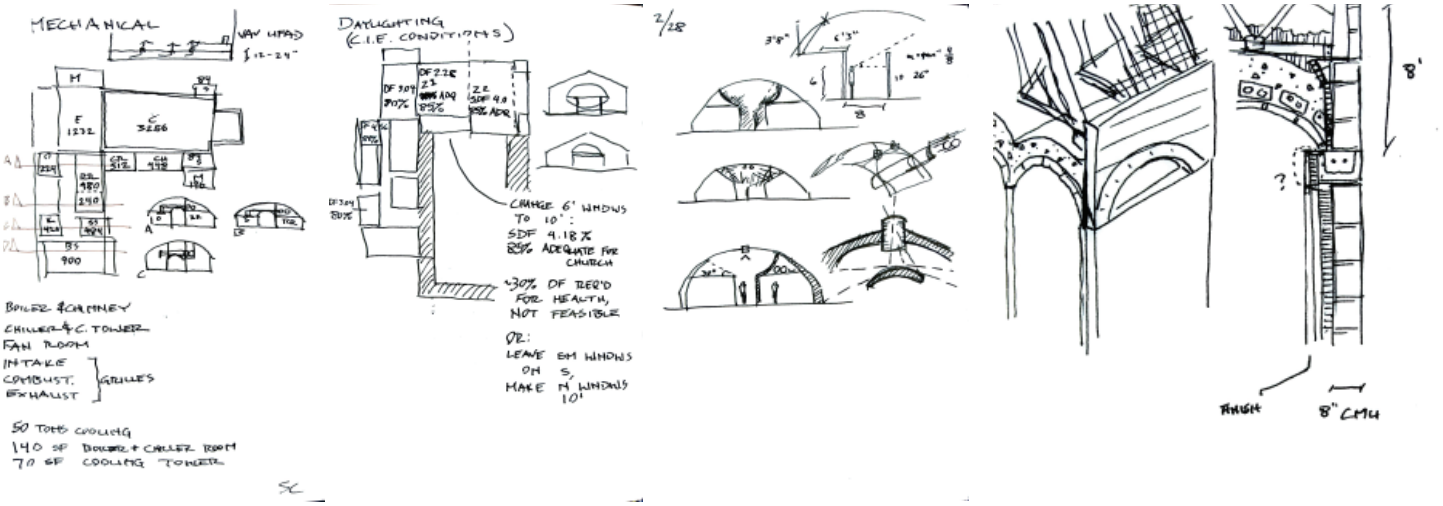
IV. DETAILS

Vaulting design of the auxiliary wing was severely restricted by the original set of Vesica integers, to the extent that further geometric extensions of the Vesica Piscis were required to yield more accommodating intervals. Much of this work built on a return to the basic terms of the Vesica series, discovering new mathematical relationships and exploring additional opportunities for integration with the whole.

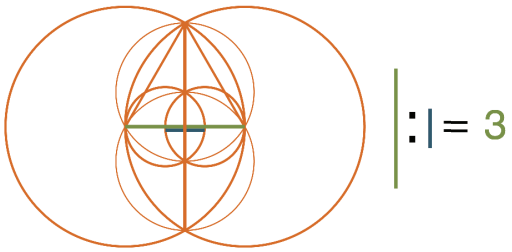








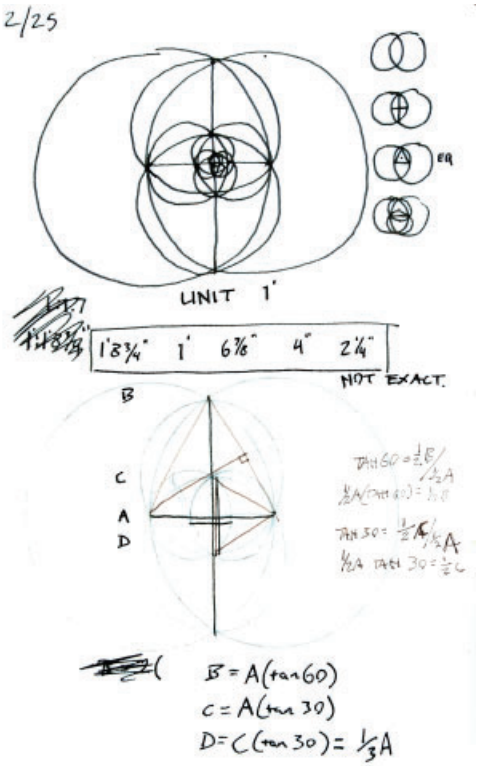
2, 4, 6, 10, 16, 28, 44, 76, 120

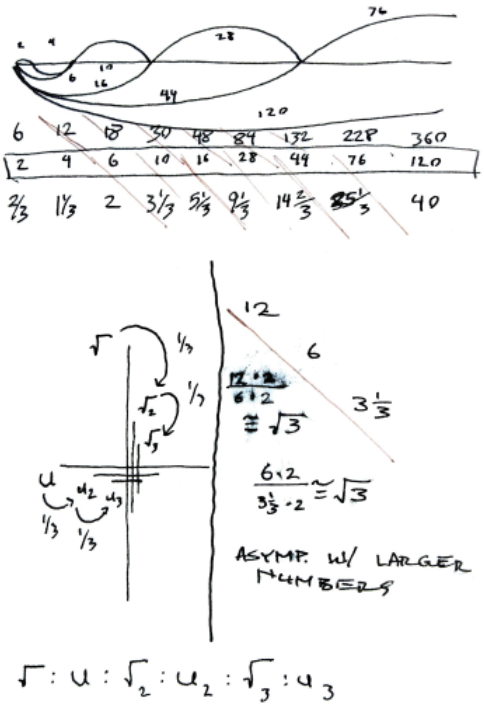


6, 12, 18, 30, 48, 84, 132, 228

2, 4, 6, 10, 16, 28, 44, 76

0.6, 1.3, 2, 2.3, 5.3, 9.3, 14.6, 25.3

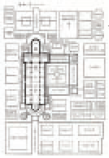




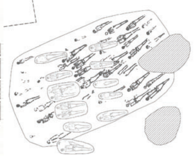
SOLUTION DOCUMENTATION

PRESENTATION BOARDS

The project presentation boards reproduced at right provide a graphic narrative of the thesis premise, underlying sacred geometry ordering, surge conversion capacity, and building structure. Renderings illustrate use of the building under both church and surge care conditions.

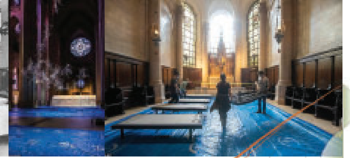


St. Gall Monastery Plan, 830



Thornton Abbey Plague Grave, UK, c. 1349

Calvary Episcopal, Pittsburgh, 1918



St. John the Divine, New York, 2020

I *__CHURCHES__ age and decay while their congregations move into storefronts, __LACKING THE RESOURCES__ to build and maintain them.*

II *In light of heightened __PUBLIC HEALTH FEARS__, uncertainty arises surrounding the __EMERGENCY SURGE CAPACITY__ of healthcare systems.*

III *Church architecture and emergency medical care share a centuries-old __COMMON HISTORY__, offering answers to __BOTH ISSUES TODAY.__*

This project proposes a __HYBRID BUILDING TYPOLOGY__, combining the functions of worship and surge healthcare to aid the viability of both.

By presenting the __SURGE-ADAPTABLE CHURCH BUILDING__ as an investment in community resilience, while examining traditional ordering principles to generate a __MODERN ECCLESIASTICAL STYLE,__ this exploration opens avenues of __COMMUNITY SUPPORT__ for church projects that increase __PREPAREDNESS__ for public health or natural emergencies. The __FLEXIBLE CHURCH BUILDING__ serves a dual role:

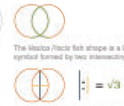
a place for taking refuge in God becomes a place of refuge from disaster.

BUILT ON THE ROCK

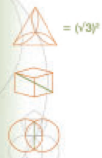
AND THE RAIN FELL, AND THE FLOODS CAME,
AND THE WINDS BLEW AND BEAT ON THAT HOUSE,
BUT IT DID NOT FALL,
BECAUSE IT HAD BEEN __FOUNDED ON THE ROCK.__
MATTHEW 7:25

PROPORTIONING SYSTEM: SACRED GEOMETRY

The Vesica Piscis fish shape is a Christian symbol formed by two intersecting circles.



The axes of the Vesica shape are related in the exact ratio of √3.



The ratio √3 relates symbolically to the Trinity and geometrically to 3-D space and 2-D constructions, representing both God and His act of creation.

$\sqrt{3} = 1.7320508...$

The exact √3 is an irrational number, making it difficult to use precisely in architectural design.

For $\sqrt{c}$,

$x_n = x_{n-1} + y_{n-1}$
$y_n = x_n + (c-1)x_{n-1}$

2, 4, 6, 10, 16, 28, 44, 76...

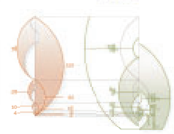
The ancient Theon's Ladder formula generates a Fibonacci series of integers whose ratios asymptotically approach a given square root ratio.

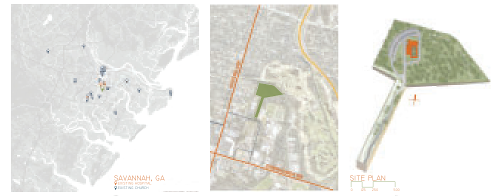
The integer sequence provides a set of rational numbers for use in design, all of which relate in a clear pattern to the perfect ratio of √3.

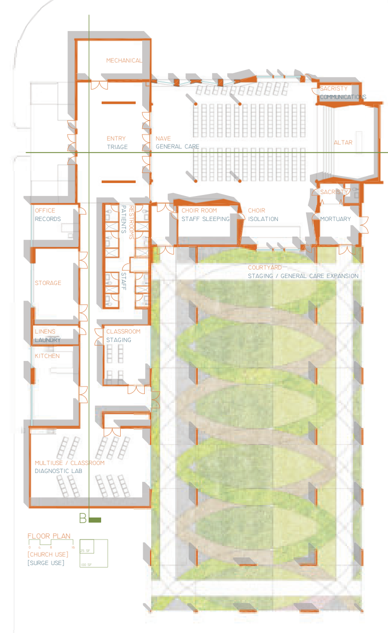
If the infinite √3 symbolizes the infinite creative power of God, the Theon sequence represents an earthly pilgrimage toward Him: as the sequence progresses, its terms literally approach perfection. The √3 Theon sequence is therefore an ideal system of symbolic numbers and geometry for the design of a church.

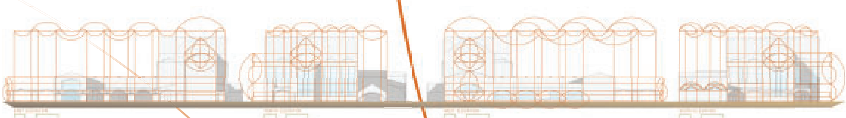
However, the Theon sequence provides only whole integers that are sometimes too large for practical use in architecture. Smaller integers are provided by constructing additional vesica shapes from the original sequence integers.

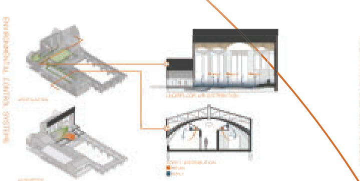
6, 12, 18, 30, 48, 84, 132, 228
2, 4, 6, 10, 16, 28, 44, 76
0.6, 1.3, 2, 3.3, 5.3, 9.3, 14.6, 25.3



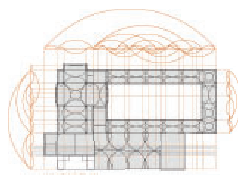


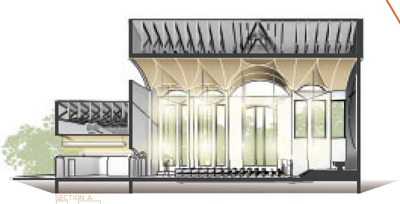


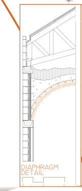


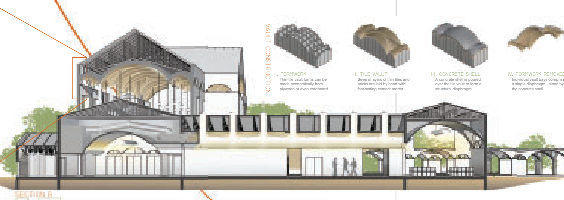


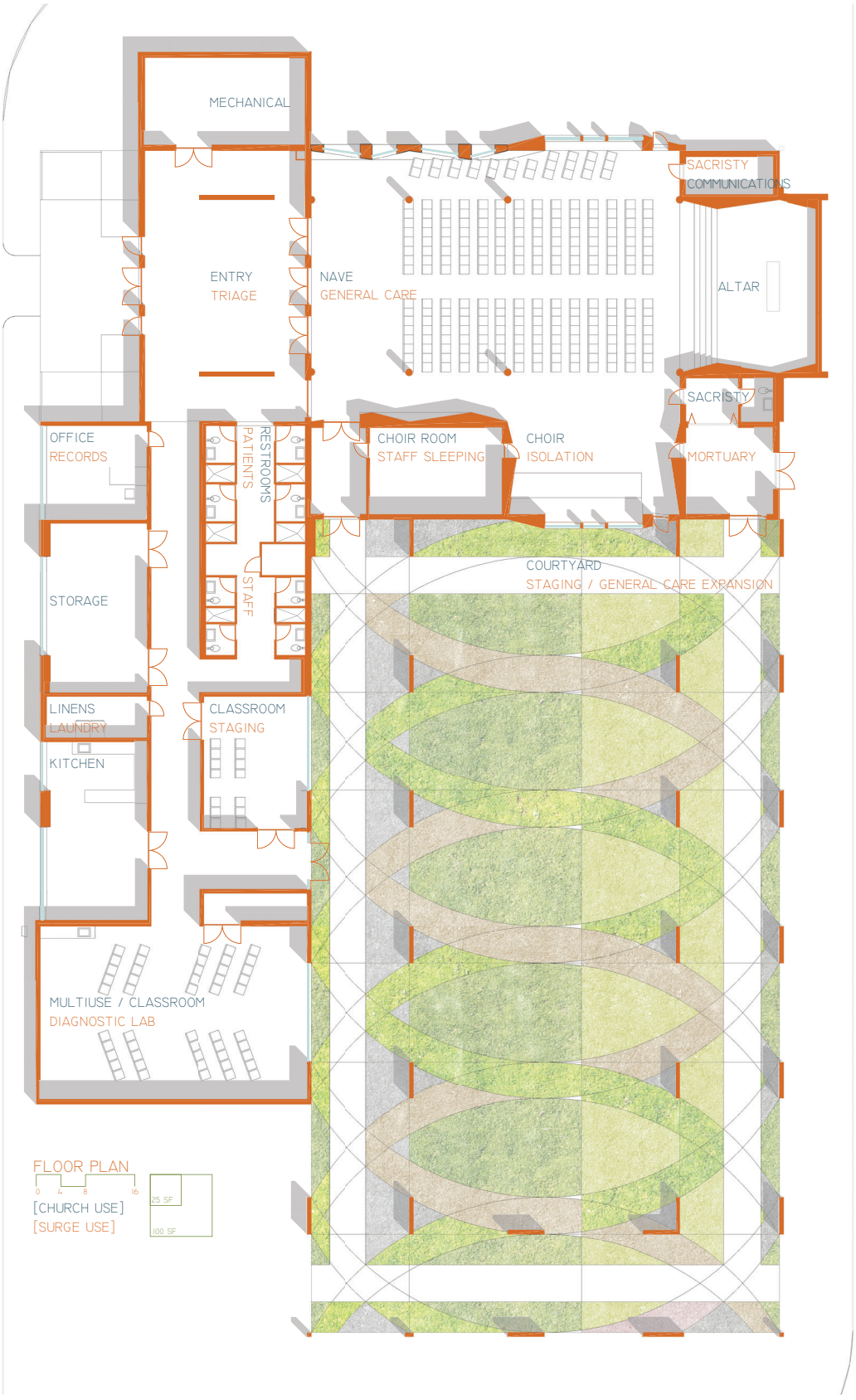
The project's location on the hurricane-prone southeast coast prompts another dimension of resilience. Based on the guidelines of the FEMA Coastal Construction Manual, the main volumes of the building are stabilized with tile and concrete vaults acting as diaphragms against lateral wind loads. The drawings at left illustrate continuous load paths that diffuse hurricane forces across the entire building and into the ground.

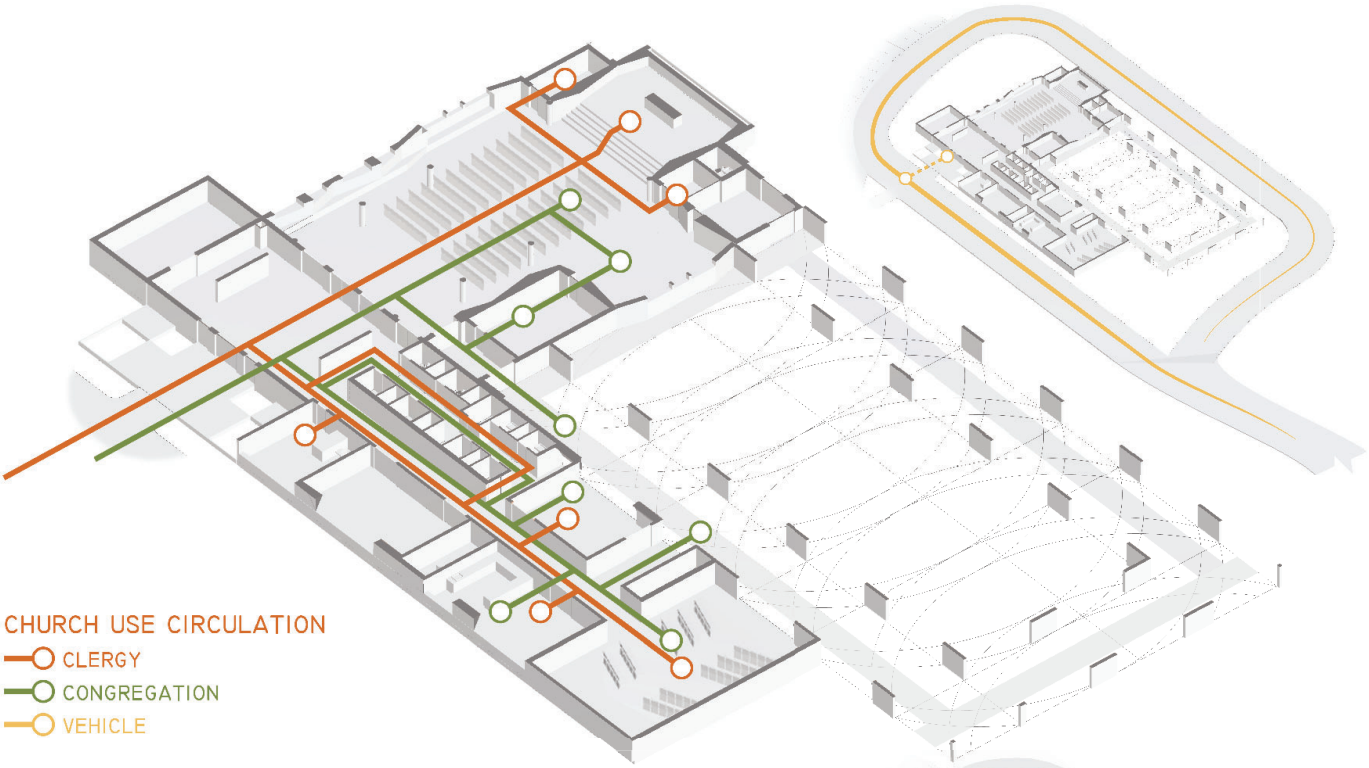




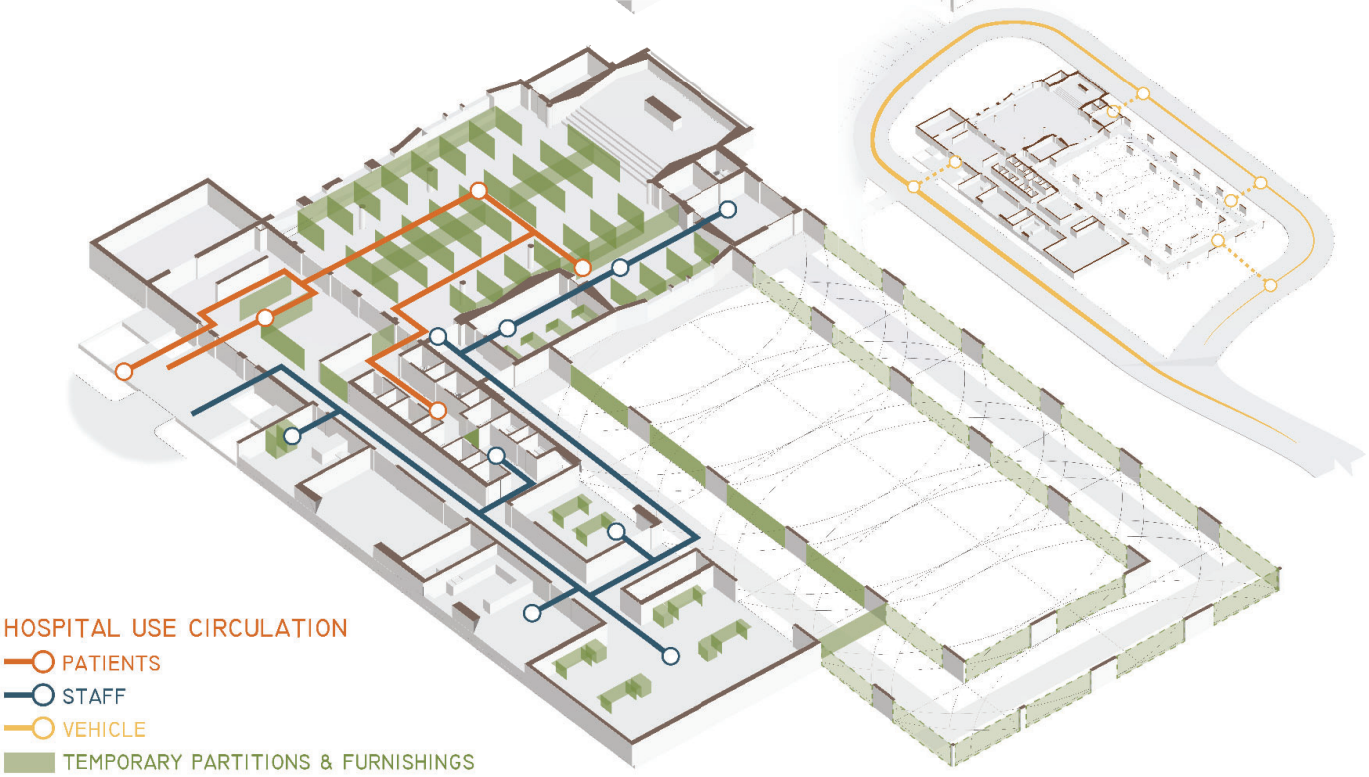




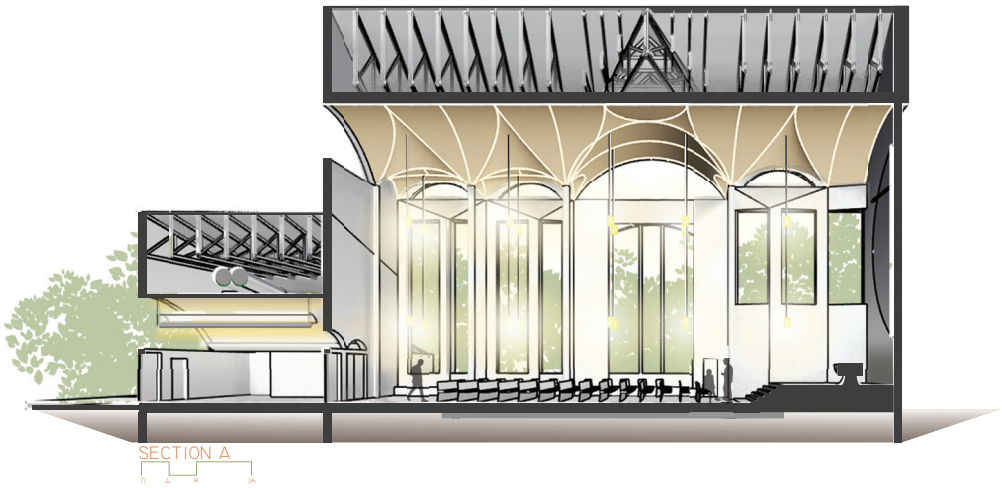

MECHANICAL
SACRISTY
COMMUNICATIONS
ENTRY
TRIAGE
NAVE
GENERAL CARE
ALTAR
SACRISTY
OFFICE
RECORDS
RESTROOMS
PATIENTS
CHOIR ROOM
STAFF SLEEPING
CHOIR
ISOLATION
MORTUARY
COURTYARD
STAGING / GENERAL CARE EXPANSION
STORAGE
STAFF
LINENS
LAUNDRY
CLASSROOM
STAGING
KITCHEN
MULTIUSE / CLASSROOM
DIAGNOSTIC LAB
FLOOR PLAN
0 4 8 16
[CHURCH USE]
[SURGE USE]
25 SF
100 SF

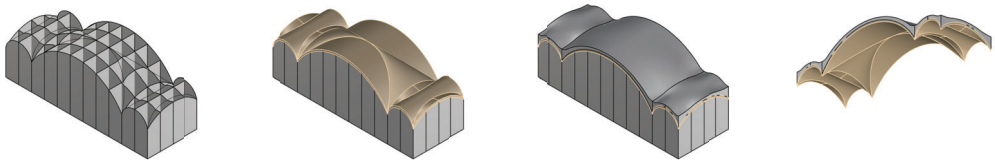


CHURCH USE CIRCULATION
- CLERGY
- CONGREGATION
- VEHICLE



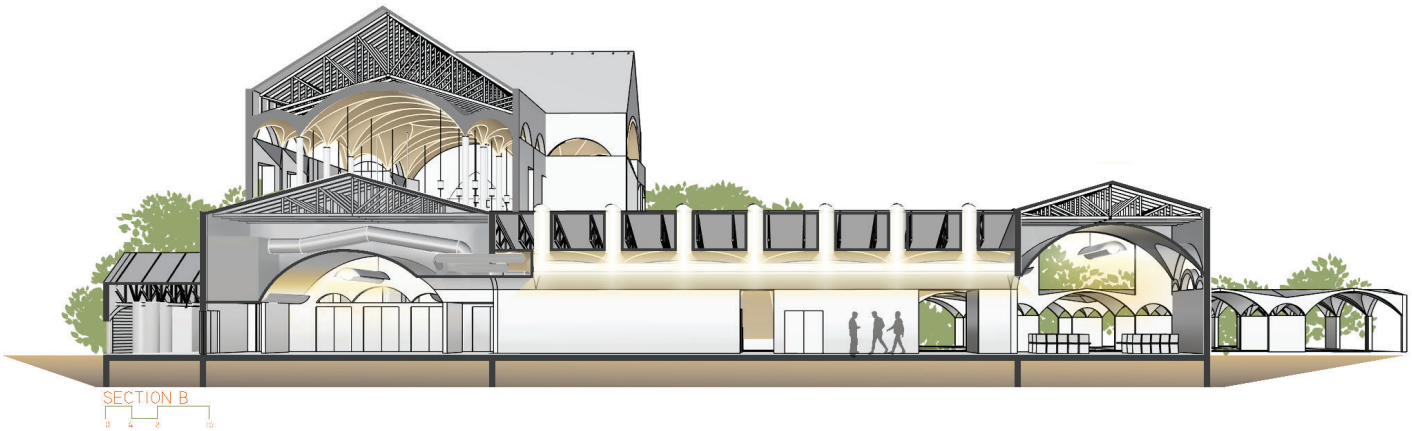
HOSPITAL USE CIRCULATION
- PATIENTS
- STAFF
- VEHICLE
- TEMPORARY PARTITIONS & FURNISHINGS

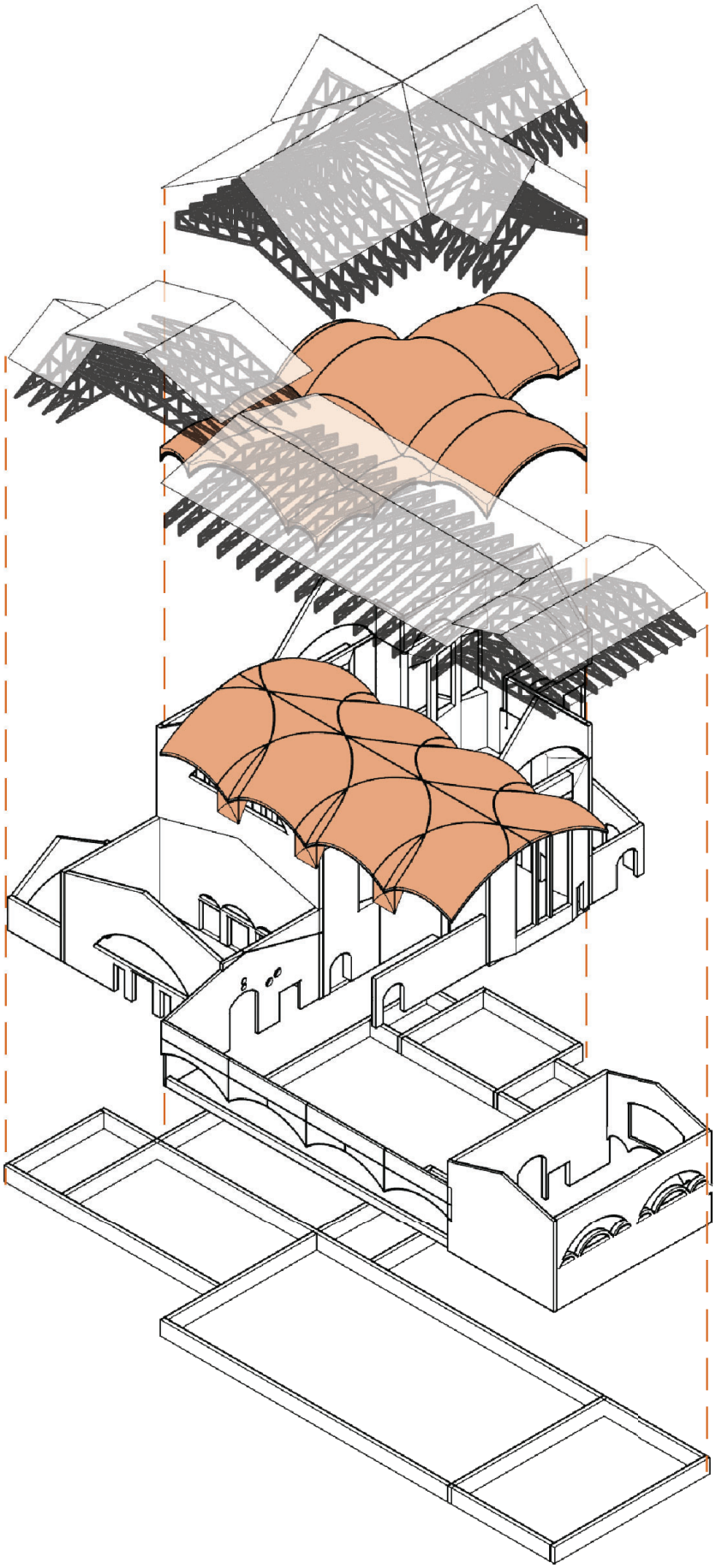


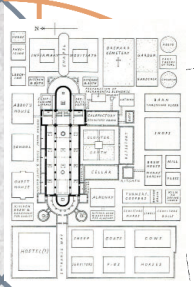


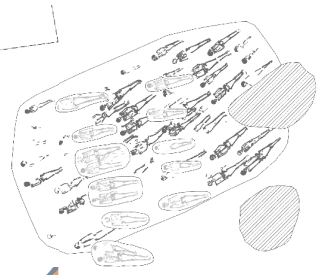
STRUCTURE

The decorative proportioned vaults over the church and auxiliary wing function as lateral diaphragms to distribute hurricane-force winds. Using Catalan thin tile vault construction methods, the first layers of these vaults can be rapidly built using economical cardboard formwork. Application of a site-cast concrete topping creates a monolithic structural unit that distributes wind forces across supporting walls.







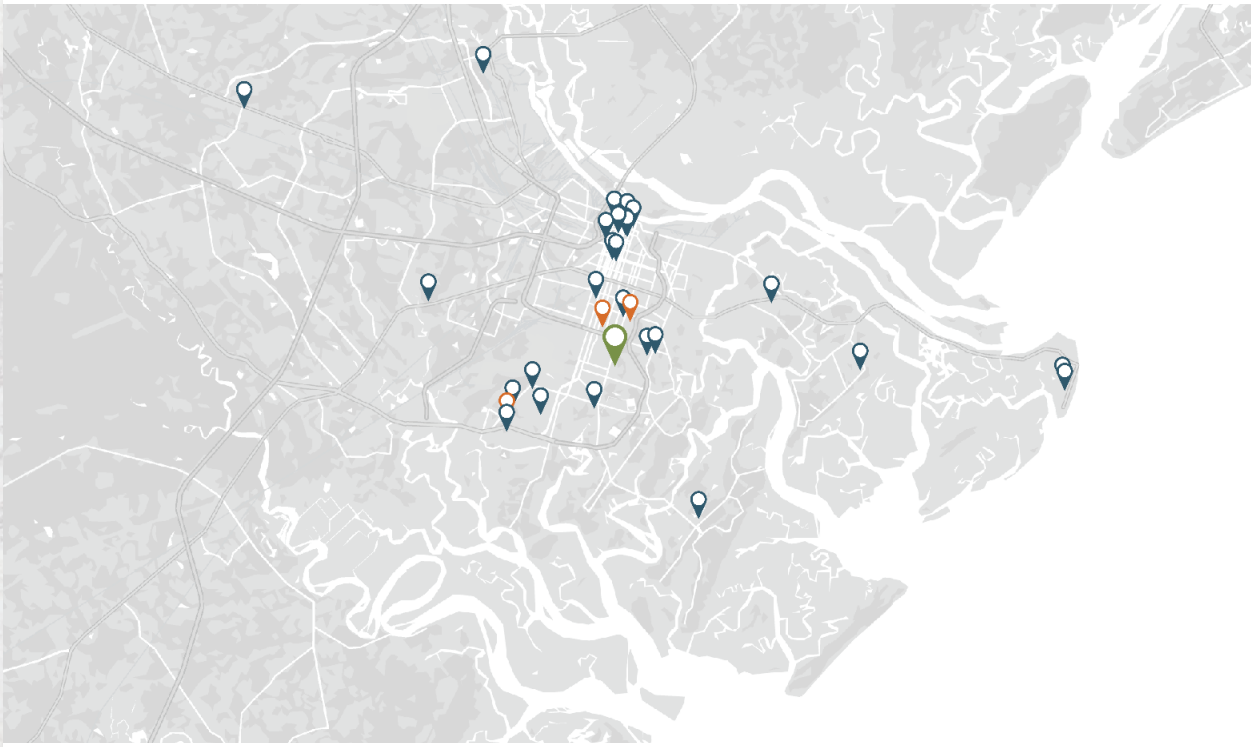


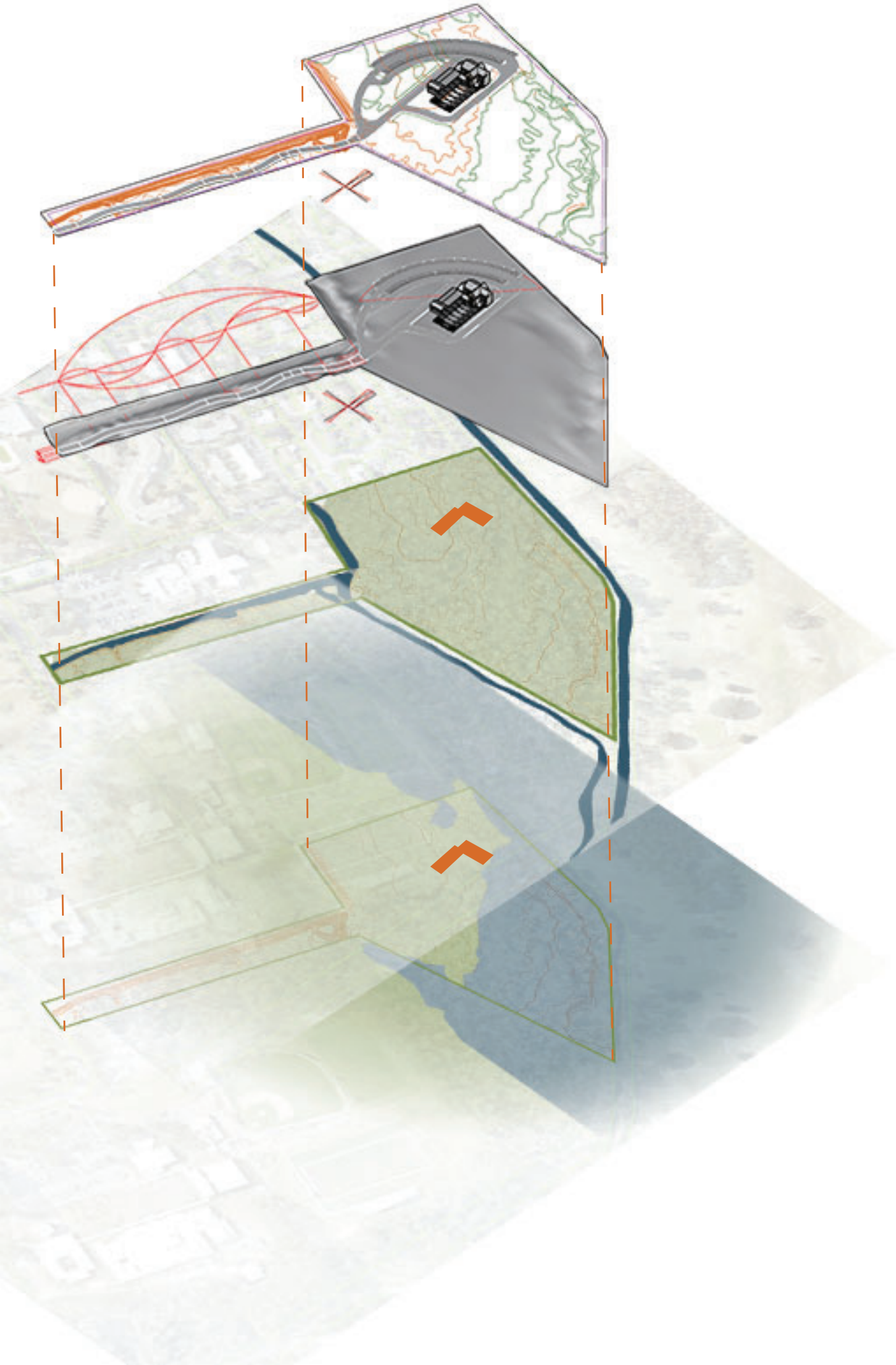
ANALYSIS: SITE AND CONTEXT

The solution responds to its historical, physical, and social context by providing the next iteration of a long-running historical trend in a uniquely ideal geographic location.

As the once-close bond between church and emergency building functions dissolves to the point that churches offer medical aid only in dire emergencies, this project offers a course correction. Church buildings can better anticipate and respond to the future needs of their communities by planning for effective and near-seamless surge care transformation. The city of Savannah is especially suited to such a pilot project, lying at the intersection of strong demand for church buildings and increased need for emergency health care capacity.

At the scale of the project site, the building responds to limits imposed by flooding and drainage as well as liturgical orientation and sacred proportioning, while aiming to leave a significant portion of the forested site untouched.

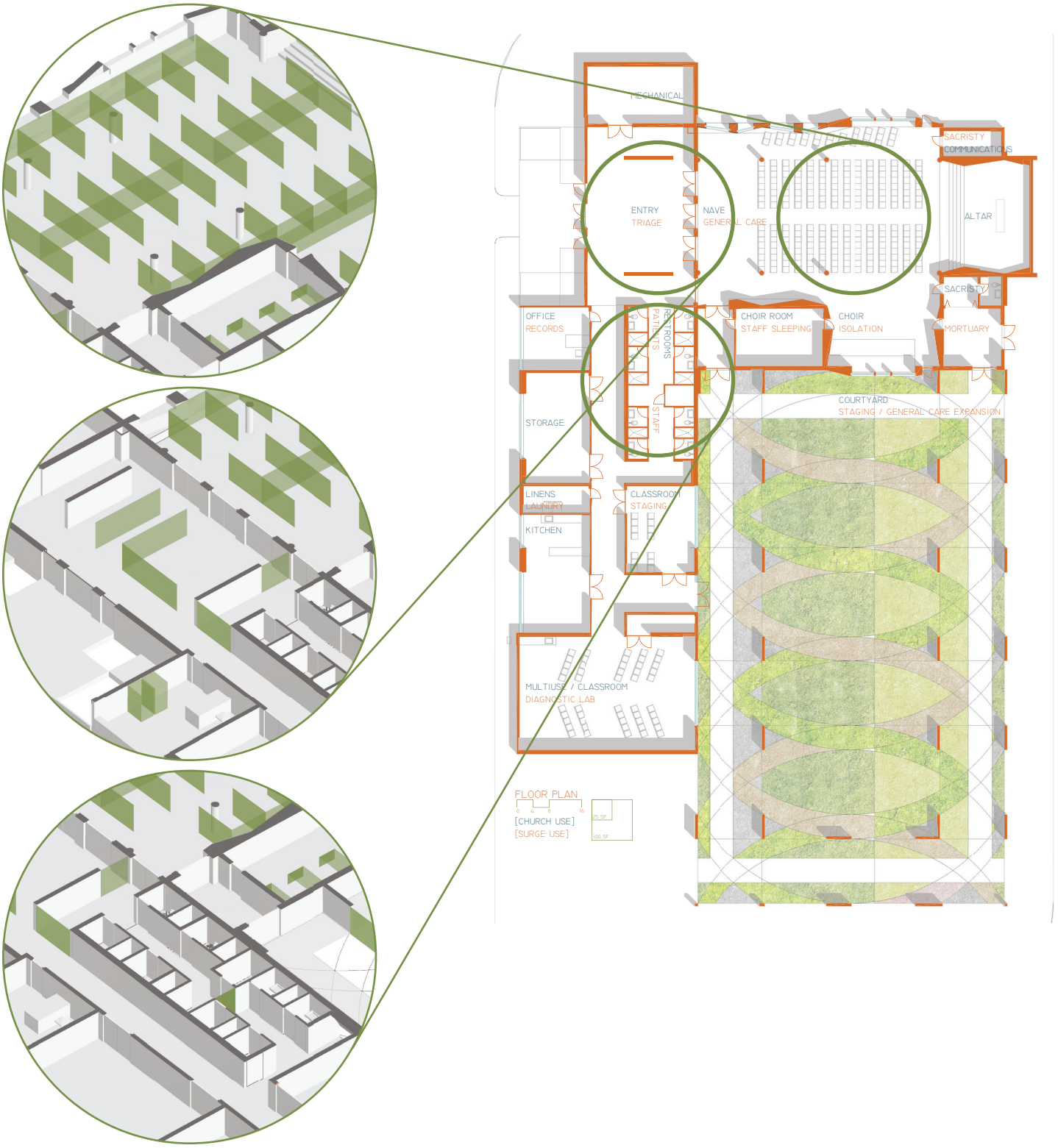




ANALYSIS: PRECEDENT RESEARCH

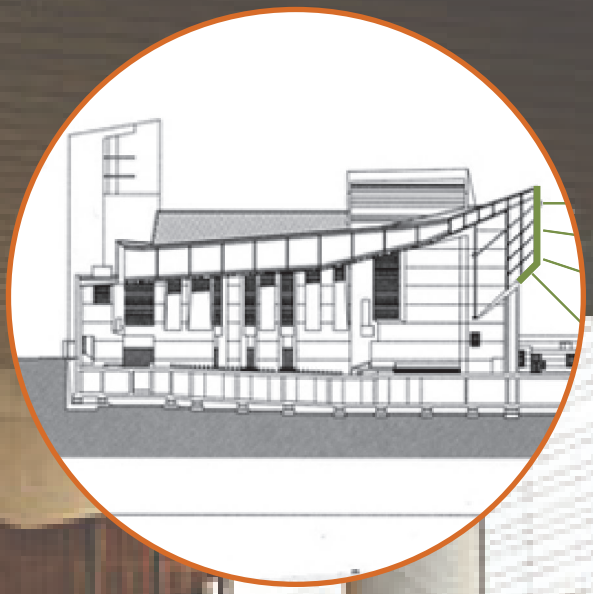
PRECEDENT 1:
ST. JOHN FIELD HOSPITAL

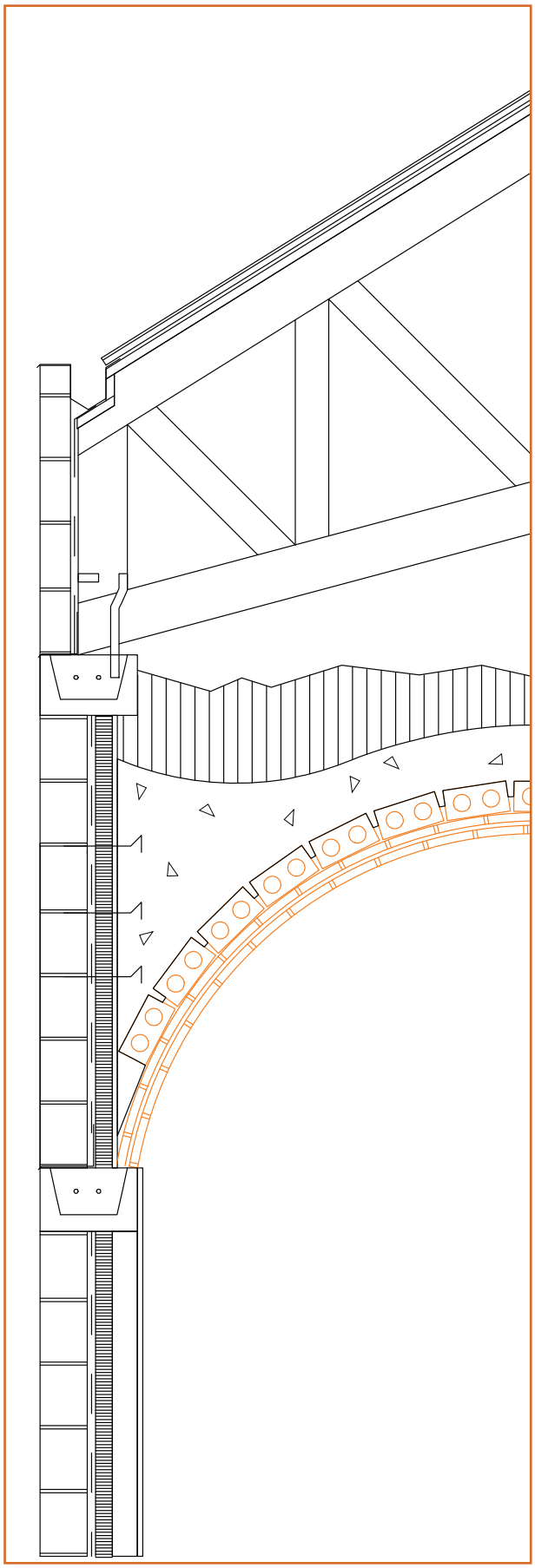
The solution addresses the example and limitations of the improvised COVID field hospital at St. John the Divine. By providing an environment that is intentionally suited to emergency medical installations, rather than one in which such interventions must be improvised, the project is a further development on the typical church building's potential for adaptability and conversion.

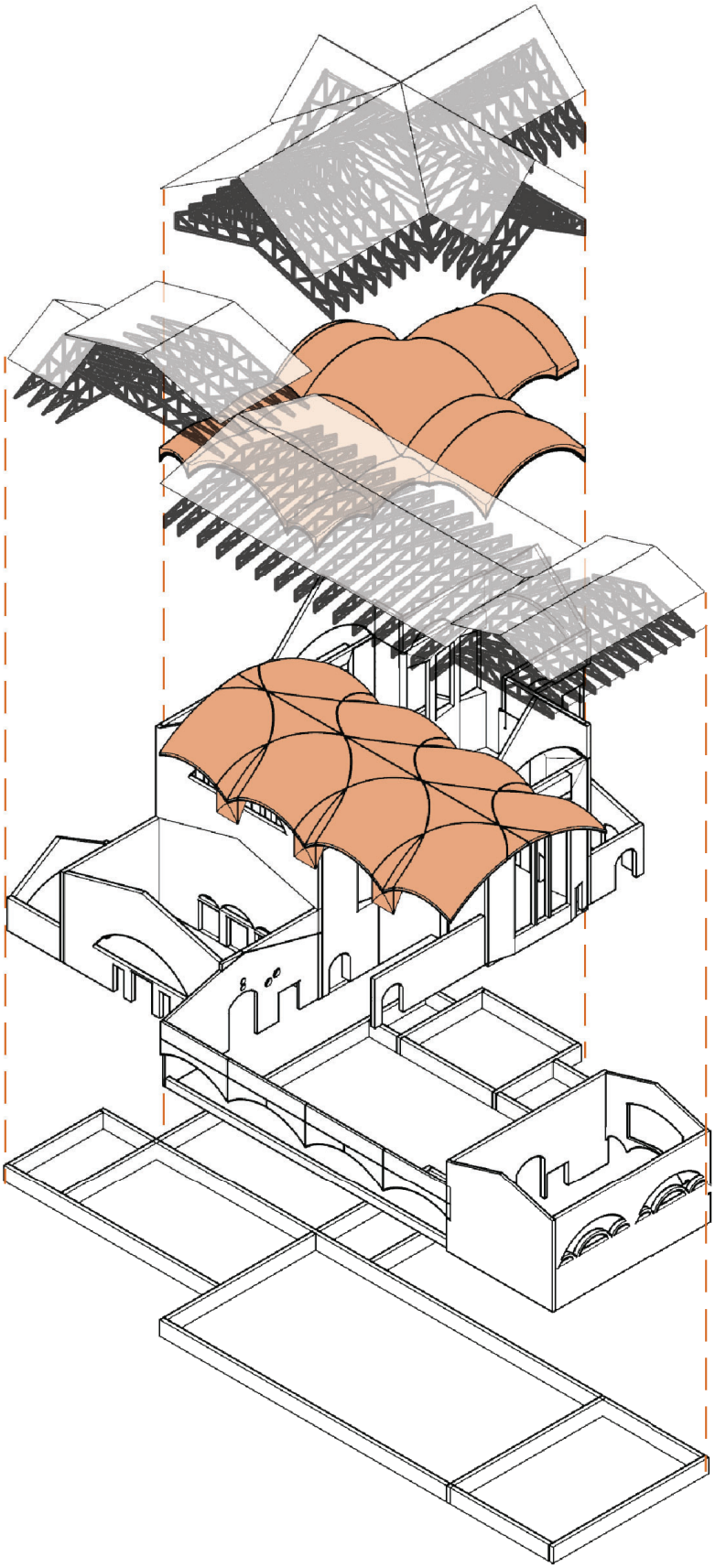


PRECEDENT II:
O.L.A. CATHEDRAL

In line with the resilience-as-aesthetic concept found in Moneo's Los Angeles cathedral, this project uses prominent ceiling vaults as structural diaphragms, a key component of the hurricane-resistant main wind force resisting system. The vaults are both an aesthetic focal point, constructed using the established sacred proportioning system, as well as an integral part of the building's ability to survive adverse natural conditions.

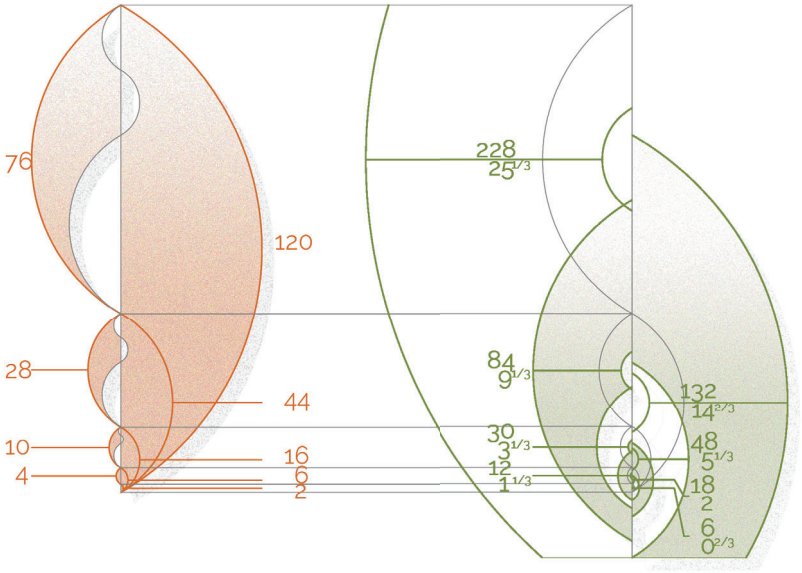


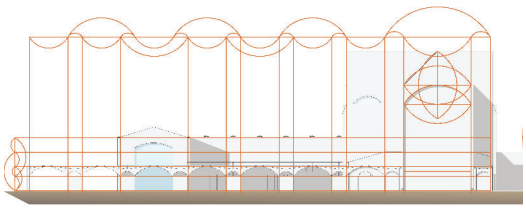


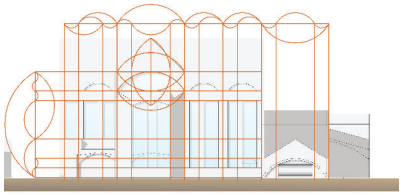


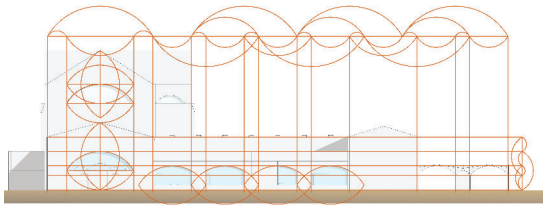
PRECEDENT III:
UNITY TEMPLE

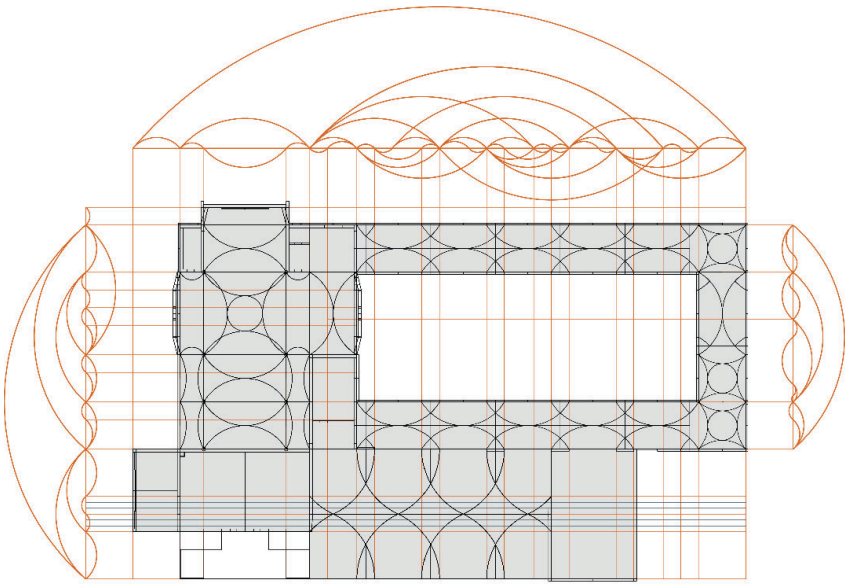
The design solution plans for future occupant changes by avoiding symbols or schematics specific to any particular denomination, instead relying on a more universal Christian vocabulary of sacred geometry. This approach is similar to that used by Wright at Unity Temple, where geometry and proportion replace conventional representation.

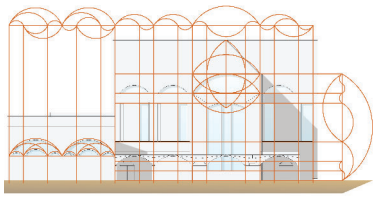


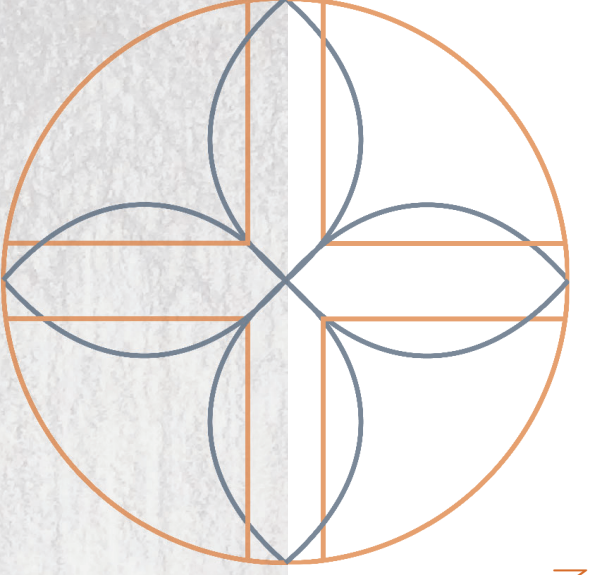












ANALYSIS: PROJECT GOALS

SPACE ALLOCATION:

Initial room area estimates vary significantly from final totals, due to the higher priority of maintaining a consistent geometric ordering system throughout the building. In spite of the numerical differences, most of the final spaces occupy nearly the same percentages of the total area as their original estimates.

INITIAL SPACE ALLOCATION

CHURCH	AREA (SF)	%	SURGE
NAVE (250 SEATS)	2400	23.1	GENERAL CARE (27 BEDS)
CHANCEL	600	5.8	
CHOIR / ORGAN	550	5.3	ISOLATION / I.C.U. (6 BEDS)
GATHERING / NARTHEX	1250	12.0	VOLUNTEER STAGING (500 SF)
			RECEPTION / TRIAGE (750 SF)
SUNDAY SCHOOL / CRY ROOM	450	4.3	STAFF STAGING
VESTING SACRISTY	200	1.9	MORTUARY
WORK SACRISTY	80	0.8	COMMUNICATIONS
CHOIR ROOM	275	2.6	STAFF SLEEPING
BIBLE STUDY	900	8.6	LAB / DIAGNOSTICS
KITCHEN	400	3.8	CAFETERIA
RESTROOMS	500	4.8	RESTROOMS / SHOWERS
	50	0.5	LAUNDRY
OFFICE	150	1.4	RECORDS
MECHANICAL	400	3.8	MECHANICAL
CIRCULATION	2050	19.7	STORAGE
STORAGE	155	1.5	STORAGE
TOTAL	10,410	100	TOTAL

FINAL SPACE ALLOCATION

CHURCH	AREA (SF)	%	SURGE
NAVE (250 SEATS)	2520	25.2	GENERAL CARE (27 BEDS)
CHANCEL	400	4.0	
CHOIR / ORGAN	405	4.1	ISOLATION / I.C.U. (6 BEDS)
GATHERING / NARTHEX	1144	11.5	VOLUNTEER STAGING
			RECEPTION / TRIAGE
SUNDAY SCHOOL / CRY ROOM	336	3.4	STAFF STAGING
VESTING SACRISTY	308	3.1	MORTUARY
WORK SACRISTY	84	0.8	COMMUNICATIONS
CHOIR ROOM	294	2.9	STAFF SLEEPING
BIBLE STUDY	1232	12.3	LAB / DIAGNOSTICS
KITCHEN	464	4.6	CAFETERIA
RESTROOMS	592	5.9	RESTROOMS / SHOWERS
	96	1.0	LAUNDRY
OFFICE	256	2.6	RECORDS
MECHANICAL	364	3.6	MECHANICAL
CIRCULATION	992	9.9	STORAGE
STORAGE	502	5.0	STORAGE
TOTAL	9989	100	TOTAL

BUDGET:

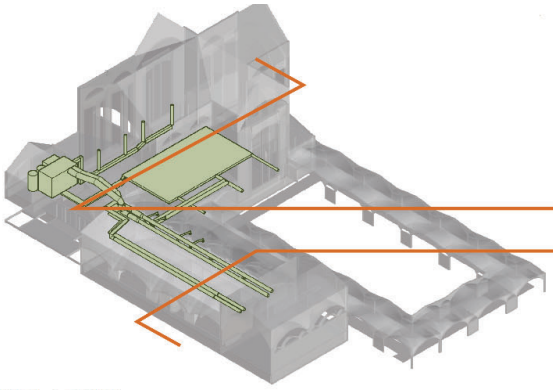
High-level estimates of project costs reflect the difference between allocated and actual development area. The unit cost of $250/sf follows a qualitative assessment of mid-range building materials and construction methods. Much of the building can be constructed by economical means, even including the thin-tile ceiling vaults.

INITIAL BUDGET

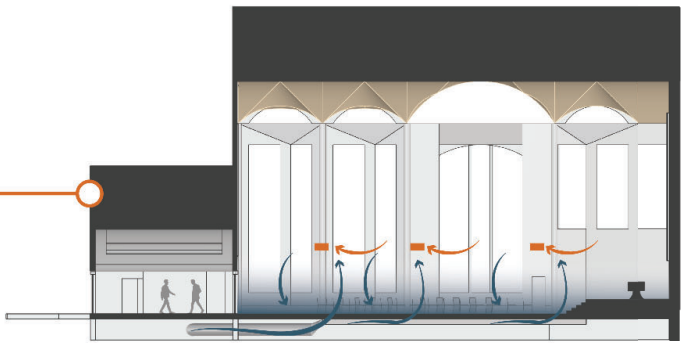
	ITEM	COST	CALCULATION	
A	BUILDING COSTS	$3,192,265.63	UNIT PRICE:	$250/SF
B	FIXED EQUIPMENT	$638,453.13	% of A:	20%
C	SITE DEVELOPMENT	$478,839.84	% of A:	15%
D	TOTAL CONSTRUCTION	**$4,309,558.59**		
E	LAND ACQUISITION	$3,200,000.00		
F	MOVABLE EQUIPMENT	$478,839.84	% of A:	15%
G	PROFESSIONAL FEES	$301,669.10	% of D:	7%
H	CONTINGENCIES	$430,955.86	% of D:	10%
I	ADMINISTRATIVE COSTS	$43,095.59	% of D:	1%
J	**TOTAL BUDGET**	**$8,764,118.98**		

FINAL BUDGET

	ITEM	COST	CALCULATION	
A	BUILDING COSTS	$2,497,250.00	UNIT PRICE:	$250/SF
B	FIXED EQUIPMENT	$499,450.00	% of A:	20%
C	SITE DEVELOPMENT	$374,587.50	% of A:	15%
D	TOTAL CONSTRUCTION	**$3,200,000.00**		
E	LAND ACQUISITION	$3,200,000.00		
F	MOVABLE EQUIPMENT	$374,587.50	% of A:	15%
G	PROFESSIONAL FEES	$235,990.13	% of D:	7%
H	CONTINGENCIES	$337,128.75	% of D:	10%
I	ADMINISTRATIVE COSTS	#33,712.88	% of D:	1%
J	**TOTAL BUDGET**	**$7,552,706.75**		



VENTILATION



UNDERFLOOR AIR DISTRIBUTION

SOFFIT DISTRIBUTION

RETURN

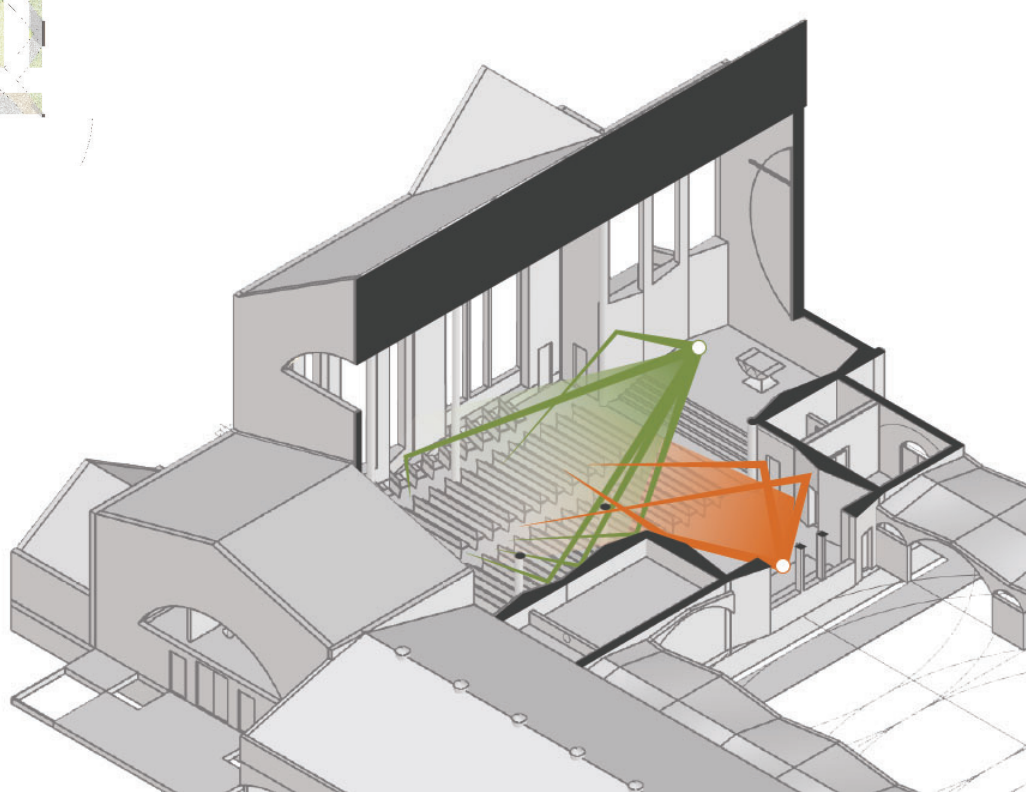
SUPPLY

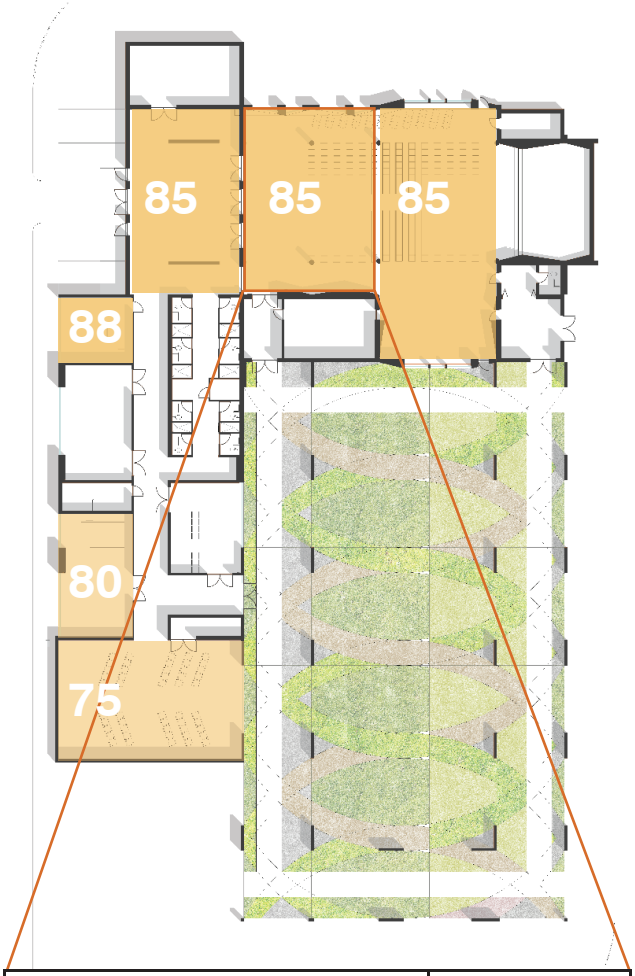
VENTILATION:

Established ventilation requirements, shown in the plan at left in cubic feet per minute, reflect the worst-case scenario requirement of forced air ventilation for surge use. The building's variable air volume system with soffit distribution, as well as underfloor air supply to more efficiently condition the high-ceilinged church, easily adapts to either church or surge use without requiring structural adjustment.

ACOUSTICS:

The angled walls of the church space imitate the acoustical control of an auditorium, specifically positioned to direct sound from the altar and choir throughout the seating area.



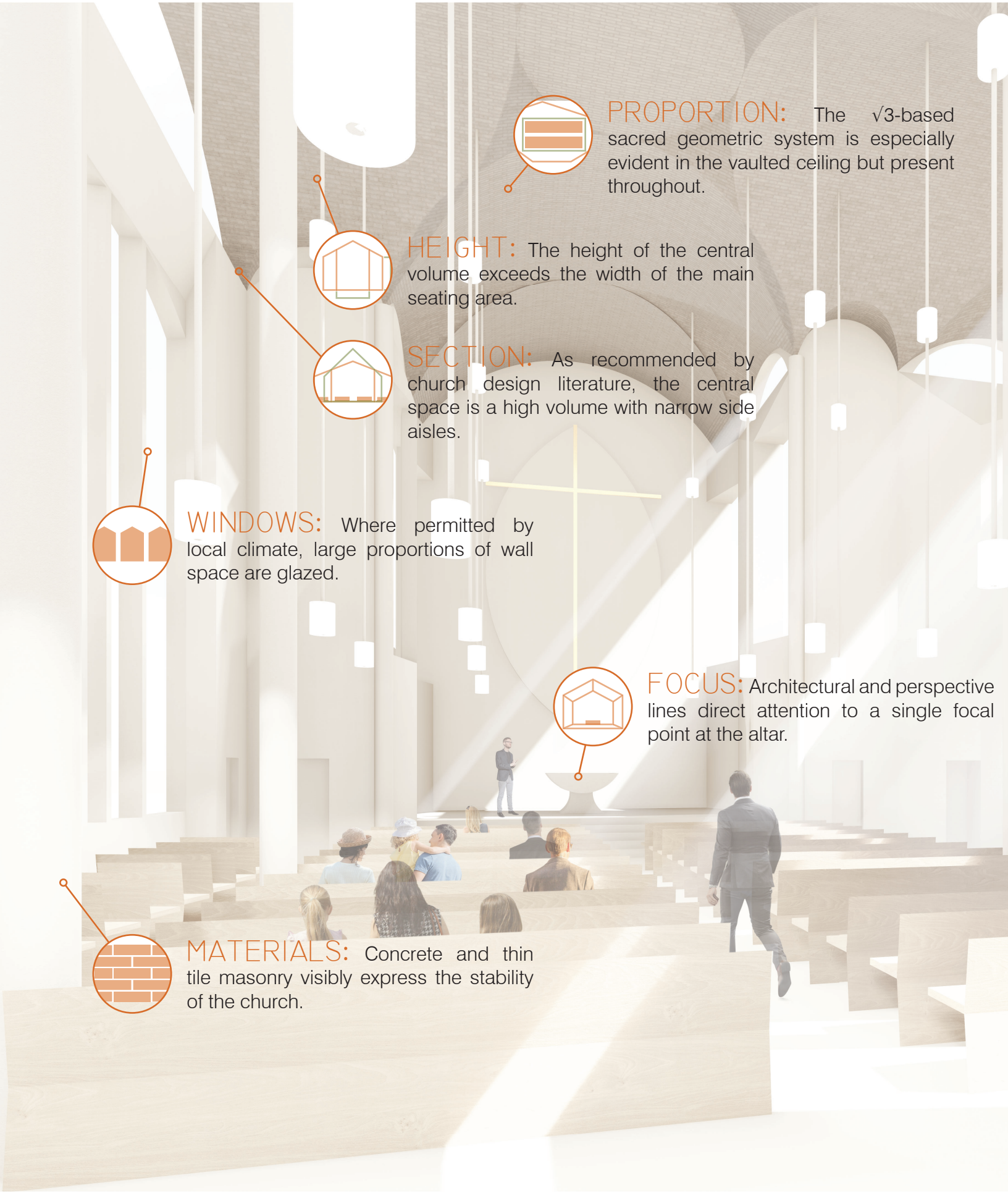


Window height (H) (ft)	18
Room depth in plan (ft)	22
Depth in terms of H	**1.22**
Window width (ft)	10
Number of windows	2
Length of window wall (ft)	32
Window coverage	**62.5%**
Design daylight factor (%)	**5.50**
Correction factors	[Enter 1.0 if N/A]
A. Transmittance	0.95
B. Dirt	0.8
C. Alternate time periods	1
Service DF (%)	**4.18**
Req'd Int. Illuminance (lux)	500
Req'd Ext. Illuminance (lux)	**11,962**
% working hours when adqt	**85**

LIGHTING:

The sample calculation method below, adapted from *Mechanical and Electrical Equipment for Buildings*, estimates the percentage of occupied hours during which a room will have adequate daylighting (expressed in the plan at left) as well as fixture requirements for artificial lighting.

ARTIFICIAL UNIFORM LIGHTING	
Ceiling material	Gyp
Ceiling reflectance	75
Wall material	CMU
Wall reflectance	55
Floor material	Tile
Floor reflectance	40
Fixture height	12
Ceiling cavity height	32
Room cavity height	9
Floor cavity height	3
Room length	32
Room width	22
Work plane area	704
CCR (ceiling cav ratio)	12.27
RCR (room cav ratio)	3.45
FCR (floor cav ratio)	1.15
Ceiling cav reflectance (rcc)	~8
Wall reflectance	55
Luminaire selection	#18
Coefficient of Utilization	0.392
S/MH	1.5
Maximum spacing (ft)	13.5
Desired illuminance (lux)	800
Equivalent footcandles (lm/sf)	74.32
Actual lamp spacing (ft)	10.00
Required flux at spacing (lm)	18959.65



PROPORTION: The √3-based sacred geometric system is especially evident in the vaulted ceiling but present throughout.

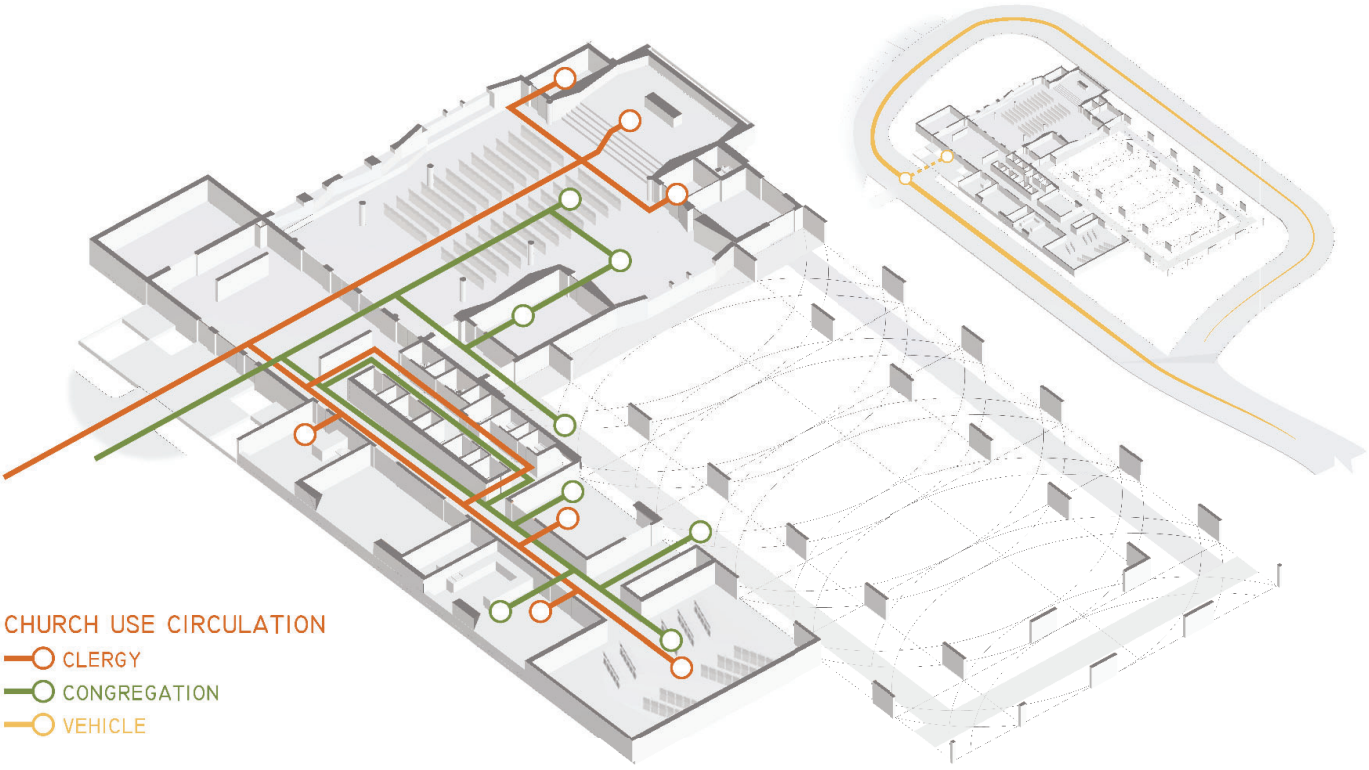
HEIGHT: The height of the central volume exceeds the width of the main seating area.

SECTION: As recommended by church design literature, the central space is a high volume with narrow side aisles.

WINDOWS: Where permitted by local climate, large proportions of wall space are glazed.

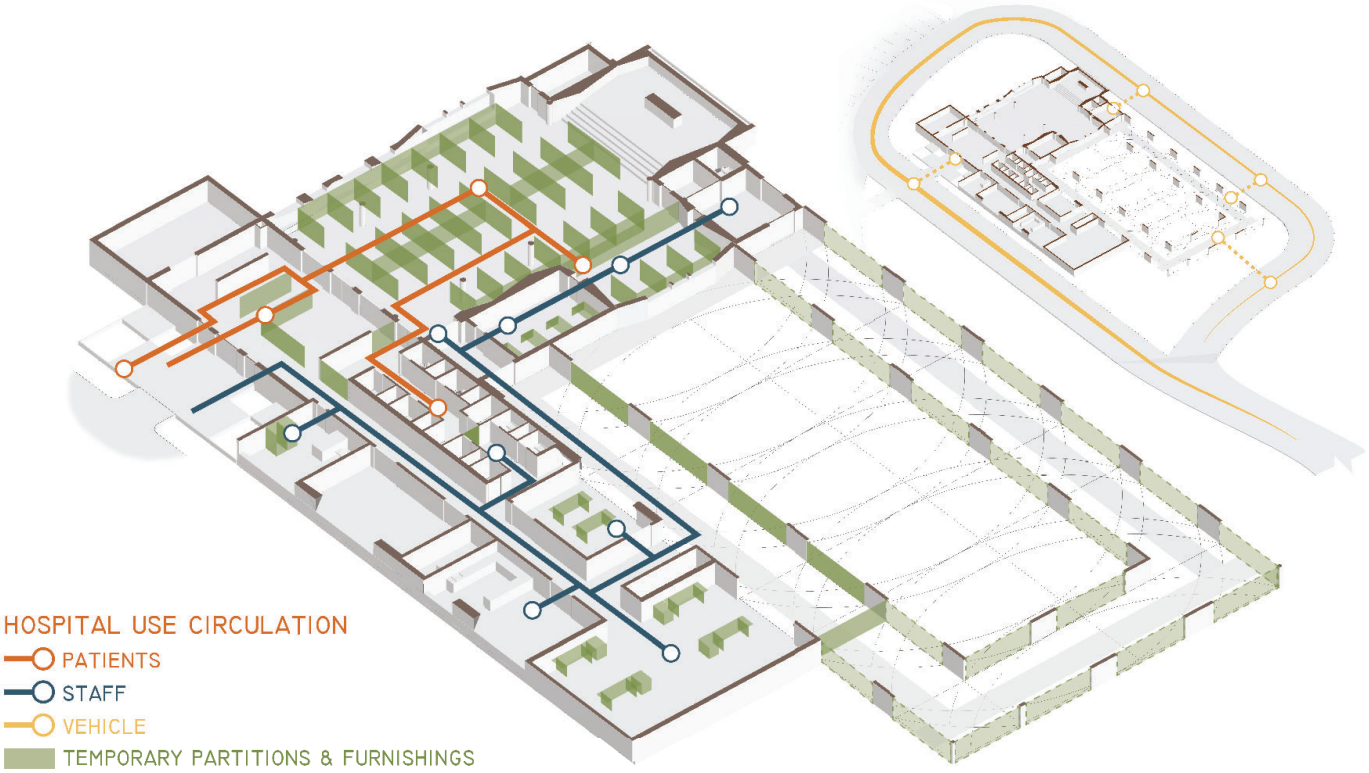
FOCUS: Architectural and perspective lines direct attention to a single focal point at the altar.

MATERIALS: Concrete and thin tile masonry visibly express the stability of the church.



BEHAVIORAL PERFORMANCE

The building plan establishes a flexible framework that changes easily between uses. Existing circulation routes are repurposed and adapted with minimal modification, defining an accommodating environment that efficiently supports a dual range of occupant behaviors.

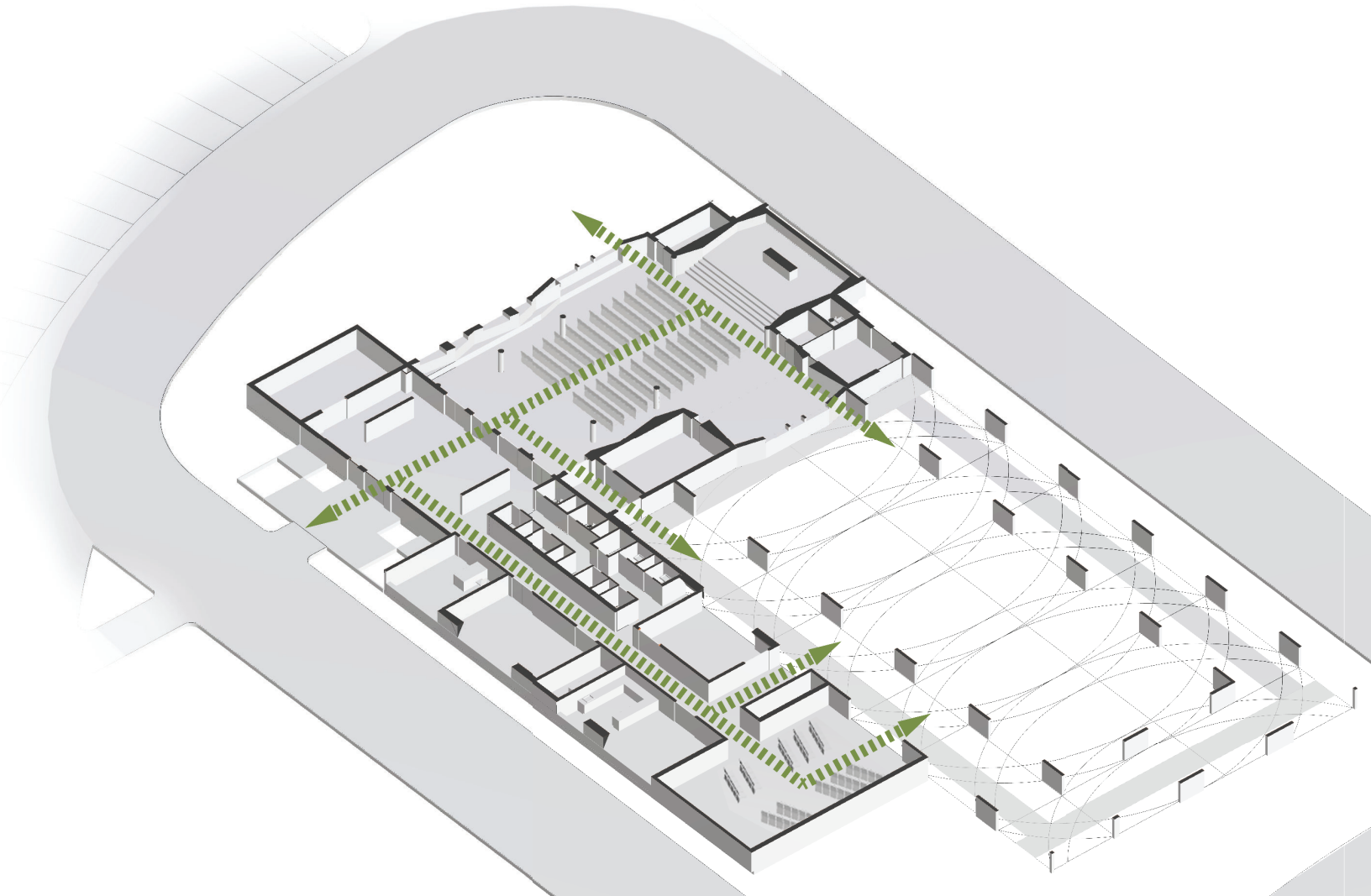


CODE COMPLIANCE:

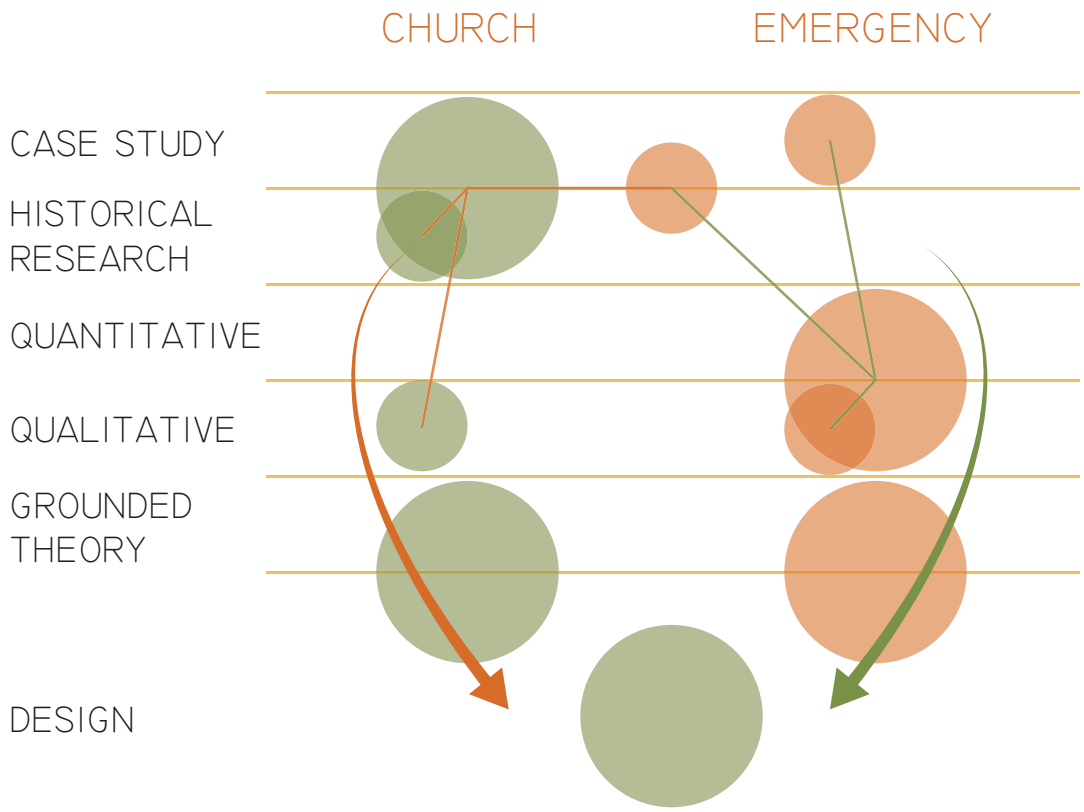
The design solution was organized using the 2018 International Building Code, currently in use at the project location, to ensure basic life safety and occupant comfort. In particular, plumbing fixture calculations and egress requirements were informed by the IBC, such as the general egress schematic below.

MATERIALS:

In accordance with the dual function of the project, interior finishes are intended to be non-porous and easily sealed and sterilized. The interior rendering at right suggests the use of ceramic floor tiles and gypsum wall board surfaces, while other materials like the thin vaulting tile are kept well above the level of human activity.



RESEARCH CRITIQUE



CASE STUDY:

Both sides of this project drew on case study research to inform the solution. Although the product of this research does not resemble its contemporary church objects, observable themes and design intents in referenced projects guided the goals and development of the design.

Medical-side case studies focused on precedent field hospital designs, summarizing documented methods and outcomes. This study produced a general list of requirements and concerns that guided the design of a fully adaptable building.

HISTORICAL RESEARCH:

Conducted historical research dealt almost exclusively with the church side of this project. A survey of precedents and literature over an approximate 100-year period provided a general understanding of differing views on appropriate church design and which among them were best suited to the present work. This study helped to develop not only a rationale for elements and ideas selected, but also a reasoned explanation for those that were discarded.

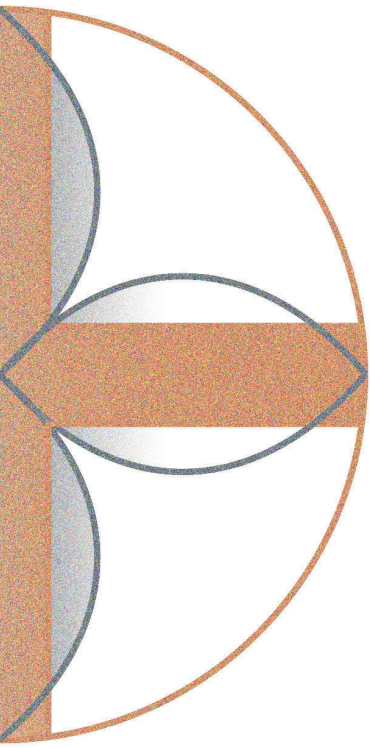
QUALITATIVE RESEARCH:

Recently published high-level resources on healthcare facility design aided the development of a qualitative program to be accommodated by surge conversion. While this area of study yielded some information on ideal room areas, dimensioned plans, etc., most of the collected data informed the functions of plan spaces and circulation schematics between them, apart from numerical assessment methods.

GROUNDED THEORY:

The research-based quality of grounded theory in design is most evident in the aesthetic composition of the church building. Rather than haphazardly borrow well-known visible elements from historical church building styles, this project began with a basic investigation of church design theories and sacred ordering systems. This research-guided approach led to the development of a church project that is consistent with its historic forbears without plagiarizing them.

Grounded theory is also evident in the surge care side of the project. Through a survey of current healthcare design guides as well as field hospital case studies, emergency care assumptions were supplanted by informed decisions on healthcare programming and function. The final design product, then, is firmly based in research on both sides of its function, and defensible in terms of theory and precedent.



APPENDIX

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PREVIOUS STUDIO EXPERIENCE

SECOND YEAR

FALL 2017: Charlott Greub, Studio Instructor
Tea House
Rowing Club Boathouse

SPRING 2018: Cindy Urness, Studio Instructor
Single-Occupant House
Downtown Mixed-Use Apartments

THIRD YEAR

FALL 2018: Mark Barnhouse, Studio Instructor
Entomology Lab
Industrial Design Office

SPRING 2019: Emily Guo, Studio Instructor
Assisted Living Home
Native American Art Museum

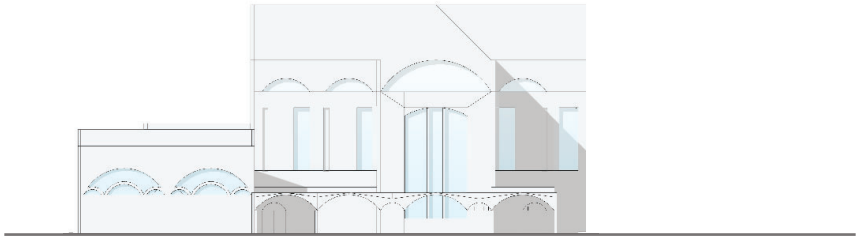
FOURTH YEAR

FALL 2019: Mark Barnhouse, Studio Instructor
Capstone Project: Mixed-Use High Rise

SPRING 2020: Mark Barnhouse, Studio Instructor
Single-Family House
Groundwater Replenishment Facility Master Plan

FIFTH YEAR

FALL 2020: Lance Josal, Studio Instructor
Fenway Park Surge Health Care Renovation



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