

Internal Wiring Plan for High-Speed Networking at St. Paul's Episcopal Church, Milwaukee

June 3, 2022

Network Core Equipment

The network is built around a central router and controller (A), and a managed hub (B), both mounted within a rack located in an equipment room (X1) in the lower level of the church. A satellite managed hub (C) is located in an equipment room (X2) in the outer area of the rector's office on the upper level of the church. Internet service is provided by a fiberoptic cable that enters the building through the frame of the first basement window east of the bell tower at the corner of E Knapp St and N Marshall St.

Wired Connections

All in-building wired connections are 1 gigabyte Ethernet service over category 6 cabling. Power over Ethernet is provided to devices connected to Hub B (only): Ports 1-16 provide GbE, 802.3at PoE+ (max 30W), and ports 1-24 provide GbE, 802.3bt PoE++ (max 60W). Connections that include publicly visible cabling (A1, A2, B5, B11, and C2-C8) should be white, so as not to call attention to themselves. All other cabling can be any color. The exposed vertical cable segments of connections A1, A2, and B11 can be secured using white or clear cable ties: Conduit is not required. The exposed portion of cables B5, B11, and C2-C8 can be secured to walls and ceilings using appropriate white or clear cable fasteners, and do not require conduit or raceways/covers. Cables C1-C8 should be terminated with Cat6 RJ45 surface mount jacks near the devices to which they connect by Cat6 patch cables.

Hub Interconnection and Upper-level Service

Hubs A and B are interconnected by a fiberoptic jumper cable. The satellite Hub C is connected to Hub A by redundant Ethernet connections (A1 and A2). Most service on the upper level of the building is provided from Hub C, and Power over Ethernet is not required. The one exception is the WiFi access point serving the rector's office and choir room, which connects directly to Hub B on port 11. These three connections from the lower-level hubs to service on the upper level follow existing fire alarm cabling that originates just outside the girls' bathroom on the lower level to the ceiling of the upper-level hallway at the foot of the stairs leading to the rector's office suite.

Ground-level WiFi Service

Most of the building service is intended for use by WiFi clients throughout the ground-level floor. But the WiFi access points are, with one exception, installed in the ceiling of the lower level. The advantage of this model is that the WiFi hubs are hidden in the historic nave, great hall, kitchen, and community room of the ground level. The ground-level floors (lower-level ceilings) are mostly wood construction except for the concrete-reinforced altar area, which is relatively transparent to the WiFi signal. By contrast, wood, concrete, and metal substantially block WiFi signals.

Library and Staff Office WiFi Service

The single exception to the installation model described in the previous paragraph is the WiFi access point installed in the ground floor acolyte room, servicing the ground floor library, hallway, and upper-level staff office suite. That WiFi access point connects to Hub B on port 13. The Ethernet cable for that room is run through a small hole in the floor of the acolyte room to the dropped ceiling of the classroom below, effectively hiding it from public view on both levels.

Wired Connections for Office Computing

The computers and other devices (copier and postage meter) in the upper-level office suite have the option of connecting by WiFi as described in the previous paragraph, but also are hard-wired to Hub C in the equipment room within the upper-level rector office suite. The cabling travels through small existing holes between the equipment room and the staff office suite across from the finance office, along the wall north wall that includes built-in book shelves.

Rector's Office

The cabling for the wired connection in use in the rector's office already exists, and will be connected directly to Hub C, port 1.

WiFi Access Points Used

Six of the seven access points to be part of the initial rollout of the new network are UniFi "Access Point WiFi 6 Long-Range" (U6-LR-US) devices offering WiFi 6 (802.11ax) service, connecting up to 300 WiFi connections each at a throughput up to 600 Mbps on a 2.4 GHz connection, or 2400 Mbps on a 5 GHz connection (subject to a compatible client interface). That vastly exceeds the capacity of the initial fiber internet connection, but positions the church for significant expansion as needed, and allows very high bandwidth for in-network traffic that may include streaming live video from multiple security cameras, making presentations for large gatherings, etc. The remaining access point is an UniFi "Access Point AC Pro" (UAP-AC-PRO-US), offering WiFi 5 (802.11ac) service, connecting up to 125 WiFi connections each at a throughput up to 650 Mbps on a 2.4 GHz connection, or 1300 Mbps on a 5 GHz connection (subject to a compatible client interface). The Pro device is less expensive than the U6 devices, and offers inferior connection capacity and throughput. However, its capacity still vastly exceeds that of the initial service level of the fiber internet service. This device likely will be installed to serve the sacristy or the library and office suite.

Software Management

All the UniFi equipment (including hubs A and B, and all WiFi access points) can be managed on-site, or via the internet using the UniFi Network app available for iOS, iPadOS, and Android. There also is a web-based interface that offers more detailed management. Hub C requires less management and does not require or provide Power over Ethernet service. That hub is managed by a web-based utility.

UniFi System

The heart of the network is Hub A, the Dream Machine Pro. In addition to managing our entire network, that device has the capacity to manage integrated [camera security](#), a [telephone system](#), and a modern [door access](#) system in one platform.

Product References

- [UniFi Product Overview](#)
- Hub A: [UniFi Dream Machine Pro \(UDM-Pro\)](#)
- Hub B: [UniFi Switch 24 PoE \(USW-Pro-24-PoE\)](#)
- Hub C: [TP-Link 16 Port Gigabit Switch \(TL-SG116E\)](#)
- WiFi 6 Access Points: [UniFi U6-LR-US Access Point](#)
- WiFi 5 Access Point: [UniFi UAP-AC-PRO-US Access Point](#)
- [UniFi Network Management Software](#)

Details of Specific Wired Connections

Note that the codes used to describe wired connections include a letter that specifies the hub from which the connection originates and a number that specifies the port number on the originating hub. For example, cable B14 originates on Hub B, port 14.

Here is a summary of the need connections. Note that “feet” includes measured horizontal distance of the recommended path to the termination (not “as the bird flies”), vertical distance traveled (including start and end points), allowance for coiling where needed, and a 5% hedge. The Status column refers to the connected equipment, not to the cable itself. Except for cable C1, all cables shown need to be installed:

Hub	Port	Terminates	Status	Feet
A	1	Hub C	GO	200
A	2	Hub C	Spare Run	200
A	3	Hub: School	Future	100
A	4	Hub: School	Future/Spare	100
B	1	Coil: Ceiling Below Parking Lot Door	Future	175
B	2	Coil: Ceiling Below Parking Lot Door	Future	175
B	3	AP: Below Kitchen	GO	150
B	4	AP: Thrift Store / Apartment	Future	240
B	5	AP: Below Community Room	GO	160
B	6	AP: Below Great Hall	GO	130
B	7	AP: Below Great Hall	Spare Run	130
B	8	AP: Below Sacristy	GO	75
B	9	Coil: Ceiling @ North Side Door	Future	120
B	10	Coil: Ceiling @ North Side Door	Future	120
B	11	AP: Rector/Choir WiFi	GO	190
B	12	AP: Below Baptistry/Console	Future	75
B	13	AP: Near Library & Below Offices	GO	150
B	14	AP: Below Nave	GO	50
B	15	AP: Below Nave	Spare Run	75
B	16	Coil: Ceiling Near Garden Door	Future	130
B	17	Coil: Ceiling Near Garden Door	Future	130
B	18	Coil: Ceiling @ South Side Door	Future	180
B	19	Coil: Ceiling @ South Side Door	Future	180
B	20	AP: Narthex	Future	125
C	1	Computer: Rector	Exists	
C	2	Computer: Bookkeeper	GO	60
C	3	Postage Meter	GO	50
C	4	Computer: Treasurer	GO	50
C	5	Copier	GO	50
C	6	Computer: Admin	GO	60
C	7	Computer: Musician	GO	60
C	8	Computer: Artist in Residence	Future	60

A1 & A2: These cables connect Hub A in the lower-level equipment room to Hub C in the upper-level equipment room. Cable A1 will be used immediately, and cable A2 will be turned off using software settings unless needed because of a physical failure of cable A1. See “Wired Connections” paragraph above for additional information.

A3 & A4: These cables optionally connect the school’s existing network to ours. Only one is needed, and the second is for redundancy. Neither will be connected initially, and they will be turned off using software settings.

B1&2, B9&10, and B16-19: These cables connect to the exterior doors that actually are in use currently, and are intended for future upgrades to the entry system. The cables should be coiled and hidden in ceiling panels until needed.

B3: Connects a WiFi access point in the ceiling of the lower-level “laundry room”, which will provide WiFi service upward through the wood floor of the kitchen on the ground floor. This access point will be part of the initial rollout of the new network.

B4: Will connect a future WiFi access point in the Thrift Store / Apartment building immediately north of the Great Hall. The two buildings do not have any connecting space (including the basement), but insulated steam pipes provide heat to the Thrift Store / Apartment building through a large pipe that terminates in the lower level of the church and in the Thrift Store / Apartment building. The cable length estimate includes a very generous allowance for termination at a location yet to be determined. There are two concerns: First, even with insulation, the short shared parallel path of the steam pipes and the Ethernet cable may exceed the cable’s operating temperature, and may damage or destroy the cable. Second, although there appears to be plenty of physical clearance in the connecting pipe, it’s not yet clear whether debris or deliberate efforts to seal the opening may block physical access. We may need to consider alternative physical paths for the cable to bridge the buildings.

B5: Connects a WiFi access point mounted to the ceiling of the lower-level “Busy Bee” classroom, which will provide WiFi service upward through the wood floor of the Community Room on the ground floor. This access point will be part of the initial rollout of the new network. See note about exposed wiring along the ceiling of the lower-level classroom in the “Wired Connections” paragraph above.

B6 & B7: Connects a WiFi access point mounted to the ceiling of the lower-level “Dolphins” classroom, which will provide WiFi service upward through the wood floor of the Great Hall on the ground floor. Initially, only B6 will be used, and B7 will be coiled in the ceiling for future use. This access point will be part of the initial rollout of the new network. Testing indicates that a single WiFi access point in this location provides a strong signal throughout the Great Hall. However, if tables and chairs are set out and the room is crowded with people, it’s possible that the WiFi signal will be noticeably degraded. In that case, an additional WiFi access point will be connected to B7, and the two access points will be separated within the dropped ceiling below the Great Hall to provide optimum coverage. The cable length shown above allows for that contingency.

B8: Connects a WiFi access point in the ceiling of the lower-level “dining room”, which will provide WiFi service upward through the wood floor of the sacristy on the ground floor. This access point will be part of the initial rollout of the new network.

B11: Connects a WiFi access point in the ceiling of the upper-level hallway, which will provide WiFi service to the Rector’s office suite and the choir room. This access point will be part of the initial rollout of the new network. See “Wired Connections” paragraph above for additional information.

B12: Can connect an optional WiFi access point in the ceiling of the lower-level furnace room, which can provide supplemental WiFi service upward through the wood floor of the nave to supplement coverage for the area around the baptistry and organ console and choir. Both those areas have diminished WiFi service because of the iron work around the baptistry and the concrete reinforced floor around the altar. The cabling will be installed and left coiled in the ceiling of the likely location of a future WiFi access point. In the near term, there is no need for this service. But possible applications might include providing reliable service at the organ console for future connections to other devices, and the ability for families to live-stream a baptism.

B13: Connects a WiFi access point in the ceiling of the ground-level acolyte room, which will provide WiFi service to the adjacent library, the well-traveled ground floor hallway, and upward through the wood floor of the staff office area on the upper floor. This access point will be part of the initial rollout of the new network. See “Library and Staff Office WiFi Service” paragraph above for additional information.

B14 & B15: Connects a WiFi access point in the ceiling of the lower-level “crafts room” (sexton space), which will provide WiFi service upward through the wood floor of the nave on the ground floor, physically near the current camera station. This access point will be part of the initial rollout of the new network. Initial testing indicates that except for baptistry, organ console, choir, and far corners of the morning chapel, a single well-placed WiFi access point provides a strong WiFi signal throughout the nave. Initially, only B14 will be used, and B15 will be coiled in the crafts room ceiling nearby. But for the same reasons described in B6 & B7 above, high occupancy in the nave may degrade the WiFi signal in that space. If that problem is observed, we can easily add an additional WiFi access point using B15, and position it where signal loss is observed. Flexible deployment of B15 is built into the cable length calculation.

B20: Can connect an optional WiFi access point in the ceiling of the “sitting room” outside the restrooms on the lower level, which can provide supplemental WiFi service upward through the wood floor of the narthex if needed. The narthex has WiFi coverage from B14 above, but the stone wall between the nave and narthex significantly degrades the signal. The cabling will be installed and left coiled in the ceiling of the likely location of a future WiFi access point. In the near term, there is no need for this service. But possible applications might include electronic kiosks in the narthex or processing credit card payments for merchandise offered at public music performances.

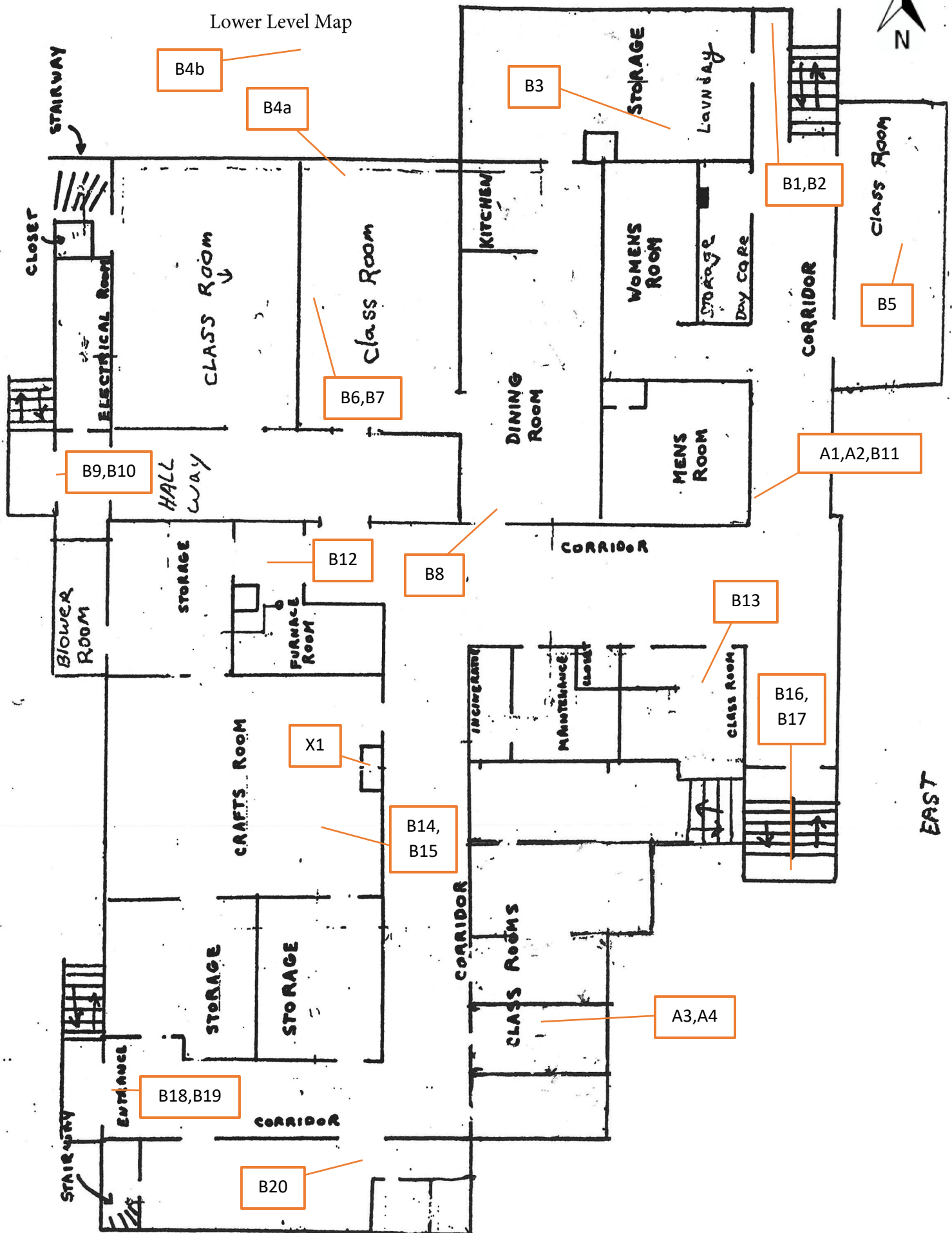
C1: This existing cable connects the upper-level equipment room to the rector’s office computer. The cable itself already exists and does not require replacement. However, the surface mount jack described at the end of the “Wired Connections” paragraph above applies.

C2-C8: See the “Wired Connections for Office Computing” paragraph above.

Lower Level Map

WEST

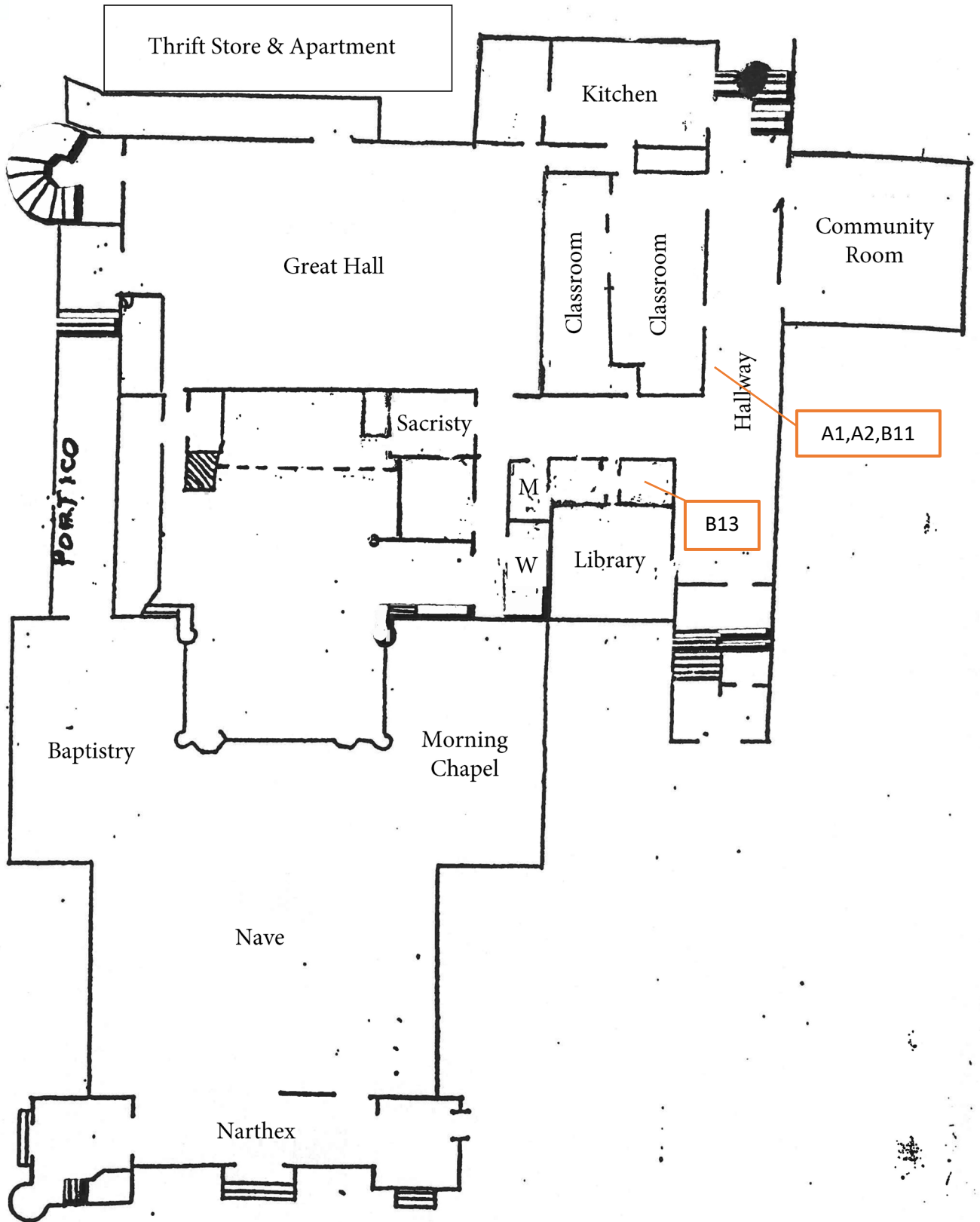
EAST



Ground Level Map



Marshall St.



Thrift Store & Apartment

Kitchen

Great Hall

Classroom

Classroom

Community Room

Hallway

A1,A2,B11

Sacristy

B13

Library

Baptistry

Morning Chapel

Nave

Narthex

Upper Floor Offices

