Table 2-1: Occupant Load and Egress Capacity

	Occupant Load (persons)		Egress Stair/Door Capacity (persons)			Available Egress (persons)
Floor	IBC	Max. Expected	West	Center	East	
3	504	473	430	575	415	1,420
2	623	197	0	720	0	720
1	161	44	880	1,320	240	2,440
Basement	171	44	220	694	220	1,134
TOTALS	**1,459**	**758**	**1,530**	**3,164**	**875**	**5,714**

Note: The IBC prescribed occupant load is nearly double the maximum expected occupant load. The IBC occupant load is not a realistic approximation of the number of building occupants at the Capitol. For this reason, **the maximum expected occupant load will be the basis of the building's assessment.**

Exit Access

Exiting and exit access was evaluated for both the **existing building** and the **proposed building** design on a per floor basis. Diagrams showing the maximum travel distances, common path of travel, and any dead-ends were created for each floor and can be found in *Figures 2-13 through 2-20* on the following pages.

Basement exit access consists of four exit doors discharging to the outdoors.

- In the **existing** floor plan, three [3] interior stairs provide access to Floor 1. Four [4] of the exit doors and two of the exit access stairs are located within the core space of the building and are available to the general public. One [1] of the stairs is located in the east suite, and the final door is located within the west suite. These exit points serve the respective suites and are not available to the general public. The maximum travel distance to an exit is approximately 135 feet; common path of egress travel is approximately 71 feet. *[Figure 2-13]*
- In the **proposed** floor plan, two [2] interior stairs provide access to Floor 1. Four [4] of the exit doors and two of the exit access stairs are located within the core space of the building and available to the general public. As part of the proposed floor plan, the existing communicating stair in the east suite has been removed. The two exit points that serve the east and west suites are not available to the general public. The maximum travel distance to an exit is 128 feet. *[Figure 2-14]*
- In addition to the exits noted, a connection to the Herschler Building exists at the Basement Level. The connection is formed by an opening in a 2-hour fire-resistance wall with 90-minute fire resistance-rated door opening, with the potential to serve as a horizontal exit between the State Capitol and the Herschler Building. The connection is not considered a horizontal exit in this analysis because it is not necessary to achieve code compliance. Potential future use will be evaluated during the Design Phase.

Floor 1 exit access is via a common public corridor providing direct connection to three of the four exits.

- In the **existing** floor plan, a fourth exit is located within the office suite at the east end of the building, providing access to the basement and additional exits if needed. The maximum travel distance to an exit is approximately 239 feet. Common path of travel is approximately 150 feet. *[Figure 2-15]*
- In the **proposed** floor plan, the aforementioned existing fourth exit no longer applies because the communicating stair will be removed. The maximum travel distance to an exit is approximately 230 feet. Common path of travel is approximately 129 feet. *[Figure 2-16]*

Floor 2 exit access for both the **existing** and **proposed** floor plans is via a common public corridor with direct connection to the interior Monumental Stairs that discharge onto Floor 1. The maximum travel distance to an exit is approximately 252 feet. Common path of travel is approximately 49 feet. *[Figures 2-17 and 2-18]*

Floor 3 exit access for both the **existing** and **proposed** floor plans is via a common public corridor to four [4] interior exit stairs – two Monumental Stairs and two stairs serving the Chambers and connecting to Floor 2. After occupants travel down any of the four interior exit access stairs, they traverse the previously referenced Monumental Stairs to reach Floor 1 and the exterior. The maximum travel distance to an exit is approximately 307 feet. Common path of travel is approximately 65 feet. *[Figures 2-19 and 2-20]*

In the existing building configuration with the exterior fire escape stairs, travel distances appear to be less than 200 feet as permitted within a nonsprinklered business occupancy. Removal of the fire escape stairs in the current building configuration demonstrates only slightly longer travel distances. Due to the relatively small building footprint, the majority of travel distances within the building are limited to less than 300 feet., the permitted travel distance in a sprinklered business occupancy.

With the exception of the Governor's Suite on the First Floor, common path of travel is limited to 75 feet or less throughout the building due to the common public corridor and the open exit access stairs within the Chambers. It is noted that exit access for some administrative spaces requires egress through an adjacent space. *Availability of such spaces should be confirmed, if necessary, in the Design Phase.*

Dead-end corridor conditions exceeding the IEBC maximum 35-foot length for a non-sprinklered building occur on Floor 2, north side of Senate Chambers; and Floor 3, north and south side of the House Chambers. The dead-end corridor length is less than 50 feet, the maximum permitted dead-end corridor condition in a building protected with automatic sprinklers. The Floor 3 Senate Chamber seating gallery provides access to both sides of the chamber and does not create a dead-end condition.

The means of egress diagrams for the **existing** building floor plates and for the **proposed** renovated building floor plate demonstrate that, although the building is to undergo large scale interior renovations, the means of egress parameters will not be significantly changed. It is also important to note that in a few small areas within the building in both the **existing** and the **proposed** building layouts, the common path of travel or travel distance is slightly longer than that permitted in the prescriptive code. The performance based analysis will analyze these. It is anticipated that they will not be a concern.

A detailed egress analysis is provided in *Appendix M2* illustrating common paths of travel, travel distances, dead ends, and exit capacities for each floor.

Handrails and Guards

Stairs are provided with handrails and guards. Handrails on all stairs, except the Monumental Stair, comply with the existing building code with regard to height and circular cross section. Both Monumental Stairs have handrail circular cross sections that exceed 2-inches diameter, the code maximum dimension.

Guards at the monumental stairs and at the Rotunda opening on Floors 2 and 3 are approximately 30 inches measured vertically above the floor walking surface. The guard height does not comply with the IEBC requirement of a minimum 42-inch height.

Accessible Means of Egress

A passenger elevator provides access to all public floors of the building. The common public corridor is accessible on all levels.

Exit Signage and Way Finding

Exit signs are provided in some spaces but are not installed throughout the building.

Egress Illumination Emergency Power

Dedicated emergency lighting was not observed during the site visit. It was also not apparent whether lighting within the means of egress was on an emergency circuit or whether a generator was located on the premises.

Emergency Generator Power

The building is not currently provided with emergency power. The majority of the building is not currently provided with emergency lighting.

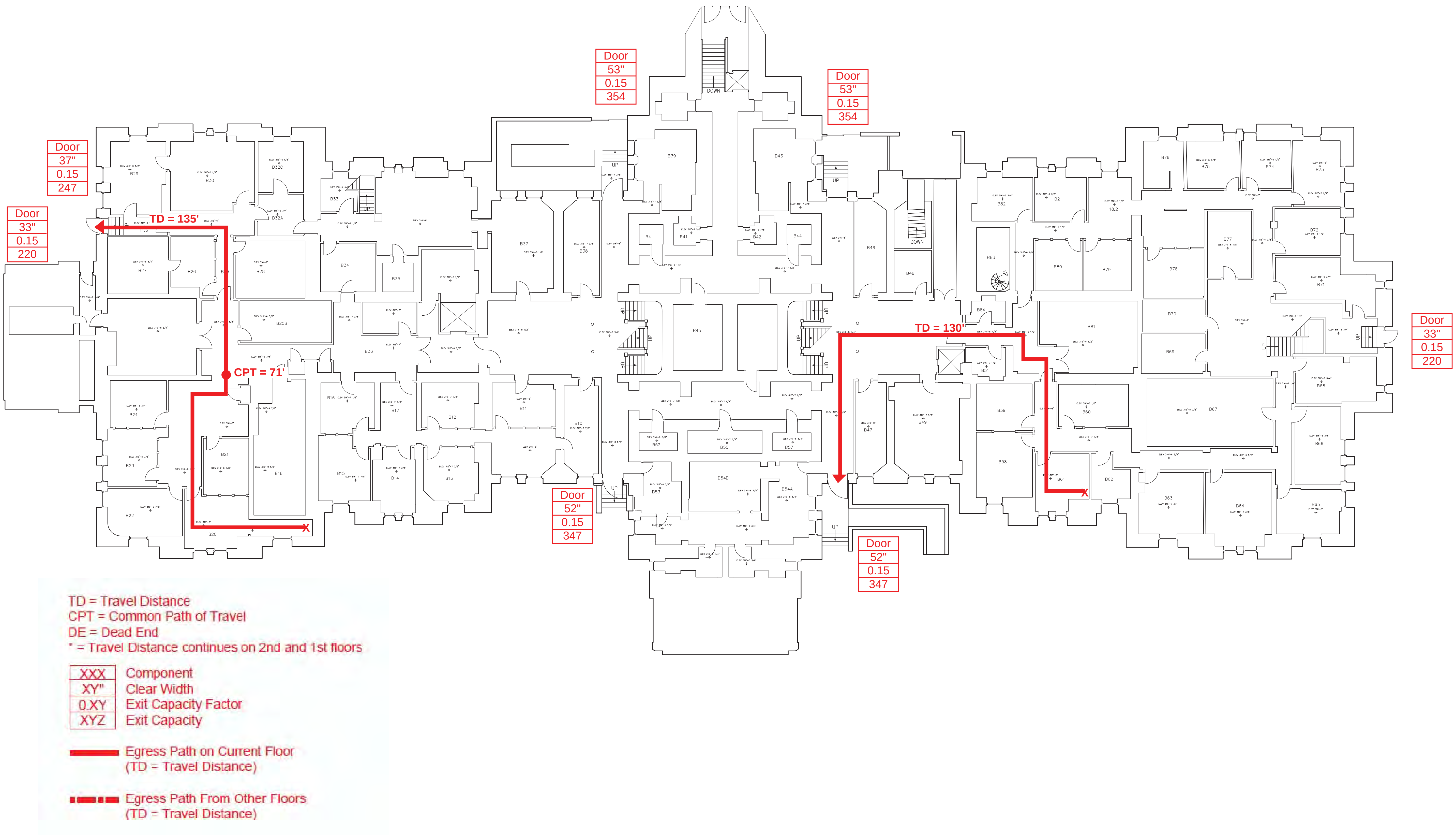
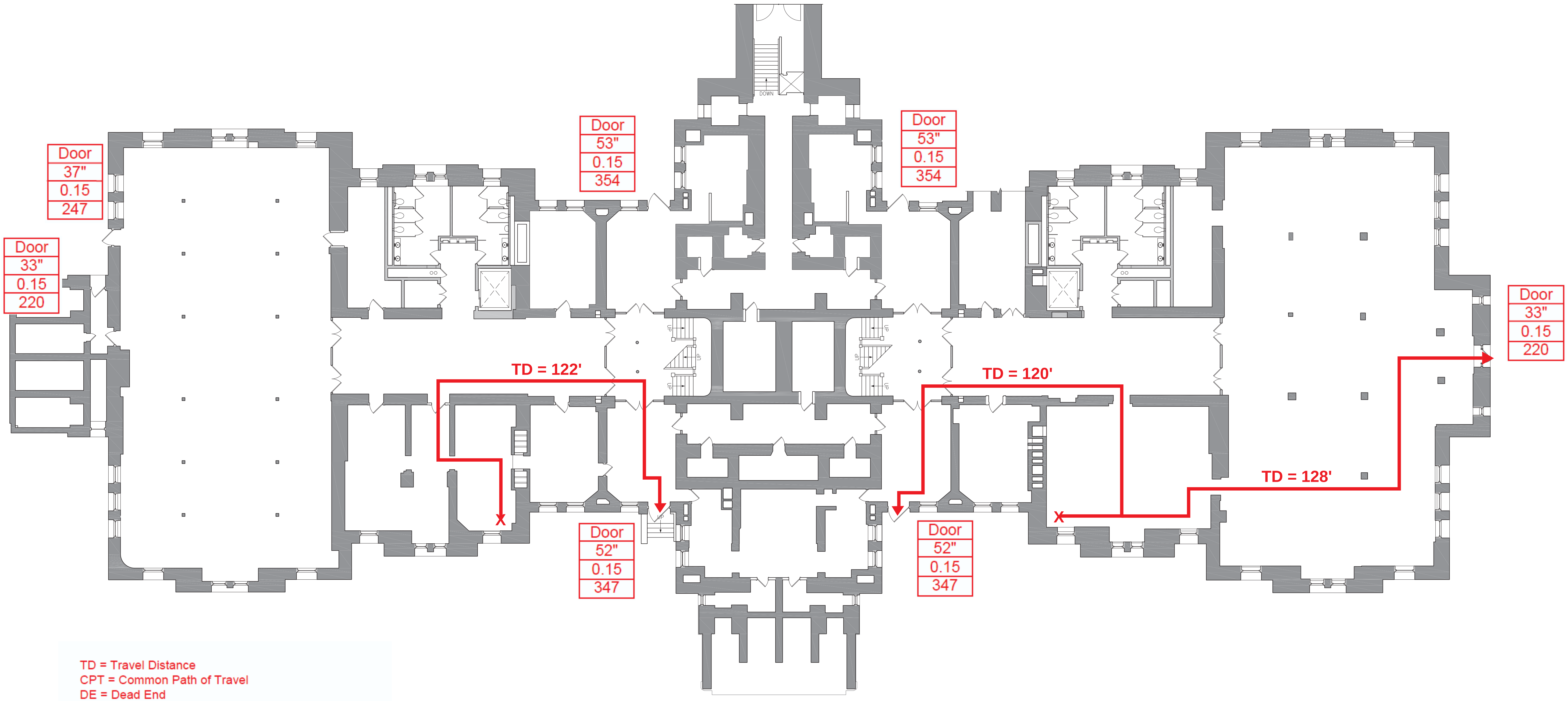


Figure 2-13. Basement Level **Existing** Egress Access.



TD = Travel Distance
CPT = Common Path of Travel
DE = Dead End
* = Travel Distance continues on 2nd and 1st floors

XXX	Component
XY"	Clear Width
0.XY	Exit Capacity Factor
XYZ	Exit Capacity

Egress Path on Current Floor (TD = Travel Distance)

Egress Path From Other Floors (TD = Travel Distance)

1 BASEMENT LEVEL PLAN
2013
0 12' 32'
PROJECT N

Figure 2-14. Basement Level **Proposed** Egress Access.

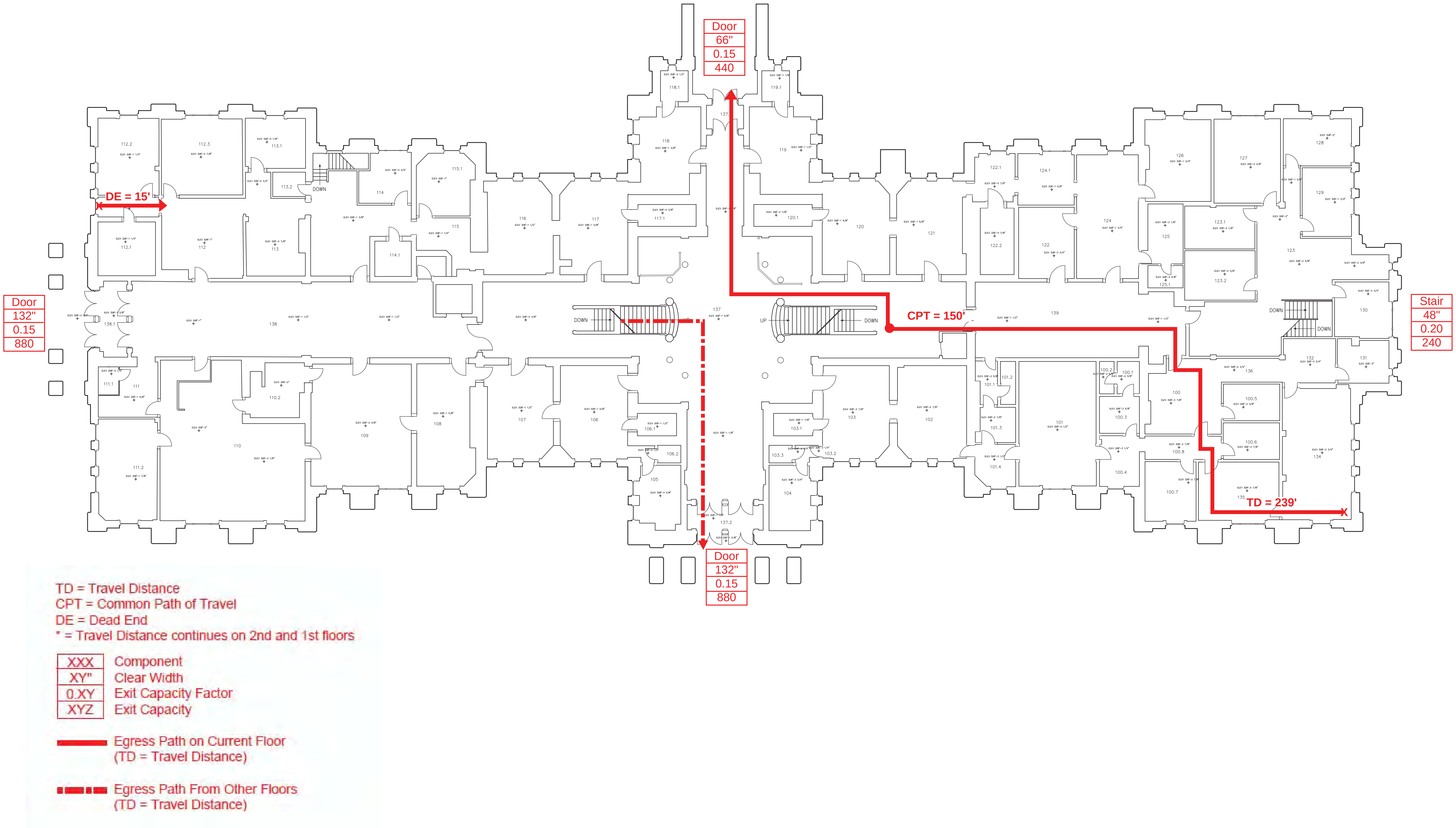


Figure 2-15. First Floor **Existing** Egress Access.

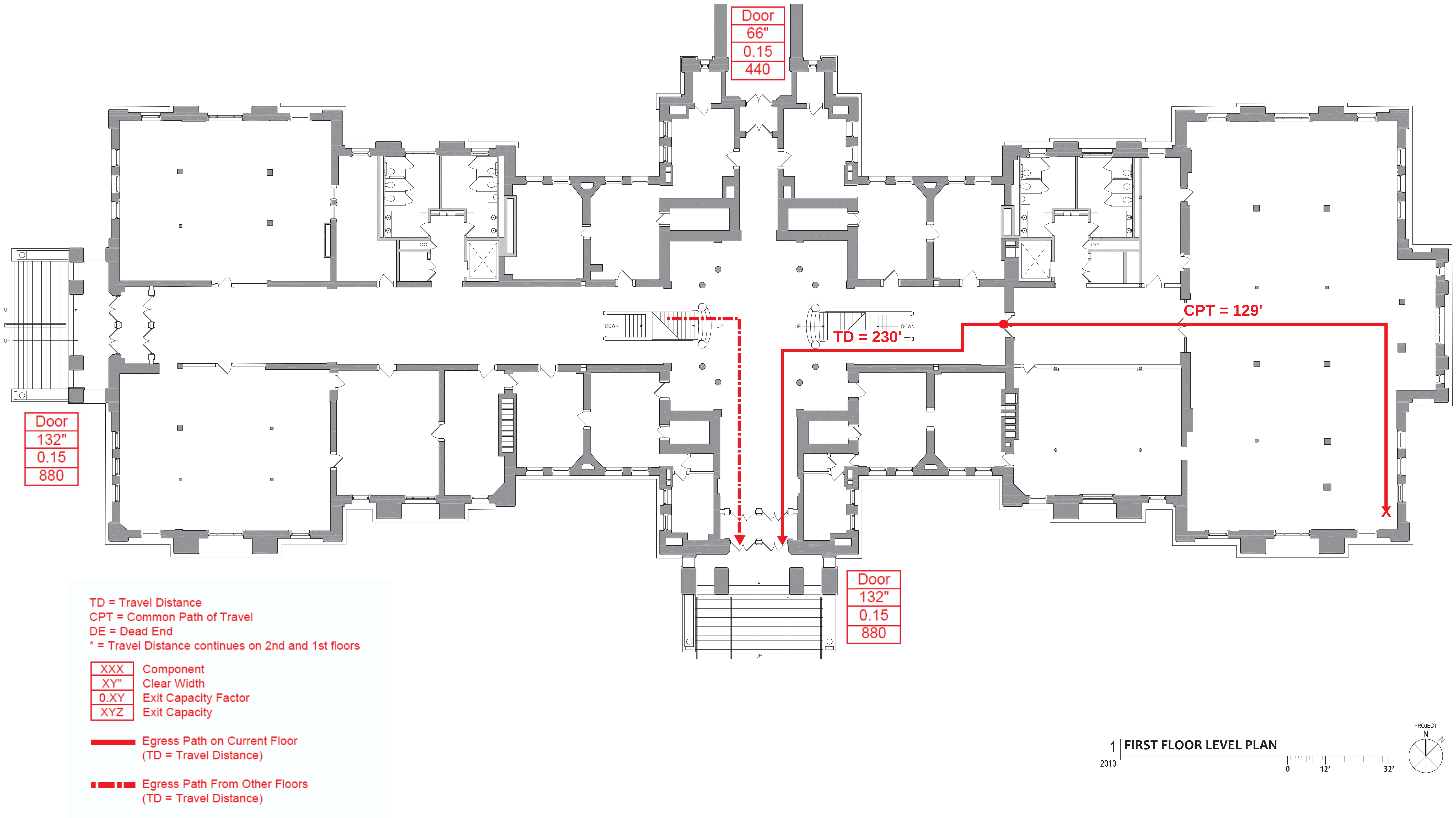
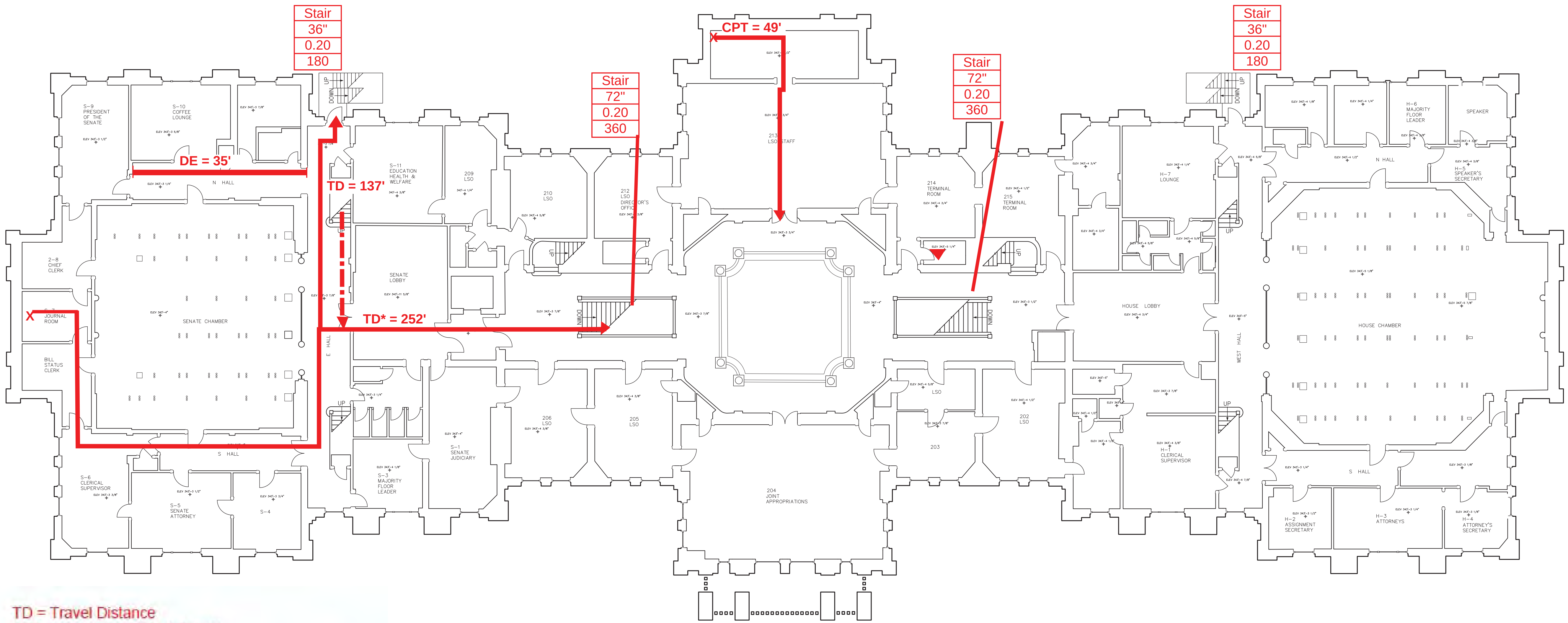


Figure 2-16. First Floor **Proposed** Egress Access.



TD = Travel Distance
CPT = Common Path of Travel
DE = Dead End
* = Travel Distance continues on 2nd and 1st floors

XXX	Component
XY"	Clear Width
0.XY	Exit Capacity Factor
XYZ	Exit Capacity

Egress Path on Current Floor (TD = Travel Distance)

Egress Path From Other Floors (TD = Travel Distance)

Figure 2-17. Second Floor **Existing** Egress Access.

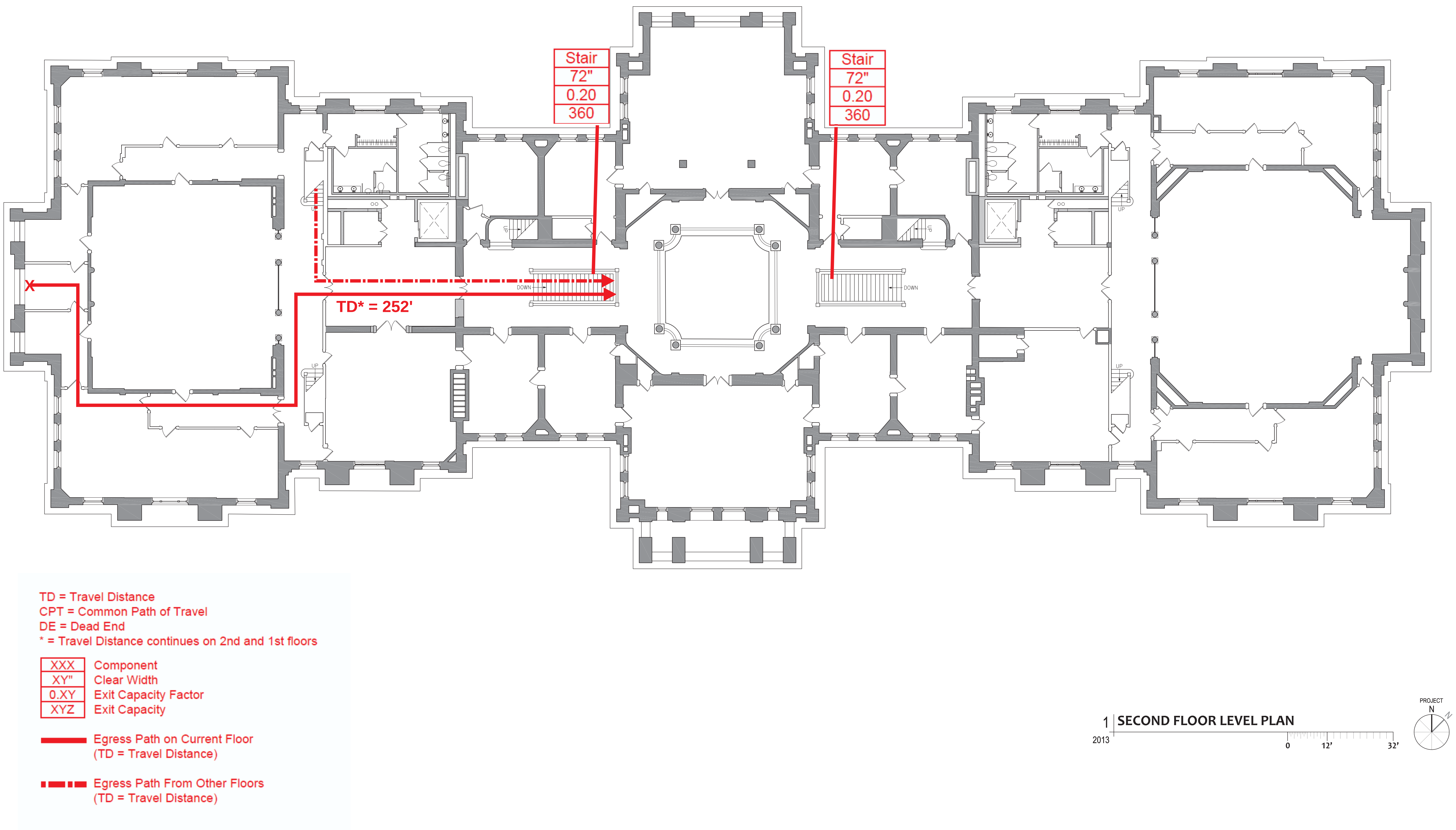
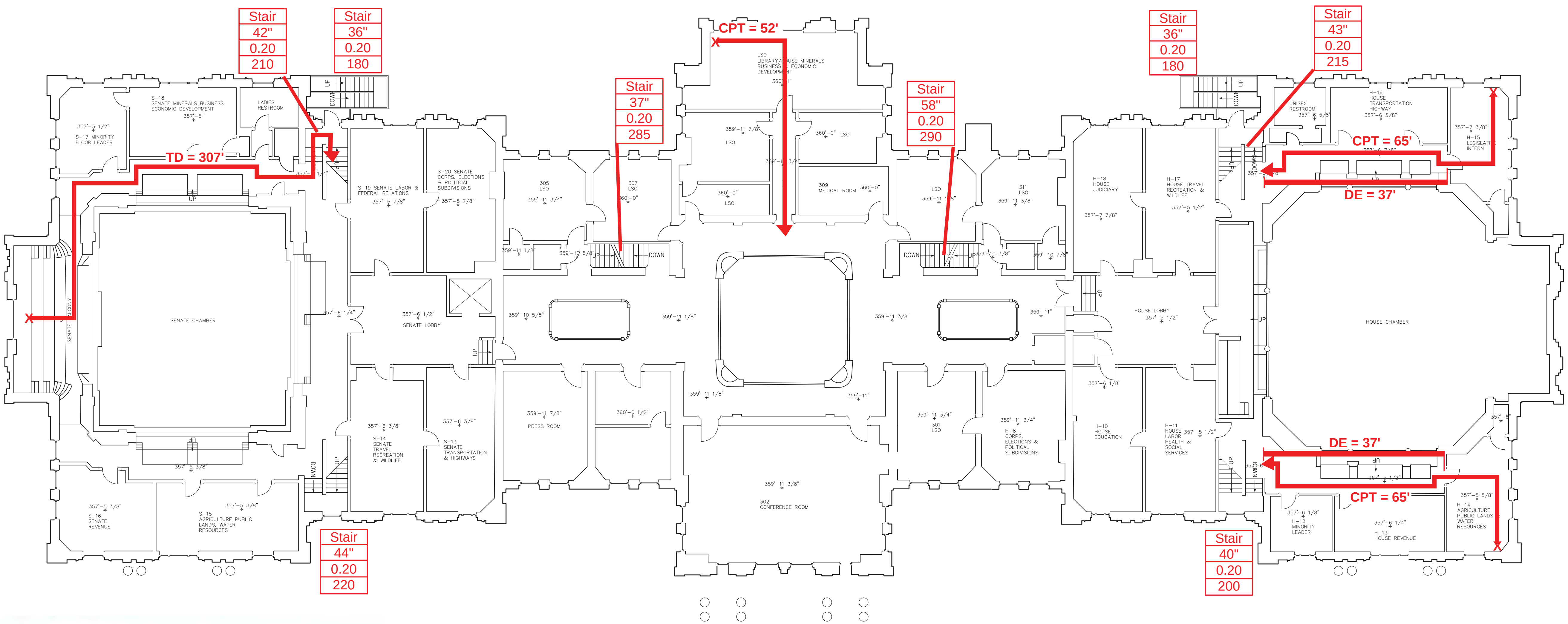


Figure 2-18. Second Floor **Proposed** Egress Access.



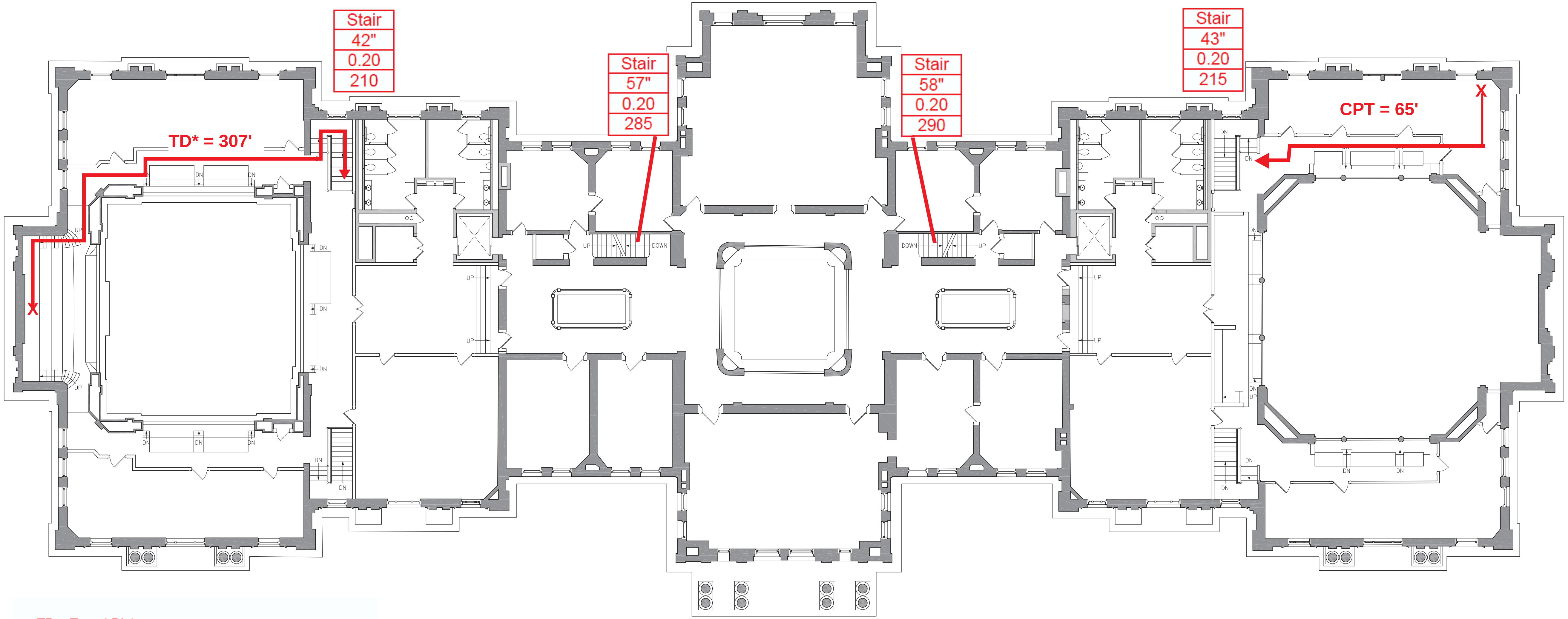
TD = Travel Distance
CPT = Common Path of Travel
DE = Dead End
* = Travel Distance continues on 2nd and 1st floors

XXX	Component
XY"	Clear Width
0.XY	Exit Capacity Factor
XYZ	Exit Capacity

Egress Path on Current Floor (TD = Travel Distance)

Egress Path From Other Floors (TD = Travel Distance)

Figure 2-19 Third Floor **Existing** Egress Access.



TD = Travel Distance
CPT = Common Path of Travel
DE = Dead End
* = Travel Distance continues on 2nd and 1st floors

XXX	Component
XY"	Clear Width
0.XY	Exit Capacity Factor
XYZ	Exit Capacity

Egress Path on Current Floor (TD = Travel Distance)

Egress Path From Other Floors (TD = Travel Distance)

1 THIRD FLOOR LEVEL PLAN
2013

Figure 2-20. Third Floor **Proposed** Egress Access.

2.5 Non-Compliance Issues

1. Fire Containment and Building Compartmentalization

Issue: The building's open interior stairways, floor openings, and Rotunda connectivity with the attic result in Floors 1 through 3 and the attic being a single fire area. Openness between floors allows for natural smoke migration and potential fire spread. The outcome will likely have a negative impact on the fire safety goals identified for the Capitol Building.

Compliance Approach: The installation of automatic fire detection and suppression throughout the building combined with fire safety subsystems to manage smoke spread will create an alternative protection strategy to the prescriptive building code compliance requirements and achieve the project's fire safety goals. See **Section 2.6** for further discussion.

2. Combustible Building Construction Materials in the Attic Spaces

Issue: Portions of the attic space contain an appreciable amount of wood construction and combustible materials. The space is not protected with an automatic fire suppression system. A fire originating in or extending to this area could result in unacceptable consequences in occupant life safety exposure and property damage.

Compliance Approach: The installation of automatic fire suppression throughout the attic space, combined with enclosing unnecessary openings / connectivity between the attic and the building floors below, will result in a protection strategy that will likely achieve the project's fire safety objectives and achieve compliance with the building code and IEBC.

3. Means of Egress

Issue: Portions of Floor 2 and Floor 3 contain dead-end corridor conditions exceeding the IEBC 35-foot maximum. One suite on the First Floor [the Governor's Suite] has a common path of travel that exceeds 75 feet.

Compliance Approach: Installation of automatic sprinklers throughout the building increases the code-prescribed maximum dead-end corridor length to 50 feet and the common path of travel allowance within a business occupancy to 100 feet. There are no dead-end corridor conditions greater than 50 feet in the current building configuration. *Reconfiguration of the suites as part of the renovations will meet the common path of travel requirements.*

4. Fire Suppression and Control

Issue: The building is a multi-story, single volume building with historic interior features that inhibit use of conventional fire compartmentalization concepts. As previously stated, the protection strategy includes an automatic sprinkler system, currently not present in the building. The reliability and availability of the sprinkler system is an integral part of achieving the project's fire safety goals.

Compliance Approach: Eliminate single-point failure in fire protection strategy by providing a two-source feed to the automatic sprinkler systems on each floor level. Provide two-source fire protection feed to building fire pump system and connect the fire service main to two separate points on the city municipal water main to significantly reduce the potential for no water service. Additionally, the existing standpipes will be removed and replaced with two new standpipes – one located within each of the new building cores at the east and west ends of the building. The relocation of these standpipes is to provide code-compliant, full coverage of the building. Each standpipe will have an access panel within the restrooms at each building core.

5. Fire Detection and Alarm

Issue: A manual fire alarm system, complete with audible alarm indicating appliances and visual alarm indicating appliances, is required by the building code because the calculated assembly use occupancy population exceeds 300 persons within the House and Senate Chambers.

Compliance Approach: Comply with the building code. The installation of manual pull stations is not required by code when the building is protected throughout with an automatic sprinkler system that activates the building's fire alarm system upon a waterflow condition. **The installation of automatic smoke detection is evaluated as part of an alternative compliance strategy to determine the necessary improvements to achieve the project's fire safety goals.**

6. Emergency Lighting

Issue: The building is not currently provided with emergency lighting.

Compliance Approach: The building's normal lighting circuits will be wired / connected to an emergency generator.

7. Exit Signage / Way Finding

Issue: Exits and exit access doors shall be marked by an approved exit sign readily visible from any direction of egress travel. Exit sign placement shall be such that no point in an exit access corridor or exit passageway is more than 100 feet, or the listed viewing distance for the sign, whichever is less. Exit signs might not be desirable since they could be considered to adversely affect the building's historic character.

Compliance Approach: An evaluation to determine the code-prescribed location/placement of exit signs throughout the building should be conducted. In those locations where sign installation is deemed to negatively impact the building's historic character, alternatives to conventional exit signs could be considered. The installation of directional sound technology – sounder devices that operate upon activation of the building's fire alarm system and emit a distinctive tone directing building occupants toward the exit – should be evaluated to determine its suitability for this space.

8. Monumental Stair Handrails

Issue: The Monumental Stair handrails exceed the code-permitted 2-inch-maximum diameter.

Compliance Approach: Handrails achieving the code-required diameters and mounting height should be integrated into the stairs.

9. Guardrails

Issue: The monumental stair Rotunda guardrails are approximately 30-inches high, measured vertically above the adjacent walking surface. The building code and IEBC require guards be minimum 42-inches high.

Compliance Approach: Guards achieving the code-required 42-inches-high mounting height should be integrated into the existing Rotunda guards.

2.6 Alternative Compliance Strategy

The primary goals of this study are to provide an increased level of life safety to occupants while maintaining the historic character and fabric of the building. Since the Wyoming State Capitol Building is an existing structure currently operating, no upgrades are required per the IBC unless the building official judges the building to constitute a distinct life safety hazard. The IEBC provisions for renovations and alterations are neither reasonable nor practical for an historic building. As referenced in NFPA 914, NFPA 550 is also utilized in this analysis to address the independent features of the building and the impact of the implementation of new life safety systems.

NFPA 914, *Code for Fire Protection of Historic Structures*, recognizes the importance of life safety and fire protection in the structure not impacting the architectural integrity of the building. NFPA 914 utilizes **prescriptive requirements**, as well as a **performance-based approach**, to evaluate the structure's expected performance with respect to the life safety and preservation goals. NFPA 550, Guide to the Fire Safety Concepts Tree, applies a systems-based methodology that examines the interrelation of fire safety features and their effect on achieving fire and life safety goals. NFPA 550 examines the reliability or availability and success of building systems and their effects on overall life safety. An overview of NFPA 550 is provided in Appendix B.

Application of NFPA 914 and NFPA 550 create a holistic approach by which the life safety objectives of the Capitol Building's modernization project can be evaluated to determine the building's expected performance in a fire condition. Analysis of various fire safety subsystems and their contribution to improved building fire safety are evaluated.

Specific building features to be evaluated include:

- Single fire area created by the building's open interior stairways, Rotunda floor opening, and Rotunda connectivity with the attic
- Common path of travel conditions exceeding the code-prescribed maximum 100 feet
- Use of interior exit access stairs on Floors 2 and 3 as the means of egress in lieu of the exterior fire escape stairs

The alternative compliance strategy will employ the concept of determining both the Required Safe Egress Time [RSET] and comparing this against the Available Safe Egress Time [ASET]. RSET versus ASET strategy analyzes the building's interior environmental conditions in a fire and evaluates various fire safety subsystems to determine which systems are necessary to maintain safe conditions for building occupant evacuation.

2.7 Acceptance Criteria

A smoke control system utilizing the exhaust method designed in accordance with NFPA 92B will be used to maintain tenable conditions within the means of egress. A computational fluid dynamics model is used to evaluate the smoke control performance.

The environmental conditions in the building's means of egress are analyzed to determine if tenable conditions are maintained for safe egress. Six [6] environmental conditions and associated acceptance criteria are analyzed:

- Visibility – 33-feet minimum
- Temperature – 140˚F maximum
- Carbon monoxide – 1600 ppm maximum
- Carbon dioxide – 6000 ppm maximum
- Oxygen (O2) – more than 12 percent
- Smoke layer height – 2,100mm above the means of egress walking surface

Additional information regarding these parameters can be found in *Appendix M2*. The tenable environment, also referred to as the Available Safe Egress Time [ASET], must be maintained for a period of time equal to 1.5 times the RSET or 20 minutes after detection of the fire event, whichever is less. Tenability information is measured at various locations in the atrium means of egress. See *Appendix M2* for measurement locations. All measurements are at six feet above the walking surface.

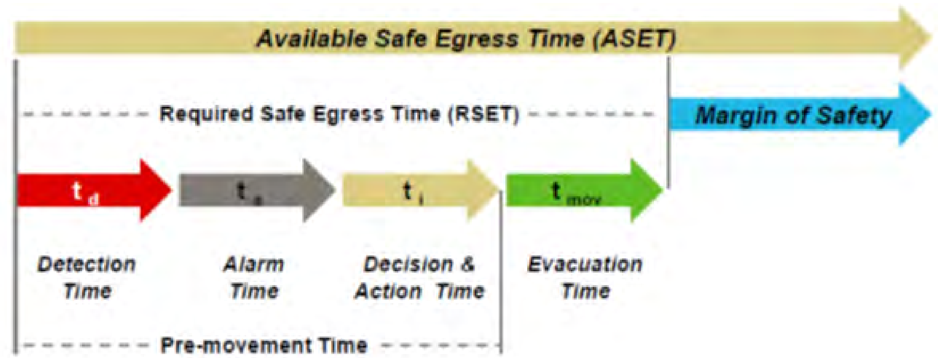


Figure 3-1: Diagram illustrating pre-movement time as a component of Available Safe Egress Time [ASET]

Table 3-1: Egress Times for Full Evacuation (min : sec) - IBC-prescribed Occupant Load

	Basement	First Floor	Second Floor	Third Floor
Pre-movement	2:00	2:00	2:00	2:00
Evacuation	0:43	6:07	5:37	3:00
Subtotal	2:43	8:07	7:37	5:00
Total Egress Time [RSET] Including Safety Factor	**4:04**	**12:10**	**11:25**	**7:30**

Table 3-2: Egress Times for Maximum Actual Occupant Load Evacuation (min : sec)

	Basement	First Floor	Second Floor	Third Floor
Pre-movement	2:00	2:00	2:00	2:00
Evacuation	0:30	3:56	3:34	1:41
Subtotal	2:30	5:56	5:34	3:41
Total Egress Time [RSET] Including Safety Factor	**3:45**	**8:54**	**8:21**	**5:32**

Table 3-3: Egress Times for Blocked Evacuation (min : sec) - IBC-prescribed Occupant Load [One Stair Blocked]

	Basement	First Floor	Second Floor	Third Floor
Pre-movement	2:00	2:00	2:00	2:00
Evacuation	0:48	11:39	11:39	3:59
Subtotal	2:48	13:39	12:57	5:59
Total Egress Time [RSET] Including Safety Factor	**4:12**	**20:28**	**19:25**	**8:58**

Table 3-4: Egress Times for Blocked Evacuation (min : sec) - Maximum Actual Occupant Load [One Stair Blocked]

	Basement	First Floor	Second Floor	Third Floor
Pre-movement	2:00	2:00	2:00	2:00
Evacuation	0:44	7:22	6:42	2:28
Subtotal	2:44	9:22	8:42	4:28
Total Egress Time [RSET] Including Safety Factor	**4:06**	**14:03**	**13:03**	**6:42**

3.1 Building Evacuation Modeling

The building evacuation was evaluated with multiple scenarios – a full evacuation where all exits are available and a full evacuation where one of the Monumental Stairs is blocked. Two different building occupant loads / populations were evaluated:

- IBC-prescribed occupant load
- The maximum expected occupant load.

Evacuation times were determined using the STEPS program. More information regarding the program, inputs, and scenarios can be found in *Appendix M2*.

Evacuation times are determined by summing the pre-movement and movement times. Pre-movement time is the period after a fire starts until occupants begin to move toward exits. This time includes detection time, notification [alarm] time, and a delay [decision and action] for occupants to hear the notification and respond [*Figure 3-1*]. Further discussion of pre-movement time can be found in *Appendix M2*. The total evacuation time for all the occupants to exit that floor for the full evacuation of the IBC-prescribed load and maximum expected load with all exits available is shown in *Table 3-1* and *Table 3-2*, respectively. It is noted in *Table 3-2* on the First and Second Floors that the evacuation time for the maximum expected building occupant load is nearly 9 minutes. These evacuation times are based on the occupant loads provided in *Appendix M1*.

Table 3-3 and *Table 3-4* show the evacuation time when a stair is not available. It is noted on the First Floor and the Second Floor that the times exceed 14 minutes when analyzing the maximum actual building occupant load. As such, per IBC Section 909.4.6, the required safe egress time - time duration in which the building's means of egress shall remain tenable - is 14 minutes.

The existing configuration of the State Capitol was used in the construction of the fire and egress models as the proposed layouts were not finalized. After review of the proposed layouts it was determined that the main corridor and Rotunda configuration is essentially unchanged and will not have an appreciable effect on the findings of this report. As such, additional runs of the modeling to reflect the revised floor plans are not necessary at this time.

Two evacuation scenarios for two different occupant loads were evaluated. The first occupant load is the code prescribed occupant load that applies the occupant load factors found in IBC Chapter 10. These occupant load factors result in an overall occupant load of 1,459 people. This number is almost twice that which would be anticipated within the building during peak crowds in legislative season. As such, a more realistic maximum occupant load, based on prior legislative occupant load counts, of **758 occupants** was also evaluated in the egress analysis. The egress times for both occupant loads were calculated when all interior stairs were available, as well as when one of the monumental stairs was blocked.

3.2 Fire Modeling

3.2.1 Fire Scenarios

NFPA 101 fire scenarios were applied to the Wyoming State Capitol. Of the eight fire scenarios, five were identified as potential design fires and deemed applicable to the building. These five scenarios were combined and whittled down to three scenarios – one that represents a typical occupancy fire, one that is an ultrafast fire within the means of egress, and one that represents the largest fire load within the building.

3.2.2 Fire Locations

Design Fire Scenario 1 is the occupancy-specific fire typical of the building occupancy. This fire is located within the House Chambers, where the floor-to-ceiling height is greater than that of the office space. Since the building is symmetrical, this fire scenario is assumed to be reflective of a similar fire with the Senate Chambers.

Design Fire Scenario 2 is an arson fire located within the means of egress. This fire is located at the base of the east Monumental Stairs at the First Floor. This scenario is assumed to start as an act of arson where gasoline is dumped on the stairs. The fire initiates on these stairs causing them to be impassable.

Design Fire Scenario 3 represents the worst-case fuel loading within the Wyoming State Capitol. It has been observed that a 2-story Christmas tree is predominantly displayed within the high-bay Rotunda during the month of December. Based on fire test data within the SFPE Handbook [Section 3-1], this fire could represent a potential heat release rate upwards of 5 MW.

3.2.3 Mechanical Smoke Exhaust

Current model simulations utilized an exhaust capacity of 90,000 CFM. Two exhaust configurations were modeled for the fire scenarios – one with exhaust located in the base of the dome and the second with exhaust located in the laylights above the Monumental Stairs and floor openings.

This capacity of exhaust was determined based on the available make-up air utilizing the exterior doors. Make-up air is required to be 85 percent of the exhaust capacity, or 76,500 CFM. Maximizing the available open doors results in approximately 72,000 CFM of available make-up air. One additional vent was included within the model in the wall of the security station to increase capacity and provide air flow in all directions.

In the evaluation of the fire modeling analysis, environmental factors such as temperature and wind were considered. Of these factors it was determined that the prevailing W-NW winds in Cheyenne would have the greatest impact. Since the wind speeds within the region are of considerable size and could greatly impact the performance of the smoke control system, it was determined that only conditioned air would be provided as part of the system supply. Direct exterior openings would not be included as part of the system. Instead, air will be brought in at the basement level through a conditioned space and then supplied to the Rotunda. Modeling runs incorporated extreme winter and summer weather temperatures as further detailed in *Appendix M3*.

Diagrams illustrating both the existing and the proposed building as a single volume are shown on pages M.3.2 through M.3.10.

3.3 Sensitivity Analysis

The sensitivity analysis evaluated three different input factors for the fire modeling analysis – fire growth rate, peak heat release rate, and soot yield factor. Of these factors, it was determined that varying the soot yield factor could have the potential for the greatest impact on the outcome of the fire modeling analysis.

The soot yield factor was varied from 0.03 g/g to 0.05 g/g to represent a sootier fire than that which would be anticipated in the space based on the potential fuel sources and combustibles. The results of the analysis showed that, while soot levels were higher in the area of origin, the overall smoke spread was comparable to the design fire scenarios. The proposed smoke control system was still able to maintain tenability in areas outside of the fire origin and, in time, clear the smoke from the area of fire origin too.

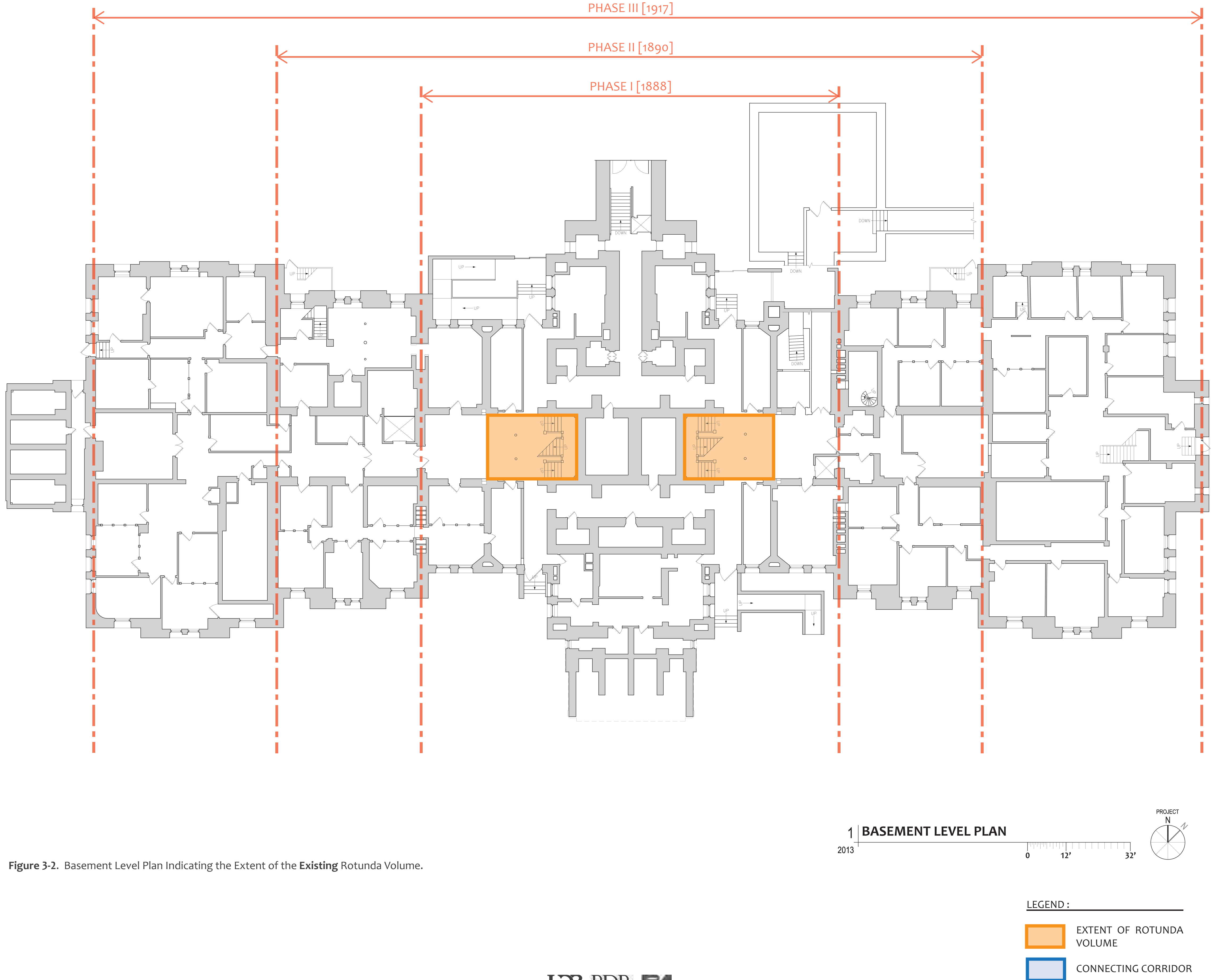


Figure 3-2. Basement Level Plan Indicating the Extent of the **Existing** Rotunda Volume.

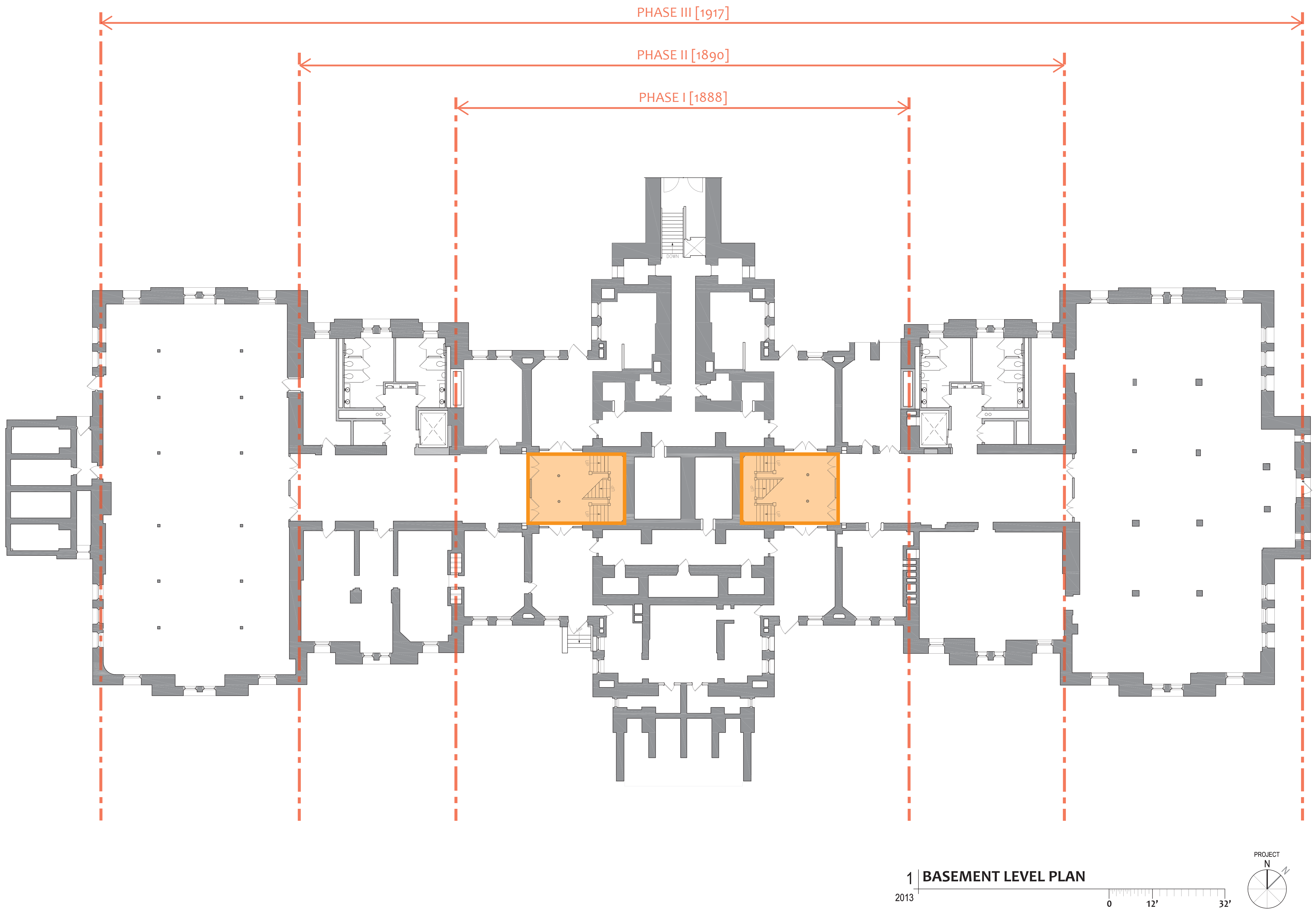


Figure 3-3. Basement Level Plan Indicating the Extent of the **Proposed** Rotunda Volume.

LEGEND :

EXTENT OF ROTUNDA VOLUME

CONNECTING CORRIDOR

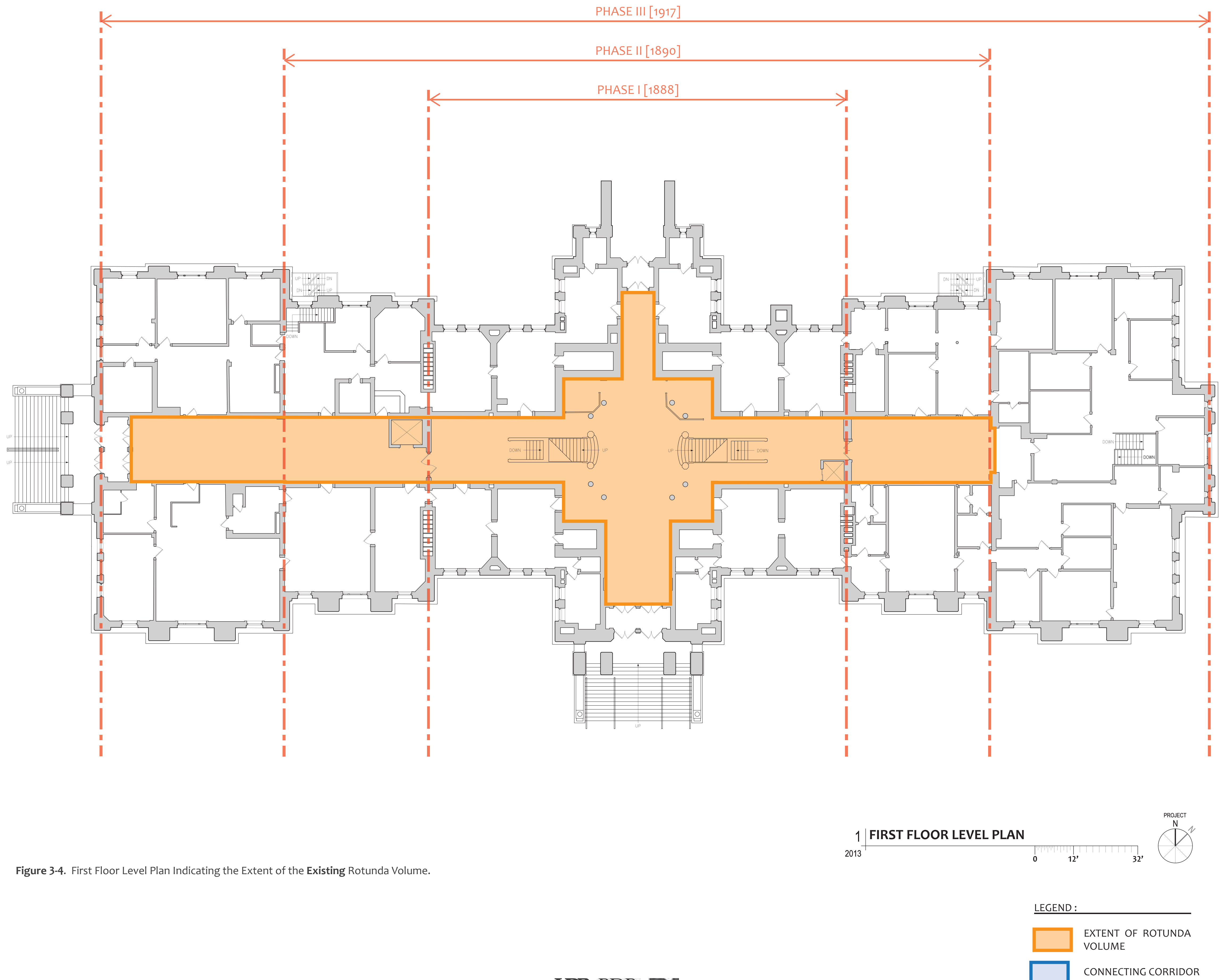


Figure 3-4. First Floor Level Plan Indicating the Extent of the **Existing** Rotunda Volume.

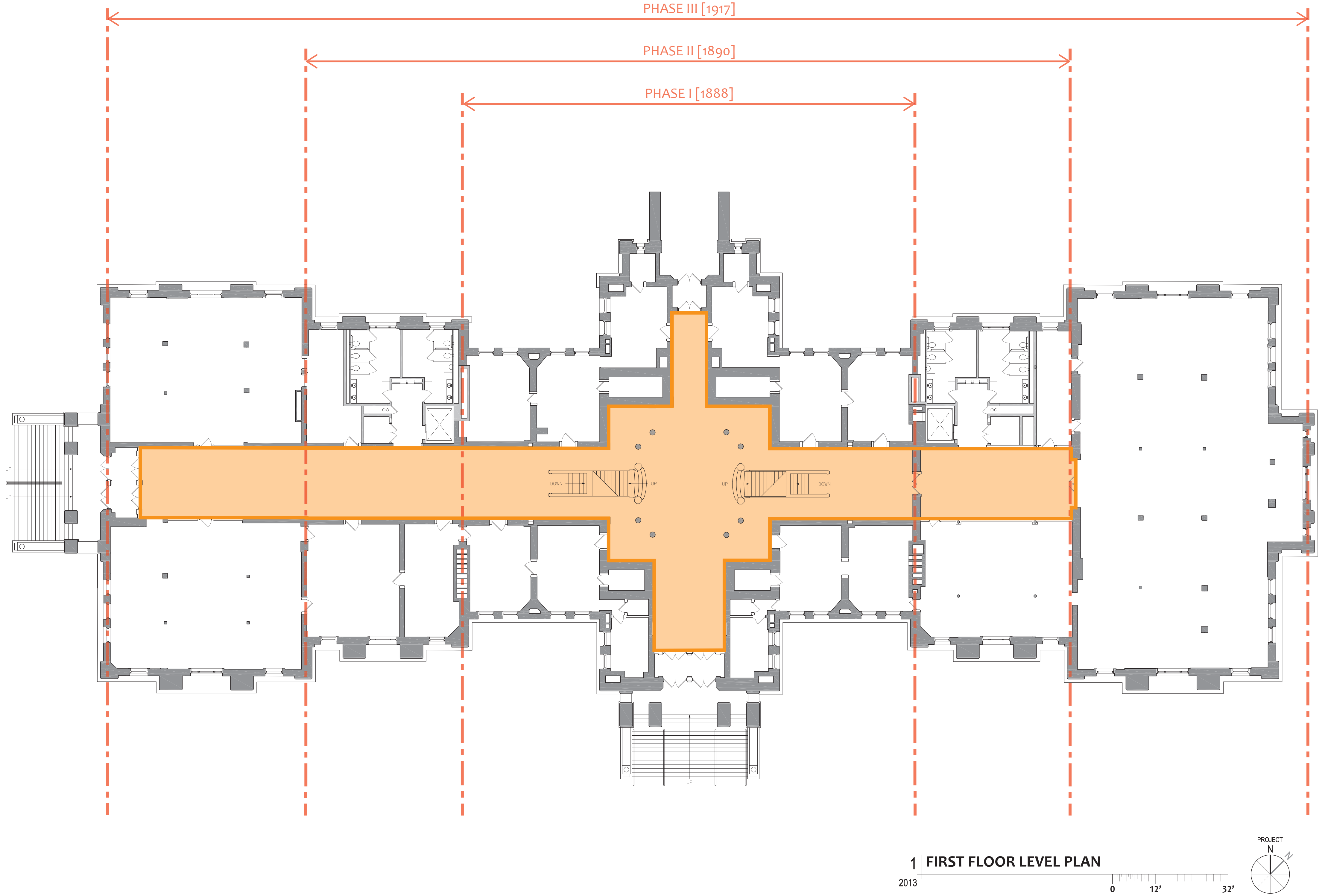


Figure 3-5. First Floor Level Plan Indicating the Extent of the **Proposed** Rotunda Volume.

LEGEND :

EXTENT OF ROTUNDA VOLUME

CONNECTING CORRIDOR

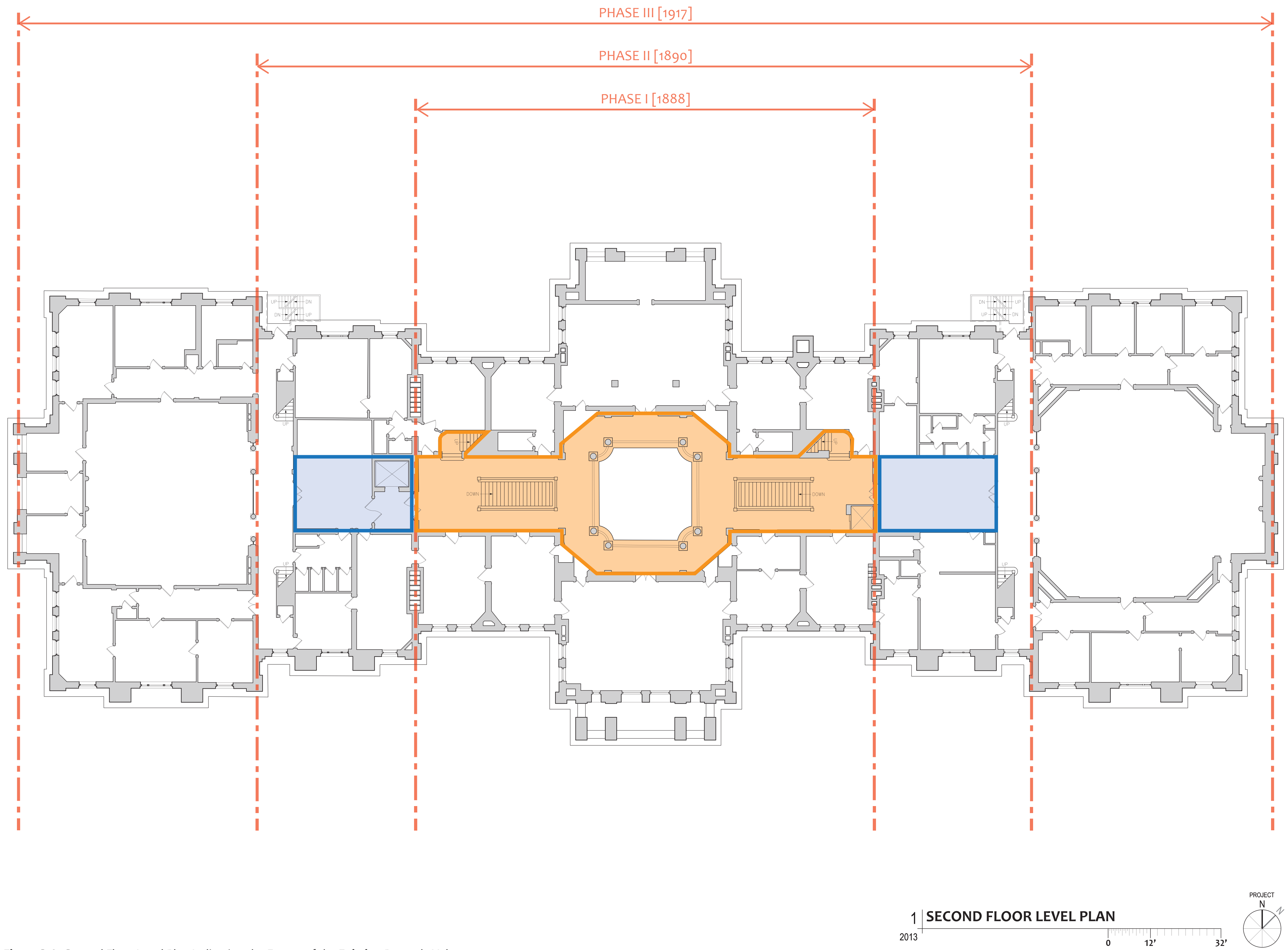


Figure 3-6. Second Floor Level Plan Indicating the Extent of the **Existing** Rotunda Volume.

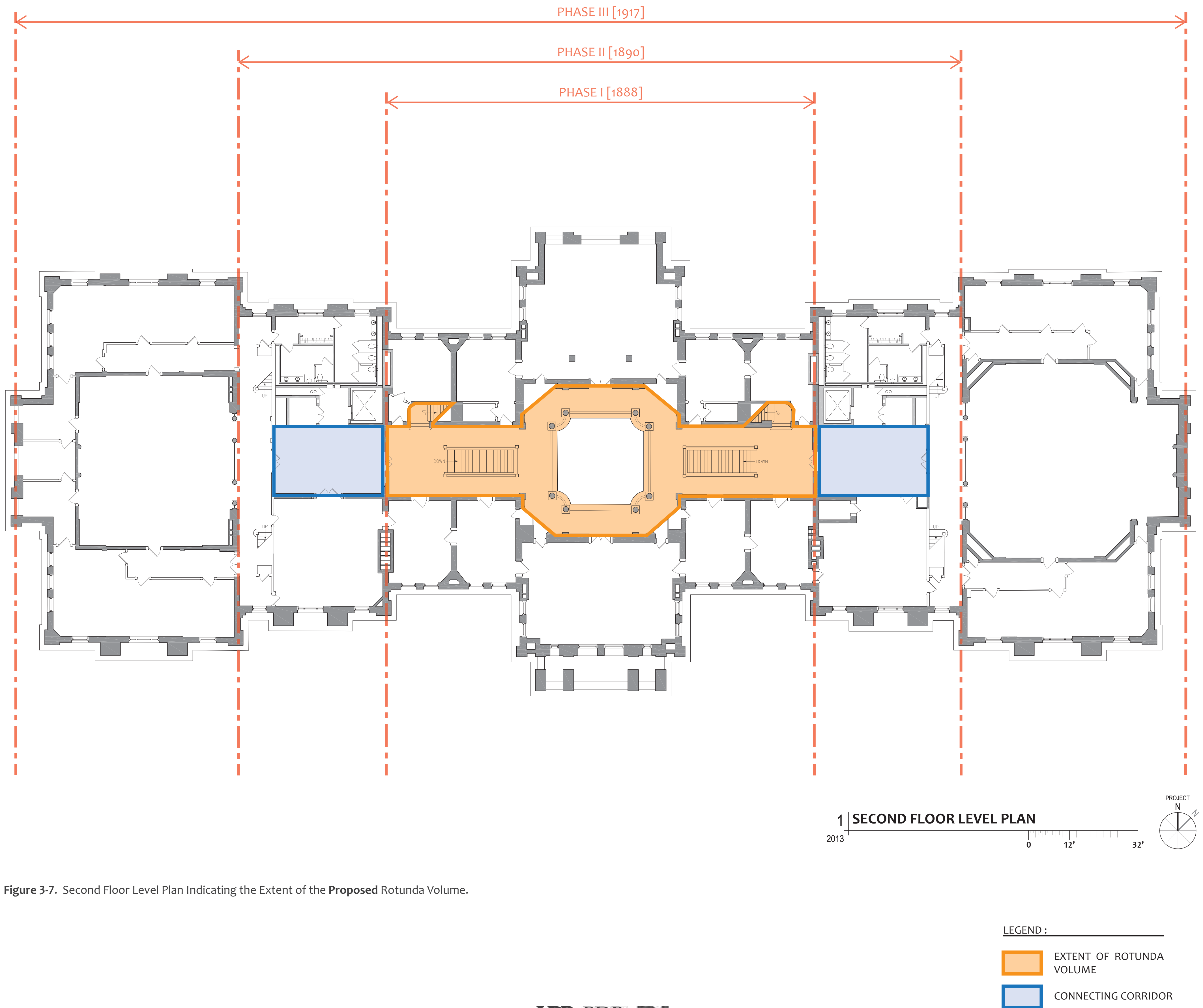


Figure 3-7. Second Floor Level Plan Indicating the Extent of the **Proposed** Rotunda Volume.

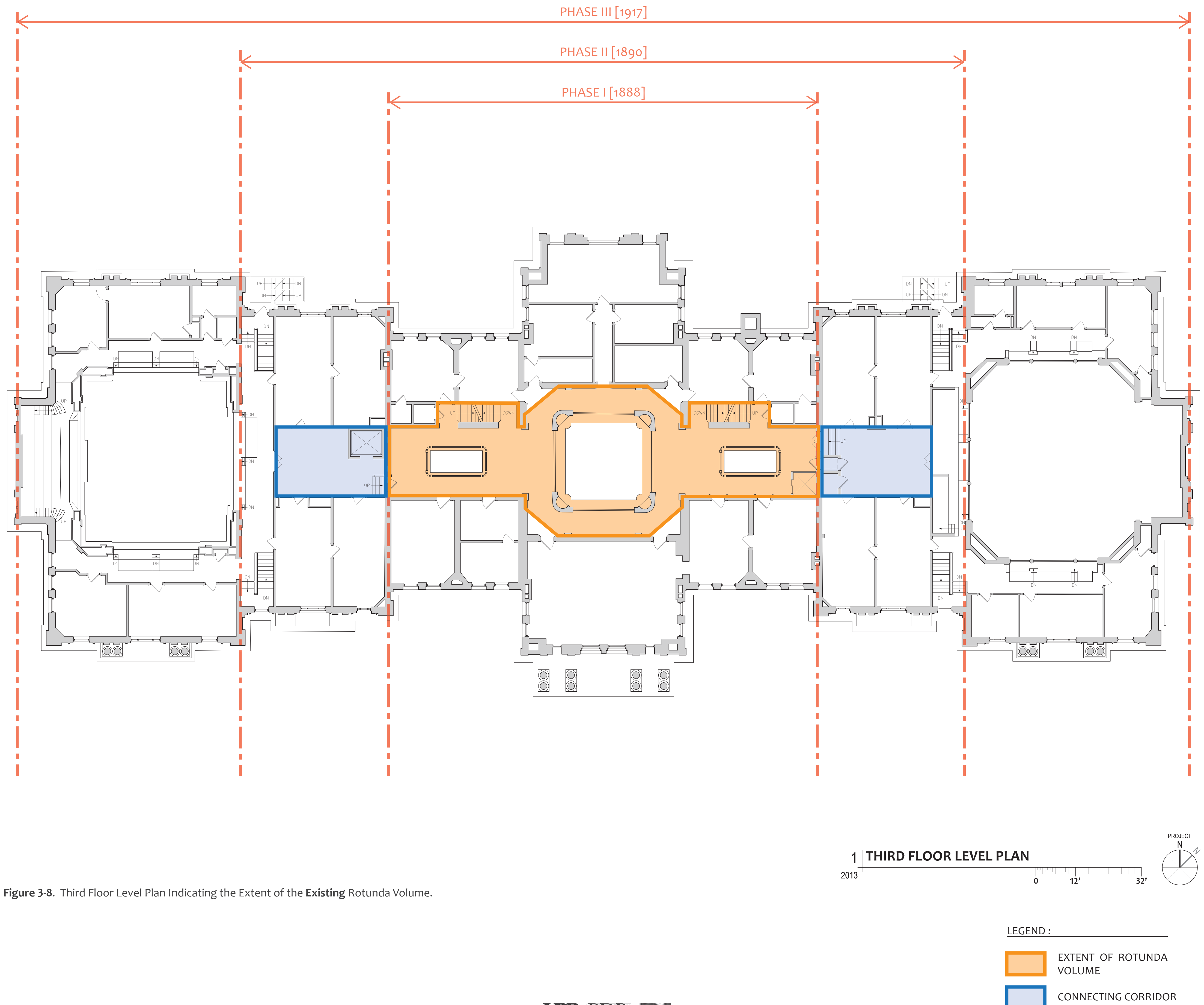


Figure 3-8. Third Floor Level Plan Indicating the Extent of the **Existing** Rotunda Volume.

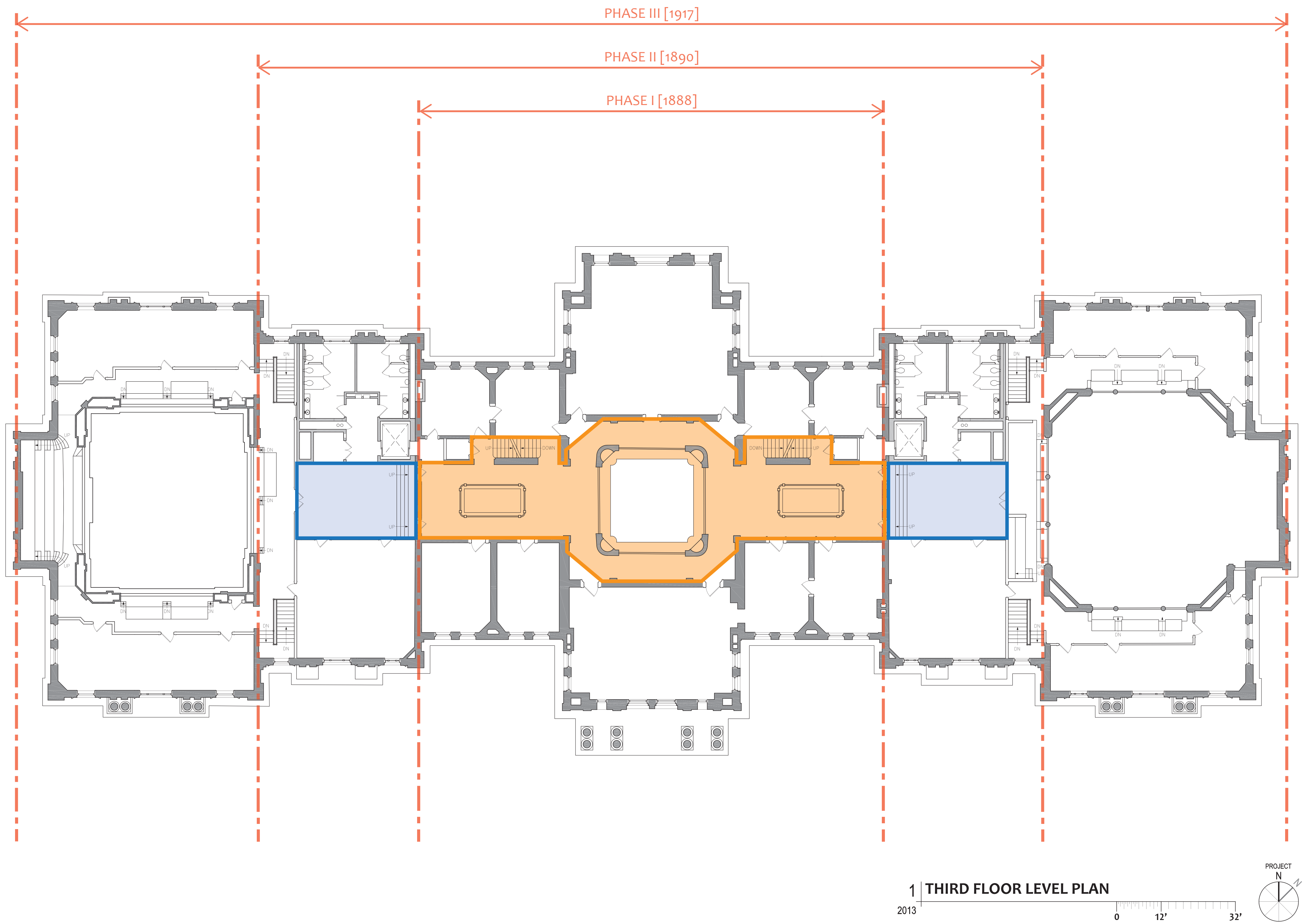


Figure 3-9. Third Floor Level Plan Indicating the Extent of the **Proposed** Rotunda Volume.

LEGEND :

EXTENT OF ROTUNDA VOLUME

CONNECTING CORRIDOR

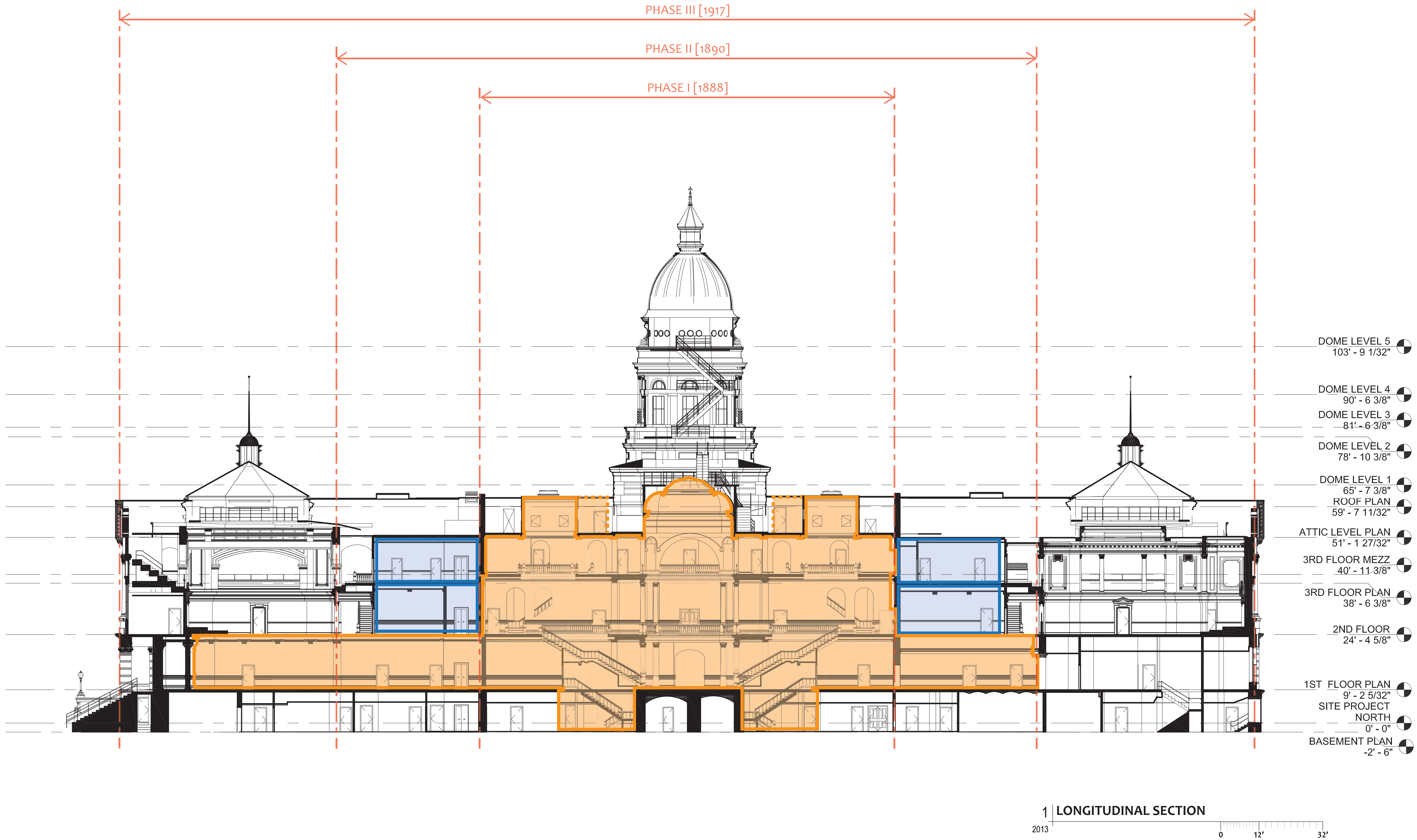


Figure 3-10. Longitudinal [East-West] Building Section Indicating the Extent of the Rotunda Volume. The Section Shown Illustrates the **Existing** Building Construction; However, the Extent of the Rotunda Volume Will Not Change as part of the **Proposed** Design Scheme.

LEGEND :

- EXTENTS OF ROTUNDA VOLUME
- ADJACENT CORRIDOR

Table 4-1: Fire and Evacuation Modeling Results

Design Fire Scenario	Building Occupant Load	Evacuation Scenario	Required Safe Egress Time	Exhaust Capacity	Results of Fire Modelling Analysis [Figures 4-1 and 4-2]
Design Fire Scenario 1 - Fire within the House Chambers	Maximum Expected Occupant load – 758 people	All Stairs Available	9 minutes [See Table 3-2.]	90,000 CFM	Evacuation routes and tenable conditions outside of the House Chambers and anterooms maintained for 20+ minutes
Design Fire Scenario 2 - Fire at the base of the monumental stair [Blocked evacuation]	Maximum Expected Occupant load – 758 people	One monumental stair at first floor blocked	14 minutes [See Table 3-4.]	90,000 CFM	After smoke exhaust system initiation, tenable conditions within the building and evacuation routes maintained for 20+ minutes
Design Fire Scenario 1 - Fire within the House Chambers	Maximum Expected Occupant load – 758 people	All Stairs Available	9 minutes [See Table 3-2.]	None	Smoke spread has reduced visibility throughout the third floor corridor to less than tenable conditions within 10 minutes. By 14 minutes visibility conditions have been reduced below tenability limits throughout the corridor on the second floor.
Design Fire Scenario 2 - Fire at the base of the monumental stair [Blocked evacuation]	Maximum Expected Occupant load – 758 people	One monumental stair at first floor blocked	14 minutes [See Table 3-4.]	None	Smoke spread has reduced visibility throughout the second floor corridors and Rotunda to less than tenable conditions within 3 minutes. By 8 minutes visibility conditions have been reduced below tenability limits throughout the corridor on the third floor.
Design Fire Scenario 1 - Fire within the House Chambers	IBC Occupant load – 1,459 people	All Stairs Available	12 minutes [See Table 3-1.]	90,000 CFM	Evacuation routes and tenable conditions outside of the House Chambers and anterooms maintained for 20+ minutes
Design Fire Scenario 2 - Fire at the base of the monumental stair [Blocked evacuation]	IBC Occupant load – 1,459 people	One monumental stair at first floor blocked	20 minutes [See Table 3-3.]	90,000 CFM	After smoke exhaust system initiation, tenable conditions within the building and evacuation routes maintained for 20+ minutes
Design Fire Scenario 1 - Fire within the House Chambers	IBC Occupant load – 1,459 people	All Stairs Available	12 minutes [See Table 3-1.]	None	Smoke spread has reduced visibility throughout the third floor corridor to less than tenable conditions within 10 minutes. By 14 minutes visibility conditions have been reduced below tenability limits throughout the corridor on the second floor.
Design Fire Scenario 2 - Fire at the base of the monumental stair [Blocked evacuation]	IBC Occupant load – 1,459 people	One monumental stair at first floor blocked	20 minutes [See Table 3-3.]	None	Smoke spread has reduced visibility throughout the second floor corridors and Rotunda to less than tenable conditions within 3 minutes. By 8 minutes visibility conditions have been reduced below tenability limits throughout the corridor on the third floor.

The fire models demonstrated that, with an exhaust capacity of 90,000 CFM, life safety conditions are improved greatly throughout the State Capitol. Failures with respect to the tenability criteria would be experienced in the Capitol without smoke exhaust. These failures occur before egress is completed.

Figures 4-1 and 4-2 [on Pages M.4-2 through M.4-5] show a comparison of the smoke conditions within the Capitol for the existing building without smoke exhaust, and the building with the proposed exhaust system for the two [2] design fire scenarios. It should be noted that the smoke spread is nearly identical for the images during the first two minutes as the smoke exhaust system operates and reaches full operating capacity. The full impact of the smoke control is demonstrated in the subsequent images.

In **Design Fire Scenario 1**, the Chambers fire scenario without a smoke exhaust system, smoke spreads throughout the Third Floor and eventually banks down within the Rotunda. By the end of the simulation at 20 minutes, smoke has filled the Rotunda and corridors within the Second and Third Floors. In contrast, the images show that, in the model with a smoke exhaust system, smoke spread is limited to only the Chambers and the anteroom immediately exterior to the space. Smoke is pulled into the Rotunda by the smoke exhaust system but remains at the ceiling level with no impact on occupants.

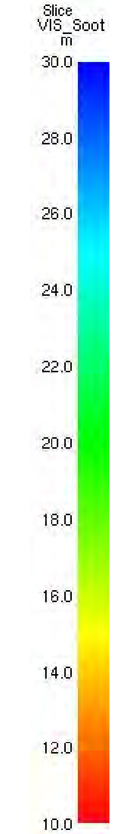
In **Design Fire Scenario 2**, the Stair fire scenario, when no smoke exhaust is present, smoke spreads throughout the Rotunda, filling the First, Second and Third Floors within the Rotunda within 8 minutes. Smoke continues to spread down the corridors, filling the remainder of the Third, Second and First floors before 20 minutes has elapsed. In the identical fire scenario, but with smoke exhaust within the building, the smoke is confined to the area of fire origin within the Rotunda. After the smoke control system is initiated, the smoke is confined to the monumental stair and spaces immediately surrounding it. The smoke does not spread to other portions of the building, nor does it fill the Rotunda.

The results of **Design Fire Scenarios 1 and 2** show that the provision of an atrium smoke control system improves the life safety of occupants within the building significantly so that the available safe egress time [ASET] is greater than the required safe egress time [RSET] in areas other than the fire origin.

A third scenario was also explored - the "Christmas tree" scenario. In this scenario, a large magnitude fire is developed very quickly. A smoke control system of sufficient capacity to maintain tenability throughout the building during the initial stage of fire development is not feasible. The fire becomes too large too quickly for a smoke control system to achieve maximum exhaust capacity at the same rate smoke is produced. Fire test data show that such a fire is a rapid burn scenario with the tree entirely consumed within 60 seconds of ignition. The automatic sprinkler system is expected to control and possibly extinguish the resultant fire but not before a significant quantity of smoke is produced. The smoke control system is expected to minimize smoke spread throughout the building.

Other preventive measures and life safety procedures will be relied on within the Capitol to address the concern of the Christmas tree fire. These may include shortening of the time period when the tree is in the building, frequent watering, additional readily accessible portable fire extinguishers, and the relocation of combustibles near the tree. Specific measures, including possible reduction of the size of the tree, will be determined.

Chambers Fire Scenario



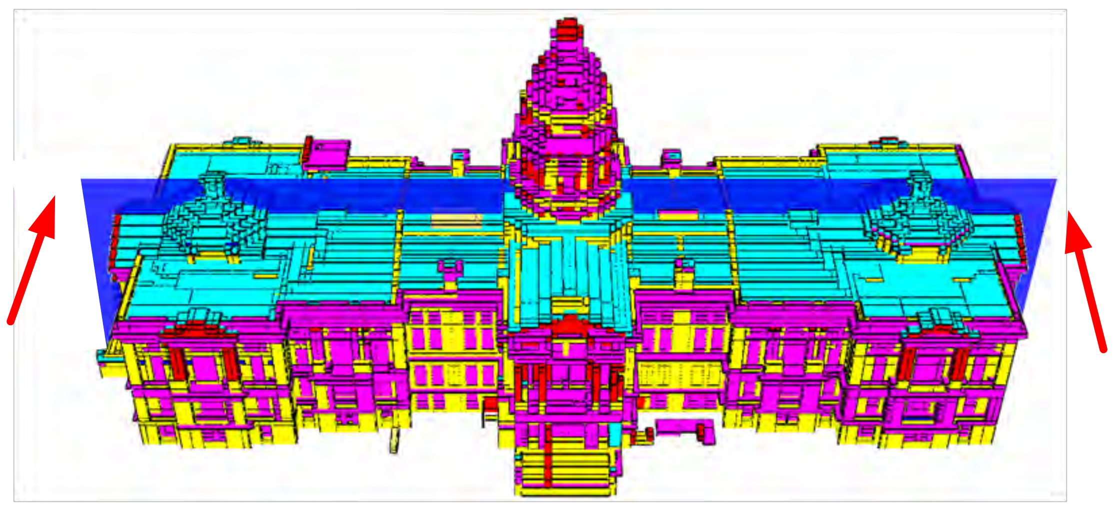
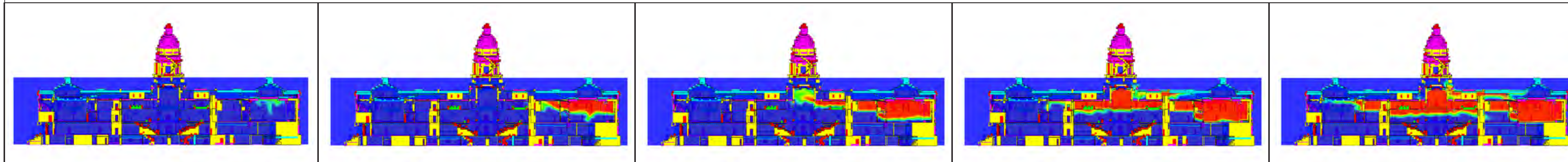
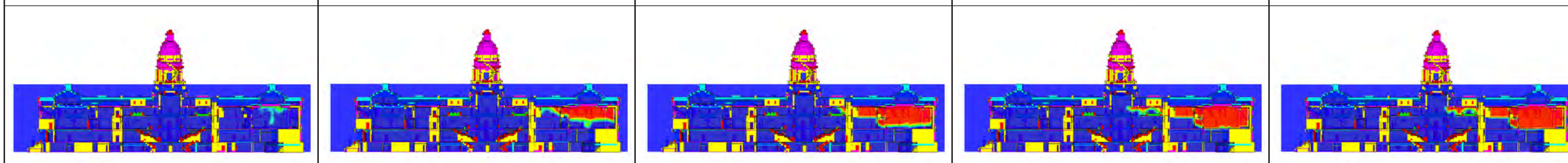


Figure 4-1: Design Scenario 1 - Chambers Fire Scenario Modeling Results

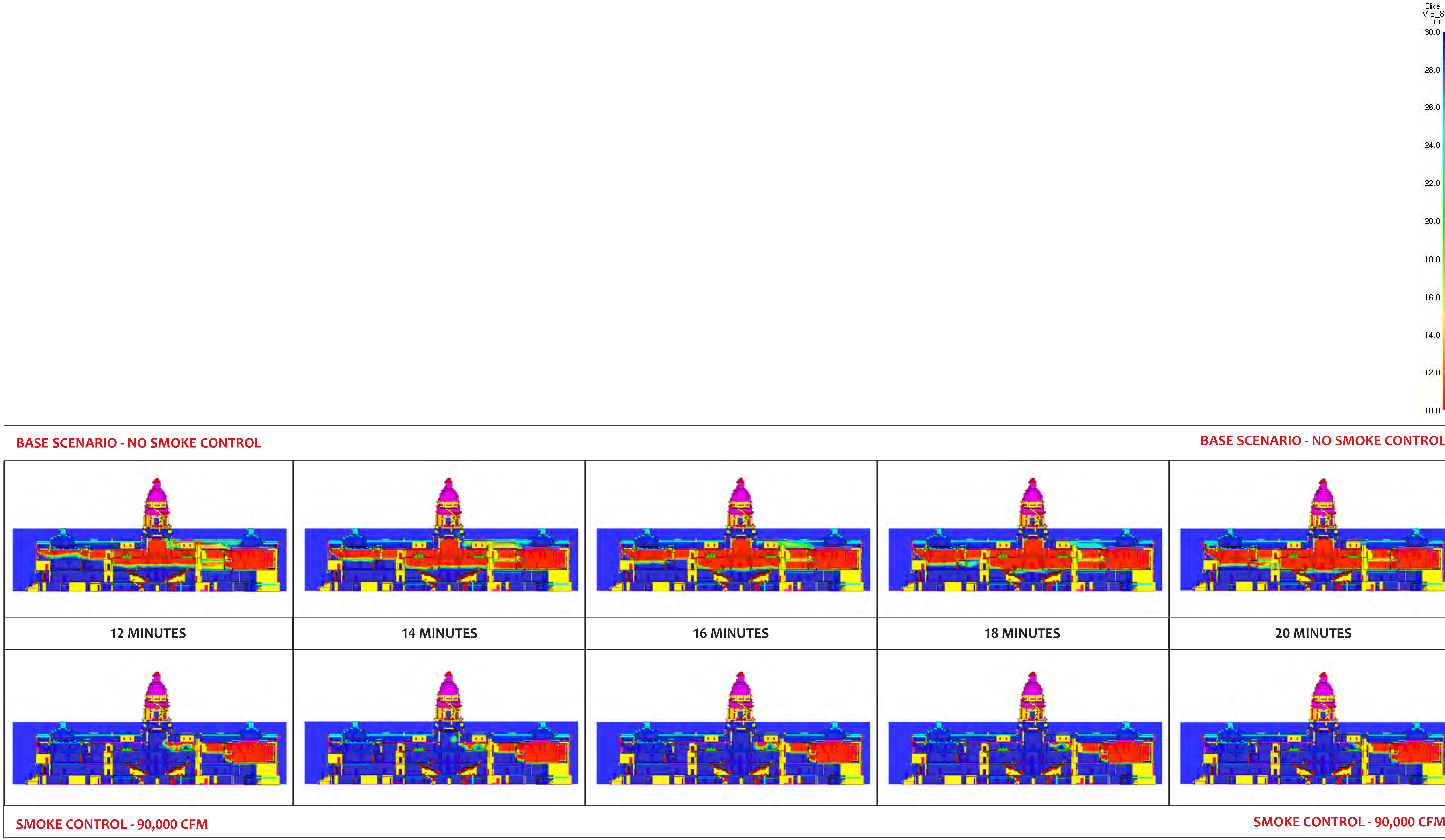
BASE SCENARIO - NO SMOKE CONTROL | **BASE SCENARIO - NO SMOKE CONTROL**

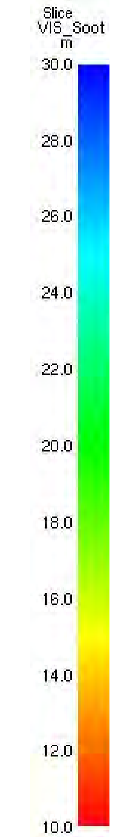


2 MINUTES	4 MINUTES	6 MINUTES	8 MINUTES	10 MINUTES



SMOKE CONTROL - 90,000 CFM | **SMOKE CONTROL - 90,000 CFM**


Slice
VIS_Soot
m
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
BASE SCENARIO - NO SMOKE CONTROL
BASE SCENARIO - NO SMOKE CONTROL
12 MINUTES
14 MINUTES
16 MINUTES
18 MINUTES
20 MINUTES
SMOKE CONTROL - 90,000 CFM
SMOKE CONTROL - 90,000 CFM



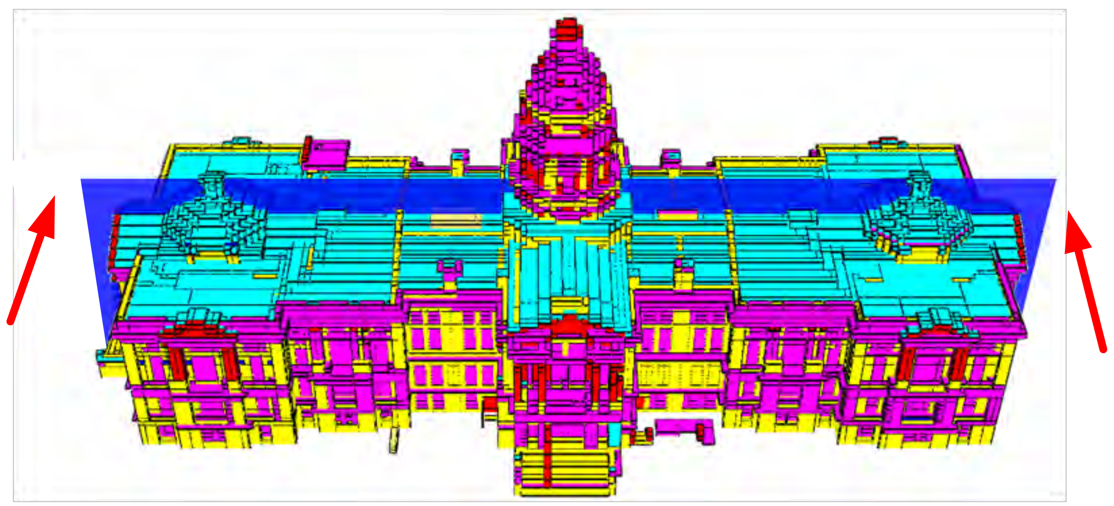
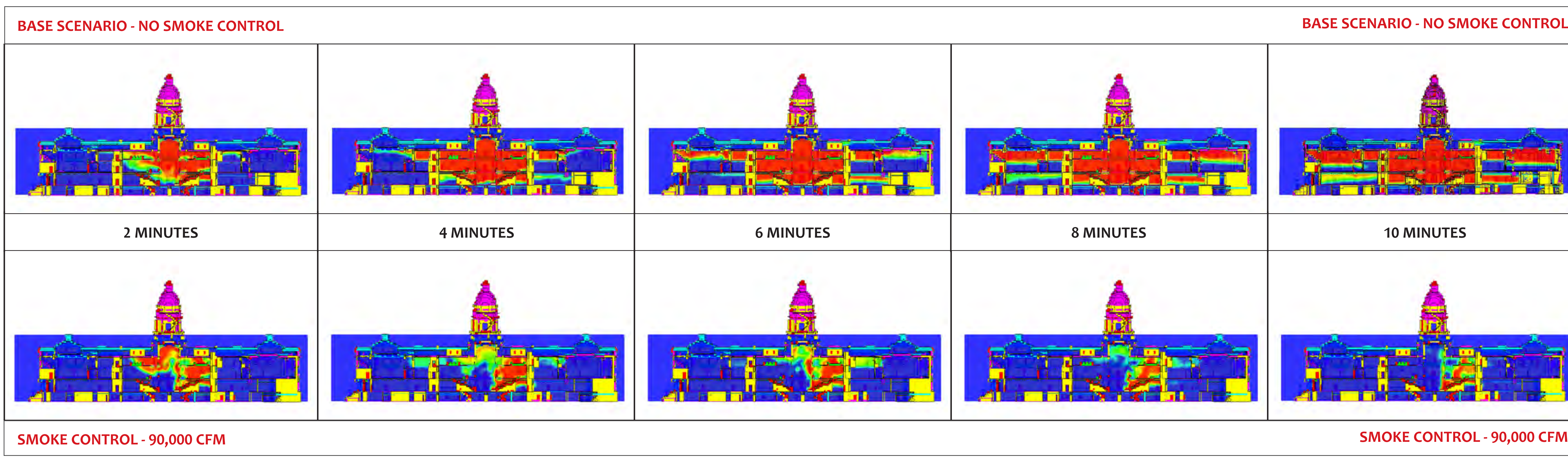
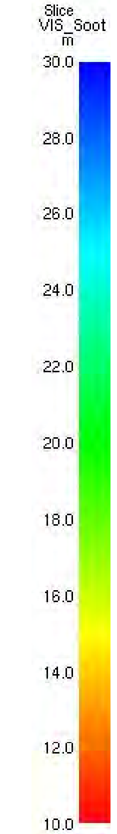


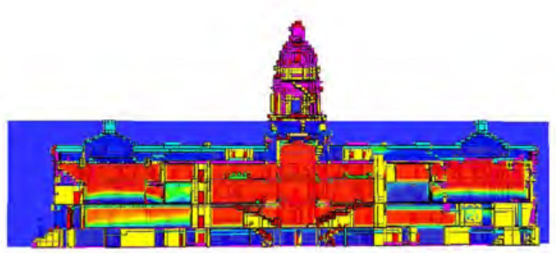
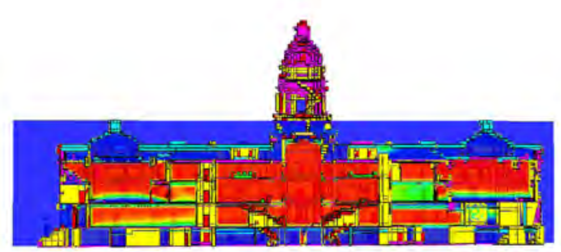
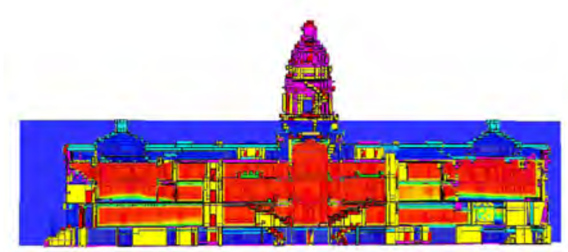
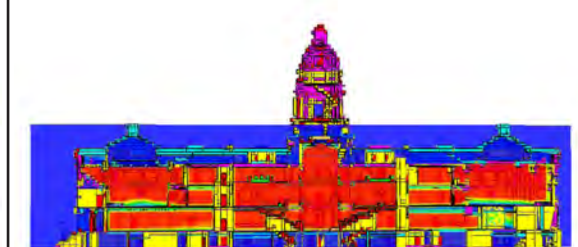
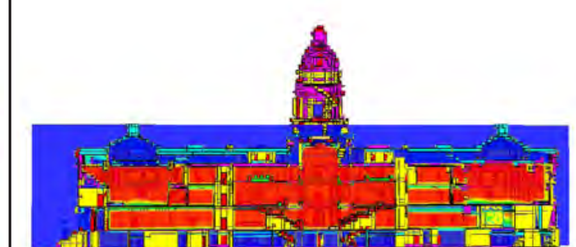
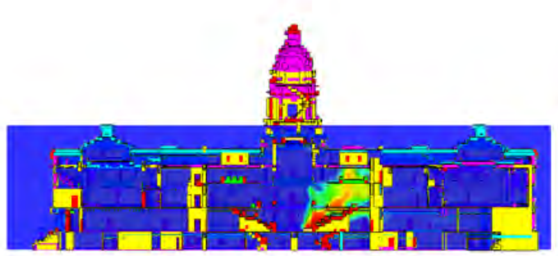
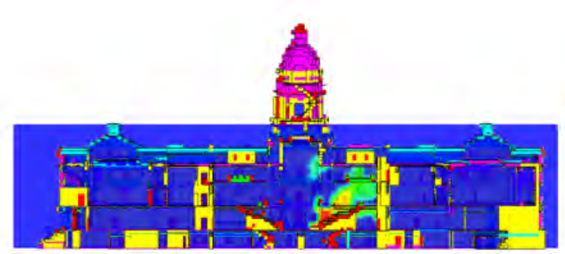
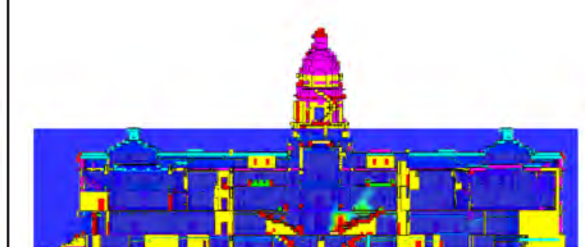
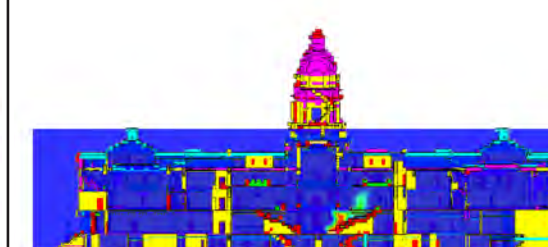
Figure 4-2: Design Scenario 2 - Stair Fire Scenario Modeling Results





BASE SCENARIO - NO SMOKE CONTROL

BASE SCENARIO - NO SMOKE CONTROL

				
12 MINUTES	**14 MINUTES**	**16 MINUTES**	**18 MINUTES**	**20 MINUTES**
				

SMOKE CONTROL - 90,000 CFM

SMOKE CONTROL - 90,000 CFM

As a result of this code compliance assessment of the existing building, several items of noncompliance were noted that would impact the overall life safety for occupants in the structure. A performance based analysis was developed to evaluate several of these existing conditions and evaluate the impact of employing additional measures. The results of this analysis demonstrate that the implementation of additional life safety subsystems significantly improves the overall life safety of the building occupants. Specifically the subsystems are able to manage fire and smoke such that occupants can evacuate the building meeting the code prescribed performance criteria, without exposure to untenable conditions.

The following actions pertaining to fire protection and life safety are recommended for the renovation of the Wyoming State Capitol:

1. ***Install automatic sprinkler protection throughout the building in accordance with NFPA 13.*** Fire suppression is an essential action to provide life safety and minimize building damage from a fire. As demonstrated in the performance-based analysis, tenable conditions can be maintained throughout the building for occupant evacuation via the interior open stairs. This includes the extraordinary fire event where one exit is blocked by the fire. Sprinkler protection should include the entire building, even the attic, which would also alleviate the concern for combustible materials within the attic construction. Two-source feed to sprinkler piping should be provided to increase overall system reliability.

2. ***Install a smoke control system.*** A smoke control system, as detailed within this report, should be installed to mitigate the potential for smoke spread in the single volume building. This system is essential in maintaining available paths of egress during a fire event within the single volume building. The smoke control system should have an exhaust capacity of approximately 90,000 CFM with a make-up air capacity of 76,500 CFM. It should be installed in accordance with the requirements of IBC Chapter 9 and NFPA 92B.

3. ***Install automatic smoke detection and fire alarm system in accordance with NFPA 72.*** The value of early detection and subsequent notification to occupants is recognized within the performance based analysis. Detection within the incipient stages of the fire allows for effective application of manual suppression, as well as earlier movement of occupants. The implementation of a widespread smoke detection system will assist in detecting fires in the early stages of development affording occupants time to react and evacuate, as well as notifying trained personnel of the presence of a fire. Systems will be comprised of spot detection, beam detection, and aspirating smoke detection, all strategically placed to maximize detection rates and minimize disturbance of the historic architecture of the building.

4. ***Eliminate existing exterior fire escape stairs.*** Existing exterior fire escape stairs were installed to provide a means of building escape that is protected from fire. The proposed enhanced building protection strategy of early fire detection, fire suppression, and smoke management provides occupants fire safety that is superior to that afforded by the fire escape stairs. The fire escapes are open to the outdoors and subject to potential snow and ice conditions. The stairs are not normally used and are unfamiliar to the building occupant. In addition, the existing exterior fire stairs have several deficiencies at several locations, as designed and installed. The performance based analysis has demonstrated that sufficiently sized means of egress are provided without use of the exterior fire escape stairs. Instead, the building would be protected by several new and redundant life safety systems, such as sprinklers, smoke detection, and smoke exhaust. With the installation of these systems, occupants would be able to exit the building in sufficient time to avoid hazardous exposure to smoke in the design fire scenarios.

5. ***Install egress signage and wayfinding devices.*** The installation of exit signs, or other wayfinding devices, is necessary in effectively egressing occupants from the building. It is understood that some occupants within the building may not be familiar with the layout of the space, so signage will be added to the building where the exit path may not be inherently obvious.

6. ***Life safety system redundancy.*** It is recommended that the automatic sprinkler system be provided with dual water supply from two different connections to the city water supply. This approach will eliminate the potential for single point failure for one of the key life safety systems within the building. It is also recommended that the smoke control system, smoke detection system, and emergency lighting be provided with emergency back-up power, such as a generator, to ensure uninterrupted service in the event of power failure. These life safety systems are inherent to the fire protection life safety strategy for the building.

7. ***Modify the existing noncompliant guard system at the Rotunda and Monument Corridors to provide code compliant guard height of 42 inches above the walking surface.*** It is recognized that the existing guardrails have significant historic value and to simply replace them is not an option. The installation of a glass handrail in front of the historic wood railing is an option that would meet the Secretary of the Interiors Standards, which are being used by the Wyoming State Preservation Office, an agency having jurisdiction over this project.

6. Conclusion

The Level I / Level II Fire Life Safety Assessment reviewed the existing conditions of the Wyoming State Capitol, the applicable code requirements, and presented a list of noncompliance items that required action as part of the building modernization. The key findings of this assessment are as follows:

- Life safety systems within the existing Capitol Building are limited. There is a standpipe system, but no automatic suppression or smoke detection. Exit signs are located within the Basement but are not consistent on other levels. No emergency power source (i.e. generator) is provided for any of the existing life safety systems or lighting.
- The building has a relatively small floor plate. The floor openings at the Rotunda, main egress corridors, and within the Chambers result in a single volume consideration for the majority of the building. This single volume concept significantly impacts the behavior of the building when subjected to fire conditions.
- The building has sufficient exit capacity for even the most extreme occupant loading (IBC occupant loads) without consideration of the exterior fire escape stairs. Review of the building occupancy and loading concluded that the prescribed IBC occupant loads were almost double the maximum anticipated occupant load within the building during peak crowds during the legislative session. As such, a more realistic maximum occupant load, based on prior legislative occupant loads, of 758 occupants was evaluated in the egress analysis and determined that the building currently has sufficient exit capacity without accounting for the existing exterior fire escapes.
- Due to the historic nature of the existing building and in accordance with NFPA 914, it was determined that a performance based analysis was the most appropriate measure to document the behavior of the building during a fire and to identify additional life safety measures required to meet the life safety goals of the renovation project.
- Design fire scenarios for the performance based analysis were determined utilizing NFPA 101, as referenced in NFPA 914. These fire scenarios represent ordinary fires as well as extraordinary fires. Of the identified potential fire scenarios, three [3] were chosen to represent the most extreme scenarios within the building and evaluated further utilizing an available safe egress time [ASET] and required safe egress time [RSET] analysis coupled with fire and evacuation modeling software.
- The results of the ASET and RSET analysis demonstrated that the installation of several new life safety systems is necessary to meet life safety and property protection goals of the building modernization effort. These systems include the installation of an automatic sprinkler system with a dual feed to eliminate the potential for a single point failure. The building should also be provided with a completely automatic smoke detection system. The specific design of such a system will be determined at a later date, but it is anticipated that it will contain aspirating smoke detection, spot type detection, and beam detection. Lastly, a smoke control system is integral in maintaining tenable paths of egress as occupants leave the building.
- The enhanced building, with the additional life safety systems detailed above, is sufficient to maintain tenable conditions within the paths of egress throughout the building even in extraordinary fire events, as delineated in the fire scenarios. The exterior fire escape stairs are not necessary for egress. The enhanced building features exceed the life safety benefit of these additional stairs.