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Regional Shelter Analysis Methodology

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DISCLAIMER

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SUMMARY

The fallout from a nuclear explosion has the potential to injure or kill 100,000 or more people through exposure to external gamma (fallout) radiation. Existing buildings can reduce radiation exposure by placing material between fallout particles and exposed people.

Lawrence Livermore National Laboratory was tasked with developing an operationally feasible methodology that could improve fallout casualty estimates. The methodology, called a Regional Shelter Analysis, combines the fallout protection that existing buildings provide civilian populations with the distribution of people in various locations. The Regional Shelter Analysis method allows the consideration of (a) multiple building types and locations within buildings, (b) country specific estimates, (c) population posture (e.g., unwarned vs. minimally warned), and (d) the time of day (e.g., night vs. day). The protection estimates can be combined with fallout predictions (or measurements) to (a) provide a more accurate assessment of exposure and injury and (b) evaluate the effectiveness of various casualty mitigation strategies.

This report describes the Regional Shelter Analysis methodology, highlights key operational aspects (including demonstrating that the methodology is compatible with current tools), illustrates how to implement the methodology, and provides suggestions for future work.

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INTRODUCTION

The fallout from a nuclear explosion has the potential to injure or kill 100,000 or more people through exposure to external gamma (fallout) radiation. Existing buildings can reduce radiation exposure by placing material between fallout particles and exposed people. Indeed, sheltering is well known to reduce fallout casualties and was a key civil defense measure during the cold war [1]–[3].

Currently the Department of Defense Hazard Prediction and Assessment Capability (HPAC) model estimates the fallout protection at a given region either for unsheltered (outside) populations or by combining (a) fallout protection estimates provided by the Defense Intelligence Agency *Physical Vulnerability Handbook for Nuclear Weapons* [4] for 6 shelter categories (5 building/shelter types and open terrain) with (b) the geographic distribution of these building/shelter types as provided by the Oak Ridge Global Protection Type database [5]. The latter method assumes that all people in a given region are minimally warned (i.e., have 20 min of warning) and are in the same type of shelter.

Lawrence Livermore National Laboratory (LLNL) was tasked with developing an operationally feasible methodology that could improve HPAC's ability to estimate fallout casualties and fatalities.[1] The methodology, called a *Regional Shelter Analysis* (RSA), combines the fallout protection that existing buildings provide civilian populations with the distribution of people in various locations. The RSA method allows the consideration of (a) multiple building types, (b) country specific estimates, (c) population posture (e.g., unwarned vs. minimally warned), and (d) the time of day (e.g., night vs. day). The protection estimates can be combined with fallout predictions (or measurements) to (a) provide a more accurate assessment of exposure and injury and (b) evaluate the effectiveness of various casualty mitigation strategies.

This report describes the RSA methodology, highlights key operational aspects (including demonstrating that the methodology is compatible with current tools), and illustrates how to implement the RSA methodology.

[1] It is beyond the scope of this study to consider the full suite of nuclear explosion injuries, e.g., thermal radiation, blast overpressure, and prompt radiation. As such, the methodology described in this study is most applicable to fallout zones without significant building damage, e.g. locations outside the Light Damage Zone described in [6]. For context, the Light Damage Zone from a 10 KT surface explosion extends ~3 mi from ground zero while the Dangerous Fallout Zone extends up to 20 mi from ground zero and shelter may be warranted beyond the Dangerous Fallout Zone to minimize radiation exposure [6].

REGIONAL SHELTER ANALYSIS METHODOLOGY

CALCULATING SHELTER QUALITY

The RSA method estimates the range (regional distribution) of building protection (shelter quality) for each region,[2] population posture, and time of interest in three steps:

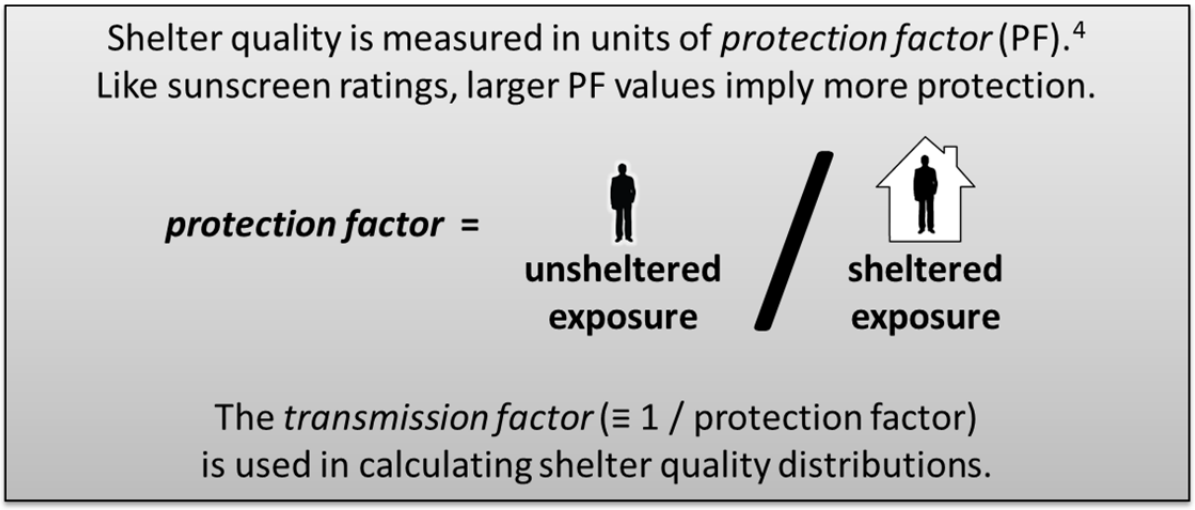
(1) Identify the locations[3] in which people are present,

(2) Characterize the protection and the fraction of the regional population associated with each location, and

(3) Combine the individual location specific protection factors and population fractions into a regional shelter quality distribution.

To streamline shelter quality and casualty calculations, the RSA methodology measures protection in units of protection factor and transmission factor (see sidebar).

The details of the first two steps can vary by method implementation and so are discussed in the *demonstration capability* section. The third step is described here and illustrated with **Figure 1** using an example dataset, see **Table 1**.



[2] For the purposes of this study, a region is defined as a geographic area that we can (or do) not resolve further. While we consider the range of protection present within a given region, the geographic distribution of this protection is not specified. The size of a region can vary with input(s) and/or application(s). In the spatial database discussed later, each grid cell is a region.

[3] For the purposes of this study, a location is defined as a place within a region in which people are present. Like regions, the size of a location can vary, e.g. a room in a building or all residential buildings.

[4] Specifically, protection factors are defined as the ratio of [the "open field" exposure] to [the exposure experienced by the sheltered population]. For fallout radiation, "open field" exposure is the radiation exposure measured 1 m (~3 ft.) above an infinite flat plane contaminated with radioactive fallout.

TABLE 1 – EXAMPLE DATASET

location number	1	2	3	4	5	6	7	8
protection factor	50	50	20	10	50	100	2	20
population (percent)	22.1	5.4	13.5	8.2	12.3	16	8.7	13.8

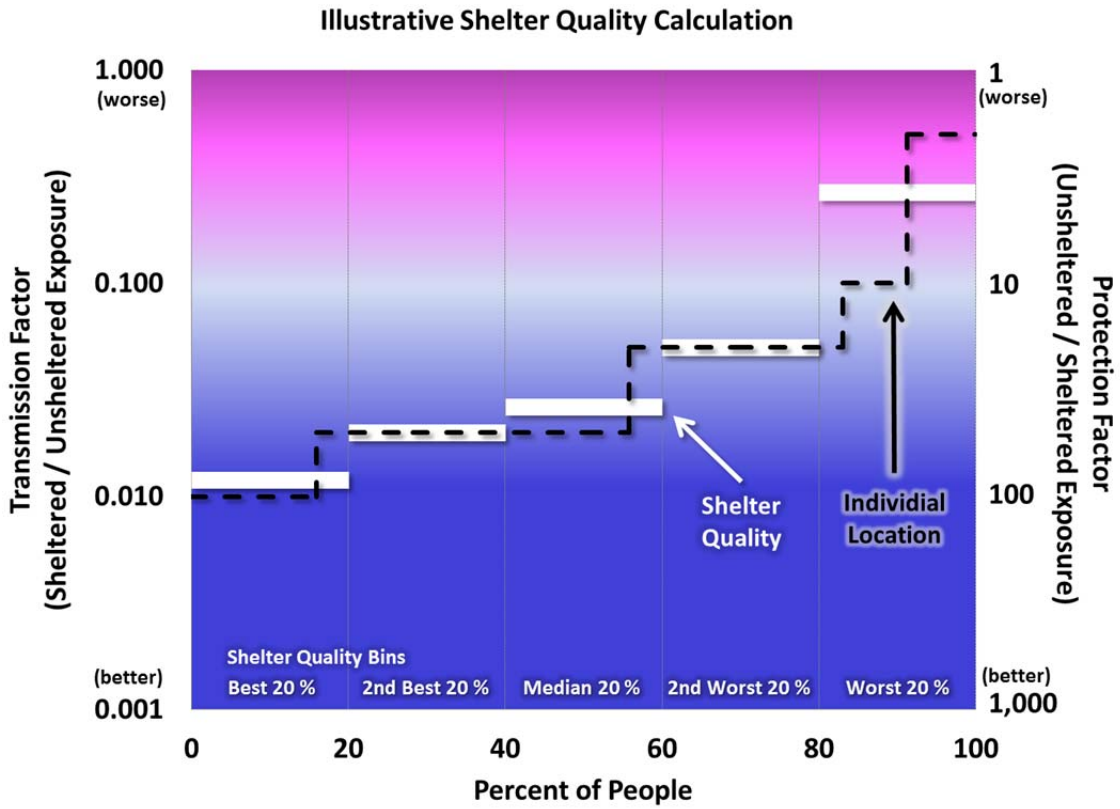


FIGURE 1 – ILLUSTRATIVE SHELTER QUALITY CALCULATION FOR A GIVEN TIME, REGION, AND POPULATION POSTURE

First, the black dashed line in Figure 1 (location protection factor cumulative probability distribution) was determined by (a) sorting the location protection factors in order of decreasing value and (b) summing the corresponding population percents, see **Table 2**.

TABLE 2 – EXAMPLE LOCATION PROTECTION FACTOR CUMULATIVE PROBABILTY DISTRIBUTION

location number	6	5	1	2	8	3	4	7
protection factor	100	50	50	50	20	20	10	2
start of population probability (percent)	0	16	28.3	50.4	55.8	69.6	83.1	91.3
stop of population probability (percent)	16	28.3	50.4	55.8	69.6	83.1	91.3	100

Second, the shelter quality transmission factors (solid white lines in Figure 1) were determined by a population-weighted average of the location transmission factors in each shelter quality probability bin. This example, and the demonstration capability discussed later, uses five equal shelter quality probability bins, see **Table 3**.

TABLE 3 – EXAMPLE SHELTER QUALITY TRANSMISSION FACTOR CUMULATIVE PROBABILITY DISTRIBUTION

shelter quality probability bin	shelter quality transmission factor (1 / protection factor)	location number	location transmission factor (1 / protection factor)	relative weight
best 20%	0.012	6	0.01	0.8 (= 16/20)
		5	0.02	0.2 (= 4/20)
2nd best 20%	0.02	5	0.02	0.42 (= 8.3/20)
		1	0.02	0.59 (= 11.7/20)
median 20%	0.0263	1	0.02	0.52 (= 10.4/20)
		2	0.02	0.27 (= 5.4/20)
		8	0.05	0.21 (= 4.2/20)
2nd worst 20%	0.05	8	0.05	0.48 (= 9.6/20)
		3	0.05	0.52 (= 10.4/20)
worst 20%	0.26625	3	0.05	0.16 (= 3.1/20)
		4	0.1	0.41 (= 8.2/20)
		7	0.5	0.44 (= 8.7/20)

Third, the shelter quality protection factors were determined by inverting the corresponding shelter quality transmission factors, see **Table 4**.

TABLE 4 – EXAMPLE SHELTER QUALITY PROTECCTION FACTOR DISTRIBUTION

probability bin	best 20%	2nd best 20%	median 20%	2nd worst 20%	worst 20%
transmission factor	0.012	0.02	0.0263	0.05	0.26625
protection factor	83	50	38	20	3.8

CREATING A DATABASE

The RSA method develops a shelter quality database by combining the region-specific shelter quality estimates with the region boundaries, see **Figure 2**. The details of how the shelter quality estimates are geo-located can vary by method implementation and so are discussed in the *demonstration capability* section.

Shelter Quality Distribution

	best 20%	2nd best 20%	median 20%	2nd worst 20%	worst 20%
France	51	25	8.2	2.1	1.0
Portugal	44	24	10	2.3	1.0
Spain	44	25	11	2.7	1.0

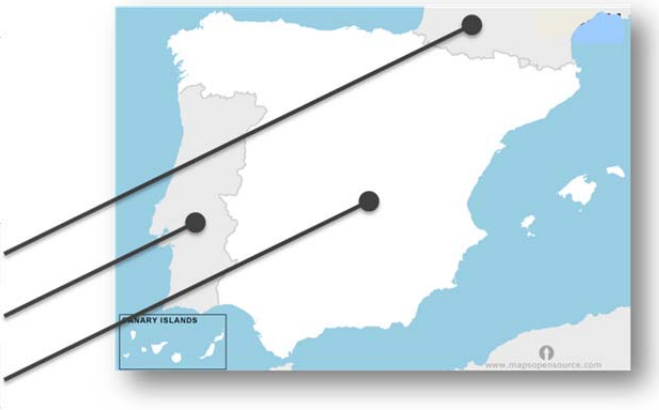


FIGURE 2 – ILLUSTRATIVE GEO-LOCATION OF RSA SHELTER QUALITY ESTIMATES

CALCULATING CASUALTIES

Equation 1 calculates the sheltered exposure by dividing the unsheltered (outdoor) exposure, which can be calculated by the HPAC model, by the RSA shelter quality estimates. **Equation 2** calculates the fraction of people impacted in a given region by a weighted average of the fraction of people impacted in each probability bin, which in turn is calculated using a health effect model and the shelter exposures.[5] **Equation 3** calculates the casualties in a given region, e.g., a model grid cell, by multiplying the fraction of people affected with the corresponding population estimate. **Equation 4** calculates the total casualties by summing all regional casualties.

(equation 1)

$$Sheltered\ Exposure_{r,p} = Unsheltered\ Exposure_r \div Shelter\ Quality_{r,p}$$

where
$Sheltered\ Exposure_{r,p}$ = exposure in region r and probability bin p (units vary)
$Unsheltered\ Exposure_r$ = unprotected (often outdoor) exposure in region r (units vary)
$Shelter\ Quality_{r,p}$ = shelter quality in region r and probability bin p (protection factor)

(equation 2)

$$Casualty\ Fraction_r = \sum_{p \in probabilty\ bins} \frac{Health\ Effect\ Model\left(Sheltered\ Exposure_{r,p}\right)}{\Delta prob_p}$$

where
$Casualty\ Fraction_r$ = fraction of people impacted in region r (no units)
$Health\ Effect\ Model\ (Exposure)$ = probability of a casualty for given exposure (no units)
$\Delta prob_p$ = probability fraction for probability bin p (no units)

(equation 3)

$$Regional\ Casualties_r = Casualty\ Fraction_r \times Population_r$$

where
$Regional\ Casualties_r$ = number of casualties in region r (people)
$Population_r$ = people in region r (people)

(equation 4)

$$Total\ Casualties = \sum_{r \in regions} Regional\ Casualties_r$$

where
$Total\ Casualties$ = total number of casualties (people)

[5] Equation 2 can also be written as a definite integral. However, numerical integration is significantly slower than multiplication and addition and so for operational reasons we recommend using the Riemann sum version shown with a small number of probability bins.

OPERATIONAL CONSIDERATIONS

COMPATIBILITY WITH CURRENT TOOLS

The RSA methodology is compatible with current tools because, from a computational point of view, it is similar to the current consequence assessment method.

The current method follows the methodology described in the *calculating casualties* section[6] using a single probability bin (i.e., all people in a given location are protected to the same degree), the shelter quality as determined by combining (a) fallout protection estimates provided by the Defense Intelligence Agency *Physical Vulnerability Handbook for Nuclear Weapons* [4] for 6 shelters with (b) the geographic distribution of these shelters as provided by the Oak Ridge Global Protection Type database [5]; the regional population determined by the ORNL Landscan population database [8]; and the Applied Research Associates RIPD health effect model [9].

The RSA method expands the current method by (a) using multiple probability bins and (b) differentiates the shelter quality protection factors by time of day and population posture. This means that the RSA casualties estimates can be based on HPAC-generated plume exposures and the ORNL Landscan population database. The esri fallout casualty calculator, provided as supplemental material, provides a worked example of how to calculate casualties from a HPAC fallout plume, RSA shelter quality distributions, and the ORNL Landscan population data.[7]

USE OF BEST AVAILABLE DATA

The RSA methodology is capable of using disparate building and population datasets in an operationally feasible manner.

The availability and types of building and population data varies greatly by location, with highly-detailed information available in some locations and broad (and uncertain) estimates available in others. As the accuracy of the shelter quality estimates depends, in part, on the accuracy of the underlying data; enhanced casualty estimates are possible in regions of higher quality data.

The RSA method unifies disparate data by developing a world-wide fallout shelter database. The database is first populated with world-wide, but low-fidelity fallout shelter quality estimates to provide default estimates of shelter quality for all locations. In locations where higher-fidelity building data is available, the default estimates are replaced with the higher-fidelity estimates.[8] Since the form of the database does not change with the inclusion of more detailed shelter quality estimates, operational considerations are not affected.

The *demonstration capability* section develops an illustrative example of this type of integrated database using two building/population datasets:

- PAGER dataset which provides lower fidelity, worldwide coverage, and
- HAZUS dataset which provides higher fidelity, US only coverage.

[6] For computational efficiency, HPAC combines equations 1 and 2 [7].
[7] A US EPA health effect model was used because the RIPD health effect model was not available.
[8] During this process, consideration should be paid to ensuring the protection factor estimates are consistent across similar location types.

IMPORTANCE OF USING A RANGE OF PROTECTION

The RSA methodology allows casualty calculations to consider a range of hazardous exposures to more accurately assess regional casualty estimates.

For many impacts, the probability of impact does not vary linearly with exposure. This is true for acute (rapid) fatal and non-fatal injuries due to fallout radiation exposure.[9] If shelter quality varies widely in a region with hazardous levels of fallout radiation, then an accurate casualty estimate requires consideration of a range of exposures as it is possible for casualties to occur only in relatively poorly sheltered populations. **Figure 3** illustrates this case where, for this hypothetical example, almost all acute injuries are predicted to occur in the worst protected 20% of the population.

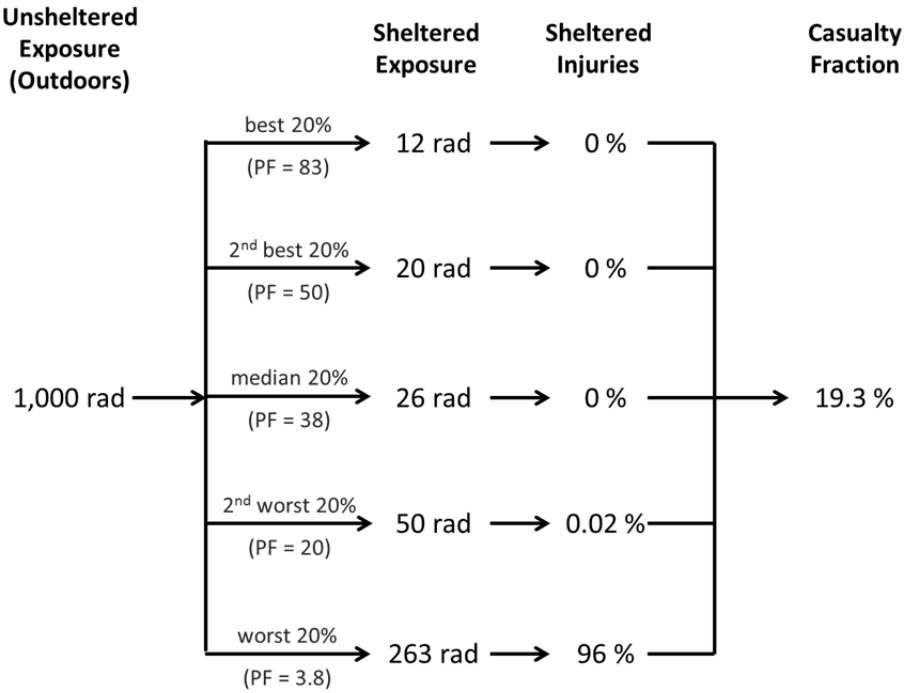


FIGURE 3 – ILLUSTRATIVE CASUALITY CALCULATION USING AN US EPA HEALTH EFFECT MODEL

The RSA method allows casualty calculations to consider a range of exposures by allowing the shelter qualities to be defined for multiple probability bins (groups of people). The overall analysis accuracy will depend, in part, upon the degree to which the probability bin specification resolves the underlying shelter quality distribution.

[9] For more detail, see the US Environmental Protection Agency health effect model described in the *demonstration capability* section.

DEMONSTRATION CAPABILITY

This section demonstrates the development and use of a prototype fallout RSA database. As this database is intended to illustrate the RSA methodology, further review is recommended prior to using this prototype database operationally.

CALCULATING SHELTER QUALITY

The demonstration shelter quality estimates were derived following the RSA methodology with the location definitions, protection factors, and populations described in this section. The results are provided as supplemental material in "US_LLNL_RSA.xlsx" and "Global_LLNL_RSA.xlsx" .

LOCATIONS

Time use studies track where and how people spend their time during the course of a normal day. Time use studies have been performed over many decades and in numerous countries, e.g., [10] and references therein, and form a foundation for population location definitions. Natural hazard, e.g. earthquake, planning and response tools have extended the time use study results by correlating time use categories with the geographical distribution of building structural characteristics.

The demonstration RSA capability leverages the population location data of two complementary earthquake assessment tools, see **Table 5**. The United States Geological Survey (USGS) and World Housing Encyclopedia (WHE) Prompt Assessment of Global Earthquakes for Response (PAGER) provides global estimates of population distributed into 90 different location types [11]. **Table 6 to Table 8** and [11]–[14] (and reference therein) provides a brief description of these building types and considerations for their use. The Department of Homeland Security, Federal Emergency Management Agency Hazards-United States (DHS FEMA HAZUS) provides higher fidelity estimates of US population distributed into 45 different location types [15].[10] **Table 9 to Table 10** and [16]–[18] provide descriptions of the HAZUS building types. [19] provides an approximate mapping between the HAZUS and PAGER building types (PAGER extends the HAZUS building classification).

TABLE 5 – SUMMARY OF THE HAZUS AND PAGER MODEL POPULATION LOCATION DATA

Model	DHS FEMA HAZUS	USGS/WHE PAGER
Coverage	United States	Global
Spatial resolution	US Census Tract Geographic size varies (each tract contains ~4,000 people)	Country Urban vs. rural
Temporal resolution	Workday Night Commuting	Workday Night Commuting
Locations	42 building types* 2 transportation types Outdoors	89 building types Outdoors

* There are 36 HAZUS building types. 6 additional building types are added to track buildings with basements.

[10] Nominally HAZUS has 36 distinct building types. However, 6 building types may have basements. We have separated the buildings with basements into separate building types. For computation purposes, we combined the outdoor and transportation location types.

TABLE 6 – SUMMARY OF PAGER BASED LOCATION TYPES. THIS STUDY EXTENDS THE ORIGINAL PAGER BUILDING CONSTRUCTION TYPES TO EXPLICITLY INCLUDE THE OUTDOORS

PAGER based location type	Description
Outdoor	**OUTDOORS**
W	**WOOD**
W1	Wood Frame, Wood Stud, Wood, Stucco, or Brick Veneer
W2	Wood Frame, Heavy Members, Diagonals or Bamboo Lattice, Mud Infill
W3	Wood Frame, Prefabricated Steel Stud Panels, Wood or Stucco Exterior Walls
W4	Log building
S	**STEEL**
S1	Steel Moment Frame
S1L	Low-Rise
S1M	Mid-Rise
S1H	High-Rise
S2	Steel Braced Frame
S2L	Low-Rise
S2M	Mid-Rise
S2H	High-Rise
S3	Steel Light Frame
S4	Steel Frame with Cast-in-Place Concrete Shear Walls
S4L	Low-Rise
S4M	Mid-Rise
S4H	High-Rise
S5	Steel Frame with Un-reinforced Masonry Infill Walls
S5L	Low-Rise
S5M	Mid-Rise
S5H	High-Rise
C	**REINFORCED CONCRETE**
C1	Ductile Reinforced Concrete Moment Frame
C1L	Low-Rise
C1M	Mid-Rise
C1H	High-Rise
C2	Reinforced Concrete Shear Walls
C2L	Low-Rise
C2M	Mid-Rise
C2H	High-Rise
C3	Nonductile Reinforced Concrete Frame with Masonry Infill Walls
C3L	Low-Rise
C3M	Mid-Rise
C3H	High-Rise

TABLE 7 – SUMMARY OF PAGER BASED LOCATION TYPES, CONTINUED

PAGER based location type	Description
C4	Nonductile Reinforced Concrete Frame without Masonry Infill Walls
C4L	Low-Rise
C4M	Mid-Rise
C4H	High-Rise
C5	Steel Reinforced Concrete (Steel Members Encased in Reinforced Concrete)
C5L	Low-Rise
C5M	Mid-Rise
C5H	High-Rise
PC1	Precast Concrete Tilt-Up Walls
PC2	Precast Concrete Frames with Concrete Shear Walls
PC2L	Low-Rise
PC2M	Mid-Rise
PC2H	High-Rise
RM	**REINFORCED MASONRY**
RM1	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms
RM1L	Low-Rise
RM1M	Mid-Rise (4+ stories)
RM2	Reinforced Masonry Bearing Walls with Concrete Diaphragms
RM2L	Low-Rise
RM2M	Mid-Rise
RM2H	High-Rise
MH	**MOBILE HOMES**
M	**MUD WALLS**
M1	Mud walls without horizontal wood elements
M2	Mud walls with horizontal wood elements
A	**ADOBE BLOCK (UNBAKED DRIED MUD BLOCK) WALLS**
A1	Adobe block, mud mortar, wood roof and floors
A2	Same as A1, bamboo, straw, and thatch roof
A3	Same as A1, cement-sand mortar
A4	Same as A1, reinforced concrete bond beam, cane and mud roof
A5	Same as A1, with bamboo or rope reinforcement
RE	**RAMMED EARTH/PNEUMATICALLY IMPACTED STABILIZED EARTH**

TABLE 8 – SUMMARY OF PAGER BASED LOCATION TYPES, CONTINUED

PAGER based location type	Description
RS	**RUBBLE STONE (FIELD STONE) MASONRY**
RS1	Local field stones dry stacked (no mortar). Timber floors. Timber, earth, or metal roof.
RS2	Same as RS1 with mud mortar.
RS3	Same as RS1 with lime mortar.
RS4	Same as RS1 with cement mortar, vaulted brick roof and floors
RS5	Same as RS1 with cement mortar and reinforced concrete bond beam.
DS	**RECTANGULAR CUT STONE MASONRY BLOCK**
DS1	Rectangular cut stone masonry block with mud mortar, timber roof and floors
DS2	Same as DS1 with lime mortar
DS3	Same as DS1 with cement mortar
DS4	Same as DS2 with reinforced concrete floors and roof
UFB	**UNREINFORCED FIRED BRICK MASONRY**
UFB1	Unreinforced brick masonry in mud mortar without timber posts
UFB2	Unreinforced brick masonry in mud mortar with timber posts
UFB3	Unreinforced fired brick masonry, cement mortar, timber flooring, timber or steel beams and columns, tie courses (bricks aligned perpendicular to the plane of the wall)
UFB4	Same as UFB3, but with reinforced concrete floor and roof slabs
UCB	**UNREINFORCED CONCRETE BLOCK MASONRY, LIME/CEMENT MORTAR**
MS	**MASSIVE STONE MASONRY IN LIME/CEMENT MORTAR**
TU	**PRECAST CONCRETE TILT-UP WALLS** Precast Wall Panel Construction (Mid to high rise, Former Soviet Union style)
INF	**INFORMAL CONSTRUCTIONS (PARTS OF SLUMS/SQUATTERS)** Constructions made of wood/plastic sheets/GI Sheets/light metal or composite etc., not confirming to engineering standards.
UNK	**UNKNOWN CATEGORY (NOT SPECIFIED)**

TABLE 9 – SUMMARY OF HAZUS BASED LOCATION TYPES. THIS STUDY EXTENDS THE ORIGINAL HAZUS BUILDING CONSTRUCTION TYPES TO EXPLICITLY INCLUDE BASEMENTS (INDICATED BY THE "_B" SUFFIX) AND OUTDOORS

HAZUS-based location type	Description	Typical height (ft.)	Typical stories (range)
Outdoor	**OUTDOORS AND TRANSPORTATION**		
	WOOD		
W1	Wood, Light Frame (≤ 5,000 sq. ft.)	14	1 (1-2)
W1_B	W1 + Single Story Basement	14	1 (1-2)
W2	Wood, Commercial and Industrial (> 5,000 sq. ft.)	24	2 (all)
	STEEL		
S1L	Steel Moment Frame, Low Rise	24	2 (1-3)
S1M	Steel Moment Frame, Mid Rise	60	5 (4-7)
S1H	Steel Moment Frame, High Rise	156	13 (8+)
S2L	Steel Braced Frame, Low Rise	24	2 (1-3)
S2M	Steel Braced Frame, Mid Rise	60	5 (4-7)
S2H	Steel Braced Frame, High Rise	156	13 (8+)
S3	Steel Light Frame	15	1 (all)
S3_B	S3 + Single Story Basement	15	1 (all)
S4L	Steel Frame with Cast-in-Place Concrete Shear Walls, Low Rise	24	2 (1-3)
S4M	Steel Frame with Cast-in-Place Concrete Shear Walls, Mid Rise	60	5 (4-7)
S4H	Steel Frame with Cast-in-Place Concrete Shear Walls, High Rise	156	13 (8+)
S5L	Steel Frame with Unreinforced Masonry Infill Walls, Low Rise	24	2 (1-3)
S5L_B	S5L + Single Story Basement	24	2 (1-3)
S5M	Steel Frame with Unreinforced Masonry Infill Walls, Mid Rise	60	5 (4-7)
S5H	Steel Frame with Unreinforced Masonry Infill Walls, High Rise	156	13 (8+)
	CONCRETE		
C1L	Concrete Moment Frame, Low Rise	20	2 (1-3)
C1M	Concrete Moment Frame, Mid Rise	50	5 (4-7)
C1H	Concrete Moment Frame, High Rise	120	12 (8+)
C2L	Concrete Shear Walls, Low Rise	20	2 (1-3)
C2L_B	C2L + Single Story Basement	20	2 (1-3)
C2M	Concrete Shear Walls, Mid Rise	50	5 (4-7)
C2H	Concrete Shear Walls, High Rise	120	12 (8+)
C3L	Concrete Frame with Unreinforced Masonry Infill Walls, Low Rise	20	2 (1-3)
C3M	Concrete Frame with Unreinforced Masonry Infill Walls, Mid Rise	50	5 (4-7)
C3H	Concrete Frame with Unreinforced Masonry Infill Walls, High Rise	120	12 (8+)
PC1	Precast Concrete Tilt-Up Walls	15	1 (all)
PC2L	Precast Concrete Frames with Concrete Shear Walls, Low Rise	20	2 (1-3)
PC2M	Precast Concrete Frames with Concrete Shear Walls, Mid Rise	50	5 (4-7)
PC2H	Precast Concrete Frames with Concrete Shear Walls, High Rise	120	12 (8+)

TABLE 10 – SUMMARY OF HAZUS BASED LOCATION TYPES, CONTINUED

HAZUS based location type	Description	Typical height (ft.)	Typical stories (range)
	REINFORCED MASONRY		
RM1L	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms, Low Rise	20	2 (1-3)
RM1L_B	RM1L + Single Story Basement	20	2 (1-3)
RM1M	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms, Mid Rise	50	5 (4+)
RM2L	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms, Low Rise	20	2 (1-3)
RM2M	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms, Mid Rise	50	5 (4-7)
RM2H	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms, High Rise	120	12 (8+)
	UNREINFORCED MASONRY		
URML	Unreinforced Masonry Bearing Walls, Low Rise	15	1 (1-2)
URML_B	URML + Single Story Basement	15	1 (1-2)
URMM	Unreinforced Masonry Bearing Walls, Mid Rise	35	3 (3+)
MH	**MOBILE HOMES**	10	1 (all)

LOCATION POPULATION

Both the HAZUS and PAGER models estimate where the typical weekday population is located during the day (nominally 10am to 5pm), night (nominally 10pm to 5am), and commuting hours (nominally 6am to 9am and 6pm to 9pm).

The demonstration RSA capability population locations for the unwarned and minimally warned population postures were derived from the PAGER and HAZUS weekday population estimates (**Appendices A and B**, respectively). The unwarned[11] population locations are the PAGER and HAZUS typical weekday population distribution estimates (vehicle locations are assumed to be outside). Time periods on other days, e.g. weekends and holidays, are assumed to be similar to the corresponding workday time period. This assumption should be reexamined in future efforts as it is known that people's activities during the weekend and workday differ. The minimally warned[12] population locations was estimated by (a) redistributing the outdoor/vehicular population indoors (see Appendices A and B for more detail) and (b) assuming that all people obtain shelter prior to the arrival of radioactive fallout. **Figure 4** illustrates the population redistribution from the unwarned to minimally warned cases.

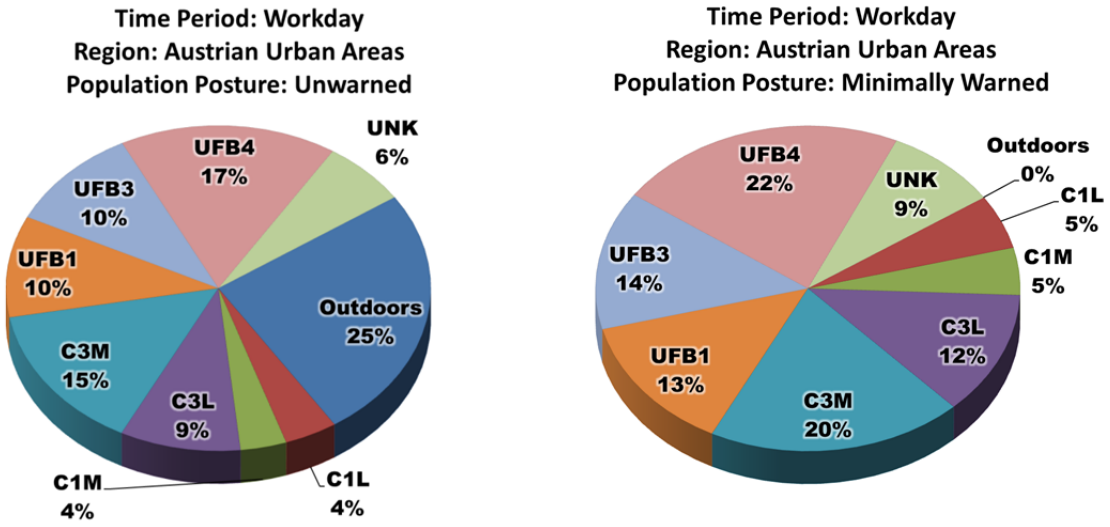


FIGURE 4 – EXAMPLE WORKDAY POPULATION LOCATIONS FOR (LEFT) UNWARNED AND (RIGHT) MINIMALLY WARNED POPULATION POSTURES

[11] People are in their normal location, also called no-response
[12] People move to the most protective location in the nearest building, also called shelter-in-place

LOCATION PROTECTION

Buildings provide protection to their occupants by (a) increasing the distance between fallout particles and those at risk and (b) blocking (scattering) fallout radiation as it travels through a building. The specific properties required to accurately assess the distribution of protection factors within a given building remains an active research area. However, it is known that the following properties can be important: mass (areal density) of external wall, roof, and floors; the presence of a basement; the number of stories; the internal building structure; the presence of apertures (e.g. windows, doors); and the surrounding environment [1].[13]

Building protection can vary considerably from building to building, at different locations within a given building, and at different times from detonation [1]. For example, single story, lightly constructed buildings such as wood or vinyl sided frame homes, offer limited protection (PF ≈ 2 to 3); e.g., [25], [26]; whereas the inner portions of large, multi-story concrete or masonry office buildings can offer excellent protection (PF > 100); e.g. [27], [28]. Basements, in general, offer adequate or better protection (PF ≥ 10), e.g. [6], [26]–[29]. Furthermore, protection can vary more than an order of magnitude between locations near the edge of the building compared to those further inside, particularly in larger buildings, e.g. [27]–[29].

The HAZUS and PAGER building types, which were primarily developed for earthquake assessments, vary in their specification of properties needed to accurately assess fallout protection. For example, the PC1 (precast concrete tilt-up walls) building type definition provides useful information on which to base a protection factor estimate, i.e., thin, heavy concrete walls with lightweight (wood or metal) roofs [17]. In contrast, the S1L (low-rise steel moment frame) type definition describes the internal load-bearing structure and provides no information on the exterior wall, roof or floor (which can be made of almost any material including glass and/or precast concrete) [17].

The protection factor distributions used in this demonstration capability, **Table 11 to Table 14**, were chosen by the authors to qualitatively illustrate a reasonable, but not comprehensive, range of protection experienced by people in different building types 1 hr after detonation.[14,15] When developing an operational capability, the authors recommend updating these estimates, see the *Discussion and Conclusions* section for more detail.

[13] For some buildings such as libraries and warehouses, the building contents contain more mass than the building construction materials, e.g. [20]. Prior protection factor calculations performed during the US civil defense program, e.g., [1] and references therein, or in nuclear power plant accident remediation studies, e.g. [21]–[23], do not appear to have considered building contents. The experimental measurements of in-use buildings cited in the main text and related remediation studies, e.g. [24], inherently include the influence, if any, of the building contents.

[14] It is beyond the scope of this study to (a) identify the minimum set of building parameters needed to accurately estimate fallout protection and (b) quantitatively assess the range of fallout protection both (i) within a building and (ii) among different buildings that can be categorized within a given building type.

[15] For demonstration purposes, the minimally warned protection factors have been set to the best protected unwarned shelter quality in each building type. When updating the protection factor estimates, future researchers should consider not only the building construction characteristics, but also the degree to which individuals can identify and obtain well-sheltered locations in a timely manner. Analogous to the unwarned case, accurate assessment of minimally sheltered individuals may require the use of a protection factor distribution.

TABLE 11 - PROTECTION FACTOR DISTRIBUTIONS FOR HAZUS BASED LOCATION TYPES

HAZUS location type	Unwarned (no-response)					Minimally warned (shelter-in-place)
	Best 20%	2nd Best 20%	Median 20%	2nd Worst 20%	Worst 20%	
Outdoor	1.0	1.0	1.0	1.0	1.0	1.0
W1	6.0	3.3	2.5	2.5	1.7	6.0
W1_B	20.0	10.0	2.5	2.5	1.7	20.0
W2	6.0	3.3	3.3	2.5	2.0	6.0
S1L	50.0	33.3	20.0	10.0	5.0	50.0
S1M	100.0	50.0	25.0	10.0	5.0	100.0
S1H	200.0	50.0	33.3	10.0	5.0	200.0
S2L	50.0	33.3	20.0	10.0	5.0	50.0
S2M	100.0	50.0	25.0	10.0	5.0	100.0
S2H	200.0	50.0	33.3	10.0	5.0	200.0
S3	3.3	3.3	2.5	2.5	1.7	3.3
S3_B	25.0	20.0	5.0	2.5	1.7	25.0
S4L	50.0	33.3	20.0	10.0	5.0	50.0
S4M	100.0	50.0	25.0	10.0	5.0	100.0
S4H	200.0	50.0	33.3	10.0	5.0	200.0
S5L	50.0	33.3	20.0	10.0	5.0	50.0
S5L_B	50.0	33.3	20.0	10.0	5.0	50.0
S5M	100.0	50.0	25.0	10.0	5.0	100.0
S5H	200.0	50.0	33.3	10.0	5.0	200.0
C1L	50.0	33.3	20.0	10.0	5.0	50.0
C1M	100.0	50.0	25.0	10.0	5.0	100.0
C1H	200.0	50.0	33.3	10.0	5.0	200.0
C2L	50.0	33.3	20.0	10.0	5.0	50.0
C2L_B	50.0	33.3	20.0	10.0	5.0	50.0
C2M	100.0	50.0	25.0	10.0	5.0	100.0
C2H	200.0	50.0	33.3	10.0	5.0	200.0
C3L	50.0	33.3	20.0	10.0	5.0	50.0
C3M	100.0	50.0	25.0	10.0	5.0	100.0
C3H	200.0	50.0	33.3	10.0	5.0	200.0
PC1	50.0	33.3	20.0	10.0	5.0	50.0
PC2L	50.0	33.3	20.0	10.0	5.0	50.0
PC2M	100.0	50.0	25.0	10.0	5.0	100.0
PC2H	200.0	50.0	33.3	10.0	5.0	200.0
RM1L	50.0	33.3	20.0	10.0	5.0	50.0
RM1L_B	50.0	33.3	20.0	10.0	5.0	50.0
RM1M	100.0	50.0	25.0	10.0	5.0	100.0
RM2L	50.0	33.3	20.0	10.0	5.0	50.0
RM2M	100.0	50.0	25.0	10.0	5.0	100.0
RM2H	200.0	50.0	33.3	10.0	5.0	200.0
URML	50.0	33.3	20.0	10.0	5.0	50.0
URML_B	50.0	33.3	20.0	10.0	5.0	50.0
URMM	100.0	50.0	25.0	10.0	5.0	100.0
MH	5.0	3.3	2.5	2.5	1.7	5.0

TABLE 12 – PROTECTION FACTOR DISTRIBUTIONS FOR PAGER BASED LOCATION TYPES

PAGER location type	Unwarned (no-response) Best 20%	2nd Best 20%	Median 20%	2nd Worst 20%	Worst 20%	Minimally warned (shelter-in-place)
Outdoors	1.0	1.0	1.0	1.0	1.0	1.0
W	6.0	3.3	2.5	2.5	1.7	6.0
W1	6.0	3.3	2.5	2.5	1.7	6.0
W2	6.0	3.3	2.5	2.5	1.7	6.0
W3	6.0	3.3	2.5	2.5	1.7	6.0
W4	5.0	3.3	2.5	2.5	1.7	5.0
S	50.0	33.3	20.0	10.0	5.0	50.0
S1	50.0	33.3	20.0	10.0	5.0	50.0
S1L	50.0	33.3	20.0	10.0	5.0	50.0
S1M	100.0	50.0	25.0	10.0	5.0	100.0
S1H	200.0	50.0	33.3	10.0	5.0	200.0
S2	50.0	33.3	20.0	10.0	5.0	50.0
S2L	50.0	33.3	20.0	10.0	5.0	50.0
S2M	100.0	50.0	25.0	10.0	5.0	100.0
S2H	200.0	50.0	33.3	10.0	5.0	200.0
S3	3.3	3.3	2.5	2.5	1.7	3.3
S4	50.0	33.3	20.0	10.0	5.0	50.0
S4L	50.0	33.3	20.0	10.0	5.0	50.0
S4M	100.0	50.0	25.0	10.0	5.0	100.0
S4H	200.0	50.0	33.3	10.0	5.0	200.0
S5	50.0	33.3	20.0	10.0	5.0	50.0
S5L	50.0	33.3	20.0	10.0	5.0	50.0
S5M	100.0	50.0	25.0	10.0	5.0	100.0
S5H	200.0	50.0	33.3	10.0	5.0	200.0
C	50.0	33.3	20.0	10.0	5.0	50.0
C1	50.0	33.3	20.0	10.0	5.0	50.0
C1L	50.0	33.3	20.0	10.0	5.0	50.0
C1M	100.0	50.0	25.0	10.0	5.0	100.0
C1H	200.0	50.0	33.3	10.0	5.0	200.0
C2	50.0	33.3	20.0	10.0	5.0	50.0
C2L	50.0	33.3	20.0	10.0	5.0	50.0
C2M	100.0	50.0	25.0	10.0	5.0	100.0
C2H	200.0	50.0	33.3	10.0	5.0	200.0
C3	50.0	33.3	20.0	10.0	5.0	50.0
C3L	50.0	33.3	20.0	10.0	5.0	50.0
C3M	100.0	50.0	25.0	10.0	5.0	100.0
C3H	200.0	50.0	33.3	10.0	5.0	200.0
C4	50.0	33.3	20.0	10.0	5.0	50.0
C4L	50.0	33.3	20.0	10.0	5.0	50.0
C4M	100.0	50.0	25.0	10.0	5.0	100.0
C4H	200.0	50.0	33.3	10.0	5.0	200.0
C5	50.0	33.3	20.0	10.0	5.0	50.0
C5L	50.0	33.3	20.0	10.0	5.0	50.0

TABLE 13 – PROTECTION FACTOR DISTRIBUTIONS FOR PAGER BASED LOCATION TYPES, CONTINUED

PAGER location type	Unwarned (no-response) Best 20%	2nd Best 20%	Median 20%	2nd Worst 20%	Worst 20%	Minimally warned (shelter-in-place)
C5M	100.0	50.0	25.0	10.0	5.0	100.0
C5H	200.0	50.0	33.3	10.0	5.0	200.0
PC1	50.0	33.3	20.0	10.0	5.0	50.0
PC2	50.0	33.3	20.0	10.0	5.0	50.0
PC2L	50.0	33.3	20.0	10.0	5.0	50.0
PC2M	100.0	50.0	25.0	10.0	5.0	100.0
PC2H	200.0	50.0	33.3	10.0	5.0	200.0
RM	50.0	33.3	20.0	10.0	5.0	50.0
RM1	50.0	33.3	20.0	10.0	5.0	50.0
RM1L	50.0	33.3	20.0	10.0	5.0	50.0
RM1M	100.0	50.0	25.0	10.0	5.0	100.0
RM2	50.0	33.3	20.0	10.0	5.0	50.0
RM2L	50.0	33.3	20.0	10.0	5.0	50.0
RM2M	100.0	50.0	25.0	10.0	5.0	100.0
RM2H	200.0	50.0	33.3	10.0	5.0	200.0
MH	5.0	3.3	2.5	2.5	1.7	5.0
M	50.0	33.3	20.0	10.0	5.0	50.0
M1	50.0	33.3	20.0	10.0	5.0	50.0
M2	50.0	33.3	20.0	10.0	5.0	50.0
A	50.0	33.3	20.0	10.0	5.0	50.0
A1	50.0	33.3	20.0	10.0	5.0	50.0
A2	50.0	33.3	20.0	10.0	5.0	50.0
A3	50.0	33.3	20.0	10.0	5.0	50.0
A4	50.0	33.3	20.0	10.0	5.0	50.0
A5	50.0	33.3	20.0	10.0	5.0	50.0
RE	50.0	33.3	20.0	10.0	5.0	50.0
RS	50.0	33.3	20.0	10.0	5.0	50.0
RS1	50.0	33.3	20.0	10.0	5.0	50.0
RS2	50.0	33.3	20.0	10.0	5.0	50.0
RS3	50.0	33.3	20.0	10.0	5.0	50.0
RS4	50.0	33.3	20.0	10.0	5.0	50.0
RS5	50.0	33.3	20.0	10.0	5.0	50.0
DS	50.0	33.3	20.0	10.0	5.0	50.0
DS1	50.0	33.3	20.0	10.0	5.0	50.0
DS2	50.0	33.3	20.0	10.0	5.0	50.0
DS3	50.0	33.3	20.0	10.0	5.0	50.0
DS4	50.0	33.3	20.0	10.0	5.0	50.0
UFB	50.0	33.3	20.0	10.0	5.0	50.0
UFB1	50.0	33.3	20.0	10.0	5.0	50.0
UFB2	50.0	33.3	20.0	10.0	5.0	50.0
UFB3	50.0	33.3	20.0	10.0	5.0	50.0
UFB4	50.0	33.3	20.0	10.0	5.0	50.0

TABLE 14 – PROTECTION FACTOR DISTRIBUTIONS FOR PAGER BASED LOCATION TYPES, CONTINUED

PAGER location type	Unwarned (no-response)					Minimally warned (shelter-in-place)
	Best 20%	2nd Best 20%	Median 20%	2nd Worst 20%	Worst 20%	
UCB	50.0	33.3	20.0	10.0	5.0	50.0
MS	50.0	33.3	20.0	10.0	5.0	50.0
TU	100.0	50.0	25.0	10.0	5.0	100.0
INF	2.0	2.0	2.0	2.0	2.0	2.0
UNK	2.0	2.0	2.0	2.0	2.0	2.0

CREATING A DATABASE

The demonstration RSA database is comprised of several shelter quality layers, each with a different horizontal resolution, see **Table 15**. For computational convenience, each database layer was divided into a set of equal area tiles that cover the globe. The "ASCII Tiles" zip archives, provided as supplemental material, are worked examples for the multi-resolution database.

TABLE 15 – DEMONSTRATION RSA SHELTER QUALITY DATABASE LAYERS

Database layer	Horizontal resolution	Individual tile size	Number of tiles
1	30 arc sec (~1 km)	2 deg x 2 deg	16,200
2	1.5 arc min (~3 km)	6 deg x 6 deg	1,800
3	4.5 arc min (~9 km)	18 deg x 18 deg	200
4	9 arc min (~18 km)	36 deg x 36 deg	50
5	27 arc min (~54 km)	90 deg x 90 deg	8
6	54 arc min (~108 km)	180 deg x 360 deg	1

The highest resolution layer (database layer 1) was developed by:

1) Assigning each location a:

    a. Country based on the shapefile boundaries downloaded by Natural Earth [30].[16] Null values were assigned when the location was outside any country boundary.

    b. US census tract based on shapefile boundaries downloaded from US Census Bureau [31]. Null values were assigned when the location was outside the US.

    c. Land type (urban, rural, or other) based on the Global Rural-Urban Mapping Project (GRUMP v1) 1995 Urban Extents Grid [32]. The other category was assigned to any location outside the GRUMP dataset domain.

2) The country, US census tract, and land use was used to look up the previously developed shelter quality estimates for each time period and population posture of interest.

    a. Locations with an "other" land type were assigned a protection factor of 1 (no protection),

    b. US locations were assigned a HAZUS-derived shelter quality distribution from the corresponding US census tract,[17]

    c. Non-US locations were assigned a PAGER-derived shelter quality distribution from the corresponding country and land type (urban or rural).

The population associated with each layer 1 database location was identified for later use in developing the lower resolution database layers.

[16] Minor edits were made to select shapefiles.

[17] The HAZUS database does not provide information for every US census tract. The shelter quality estimates for these "missing" census tracts were assigned using the global (PAGER) database.

The lower resolution layers (database layers 2 through 6) were developed from the next higher resolution layer (database layer 1 through 5, respectively). For each lower resolution grid cell, the:

1) Higher resolution grid cells that geographically overlap the lower resolution grid cell were identified,

2) Lower resolution population was set equal to the sum of the overlapping higher resolution populations, and the

3) Lower resolution shelter quality distribution for each time period and population posture was determined using the algorithm described in the *Regional Shelter Analysis Methodology* section and assigning:

    a. Population locations to be equal to the overlapping higher resolution grid cell shelter quality distributions, and the corresponding

    b. Population fractions to be equal to the higher resolution populations divided by (the lower resolution population times five).[18]

CALCULATING CASUALTIES

The demonstration capability follows the casualty calculation methodology described in the *Regional Shelter Analysis Methodology* section above and uses the Health Effect Model described in the next section.

The "Fallout Casualty Calculator - Global.xlsx" and "Fallout Casualty Calculator – US only.xlsx" Microsoft Excel spreadsheets, provided as supplemental material, are worked examples of how to calculate total and fatal injuries for a single region.

The esri fallout casualty calculator, provided as supplemental material, provides a more comprehensive worked example of how a HPAC fallout plume, RSA shelter quality distributions, and the ORNL Landscan population data can be used to calculate casualties.

[18] This demonstration database uses 5 equal probability shelter quality bins.

HEALTH EFFECT MODEL

The US Environmental Protection Agency (EPA) developed information to advise emergency workers on the risks of the acute health effects associated with large doses of radiation [33]. We manually fit a probit model to the EPA results. **Table 17** and **Figure 5** summarize the EPA values and curve fit.

This model estimates two types of injuries:

Total Injuries: Moderately severe effects that occur shortly after exposure (also called prodromal effects). These effects can include, but are not limited to, nausea, vomiting, and diarrhea.

Fatalities: Exposed individuals may die within 60 days after exposure without medical treatment.

This model does not consider other effects (e.g., increased cancer risk) and may not adequately capture the impact of low-dose exposures.

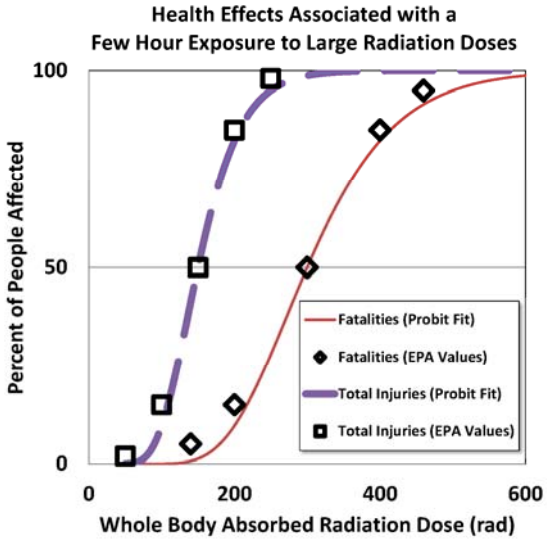


FIGURE 5 – PERCENT OF PEOPLE AFFECTED BY EXPOSURE TO LARGE DOSES OF FALLOUT RADIATION

The probit model is defined as:

$$Z = m\left(log_{10}(Dose) - log_{10}(ED_{50})\right)$$

$$Percent\ of\ People\ Affected = 50\% * ComplementaryErrorFunction\left(-Z/\sqrt{2}\right)$$

TABLE 16 – PERCENT OF PEOPLE INJURED DUE TO A FEW HOUR EXPOSURE TO LARGE DOSES OF FALLOUT RADIATION (ADAPTED FROM TABLE 2-3 IN [33])

Whole Body Absorbed Dose (rad)	Prodromal Effects (Percent of People)
50	2
100	15
150	50
200	85
250	98

PRODROMAL EFFECTS
PROBIT FIT PARAMETERS

Effective Dose (ED_{50})	150 (rad)
Probit Slope (m)	7.4 (no units)

TABLE 17 – PERCENT OF PEOPLE FATALLY INJURED DUE TO A FEW HOUR EXPOSURE TO LARGE DOSES OF FALLOUT RADIATION (ADAPTED FROM TABLE 2-3 IN [33])

Whole Body Absorbed Dose (rad)	Fatalities (Percent of People)
140	5
200	15
300	50
400	85
460	95

FATAL INJURIES
PROBIT FIT PARAMETERS

Lethal Dose (ED_{50})	300 (rad)
Probit Slope (m)	7.4 (no units)

DISCUSSION AND CONCLUSIONS

The Regional Shelter Analysis methodology combines, in an operationally feasible manner, the fallout protection that existing buildings provide civilian populations with the distribution of people in various locations. The Regional Shelter Analysis method allows the consideration of (a) multiple building types and locations within buildings, (b) country specific estimates, (c) population posture (e.g., unwarned vs. minimally warned), and (d) the time of day (e.g., night vs. day). The protection estimates can be combined with fallout predictions (or measurements) to (a) provide a more accurate assessment of exposure and injury and (b) evaluate the effectiveness of various casualty mitigation strategies.

The fallout protection estimates depend, in part, upon the accuracy of both building protection and population location estimates. These topics are active research areas and potential Regional Shelter Analysis improvements could include:

- Identifying the set of properties required to accurately assess the distribution of protection factors throughout a given building and determining the precision to which they should be specified;
- Using building categories (taxonomies) that more closely describe the building properties of interest. Recent developments in building taxonomies should be investigated for their applicability, see [34]–[36] and references therein;
- Refining methods that incorporate detailed, individual building and population data where it exists, e.g., [20], [37], [38];
- Consider the potential for shelter contamination if decontamination procedures are not followed by individuals entering buildings after the fallout arrival; and
- Considering actions people may take other than sheltering in the nearest building, e.g., traveling to highly protective neighborhood shelter. This consideration may require (a) an improved, integrated understanding of government policy, warning dissemination and compliance, and human behavior during disasters, e.g. [39]–[44] and (b) extensions to the current framework. Actions taken after fallout arrival may either decrease radiation exposure, e.g. individuals with poor shelter may move to higher quality shelters [45], or increase radiation exposure, e.g. individuals with good shelter may temporarily go outside (where they are unprotected) to assist in rescue operations or obtain food and medical assistance.

Finally, the current Regional Shelter Analysis methodology is most applicable to locations in which the fallout radiation is the dominant injury pathway. A capability that considers all nuclear explosion injury pathways (e.g., thermal radiation, blast overpressure, and prompt radiation); would involve either expanding the current methodology or integrated it within an existing integrated exposure and health effects model.

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APPENDICES

APPENDIX A – GLOBAL (PAGER) DATA

The global (lower fidelity) shelter quality estimates used in the demonstration Regional Shelter Analysis database are based on building population data and methods provided by the United Stated Geological Survey (USGS) and World Housing Encyclopedia (WHE) Prompt Assessment of Global Earthquakes for Response (PAGER) program [11], [46]. We extracted and processed the PAGER data using 2010 Microsoft Office for Windows and Mathworks Matlab R2013b.

UNWARNED (NO-RESPONSE) LOCATION POPULATION

Figure 6 illustrates the derivation of the unwarned (people do not move from their normal position, also called no-response) population location distribution, the fraction of people in each building construction type for a given country, time period (workday vs. night) and region (urban vs. rural). The algorithm is briefly discussed here and full details are provided in the supplementary spreadsheets ("LLNL_RSA_GlobalLayer_OC_Population.xlsx" and "LLNL_RSA_GlobalLayer_BC_Population.xlsx").[19]

Step 1: We calculate the fraction of people occupied in different activities (occupation class population) using the algorithm specified in **Table 18** and country level demographic data.

Step 2: We distribute the occupation class population derived in step 1 within each building construction type using the PAGER provided mapping.

Step 3: We derive the overall population location distribution by summing the fractions of people in each building construction type across all occupancy classes.

MINIMALLY WARNED (SHELTER-IN-PLACE) LOCATION POPULATION

The corresponding minimally warned (people move to the most protective location in the nearest building, also called shelter-in-place) building population distribution is calculated similarly to the unwarned (no-response) building population distribution except that the outdoor population fraction was assumed to be indoors. Specifically, we assume (a) the outdoor working population moves into non-residential buildings and (b) the outdoor non-working population moves into residential and non-residential buildings in proportion to the relative fraction of the indoor residential and service sector populations (see "LLNL_RSA_GlobalLayer_OC_Population.xlsx").

[19] Due to space limitations, the "data" in Figure 6 is notional. The supplementary spreadsheets contain the full calculations.

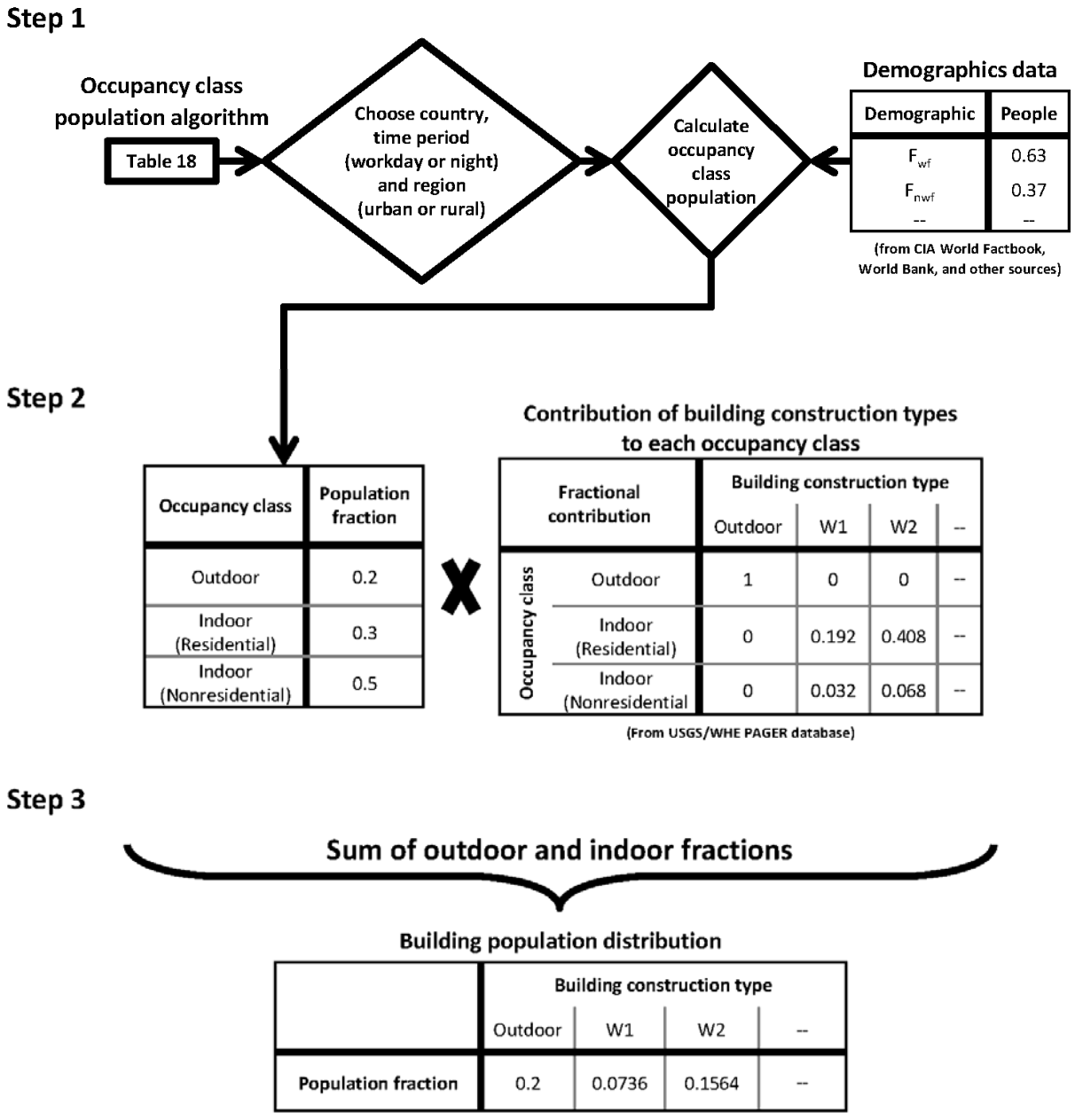

FIGURE 6 – STEPS IN DERIVING THE PAGER POPULATION LOCATION DISTRIBUTION

TABLE 18 – POPULATION FRACTION IN VARIOUS OCCUPANCY CLASSES (ADAPTED FROM TABLE 1 IN [47]).

Occupancy class	Night (10 pm to 5 am)	Workday (10 am to 5 pm)
Urban		
Indoor Residential	$0.999(F_{nwf})$ $+ 0.84(F_{wf})(F_{ind})$ $+ 0.89(F_{wf})(F_{ser})$ $+ 0.998(F_{wf})(F_{agr})$	$0.4(F_{nwf})$ $+ 0.01(F_{wf})(F_{ind})$ $+ 0.01(F_{wf})(F_{ser})$ $+ 0.01(F_{wf})(F_{agr})$
Indoor Nonresidential	$0.15(F_{wf})(F_{ind})$ $+ 0.1(F_{wf})(F_{ser})$ $+ 0.001(F_{wf})(F_{agr})$	$0.25(F_{nwf})$ $+ 0.89(F_{wf})(F_{ind})$ $+ 0.89(F_{wf})(F_{ser})$ $+ 0.34(F_{wf})(F_{agr})$
Outdoor	$0.001(F_{nwf})$ $+ 0.01(F_{wf})(F_{ind})$ $+ 0.01(F_{wf})(F_{ser})$ $+ 0.001(F_{wf})(F_{agr})$	$0.35(F_{nwf})$ $+ 0.1(F_{wf})(F_{ind})$ $+ 0.1(F_{wf})(F_{ser})$ $+ 0.65(F_{wf})(F_{agr})$
Rural		
Indoor Residential	$0.999(F_{nwf})$ $+ 0.89(F_{wf})(F_{ind})$ $+ 0.89(F_{wf})(F_{ser})$ $+ 0.998(F_{wf})(F_{agr})$	$0.4(F_{nwf})$ $+ 0.05(F_{wf})(F_{ind})$ $+ 0.05(F_{wf})(F_{ser})$ $+ 0.01(F_{wf})(F_{agr})$
Indoor Nonresidential	$0.1(F_{wf})(F_{ind})$ $+ 0.1(F_{wf})(F_{ser})$ $+ 0.001(F_{wf})(F_{agr})$	$0.25(F_{nwf})$ $+ 0.85(F_{wf})(F_{ind})$ $+ 0.85(F_{wf})(F_{ser})$ $+ 0.04(F_{wf})(F_{agr})$
Outdoor	$0.001(F_{nwf})$ $+ 0.01(F_{wf})(F_{ind})$ $+ 0.01(F_{wf})(F_{ser})$ $+ 0.001(F_{wf})(F_{agr})$	$0.35(F_{nwf})$ $+ 0.1(F_{wf})(F_{ind})$ $+ 0.1(F_{wf})(F_{ser})$ $+ 0.95(F_{wf})(F_{agr})$

F_{wf} fraction of the total population that is part of the workforce

F_{nwf} fraction of the total population that is NOT part of the workforce

F_{ind} fraction of the total workforce that is employed in the industrial sector

F_{agr} fraction of the total workforce that is employed in the agricultural sector

F_{ser} fraction of the total workforce that is employed in the service sector

APPENDIX B – US (HAZUS) DATA

The US (higher fidelity) shelter quality estimates used in the demonstration Regional Shelter Analysis database are based on building population data and methods provided by the Department of Homeland Security, Federal Emergency Management Agency Hazards-United States (DHS FEMA HAZUS) program [15]. We extracted and processed the MH4 HAZUS data [48][20] using 2010 Microsoft Office for Windows and Mathworks Matlab R2013b.

UNWARNED (NO-RESPONSE) LOCATION POPULATION

Figure 7 illustrates the derivation of the unwarned (people do not move from their normal position, also called no-response) population location distribution, the fraction of people in or near each building construction type, for a given US census tract and time period. The outdoor and indoor populations are calculated in steps 1 through 4. Commuting populations are calculated in step 1.

Step 1: We calculate the number of people engaged in different activities (occupation class population) based on the algorithm specified in **Table 19** and HAZUS provided 2000 US Census demographic data.[21]

Step 2: We calculate the number of people in or near buildings used for different purposes (building occupancy type population) by distributing the occupancy class population among the building occupancy types within each occupancy class (**Table 20**) in proportion to the HAZUS reported usable building area for each building occupancy type. This step implicitly assumes a constant number of people per area (population density) for all buildings in a given occupancy class.

Step 3: We calculate the population in each building construction type (building construction type population) by multiplying the building occupancy type population by the contribution of building construction types to each building occupancy type (the latter quantity is derived in the *Building Occupancy Type to Building Construction Type Mapping* subsection below).

Step 4: We derive the overall population location distribution by normalizing the sum of the indoor, outdoor, and commuting populations.

[20] The MH4 version was current at the time the demonstration database was developed. Recently the DHS HAZUS program as released an update (MH 2.2) which is based on the 2010 US Census data.

[21] Algorithm used differs slightly from the HAZUS algorithm to ensure conservation of population, specifically the coefficient for indoor nighttime NRES population was increased from 0.989 to 0.98901.

MINIMALLY WARNED (SHELTER-IN-PLACE) LOCATION POPULATION

The corresponding minimally warned (people move to the most protective location in the nearest building, also called shelter-in-place) building population distribution is calculated similarly to the unwarned (no-response) building population distribution except that all people are assumed to be indoors. Specifically, (a) in step 2 both the indoor and outdoor populations are assumed to be indoors and (b) the commuting population is distributed into the building construction types in proportion of the sum of the indoor and outdoor populations.

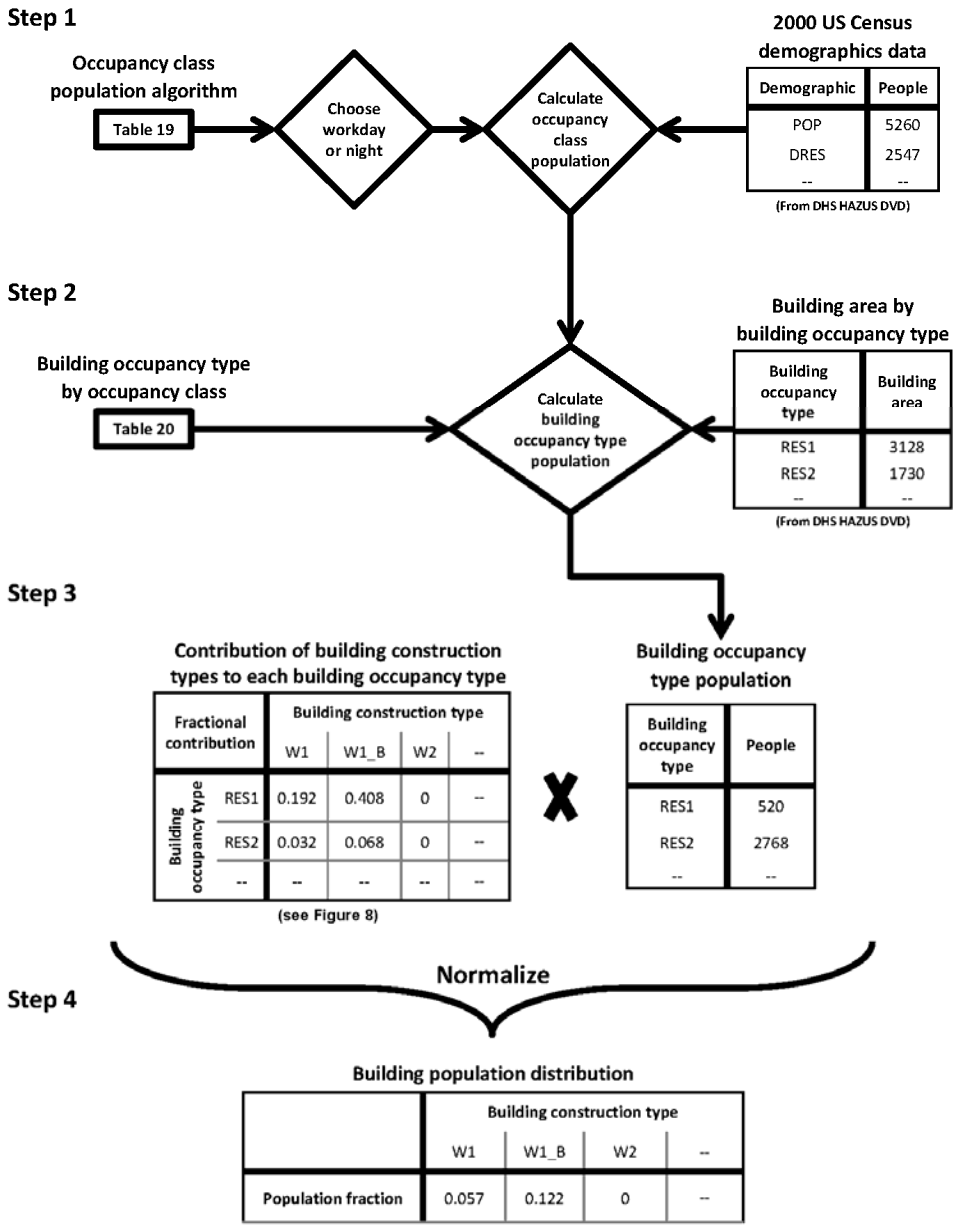

FIGURE 7 – STEPS IN DERIVING THE HAZUS POPULATION LOCATION DISTRIBUTION

TABLE 19 – POPULATION IN VARIOUS OCCUPANCY CLASSES (ADAPTED FROM TABLE 13.2 IN [47])

Occupancy class(es)	Night (2 am)	Workday (2 pm)
	INDOORS	
Residential (inc. Hotels)	0.98901(NRES) + 0.999(HOTEL)	0.525(DRES) + 0.19(HOTEL)
Commercial + Governmental + Religious	0.01998(COMW)	0.9702(COMW) + 0.16(DRES) + 0.80(HOTEL) + 0.8(VISIT)
Educational	0	0.72(GRADE) + 0.8(COLLEGE)
Industrial + Agricultural	0.0999(INDW)	0.72(INDW)
	OUTDOORS	
Residential (inc. Hotels)	0.00099(NRES) + 0.001(HOTEL)	0.225(DRES) + 0.01(HOTEL)
Commercial + Governmental + Religious	0.00002(COMW)	0.0098(COMW) + 0.04(DRES) + 0.2(VISIT) + 0.025(1-PRFIL)(POP)
Educational	0	0.08(GRADE) + 0.2(COLLEGE)
Industrial + Agricultural	0.0001(INDW)	0.08(INDW)
	COMMUTING	
Commuting in cars	0.005(POP)	0.05(PRFIL)(POP)
Commuting using other modes	0	0.025(1-PRFIL)(POP)

POP	census tract population taken from census data
DRES	daytime residential population inferred from census data
NRES	nighttime residential population inferred from census data
COMW	number of people employed in the commercial sector
INDW	number of people employed in the industrial sector
GRADE	number of students in grade schools (K-12)
COLLEGE	number of students on college and university campuses in the census tract
HOTEL	number of people staying in hotels in the census tract
PRFIL	factor representing the proportion of commuters using automobiles (set to 0.80).
VISIT	number of regional residents who do not live in the study area, but visit the census tract for shopping and entertainment (set to zero).

TABLE 20 – DHS HAZUS OCCUPANCY CLASSES AND BUILDING OCCUPANCY TYPES (ADAPTED FROM TABLE 3.2 IN [48])

Occupancy class	HAZUS building occupancy type	Description
Residential	RES1	Single Family Dwelling
	RES2	Mobile Home
	RES3A	Multi Family Dwelling: Duplex
	RES3B	Multi Family Dwelling: 3-4 Units
	RES3C	Multi Family Dwelling: 5-9 Units
	RES3D	Multi Family Dwelling: 10-19 Units
	RES3E	Multi Family Dwelling: 20-49 Units
	RES3F	Multi Family Dwelling: 50+ Units
	RES4	Temporary Lodging (e.g., Hotel/Motel)
	RES5	Institutional Dormitory (e.g., Group Housing (Military, College), Jails)
	RES6	Nursing Home
Commercial	COM1	Retail Trade (e.g., Stores)
	COM2	Wholesale Trade (e.g., Warehouses)
	COM3	Personal and Repair Services (e.g., Service Station, Shop)
	COM4	Professional/Technical Services (e.g., Offices)
	COM5	Banks
	COM6	Hospital
	COM7	Medical Office/Clinic
	COM8	Entertainment & Recreation (e.g., Restaurants/Bars)
	COM9	Theaters
	COM10	Parking (e.g., Garages)
Industrial	IND1	Heavy Industry (e.g., Factory)
	IND2	Light Industry (e.g., Factory)
	IND3	Food/Drugs/Chemicals (e.g., Factory)
	IND4	Metals/Minerals Processing (e.g., Factory)
	IND5	High Technology (e.g., Factory)
	IND6	Construction (e.g., Office)
Agricultural	AGR1	Agriculture
Religious	REL1	Church/Non-profit
Governmental	GOV1	General Services (e.g., Office)
	GOV2	Emergency Response (e.g., Police, Fire Station, EOC)
Educational	EDU1	Grade Schools
	EDU2	Colleges/Universities (does not include group housing)

BUILDING OCCUPANCY TYPE TO BUILDING CONSTRUCTION TYPE MAPPING

The method to calculate the fractional contribution of building construction types to each building occupancy type is illustrated in **Figure 8** and derived separately for single family dwellings (RES1) and other building occupancy types:

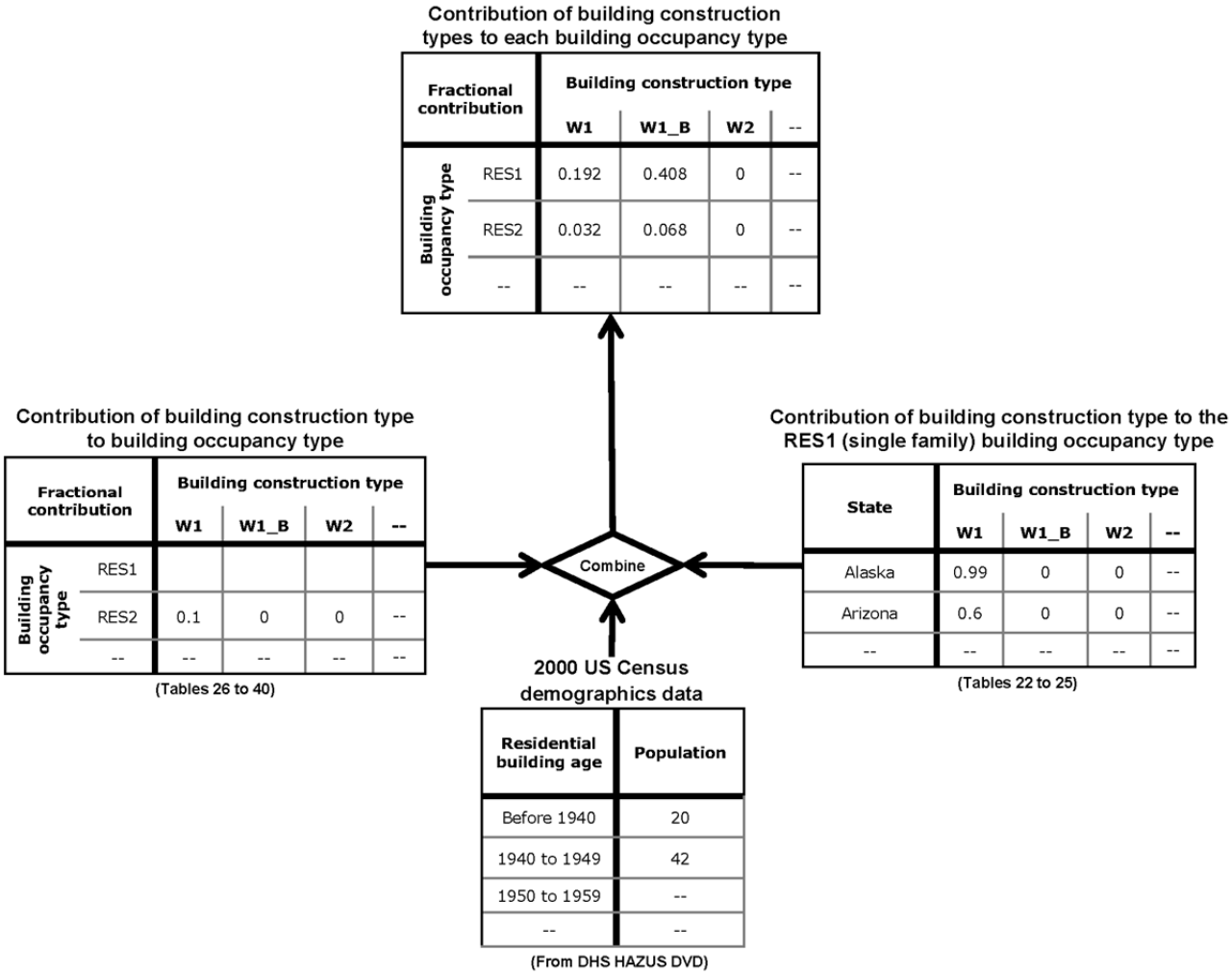

FIGURE 8 – DERIVATION OF BUILDING OCCUPANCY TYPE TO BUILDING CONSTRUCTION TYPE MAPPING

SINGLE FAMILY DWELLING (RES1) BUILDING OCCUPANCY TYPE

For census tracts in the eastern and midwestern states, **Table 22** provides the percent contribution of various building construction types to the RES1 building occupancy type. In some western states, building construction is known to vary with building age. Therefore for each western census tract, a row equivalent to a row in Table 22 was derived by averaging the appropriate rows in **Table 23 to Table 25** as weighted by the HAZUS provided 2000 US Census residential building age distribution.

The values provided in Table 22 to Table 25 were determined by combining Tables 3A.17 to 3A.21 in the HAZUS MH4 earthquake technical manual with regional estimates of residential basement frequency provided by the 1997 Department of Energy Residential Energy Consumption Survey as reported in the HAZUS manual [48]. The HAZUS provided Arizona (AZ) RES1 building occupancy type percentages for pre-1950 buildings added to 101% and so the AZ W1 building construction type frequency was decreased from 41% to 40%.

OTHER BUILDING OCCUPANCY TYPES

For census tracts in the eastern and midwestern states, **Table 26 to Table 31** were combined in proportion to the fraction of low, mid, and high rise buildings present (see next paragraph). For census tracts in the western states, **Table 32 to Table 40** were combined in proportion to both (a) the fraction of low, mid, and high rise buildings and (b) the 2000 US Census age distribution of residential buildings for the given census tract. This procedure implicitly assumes that buildings used for commercial, industrial, agricultural, religious (non-profit), governmental, or educational purposes are similar in age to nearby residences. This assumption is considered reasonable based on an analysis of western US commercial and residential buildings, see **Figure 9**.[22]

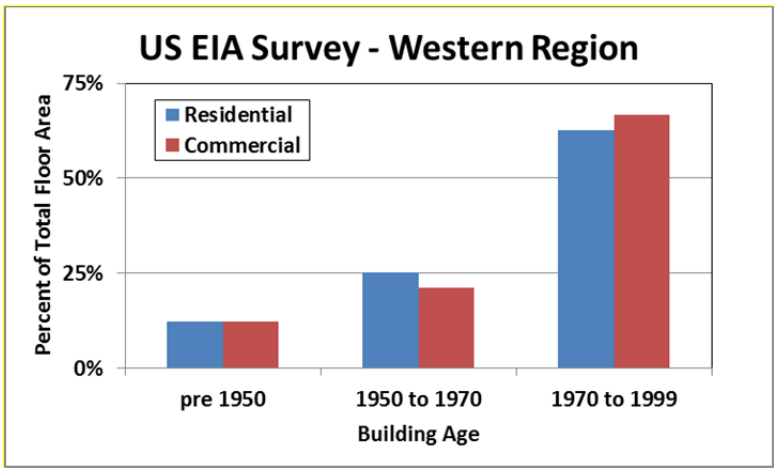

FIGURE 9 – BUILDING AGE DISTRIBUTION

[22] This graph was derived from the US Energy Information Administration (EIA) 2012 Commercial and 2009 Residential energy consumption survey building characteristics [49], [50] for the western census region (Tables A2 and HC10-12a, respectively). Similar results are obtained for a building number/household unit comparison. Note that the EIA definition of commercial building excludes industrial and agricultural buildings, but does include schools, hospitals, stores, offices, restaurants, government buildings, religious buildings, and warehouses.

Table 26 to Table 40 were derived from Tables BA.2 to BA.16 in the HAZUS earthquake technical manual. For building occupancy types, such as RES2, where the HAZUS manual did not specify mid or high rise values, the corresponding low rise value was substituted. The HAZUS provided GOV1 eastern state building occupancy type percentages for low and high rise buildings added to 99% and so the S1L building construction type frequency was increased from 24% to 25%.

As no method was specified in the HAZUS technical manual, the fraction of low, mid, and high rise buildings in a given census tract was calculated in four steps. First, the height and volume of US buildings in 110 regions (cities and other areas) was calculated from National Geospatial-Intelligence Agency (NGA) shapefile data. These shapefiles are derived from LIDAR data and describe a 2-D footprint and average height for individual buildings.[23] Second, each building was characterized as low, mid, or high rise according to **Table 21**. Third, each region was divided up into 250 m x 250 m resolution grid cells and the total low, mid, and high rise building volume was calculated for each cell. Fourth for each census tract, the total low, mid, and high rise building volume was determined by summing the building volumes for any grid cell whose center was located within the census tract. The fraction of low, mid, and high rise buildings in a given census tract is assumed to be equal to the relative contributions of the low, mid, and high rise building volumes to the total census tract building volume. Census tracts that did not contain any NGA LIDAR data were assumed to contain only low rise buildings.

TABLE 21 – LOW, MID, AND HIGH RISE BUILDING DEFINITIONS

Building height	Height (m)	Stories
Low rise	≤ 13	1 to 3
Mid rise	13 to 27	4 to 7
High rise	≥ 27	≥ 8

[23] Data was obtained directly from NGA.

TABLE 22 – PERCENT OF BUILDING CONSTRUCTION TYPES IN A GIVEN STATE'S SINGLE FAMILY DWELLINGS (RES1 BUILDING OCCUPANCY TYPE)

State	W1	W1_B	C2L	C2L_B	URML	URML_B
AL	71	24	0	0	4	1
CT	18	78	0	0	1	3
DC	16	5	2	1	59	17
DE	55	16	1	0	22	6
FL	19	6	4	1	54	16
GA	72	21	0	0	5	2
MA	18	78	0	0	1	3
MD	13	58	0	1	5	23
ME	19	80	0	0	0	1
NC	61	29	0	0	7	3
NH	24	73	0	1	1	2
NJ	23	68	0	0	2	7
NY	21	64	0	1	4	11
PA	16	50	0	0	8	26
RI	19	79	0	0	0	2
SC	71	21	0	0	6	2
VA	51	24	0	0	17	8
VT	18	78	0	2	0	2
WV	23	49	0	0	9	19
AR	76	11	0	0	11	2
IA	80	12	0	0	7	1
IL	19	58	0	1	6	17
IN	20	60	0	0	5	15
KS	23	68	0	0	2	7
KY	66	22	0	0	9	3
LA	85	4	0	0	10	1
MI	28	58	0	0	4	10
MN	24	71	0	1	1	3
MO	19	57	0	0	6	18
MS	24	71	0	0	2	5
ND	67	31	0	0	1	1
NE	22	67	0	1	3	8
OH	24	52	0	0	8	16
OK	67	4	0	0	28	1
SD	24	73	0	0	1	2
TN	68	23	0	0	8	3
TX	95	5	0	0	0	0
WI	29	61	0	0	3	7

TABLE 23 – PERCENT OF BUILDING CONSTRUCTION TYPES IN A GIVEN STATE'S SINGLE FAMILY DWELLINGS (RES1 BUILDING OCCUPANCY TYPE) FOR BUILDINGS BUILT BEFORE 1950

State	W1	W1_B	S3	S3_B	S5L	S5L_B	C2L	C2L_B	RM1L	RM1L_B	URML	URML_B
AK	86	13	0	0	0	0	1	0	0	0	0	0
AZ	40	19	0	0	0	0	0	0	17	8	11	5
CA	86	13	0	0	0	0	0	0	1	0	0	0
CO	52	24	0	0	0	0	0	0	10	5	6	3
HI	80	12	0	0	0	0	1	0	3	1	3	0
ID	65	30	0	0	0	0	0	0	2	1	1	1
MT	67	31	0	0	0	0	0	0	1	0	1	0
NM	50	24	0	0	0	0	0	0	11	5	7	3
NV	66	31	0	0	0	0	0	0	1	1	1	0
OR	86	13	0	0	0	0	0	0	1	0	0	0
UT	56	26	0	0	0	0	0	0	7	4	5	2
WA	85	13	0	0	0	0	0	0	1	0	1	0
WY	63	29	0	0	0	0	0	0	3	2	2	1

TABLE 24 – PERCENT OF BUILDING CONSTRUCTION TYPES IN A GIVEN STATE'S SINGLE FAMILY DWELLINGS (RES1 BUILDING OCCUPANCY TYPE) FOR BUILDINGS BUILT BETWEEN 1950 AND 1970

State	W1	W1_B	S3	S3_B	S5L	S5L_B	C2L	C2L_B	RM1L	RM1L_B	URML	URML_B
AK	86	13	0	0	0	0	1	0	0	0	0	0
AZ	41	19	0	0	0	0	0	0	24	12	3	1
CA	86	13	0	0	0	0	0	0	1	0	0	0
CO	52	24	0	0	0	0	0	0	14	7	2	1
HI	80	12	0	0	0	0	1	0	5	1	1	0
ID	65	30	0	0	0	0	0	0	3	1	1	0
MT	67	31	0	0	0	0	0	0	1	1	0	0
NM	50	24	0	0	0	0	0	0	16	7	2	1
NV	66	31	0	0	0	0	0	0	2	1	0	0
OR	86	13	0	0	0	0	0	0	1	0	0	0
UT	56	26	0	0	0	0	0	0	11	5	1	1
WA	85	13	0	0	0	0	0	0	2	0	0	0
WY	63	29	0	0	0	0	0	0	5	2	1	0

TABLE 25 – PERCENT OF BUILDING CONSTRUCTION TYPES IN A GIVEN STATE'S SINGLE FAMILY DWELLINGS (RES1 BUILDING OCCUPANCY TYPE) FOR BUILDINGS BUILT AFTER 1970

State	W1	W1_B	S3	S3_B	S5L	S5L_B	C2L	C2L_B	RM1L	RM1L_B	URML	URML_B
AK	86	13	0	0	0	0	1	0	0	0	0	0
AZ	41	19	0	0	0	0	0	0	27	13	0	0
CA	86	13	0	0	0	0	0	0	1	0	0	0
CO	52	24	0	0	0	0	0	0	16	8	0	0
HI	80	12	0	0	0	0	1	0	6	1	0	0
ID	65	30	0	0	0	0	0	0	3	2	0	0
MT	67	31	0	0	0	0	0	0	1	1	0	0
NM	50	24	0	0	0	0	0	0	18	8	0	0
NV	66	31	0	0	0	0	0	0	2	1	0	0
OR	86	13	0	0	0	0	0	0	1	0	0	0
UT	56	26	0	0	0	0	0	0	12	6	0	0
WA	85	13	0	0	0	0	0	0	2	0	0	0
WY	63	29	0	0	0	0	0	0	5	3	0	0

TABLE 26 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH LOW RISE BUILDING OCCUPANCY TYPE IN THE EASTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table B3																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	62	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	5	0	4	0	0	22	0	0
RES3B	62	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	5	0	4	0	0	22	0	0
RES3C	62	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	5	0	4	0	0	22	0	0
RES3D	62	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	5	0	4	0	0	22	0	0
RES3E	62	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	5	0	4	0	0	22	0	0
RES3F	62	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	5	0	4	0	0	22	0	0
RES4	48	0	5	0	0	4	0	0	0	0	0	0	4	0	0	8	0	0	4	0	0	0	0	0	3	3	0	0	3	0	3	0	0	15	0	0
RES5	7	0	7	0	0	6	0	0	0	0	0	0	6	0	0	17	0	0	6	0	0	3	0	0	8	6	0	0	5	0	5	0	0	24	0	0
RES6	22	0	11	0	0	8	0	0	0	0	0	0	8	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	5	0	4	0	0	22	0	0
COM1	0	14	20	0	0	15	0	0	5	0	0	0	16	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	4	0	2	0	0	17	0	0
COM2	0	10	21	0	0	15	0	0	7	0	0	0	16	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	3	0	4	0	0	17	0	0
COM3	0	25	7	0	0	5	0	0	11	0	0	0	5	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	6	0	4	0	0	30	0	0
COM4	0	26	11	0	0	8	0	0	4	0	0	0	9	0	0	4	0	0	2	0	0	0	0	0	3	0	0	0	5	0	4	0	0	24	0	0
COM5	0	13	13	0	0	9	0	0	13	0	0	0	10	0	0	5	0	0	3	0	0	0	0	0	2	2	0	0	5	0	3	0	0	22	0	0
COM6	0	2	22	0	0	15	0	0	0	0	0	0	18	0	0	10	0	0	4	0	0	2	0	0	5	4	0	0	3	0	2	0	0	13	0	0
COM7	0	24	10	0	0	7	0	0	15	0	0	0	8	0	0	3	0	0	2	0	0	0	0	0	3	0	0	0	4	0	4	0	0	20	0	0
COM8	0	19	19	0	0	13	0	0	6	0	0	0	15	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	3	0	3	0	0	15	0	0
COM9	0	5	20	0	0	13	0	0	12	2	0	0	16	0	0	7	0	0	2	0	0	0	0	0	3	3	0	0	3	0	2	0	0	12	0	0
COM10	0	0	10	0	0	7	0	0	0	0	0	0	8	0	0	30	0	0	11	0	0	6	0	0	14	12	0	0	0	0	0	0	0	2	0	0
IND1	0	5	22	0	0	15	0	0	4	2	0	0	17	0	0	7	0	0	3	0	0	0	0	0	3	3	0	0	3	0	3	0	0	13	0	0
IND2	0	10	15	0	0	9	0	0	15	0	0	0	11	0	0	5	0	0	3	0	0	0	0	0	2	2	0	0	4	0	5	0	0	19	0	0
IND3	0	7	25	0	0	18	0	0	3	0	0	0	19	0	0	4	0	0	2	0	0	0	0	0	2	2	0	0	3	0	2	0	0	13	0	0
IND4	0	7	26	0	0	19	0	0	3	0	0	0	20	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	2	0	3	0	0	13	0	0
IND5	0	5	25	0	0	17	0	0	3	2	0	0	20	0	0	7	0	0	3	0	0	0	0	0	3	3	0	0	0	0	2	0	0	10	0	0
IND6	0	10	21	0	0	14	0	0	7	2	0	0	16	0	0	5	0	0	2	0	0	0	0	0	2	2	0	0	2	0	3	0	0	14	0	0
AGR1	0	48	8	0	0	6	0	0	12	0	0	0	7	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	12	0	0
REL1	36	0	4	0	0	4	0	0	0	0	0	0	3	0	0	2	0	0	2	0	0	0	0	0	2	0	0	0	7	0	6	0	0	34	0	0
GOV1	0	7	24	0	0	16	0	0	3	0	0	0	19	0	0	5	0	0	3	0	0	0	0	0	2	1	0	0	3	0	3	0	0	13	0	0
GOV2	0	8	16	0	0	11	0	0	4	0	0	0	13	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	4	0	5	0	0	19	0	0
EDU1	0	13	17	0	0	13	0	0	0	0	0	0	13	0	0	5	0	0	3	0	0	0	0	0	2	2	0	0	5	0	5	0	0	22	0	0
EDU2	0	4	18	0	0	13	0	0	0	0	0	0	14	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	5	0	4	0	0	22	0	0

TABLE 27 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH MID RISE BUILDING OCCUPANCY TYPE IN THE EASTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table B3																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	6	0	0	3	0	0	0	0	0	0	14	0	0	0	0	13	0	0	57	0
RES3B	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	6	0	0	3	0	0	0	0	0	0	14	0	0	0	0	13	0	0	57	0
RES3C	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	6	0	0	3	0	0	0	0	0	0	14	0	0	0	0	13	0	0	57	0
RES3D	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	6	0	0	3	0	0	0	0	0	0	14	0	0	0	0	13	0	0	57	0
RES3E	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	6	0	0	3	0	0	0	0	0	0	14	0	0	0	0	13	0	0	57	0
RES3F	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	6	0	0	3	0	0	0	0	0	0	14	0	0	0	0	13	0	0	57	0
RES4	0	0	0	9	0	0	12	0	0	0	0	0	0	3	0	0	18	0	0	9	0	0	2	0	0	0	11	0	0	0	0	7	0	0	29	0
RES5	0	0	0	7	0	0	10	0	0	0	0	0	0	3	0	0	23	0	0	11	0	0	3	0	0	0	12	0	0	0	0	5	0	0	26	0
RES6	22	0	11	0	0	8	0	0	0	0	0	8	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	5	0	4	0	0	22	0	0	
COM1	0	0	0	23	0	0	29	0	0	0	2	0	0	8	0	0	5	0	0	3	0	0	0	0	0	0	5	0	0	0	0	5	0	0	20	0
COM2	0	0	0	23	0	0	30	0	0	0	3	0	0	8	0	0	4	0	0	3	0	0	0	0	0	0	5	0	0	0	0	5	0	0	19	0
COM3	0	0	0	10	0	0	13	0	0	0	0	0	0	3	0	0	5	0	0	4	0	0	0	0	0	0	11	0	0	0	0	10	0	0	44	0
COM4	0	0	0	14	0	0	19	0	0	0	2	0	0	5	0	0	7	0	0	4	0	0	0	0	0	0	9	0	0	0	0	7	0	0	33	0
COM5	0	0	0	15	0	0	21	0	0	0	2	0	0	6	0	0	8	0	0	5	0	0	0	0	0	0	8	0	0	0	0	6	0	0	29	0
COM6	0	0	0	21	0	0	27	0	0	0	2	0	0	8	0	0	12	0	0	6	0	0	2	0	0	0	7	0	0	0	0	2	0	0	13	0
COM7	0	0	0	15	0	0	20	0	0	0	2	0	0	5	0	0	7	0	0	4	0	0	0	0	0	0	9	0	0	0	0	6	0	0	32	0
COM8	0	0	0	22	0	0	30	0	0	0	3	0	0	8	0	0	5	0	0	3	0	0	0	0	0	0	5	0	0	0	0	5	0	0	19	0
COM9	0	5	20	0	0	13	0	0	12	2	0	0	16	0	0	7	0	0	2	0	0	0	0	0	3	3	0	0	3	0	2	0	0	12	0	0
COM10	0	0	0	10	0	0	13	0	0	0	0	0	0	3	0	0	38	0	0	17	0	0	6	0	0	0	11	0	0	0	0	0	0	0	2	0
IND1	0	5	22	0	0	15	0	0	4	2	0	0	17	0	0	7	0	0	3	0	0	0	0	0	3	3	0	0	3	0	3	0	0	13	0	0
IND2	0	0	0	22	0	0	28	0	0	0	2	0	0	8	0	0	10	0	0	5	0	0	2	0	0	0	6	0	0	0	0	3	0	0	14	0
IND3	0	0	0	25	0	0	32	0	0	0	3	0	0	9	0	0	6	0	0	4	0	0	0	0	0	0	4	0	0	0	0	3	0	0	14	0
IND4	0	7	26	0	0	19	0	0	3	0	0	0	20	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	2	0	3	0	0	13	0	0
IND5	0	0	0	24	0	0	32	0	0	0	3	0	0	9	0	0	9	0	0	6	0	0	0	0	0	0	5	0	0	0	0	2	0	0	10	0
IND6	0	10	21	0	0	14	0	0	7	2	0	0	16	0	0	5	0	0	2	0	0	0	0	0	2	2	0	0	2	0	3	0	0	14	0	0
AGR1	0	0	0	19	0	0	25	0	0	0	2	0	0	7	0	0	4	0	0	2	0	0	0	0	0	0	7	0	0	0	0	6	0	0	28	0
REL1	0	0	0	5	0	0	9	0	0	0	0	0	0	2	0	0	4	0	0	3	0	0	0	0	0	0	12	0	0	0	0	12	0	0	53	0
GOV1	0	0	0	24	0	0	30	0	0	0	3	0	0	9	0	0	7	0	0	5	0	0	0	0	0	0	5	0	0	0	0	3	0	0	14	0
GOV2	0	8	16	0	0	11	0	0	4	0	0	0	13	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	4	0	5	0	0	19	0	0
EDU1	0	13	17	0	0	13	0	0	0	0	0	0	13	0	0	5	0	0	3	0	0	0	0	0	2	2	0	0	5	0	5	0	0	22	0	0
EDU2	0	0	0	17	0	0	23	0	0	0	2	0	0	6	0	0	10	0	0	5	0	0	2	0	0	0	8	0	0	0	0	4	0	0	23	0

TABLE 28 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH HIGH RISE BUILDING OCCUPANCY TYPE IN THE EASTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table B3																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES3B	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES3C	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES3D	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES3E	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES3F	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES4	0	0	0	0	8	0	0	21	0	0	0	8	0	0	0	0	0	34	0	0	17	0	0	2	0	0	0	5	0	0	0	0	5	0	0	0
RES5	0	0	0	0	6	0	0	16	0	0	0	6	0	0	0	0	0	40	0	0	20	0	0	3	0	0	0	5	0	0	0	0	4	0	0	0
RES6	22	0	11	0	0	8	0	0	0	0	0	0	8	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	5	0	4	0	0	22	0	0
COM1	0	14	20	0	0	15	0	0	5	0	0	0	16	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	4	0	2	0	0	17	0	0
COM2	0	10	21	0	0	15	0	0	7	0	0	0	16	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	3	0	4	0	0	17	0	0
COM3	0	25	7	0	0	5	0	0	11	0	0	0	5	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	6	0	4	0	0	30	0	0
COM4	0	0	0	0	15	0	0	36	0	0	0	15	0	0	0	0	0	15	0	0	8	0	0	0	0	0	0	2	0	0	0	0	9	0	0	0
COM5	0	0	0	0	15	0	0	36	0	0	0	15	0	0	0	0	0	15	0	0	8	0	0	0	0	0	0	2	0	0	0	0	9	0	0	0
COM6	0	0	0	0	14	0	0	35	0	0	0	14	0	0	0	0	0	17	0	0	8	0	0	2	0	0	0	2	0	0	0	0	8	0	0	0
COM7	0	0	0	0	15	0	0	38	0	0	0	15	0	0	0	0	0	14	0	0	8	0	0	0	0	0	0	2	0	0	0	0	8	0	0	0
COM8	0	19	19	0	0	13	0	0	6	0	0	0	15	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	3	0	3	0	0	15	0	0
COM9	0	5	20	0	0	13	0	0	12	2	0	0	16	0	0	7	0	0	2	0	0	0	0	0	3	3	0	0	3	0	2	0	0	12	0	0
COM10	0	0	0	0	5	0	0	12	0	0	0	5	0	0	0	0	0	43	0	0	21	0	0	4	0	0	0	6	0	0	0	0	4	0	0	0
IND1	0	5	22	0	0	15	0	0	4	2	0	0	17	0	0	7	0	0	3	0	0	0	0	0	3	3	0	0	3	0	3	0	0	13	0	0
IND2	0	10	15	0	0	9	0	0	15	0	0	0	11	0	0	5	0	0	3	0	0	0	0	0	2	2	0	0	4	0	5	0	0	19	0	0
IND3	0	7	25	0	0	18	0	0	3	0	0	0	19	0	0	4	0	0	2	0	0	0	0	0	2	2	0	0	3	0	2	0	0	13	0	0
IND4	0	7	26	0	0	19	0	0	3	0	0	0	20	0	0	3	0	0	2	0	0	0	0	0	2	0	0	0	2	0	3	0	0	13	0	0
IND5	0	5	25	0	0	17	0	0	3	2	0	0	20	0	0	7	0	0	3	0	0	0	0	0	3	3	0	0	0	0	2	0	0	10	0	0
IND6	0	10	21	0	0	14	0	0	7	2	0	0	16	0	0	5	0	0	2	0	0	0	0	0	2	2	0	0	2	0	3	0	0	14	0	0
AGR1	0	0	0	0	7	0	0	4	0	0	0	18	0	0	0	0	0	20	0	0	42	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0
REL1	36	0	4	0	0	4	0	0	0	0	0	0	3	0	0	2	0	0	2	0	0	0	0	0	2	0	0	0	7	0	6	0	0	34	0	0
GOV1	0	7	25	0	0	16	0	0	3	0	0	0	19	0	0	5	0	0	3	0	0	0	0	0	2	1	0	0	3	0	3	0	0	13	0	0
GOV2	0	8	16	0	0	11	0	0	4	0	0	0	13	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	4	0	5	0	0	19	0	0
EDU1	0	13	17	0	0	13	0	0	0	0	0	0	13	0	0	5	0	0	3	0	0	0	0	0	2	2	0	0	5	0	5	0	0	22	0	0
EDU2	0	4	18	0	0	13	0	0	0	0	0	0	14	0	0	8	0	0	3	0	0	2	0	0	4	3	0	0	5	0	4	0	0	22	0	0

TABLE 29 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH LOW RISE BUILDING OCCUPANCY TYPE IN THE MIDWESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 22																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	23	0	0
RES3B	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	23	0	0
RES3C	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	23	0	0
RES3D	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	23	0	0
RES3E	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	23	0	0
RES3F	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	23	0	0
RES4	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	45	0	0
RES5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	13	0	0	2	0	0	22	4	0	0	2	0	0	0	0	33	0	0
RES6	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
COM1	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM2	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	2	0	0	0	0	28	0	0
COM3	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM4	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM5	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM6	0	0	0	0	0	2	0	0	4	2	0	0	2	0	0	6	0	0	21	0	0	4	0	0	33	6	0	0	2	0	0	0	0	18	0	0
COM7	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM8	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM9	0	0	2	0	0	6	0	0	14	8	0	0	10	0	0	4	0	0	13	0	0	2	0	0	22	4	0	0	0	0	0	0	0	15	0	0
COM10	0	0	2	0	0	4	0	0	11	6	0	0	7	0	0	6	0	0	21	0	0	4	0	0	33	6	0	0	0	0	0	0	0	0	0	0
IND1	0	0	5	0	0	10	0	0	25	13	0	0	17	0	0	2	0	0	7	0	0	2	0	0	12	2	0	0	0	0	0	0	0	5	0	0
IND2	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	3	0	0	0	0	27	0	0
IND3	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	3	0	0	0	0	27	0	0
IND4	0	0	5	0	0	10	0	0	25	13	0	0	17	0	0	2	0	0	7	0	0	2	0	0	12	2	0	0	0	0	0	0	0	5	0	0
IND5	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	2	0	0	0	0	28	0	0
IND6	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
AGR1	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	2	0	0	0	0	28	0	0
REL1	30	0	0	0	0	3	0	0	5	3	0	0	4	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	2	0	0	41	0	0
GOV1	0	15	14	0	0	21	0	0	0	0	0	0	0	0	0	7	0	0	6	0	0	0	0	0	4	0	0	0	3	0	0	0	0	30	0	0
GOV2	0	14	7	0	0	17	0	0	0	0	0	0	0	0	0	4	0	0	12	0	0	0	0	0	0	0	0	0	0	0	3	0	0	43	0	0
EDU1	0	10	5	0	0	12	0	0	0	0	0	0	0	0	0	5	0	0	7	0	0	0	0	0	0	0	0	0	11	0	0	0	0	50	0	0
EDU2	0	14	6	0	0	12	0	0	0	0	0	0	2	0	0	8	0	0	11	0	0	0	0	0	0	0	0	0	0	0	10	0	0	37	0	0

TABLE 30 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH MID RISE BUILDING OCCUPANCY TYPE IN THE MIDWESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 22																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	39	0	0	0	0	0	0	7	0	0	0	0	2	0	0	18	0
RES3B	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	39	0	0	0	0	0	0	7	0	0	0	0	2	0	0	18	0
RES3C	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	39	0	0	0	0	0	0	7	0	0	0	0	2	0	0	18	0
RES3D	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	39	0	0	0	0	0	0	7	0	0	0	0	2	0	0	18	0
RES3E	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	39	0	0	0	0	0	0	7	0	0	0	0	2	0	0	18	0
RES3F	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	39	0	0	0	0	0	0	7	0	0	0	0	2	0	0	18	0
RES4	0	0	0	0	0	0	10	0	0	0	7	0	0	3	0	0	14	0	0	37	0	0	2	0	0	0	7	0	0	0	0	2	0	0	18	0
RES5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	62	0	0	2	0	0	0	11	0	0	0	0	0	0	0	0	0
RES6	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
COM1	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
COM2	0	0	0	0	0	0	7	0	0	0	3	0	0	0	0	0	14	0	0	37	0	0	2	0	0	0	7	0	0	0	0	3	0	0	27	0
COM3	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
COM4	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
COM5	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
COM6	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	12	0	0	30	0	0	2	0	0	0	6	0	0	0	0	0	0	0	5	0
COM7	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
COM8	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
COM9	0	0	2	0	0	6	0	0	14	8	0	0	10	0	0	4	0	0	13	0	0	2	0	0	22	4	0	0	0	0	0	0	0	15	0	0
COM10	0	0	0	2	0	0	14	0	0	0	10	0	0	4	0	0	17	0	0	43	0	0	2	0	0	0	8	0	0	0	0	0	0	0	0	0
IND1	0	0	5	0	0	10	0	0	25	13	0	0	17	0	0	2	0	0	7	0	0	2	0	0	12	2	0	0	0	0	0	0	0	5	0	0
IND2	0	0	0	0	0	0	7	0	0	0	3	0	0	0	0	0	14	0	0	37	0	0	2	0	0	0	7	0	0	0	0	3	0	0	27	0
IND3	0	0	0	0	0	0	7	0	0	0	3	0	0	0	0	0	14	0	0	37	0	0	2	0	0	0	7	0	0	0	0	3	0	0	27	0
IND4	0	0	5	0	0	10	0	0	25	13	0	0	17	0	0	2	0	0	7	0	0	2	0	0	12	2	0	0	0	0	0	0	0	5	0	0
IND5	0	0	0	0	0	0	7	0	0	0	3	0	0	0	0	0	14	0	0	37	0	0	2	0	0	0	7	0	0	0	0	3	0	0	27	0
IND6	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
AGR1	0	0	0	0	0	0	7	0	0	0	3	0	0	0	0	0	14	0	0	37	0	0	2	0	0	0	7	0	0	0	0	3	0	0	27	0
REL1	0	0	0	3	0	0	20	0	0	0	16	0	0	6	0	0	11	0	0	27	0	0	2	0	0	0	5	0	0	0	0	2	0	0	8	0
GOV1	0	0	0	20	0	0	24	0	0	0	0	0	0	0	0	0	11	0	0	9	0	0	0	0	0	0	0	0	0	0	0	5	0	0	31	0
GOV2	0	14	7	0	0	17	0	0	0	0	0	0	0	0	0	4	0	0	12	0	0	0	0	0	0	0	0	0	0	0	3	0	0	43	0	0
EDU1	0	10	5	0	0	12	0	0	0	0	0	0	0	0	0	5	0	0	7	0	0	0	0	0	0	0	0	0	11	0	0	0	0	50	0	0
EDU2	0	0	0	7	0	0	14	0	0	0	0	0	0	0	0	0	9	0	0	13	0	0	0	0	0	0	0	0	0	0	0	13	0	0	44	0

TABLE 31 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH HIGH RISE BUILDING OCCUPANCY TYPE IN THE MIDWESTERN US

Building occupancy type	Building construction type																																			
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 22																																			
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES3B	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES3C	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES3D	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES3E	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES3F	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES4	0	0	0	0	3	0	0	13	0	0	0	4	0	0	0	0	0	16	0	0	44	0	0	7	0	0	0	7	0	0	0	0	6	0	0	0
RES5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RES6	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
COM1	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM2	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	2	0	0	0	0	28	0	0
COM3	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM4	0	0	0	0	7	0	0	29	0	0	0	9	0	0	0	0	0	12	0	0	32	0	0	4	0	0	0	4	0	0	0	0	3	0	0	0
COM5	0	0	0	0	7	0	0	29	0	0	0	9	0	0	0	0	0	12	0	0	32	0	0	4	0	0	0	4	0	0	0	0	3	0	0	0
COM6	0	0	0	0	7	0	0	29	0	0	0	9	0	0	0	0	0	13	0	0	36	0	0	2	0	0	0	2	0	0	0	0	2	0	0	0
COM7	0	0	0	0	7	0	0	29	0	0	0	9	0	0	0	0	0	12	0	0	32	0	0	4	0	0	0	4	0	0	0	0	3	0	0	0
COM8	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
COM9	0	0	2	0	0	6	0	0	14	8	0	0	10	0	0	4	0	0	13	0	0	2	0	0	22	4	0	0	0	0	0	0	0	15	0	0
COM10	0	0	0	0	5	0	0	19	0	0	0	6	0	0	0	0	0	18	0	0	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IND1	0	0	5	0	0	10	0	0	25	13	0	0	17	0	0	2	0	0	7	0	0	2	0	0	12	2	0	0	0	0	0	0	0	5	0	0
IND2	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	3	0	0	0	0	27	0	0
IND3	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	3	0	0	0	0	27	0	0
IND4	0	0	5	0	0	10	0	0	25	13	0	0	17	0	0	2	0	0	7	0	0	2	0	0	12	2	0	0	0	0	0	0	0	5	0	0
IND5	0	10	2	0	0	4	0	0	11	6	0	0	7	0	0	2	0	0	10	0	0	2	0	0	14	2	0	0	2	0	0	0	0	28	0	0
IND6	0	30	2	0	0	4	0	0	11	6	0	0	7	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	0	0	0	28	0	0
AGR1	0	0	0	0	2	0	0	6	0	0	0	2	0	0	0	0	0	16	0	0	44	0	0	11	0	0	0	11	0	0	0	0	8	0	0	0
REL1	30	0	0	0	0	3	0	0	5	3	0	0	4	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	2	0	2	0	0	41	0	0
GOV1	0	15	14	0	0	21	0	0	0	0	0	0	0	0	0	7	0	0	6	0	0	0	0	0	4	0	0	0	3	0	0	0	0	30	0	0
GOV2	0	14	7	0	0	17	0	0	0	0	0	0	0	0	0	4	0	0	12	0	0	0	0	0	0	0	0	0	0	0	3	0	0	43	0	0
EDU1	0	10	5	0	0	12	0	0	0	0	0	0	0	0	0	5	0	0	7	0	0	0	0	0	0	0	0	0	11	0	0	0	0	50	0	0
EDU2	0	14	6	0	0	12	0	0	0	0	0	0	2	0	0	8	0	0	11	0	0	0	0	0	0	0	0	0	0	0	10	0	0	37	0	0

TABLE 32 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH PRE-1950, LOW RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 23																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	73	0	1	0	0	1	0	0	1	0	0	0	6	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	0	9	0	2
RES3B	73	0	1	0	0	1	0	0	1	0	0	0	6	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	0	9	0	2
RES3C	73	0	1	0	0	1	0	0	1	0	0	0	6	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	0	9	0	2
RES3D	73	0	1	0	0	1	0	0	1	0	0	0	6	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	0	9	0	2
RES3E	73	0	1	0	0	1	0	0	1	0	0	0	6	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	0	9	0	2
RES3F	73	0	1	0	0	1	0	0	1	0	0	0	6	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	0	9	0	2
RES4	34	0	2	0	0	1	0	0	2	1	0	0	19	0	0	0	0	0	16	0	0	3	0	0	0	0	0	0	4	0	0	0	0	18	0	0
RES5	20	0	5	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	28	0	0	18	0	0	0	0	0	0	6	0	0	0	0	21	0	0
RES6	45	0	0	0	0	0	0	0	10	0	0	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	20	0	0	0	0	10	0	0
COM1	0	22	2	0	0	0	0	0	6	3	0	0	20	0	0	0	0	0	17	0	0	1	0	0	0	0	0	0	6	0	0	0	0	23	0	0
COM2	0	8	3	0	0	0	0	0	4	2	0	0	41	0	0	0	0	0	18	0	0	1	0	0	3	0	0	0	5	0	2	0	0	13	0	0
COM3	0	28	1	0	0	1	0	0	3	0	0	0	18	0	0	0	0	0	7	0	0	0	0	0	1	0	0	0	8	0	0	0	0	33	0	0
COM4	0	27	2	0	0	1	0	0	3	0	0	0	19	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	26	0	0
COM5	0	27	2	0	0	1	0	0	3	0	0	0	19	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	26	0	0
COM6	0	8	5	0	0	2	0	0	11	0	0	0	11	0	0	0	0	0	27	0	0	2	0	0	1	0	0	0	27	0	0	0	0	6	0	0
COM7	0	25	5	0	0	2	0	0	10	0	0	0	10	0	0	0	0	0	15	0	0	2	0	0	1	0	0	0	20	0	0	0	0	10	0	0
COM8	0	8	12	0	0	1	0	0	2	3	0	0	16	0	0	0	0	0	27	0	0	4	0	0	0	0	0	0	5	0	1	0	0	21	0	0
COM9	0	5	20	0	0	7	0	0	0	0	0	0	15	0	0	0	0	0	20	0	0	3	0	0	0	0	0	0	10	0	0	0	0	20	0	0
COM10	0	0	0	0	0	8	0	0	0	8	0	0	18	0	0	0	0	0	43	0	0	7	0	0	0	1	0	0	6	0	3	0	0	6	0	0
IND1	0	3	29	0	0	13	0	0	2	2	0	0	15	0	0	0	0	0	14	0	0	7	0	0	1	0	0	0	4	0	2	0	0	8	0	0
IND2	0	4	14	0	0	8	0	0	22	1	0	0	18	0	0	0	0	0	16	0	0	1	0	0	1	0	0	0	2	0	0	0	0	13	0	0
IND3	0	1	18	0	0	8	0	0	3	3	0	0	20	0	0	0	0	0	22	0	0	0	0	0	2	0	0	0	3	0	0	0	0	20	0	0
IND4	0	2	24	0	0	12	0	0	7	2	0	0	13	0	0	0	0	0	16	0	0	0	0	0	2	0	0	0	2	0	6	0	0	14	0	0
IND5	0	0	21	0	0	5	0	0	5	0	0	0	3	0	0	0	0	0	35	0	0	2	0	0	10	2	0	0	15	0	0	0	0	2	0	0
IND6	0	32	3	0	0	2	0	0	10	0	0	0	18	0	0	0	0	0	8	0	0	7	0	0	0	0	0	0	0	0	0	0	0	13	0	7
AGR1	56	0	3	0	0	2	0	0	14	0	0	0	2	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	1	0	0	13	0	0
REL1	22	0	8	0	0	0	0	0	2	0	0	0	21	0	0	0	0	0	15	0	0	5	0	0	0	0	0	0	8	0	0	0	0	19	0	0
GOV1	0	9	8	0	0	1	0	0	3	4	0	0	12	0	0	0	0	0	42	0	0	4	0	0	0	0	0	0	6	0	0	0	0	11	0	0
GOV2	45	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	3	0	0	0	0	13	0	0
EDU1	11	0	6	0	0	0	0	0	3	3	0	0	21	0	0	0	0	0	21	0	0	4	0	0	0	0	0	0	9	0	0	0	0	22	0	0
EDU2	2	0	5	0	0	10	0	0	0	5	0	0	15	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	20	0	5	0	0	18	0	0

TABLE 33 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH PRE-1950, MID RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 23																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	15	0	0	4	0	0	0	5	0	0	0	0	0	1	0	0	19	0	0	25	0	0	0	0	0	0	8	0	0	0	0	23	0
RES3B	0	0	0	15	0	0	4	0	0	0	5	0	0	0	0	0	1	0	0	19	0	0	25	0	0	0	0	0	0	8	0	0	0	0	23	0
RES3C	0	0	0	15	0	0	4	0	0	0	5	0	0	0	0	0	1	0	0	19	0	0	25	0	0	0	0	0	0	8	0	0	0	0	23	0
RES3D	0	0	0	15	0	0	4	0	0	0	5	0	0	0	0	0	1	0	0	19	0	0	25	0	0	0	0	0	0	8	0	0	0	0	23	0
RES3E	0	0	0	15	0	0	4	0	0	0	5	0	0	0	0	0	1	0	0	19	0	0	25	0	0	0	0	0	0	8	0	0	0	0	23	0
RES3F	0	0	0	15	0	0	4	0	0	0	5	0	0	0	0	0	1	0	0	19	0	0	25	0	0	0	0	0	0	8	0	0	0	0	23	0
RES4	0	0	0	18	0	0	4	0	0	0	12	0	0	0	0	0	1	0	0	20	0	0	20	0	0	0	0	0	0	8	0	0	0	0	17	0
RES5	0	0	0	16	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0	40	0	0	20	0	0	0	0	0	0	0	0	0	0	0	18	0
RES6	0	0	0	20	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	35	0	0	20	0	0	0	0	0	0	10	0	0	0	0	10	0
COM1	0	0	0	8	0	0	6	0	0	0	3	0	0	0	0	0	0	0	0	21	0	0	34	0	0	0	0	0	0	11	0	1	0	0	16	0
COM2	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	53	0	0	0	0	0	0	5	0	0	0	0	7	0
COM3	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	42	0	0	0	0	0	0	5	0	0	0	0	13	0
COM4	0	0	0	25	0	0	7	0	0	0	10	0	0	0	0	0	2	0	0	22	0	0	16	0	0	0	0	0	0	9	0	0	0	0	9	0
COM5	0	0	0	25	0	0	7	0	0	0	10	0	0	0	0	0	2	0	0	22	0	0	16	0	0	0	0	0	0	9	0	0	0	0	9	0
COM6	0	0	0	18	0	0	4	0	0	0	6	0	0	0	0	0	1	0	0	35	0	0	19	0	0	0	0	0	0	8	0	0	0	0	9	0
COM7	0	0	0	20	0	0	5	0	0	0	5	0	0	0	0	0	0	0	0	30	0	0	20	0	0	0	0	0	0	10	0	0	0	0	10	0
COM8	0	0	0	25	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	40	0	0	5	0	0	0	0	0	0	0	0	0	0	0	10	0
COM9	0	0	0	30	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	40	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10	0
COM10	0	0	0	0	0	0	10	0	0	0	5	0	0	0	0	0	2	0	0	55	0	0	18	0	0	0	0	0	0	3	0	2	0	0	5	0
IND1	0	3	29	0	0	13	0	0	2	2	0	0	15	0	0	0	0	0	14	0	0	7	0	0	1	0	0	0	4	0	2	0	0	8	0	0
IND2	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	5	0	0	75	0	0	0	0	0	0	0	0	0	0	0	10	0
IND3	0	0	0	32	0	0	3	0	0	0	1	0	0	0	0	0	1	0	0	14	0	0	41	0	0	0	0	0	0	3	0	0	0	0	5	0
IND4	0	0	0	25	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	9	0	0	52	0	0	0	0	0	0	0	0	0	0	0	10	0
IND5	0	0	0	35	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	5	0	0	0	0	0	0	20	0	0	0	0	0	0
IND6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0
AGR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0
REL1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0
GOV1	0	0	0	30	0	0	15	0	0	0	5	0	0	0	0	0	3	0	0	23	0	0	10	0	0	0	0	0	0	4	0	0	0	0	10	0
GOV2	45	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	3	0	0	0	0	13	0	0
EDU1	11	0	6	0	0	0	0	0	3	3	0	0	21	0	0	0	0	0	21	0	0	4	0	0	0	0	0	0	9	0	0	0	0	22	0	0
EDU2	0	0	0	10	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	60	0	0	3	0	0	0	0	0	0	5	0	0	0	0	2	0

TABLE 34 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH PRE-1950, HIGH RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																			
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 23																																			
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	0	39	0	0	1	0	0	0	2	0	0	0	0	0	8	0	0	24	0	0	23	0	0	0	3	0	0	0	0	0	0	0	0
RES3B	0	0	0	0	39	0	0	1	0	0	0	2	0	0	0	0	0	8	0	0	24	0	0	23	0	0	0	3	0	0	0	0	0	0	0	0
RES3C	0	0	0	0	39	0	0	1	0	0	0	2	0	0	0	0	0	8	0	0	24	0	0	23	0	0	0	3	0	0	0	0	0	0	0	0
RES3D	0	0	0	0	39	0	0	1	0	0	0	2	0	0	0	0	0	8	0	0	24	0	0	23	0	0	0	3	0	0	0	0	0	0	0	0
RES3E	0	0	0	0	39	0	0	1	0	0	0	2	0	0	0	0	0	8	0	0	24	0	0	23	0	0	0	3	0	0	0	0	0	0	0	0
RES3F	0	0	0	0	39	0	0	1	0	0	0	2	0	0	0	0	0	8	0	0	24	0	0	23	0	0	0	3	0	0	0	0	0	0	0	0
RES4	0	0	0	0	45	0	0	3	0	0	0	3	0	0	0	0	0	8	0	0	20	0	0	18	0	0	0	3	0	0	0	0	0	0	0	0
RES5	0	0	0	0	15	0	0	5	0	0	0	10	0	0	0	0	0	0	0	0	30	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0
RES6	45	0	0	0	0	0	0	0	10	0	0	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	20	0	0	0	0	10	0	0
COM1	0	22	2	0	0	0	0	0	6	3	0	0	20	0	0	0	0	0	17	0	0	1	0	0	0	0	0	0	6	0	0	0	0	23	0	0
COM2	0	8	3	0	0	0	0	0	4	2	0	0	41	0	0	0	0	0	18	0	0	1	0	0	3	0	0	0	5	0	2	0	0	13	0	0
COM3	0	28	1	0	0	1	0	0	3	0	0	0	18	0	0	0	0	0	7	0	0	0	0	0	1	0	0	0	8	0	0	0	0	33	0	0
COM4	0	0	0	0	47	0	0	10	0	0	0	4	0	0	0	0	0	1	0	0	21	0	0	16	0	0	0	1	0	0	0	0	0	0	0	0
COM5	0	0	0	0	47	0	0	10	0	0	0	4	0	0	0	0	0	1	0	0	21	0	0	16	0	0	0	1	0	0	0	0	0	0	0	0
COM6	0	0	0	0	56	0	0	9	0	0	0	1	0	0	0	0	0	1	0	0	24	0	0	8	0	0	0	1	0	0	0	0	0	0	0	0
COM7	0	25	5	0	0	2	0	0	10	0	0	0	10	0	0	0	0	0	15	0	0	2	0	0	1	0	0	0	20	0	0	0	0	10	0	0
COM8	0	8	12	0	0	1	0	0	2	3	0	0	16	0	0	0	0	0	27	0	0	4	0	0	0	0	0	0	5	0	1	0	0	21	0	0
COM9	0	5	20	0	0	7	0	0	0	0	0	0	15	0	0	0	0	0	20	0	0	3	0	0	0	0	0	0	10	0	0	0	0	20	0	0
COM10	0	0	0	0	0	8	0	0	0	8	0	0	18	0	0	0	0	0	43	0	0	7	0	0	0	1	0	0	6	0	3	0	0	6	0	0
IND1	0	3	29	0	0	13	0	0	2	2	0	0	15	0	0	0	0	0	14	0	0	7	0	0	1	0	0	0	4	0	2	0	0	8	0	0
IND2	0	4	14	0	0	8	0	0	22	1	0	0	18	0	0	0	0	0	16	0	0	1	0	0	1	0	0	0	2	0	0	0	0	13	0	0
IND3	0	1	18	0	0	8	0	0	3	3	0	0	20	0	0	0	0	0	22	0	0	0	0	0	2	0	0	0	3	0	0	0	0	20	0	0
IND4	0	2	24	0	0	12	0	0	7	2	0	0	13	0	0	0	0	0	16	0	0	0	0	0	2	0	0	0	2	0	6	0	0	14	0	0
IND5	0	0	21	0	0	5	0	0	5	0	0	0	3	0	0	0	0	0	35	0	0	2	0	0	10	2	0	0	15	0	0	0	0	2	0	0
IND6	0	32	3	0	0	2	0	0	10	0	0	0	18	0	0	0	0	0	8	0	0	7	0	0	0	0	0	0	0	0	0	0	0	13	0	7
AGR1	56	0	3	0	0	2	0	0	14	0	0	0	2	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	1	0	0	13	0	0
REL1	22	0	8	0	0	0	0	0	2	0	0	0	21	0	0	0	0	0	15	0	0	5	0	0	0	0	0	0	8	0	0	0	0	19	0	0
GOV1	0	0	0	0	53	0	0	5	0	0	0	5	0	0	0	0	0	3	0	0	30	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0
GOV2	45	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	3	0	0	0	0	13	0	0
EDU1	11	0	6	0	0	0	0	0	3	3	0	0	21	0	0	0	0	0	21	0	0	4	0	0	0	0	0	0	9	0	0	0	0	22	0	0
EDU2	0	0	0	0	5	0	0	5	0	0	0	35	0	0	0	0	0	0	0	0	40	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 35 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH 1950-1970, LOW RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 24																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	72	0	1	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	8	0	0	0	0	3	0	3
RES3B	72	0	1	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	8	0	0	0	0	3	0	3
RES3C	72	0	1	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	8	0	0	0	0	3	0	3
RES3D	72	0	1	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	8	0	0	0	0	3	0	3
RES3E	72	0	1	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	8	0	0	0	0	3	0	3
RES3F	72	0	1	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	8	0	0	0	0	3	0	3
RES4	55	0	1	0	0	2	0	0	2	2	0	0	3	0	0	0	0	0	11	0	0	2	0	0	0	0	0	0	18	0	1	0	0	3	0	0
RES5	39	0	3	0	0	3	0	0	0	1	0	0	8	0	0	0	0	0	16	0	0	6	0	0	0	0	0	0	18	0	1	0	0	5	0	0
RES6	70	0	0	0	0	0	0	0	3	1	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
COM1	0	34	3	0	0	1	0	0	3	2	0	0	4	0	0	0	0	0	13	0	0	5	0	0	10	1	0	0	18	0	2	0	0	4	0	0
COM2	0	12	4	0	0	5	0	0	5	3	0	0	3	0	0	0	0	0	18	0	0	0	0	0	22	1	0	0	19	0	4	0	0	4	0	0
COM3	0	12	3	0	0	5	0	0	5	2	0	0	3	0	0	0	0	0	23	0	0	4	0	0	12	1	0	0	22	0	4	0	0	4	0	0
COM4	0	34	3	0	0	3	0	0	1	2	0	0	3	0	0	0	0	0	17	0	0	5	0	0	3	0	0	0	23	0	4	0	0	2	0	0
COM5	0	34	3	0	0	3	0	0	1	2	0	0	3	0	0	0	0	0	17	0	0	5	0	0	3	0	0	0	23	0	4	0	0	2	0	0
COM6	0	32	5	0	0	2	0	0	4	3	0	0	0	0	0	0	0	0	16	0	0	6	0	0	0	0	0	0	28	0	4	0	0	0	0	0
COM7	0	46	13	0	0	1	0	0	3	3	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	20	0	0	0	0	5	0	0
COM8	0	13	17	0	0	12	0	0	3	3	0	0	0	0	0	0	0	0	13	0	0	6	0	0	0	0	0	0	30	0	3	0	0	0	0	0
COM9	0	10	10	0	0	30	0	0	0	0	0	0	5	0	0	0	0	0	10	0	0	0	0	0	5	0	0	0	30	0	0	0	0	0	0	0
COM10	0	0	5	0	0	8	0	0	0	20	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	5	0	0	20	0	6	0	0	2	0	0
IND1	0	10	25	0	0	30	0	0	3	0	0	0	0	0	0	7	0	0	14	0	0	0	0	0	0	0	0	0	9	0	2	0	0	0	0	0
IND2	0	8	5	0	0	14	0	0	17	4	0	0	0	0	0	0	0	0	10	0	0	5	0	0	22	3	0	0	12	0	0	0	0	0	0	0
IND3	0	0	14	0	0	16	0	0	6	1	0	0	0	0	0	5	0	0	17	0	0	0	0	0	28	1	0	0	10	0	2	0	0	0	0	0
IND4	0	0	18	0	0	25	0	0	9	0	0	0	0	0	0	11	0	0	10	0	0	0	0	0	7	0	0	0	15	0	3	0	0	0	0	2
IND5	0	0	4	0	0	9	0	0	3	2	0	0	0	0	0	4	0	0	20	0	0	0	0	0	35	3	0	0	15	0	4	0	0	0	0	1
IND6	0	30	0	0	0	1	0	0	15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	4	0	0	0	20	0	3	0	0	0	0	20
AGR1	51	0	4	0	0	8	0	0	12	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	10	0	0	0	11	0	2	0	0	0	0	0
REL1	20	0	4	0	0	1	0	0	3	3	0	0	0	0	0	0	0	0	24	0	0	0	0	0	4	0	0	0	37	0	4	0	0	0	0	0
GOV1	0	21	6	0	0	3	0	0	2	2	0	0	0	0	0	0	0	0	26	0	0	5	0	0	4	2	0	0	27	0	2	0	0	0	0	0
GOV2	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	7	0	0	0	20	0	10	0	0	0	0	0
EDU1	25	0	3	0	0	4	0	0	5	4	0	0	0	0	0	0	0	0	20	0	0	0	0	0	4	2	0	0	29	0	4	0	0	0	0	0
EDU2	5	0	2	0	0	12	0	0	0	5	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	50	0	6	0	0	0	0	0

TABLE 36 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH 1950-1970, MID RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 24																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	10	0	0	15	0	0	0	6	0	0	0	0	0	4	0	0	37	0	0	0	0	0	0	1	0	0	21	0	6	0	0	0	0	
RES3B	0	0	0	10	0	0	15	0	0	0	6	0	0	0	0	0	4	0	0	37	0	0	0	0	0	0	1	0	0	21	0	6	0	0	0	0	
RES3C	0	0	0	10	0	0	15	0	0	0	6	0	0	0	0	0	4	0	0	37	0	0	0	0	0	0	1	0	0	21	0	6	0	0	0	0	
RES3D	0	0	0	10	0	0	15	0	0	0	6	0	0	0	0	0	4	0	0	37	0	0	0	0	0	0	1	0	0	21	0	6	0	0	0	0	
RES3E	0	0	0	10	0	0	15	0	0	0	6	0	0	0	0	0	4	0	0	37	0	0	0	0	0	0	1	0	0	21	0	6	0	0	0	0	
RES3F	0	0	0	10	0	0	15	0	0	0	6	0	0	0	0	0	4	0	0	37	0	0	0	0	0	0	1	0	0	21	0	6	0	0	0	0	
RES4	0	0	0	9	0	0	24	0	0	0	9	0	0	0	0	0	5	0	0	34	0	0	1	0	0	0	0	0	0	14	0	4	0	0	0	0	
RES5	0	0	0	6	0	0	1	0	0	0	11	0	0	0	0	0	9	0	0	45	0	0	0	0	0	0	0	0	0	18	0	10	0	0	0	0	
RES6	0	0	0	15	0	0	10	0	0	0	15	0	0	0	0	0	5	0	0	25	0	0	0	0	0	0	0	0	0	25	0	5	0	0	0	0	
COM1	0	0	0	7	0	0	25	0	0	0	5	0	0	0	0	0	3	0	0	31	0	0	0	0	0	0	0	0	0	22	0	7	0	0	0	0	
COM2	0	0	0	21	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	34	0	0	0	0	0	0	1	0	0	34	0	5	0	0	0	0	
COM3	0	0	0	10	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	54	0	5	0	0	0	0	
COM4	0	0	0	17	0	0	18	0	0	0	9	0	0	0	0	0	9	0	0	18	0	0	0	0	0	0	2	0	0	23	0	4	0	0	0	0	
COM5	0	0	0	17	0	0	18	0	0	0	9	0	0	0	0	0	9	0	0	18	0	0	0	0	0	0	2	0	0	23	0	4	0	0	0	0	
COM6	0	0	0	14	0	0	10	0	0	0	14	0	0	0	0	0	5	0	0	23	0	0	0	0	0	0	3	0	0	23	0	8	0	0	0	0	
COM7	0	0	0	15	0	0	10	0	0	0	15	0	0	0	0	0	5	0	0	25	0	0	0	0	0	0	0	0	0	25	0	5	0	0	0	0	
COM8	0	0	0	5	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	52	0	0	0	0	0	0	0	0	0	10	0	5	0	0	0	0	
COM9	0	0	0	5	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	10	0	5	0	0	0	0	
COM10	0	0	0	5	0	0	8	0	0	0	8	0	0	0	0	0	7	0	0	39	0	0	0	0	0	0	8	0	0	18	0	7	0	0	0	0	
IND1	0	0	0	0	0	0	10	0	0	0	20	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	20	0	10	0	0	0	0	
IND2	0	0	0	0	0	0	15	0	0	0	10	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	20	0	5	0	0	0	0	
IND3	0	0	0	11	0	0	4	0	0	0	10	0	0	0	0	0	30	0	0	20	0	0	0	0	0	0	1	0	0	15	0	9	0	0	0	0	
IND4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
IND5	0	0	0	10	0	0	5	0	0	0	13	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	30	0	10	0	0	0	0	
IND6	0	30	0	0	0	1	0	0	15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	4	0	0	0	20	0	3	0	0	0	0	20	
AGR1	51	0	4	0	0	8	0	0	12	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	10	0	0	0	11	0	2	0	0	0	0	0	
REL1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	10	0	10	0	0	0	0	
GOV1	0	0	0	15	0	0	6	0	0	0	15	0	0	0	0	0	11	0	0	28	0	0	0	0	0	0	2	0	0	18	0	5	0	0	0	0	
GOV2	0	0	0	5	0	0	10	0	0	0	10	0	0	0	0	0	5	0	0	60	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	
EDU1	25	0	3	0	0	4	0	0	5	4	0	0	0	0	0	0	0	0	20	0	0	0	0	0	4	2	0	0	29	0	4	0	0	0	0	0	
EDU2	0	0	0	20	0	0	0	0	0	0	15	0	0	0	0	0	5	0	0	35	0	0	0	0	0	0	0	0	0	15	0	10	0	0	0	0	

TABLE 37 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH 1950-1970, MID RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 24																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	0	30	0	0	21	0	0	0	6	0	0	0	0	0	13	0	0	24	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
RES3B	0	0	0	0	30	0	0	21	0	0	0	6	0	0	0	0	0	13	0	0	24	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
RES3C	0	0	0	0	30	0	0	21	0	0	0	6	0	0	0	0	0	13	0	0	24	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
RES3D	0	0	0	0	30	0	0	21	0	0	0	6	0	0	0	0	0	13	0	0	24	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
RES3E	0	0	0	0	30	0	0	21	0	0	0	6	0	0	0	0	0	13	0	0	24	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
RES3F	0	0	0	0	30	0	0	21	0	0	0	6	0	0	0	0	0	13	0	0	24	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
RES4	0	0	0	0	48	0	0	10	0	0	0	9	0	0	0	0	0	12	0	0	19	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
RES5	0	0	0	0	20	0	0	15	0	0	0	25	0	0	0	0	0	30	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
RES6	70	0	0	0	0	0	0	0	3	1	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
COM1	0	34	3	0	0	1	0	0	3	2	0	0	4	0	0	0	0	0	13	0	0	5	0	0	10	1	0	0	18	0	2	0	0	4	0	0
COM2	0	12	4	0	0	5	0	0	5	3	0	0	3	0	0	0	0	0	18	0	0	0	0	0	22	1	0	0	19	0	4	0	0	4	0	0
COM3	0	12	3	0	0	5	0	0	5	2	0	0	3	0	0	0	0	0	23	0	0	4	0	0	12	1	0	0	22	0	4	0	0	4	0	0
COM4	0	0	0	0	40	0	0	26	0	0	0	18	0	0	0	0	0	6	0	0	7	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0
COM5	0	0	0	0	40	0	0	26	0	0	0	18	0	0	0	0	0	6	0	0	7	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0
COM6	0	0	0	0	35	0	0	27	0	0	0	17	0	0	0	0	0	4	0	0	15	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
COM7	0	46	13	0	0	1	0	0	3	3	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	20	0	0	0	0	5	0	0
COM8	0	13	17	0	0	12	0	0	3	3	0	0	0	0	0	0	0	0	13	0	0	6	0	0	0	0	0	0	30	0	3	0	0	0	0	0
COM9	0	10	10	0	0	30	0	0	0	0	0	0	5	0	0	0	0	0	10	0	0	0	0	0	5	0	0	0	30	0	0	0	0	0	0	0
COM10	0	0	5	0	0	8	0	0	0	20	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	5	0	0	20	0	6	0	0	2	0	0
IND1	0	10	25	0	0	30	0	0	3	0	0	0	0	0	0	7	0	0	14	0	0	0	0	0	0	0	0	0	9	0	2	0	0	0	0	0
IND2	0	8	5	0	0	14	0	0	17	4	0	0	0	0	0	0	0	0	10	0	0	5	0	0	22	3	0	0	12	0	0	0	0	0	0	0
IND3	0	0	14	0	0	16	0	0	6	1	0	0	0	0	0	5	0	0	17	0	0	0	0	0	28	1	0	0	10	0	2	0	0	0	0	0
IND4	0	0	18	0	0	25	0	0	9	0	0	0	0	0	0	11	0	0	10	0	0	0	0	0	7	0	0	0	15	0	3	0	0	0	0	2
IND5	0	0	4	0	0	9	0	0	3	2	0	0	0	0	0	4	0	0	20	0	0	0	0	0	35	3	0	0	15	0	4	0	0	0	0	1
IND6	0	30	0	0	0	1	0	0	15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	4	0	0	0	20	0	3	0	0	0	0	20
AGR1	51	0	4	0	0	8	0	0	12	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	10	0	0	0	11	0	2	0	0	0	0	0
REL1	20	0	4	0	0	1	0	0	3	3	0	0	0	0	0	0	0	0	24	0	0	0	0	0	4	0	0	0	37	0	4	0	0	0	0	0
GOV1	0	0	0	0	46	0	0	13	0	0	0	22	0	0	0	0	0	10	0	0	8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
GOV2	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	7	0	0	0	20	0	10	0	0	0	0	0
EDU1	25	0	3	0	0	4	0	0	5	4	0	0	0	0	0	0	0	0	20	0	0	0	0	0	4	2	0	0	29	0	4	0	0	0	0	0
EDU2	0	0	0	0	35	0	0	20	0	0	0	20	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 38 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH POST-1970, LOW RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 25																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	73	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	1	0	0	9	0	0	0	0	0	0	5
RES3B	73	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	1	0	0	9	0	0	0	0	0	0	5
RES3C	73	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	1	0	0	9	0	0	0	0	0	0	5
RES3D	73	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	1	0	0	9	0	0	0	0	0	0	5
RES3E	73	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	1	0	0	9	0	0	0	0	0	0	5
RES3F	73	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	1	0	0	9	0	0	0	0	0	0	5
RES4	53	0	3	0	0	0	0	0	2	3	0	0	0	0	0	4	0	0	13	0	0	0	0	0	0	0	0	0	20	0	2	0	0	0	0	0
RES5	33	0	3	0	0	3	0	0	0	6	0	0	0	0	0	5	0	0	24	0	0	0	0	0	0	0	0	0	23	0	3	0	0	0	0	0
RES6	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	20	0	0	0	0	0	0	0
COM1	0	26	9	0	0	1	0	0	2	1	0	0	0	0	0	6	0	0	10	0	0	1	0	0	15	5	0	0	21	0	3	0	0	0	0	0
COM2	0	8	4	0	0	1	0	0	3	4	0	0	0	0	0	2	0	0	12	0	0	0	0	0	41	3	0	0	19	0	3	0	0	0	0	0
COM3	0	13	3	0	0	2	0	0	2	3	0	0	0	0	0	3	0	0	13	0	0	0	0	0	20	5	0	0	34	0	2	0	0	0	0	0
COM4	0	35	3	0	0	2	0	0	1	3	0	0	0	0	0	4	0	0	15	0	0	0	0	0	8	3	0	0	24	0	2	0	0	0	0	0
COM5	0	35	3	0	0	2	0	0	1	3	0	0	0	0	0	4	0	0	15	0	0	0	0	0	8	3	0	0	24	0	2	0	0	0	0	0
COM6	0	31	6	0	0	1	0	0	1	7	0	0	0	0	0	4	0	0	13	0	0	0	0	0	7	0	0	0	28	0	2	0	0	0	0	0
COM7	0	47	16	0	0	0	0	0	0	5	0	0	0	0	0	4	0	0	6	0	0	0	0	0	2	0	0	0	20	0	0	0	0	0	0	0
COM8	0	4	23	0	0	8	0	0	1	3	0	0	0	0	0	2	0	0	15	0	0	0	0	0	4	1	0	0	32	0	7	0	0	0	0	0
COM9	0	5	27	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	4	0	0	0	27	0	5	0	0	0	0	0
COM10	0	0	8	0	0	8	0	0	0	6	0	0	0	0	0	3	0	0	49	0	0	0	0	0	3	13	0	0	7	0	3	0	0	0	0	0
IND1	0	11	19	0	0	28	0	0	3	2	0	0	0	0	0	1	0	0	9	0	0	0	0	0	11	3	0	0	11	0	1	0	0	0	0	1
IND2	0	3	13	0	0	9	0	0	6	3	0	0	0	0	0	0	0	0	10	0	0	0	0	0	41	3	0	0	12	0	0	0	0	0	0	0
IND3	0	2	15	0	0	10	0	0	5	3	0	0	0	0	0	0	0	0	12	0	0	0	0	0	28	7	0	0	18	0	0	0	0	0	0	0
IND4	0	1	26	0	0	18	0	0	5	4	0	0	0	0	0	1	0	0	11	0	0	1	0	0	12	5	0	0	15	0	1	0	0	0	0	0
IND5	0	1	12	0	0	8	0	0	2	3	0	0	0	0	0	0	0	0	10	0	0	0	0	0	38	7	0	0	17	0	1	0	0	0	0	1
IND6	0	30	4	0	0	6	0	0	11	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	16	6	0	0	14	0	0	0	0	0	0	5
AGR1	40	0	8	0	0	11	0	0	8	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	11	1	0	0	15	0	1	0	0	0	0	2
REL1	23	0	12	0	0	3	0	0	1	6	0	0	0	0	0	0	0	0	26	0	0	0	0	0	1	3	0	0	22	0	3	0	0	0	0	0
GOV1	0	8	15	0	0	4	0	0	3	7	0	0	0	0	0	2	0	0	32	0	0	0	0	0	0	4	0	0	16	0	9	0	0	0	0	0
GOV2	40	0	3	0	0	7	0	0	0	23	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	7	0	0	3	0	7	0	0	0	0	0
EDU1	24	0	9	0	0	6	0	0	1	5	0	0	0	0	0	3	0	0	16	0	0	3	0	0	4	3	0	0	21	0	5	0	0	0	0	0
EDU2	5	0	10	0	0	10	0	0	0	5	0	0	0	0	0	0	0	0	20	0	0	0	0	0	5	0	0	0	40	0	5	0	0	0	0	0

TABLE 39 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH POST-1970, MID RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 25																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	9	0	0	23	0	0	0	8	0	0	0	0	0	10	0	0	28	0	0	0	0	0	0	7	0	0	12	0	3	0	0	0	0
RES3B	0	0	0	9	0	0	23	0	0	0	8	0	0	0	0	0	10	0	0	28	0	0	0	0	0	0	7	0	0	12	0	3	0	0	0	0
RES3C	0	0	0	9	0	0	23	0	0	0	8	0	0	0	0	0	10	0	0	28	0	0	0	0	0	0	7	0	0	12	0	3	0	0	0	0
RES3D	0	0	0	9	0	0	23	0	0	0	8	0	0	0	0	0	10	0	0	28	0	0	0	0	0	0	7	0	0	12	0	3	0	0	0	0
RES3E	0	0	0	9	0	0	23	0	0	0	8	0	0	0	0	0	10	0	0	28	0	0	0	0	0	0	7	0	0	12	0	3	0	0	0	0
RES3F	0	0	0	9	0	0	23	0	0	0	8	0	0	0	0	0	10	0	0	28	0	0	0	0	0	0	7	0	0	12	0	3	0	0	0	0
RES4	0	0	0	16	0	0	28	0	0	0	8	0	0	0	0	0	11	0	0	18	0	0	0	0	0	0	3	0	0	13	0	3	0	0	0	0
RES5	0	0	0	9	0	0	10	0	0	0	11	0	0	0	0	0	16	0	0	34	0	0	0	0	0	0	4	0	0	11	0	5	0	0	0	0
RES6	0	0	0	25	0	0	10	0	0	0	15	0	0	0	0	0	10	0	0	35	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
COM1	0	0	0	34	0	0	9	0	0	0	3	0	0	0	0	0	12	0	0	17	0	0	0	0	0	0	5	0	0	15	0	5	0	0	0	0
COM2	0	0	0	20	0	0	17	0	0	0	0	0	0	0	0	0	15	0	0	10	0	0	0	0	0	0	8	0	0	15	0	15	0	0	0	0
COM3	0	0	0	11	0	0	17	0	0	0	3	0	0	0	0	0	10	0	0	17	0	0	0	0	0	0	12	0	0	17	0	13	0	0	0	0
COM4	0	0	0	37	0	0	10	0	0	0	12	0	0	0	0	0	9	0	0	15	0	0	0	0	0	0	3	0	0	9	0	5	0	0	0	0
COM5	0	0	0	37	0	0	10	0	0	0	12	0	0	0	0	0	9	0	0	15	0	0	0	0	0	0	3	0	0	9	0	5	0	0	0	0
COM6	0	0	0	25	0	0	9	0	0	0	15	0	0	0	0	0	10	0	0	33	0	0	0	0	0	0	1	0	0	6	0	1	0	0	0	0
COM7	0	0	0	25	0	0	10	0	0	0	15	0	0	0	0	0	10	0	0	35	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
COM8	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COM9	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COM10	0	0	0	4	0	0	8	0	0	0	3	0	0	0	0	0	4	0	0	66	0	0	0	0	0	0	8	0	0	6	0	1	0	0	0	0
IND1	0	11	19	0	0	28	0	0	3	2	0	0	0	0	0	1	0	0	9	0	0	0	0	0	11	3	0	0	11	0	1	0	0	0	0	1
IND2	0	3	13	0	0	9	0	0	6	3	0	0	0	0	0	0	0	0	10	0	0	0	0	0	41	3	0	0	12	0	0	0	0	0	0	0
IND3	0	0	0	62	0	0	5	0	0	0	1	0	0	0	0	0	23	0	0	4	0	0	0	0	0	0	1	0	0	3	0	1	0	0	0	0
IND4	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IND5	0	0	0	18	0	0	14	0	0	0	3	0	0	0	0	0	34	0	0	13	0	0	0	0	0	0	5	0	0	10	0	3	0	0	0	0
IND6	0	30	4	0	0	6	0	0	11	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	16	6	0	0	14	0	0	0	0	0	0	5
AGR1	40	0	8	0	0	11	0	0	8	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	11	1	0	0	15	0	1	0	0	0	0	2
REL1	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
GOV1	0	0	0	25	0	0	11	0	0	0	15	0	0	0	0	0	22	0	0	12	0	0	0	0	0	0	4	0	0	9	0	2	0	0	0	0
GOV2	0	0	0	25	0	0	20	0	0	0	35	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDU1	24	0	9	0	0	6	0	0	1	5	0	0	0	0	0	3	0	0	16	0	0	3	0	0	4	3	0	0	21	0	5	0	0	0	0	0
EDU2	0	0	0	20	0	0	5	0	0	0	10	0	0	0	0	0	25	0	0	25	0	0	0	0	0	0	0	0	0	10	0	5	0	0	0	0

TABLE 40 – PERCENT OF BUILDING CONSTRUCTION TYPES FOR EACH POST-1970, HIGH RISE BUILDING OCCUPANCY TYPE IN THE WESTERN US

Building occupancy type	Building construction type																																				
	W1	W2	S1L	S1M	S1H	S2L	S2M	S2H	S3	S4L	S4M	S4H	S5L	S5M	S5H	C1L	C1M	C1H	C2L	C2M	C2H	C3L	C3M	C3H	PC1	PC2L	PC2M	PC2H	RM1L	RM1M	RM2L	RM2M	RM2H	URML	URMM	MH
RES1	State specific – see Table 25																																				
RES2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RES3A	0	0	0	0	44	0	0	6	0	0	0	5	0	0	0	0	0	18	0	0	20	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0
RES3B	0	0	0	0	44	0	0	6	0	0	0	5	0	0	0	0	0	18	0	0	20	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0
RES3C	0	0	0	0	44	0	0	6	0	0	0	5	0	0	0	0	0	18	0	0	20	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0
RES3D	0	0	0	0	44	0	0	6	0	0	0	5	0	0	0	0	0	18	0	0	20	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0
RES3E	0	0	0	0	44	0	0	6	0	0	0	5	0	0	0	0	0	18	0	0	20	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0
RES3F	0	0	0	0	44	0	0	6	0	0	0	5	0	0	0	0	0	18	0	0	20	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0
RES4	0	0	0	0	56	0	0	10	0	0	0	6	0	0	0	0	0	16	0	0	9	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0
RES5	0	0	0	0	25	0	0	18	0	0	0	20	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RES6	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	20	0	0	0	0	0	0	0
COM1	0	26	9	0	0	1	0	0	2	1	0	0	0	0	0	6	0	0	10	0	0	1	0	0	15	5	0	0	21	0	3	0	0	0	0	0
COM2	0	8	4	0	0	1	0	0	3	4	0	0	0	0	0	2	0	0	12	0	0	0	0	0	41	3	0	0	19	0	3	0	0	0	0	0
COM3	0	13	3	0	0	2	0	0	2	3	0	0	0	0	0	3	0	0	13	0	0	0	0	0	20	5	0	0	34	0	2	0	0	0	0	0
COM4	0	0	0	0	56	0	0	10	0	0	0	14	0	0	0	0	0	14	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
COM5	0	0	0	0	54	0	0	10	0	0	0	15	0	0	0	0	0	15	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
COM6	0	0	0	0	45	0	0	6	0	0	0	19	0	0	0	0	0	13	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COM7	0	47	16	0	0	0	0	0	0	5	0	0	0	0	0	4	0	0	6	0	0	0	0	0	2	0	0	0	20	0	0	0	0	0	0	0
COM8	0	4	23	0	0	8	0	0	1	3	0	0	0	0	0	2	0	0	15	0	0	0	0	0	4	1	0	0	32	0	7	0	0	0	0	0
COM9	0	5	27	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	4	0	0	0	27	0	5	0	0	0	0	0
COM10	0	0	8	0	0	8	0	0	0	6	0	0	0	0	0	3	0	0	49	0	0	0	0	0	3	13	0	0	7	0	3	0	0	0	0	0
IND1	0	11	19	0	0	28	0	0	3	2	0	0	0	0	0	1	0	0	9	0	0	0	0	0	11	3	0	0	11	0	1	0	0	0	0	1
IND2	0	3	13	0	0	9	0	0	6	3	0	0	0	0	0	0	0	0	10	0	0	0	0	0	41	3	0	0	12	0	0	0	0	0	0	0
IND3	0	2	15	0	0	10	0	0	5	3	0	0	0	0	0	0	0	0	12	0	0	0	0	0	28	7	0	0	18	0	0	0	0	0	0	0
IND4	0	1	26	0	0	18	0	0	5	4	0	0	0	0	0	1	0	0	11	0	0	1	0	0	12	5	0	0	15	0	1	0	0	0	0	0
IND5	0	1	12	0	0	8	0	0	2	3	0	0	0	0	0	0	0	0	10	0	0	0	0	0	38	7	0	0	17	0	1	0	0	0	0	1
IND6	0	30	4	0	0	6	0	0	11	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	16	6	0	0	14	0	0	0	0	0	0	5
AGR1	40	0	8	0	0	11	0	0	8	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	11	1	0	0	15	0	1	0	0	0	0	2
REL1	23	0	12	0	0	3	0	0	1	6	0	0	0	0	0	0	0	0	26	0	0	0	0	0	1	3	0	0	22	0	3	0	0	0	0	0
GOV1	0	0	0	0	52	0	0	14	0	0	0	14	0	0	0	0	0	14	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GOV2	40	0	3	0	0	7	0	0	0	23	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	7	0	0	3	0	7	0	0	0	0	0
EDU1	24	0	9	0	0	6	0	0	1	5	0	0	0	0	0	3	0	0	16	0	0	3	0	0	4	3	0	0	21	0	5	0	0	0	0	0
EDU2	0	0	0	0	30	0	0	10	0	0	0	10	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0