Attachment 2

Mountain View
Soft Story Study Report

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Task 1: Inventory of Soft Story Buildings

1. Summary

This is a report of findings from Task 1 of the Mountain View Soft Story Study. The Task 1 deliverable is a tentative inventory of Mountain View's multi-unit housing stock with a rough count and characterization of buildings that might be subject to a "soft story" seismic mitigation ordinance.

The purpose of the tentative inventory is to provide background and supporting data for assessment of program options, not to create a definitive list of deficient buildings or a tracking tool for program implementation.

1.1 Mountain View's multi-unit housing stock

Subset	Description	Buildings	Units
A	All parcels and buildings (including 0-unit hotels)	1,383	16,596
B	Buildings with 3 or more units	1,275	16,490
C	Subset B buildings, woodframe, built between 1950 and 1980	1,152	11,800
D	Subset C buildings with a woodframe "target story" (WFTS)	488	5,123

The multi-unit housing stock comprises about 16,600 units in about 1380 buildings. This represents about 50 percent of Mountain View's overall housing stock.

Of these, the vast majority were built between 1950 and 1980 – about 90 percent of the buildings and about 78 percent of the units. Newer buildings, expected to pose lower seismic risks, account for almost all of the rest. An insignificant number of the buildings, if any, have been retrofitted.

Of the buildings with 3 or more units, about 94 percent appear to be of wood construction; a few also feature reinforced masonry (block) walls. Mountain View has practically no other multi-unit residential buildings with structure types widely recognized as vulnerable, such as unreinforced masonry or obsolete (non-ductile) concrete:

- Nearly all of the concrete structures are newer buildings, expected to pose lower seismic risks.

Thus, Mountain View's multi-unit housing stock is dominated by buildings:

- With at least 3 units
- Built of wood construction
- Built between 1950 and 1980.

This dominant subset, Subset C in the table above, comprises about 11,800 units in about 1,150 buildings, representing 71 percent of the units and 83 percent of the buildings in the overall multi-unit housing stock.

Within this dominant subset, 488 buildings (containing about 5,123 units), appear to have a "woodframe target story" (WFTS) – that is, a first story condition associated with disproportionate earthquake damage and potential collapse. Of these, about 430 buildings have at least one residential unit or an occupied commercial space in the vulnerable target story. An occupied target story, as opposed to a story used only for parking or storage, represents a greater safety risk in the event of collapse.

The 488 WFTS buildings represent about 16 percent of the city's overall housing stock. This is as large a proportion of earthquake-vulnerable "soft story" housing as exists in Oakland or San Francisco, and a larger proportion than exists in Berkeley or Palo Alto.

City	Total occupied housing units	Housing units in suspected "soft story" buildings	Portion of housing units in suspected "soft story" buildings
Mountain View	32,849	5,123	16%
Palo Alto	28,228	2,900	10%
Berkeley	46,078	2,841	6%
Oakland	158,084	24,273	15%
San Francisco	358,703	49,000	14%

The 488 WFTS buildings also represent substantially more at-risk residential units than Mountain View's other earthquake-vulnerable housing types. These buildings contain more units than the city's unreinforced masonry or non-ductile concrete buildings, hillside houses, cripple wall houses, and mobile homes combined.

These building and unit counts are significantly higher than estimates made in 2003 and cited in the *City of Mountain View 2015-2023 Housing Element* (Section 4.3.1).

Multi-unit housing subset	2003 estimate	This study
All buildings	584	1,275
Earthquake-vulnerable buildings	111 "soft story"	488 WFTS
Earthquake-vulnerable units	1,129 "soft story"	5,123 WFTS

Of the 660 or so buildings in the dominant subset that do *not* show an obvious WFTS condition, about 180 are 1-story buildings and therefore very low risk in terms of earthquake collapse potential. The other 480 are probably less vulnerable than the WFTS buildings, but it is likely that they still have deficiencies and could sustain damage that would delay reoccupancy, especially if the ground story walls are sheathed only in stucco and gypsum board (drywall).

Compared with other Bay Area cities, Mountain View's multi-unit housing stock is distinguished by the following attributes:

- Age. The Mountain View buildings include very few from the 1920s boom, unlike San Francisco and Oakland.

- Multi-building parcels. More than 60 percent of the Mountain View buildings and units are on multi-building parcels. (This is true of the housing stock overall and of the dominant subset.) Multi-building parcels are relatively uncommon in San Francisco, Oakland, and Berkeley.

- Height. Two-story buildings make up 71 percent of the dominant subset, and even these short buildings average more than 9 units per building, often in a long rectangular plan a single unit wide. These buildings are shorter than typical buildings in San Francisco (known for its dense construction) and larger in unit count than the typical 2-story building in Berkeley.

- Ground story use. Essentially none of the vulnerable woodframe Mountain View buildings have commercial space in the ground story. A large majority include at least one residential unit in this critical story, as opposed to having only parking and storage areas there.

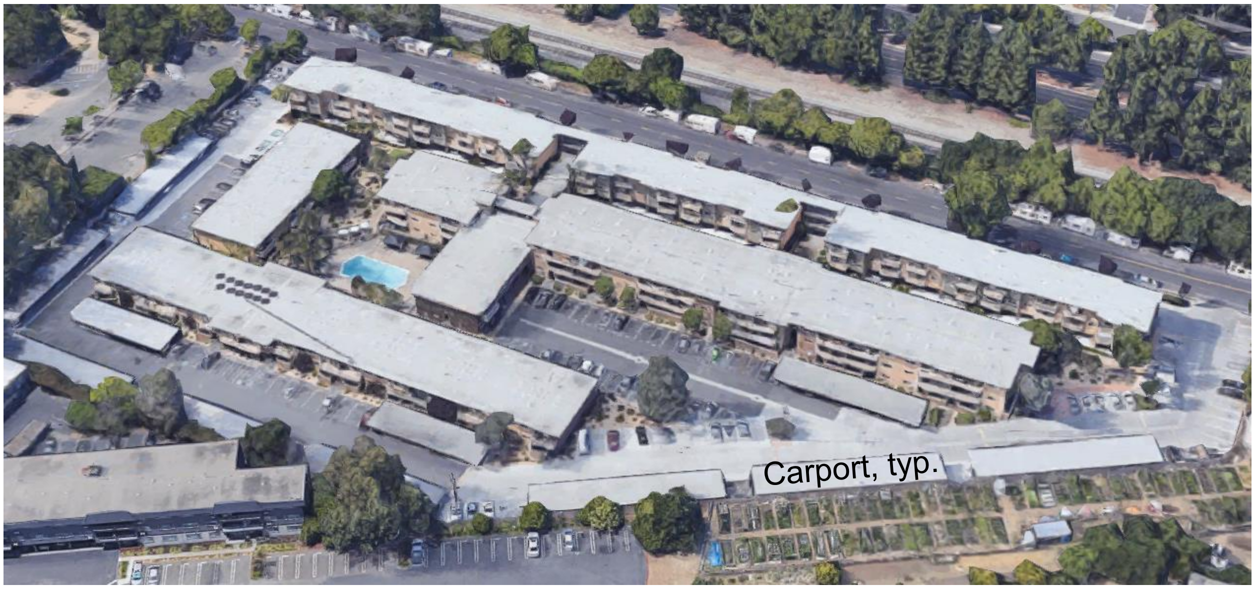
- Woodframe target story condition. Within the dominant subset, less than half of the buildings have an apparent WFTS condition. This is largely due to the relatively low density of development and the availability of surface parking within the lot, even on a parcel with multiple buildings and dozens of units. Even at a parcel with several otherwise similar buildings, “tuckunder” parking might have been built into only some of them. This varies significantly from denser development in Berkeley, San Francisco, and Oakland. In San Francisco, for example, close to 80 percent of the woodframe multi-unit buildings targeted by the city’s retrofit ordinance were found to have a vulnerable target story. The Mountain View condition means fewer buildings will be at the highest and most obvious risk, but it might make for a slightly more complicated screening phase if an ordinance is enacted.

- Liquefaction. About a quarter of the vulnerable WFTS buildings are in areas mapped as prone to liquefaction. Most “soft story” mitigation programs ignore the smaller conditional probability of ground failure in addition to strong shaking, but a substantial liquefaction risk does reduce the benefit-cost ratio of a typical “soft story” retrofit.

Figure 1. Typical buildings: Multi-building parcels

Front house (1 unit), with rear 5-unit 2-story building. Rear building presents WFTS condition.

Three 2-story buildings (13 units total). No WFTS; parking provided under adjacent carports.



Multiple large buildings. No WFTS; parking spaces in adjacent surface lots, some under carports.

Figure 2. Typical buildings: Similarly sized buildings with and without woodframe target story (WFTS) conditions

3-unit buildings. Left: 1-story, no WFTS. Right: WFTS, “House Over Garage” type.

2-story, 6-unit buildings. Left: No WFTS. Right: WFTS, “Long Side Open” type.

Different buildings on same parcel. Left: 3-story, WFTS, parking below grade. Right: 2-story, No WFTS

1.2 Next steps

Task 3 provides an optional scope item (with a limited budget) the city can use to confirm or extend the Task 1 inventory data. Additional work might include:

- Field confirmation of unknown or assumed conditions, especially regarding the use of reinforced masonry in first story walls.
- Review of drawings (to be made available by the city) for representative buildings, to confirm inventory assumptions.
- For a few representative buildings, analysis to evaluate existing conditions and assess the relative collapse risk of buildings with and without WFTS conditions, assuming the availability of drawings to be provided by the city.
- Analysis to confirm feasibility of conceptual retrofit design for representative buildings.
- Analysis to establish appropriate FEMA P-807 retrofit objectives.

2. Data resolution

2.1 Process

Upon receipt of the “given” data in spreadsheet form from city staff, the following steps were applied:

- Visual characterization of a 20 percent sample using online images and data. Review of the sample revealed a substantial number of multi-building parcels, suggesting the need to resolve the parcel data into individual building records.
- Resolution of parcels into individual buildings.
- Identification of distinct building subsets: As shown below, there is a distinct difference in the number of 4-unit buildings and the number of 5-unit buildings, suggesting a significantly different building stock in each case. This might be related to past zoning or to California regulations and lending policies that treat 5-unit buildings as commercial. Analysis therefore proceeds with two key subsets:
    - Analysis of 3-4 unit buildings.
    - Analysis of 5+ unit buildings.
- Context analysis, considering other cities and Mountain View’s single-family housing stock.
- Recommendations for further data confirmation and analysis.

2.2 Given data

The given data was compiled November 13, 2017 from Housing department records and received by DBSE December 4, 2017. Compiled data does *not* include or make use of 2003 San Jose State University study.

The given data comprised 710 records by address and parcel number, each showing the number of residential units. Characteristics of the given data that required resolution included:

- Missing data: Unit counts blank or shown as 0 require resolution or confirmation.
- Inconsistency in listing similar buildings with separate ownership. In some cases, multiple adjacent buildings with shared drive aisle and matching construction (but different addresses) are listed separately. In others, similar cases are listed as a single record. In these cases, the records need to be split into individual buildings.
- Inconsistency in listing number of units on parcel when one or more buildings on the parcel is a 1-unit dwelling. In some cases, the total number of units appears to include the dwelling; in others, it does not. (Also, on some parcels, the different buildings share the same address; at others, each building has a distinct house number.)

- Possible discrepancy in actual number of units: In some cases, the building does not appear to match the number of units given, possibly because a unit used as a manager's unit or as a sales office is not counted as a unit in the city's data.
- No data on age, construction, number of buildings (or units/building), stories, lateral system, retrofit status, first story use (commercial, parking), geologic hazard. This information needs to be added.

2.3 Resolution of incomplete unit counts

Records with incomplete unit counts were completed and corrected based on comparison with similar adjacent buildings and using online data sources (such as Zillow and Redfin). The corrected records included:

- 7 parcel records with blank unit counts:
    - 4 completed to 0 units as "Vacant/In Construction."
    - 1 (1030 Castro) completed to 0 units as "Now part of 801 W El Camino Real."
    - 1 (801 W El Camino Real) completed to 164 units; new construction, built in 2017.
    - 1 (4321 Collins Court) completed to 9 units based on comparison with 4312 and 4315 Collins Court.
- 40 parcel records shown with 0 unit counts:
    - 3 noted as demolished or scheduled to be demolished.
    - 18 noted as hotels (R1 occupancy) and confirmed as 0 units for purposes of housing data.
    - 19 corrected based on similar buildings or online data.

In summary, the given data became the resolved data as follows:

- Data as given: 710 parcel records, 16,334 units
- Data as resolved: 710 parcel records, 16,582 units. Total shown in tables above and below (16,596 units) differs from 16,582 due to rounding in estimates of units/building. Difference is less than 0.1 percent.

2.4 Resolution of units per building

Each parcel record was reviewed. For each record, I identified each residential building on the site and created separate records for each building *type*. I ignored pool houses and common rooms. I ignored standalone parking sheds, carports, and garages.

Buildings of similar height, configuration, apparent target story, etc. were grouped together as a single building record for multiple buildings. In these cases, I accepted the total unit count for the site, then approximated the breakdown per building type; from that, I approximated the number of units per building for each type and rounded up to next whole number. Thus, 85 units in 6 similar buildings gives 14.2 units/building average, rounded up to 15 units/building.

It appears that the given unit counts might not include units used as sales offices or as live-in manager's units. For example, a building that obviously has 8 units might be given as a 7-unit property. Nevertheless, I accepted the given count as the total for the property.

The following table compares the given parcel data with the resolved building data. The differences illustrate the need to look at individual buildings or building groups to get a meaningful understanding of the housing stock in structural terms.

Units per parcel (corrected) or units per building (resolved)	**Parcel data (corrected unit counts)**		**Building data (resolved)**	
	Parcels	**Units**	**Buildings**	**Units** [1]
0	26	0	30	0
1	0	0	50	50
2	0	0	28	56
3	74	222	106	314
4	139	556	257	1,021
5	52	260	69	337
6 – 7	83	511	130	810
8 – 9	45	379	198	1,600
10 – 15	76	909	225	2,665
16 – 31	99	2,067	200	4,503
32+	116	11,678	90	5,240
All	**710**	**16,582**	**1,383**	**16,596**

[1] Total units within each row and overall varies slightly from the product of the number of buildings and the number of units/building due to rounding in the estimate of units per building; see text for further explanation.

"Units per parcel" is misleading regarding building size. Because so many parcels include multiple buildings, the actual buildings are smaller than the parcel-level data by itself would suggest. Following are characteristics of parcels with multiple buildings:

- Number of parcels with multiple buildings: 213 parcels, 874 buildings (63% of all buildings), 10,949 units (66% of all units).
- Breakdown by buildings/parcel:
  - 2 buildings: 119 parcels
  - 3 buildings: 34 parcels
  - 4 buildings: 16 parcels
  - 5 to 10 buildings: 29 parcels
  - 11 or more buildings: 16 parcels
- Parcels with the most individual buildings:
  - 100 N. Whisman Road (47 buildings, 354 units)
  - 151 Calderon Avenue (34 buildings, 294 units)
- Number of parcels with a one-unit house and one or more rear buildings: 48

2.5 Mountain View's multi-unit housing stock in context

The resolved unit counts, tabulated above, can be compared with estimates of Mountain View's overall housing stock to estimate the portion represented by multi-unit buildings.

Census data from the "2012-2016 American Community Survey 5-year Estimates" gives the following:

- Total number of occupied housing units: 32,849
- Total excluding 1,051 mobile home units: 31,798
- Total number of units in buildings with 3 or more units: 16,983
  - This is within 3 percent of the total of 16,490 estimated by this study.
- Total number of units in buildings with 5 or more units: 14,913
  - This is within 2 percent of the total of 15,155 estimated by this study.

It is unclear what the census data means by 1 unit, "attached." Presumably this means a townhouse structure in which each unit has its own direct entrance and egress but shares structural elements (walls and roof) with adjacent units. Possibly it also includes a few recent developments in Mountain View in which distinct dwelling structures share a common podium with below-grade parking.

The portion of the overall housing stock represented by multi-unit buildings thus depends on how you count the various categories. The following table shows the range of possible values:

Estimate of total units in multi-unit buildings	**Total housing units, excluding mobile homes: 31,798**	**Total housing units, including mobile homes: 32,849**
Buildings with 3 or more units		
Census data, including 1-attached: 21,319	67%	65%
Census data, excluding 1-attached: 16,983	53%	52%
This study: 16,490	52%	50%
Buildings with 5 or more units		
Census data, including 1-attached: 19,250	61%	59%
Census data, excluding 1-attached: 14,193	45%	43%
This study: 15,155	48%	46%

Thus, buildings with at least 3 units represent about 52 percent of Mountain View's total housing stock, and buildings with at least 5 units represent about 45 percent of the total stock.

The portion of the housing stock represented by earthquake-vulnerable buildings (including vulnerable 1- and 2-family dwellings) is addressed in the section below on "Mountain View's WFTS housing units in context."

3. Data analysis

3.1 Estimated building age

The given data includes no information about the date of original construction or about more recent structural renovations, additions, or seismic retrofits. Prior retrofits can perhaps be researched from separate building department records, but visual review of these buildings, most of which have exposed tuck-under parking (not operable garage doors) showed practically no such work. So there is no need to account in this inventory for a significant number of already-retrofitted buildings. If prior retrofits will be exempted from a future mitigation program, that should require demonstration of adequacy in any case, and not be based on *a priori* exemption.

The age estimate used three broad bins based on Mountain View history, precedents in the California Health and Safety Code (HSC) and in other mitigation programs around the state, and knowledge of Bay Area construction practices:

- Pre-1950. This is the period prior to Mountain View's post-war development; it includes the general Bay Area 1920s building boom. These buildings are expected to have non-conforming materials and might have ground floor open areas for commercial use if located on historic commercial streets, but will likely not have ground level parking because there was no need for it with low density residential development (contrary to, say, San Francisco).
- 1950-1980. This is the period of Mountain View's prolific development. The cutoff at 1980 is intended to align roughly with the pre-1978 date in HSC Section 19160 ff.
- Post-1980. The cutoff for this bin matches the upper end of the previous bin.

Age estimates were made by eye based on architectural style, with confirmation in most cases from online realtor data. Online data can perhaps make more specific distinctions between, say, early 1960s and mid-1970s, but this distinction is not significant in terms of changes to typical construction or expected earthquake performance.

Age estimates were assigned to individual buildings, not to parcels. In most cases, the same estimate applies to all buildings on the parcel. At parcels with a front house and a larger rear building, however, the front house is commonly older.

Following is a breakdown of the full data set by age:

- Pre-1950: 26 buildings, 79 units
- 1950-1980: 1235 buildings, 12,872 units
- Post-1980: 97 buildings, 3,645 units
- Blank (unconfirmed): 25/0. These are the 0-unit parcels described above, most of which are hotels.

Thus, the 1950-1980 buildings comprise 89 percent of all the buildings (91 percent if the 0-unit buildings are ignored) and 77% of all the units in the overall database.

The following breakdown by age and building size shows that the overall pattern holds for smaller and larger buildings, with those built between 1950 and 1980 accounting for 93 percent of the 3-4 unit buildings and 91 percent of the buildings with 5 or more units. The breakdown of the larger buildings by age suggests that the newer buildings are larger; the 6 oldest buildings contain only 37 units, while the newest 80 buildings contain 3,581. The actual average building size for each age group, considering only buildings with 5 or more units, is 6 units/building for the pre-1950 group, 16 units/building for the 1950-1980 group, and 62 units/building for the post-1980 group.

Subset	Description	Buildings	Units
B-34	Buildings with 3 or 4 units (363 buildings, 1,335 units)		
	Pre-1950	9	31
	1950-1980	338	1,240
	Post-1980	16	64
B-5+	Buildings with 5 or more units (912 buildings, 15,155 units)		
	Pre-1950	6	37
	1950-1980	826	11,537
	Post-1980	80	3,581

3.2 Construction type

The given data includes no information about construction, let alone details regarding structural materials, seismic force-resisting systems, or structural deficiencies. Therefore, all of the information presented here is estimated, or presumed, and subject to confirmation through a screening phase of a future mitigation program.

The purpose of review for construction type was to estimate the prevalence of completely different systems: woodframe, unreinforced masonry, reinforced block (CMU), concrete, or steel (the latter two being more typical of taller buildings). The presumption, based on knowledge of Bay Area construction, is that most of these multi-unit residential buildings will be of wood construction. Based on visual review of online images, nearly all of the reviewed buildings appear to support the presumption of wood construction, with CMU ground story walls in a few cases. The wood-CMU combination is found mostly where sites were graded to have access to the first occupied story at ground level on the street-facing side, with CMU or wood walls forming a lower (but still above grade) parking level.

The 3-4 unit buildings are, for all practical purposes, entirely of wood construction. A combination of wood and CMU is suspected at just one site, 870 East El Camino Real, with eight 4-unit buildings.

The following breakdown of the buildings with 5 or more units by age and apparent construction type shows that through 1980, Mountain View's multi-unit housing was built almost entirely with wood construction. After 1950, Mountain View began to see the use of reinforced masonry and concrete in residential buildings, typically in combination with wood. Even so, of the buildings built between 1950 and 1980, traditional woodframe construction still accounts for the vast majority: 97 percent of the buildings and 90 percent of the units. After 1980, all-wood construction is less common. Concrete podium structures allow for flexible open plans for parking or commercial spaces in the building's lower levels. By doing so, they also effectively eliminate a vulnerable woodframe target story condition. Concrete podium structures account for at least half of Mountain View's post-1980 housing, and perhaps as much as 80 percent of the buildings and 90 percent of the units.

Subset	Description	Buildings	Units
B-5+/pre50	Buildings with 5 or more units, pre-1950 (6 buildings, 37 units)		
	Wood (W)	6	37
B-5+/50-80	Buildings with 5 or more units, 1950-1980 (826 buildings, 11,537 units)		
	Wood (W)	804	10,435
	Wood with reinforced masonry (W,RM)	10	125
	Concrete podium (wood above)	8	659
	Unknown	4	318
B-5+/post80	Buildings with 5 or more units, post-1980 (80 buildings, 3,581 units)		
	Wood (W)	15	337
	Concrete podium (wood above)	45	1,860
	Unknown	20	1,384

3.3 Ground floor use

The given data includes no information about ground floor use. Eighteen buildings have been identified as hotels or motels (R1 occupancy). Since Mountain View does not count hotel rooms as permanent residential units, these buildings are largely excluded from this study.

The following breakdown shows that buildings with only unoccupied area (such as parking or storage) at the ground floor, are rare in Mountain View. In large and small buildings alike, more than 90 percent of the multi-unit buildings have at least one residential unit in the critical ground story.

The Mountain View building stock has practically no buildings with vulnerable ground stories used for mercantile occupancy. Of the 346 buildings with a mixed-use ground story, only 2 combine residential with mercantile occupancy, and both of those are post-1980 buildings. Of the 5 buildings with mercantile only ground floor use, 1 is pre-1950 and 4 are post-1980 buildings. Of the 16 buildings shown with unknown ground floor use, all but one are post-1980.

Subset	Description	Buildings	Units
B-34	Buildings with 3 or 4 units (363 buildings, 1,335 units)		
	Parking only	23	87
	Residential only	167	626
	Residential w/ attached 1-story parking under separate roof	10	37
	Parking plus at least one residential unit	163	585
B-5+	Buildings with 5 or more units (912 buildings, 15,155 units)		
	Parking only	80	2,305
	Residential only	464	6,600
	Residential w/ attached 1-story parking under separate roof	1	5
	Parking or mercantile plus at least one residential unit	346	4,680
	Mercantile only	5	340
	Unknown	16	1,225

3.4 The dominant subset (Subset C)

Based on the previous breakdowns of unit count, age, and construction, the analysis can focus on the most relevant subset of the overall Mountain View multi-unit housing stock, characterized by size, age, and construction.

Buildings with 3 or more units. California regulations and lending policies treat buildings with 5 or more units as commercial properties. In Mountain View, however, the smaller buildings are of interest to policy-makers and are likely to be included in any proposed mitigation programs. Therefore, the dominant subset includes 3- and 4-unit buildings, but in some cases (as above) it will be useful to show separate statistics for the smaller and larger buildings.

Buildings built between 1950 and 1980. As discussed above, the post-1980 buildings can be assumed to be less vulnerable to earthquake collapse. The pre-1950 buildings can be vulnerable, but usually in ways that do not involve a typical “soft story” condition. Of the woodframe buildings with 3 or more units, only 14 (containing 63 units total) are pre-1950, and of these, none exhibit a woodframe target story. (Seven of them do appear to have underfloor crawl spaces with unbraced cripple walls, but that condition is not generally life-threatening and would be addressed by a different retrofit solution than a typical “soft story” building.)

Wood (W) or wood with reinforced masonry (W,RM) first stories. Ignoring the (mostly post-1980) concrete podium buildings provides a more uniform data set with no significant loss of quantity. Also ignore the few buildings of unknown structure type; among the 1950-1980 buildings with 3 or more units, there are only 4 buildings (containing 318 units) in this category, and they are all significantly larger than the typical building, suggesting they are likely podium or concrete structures. In any case, ignoring them for analysis does not mean they will be exempted from a screening phase of a future program. The buildings recognized from online street views as wood with reinforced masonry are few (18 buildings, 157 units). However, it is likely that this sub-group has false positives and false negatives, so it is best to include these and let them be screened out through a program (or possibly analyzed in Task 3).

The dominant subset is defined for purposes of this general analysis only, to help ensure uniform data not skewed by rare or outlier conditions. The defined subset is not necessarily the same group of buildings that might be targeted by a future mitigation program or subject to further analysis. On the contrary, it is likely that an outreach or screening program would extend beyond this subset and let owners or their engineers assess their own eligibility and requirements based on more accurate building-specific findings.

The dominant subset comprises about 11,800 units in about 1,152 buildings, representing 71 percent of the units and 83 percent of the buildings in the overall multi-unit housing stock. As shown in previous tables, the balance of the city's multi-unit housing stock comprises mostly post-1980 developments, about 78 1- and 2-unit buildings, and a small number of non-wood structures from the 1950-1980 period.

Units per building (resolved)	**All buildings on multi-unit parcels (resolved data)**		**Dominant subset buildings (1950-1980, 3+ units, W or W,RM structure)**	
	Buildings	**Units [1]**	**Buildings**	**Units [1]**
0	30	0	0	0
1	50	50	0	0
2	28	56	0	0
3	106	314	101	299
4	257	1,021	237	941
5	69	337	67	327
6 – 7	130	810	127	792
8 – 9	198	1,600	194	1,564
10 – 15	225	2,665	218	2,585
16 – 31	200	4,503	172	3,815
32+	90	5,240	36	1,477
All	**1,383**	**16,596**	**1,152**	**11,800**

[1] Total units within each row and overall varies slightly from the product of the number of buildings and the number of units/building due to rounding in the estimate of units per building; see text above for further explanation.

The following breakdown by building height shows that 2-story buildings account for roughly two-thirds of the dominant subset.

Subset	**Description**	**Buildings**	**Units**
C-34	Dominant subset buildings with 3 or 4 units (338 buildings, 1,240 units)		
	1-story	101	362
	2-story	229	849
	3-story	8	29
C-5+	Dominant subset buildings with 5 or more units (814 buildings, 10,560 units)		
	1-story	78	566
	2-story	591	6,872
	3-story	143	3,042
	4-story	2	80

3.5 Woodframe target stories (Subset D)

Whether an actual seismic deficiency exists should be determined by analysis following a building-specific investigation. For purposes of this inventory, however, we can make a tentative visual assessment of whether a "woodframe target story" (WFTS) is likely based on the appearance from the exterior, using online street views.

A WFTS is any story whose wall configuration is substantially different from the story above and whose lateral seismic resistance is provided, in whole or in part, by woodframe wall elements. Typically, the difference in configuration arises from the absence of sheathed interior or continuous perimeter walls in the lower story. The WFTS concept originated with the San Francisco "soft story" program based on lessons learned in the development of FEMA P-807. The FEMA P-807 work showed that the standard definition of a “soft story” or “weak story” irregularity is not a reliable indicator of vulnerability to damage, excessive deformation, or collapse.

For each reviewed building, the database makes a tentative Yes/No assessment of whether a WFTS exists, with Unknown entered for a few buildings where online imagery is unclear. Each WFTS is then classified as one of:

LSO	Long side open
LSOx2	Both long sides of a rectangular plan open
SSO	Short side open
SSOx2	Both short sides of a rectangular plan open
1SO	One side open
2SO	Two sides open, typically one in each principal direction
3SO	Three sides open
HOG	House over garage; an entire wing of a small building over open parking
ROG	Room over garage; a portion of a small building over open parking
Cripple wall	Unoccupied crawl space
End bay parking	Open area limited to one end or a small area of the ground story

Of the 1,152 buildings in the dominant subset, 488 (containing 5,123 units) appear to have a vulnerable woodframe target story. The WTFS portion is about the same, 42 percent, for the 3-4 unit buildings and for the buildings with 5 or more units. The following table gives the breakdown by building configuration. By definition, a 1-story building cannot have a WFTS, but the table shows that within the dominant subset of the Mountain View housing stock, the taller the building, the more likely it is to have an apparent WFTS condition. Of the 153 3-story and 4-story buildings, 108 (71 percent) appear to have a WFTS.

Subset	**Description**	**No apparent WFTS (or unknown)**		**Apparent WFTS**	
		Buildings	**Units**	**Buildings**	**Units**
C-34	Dominant subset buildings with 3 or 4 units				
	1-story	101	362	0	0
	2-story	89	340	140	509
	3-story	0	0	8	29
C-5+	Dominant subset buildings with 5 or more units				
	1-story	78	566	0	0
	2-story	351	4,088	240	2,784
	3-story	45	1,321	98	1,721
	4-story	0	0	2	80

Different types of WFTS conditions pose different levels of collapse risk. For any given building, a judgment of relative risk should only be made based on building-specific evaluation. In general, however, the WFTS types expected to be more vulnerable to damage and collapse are as follows:

- For 3-4 unit buildings (148 buildings with apparent WFTS):
  - HOG: 27 buildings, 89 units
  - LSOx2: 8 buildings, 32 units
  - LSO: 74 buildings, 272 units
- For buildings with 5 or more units (340 buildings with apparent WFTS):
  - HOG: 16 buildings, 79 units
  - 3SO: 10 buildings, 281 units
  - 2SO: 28 buildings, 450 units

  - LSOx2: 20 buildings, 511 units
  - LSO: 207 buildings, 2,437 units

Most of the WFTS buildings will be amenable to typical retrofit schemes involving wood structural panel sheathing added to existing stud walls and steel frame elements installed along the open side. Typically, the necessary work can be done within the ample unoccupied spaces, but it can sometimes be complicated by the presence of occupied units in the ground story, especially for smaller buildings that present fewer retrofit options. (See this study's Task 2 report for more on typical retrofit schemes and their impacts. Optional Task 3 of this study gives Mountain View the opportunity to study representative buildings in a way that should help confirm the most likely impacts on tenants.) As noted above, 90 percent of Mountain View's multi-unit buildings have at least one residential unit in the ground story. For the 488 WFTS buildings, even though they typically have open parking areas, roughly the same trend holds:

- For 3-4 unit buildings: 125/148 (or 84 percent) have at least one ground floor residential unit
- For buildings with 5 or more units: 302/340 (89 percent) have at least one ground floor unit

3.6 Mountain View's WFTS housing units in context

The following table shows the portion of the total Mountain View housing stock represented by WFTS buildings from the dominant subset. As described above (and as shown in the table), the number of total housing units can be taken with or without mobile home units. In either case, the WFTS units represent about 16 percent of the city's overall housing stock.

Estimate of total units in WFTS buildings	Total housing units, excluding mobile homes: 31,798	Total housing units, including mobile homes: 32,849
Dominant subset buildings with 3 or 4 units: 148 buildings, 538 units	1.7%	1.7%
Dominant subset buildings with 5 or more units: 340 buildings, 4,585 units	14%	14%

The following table shows how the WFTS portion of the housing stock in Mountain View compares with similar portions in other Bay Area cities with "soft story" mitigation programs. The total number of housing units for each city comes from 2016 census data. Each city's program is different in terms of its scope and requirements, and in some cases in terms of its goals. Despite these differences, the table shows that the Mountain View "soft story" housing stock is as large, proportionally, as that in any Bay Area city.

City	Total occupied housing units	Scope of "soft story" mitigation program	Portion of housing stock subject to mandatory program
Mountain View (Program under consideration)	32,849	488 buildings 5,123 units	16%
Palo Alto (Program under consideration)	28,228	294 buildings 2,900 units	10%
Berkeley (Mandatory retrofit)	46,078	270 buildings 2,841 units	6%
Oakland (Mandatory screening; retrofit under consideration)	158,084	1,479 buildings 24,273 units	15%
San Francisco (Mandatory retrofit)	358,703	4,900 buildings 49,000 units	14%

Mountain View's "soft story" risk can also be compared with risks posed by housing units in buildings with other vulnerable structure types. As shown in the following table, the WFTS buildings are by far the largest group of earthquake-vulnerable residential buildings.

Vulnerable residential structure type	**Units (% of 32,849 total units)**	**Notes**
WFTS, 3-4 units/building	538 (1.7%)	• As described above
WFTS, 5+ units/building	4,590 (14%)	• As described above
Non-ductile concrete	977 (3%)	• Worst case estimate based on 1950-1980 multi-family buildings, as described above: 8 concrete podium structures, 4 buildings of unknown structure type
Mobile homes	1,051 (3%)	• Worst case estimate, assuming all mobile homes have inadequate undercarriage bracing • Unit count from 2016 census data
Hillside house	0 (0%)	• Based on recognition that essentially all Mountain View parcels are on essentially flat sites
Cripple wall house	1,380 (4%)	• Unbraced woodframe cripple walls are associated with pre-1940 construction • Worst case estimate, assuming 1) all pre-1940 units identified in 2016 census data have unbraced woodframe cripple walls (as opposed to concrete or masonry stem walls), and 2) no voluntary retrofits of existing woodframe cripple wall houses.
Room over garage (moderate risk)	3,300 (10%)	• Estimate based on 10,479 units in 1- or 2-unit detached dwellings, per 2016 census data • Subtract 1380 units already counted as cripple wall houses: 10,479 – 1380 = 9099 • Of 78 1-2 unit buildings reviewed for this study (containing 106 units), 28 (containing 56 units) are 2-story buildings, and only 5 or 6 of those showed a possible ROG or other target story. • Worst case estimate, assuming all 2-story buildings have likely ROG or similar deficiencies, number of vulnerable units is 9099 x (28/78) = 3300 • Best guess estimate is probably closer to 650 (2%)

3.7 Distribution of WFTS buildings by neighborhood

The following table gives the breakout of the dominant subset buildings by WFTS condition and planning area. Planning areas were assigned based on *Mountain View 2030 General Plan*, Fig 2.1.

The Grant/Sylvan Park, Miramonte/Springer and San Antonio planning areas have higher than average rates of WFTS buildings. The Monta Loma/Farley/Rock and Moffett/Whisman planning areas have lower than average WFTS rates.

Planning Area	**No apparent WFTS (or unknown)**		**Apparent WFTS**	
	Buildings	**Units**	**Buildings**	**Units**
Central/Downtown	143	1,317	132	844
El Camino Real	0	0	1	5
Grant/Sylvan Park	41	544	63	529
Miramonte/Springer	46	365	67	667
Monta Loma/Farley/Rock	200	1,648	69	577
Moffett/Whisman	153	1,604	47	515
North Bayshore	1	3	0	0
San Antonio	80	1,196	109	1,986
All	**664**	**6,677**	**488**	**5,123**

3.8 Distribution of WFTS buildings by hazard

According to the maps at myplan.calema.ca.gov, Mountain View planning areas roughly on the Bay side of the Central Expressway – including the Monta Loma/Farley/Rock and Moffett/Whisman areas – fall within a zone of required investigation for liquefaction. (Fig. 8.2 of *Mountain View 2030 General Plan* is similar.) Despite this, the USGS classifies all of the area south of Highway 101 as Site Class D, with parts of the San Antonio and Miramonte/Springer planning areas in less hazardous Site Class C.

The design-level shaking hazard is essentially uniform throughout Mountain View. The mapped short-period spectral acceleration is 1.50 g, which is typical for coastal California, but about 30 percent lower than in near-fault communities like Berkeley or the west side of San Francisco.

Thus, for code compliance purposes, essentially all of Mountain View's "soft story" buildings would be assigned to Seismic Design Category D.

Task 2: State of Practice

1. Summary

This memo report on current practices in earthquake risk reduction for "soft story"[a] buildings is intended to provide background for the Mountain View city council as it considers options for its own customized program. This report is the deliverable for Task 2 of the Mountain View Soft Story Study. The Task 1 inventory study (Bonowitz, 2018) showed that soft story buildings pose a substantial earthquake risk to Mountain View. The risk is larger than previously estimated, as large proportionally as in any Bay Area city, and by far the largest earthquake threat to Mountain View's housing stock.

A growing consensus among California cities holds that mandatory retrofit targeting just the deficient structural elements in the ground story is both appropriate and feasible. This project scope requires more than just evaluation but focuses the required work on the most critical collapse-prone elements.

The nature of Mountain View's soft story building stock, together with a robust Bay Area market for seismic retrofit, should result in lower project costs than those observed in San Francisco. For purposes of program development, a reasonable assumption of the total cost to comply with a mandatory retrofit program should be about $40,000 for a typical two-story building with three or four units, or about $65,000 for a typical building with five or more units. The cost per building should be lower for developments with multiple similar buildings on the same parcel. Costs will, of course, vary with building-specific conditions and market conditions.

Appropriate cost-sharing between owners and tenants is a key issue. Other cities, which share Mountain View's concerns for housing resilience, stability, and affordability, have addressed this issue in various ways, generally allowing the pass-through of capital improvement costs paired with caps and other protections for tenants.

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[a] "Soft story" is a technical term with a specific meaning in engineering codes and standards. In recent years, especially in California, it has acquired a non-technical meaning among policy-makers and earthquake safety advocates and is now understood to mean, generally, a multi-story woodframe residential building prone to collapse due to deficiencies in a critical lower story called the "target story". This understanding is consistent with a description given in the Mountain View *Housing Element* (Mountain View, 2014). Each jurisdiction with a soft story mitigation program has codified a specific definition for its own purposes, as discussed later in this report. Except where a specific program or definition is being discussed, this report uses the term soft story to mean any building with at least two stories above grade, at least three residential units, woodframe construction in the target (ground) story, and a target (ground) story whose layout of walls and partitions is substantially more open than that of the story above.

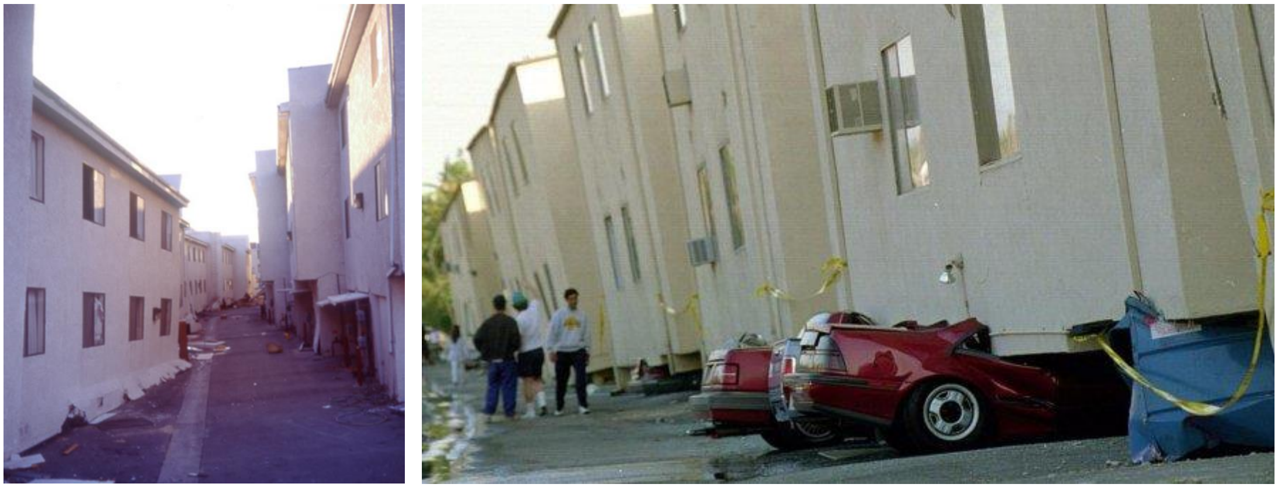
2. Background

“Soft story” woodframe apartment buildings have been recognized as collapse-prone seismic risks since at least the 1971 San Fernando earthquake. Figure 1 shows soft story buildings with severe damage and collapse in the 1989 Loma Prieta and 1994 Northridge earthquakes. Due to inadequate walls, a soft ground story is prone to excessive lateral and torsional deformation under earthquake shaking; if the deformation becomes large enough the first story can collapse, causing deaths and injuries, a total financial loss, damage to adjacent properties, and forced relocation for surviving tenants.

Figure 1. Damage and collapse of soft story buildings in Loma Prieta and Northridge earthquakes

1A. Near-collapse, San Francisco, Loma Prieta earthquake

1B. Collapsed 4-story building, San Francisco, Loma Prieta earthquake



1B. Left: Collapsed 3-story building. Right: Sidesway damage, Los Angeles, Northridge earthquake (Credit: Gary D. Avey)

1D. Collapsed 3-story building, Los Angeles, Northridge earthquake (Credit: Boris Yaro, Los Angeles Times)

A collapsed soft story building adjacent to a public way also threatens public safety and blocks sidewalks and streets. Where soft story buildings comprise a large portion of a city’s housing stock, the aggregate effect of their poor performance can exceed emergency shelter capacity, exacerbate housing shortages, and delay recovery citywide.

In 2005, after high-profile collapses in Loma Prieta and Northridge, the *California Health and Safety Code* (Section 19160 ff) was revised to include soft story buildings as a class of “potentially hazardous buildings” and to encourage cities to adopt mitigation programs. In 2014, Mountain View committed to "conduct a study that evaluates the City's policy options, opportunities, and constraints for retrofitting soft-story buildings" and, if necessary, to "create a new program to address the findings of the report." (Mountain View, 2014, Table 8-1)

This memo report is part of that study. Also part of the study is an inventory report (Bonowitz, 2018) that shows:

- Mountain View has a substantial number of suspected soft story buildings – 488 buildings with at least three units.
- The number is much larger than the estimate made in 2003 – only 111 buildings with at least four units.
- The 488 buildings comprise about 16 percent of the City's housing units. This is as large a portion as in any Bay Area city that has studied the issue.
- Mountain View's soft story buildings represent, by far, the largest earthquake risk to its housing stock.

3. Soft story mitigation programs

3.1 Current status

A decade after the Northridge earthquake, the City of Berkeley enacted California's first mandatory soft story mitigation program, requiring evaluations but not retrofits. In 2007, the City of Fremont would enforce the first mandatory retrofit program, targeting about two dozen buildings. In 2013, after voluntary incentives proved ineffective, and nearly a quarter century after Loma Prieta, San Francisco approved the state's first sizable mandatory retrofit program. Other cities would follow, as shown in Table 1. As a group, these soft story programs will eventually result in more retrofits than California's post-1986 unreinforced masonry programs.

In addition to the work shown in Table 1, many cities are in the same position as Mountain View – reviewing the available data, watching the progress in other cities, and studying the program options. The Association of Bay Area Governments has coordinated efforts and made conservative building counts on behalf of thirteen East Bay cities (ABAG, 2017). Sebastopol and San Leandro have completed inventories (ABAG, 2016), and Hayward developed background reports for a city council work session in 2016 (Hayward, 2016).

In Santa Clara County, Palo Alto (as shown in Table 1) and San Jose are considering soft story mitigation programs. In 2003, an unpublished report for the county's Emergency Preparedness Council estimated the number of soft story buildings (with at least four units) in 17 cities using a "sidewalk survey" (Selvaduray et al., 2003). While ahead of its time, more recent work suggests that the 2003 survey undercounted the vulnerable buildings. It estimated 130 soft story buildings in Palo Alto; the city's 2017 report concluded the number is about 294 (Palo Alto, 2017). Similarly, the 2003 survey counted 111 soft story buildings in Mountain View; the inventory produced for this study is significantly larger, about 488 buildings.

Table 1. California cities' soft story mitigation programs[a] as of April 2018

City	Program Type (year implemented)	Approximate Number of Buildings	Program Status
Bay Area			
Berkeley	Mandatory evaluation (2005) Mandatory retrofit (2014)	270	All retrofits due to be complete by the end of 2018.
Fremont	Mandatory retrofit (2007)	22	Complete in 2012.
Alameda	Mandatory evaluation (2009)	100	Complete in 2012.
Oakland	Mandatory screening (2009) Subsidized voluntary retrofit (2017)	1400	Screening complete in 2011. Subsidy program with FEMA, covering about 100 buildings, ongoing. Mandatory retrofit ordinance in development.
San Francisco	Incentivized voluntary retrofit (2009) Mandatory retrofit (2013)	4900	Ongoing with phased deadlines. About 4000 retrofits expected to be complete by mid-2019, balance by late 2020.
Palo Alto	None	300	Ordinance development in progress.
Greater Los Angeles			
Los Angeles	Mandatory retrofit (2015)	13,500	Ongoing with staggered deadlines. All retrofits expected to be complete by 2024.
Santa Monica	Mandatory retrofit (2017)	1,600	6-year plan, begun in September 2017, all retrofits to be complete by end of 2024.
West Hollywood	Mandatory retrofit (2017)	800	5-year plan, begun in April 2018, all retrofits to be complete by 2023.
Beverly Hills	None	300	Ordinance development in progress.

[a] Purely voluntary programs are not included, as they have no reliable scope or status. Cities with purely voluntary programs, consisting of the adoption of retrofit criteria with no significant government outreach or incentives, include Burbank and Long Beach.
References: Berkeley (2017); Fremont (2007; ABAG, 2016); Alameda (2017); Oakland (2009, 2017); San Francisco (2013); Palo Alto (2017); Los Angeles (2017); Santa Monica (2017A; 2017B); West Hollywood (2017); Beverly Hills (2017).

3.2 Program options

Each program listed in Table 1 represents a series of technical, logistical, and political decisions. The two most basic decisions, which a city will necessarily consider together, are whether to focus on evaluation or on retrofit, and whether to make the program voluntary or mandatory.

Table 2 summarizes the arguments for and against each of these main options. As the table shows, a *pro* argument for the city can often be a *con* argument for a building owner, and a *con* argument for an owner can be a *pro* argument for a tenant. Indeed, much of the content of Table 2 is about who controls the work and who shoulders the cost. But the bottom line of any soft story program is whether it reduces actual risk – to tenants, to owners, and to the city. The risk reduction implications of each option are therefore shown in bold.

Table 2. Pros and cons of voluntary and mandatory soft story evaluation or retrofit

	Voluntary	Mandatory
Evaluation only	Pros • Gauges community interest • Can be combined with outreach/awareness program Cons • No actual risk reduction; essentially the same as "do nothing" • Needs substantial incentives to justify participation • Creates future disclosure burden for owners	Pros • Generates data at relatively low cost to owners • Might motivate some owners to retrofit voluntarily • Could be coupled with future retrofit mandate Cons • Substantial program costs but no actual risk reduction • Building staff not set up to review evaluation reports • No evidence that evaluations prompt voluntary retrofit • Owner's evaluation costs could have been put toward retrofit • Future disclosure issues for owners
Target Story Structural Retrofit (at minimum)	Pros • Seen as less burdensome, intrusive than mandate • Effective risk reduction for those who participate • Tenants likely protected from rent increases • Eligible grants Cons • City has no control over participants, so ineffective risk reduction at city scale • Substantial incentives needed to yield meaningful risk reduction • Tenants have no control over their own risk • Work likely not eligible for rent increases	Pros • Most effective risk reduction • City can tailor the scope and schedule • Already proven feasible in other cities • Capitalizes on robust existing market for engineers and contractors • Work likely eligible for rent increases Cons • Implementation cost to city (but can be offset by normal permit fees) • Seen as intrusive by owners • Tenants likely subject to rent increases • No grants available

Each option in Table 2 represents a number of benefit-cost considerations. Yet two conclusions are clear from the experiences of the cities that already have soft story programs:

- Substantial citywide risk reduction comes only from mandatory retrofit programs, not from mandatory evaluation or from voluntary retrofit.

- Mandatory retrofit programs are politically, economically, and technically feasible in California generally and in the Bay Area specifically.

The second point is borne out by Table 3, which combines the program information from Table 1 with the layout of options from Table 2 (using a format borrowed from ABAG, 2017). “Triggered” programs require seismic work only when certain other conditions are met. For example, the building code triggers seismic evaluation (and retrofit, as needed) when a substantial addition, alteration, or repair is done. Seismic work can also be triggered by conditions not considered by the building code, such as a sale or conversion to condominiums. Triggered programs are a viable option, but to date, no California jurisdiction has used them to address soft story buildings specifically. Table 3 also shows a range of project scopes, from simply notifying owners or placarding (posting a “warning” sign on the building) to full-building retrofits.

Table 3 shows an emerging consensus that mandatory retrofit programs are both preferable and feasible. In fact, Berkeley and San Francisco started their soft story mitigation programs with voluntary or evaluation-only programs but now call for mandatory retrofit.

The current mandatory retrofit programs are also consistent with respect to the mandatory scope. By focusing on the structural system only, and the principal first story deficiency only, these programs are balancing the burden of a mandate with the most limited and cost-beneficial scope. Mandatory retrofit programs and scopes are discussed further in a later section of this report.

Table 3. Soft story mitigation program types[a]

Less effective ⟷ More effective

		Voluntary	**Triggered**	**Mandatory**
Less effort	Notice to owners	NA		
↑	Placarding only			
	Structural evaluation only			Berkeley (2005) Alameda Oakland (Screening, 2009)
	Target story structural retrofit only	San Francisco (2009) Oakland (2017)		Fremont San Francisco (2013) Berkeley (2014) Los Angeles Santa Monica West Hollywood
	Target story structural retrofit, selective nonstructural mitigation			
↓	Full building structural retrofit and nonstructural mitigation			
More effort	Full building structural, nonstructural, geologic mitigation			

[a] Purely voluntary programs are not included, as they have no scope or status. Cities with purely voluntary programs, consisting of the adoption of retrofit criteria with no significant government outreach or incentives, include Burbank and Long Beach.

3.3 Implications for Mountain View

With several programs underway, and with other cities showing increased interest, the Association of Bay Area Governments in 2016 published a guidance document on *Soft Story Retrofit Program Development* (ABAG, 2016). The document contemplates five basic stages or steps for a jurisdiction to take:

- Assess the problem
- Build consensus
- Draft a policy
- Adopt the policy
- Implement the program

The ABAG approach is sound, especially for a city responding to a new problem or taking innovative policy steps. For soft story buildings, however, the path has already been paved by large and small cities across the state. Certainly there are lessons still to be learned from their ongoing experience, and certainly it is worth considering all the options outlined above. But with this review of current practices and with the inventory already completed (Bonowitz, 2018), a strong case can be made that the first three steps are essentially complete, or can be completed in short order.

The problem is assessed. Mountain View has a substantial number of soft story buildings (close to 500), they represent a substantial portion of the city's housing stock (16%), that portion is as large as in any Bay Area city that has studied the issue, and these buildings represent by far the largest threat to the city's housing, much more than cripple wall houses, hillside houses, or unreinforced masonry housing. No expert would doubt that a Mountain View soft story mitigation program is justified.

Consensus is established. State law, Berkeley, San Francisco, Oakland, ABAG, and several Southern California cities – not to mention the community of engineers, building officials, emergency managers, and earthquake risk reduction advocates – all recognize that where soft story buildings exist in large numbers, they threaten the safety and economic stability of occupants and the resilience of cities.

Policies are drafted. A range of program types has been tried by California muncipalities. Mandatory retrofit programs have been shown to be both feasible and effective – and necessary for citywide risk reduction. Consensus engineering codes and standards exist, along with examples of local regulations and policies. ABAG (2017) has even produced a model ordinance, ready for customization and adoption by any California city.

In addition, the timing for soft story mitigation in Mountain View is ideal. The economy is strong, and interest rates are low. The Berkeley and San Francisco programs have created a robust market for retrofit services, and the engineering and contractor communities are ready. A program that rolls out in 2019 or 2020 will be able to take full advantage of the available resources.

4. Implementation of a voluntary retrofit program

Table 3 shows that voluntary soft story programs are currently rare. (Oakland has had plans to follow their mandatory screening program with a retrofit mandate but currently has only the subsidy program described below.) If Mountain View prefers a voluntary program, issues that will need resolution will include the following.

4.1 Incentives

Some owners will retrofit if significant incentives are provided, but the results of past efforts are mixed at best. Incentives can involve technical assistance, project expediting, and policy exemptions (waivers from triggered or future work), but direct financial incentives are clearly most effective. ABAG (2016) provides a more comprehensive list and discussion of retrofit incentives, including various waivers, exemptions, and bonuses.

Subsidies or tax rebates for cripple wall retrofits have been successful, but those are relatively small, low-cost projects. Before implementing its current soft story mandate, San Francisco waived certain permit fees to incentivize voluntary retrofit, but only a handful of owners took advantage; the poor response was cited as one of the justifications for the later mandatory program. Most believe the benefit was too small to motivate owners to undertake a project costing tens of thousands of dollars. Equally important, in retrospect, was the fact that San Francisco regulations would allow owners to recoup retrofit costs through rent increases only if the retrofit was mandatory. Since the city had already signaled that a retrofit mandate was coming, it made sense for owners to wait. Mountain View’s rent adjustment regulations might have similar unintended effects.

Berkeley and Oakland both recently won FEMA grants with which they will subsidize voluntary retrofit of soft story, tilt-up, and non-ductile concrete buildings. With a grant of $3 million, Oakland will reimburse up to 75 percent of a soft story building owner’s design and construction costs. Over 200 owners applied for the program, which was advertised to about 1400 owners identified in the city’s previous mandatory screening phase.

Favorable financing terms can be an incentive, but most owners who would need to borrow significantly to fund a retrofit project probably would not do so voluntarily even on good terms. Two financing programs, PACE and CALCAP, are discussed in Section 5.7.

4.2 Scope and engineering criteria

For strictly voluntary work, Mountain View will not be able to enforce any specific objectives or criteria. The *California Existing Building Code* already allows essentially any level of seismic improvement as long as the work does not make the building more hazardous. Where material incentives are offered, however, the city can establish any criteria it likes as eligibility rules. In these cases, the selection of suitable criteria is the same as in a mandatory program, discussed below.

4.3 Compliance tracking

With or without incentives, voluntary retrofit usually receives less scrutiny by the building department, since the building code requires only that the work does not increase the risk. If it will be important to the city that the retrofit actually satisfies some standard (perhaps to qualify for incentives, ensure a measure of fraud protection for owners, or avoid conflicts with a future mandate), then it will be necessary to implement new plan review and construction quality assurance procedures along with the program.

4.4 Impacts and costs

By its nature, a voluntary retrofit can usually be scoped and scheduled to avoid tenant impacts and to optimize owner costs. Even so, when the work is done it will inevitably involve many of the same impacts and costs as a mandatory retrofit, as discussed in Sections 5.5 and 5.6.

In Mountain View, the 2016 Community Stabilization and Fair Rent Act allows the cost of some capital improvements to be passed to tenants. It is likely that the CSFRA could be interpreted to apply differently to voluntary and mandatory retrofit projects, as noted in Section 6.

5. Implementation of a mandatory retrofit program

As discussed above, a strong case can already be made for a mandatory soft story retrofit program for Mountain View. Even so, a number of choices can be made to minimize or balance the burden on building owners, tenants, and city staff.

5.1 Program scope

For voluntary work, there is no reason to limit the buildings that might be eligible. For mandatory work, cities set the program's overall scopes considering the affected building stock, legal distinctions, benefit-cost data (where available), and perceptions of risk, equity, fairness, and political viability. The availability of implementation resources generally does not change the scope of the program but is considered when setting compliance deadlines. Table 4 compares the range of program scopes selected for mandatory programs in various California cities; as the table shows, no two programs' scopes are identical.

Table 4. California cities' mandatory soft story program scopes

City	Buildings	Age [a]	Stories	Units
Los Angeles	13,500	pre-1978	2+	4+ [b]
San Francisco	4,900	pre-1978	3+	5+
Santa Monica	1,600	pre-1981	2+	0+
Oakland (screening only)	1,400	pre-1991	2+	5+
West Hollywood	800	pre-1978	2+	0+
Berkeley	270	pre-1978	2+	5+
Alameda (evaluation only)	100	pre-1986	2+	5+

[a] Some of the cutoff dates shown refer to the date of construction permitting, others to the date of building code adoption.

[b] The Los Angeles program applies to both residential and non-residential buildings but exempts all-residential buildings with less than four units.

Given the Mountain View inventory, any mandatory program should certainly include the city's prevalent 2-story buildings. Any cutoff date around 1980 will capture the buildings of interest.

The remaining question is whether to include buildings with 3 or 4 units. Mountain View's 3- and 4-unit buildings make up 30 percent of the multi-unit buildings but only 10 percent of the units (Bonowitz, 2018). There is no engineering or risk-based reason to exclude the smaller buildings. Certainly, larger buildings represent a greater risk per building (and a greater benefit per retrofit), but there is no special difference between 4-unit and 5-unit buildings. Rather, most jurisdictions have scoped their programs either because of precedents from earlier programs or to reflect potential implications of lending practices that consider residential buildings with five or more units as commercial facilities.

Building size might be a consideration if it affects potential rent increases per unit. The retrofit of a small building will generally cost less than that of a big building, but not proportionately so. Thus, if retrofit costs are passed to tenants as rent increases, tenants in smaller buildings might be disproportionately affected.

Otherwise, one can imagine rational reasons for scoping a program to exempt buildings for which the required work would be a unique burden. In its early program development, Oakland considered exempting buildings owned by non-profit organizations, but the idea did not last. The more common way to address these issues is with existing appeals processes based on demonstrated hardship, not by blanket exemptions in advance. Difficult circumstances can also be mitigated through the program's phasing and deadlines. San Francisco, for example, sets later deadlines for buildings in areas prone to liquefaction and for buildings with ground floor commercial occupancy.

Related to the program scope are decisions about whether to use an initial screening phase to confirm the overall scope, whether to phase compliance to prioritize certain buildings or to spread out the work, and how to set compliance deadlines. These are detailed decisions best addressed after the main scope is decided. They are discussed further in ABAG (2017).

5.2 Project scope

Voluntary and mandatory programs have different effects at the city scale. This can change the rationale used to set project objectives, engineering criteria, and scope of work.

For an individual voluntary retrofit, an owner may choose to address the entire structure (and perhaps nonstructural deficiencies as well) or may choose simply to prevent collapse of the critical ground story. A comprehensive retrofit would thoroughly address safety issues but might also be driven by a desire to minimize future repair costs and maintain rental income. A minimal retrofit would be designed to address the most obvious safety risk (but would also cut repair costs and reoccupancy times to some degree). In short, the choice lies with the owner.

For mandatory retrofit of hundreds of buildings citywide, appropriate project objectives might be different, and the choice lies with the city's policy-makers. First, political viability and implementation logistics argue for limiting the mandated scope of work. This makes owners more willing to participate and puts city staff in a better position to help them. Second, with a citywide program, the aggregate effect of hundreds of projects can be large even if the scope of each individual project is small. Third, since an ordinance is public policy, the costs and benefits in question should be those of the city as a whole, not those of individual building owners or tenants. If the intended citywide benefits – more feasible emergency response, reduced shelter demands, preservation of housing, and faster overall recovery – can be reached with a less burdensome scope for each individual building, that is usually the preferred policy. Because of the aggregate effects, the engineering community recognizes that simply preventing collapse is an appropriate objective of a mandatory soft story retrofit even if it might not be the best choice for a specific client.

For these reasons, most mandatory programs have seen fit to require only structural work, only in the critical "target story," as shown in Table 3. This has two direct implications on the design. First, it means an acceptable retrofit may ignore nonstructural deficiencies, even those that would normally be considered safety hazards (such as unbraced chimneys, fuel lines, or veneer). Second, it means retrofit elements need only be added to the ground story, even if the building's upper stories have deficiencies.

As shown in Table 3 and as discussed in the previous section, every current mandatory soft story retrofit program limits the project scope to structural retrofit of the target story only. In addition, most programs allow other non-compliant conditions (past work done without permits, incomplete repairs, etc.) to remain, as long as they are not unsafe; that is, the program is designed to ensure owners that their scope of work will not increase because a building inspector notices something during an unrelated site visit.[b]

All of these allowances are intended to minimize the cost to building owners, and maximize the seismic benefit relative to that cost. By the same token, most programs also restrict the work to the necessary seismic improvements, to ensure that owners do not take advantage by extending favorable allowances to other building enhancements or upgrades.

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[b] Improvements normally triggered by alteration work, however, may typically still be required, at the discretion of the jurisdiction. Work triggered by state or federal law, such as accessibility improvements, may not be waived. Except for public housing, residential buildings first constructed before 1991 are exempt from accessibility upgrades per *California Building Code* Section 1102A.2.

5.3 Retrofit criteria

Retrofit designs, as well as successful retrofit programs, rely on accepted, enforceable design criteria in the form of building code provisions, technical standards, and locally customized regulations and interpretations. The building code for new construction is no longer viewed as appropriate criteria for a substantial retrofit project, as it makes assumptions that do not apply, and omits considerations that do apply, to existing buildings. Instead, three documents have been used as criteria for Bay Area soft story retrofit programs[c] to date:

California Existing Building Code (CEBC) Appendix Chapter A4 evolved from guidelines written after the 1994 Northridge earthquake by SEAOSC engineers and the Los Angeles Department of Building and Safety. It is specifically referenced in the *California Health and Safety Code* as acceptable criteria for soft story retrofit. Chapter A4 is familiar to engineers because it uses terminology and procedures that parallel the code for new construction. Because it gives no credit to existing materials, however, Chapter A4 tends to be conservative, so engineers using it are likely to petition the building official to allow variances or exemptions based on the two other documents.

FEMA P-807, *Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings With Weak First Stories* (ATC, 2012), was developed specifically for soft story programs. FEMA P-807 takes advantage of existing materials and provides a more nuanced understanding of building behavior than Chapter A4. It thus offers some advantages to owners, but it is still relatively new and unfamiliar to most building officials, and it does not apply to certain complex structures. Further, FEMA P-807 cannot be applied until the jurisdiction specifies a performance objective and customizes its provisions. Berkeley and San Francisco each developed their FEMA P-807 objectives through technical studies of their typical buildings.

ASCE 41, *Seismic Evaluation and Retrofit of Existing Buildings* (ASCE, 2017), is a national consensus standard, but it is still unfamiliar to many building officials. Because ASCE 41 is comprehensive (that is, not limited to soft story wood frame buildings), it can be tedious, with concepts and terminology not found in the building code. The main reason to use ASCE 41 is to take advantage of existing materials in buildings that are not eligible for FEMA P-807. For the San Francisco and Berkeley programs, ASCE 41 is permitted but appears to be rarely used.

Chapter A4 and FEMA P-807 explicitly address the limited retrofit scope discussed above, focusing only on the building's critical deficiency – the collapse prone target story. ASCE 41, as applied in soft story programs, is typically tailored to have a similar limited scope.

Whichever documents are selected by the city, they should be supplemented by regulations or bulletins to clarify their application to Mountain View projects and to align their generic provisions with existing Mountain View procedures. Both Berkeley and San Francisco have developed bulletins that apply some of the benefits of FEMA P-807 to the more familiar provisions of Chapter A4, tempering some of its conservatism.

5.4 Retrofit schemes

As a result of the growing consensus on project scope and retrofit criteria, a number of basic retrofit schemes are now well-established. Nearly all soft story retrofits now employ some combination of the following basic elements to add strength, stiffness, and torsion control to the critical ground story:

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[c] Los Angeles and other Southern California cities are using a different set of simplified guidelines. The L.A. approach is not consistent with the established Bay Area practice and is not recommended for Mountain View, for reasons explained by Bonowitz and Zepeda (2017).

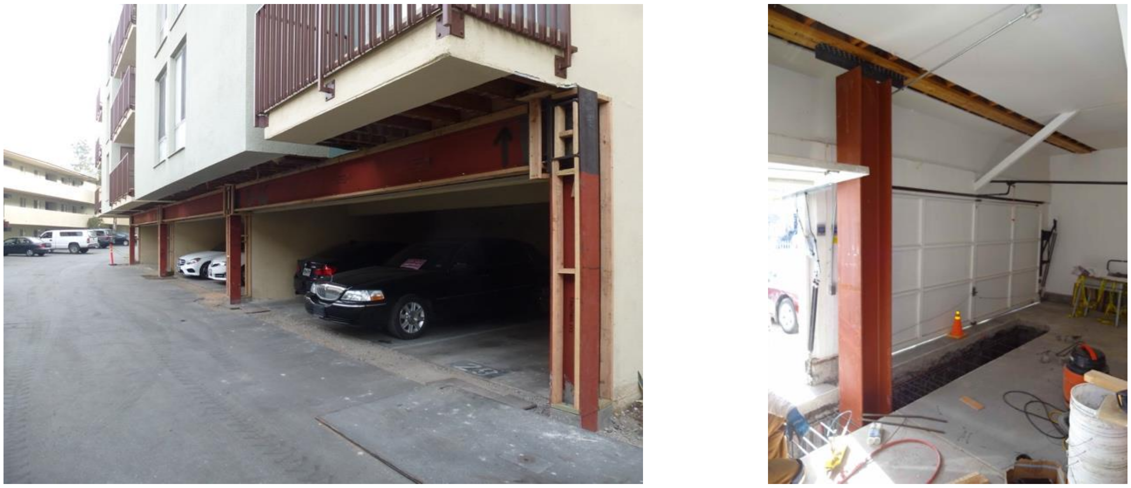
- Wood structural panels applied over existing wood stud framing to create new wood shear walls along existing wall lines.
- New woodframe shear walls installed separate from existing wall lines, with new concrete foundations.
- Proprietary shear panels, especially where wall lengths are tightly limited by the existing architecture.
- Steel moment frames (two or more columns with connecting beams at the top), especially around large openings such as garage entrances and shop windows, usually with new concrete foundations.
- Steel cantilever columns rigidly embedded in new concrete foundations, especially where limited headroom inhibits the use of a frame.
- Wood panel sheathing applied to the underside of second floor joists (above the critical ground story) as needed to locally strengthen the second floor diaphragm.
- Foundation replacement or strengthening, as needed.
- Various steel bolts, anchors, and clips as needed to ensure a complete load path from the foundation to the second floor diaphragm.

Figure 2 illustrates several of these retrofit elements installed in recent Bay Area projects. As shown, the retrofit elements are often visible when construction is complete, especially when installed in utilitarian spaces such as storage or parking areas. As needed, however, they can almost always be covered or built into the existing architecture, or at least located so as to be minimally visible.

Figure 2. Typical soft story retrofit elements

2A. Wood sheathing applied over existing studs, using the existing concrete foundation

2B. New stand-alone wood shear wall with new concrete footing



2C. Three-bay steel moment frame installed around garage door openings, with new concrete footing (Credit: Degenkolb Engineers)

2D. Cantilever column installed with new concrete footing (awaiting concrete) (Credit: Thor Matteson)

2E. Local strengthening of the second floor diaphragm (Credit: Anthony DeMascole)

2F. Sill bolting. Note the conduit temporarily removed and reinstalled.

5.5 Retrofit impacts

The typical retrofit project will likely have temporary impacts on tenants' housing services, but permanent impacts will be negligible in most cases.

Because the work is limited to the ground story, a salient feature of these projects is that tenants will rarely need to be relocated during construction. In Mountain View, this will likely be true also because nearly all the soft story buildings have open, unoccupied ground floor parking areas, as opposed to commercial spaces. On the other hand, nearly 90 percent of the suspected soft story buildings have at least one residential unit in the critical ground floor (Bonowitz, 2018). In most cases, it should be possible to design an adequate retrofit without interfering with the ground floor units. (Optional Task 3 of this study gives Mountain View the opportunity to study representative buildings in a way that should help confirm the most likely impacts on tenants.)

Aside from the unlikely need to temporarily vacate a ground floor unit, all construction projects involve a measure of disruption in the form of noise, dust, and temporary utility shut-offs. In typical cases, these would not be considered a compensable loss of housing services. The most likely significant disruptions to tenants might be the following.

During the design phase, engineers might need access to upper units to confirm the existing construction. If reliable plans are available, this can be a quick exercise. If not, some destructive investigation and creation of as-built plans might be necessary.

During the construction phase, services within the construction area will be disrupted. In typical Mountain View buildings, these are likely to be parking areas, storage areas, and possibly laundry rooms or other shared amenities. Disruption to a small lobby area can usually be avoided; doing so also avoids work on relatively costly finishes. San Francisco passed a separate ordinance to clarify and streamline compensation for temporary loss of housing services specifically related to its soft story program (San Francisco, 2014). Los Angeles requires each owner to file a Tenant Habitability Plan identifying any expected impacts on tenants and showing that efforts were made within the design to mitigate them (HCIDLA).

Permanent impacts will vary from building to building. In many cases, there will be no permanent loss of services. Indeed, the use of steel elements, which are more expensive than wood panel sheathing, is common specifically to avoid permanent loss of parking in residential buildings and glass storefronts in mixed-use buildings.

5.6 Design and construction costs

Estimates of soft story retrofit costs have been made in various studies going back to the creation of IEBC Chapter A4 after the Northridge earthquake. In particular, a 2000 study for the City of San Jose estimated the cost of a typical retrofit to be between \$9000 and \$20,000 per unit (in 2018 dollars), including design fees (Rutherford and Chekene, 2000).[d] In the background study that led to its soft story program, San Francisco estimated the cost between \$59,000 and \$158,000 per building (2018 dollars), *not* including design fees (ATC, 2009).[e]

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[d] From Rutherford & Chekene (2000), Table 8, August 1999 estimates for Life Safety retrofit of three prototype buildings, non-near-source: \$6000 to \$8500 per unit, with a reasonable range from 80% to 130%. Escalated to January 2018 dollars with RSMeans Historical Cost Index of 215.8 for January 2018 and 117.6 for 1999.

[e] From ATC (2009), Appendix 5, November 2008 estimates for various retrofits of four prototype buildings: \$49,000 to \$132,000. Escalated to January 2018 dollars with RSMeans Historical Cost Index of 215.8 for January 2018 and 180.4 for 2008.

More recently, several cities have included cost estimates in background papers, but without full sourcing. All of these are careful to indicate that costs will vary with building-specific conditions. They include:

- $2000 to $10,000 per unit (Berkeley, 2015)
- $5000 to $10,000 per unit (Santa Monica, 2016)
- $5000 to $10,000 per unit (Beverly Hills, 2017)
- $40,000 to $160,000 per building (West Hollywood, 2018)

So the estimates are fairly consistent, or at least overlapping, but with a broad range. In some cases, it is clear that cities are borrowing figures from prior reports. Projections from hypothetical studies, however, are no longer needed and can even be misleading for several reasons.

- Costs "per unit" or "per square foot," while traditional for project budgeting, do not make as much sense for projects where the work is confined to one story and is a function of the building's overall size. For example, two buildings of the same height and plan dimensions will have similar retrofit requirements even if one building has four large apartments and the other has twelve studios. The San Francisco analyses showed that even buildings of different heights will have similar retrofit requirements, finding estimated costs for a 3-story corner building were within about 10 percent of the cost for a similar 4-story building. An analysis of actual project costs from early in the San Francisco program reached the same conclusion (Bonowitz, 2015).

- With the development of consensus retrofit criteria, the engineering community now has a clearer consensus on the appropriate scope and objective for a mandatory soft story retrofit. There is no longer any need to speculate about a range of design objectives, as both the San Jose and San Francisco studies had to do.

- There is now a robust Bay Area market for retrofit design and construction services. This means that market forces, as opposed to strictly technical considerations, will affect retrofit costs. On one hand, this means competition, innovation, and volume can keep costs low. On the other hand, it means that as deadlines approach, demand for services could push costs higher. Further, it means that there is enough variety among the buyers that providers can tailor their services to a specific clientele. In all of these cases, it means that similar buildings with similar retrofit designs might not have similar costs.

- Most important, by the end of 2018 there will be thousands of projects completed in the Bay Area and greater Los Angeles, so the best estimates of future costs will be derivable from actual data, without the need for hypotheticals. Of course, the existence of all that data will also prove that these projects are economically feasible for a wide range of owners, so it will no longer be necessary to pore over estimates as part of the policy-making process.

Table 5 presents cost data from actual projects in the Berkeley and San Francisco programs. While the range is still wide – the overall San Francisco costs still vary by a factor of three – it is significantly lower than the estimate made in 2009 as San Francisco was developing its program. Despite these values, and perhaps to be on the safe side, the Director of San Francisco's Department of Building Inspection, which oversees the city's program, wrote in a 2017 article aimed at building owners that the cost of compliance would be $60,000 to $200,000 (Hui, 2017).

Table 5. Retrofit construction cost data from mandatory programs in Berkeley and San Francisco

	Berkeley [a] (McNulty, 2015)	**San Francisco** [b] (Hilt, 2015)	**San Francisco** [b] (Bonowitz, 2015)
Buildings in sample	63	290	64
Estimate type	Mean	Mean +/- 1 Std Dev	Mean +/- 1 Std Dev
Estimated retrofit construction cost (2018 dollars)	**$48,000**	**$32,000** to **$94,000**	**$32,000** to **$98,000**

[a] Cost data is from 2010 – 2014 projects. Cost escalated based on average 2012 date using RSMeans Historical Cost Index of 215.8 for January 2018 and 194.6 for 2012.

[b] Cost data is from 2014 projects. Cost escalated using RSMeans Historical Cost Index of 215.8 for January 2018 and 204.9 for 2014.

A more detailed look at the early data from San Francisco has shown that some conditions are associated with significantly higher or lower costs. Bonowitz (2015) showed that steeply sloped sites are more expensive than flat sites, as are cases where parts of the existing foundation need replacement. Another data set showed that 5- and 6-unit buildings are less expensive than larger buildings (Penhall, 2015). Data from 28 projects designed by one engineering firm showed that 1920s buildings are significantly more expensive than 1960s buildings (Collins, 2017), but that trend was not found in a more generic data set; if the cost-age correlation is valid but only shows within a tightly controlled subset of projects, this suggests that market forces such as project or client selection are at least as predictive as objective data about the buildings themselves.

Overall, none of the suggested trends in the data is surprising. More important, even between statistically distinct subsets there is much overlap, and even within a distinct subset the cost range is still wide. From the Penhall data related to number of units, for example, the mean +/- 1 standard deviation ranges for 5- and 6- unit buildings was $31,000 to $85,000, while the range for buildings with 16 or more units was $37,000 to $134,000 (2014 dollars).

In addition to construction costs, each project will involve design fees on the order of $10,000 to $15,000 depending on market conditions and the scope of services selected. For older buildings without reliable plans to work from, an additional cost of $5000 to $10,000 will be required to produce as-built plans and perform structural investigation and material testing. This should not be necessary for most Mountain View buildings

For Mountain View, a number of conditions will tend to make soft story retrofit projects less expensive than San Francisco or even Berkeley projects. As noted above, this will vary with market conditions. In general, however, Table 6 shows how the characteristics of Mountain View soft story buildings (documented in Bonowitz, 2018) can be expected to affect generic cost estimates relative to a baseline San Francisco project to which most of the existing cost studies apply.

Table 6. Retrofit construction cost factors for Berkeley, San Francisco, and Mountain View

Judgmental effects of various conditions on expected construction costs relative to a baseline project: mandatory soft story retrofit (ground story structural only) of a 4-story, 12-unit 1920s building on a flat or slightly sloped site on the east side of San Francisco.

Factor	San Francisco	Berkeley	Mountain View
General fees and overhead	Baseline	Lower Cost indices show Oakland about 4% lower than San Francisco.	Lower Cost indices show San Jose about 4% lower than San Francisco.
Seismicity	Baseline Slightly higher for projects on the west side.	Higher	Baseline
Building age	Baseline Lower for 1960s buildings. Higher for Victorian buildings with brick foundations, extensive deterioration.	Lower Baseline for relatively few pre-1950 buildings.	Lower Vast majority of buildings date from 1950 – 1980.
Site access	Baseline Typical: Urban density, built to lot line. Higher for hillside conditions.	Baseline Less dense than S.F., but limited parking and most buildings built nearly to lot lines.	Lower Suburban, with ample space on all sides, especially at multi-building parcels. All buildings on flat sites.
Architectural constraints	Baseline Typical: operable garage doors, low headroom, separate parking stalls, utility interference.	Lower Baseline for relatively few pre-1950 buildings.	Lower Vast majority of buildings have open parking stalls.
Architectural complexity	Baseline Typical: operable garage doors, low headroom, utility interference. Higher for odd-shaped parcels and light wells due to density.	Lower More uniformity for largely 1960s buildings.	Lower Vast majority of buildings are rectangular, with no vertical irregularity and no light wells due to spacing of buildings.
Severity of existing deficiency	Baseline Typical: All nonconforming materials (plaster, stucco), mostly heavy.	Lower Many lighter weight 1960s 2-story buildings.	Lower Many lighter weight 1960s 2-story buildings, especially 3-4 unit buildings.
Use of ground floor work area	Baseline Higher for commercial ground floor use. Possibly lower for unoccupied crawl space.	Baseline Higher for relatively few commercial buildings and buildings with many ground floor units.	Baseline Possibly slightly higher for buildings with many ground floor units.

Table 6 shows why Mountain View owners might reasonably expect lower construction costs than for a building with the same number of units in San Francisco. The age, height, and style of the Mountain View buildings, together with easier construction access, should all have a beneficial, if small, effect on cost. In addition, for Mountain View's many multi-building parcels, one might expect a sort of volume discount from a contractor working on three or more buildings all with the same staging area and all under the same contract.

Given the information in Tables 5 and 6, Table 7 gives estimated design and construction costs suitable for use in scoping a Mountain View soft story mitigation program and in communicating with stakeholders. In general, the estimated costs are somewhat lower than the estimates and actual values noted above. The range remains necessarily broad, however, to account for a still undefined range of actual conditions.

Table 7 shows design and construction costs separately. As a Bay Area market for soft story retrofit has developed, a few companies have begun offering design-build services, in which the design is done by an engineer working directly for the contractor. In theory, this arrangement can offer simplification and some cost savings to owners, but there is not enough information to rely on. Anecdotally, despite the potential savings, many San Francisco owners seem to prefer the traditional approach with separate contracts for the engineer and the contractor; in part, it allows them, as inexperienced construction consumers, to use the engineer to act on their behalf in reviewing contractors' bids and subsequent work.

Table 7. Estimated soft story retrofit costs for use in Mountain View program development

Cost component	**Pre-1950 building**	**Post -1950 Building: 3- or 4-units, 2 stories**	**Post-1950 Building: 5 or more units**
Pre-design investigation [a, d]	\$4000 to \$10,000	\$1000 to \$2000	\$1000 to \$2000
Retrofit design [b, d]	\$6000 to \$12,000	\$6000 to \$12,000	\$10,000 to \$20,000
Construction [c, d]	\$20,000 to \$60,000	\$20,000 to \$40,000	\$20,000 to \$80,000
Total	**\$30,000 to \$80,000**	**\$25,000 to \$50,000**	**\$30,000 to \$100,000**

[a] Includes production of as-built plans for pre-1950 buildings only, and non-destructive investigation. Does not include destructive investigation.

[b] Structural retrofit of the ground story only, with criteria similar to CEBC Appendix Chapter A4.

[c] Includes permits and other fees. Includes special inspection costs, contracted separately. Does not include costs for tenant relocation or compensation for loss of housing services, if needed.

[d] For similar buildings on the same parcel, allow a 60% discount in investigation cost, a 30% discount in design cost, and a 10% discount in construction cost for each additional building.

Finally, another way to estimate Mountain View retrofit costs might be to solicit opinions from the growing number of Bay Area engineers and contractors now familiar with typical soft story retrofit projects. Optional Task 3 of this study gives the city the opportunity to further assess representative Mountain View buildings. The conceptual retrofits developed from Task 3 could be used to solicit order of magnitude estimates from Bay Area experts.

5.7 Financing

Bay Area lenders are becoming familiar with the region's soft story programs. Several have participated in outreach efforts by San Francisco, but none appear to be marketing any special products.

Two programs originally designed to support energy efficiency improvements have been extended to soft story retrofit projects.

Property Assessed Clean Energy (PACE) allows owners to repay seismic retrofit construction loans through an assessment added to their property tax bills. The advantage to the owner is that the loan stays with the property and transfers to the buyer if the building changes hands. PACE loans tend to have higher interest rates, however, so unless an owner needs the specific benefits offered by the PACE approach, a conventional construction or commercial equity loan (for residential buildings with more than four units) might be preferred. That said, there appears to be no harm to a city in having more financing options available.

For Mountain View to take advantage of PACE financing, Santa Clara County will have to approve the concept in general and Mountain View specifically. At that point, participating lenders are allowed to offer PACE financing to Mountain View owners. Even then, however, the PACE lenders can set their own guidelines about the projects they will fund. Currently several PACE lenders are offering loans in Santa Clara County, but it is not clear whether any are prepared to fund soft story retrofits. For example:[f]

- PACEfunding offers financing in four Santa Clara County cities, but not Mountain View. Also, they currently fund only energy improvements, not seismic work.
- Ygrene funds seismic work on multi-family and commercial properties in six Santa Clara County cities, but not Mountain View.
- Renew Financial funds projects in Mountain View, but its seismic work is currently limited to cripple wall retrofits for dwellings up to three units.

The California Capital Access Program (CalCAP) is a program managed by the state treasurer to, in essence, provide loan guarantees to private lenders to encourage them to finance building improvements. In 2016, CalCAP was extended to cover certain seismic projects including soft story retrofits. However, even with the CalCAP support, lenders are not required to offer better terms to borrowers, so there is little incentive for lenders to participate or for owners to seek CalCAP-backed loans. As of May 2018, only one lender is listed on the program's website.

6. Cost sharing

In the context of soft story retrofit, "cost sharing" refers to the practice of passing some or all of the owner's cost to the tenants over time, either as special assessments or as rent increases.

Mountain View's 2016 Community Stabilization and Fair Rent Act (CSFRA) provides the general rules for how an owner can pass through the costs of certain capital improvements, as well as the rules by which an owner would need to compensate tenants for any loss of housing services. CSFRA is implemented by the Mountain View Rental Housing Committee. As of March 2018, the Committee had not yet ruled on any cases of voluntary seismic retrofit and had not set any precedents for how CSFRA might apply to this type of work (Bigelow, 2018).

Application of CSFRA to potential voluntary and mandatory soft story retrofit programs is being analyzed by the Mountain View City Attorney. Answers to the following questions will be helpful in drafting a retrofit ordinance, in developing consensus support among stakeholders, and in preparing for implementation:

- Under CSFRA, would seismic retrofit be considered a capital improvement? Or might it be considered a repair or correction to an unacceptable or substandard housing condition?

- CSFRA requires compensation for permanent loss of housing services, but how should it apply to temporary losses during the construction phase of a soft story retrofit project?

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[f] Reliable and current information can be difficult to find. The examples here result from online research and telephone calls to several PACE lenders in May 2018.

- If application of CSFRA leads to upward rent adjustments to share the cost of seismic retrofit, which costs and what portion of them should be considered, and what discount rate and amortization period should be used?

Especially for a mandatory program affecting hundreds of landlords and thousands of tenants, it will be important for the Committee to review likely scenarios in advance, issue interpretations to guide the program, and even prepare standard forms or instructions to facilitate the petition process and coordinate it with building department procedures.

It is useful to consider how the other cities with mandatory soft story retrofit programs have addressed these questions. Several have supplemented their existing pass-through policies with special provisions for soft story projects to help balance the financial impacts on owners and tenants and to support broader goals regarding housing resilience and affordability. Table 8 provides a brief summary of the policies currently in place. Outreach materials by both Berkeley (2015) and Santa Monica (2016) have noted that the Costa-Hawkins adjustments to rent control have made it less onerous for owners to take on capital improvements without pass-through. Even so, this was a critical issue during deliberations in San Francisco and Los Angeles, is recognized as an important open issue in West Hollywood, and has played a large role in delaying a mandatory program in Oakland.

Considering the policies adopted by other cities, Table 9 shows the monthly rent increases for a range of conditions. Assuming a typical Mountain View rent of about $2500 per month, the increase would range from 0.6 percent ($15/month) to 3.1 percent ($78/month). If the increase were capped at $30 as in San Francisco, the cap would only apply to the smaller buildings (5 or 6 units, where the cost is most likely to be less than the $65,000 assumed for this illustration) and to buildings up to about 15 units in the case of 100 percent pass-through with a 6% discount rate.

Table 8. Current cost sharing policies for mandatory soft story retrofit programs

City	Basic policy	Pass-thru parameters	Caps and exemptions
Berkeley	Waives "vacancy increase" offsets so that 100% of costs are eligible for pass-through. (Brown and Darrow, 2018)	• 100% over 8 years • 0% discount rate Resulting rent increase is permanent	• Applies only to owners of up to 12 units in any Berkeley property. • Applies only if building was owned prior to ordinance
San Francisco	100% of costs eligible for pass-through. (Only 50% eligible for non-mandatory projects.)	• 100% over 20 years • Discount rate to match loan rate if applicable; otherwise set by rent board annually.	• Monthly rent increase limited to $30/year and 10% of base rent. • Rent increase is non-permanent. • Hardship appeal available to tenants. • Streamlined compensation rules for temporary loss of housing services (San Francisco, 2014).
Los Angeles	50% of costs eligible for pass-through. Owners must file tenant habitability plan and notify tenants of expected impacts; plan must show attempts to mitigate tenant impacts.	• 50% over 20 years. • Period may be extended if monthly caps apply, until full 50% is recovered.	• Monthly rent increase limited to $38. • Rent increase is non-permanent, but period may be extended if $38 cap applied.
Santa Monica	50% of costs eligible for pass-through as permanent rent increase. Alternately, owners may petition for rent increase based on loss of net operating income. (Condon, 2017)	• For design costs, 50% over 5 years. • For construction costs, 50% over 20 years. (Santa Monica, 1995, Section 4113B)	• Hardship appeal available to tenants.
Beverly Hills	Depending on the category of applicable rent stabilization, either 100% pass-through (BHMC Chapter 5) or increase based on net operating income (BHMC Chapter 6).	• Discount rate up to 18%. • Amortization per straight line depreciation regulations of federal tax law. • Pass-through prorated to units based on square footage.	• Monthly rent increase limited to 10% if based on BHMC Chapter 6 (Beverly Hills, 2017)
West Hollywood	Rent increase allowed upon demonstration of loss in net operating income. City might consider pass-through regulations in late 2018. (West Hollywood, 2018)	Not applicable	Not applicable

Table 9. Monthly rent increase per unit for a $65,000 total project cost

		Pass-through amount and period	
Discount rate	**Building size**	**50% over 10 years**	**100% over 20 years**
0%	6 units	$45	$45
	12 units	$23	$23
	18 units	$15	$15
3%	6 units	$52	$60
	12 units	$26	$30
	18 units	$17	$20
6%	6 units	$60	$78
	12 units	$30	$39
	18 units	$20	$26

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