Appendix B:

BB2 Removal Project Impact Assessment and Mitigation, MCFCWCD, 2025

APPENDIX B

Building Bridge #2 Removal – Impact Assessment of Rise in Modeled Base Flood Elevation (BFE)

Introduction

The purpose of this appendix is to document the Marin County Flood Control and Water Conservation District's (District's) assessment of properties and structures[1] adjacent to San Anselmo Creek, downstream of the proposed Building Bridge #2 (BB2) Removal to support the "certification that no structures are located in areas which would be impacted by the increased base flood elevation", per 44CFR §65.12.

The analysis includes evaluation of the following three components:

- Rise: Which properties experience a modeled rise in the FEMA Base Flood Elevation (i.e., 100-year storm event);
- Effect: The effect, if any, of this rise on structures; and
- Mitigation: The appropriate flood mitigation, if any, to alleviate a potential impact to a structure.

Background

BB2 obstructs high magnitude creek water flow, and its removal will reduce historic flooding risk for hundreds of properties in downtown San Anselmo and the Town of Ross. BB2 removal will eliminate this obstruction and decrease flood risk by helping keep water within the channel during these storms and less in the urban floodplain. BB2's removal would decrease the extent of the FEMA 100-year floodplain and the overland floodway (i.e., 23 parcels would be removed from the 100-year floodplain, 54 would be partially removed[2], and 315 parcels would have a decrease in modeled 100-year water surface within the CLOMR limits). In addition to posing a flood hazard, BB2 is structurally unsound and is a risk to public safety.

While BB2 removal will reduce flood risk on the urban floodplain for the Towns of San Anselmo and Ross, it is acknowledged that more flood water within San Anselmo Creek would result in a modeled rise in the Base Flood Elevation (BFE) within the channel downstream of the BB2 site. The downstream limit of this modeled rise is the second Sir Francis Drake bridge crossing, as shown on the plan view map on **Figure 1**. The following are important points to understand associated with this modeled rise of BFE in the main channel floodway.

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[1] A "structure", as defined by FEMA 44 CFR 59.1, is a walled and roofed building, including a gas a liquid storage tank, that is principally above ground, as well as a manufactured home.

[2] Partial removal from the FEMA 100-year floodplain means that less area of the property would be within the Special Flood Hazard Area (SFHA).

- This modeled rise is localized, limited, and only occurs during large and rare storm events (e.g., 100-year). The modeled water surface rise would not occur for relatively moderate storm events (e.g., 10-year). These smaller storms are the biggest contributors to flood risk of homes and businesses since they occur much more often than larger and rarer storm events (e.g., 100-year).

- For the Base Flood (e.g., 100-year event) much of the flooding of structures along the creek would be caused by overflow from the street side (e.g., overland floodway), not from the creek (e.g., main channel floodway). The modeled water surface on the street side, which is higher than that on the creek side, drops in all modeled flood events with BB2 removed. This is shown on the longitudinal profile on **Figure 2**.

- Modeled rise of the creek water surface does not necessarily equate to direct structural effects. For example, the modeled creek water surface could rise on a particular property, but a structure could be situated higher up on the terrain, and thus not affected by the rise.

- The effect on a structure does not directly translate to an impact and need for mitigation. For example, a structure could have a modeled rise against a flood damage-resistant material (e.g., concrete foundation), which is considered an effect, but if a rise does not flood above the finished floor or compromise the structure's structural integrity, utilities, or non-living space (e.g., basements, crawl space, garage), then the rise does not create an impact and no mitigation is necessary.

- Any modeled rise in the Base Flood, which results in potential new impacts to structures would be mitigated by the District prior to or at the same time as BB2 Removal. Based on existing structure elevation information, some mitigation would be necessary for a limited number of structures. For basements, crawl spaces and garages, this flood proofing may include elevating utilities or other equipment off the ground and flood venting so that flood waters have a path to drain out of non-living spaces. For structures supported in the creek bed, this may include structural reinforcement of the foundation.

Analysis

The methods used to evaluate rise, effect, and mitigation are described in the following respective sections, along with results.

Rise

Stetson Engineers, Inc. (Stetson) obtained the current FEMA effective HEC-RAS 1D steady-flow model, and associated hydrological and topographical data, from the FEMA Engineering Library. Based on the effective model, Stetson developed a corrected RAS model for existing conditions and post-project (e.g., Post-BB2) conditions. The modeled water surface elevation associated with the 100-year flood, or Base Flood, was compared for Existing and Post-BB2 scenarios. BB2 removal is modeled to reduce the Base Flood Elevation (BFE) in San Anselmo Creek upstream of BB2 and along the overland floodway, thus reducing the modeled floodplain area as well. However, removal of the BB2 obstruction does result in a modeled "rise" in BFE within San Anselmo Creek's main channel, downstream of the BB2 site. The downstream limit of this modeled rise is the second Sir Francis Drake bridge crossing.

The modeled BFE rise occurs on a total of 58 properties, 38 in the Town of San Anselmo and 20 in the Town of Ross. The owners of these parcels have been notified of the modeled rise in BFE, as documented in **Appendix E**. These parcels are highlighted in plan view on **Figure 1**. Comparison of the Existing and Post-BB2 BFEs for the main channel and overland floodways is shown in the longitudinal profile on **Figure 2**.

Effect

The "effect" of the modeled BFE rise on structures was assessed by comparing structure elevations to the modeled BFEs. This was done to determine whether the first finished floor (FFF)[3] and lowest adjacent grade (LAG)[4] elevations of structures on the properties of interest are above the modeled BFE for Post-BB2 conditions. The FFF and LAG elevations[5] were determined based on land surveys performed by Meridian Surveying Engineering, Inc. (Meridian) between July 2022 and April 2025 under the supervision of a licensed land surveyor. The NAVD88 vertical datum was used. Some properties did not require field surveys because the structures are clearly elevated above the BFEs and set back from the modeled floodplain. In some situations, available Light Detection and Ranging (LiDAR) data was used to estimate LAG. Structures with FFF and LAG above the modeled BFEs required no further evaluation because there is no structural effect associated with the rise. Structures with LAG below the modeled BFEs do have an effect associated with the rise.

Of the 58 properties with a rise, a total of 22 structures would be affected by the rise, 7 of them commercial and 15 residential. The 9 affected structures in San Anselmo and 13 in Ross are highlighted in plan view on **Figure 1**. Comparison of FFF and LAG to the modeled BFEs is provided on **Table 1** and shown in the longitudinal profile on **Figure 2**.

Mitigation

Flood "mitigation" is needed if the structure affected by the rise would potentially be impacted. As documented in a February 21, 2025 BB2 Removal Project meeting with FEMA staff (District, 2025), "an increase in BFE is not considered an adverse impact if floodwaters do not enter the building and the building's supporting piers remain structurally sound."

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[3] First Finished Floor or Finished Floor Elevation: Elevation of the finished surface of the lowest habitable floor of a building.

[4] Lowest Adjacent Grade: The lowest elevation of the ground surface, sidewalk, or patio slab immediately adjacent to a building. It's the lowest point of the ground level next to the structure.

[5] LAG is typically lower than the FFF.

For the purposes of this analysis, mitigation is assumed to be needed if one of the following conditions apply:

(1) the Post-BB2 BFE is above the lowest floor[6] (FFF) of a structure;
(2) the Post-BB2 BFE is above the LAG of a structure and the structure is not wet floodproofed[7] below the BFE; or
(3) a structure supported within the bed of San Anselmo Creek is not able to withstand additional forces associated with the modeled BFE rise.

To evaluate appropriate flood mitigation the District performed field reconnaissance at every structure affected by a rise. This field work included marking the Existing and Post-BB2 BFEs in relation to the surveyed FFF and LAG and taking photographs to document configuration. Annotated field photographs are provided in **Exhibits 1 to 22**. If needed, key features, such as equipment (particularly with a pilot light), utilities, and crawlspace vents, were surveyed by Meridian to assess elevations relative to the BFEs. Key features were photographed as well.

Appropriate mitigation for the first criteria is to either remove the structure or elevate the structure, so that the lowest floor is above the BFE. There are no instances where such mitigation is needed for BB2 removal. There are 2 finished floors at garage level that are below the Post-BB2 BFE. However, these areas are to be used only for parking of vehicles, building access, or storage and appropriate wet floodproofing will be provided, as described below.

Appropriate mitigation for the second criteria is to wet floodproof the structure below the BFE to the extent practicable. Guidance provided in FEMA's National Flood Insurance Program (NFIP) Technical Bulletins was used to help with this assessment. The NFIP Technical Bulletins focus on structure performance criteria that apply to new construction, substantial improvements[8], and repair of damaged structures within Special Flood Hazard Areas (SFHAs) (FEMA, 2021). However, the guidance can also be used as a best practice for improving the flood resilience of existing structures that are not substantially improved (FEMA, 2021), as is the case with the structures of interest. The use of wet floodproofing measures for flood protection applies to: enclosures below elevated structures when the enclosures are used solely for parking of vehicles, building access, or storage; attached garages; and certain accessory structures used for parking of vehicles or storage (FEMA, 2022). Typical wet floodproofing measures include the following (FEMA, 2022):

- anchoring to resist flotation, collapse, and lateral movement;

[6] Lowest floor: Lowest floor of the lowest enclosed area of a building, including basement. An unfinished or flood-resistant enclosure that is used solely for parking of vehicles, building access, or storage is not the lowest floor, provided the enclosure is built in compliance with applicable requirements (FEMA, 2022).

[7] Wet floodproofing: Use of flood damage-resistant materials and construction techniques to minimize flood damage to structures by intentionally allowing floodwater to enter and exit automatically (without human intervention) to minimize unequal pressure of water on walls (called hydrostatic load or pressure) (FEMA, 2022).

[8] Substantial Improvement: Renovations or additions to a building within a flood hazard area where the cost of the work equals or exceeds 50% of the building's market value (FEMA, 2021).

- using flood damage-resistant materials below the BFE;
- installing flood openings to automatically equalize hydrostatic forces (loads or pressure caused by standing or slow-moving water) on exterior walls;
- protecting mechanical and utility equipment by elevating or by installing and configuring the equipment components to minimize damage (e.g., elevated water heater, elevated outlet); and
- anchoring tanks to resist flotation and lateral movement

Wet floodproofing mitigation is proposed for 11 structures, including 8 single-family residential houses, 2 detached garages, and 1 accessory dwelling unit.

Appropriate mitigation for the third criteria is to reinforce or strengthen a structure supported within the bed of San Anselmo Creek, such that it can withstand additional forces associated with the modeled BFE rise. This can be performed with Fiber-Reinforced Polymer (FRP) jacketing to wrap around concrete structures, like piers, to increase their strength and durability. This method effectively encases the concrete, adding additional support and resistance to various stresses, including those related to creek flow. This technology has been applied in San Anselmo Creek. A structural engineering evaluation of in-stream structures was performed by Martin/Martin Consulting Engineers (Martin/Martin) to assess whether structural mitigation is appropriate, or if the additional forces are negligible or can be withstood by the existing structure. This analysis is documented in **Attachment 1**. The base flood flow velocity and depth for the Post-BB2 scenario was used as inputs to this analysis. Preliminary structural analysis indicates that 3 commercial structures with foundations in the creek bed can withstand additional forces associated with the modeled BFE rise[9]. One structure analyzed cannot and is recommended for FRP jacketing mitigation.

In total, of the 22 structures affected by a rise, 12 were found to require flood mitigation (11 wet floodproofing mitigation and 1 FRP jacketing mitigation). The 2 structures in San Anselmo and 10 structures in Ross proposed for mitigation are highlighted in plan view on **Figure 1** and indicated on **Table 1**. The mitigations are described in **Table 2** and in the **Exhibits**.

Conclusion

Removal of BB2 results in a modeled BFE rise for 58 properties along San Anselmo Creek. Within these 58 properties, 22 structures are affected by the rise, and 12 structures are proposed for mitigation. Based on the analysis and proposed flood mitigation presented herein, the District has demonstrated that "no structures are located in areas which would be impacted by the increased base flood elevation", per 44CFR §65.12.

[9] According to the analysis, when considering a reinforced column with a minimum of 1% vertical reinforcement and #3 ties spaced at 12 inches on center (consistent with the code requirements at the time of original construction), the structural performance meets the acceptable performance threshold under loading conditions.

References

Federal Emergency Management Agency (FEMA). 2021. National Flood Insurance Program (NFIP) Technical Bulletin 0. User's Guide to Technical Bulletins. January.

FEMA. 2022. NFIP Technical Bulletin 7. Wet Floodproofing Requirements and Limitations for Buildings and Structures Located in Special Flood Hazard Areas in Accordance with NFIP. May.

Marin County Flood Control and Water Conservation District (District). 2025. Building Bridge No. 2 Removal Project Meeting Summary. February 21, 2025, 10 am.

Tables

Table 1 - Effect Assessment

Town	APN	Address	Elevation (ft) (NAV88) FFF	LAG	Existing BFE	Post-BB2 BFE	Does Rise have an Effect on the Structure?	Does Rise Require Mitigation of the Structure?
San Anselmo	006-102-25	574 - 572 San Anselmo Ave	48.64	32.81	44.13	44.86	Yes	--
	006-102-26	570 - 566 San Anselmo Ave	48.66	40.29	44.10	44.86	Yes	--
	006-102-16	564 - 558 San Anselmo Ave	48.67	48.63	44.06	44.85	--	--
	006-102-15	558- 554 San Anselmo Ave	48.78	46.59	44.03	44.84	--	--
	006-102-30	552 - 550 San Anselmo Ave	48.32	47.52	43.92	44.71	--	--
	006-102-31	546 - 538 San Anselmo Ave	48.06	31.81	43.19	43.81	Yes	Yes
	006-102-11	536 - 528 San Anselmo Ave	47.57	31.72	42.89	43.46	Yes	--
	006-102-10	520 - 510 San Anselmo Ave	47.41	29.66	43.06	43.61	Yes	--
	006-102-09	508 - 500 San Anselmo Ave	48.10	31.23	43.01	43.56	Yes	--
	006-241-06	190 Sir Francis Drake Blvd	46.23	44.42	41.20	41.62	--	--
	006-241-05	160 Sir Francis Drake Blvd	46.69	46.47	41.14	41.56	--	--
	006-241-56	130 -140 Sir Francis Drake Blvd	47.69	47.44	41.11	41.54	--	--
	006-241-61	120 Sir Francis Drake Blvd	46.58	45.86	40.90	41.33	--	--
	006-241-63	100 Sir Francis Drake Blvd	45.73	43.99	40.67	41.09	--	--
	006-191-36	98 Sir Francis Drake Blvd	44.27	35.62	40.50	40.94	Yes	--
	006-241-11	10 Lincoln Ct	48.47	45.64	41.10	41.54	--	--
	006-241-65	56 Lincoln Park(*)	45.44	45.08	41.60	42.03	--	--
	006-241-38	25 Entrada - pool house	47.56	46.66	40.99	41.43	--	--
	006-241-39	35 Entrada(*)	--	47.97	41.05	41.49	--	--
	006-241-64	15 Barber Ave	48.10	45.66	40.81	41.24	--	--
	006-191-28	12 Barber Ave	46.20	44.68	40.44	40.87	--	
	006-191-26	14 Barber Ave	44.81	44.04	39.23	39.56	--	--
	006-191-27	16 Barber Ave	45.03	44.05	39.27	39.59	--	--
	006-191-49	64 Barber Ave	46.33	42.04	39.34	39.68	--	--
	006-191-50	70 Barber Ave(*)	--	47.78	39.36	39.70	--	--
	006-191-33	126 Barber Ave(*)	--	47.91	39.40	39.74	--	--
	006-191-10	130 Barber Ave(*)	--	47.53	39.12	39.43	--	--
	006-191-11	142 Barber Ave(*)	--	45.72	38.64	38.93	--	--
	006-191-59	152 Barber Ave (*)	--	47.65	38.61	38.86	--	--
	006-191-15	172 Barber Ave - Garage	44.00	43.26	38.32	38.54	--	--
	006-191-21	54 Sir Francis Drake Blvd	43.20	41.95	39.36	39.70	--	--
	006-191-20	40 Sir Francis Drake Blvd	42.86	41.98	39.40	39.74	--	--
		40 Sir Francis Drake Blvd - Garage	42.86	42.68	39.42	39.77	--	--
	006-191-19	36 Sir Francis Drake Blvd	43.58	41.27	39.25	39.58	--	--
		36 Sir Francis Drake - Garage	40.62	34.08	39.12	39.43	Yes	Yes
	006-191-18	34 Sir Francis Drake Blvd	44.89	41.39	39.04	39.34	--	--
		34 Sir Francis Drake Blvd - Garage	41.91	37.25	38.64	38.93	Yes	--
	006-191-17	32 Sir Francis Drake Blvd	45.14	41.82	38.29	38.50	--	--
		32 Sir Francis Drake Blvd - Garage	43.27	42.69	38.53	38.76	--	--
	006-191-39	30 Sir Francis Drake Blvd- Shed	42.15	40.46	38.33	38.54	--	--
	006-191-16	28 Sir Francis Drake Blvd	41.61	39.00	38.28	38.49	--	--
	006-102-32	247 Sir Francis Drake(*)	--	48.38	45.04	45.96	--	--
Ross	072-151-01	4 Winship Ave	41.61	41.21	38.37	38.59	--	--
	072-151-02	10 Winship Ave	40.12	40.54	38.44	38.67	Yes	--
		Garage level	39.28	38.03	38.44	38.67		
	072-151-08	100 Sir Francis Drake Blvd	42.65	40.30	38.37	38.59	--	--
		100 Sir Francis Drake - Garage	40.71	35.58	38.34	38.55	Yes	--
	072-151-07	98 Sir Francis Drake Blvd	40.18	39.78	38.44	38.68	--	--
	072-151-03	96 Sir Francis Drake Blvd	42.04	39.52	38.49	38.73	--	--
	072-151-04	94 Sir Francis Drake Blvd	41.44	39.29	38.45	38.68	--	--
	072-151-05	92 Sir Francis Drake Blvd	39.12	38.82	38.36	38.56	--	--
		92 Sir Francis Drake - Garage	38.64	35.82	38.32	38.54	Yes	--
	072-151-06	90 Sir Francis Drake Blvd	41.25	34.98	38.28	38.50	Yes	Yes
		Garage level	38.83	35.51	38.28	38.50		
	072-161-01	86 Sir Francis Drake Blvd	39.05	33.85	37.76	37.90	Yes	Yes
		ADU	38.90	30.05	37.76	37.90		
	072-161-13	84 Sir Francis Drake Blvd	39.46	34.19	37.81	37.95	Yes	Yes
		84 Sir Francis Drake Blvd - ADU	38.66	30.18	37.81	37.95	Yes	Yes
	072-161-12	82 Sir Francis Drake Blvd	40.36	36.81	37.25	37.29	Yes	Yes
	072-161-11	78 Sir Francis Drake Blvd	38.88	36.52	37.29	37.34	Yes	Yes
		78 Sir Francis Drake - Garage	36.45	36.02	37.29	37.34	Yes	Yes
	072-161-10	74 Sir Francis Drake Blvd	41.13	36.21	37.33	37.38	Yes	Yes
		Garage level	37.34	36.48	37.33	37.38		
	072-161-16	72 Sir Francis Drake Blvd	46.63	42.80	37.39	37.45	--	--
	072-161-02	20 Winship Ave	44.86	37.09	37.83	37.97	Yes	Yes
		Garage level	37.19	37.09	37.83	37.97		
	072-161-03	42 Winship Ave	38.66	35.67	37.25	37.29	Yes	Yes
		42 Winship Ave - Garage	51.93	48.65	37.25	37.29	--	--
	072-161-04	46 Winship Ave(*)	--	51.38	37.29	37.34	--	--
	072-161-05	50 Winship Ave(*)	--	51.04	37.37	37.43	--	--
	072-161-06	54 Winship Ave(*)	--	49.38	37.39	37.45	--	--
	072-161-15	58 Winship Ave(*)	--	50.16	37.18	37.21	--	--

(*). LiDAR data

Table 2 - Mitigation Assessment

Town	APN	Address	Exhibit No.	Does Rise Require Mitigation of the Structure?	Proposed Mitigation
San Anselmo	006-102-25	574 - 572 San Anselmo Ave	1	No	Rise affects concrete piers, which is a flood damage-resistant material. Building piers' structural conditions are adequate to resist the additional flood-induced loads. No mitigation needed.
	006-102-26	570 - 566 San Anselmo Ave	2	No	Rise affects concrete retaining wall, which is a flood damage-resistant material. No mitigation needed.
	006-102-31	546 - 538 San Anselmo Ave	3	Yes	Rise affects concrete retaining wall, which is a flood damage-resistant material. Mitigation includes reinforcing with fiber reinforced polymer (FRP) layering on wingwalls to increase their strength and durability.
	006-102-11	536 - 528 San Anselmo Ave	4	No	Rise affects concrete piers, which is a flood damage-resistant material. Building piers' structural conditions are adequate to resist the additional flood-induced loads. No mitigation needed.
	006-102-10	520 - 510 San Anselmo Ave	5	No	Rise affects concrete piers, which is a flood damage-resistant material. Building piers' structural conditions are adequate to resist the additional flood-induced loads. No mitigation needed.
	006-102-09	508 - 500 San Anselmo Ave	6	No	Rise affects concrete retaining wall, which is a flood damage-resistant material. No mitigation needed.
	006-191-36	98 Sir Francis Drake Blvd	7	No	Rise affects concrete retaining wall, which is a flood damage-resistant material. No mitigation needed.
	006-191-19	36 Sir Francis Drake - Garage	8	Yes	Rise affects garage wooden structure joists/beam. Mitigation includes anchoring wooden structure to posts and foundation.
	006-191-18	34 Sir Francis Drake Blvd - Garage	9	No	Rise affects concrete foundation, which is a flood damage-resistant material. No mitigation needed.
Ross	072-151-02	10 Winship Ave	10	No	Rise affects garage concrete foundation, which is a flood damage-resistant material. BFE is below the garage finished floor. No mitigation needed.
	072-151-08	100 Sir Francis Drake Blvd Garage	11	No	Rise affects timber support, which is a flood damage-resistant material. No mitigation needed.
	072-151-05	92 Sir Francis Drake Blvd	12	No	Rise affects garage concrete foundation, which is a flood damage-resistant material. No mitigation needed.
	072-151-06	90 Sir Francis Drake Blvd	13	Yes	Mitigation includes elevating electrical boxes, elevating HVAC equipment, installing flood openings for crawl space, and anchoring support beams and floor joists to concrete foundations.
	072-161-01	86 Sir Francis Drake Blvd	14	Yes	Mitigation includes securing utility piping to floor joists; and anchoring wooden beams to posts and concrete foundation.
	072-161-13	84 Sir Francis Drake Blvd	15	Yes	Mitigation includes elevating and securing wiring and utility piping to underside of joists; anchoring wooden beams to posts and concrete foundation; and anchoring tank.
		84 Sir Francis Drake Blvd - ADU	16	Yes	Mitigation includes anchoring wooden beams to posts and concrete foundation.
	072-161-12	82 Sir Francis Drake Blvd	17	Yes	Mitigation includes elevating electrical boxes and installing flood openings in crawlspace.
	072-161-11	78 Sir Francis Drake Blvd	18	Yes	Mitigation includes installing flood openings for crawlspace; elevating and securing utility piping in crawlspace.
		78 Sir Francis Drake - Garage	19	Yes	Mitigation includes installing flood openings for garage.
	072-161-10	74 Sir Francis Drake Blvd	20	Yes	Mitigation includes relocating HVAC unit in crawlspace to higher elevation; securing electrical/utility piping in crawlspace to underside of floor joists; installing flood opening in crawlspace and back of garage level; anchoring building to foundation.
	072-161-02	20 Winship Ave	21	Yes	Mitigation includes elevating HVAC and water heater equipment; installing flood openings in garage door and/or garage exterior walls.
	072-161-03	42 Winship Ave	22	Yes	Mitigation includes relocating fan equipment to higher elevation; elevating and securing utility piping to floor joists; anchoring tank to foundation; and installing flood openings for crawlspace.

Figures

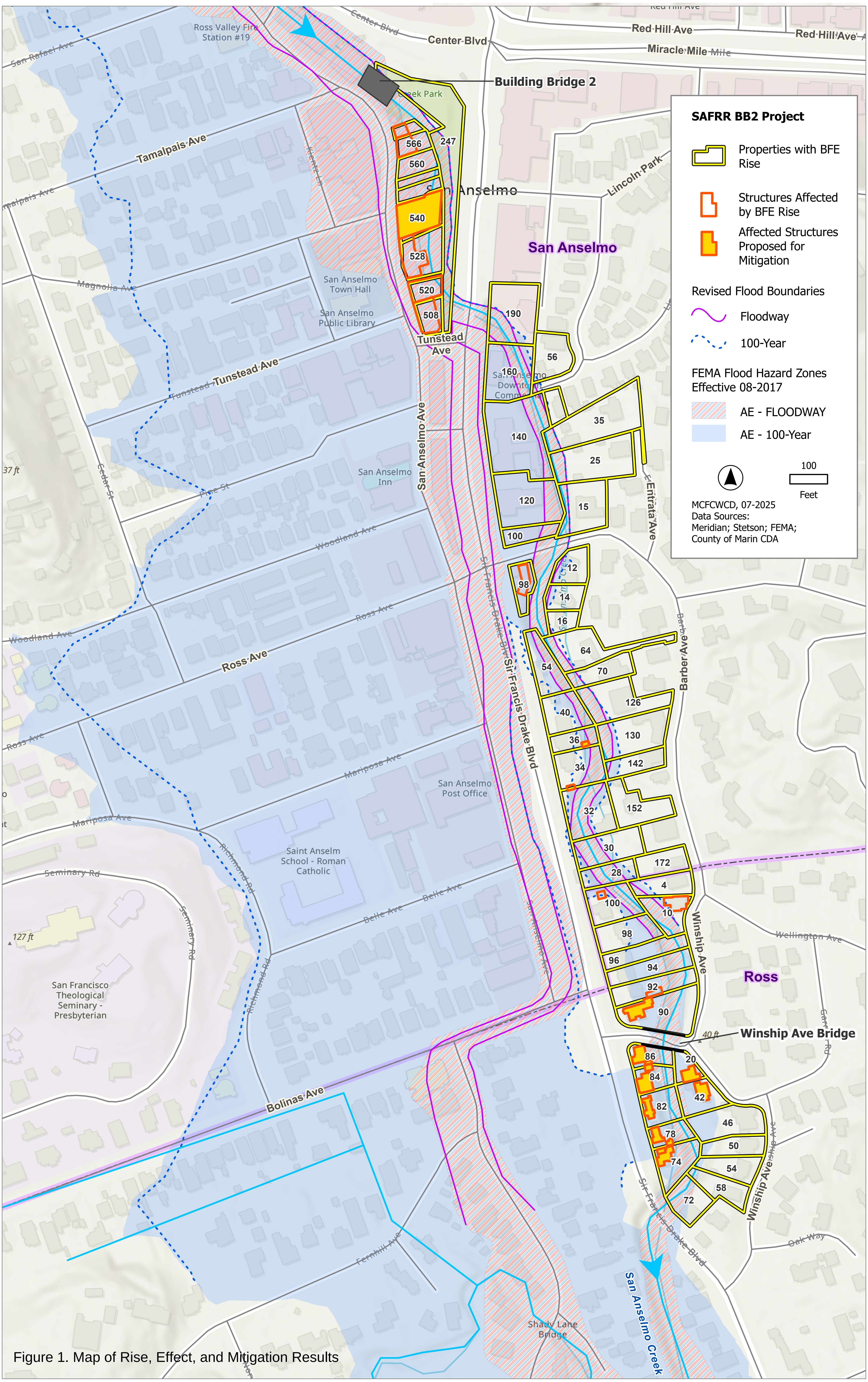


Figure 1. Map of Rise, Effect, and Mitigation Results

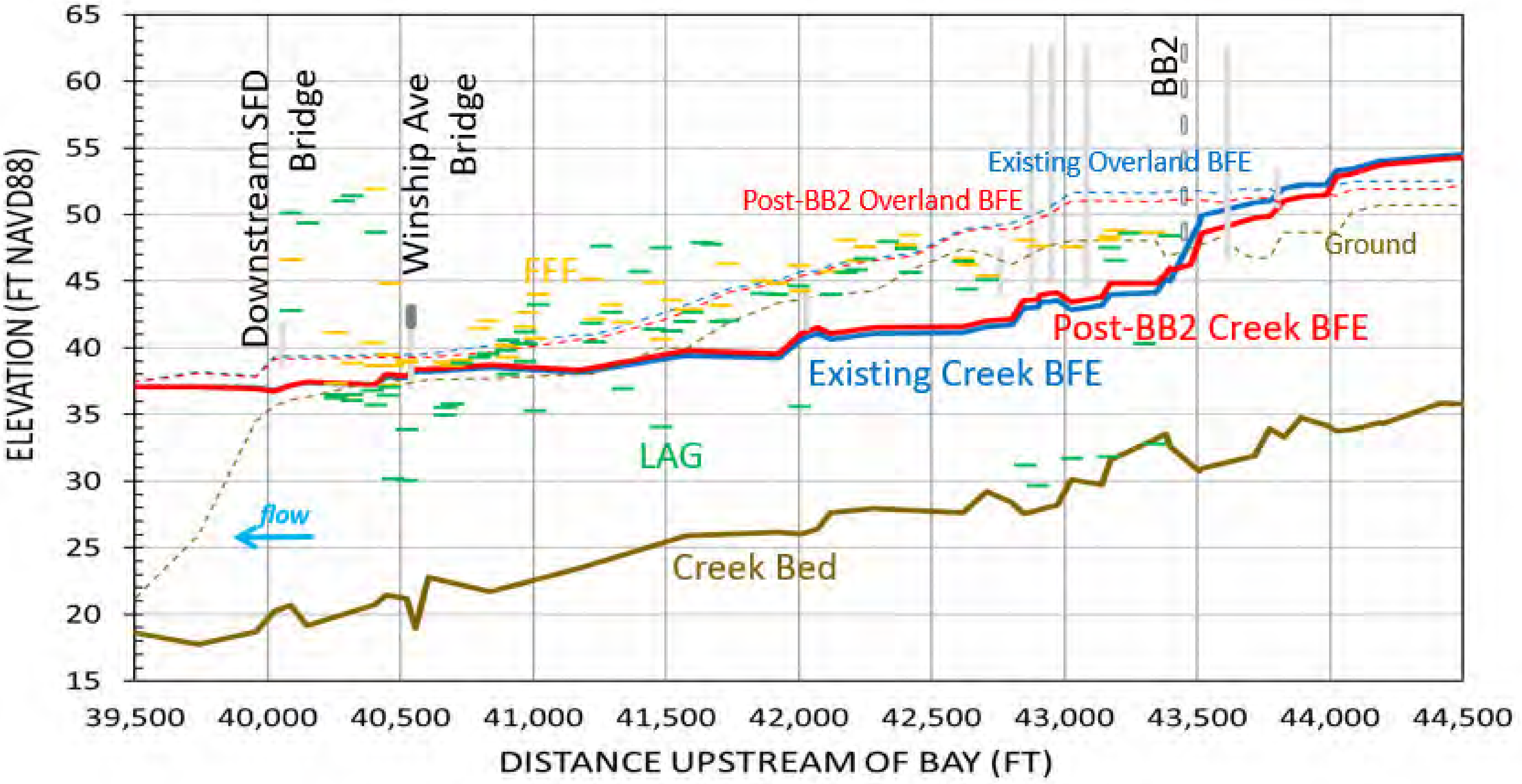
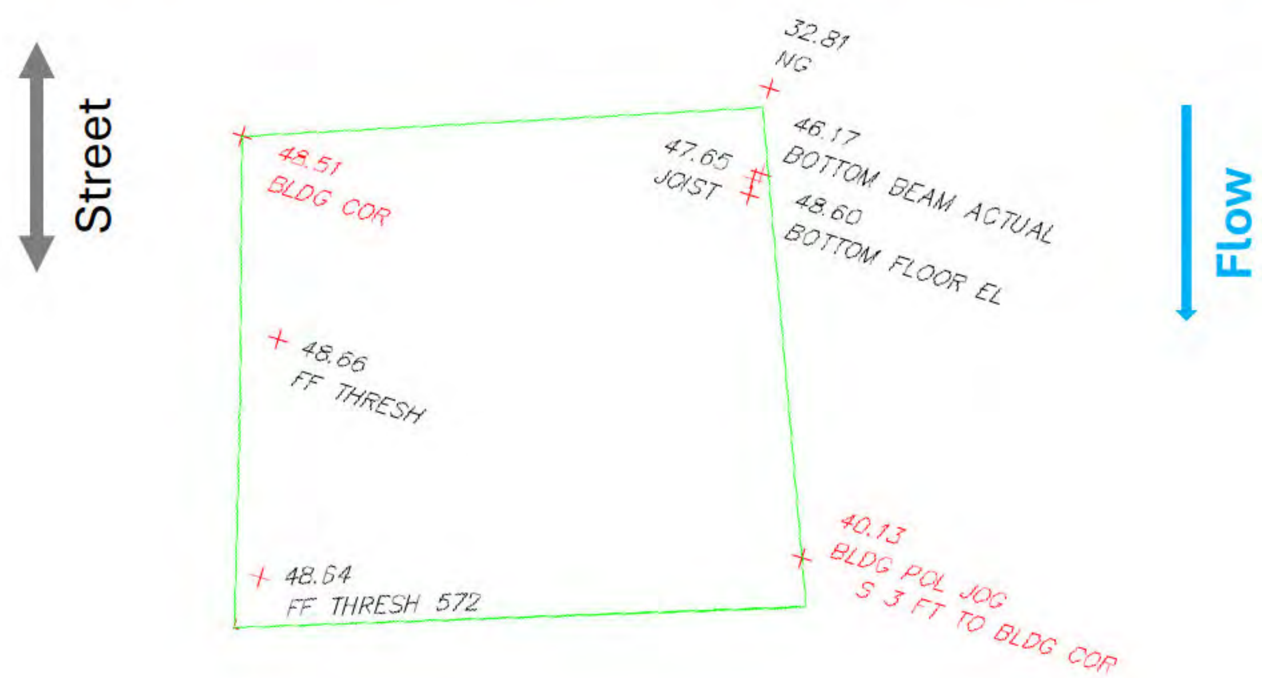


Figure 2. San Anselmo Creek Longitudinal Profile

Exhibits

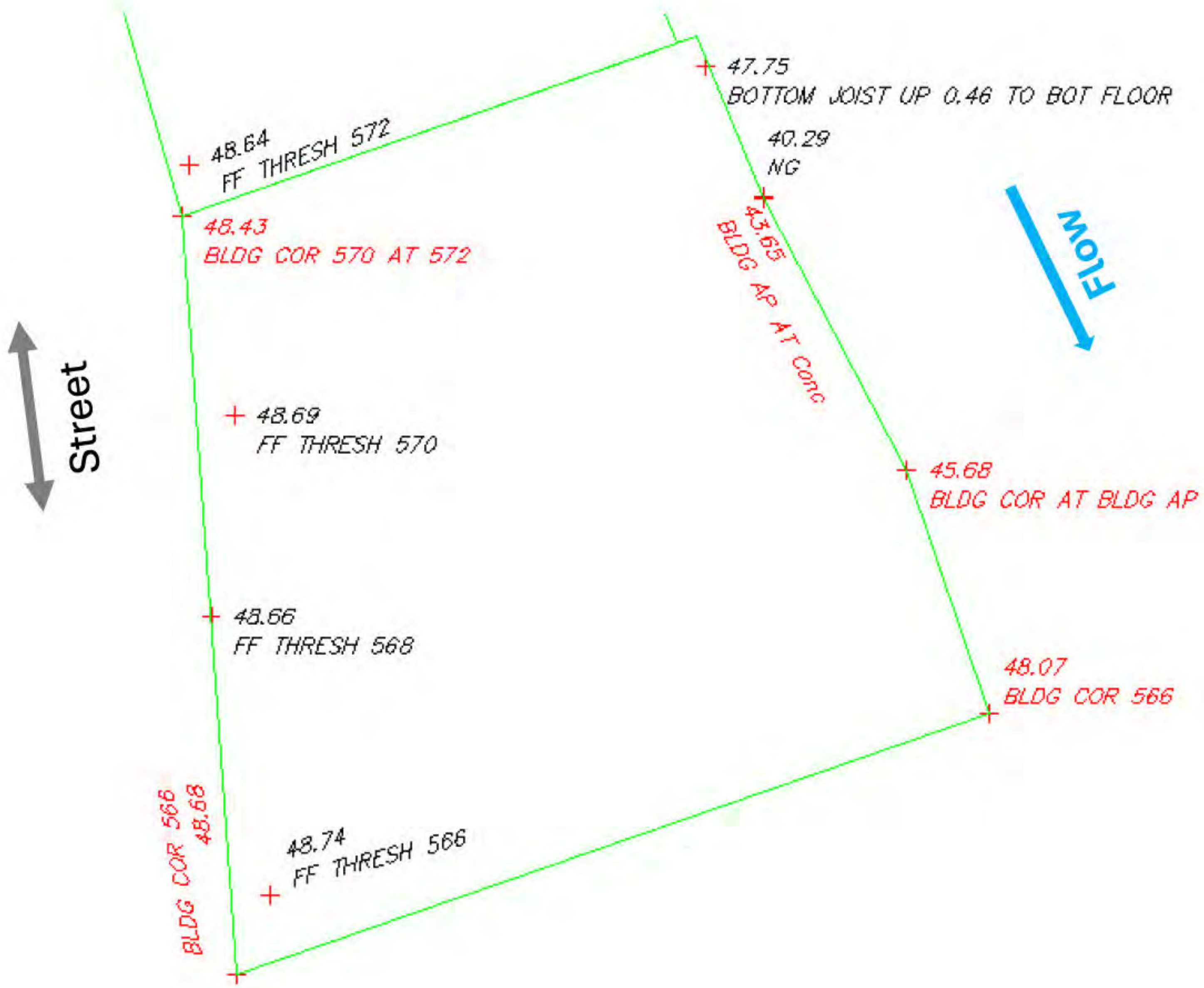
EFFECT ASSESSMENT AND MITIGATIONS
EXHIBITS 1 - 22

Exhibit No. 1: 574 – 572 San Anselmo Ave., San Anselmo



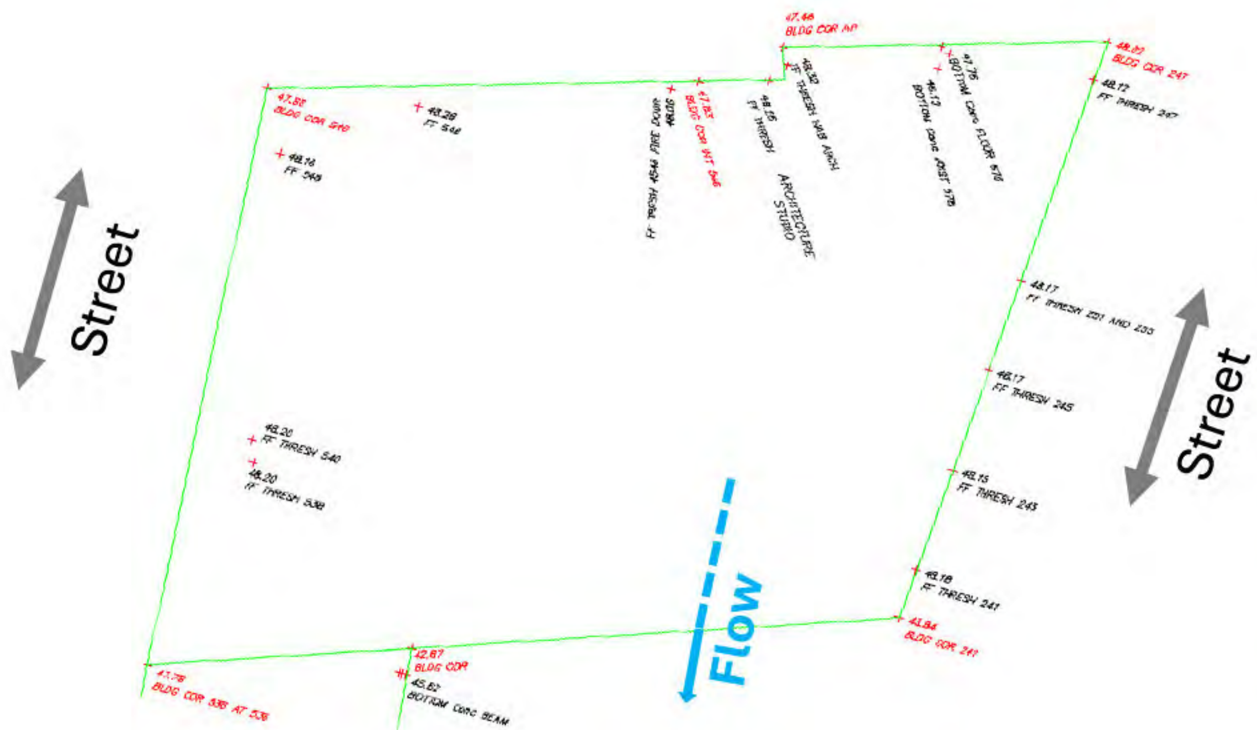
Rise affects concrete piers, which is a flood damage-resistant material.
Building piers' structural conditions are adequate to resist the additional flood-induced loads.
No mitigation needed.

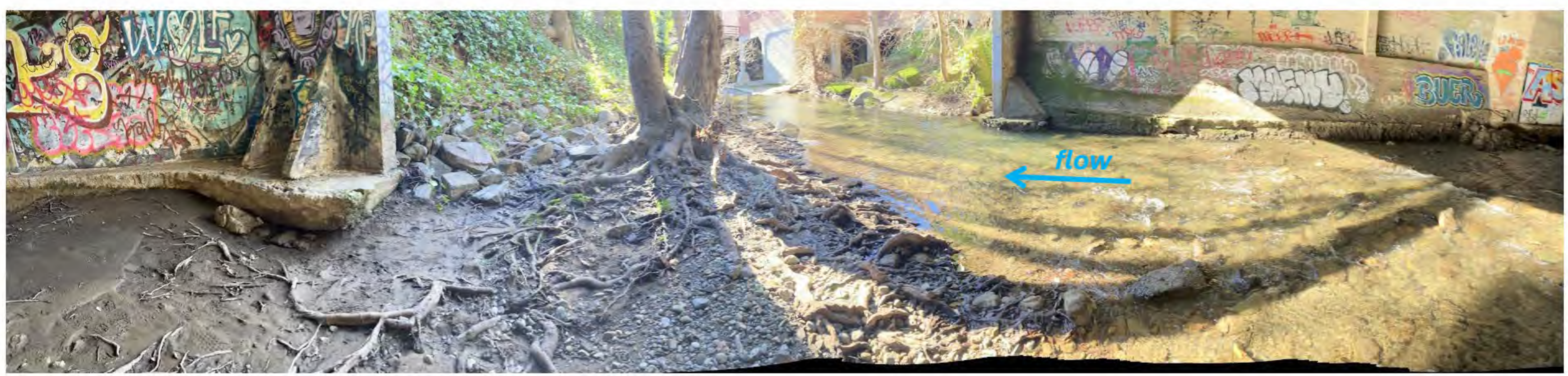
Exhibit No. 2: 570 - 566 San Anselmo Ave., San Anselmo



Rise affects concrete retaining wall, which is a flood damage-resistant material.
No mitigation needed.

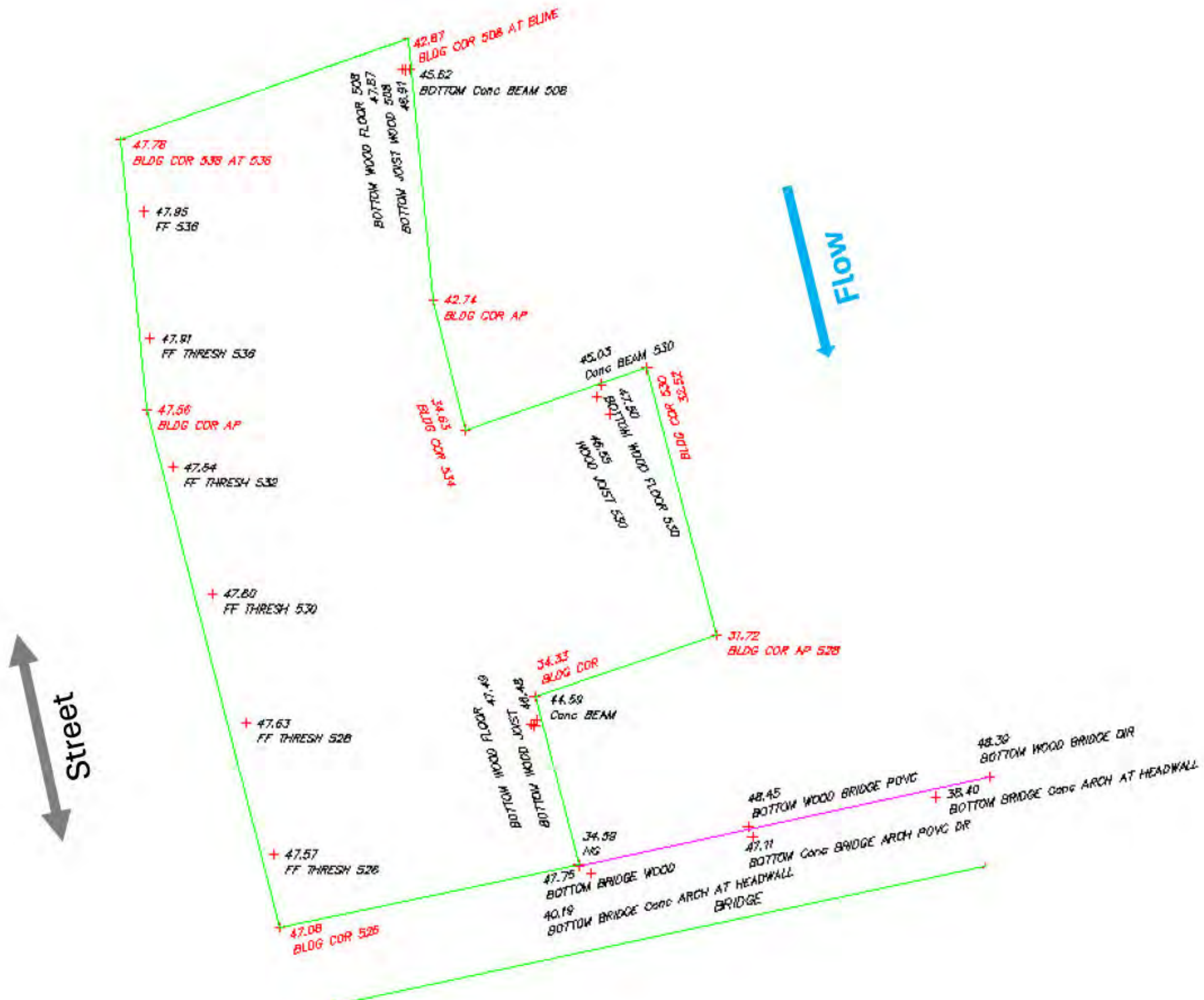
Exhibit No. 3: 546 - 538 San Anselmo Ave., San Anselmo





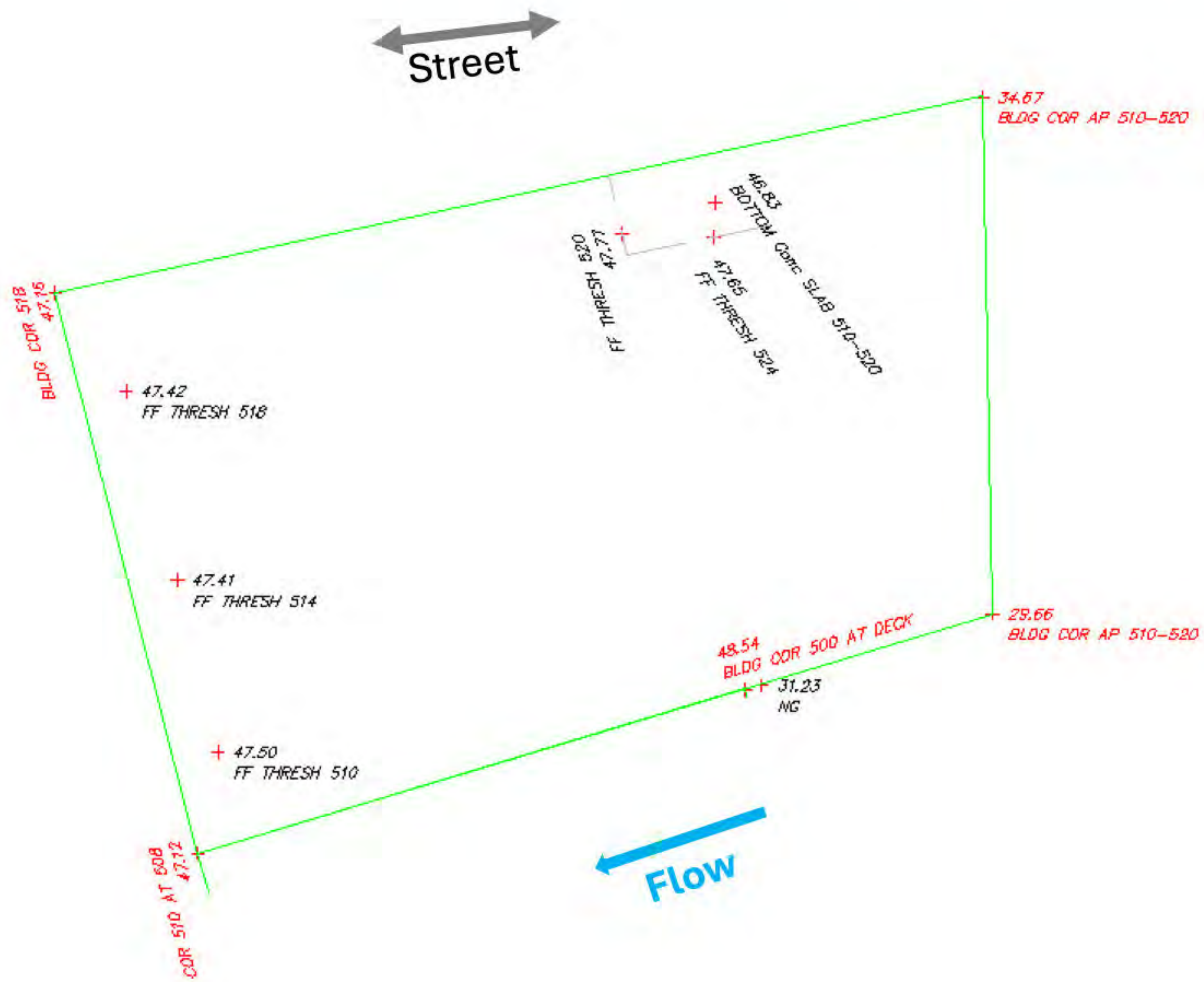
Rise affects concrete wing walls, which is a flood damage-resistant material.
Mitigation includes reinforcing with Fiber-Reinforced Polymer (FRP) layering on wingwalls to increase strength and durability.

Exhibit No. 4: 536 - 528 San Anselmo Ave., San Anselmo



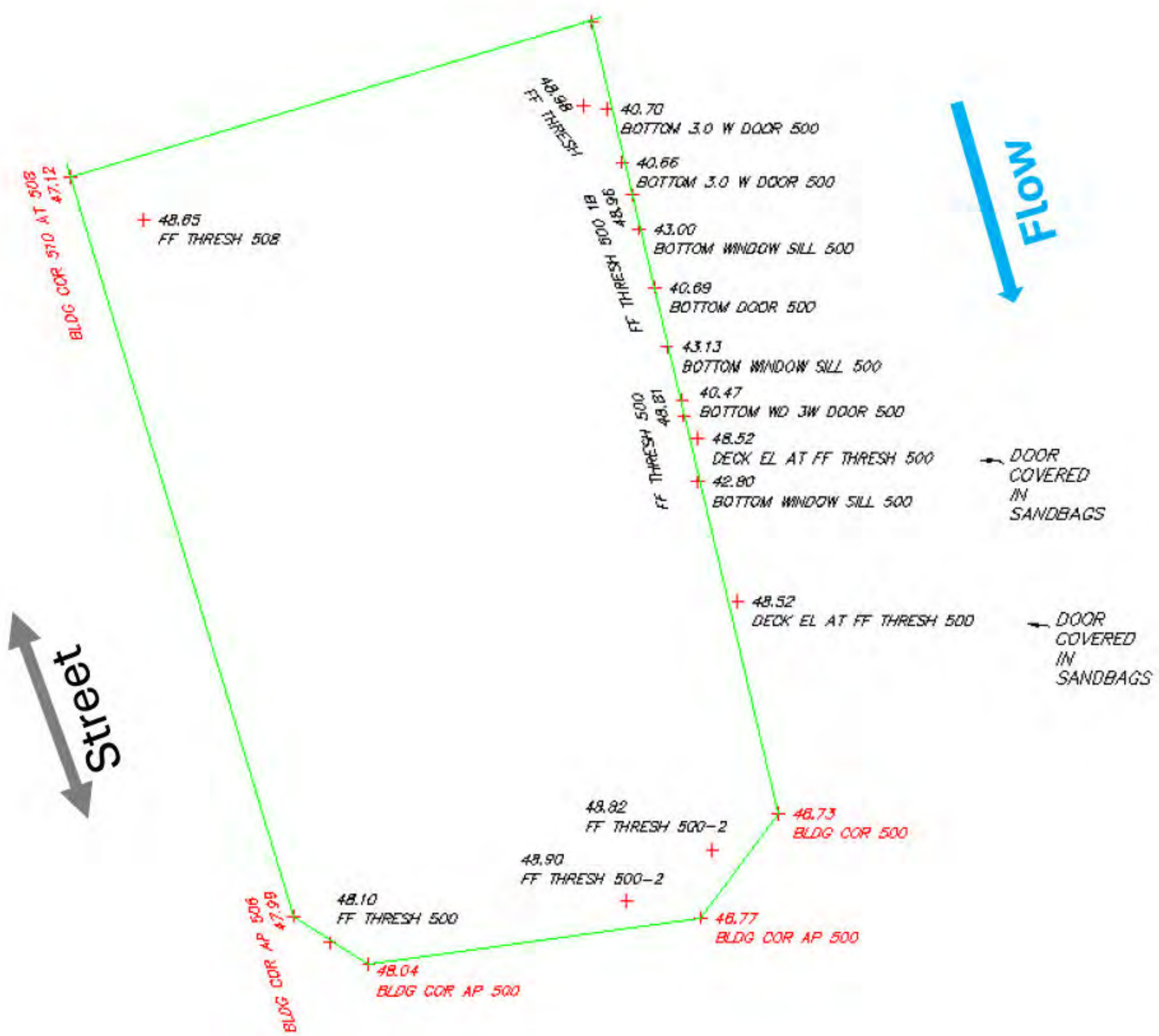
Rise affects concrete piers, which is a flood damage-resistant material.
Building piers' structural conditions are adequate to resist the additional flood-induced loads.
No mitigation needed.

Exhibit No. 5: 520 – 510 San Anselmo Ave., San Anselmo



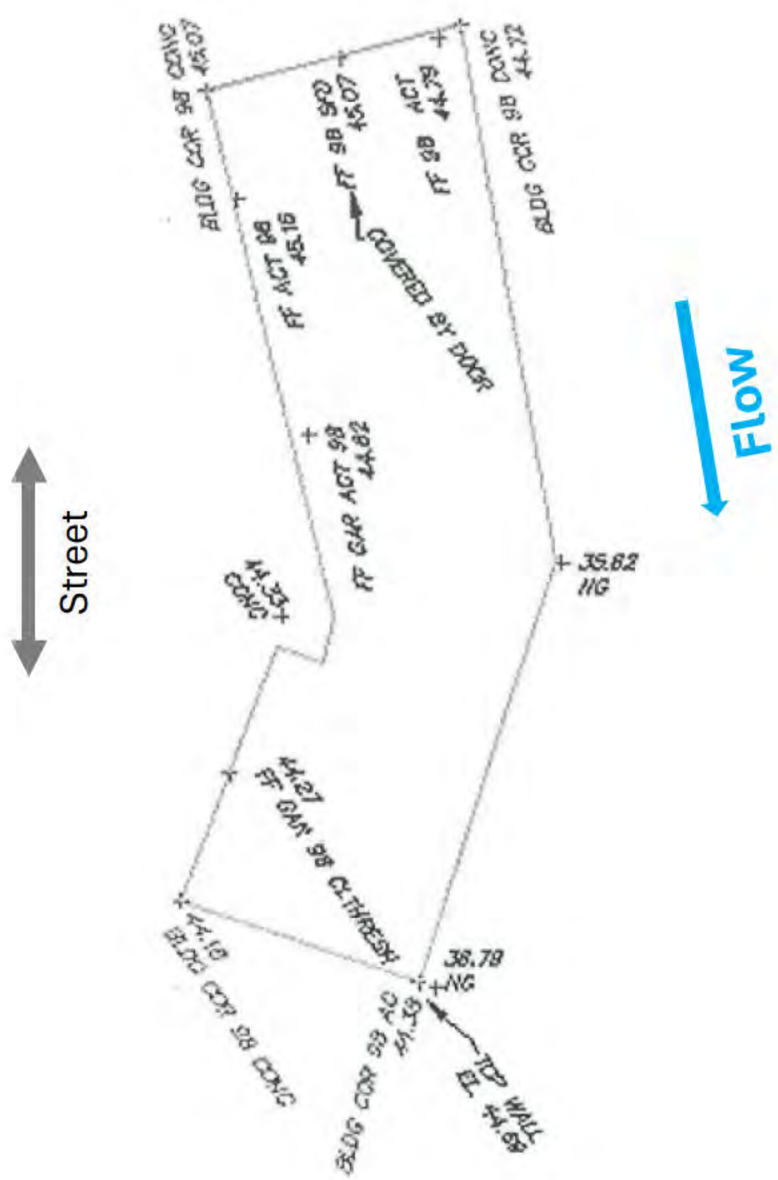
Rise affects concrete piers, which is a flood damage-resistant material.
Building piers' structural conditions are adequate to resist the additional flood-induced loads.
No mitigation needed.

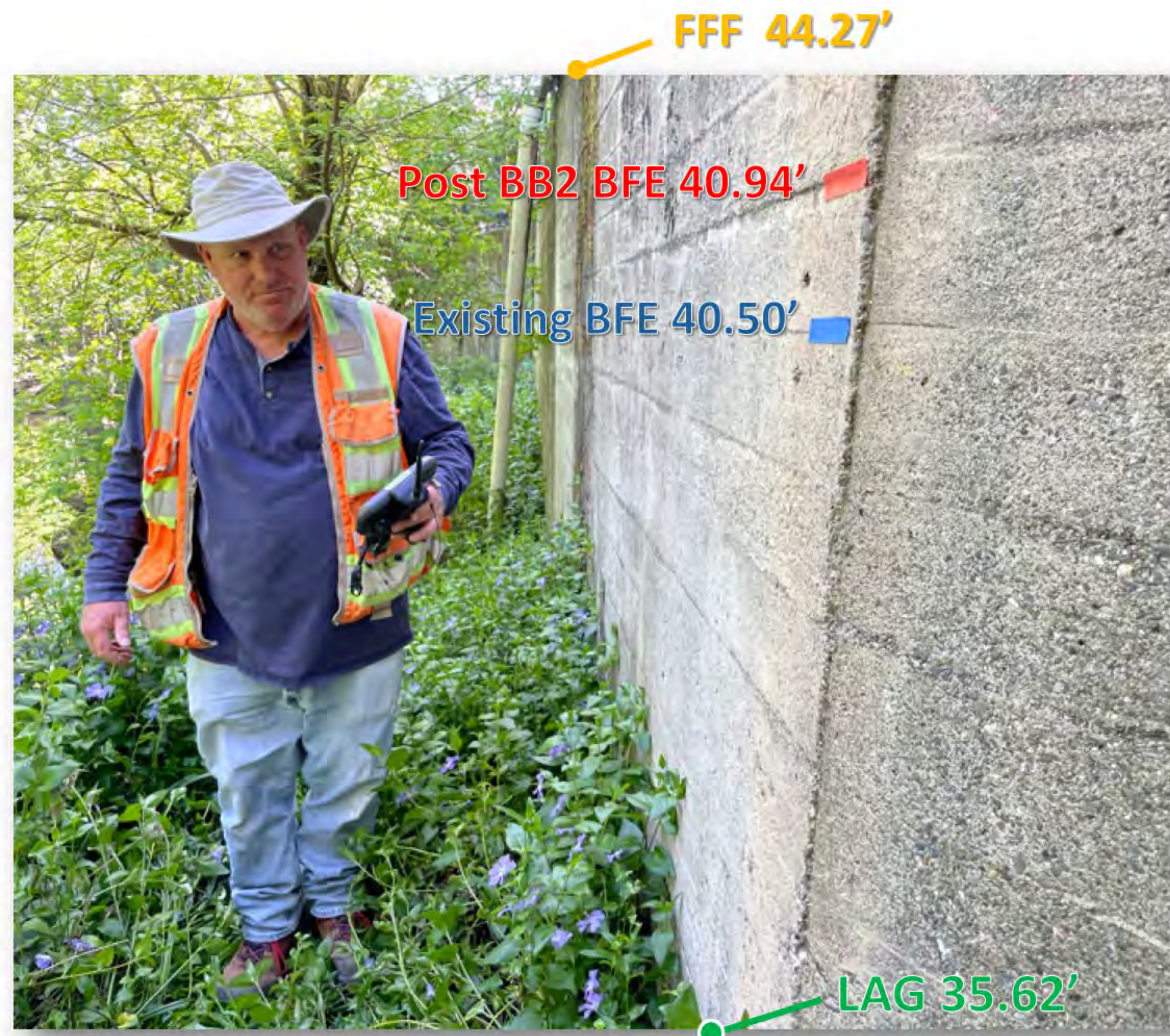
Exhibit No. 6: 508 – 500 San Anselmo Ave., San Anselmo



Rise affects concrete retaining wall, which is a flood damage-resistant material.
No mitigation needed.

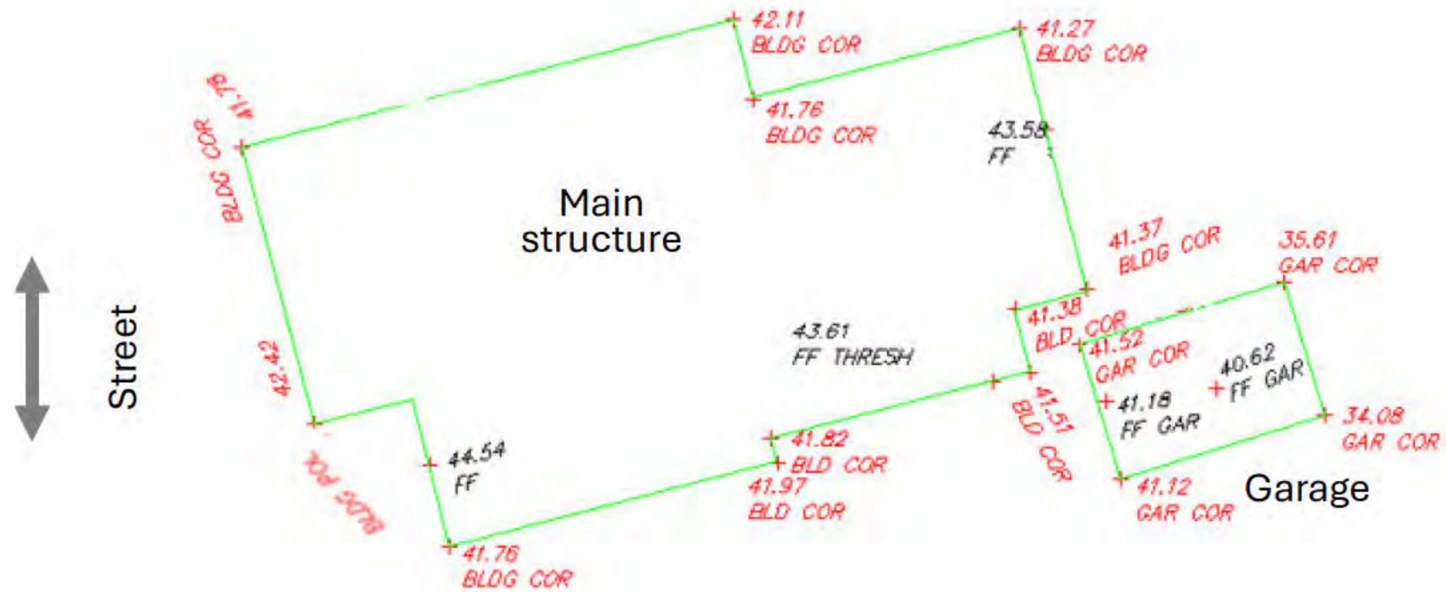
Exhibit No. 7: 98 Sir Francis Drake Blvd, San Anselmo





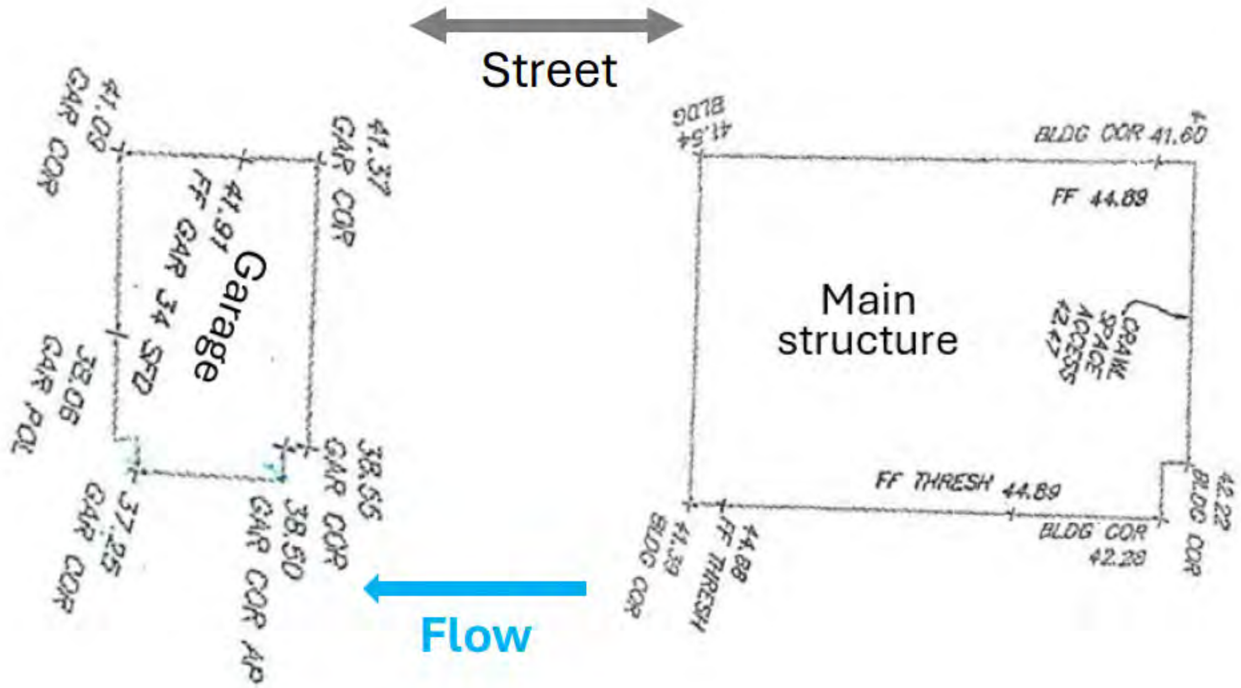
Rise affects concrete retaining wall, which is a flood damage-resistant material.
No mitigation needed.

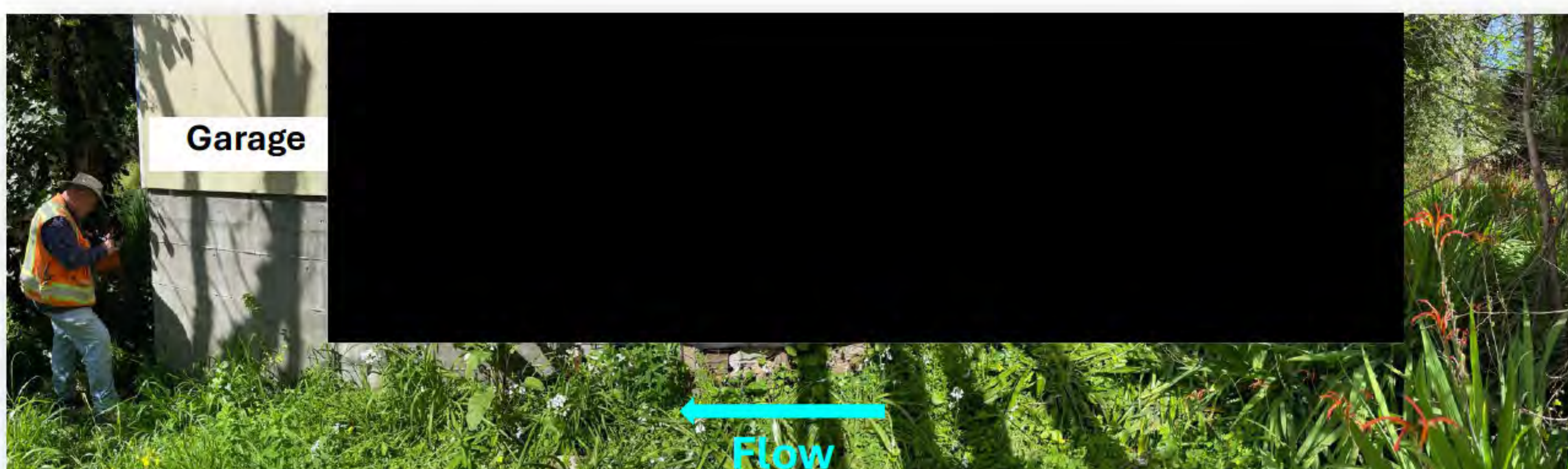
Exhibit No. 8: 36 Sir Francis Drake, San Anselmo - Garage



Mitigation includes anchoring wooden structure to posts and foundation.

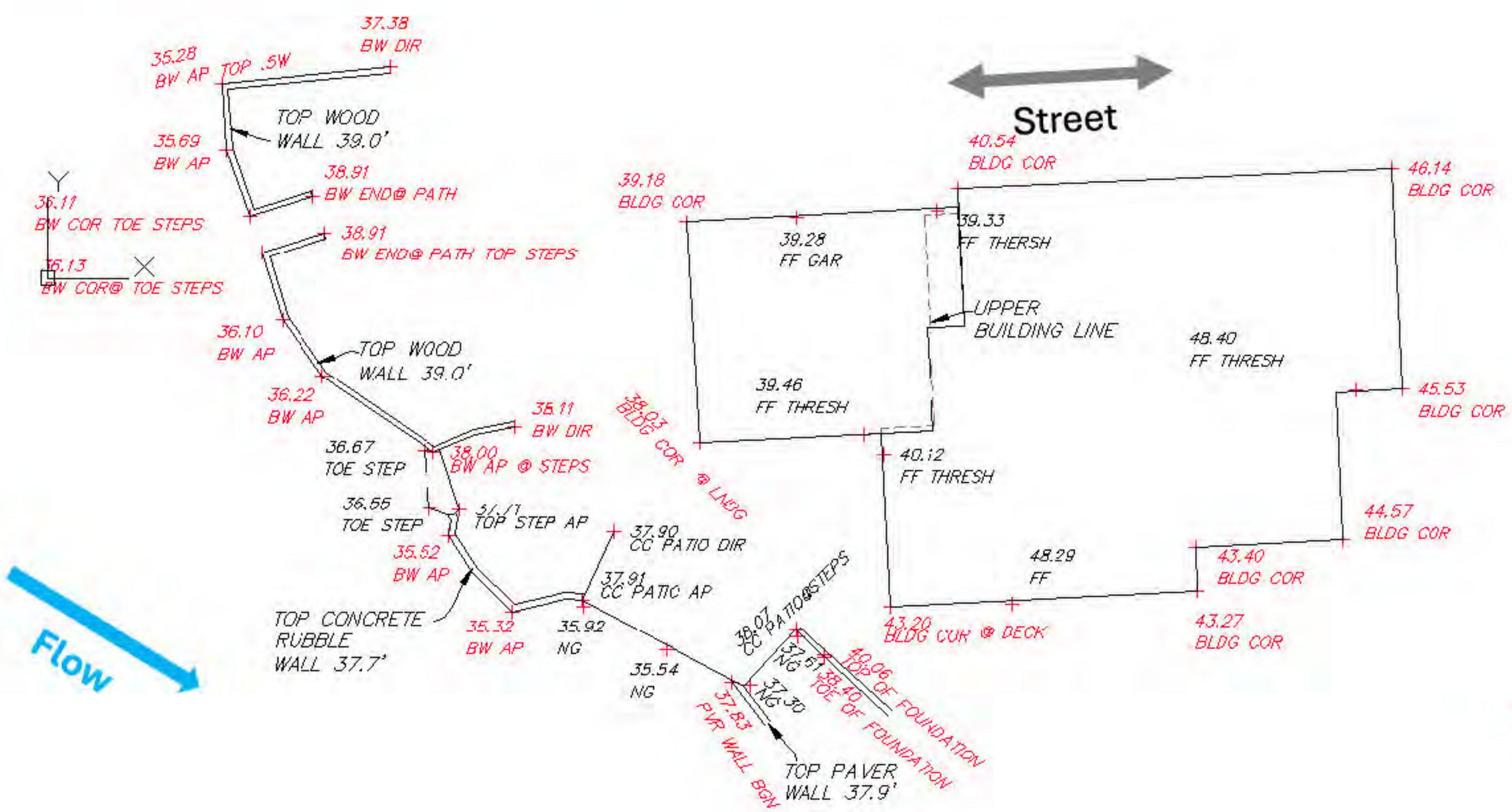
Exhibit No. 9: 34 Sir Francis Drake, San Anselmo - Garage

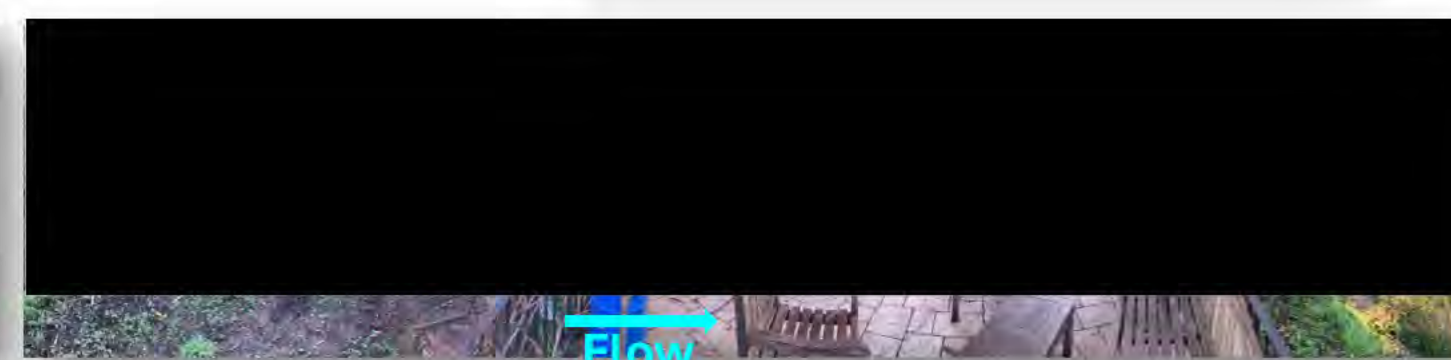




Rise affects concrete foundation, which is a flood damage-resistant material.
No mitigation needed.

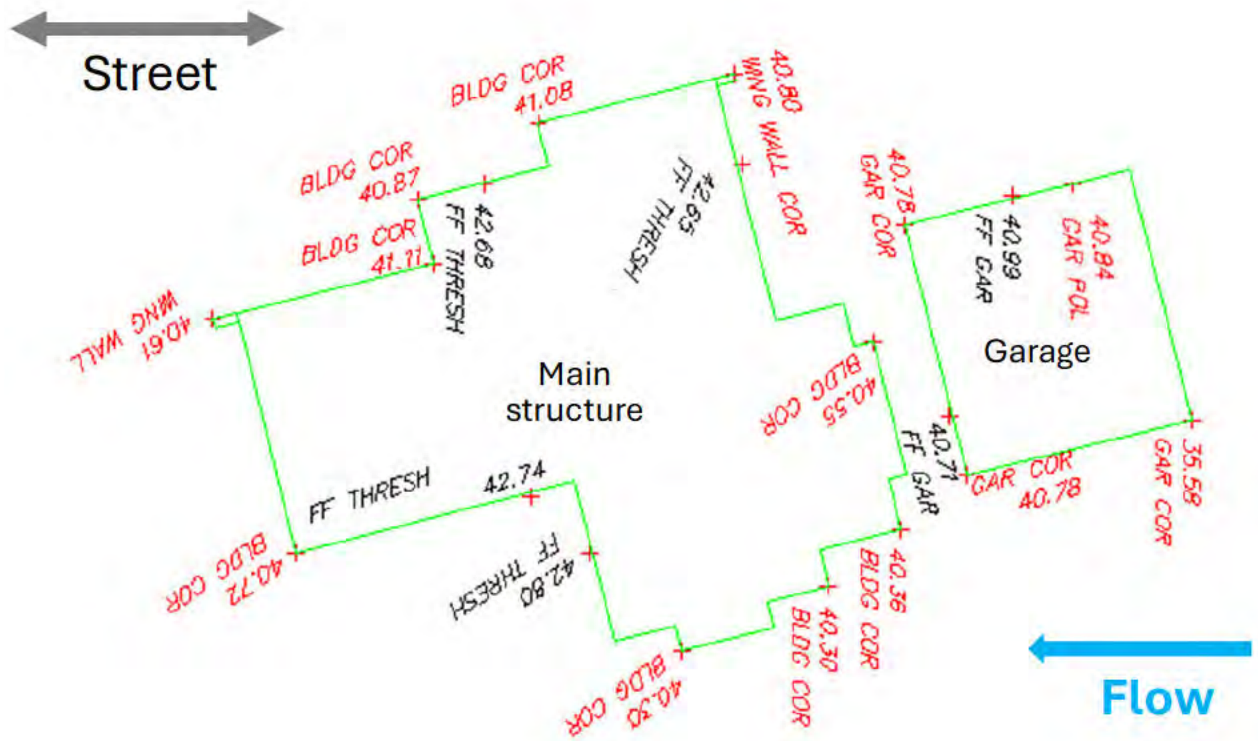
Exhibit No. 10: 10 Winship, Ross

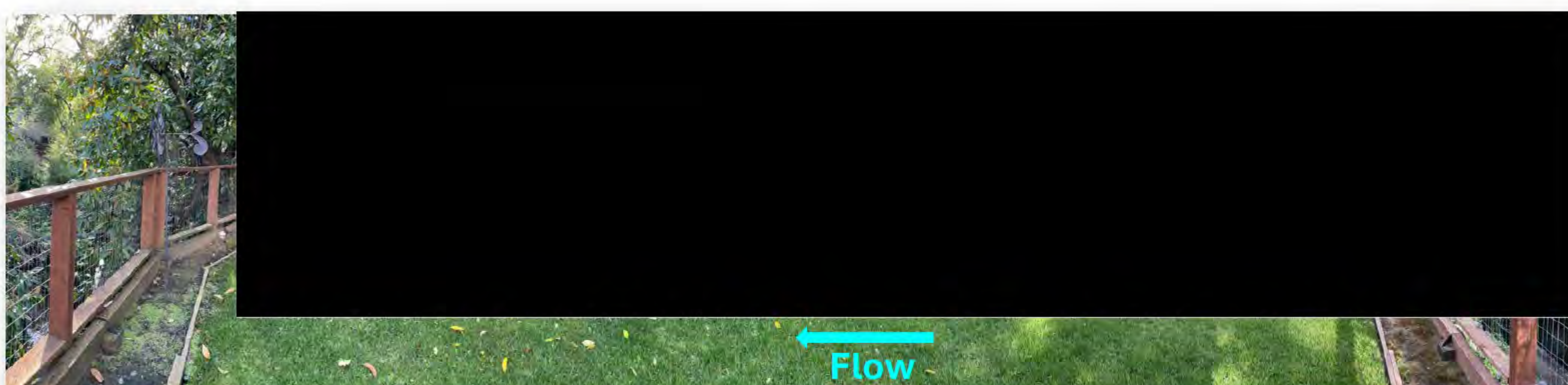




Rise affects garage concrete foundation, which is a flood damage-resistant material.
BFE is below garage finished floor. No mitigation needed.

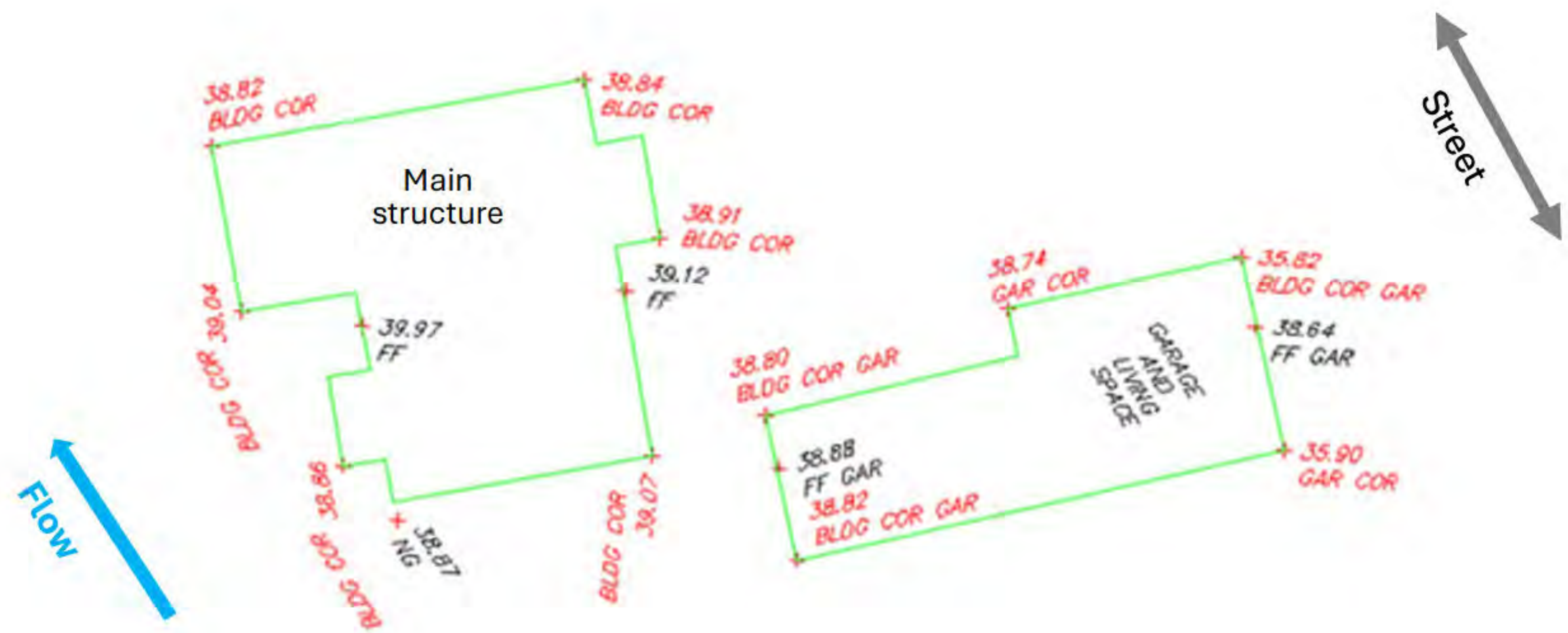
Exhibit No. 11: 100 Sir Francis Drake, Ross - Garage

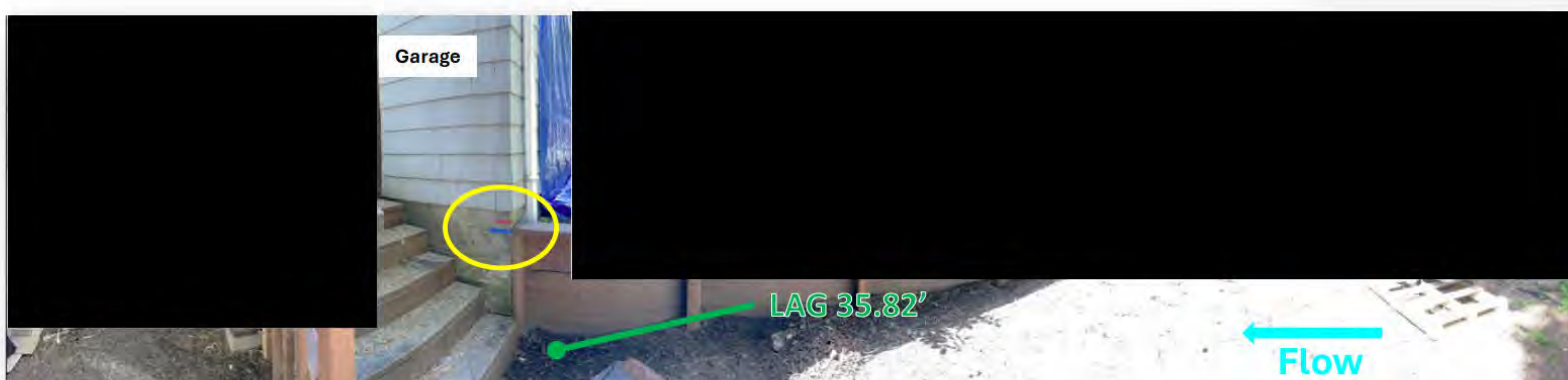




Rise affects timber support, which is a flood damage-resistant material.
No mitigation needed.

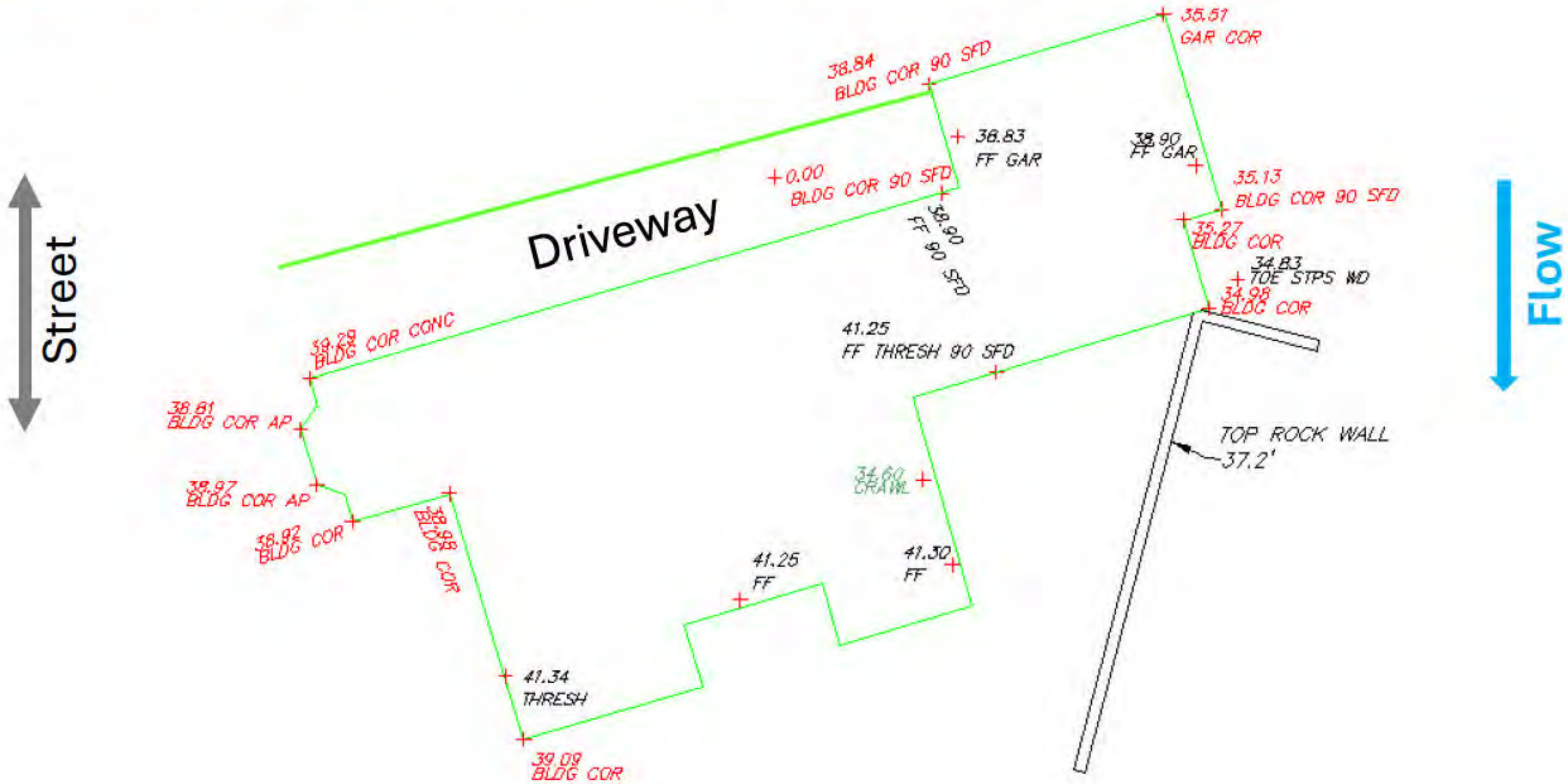
Exhibit No. 12: 92 Sir Francis Drake, Ross - Garage

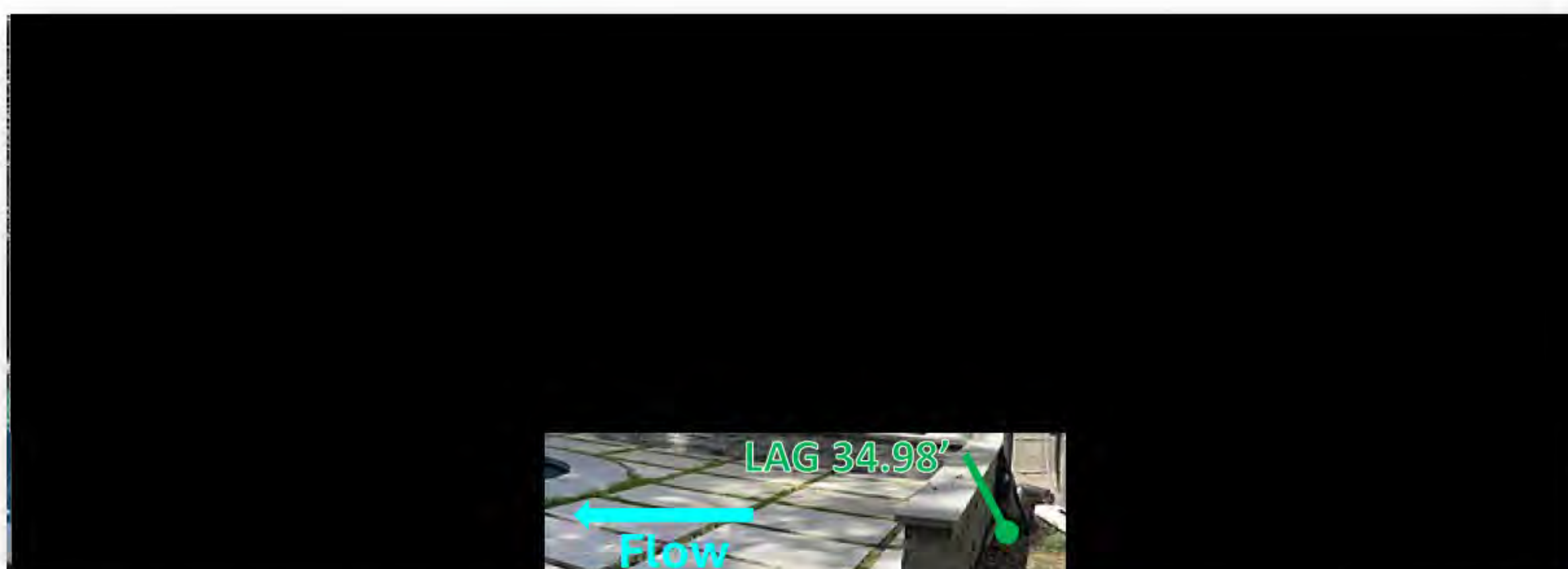


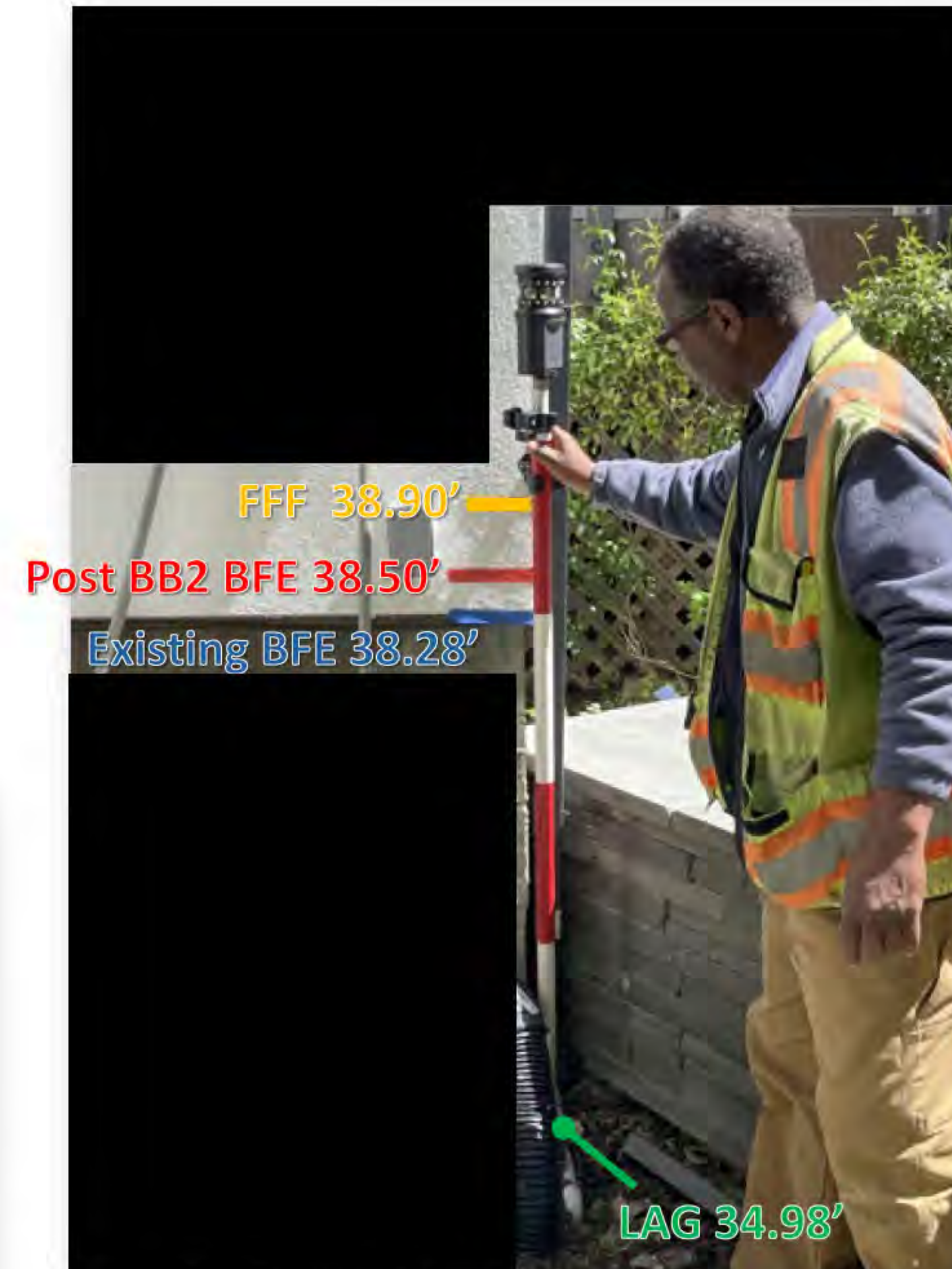


Rise affects garage concrete foundation, which is a flood damage-resistant material. No mitigation needed.

Exhibit No. 13: 90 Sir Francis Drake, Ross

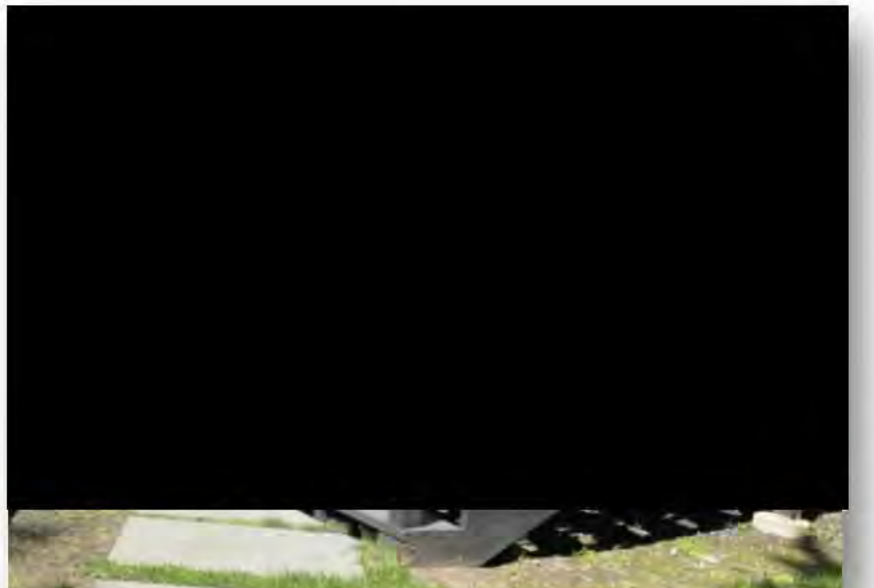




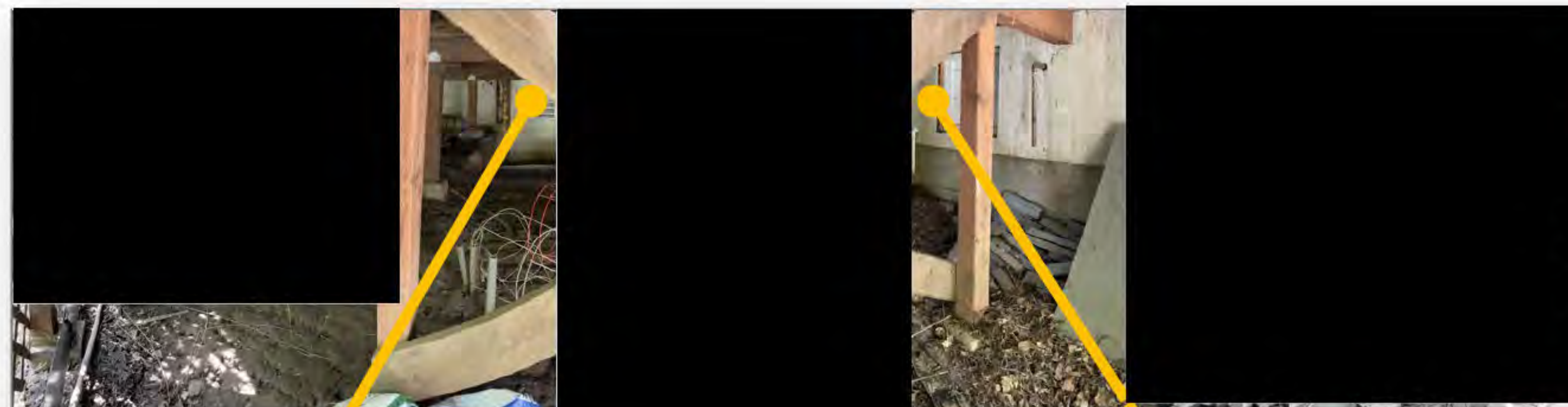


Mitigation includes: elevating electrical boxes; elevating HVAC equipment; installing flood openings for crawl space; and anchoring support beams and floor joists to concrete foundation.

Exhibit No. 13: 90 Sir Francis Drake, Ross



- Electrical outlet
- HVAC equipment



Crawlspace access

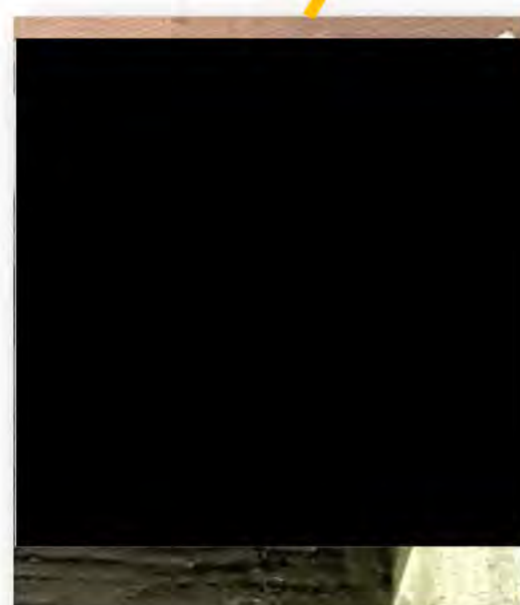
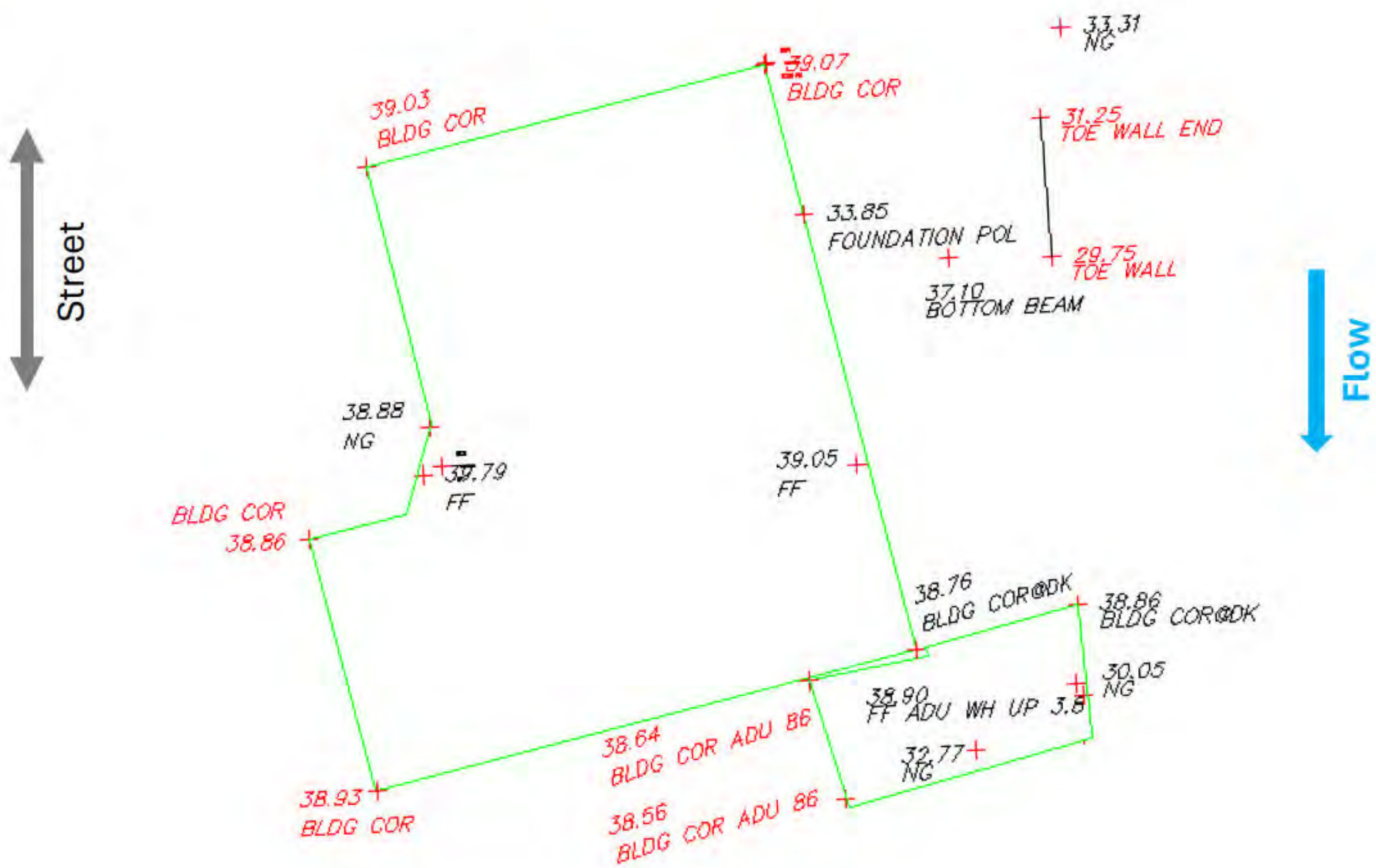
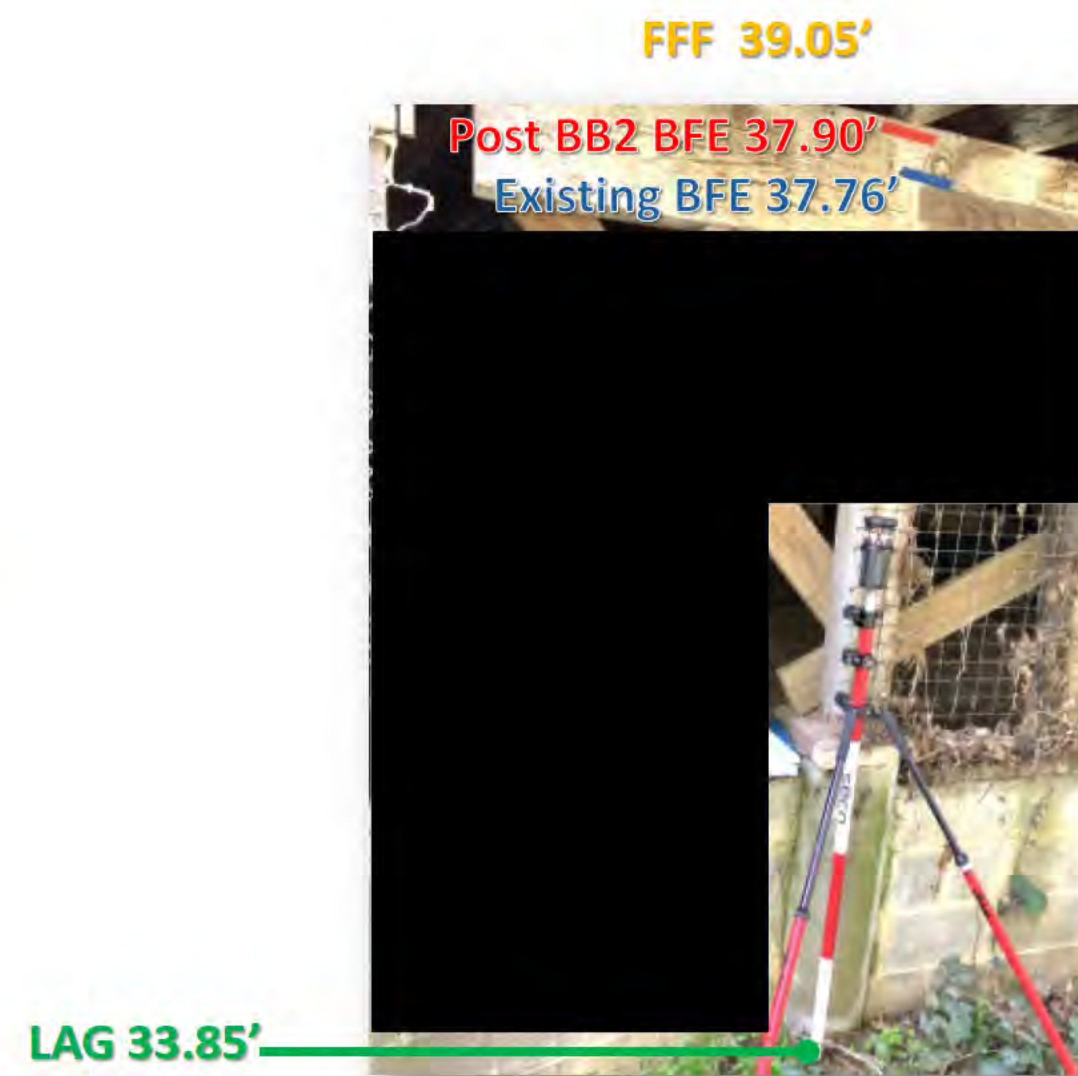
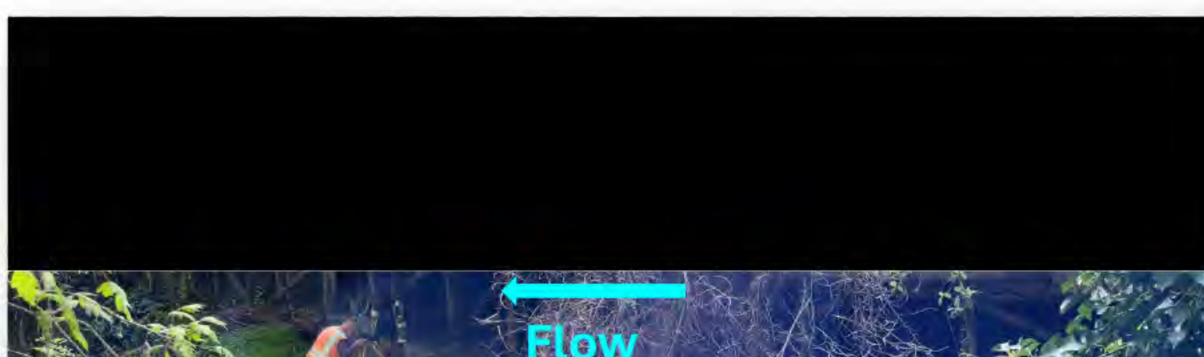
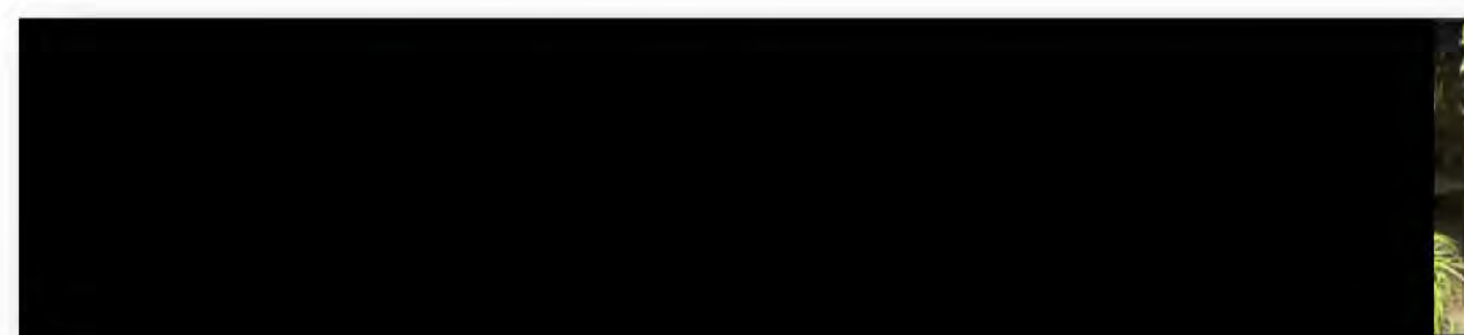


Exhibit No. 14: 86 Sir Francis Drake, Ross



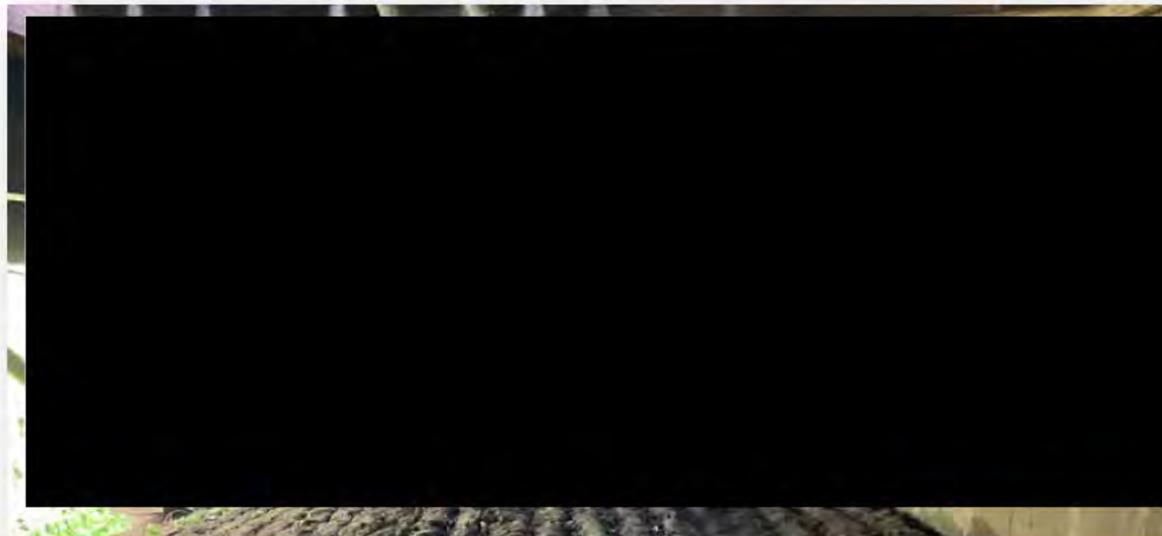


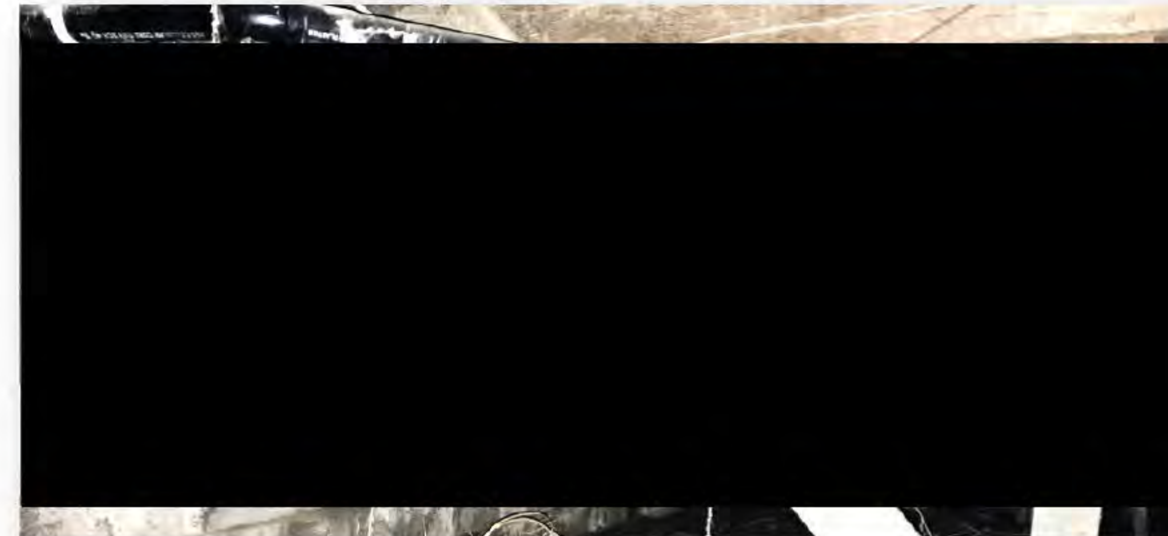




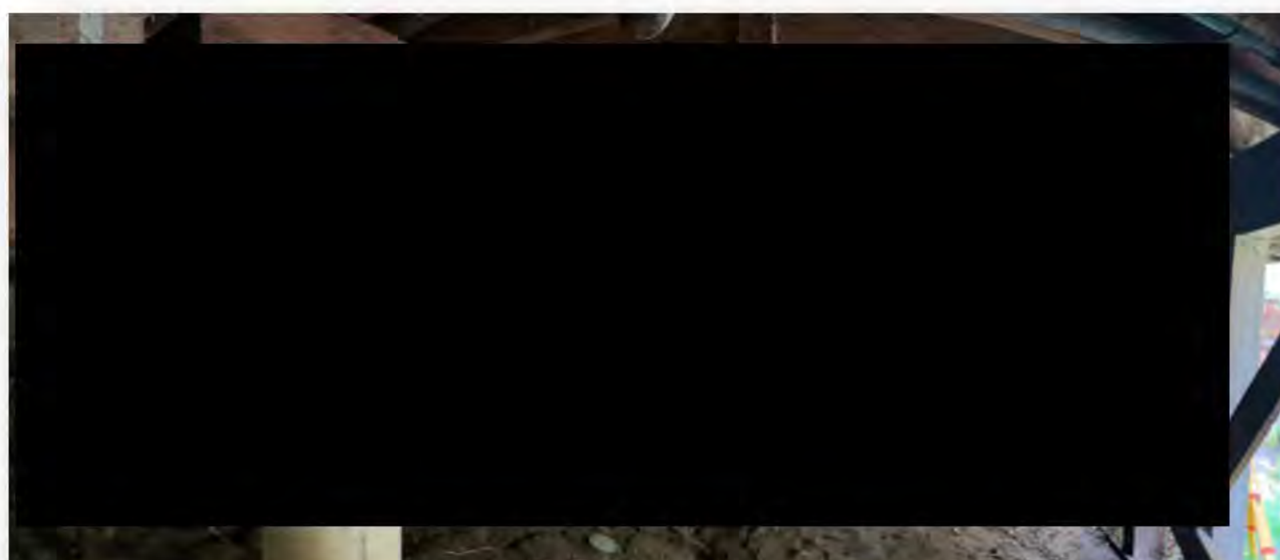
Mitigation includes: securing utility piping to floor joists; and anchoring wooden beams to posts and concrete foundation.

Exhibit No. 14: 86 Sir Francis Drake, Ross



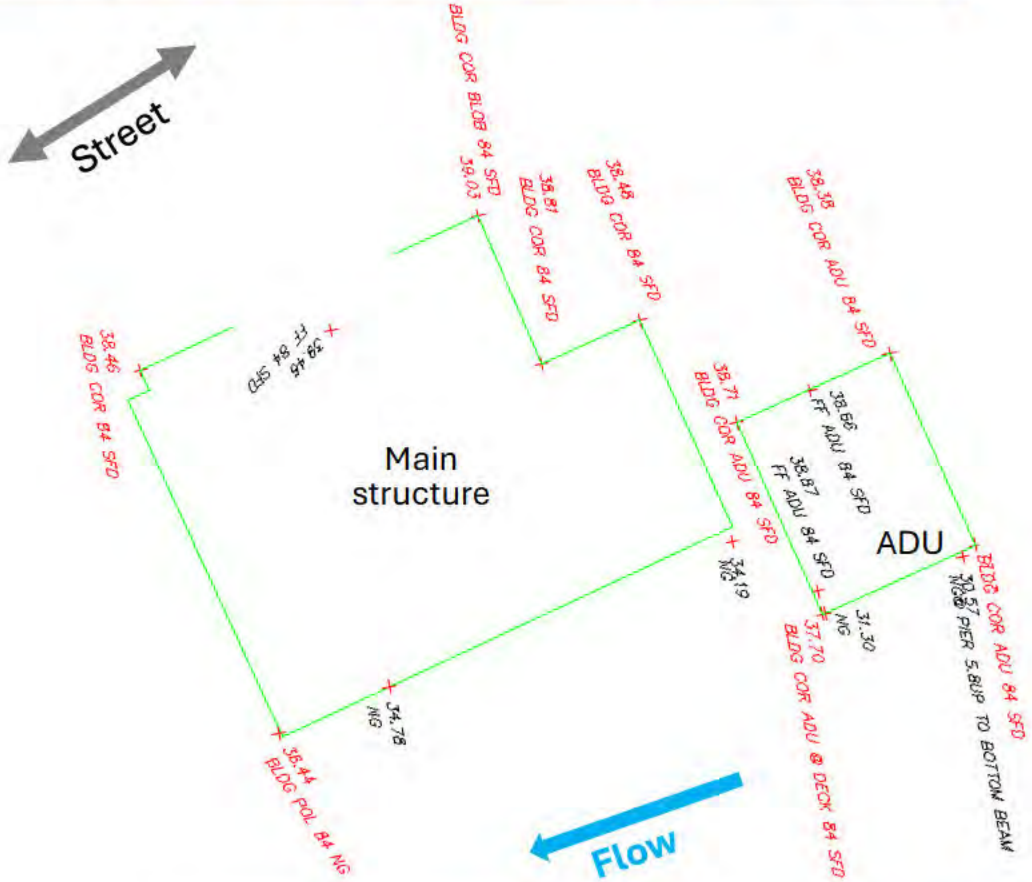


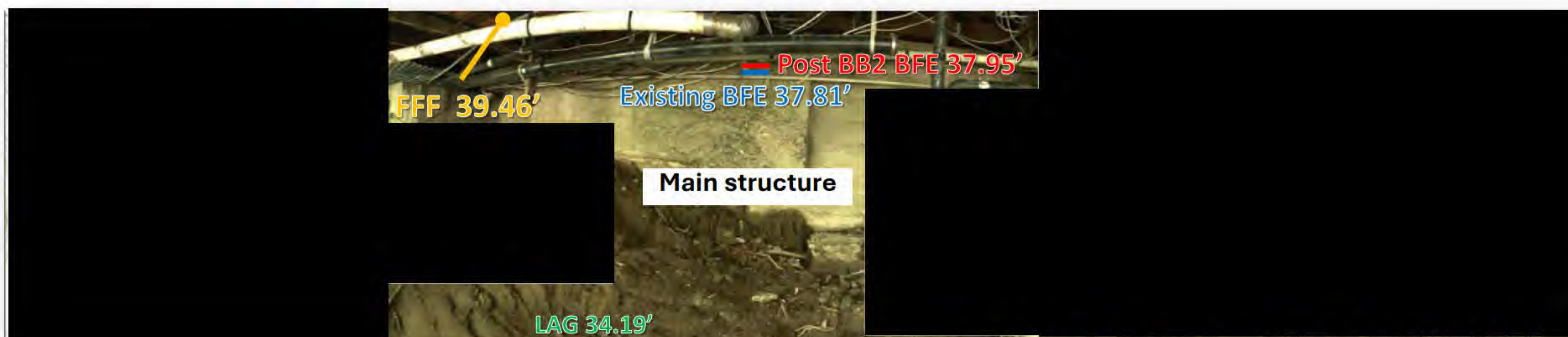
Utility piping



Wooden beams

Exhibit No. 15: 84 Sir Francis Drake, Ross





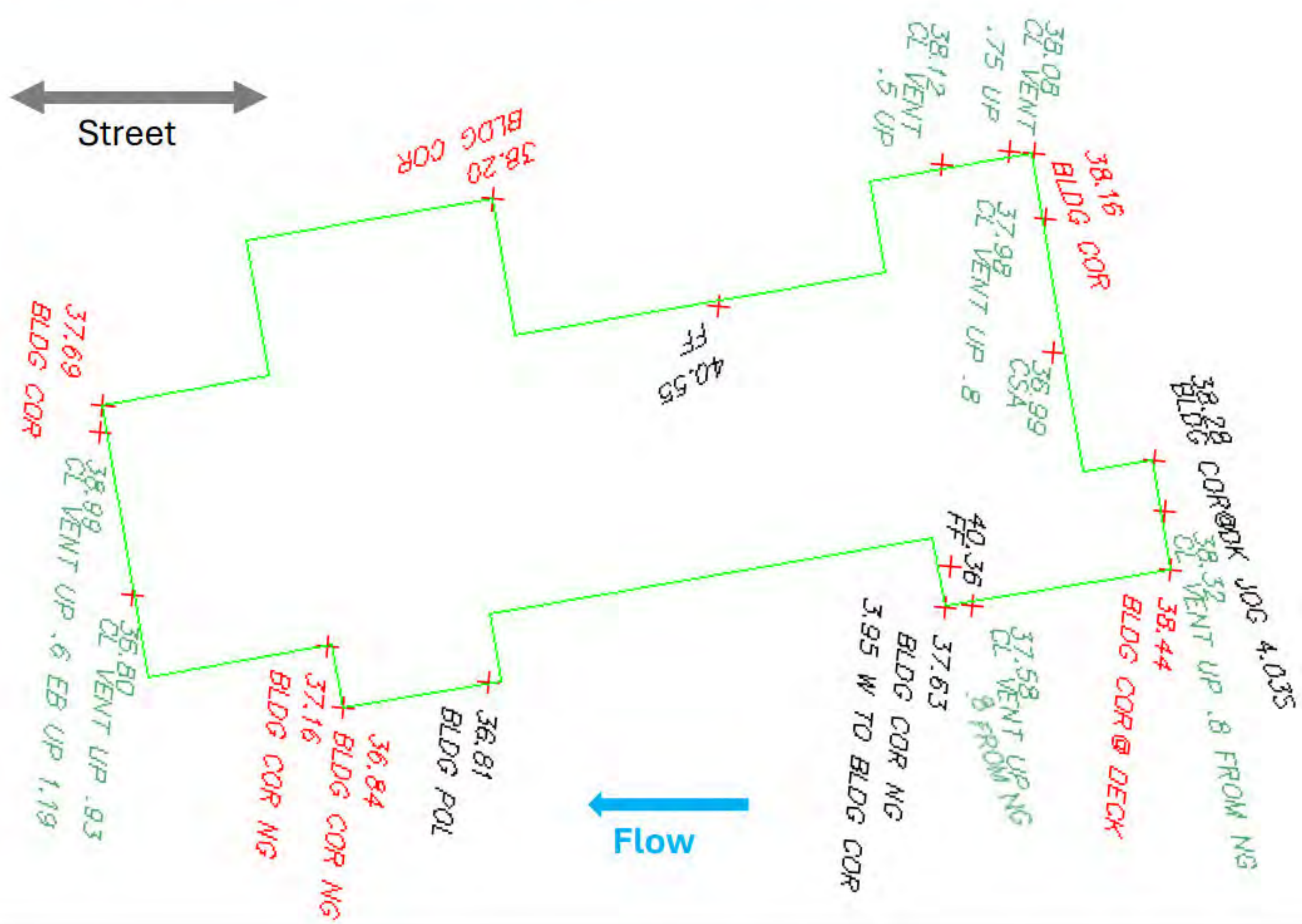
Mitigation includes: elevating and securing wiring and utility piping to underside of joists; anchoring wooden beams to posts and concrete foundation; and anchoring tank.

Exhibit No. 16: 84 Sir Francis Drake, Ross ADU

Wooden beams

Mitigation includes anchoring wooden beams to posts and concrete foundation.

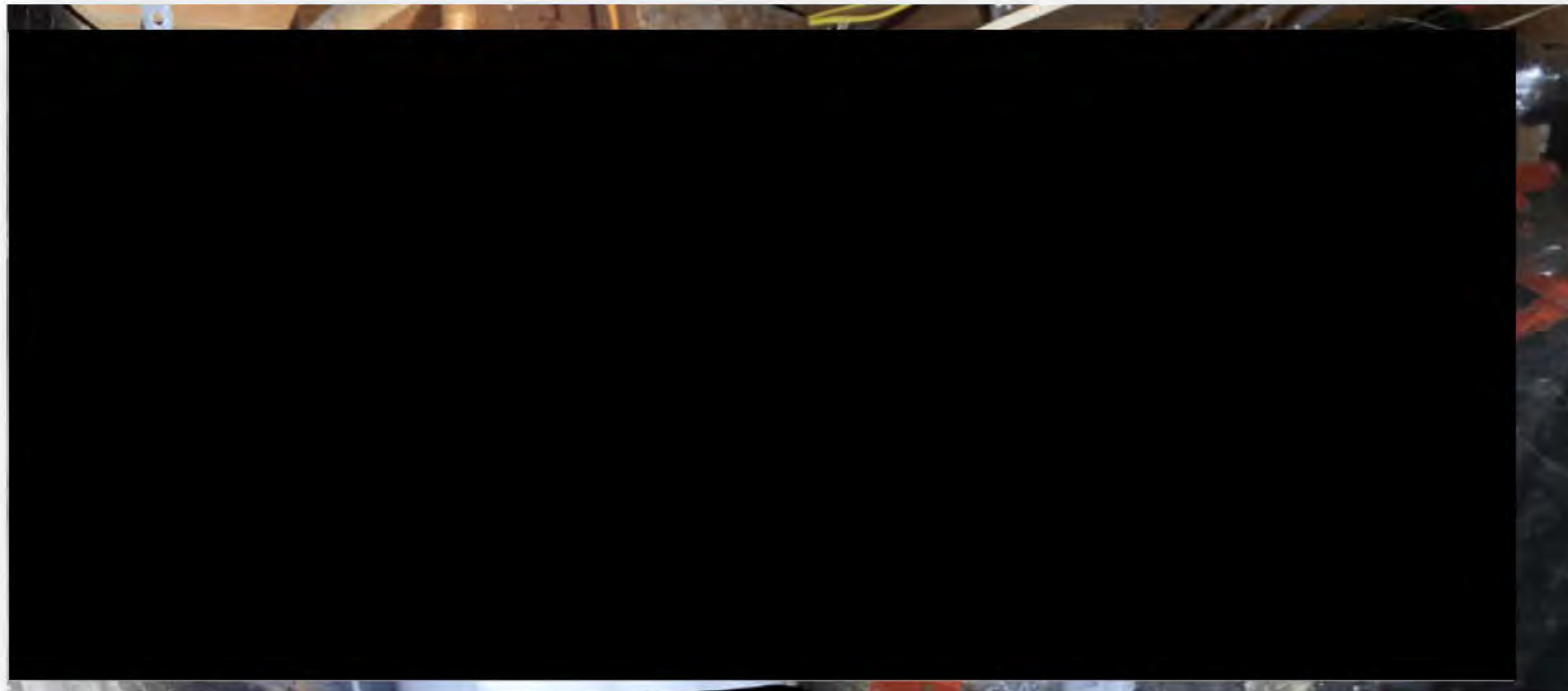
Exhibit No. 17: 82 Sir Francis Drake, Ross



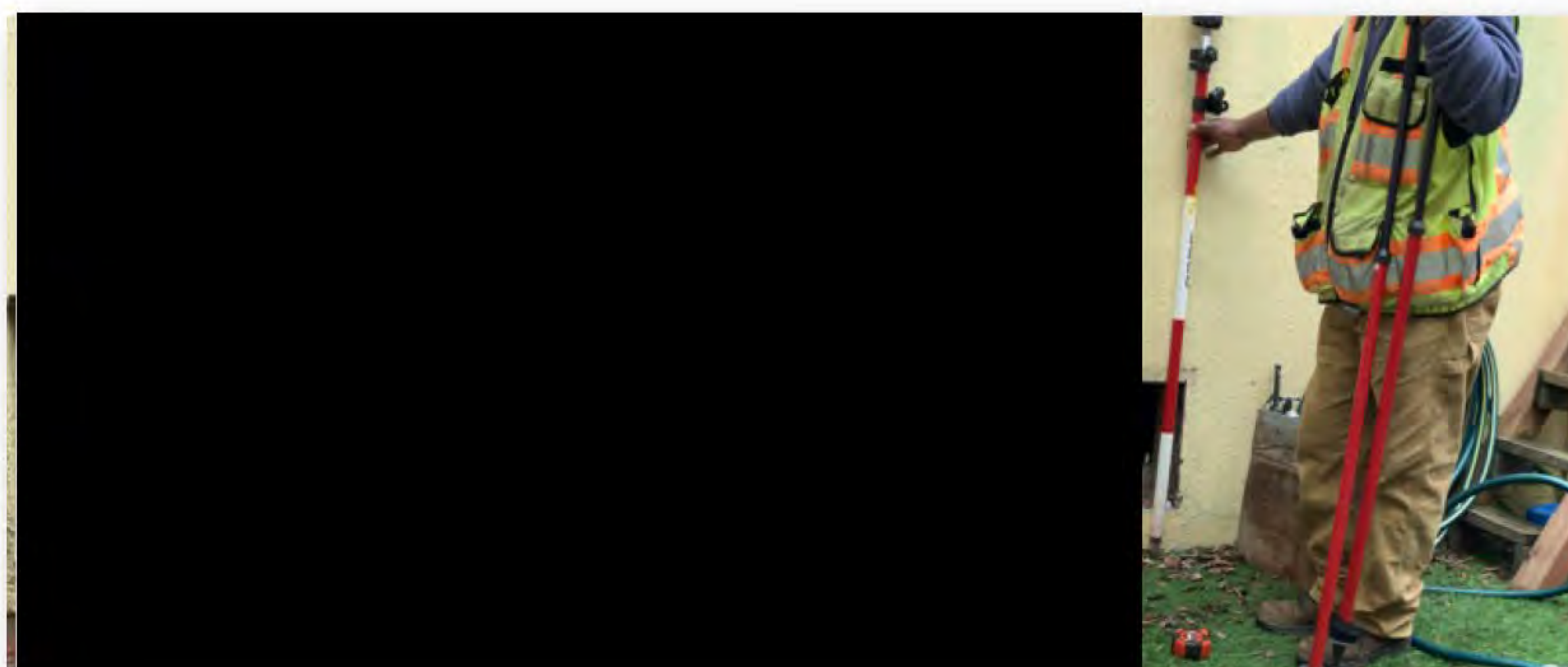
[redacted]

Mitigation includes: elevating electrical boxes; and installing flood openings in crawlspace.

Exhibit No. 17: 82 Sir Francis Drake, Ross

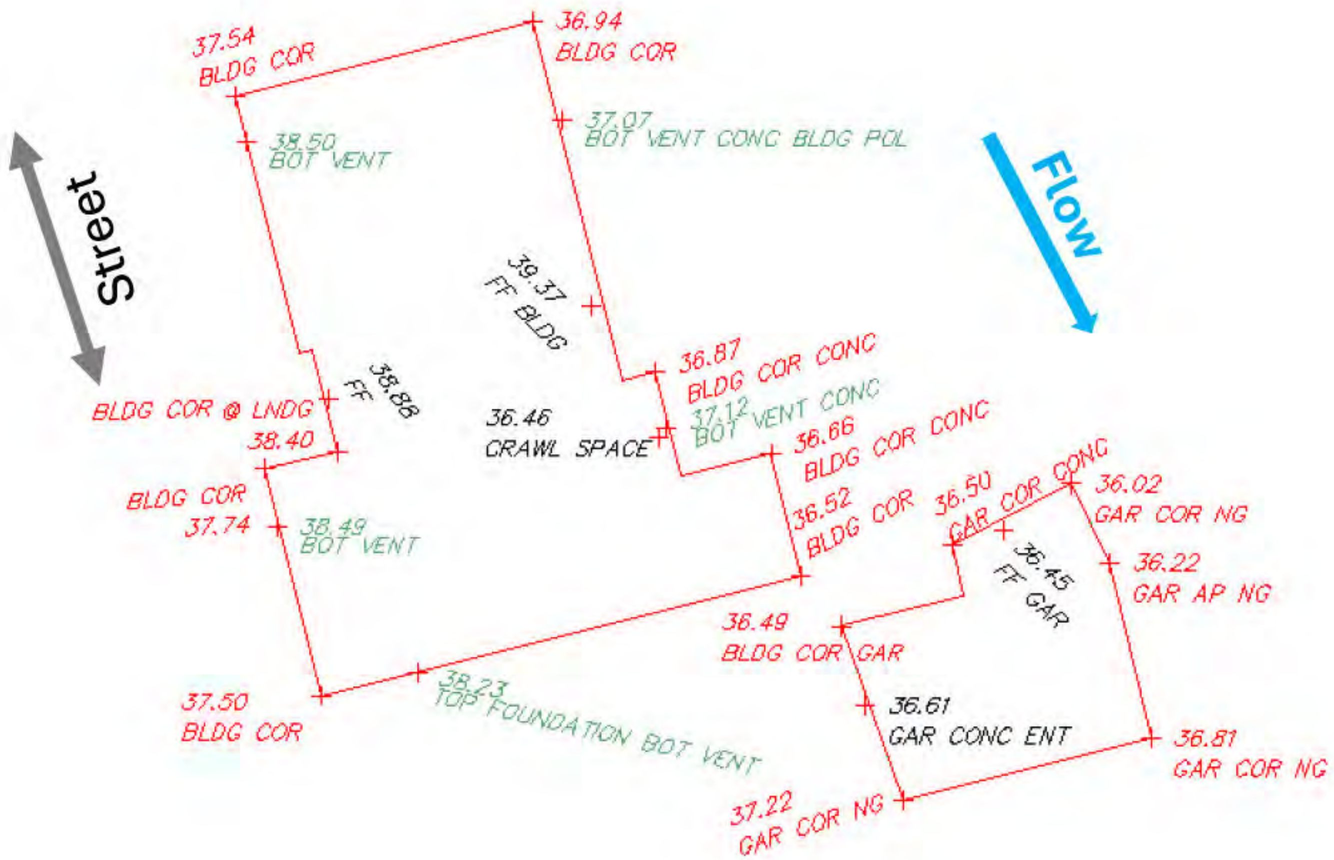


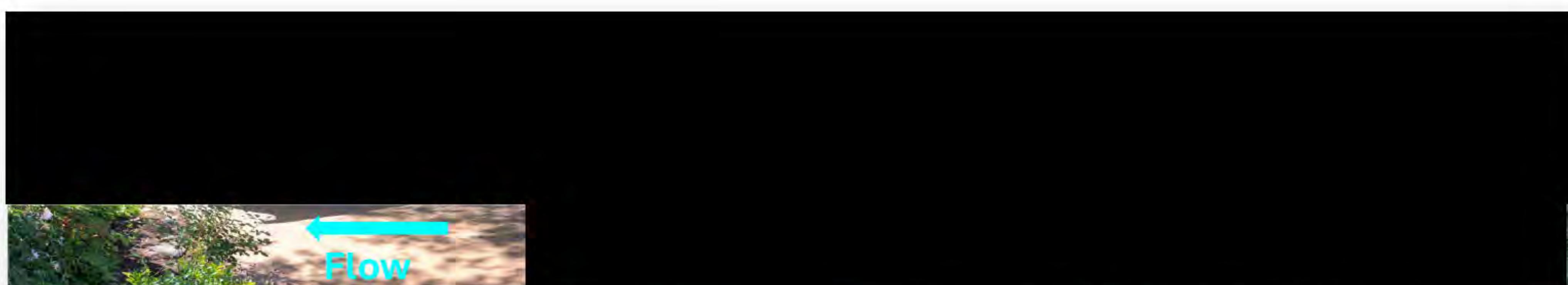
Electrical boxes

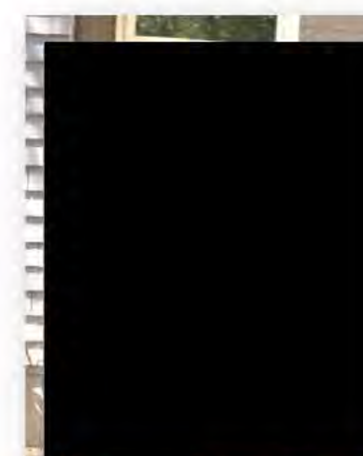


Crawlspace

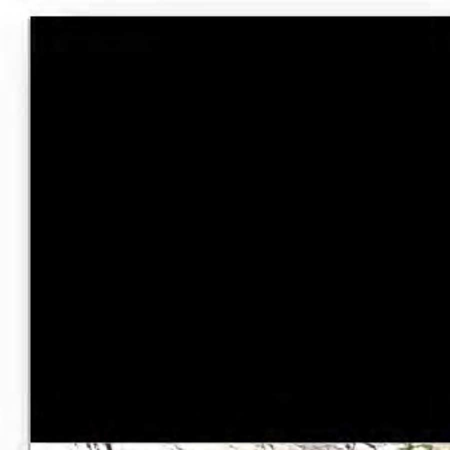
Exhibit No. 18: 78 Sir Francis Drake, Ross







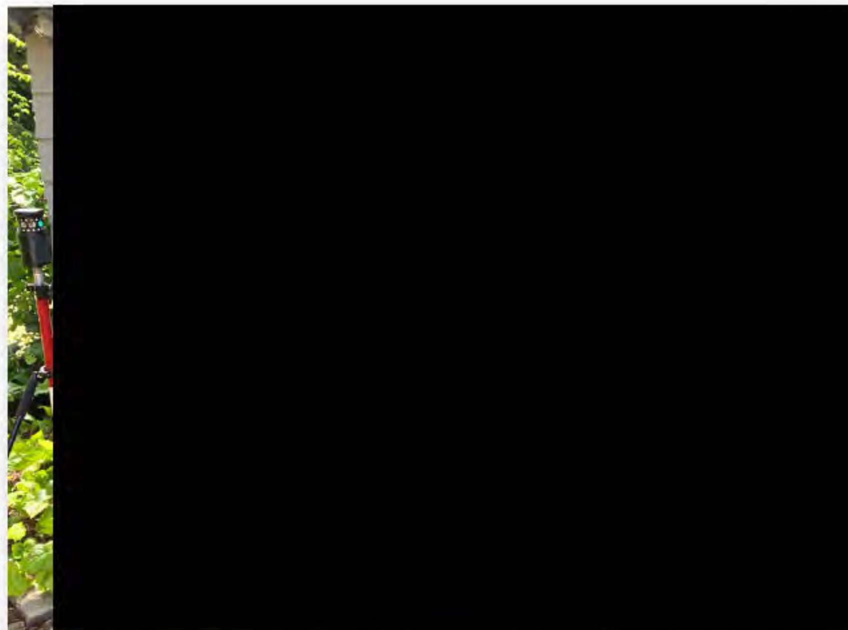
Crawlspace

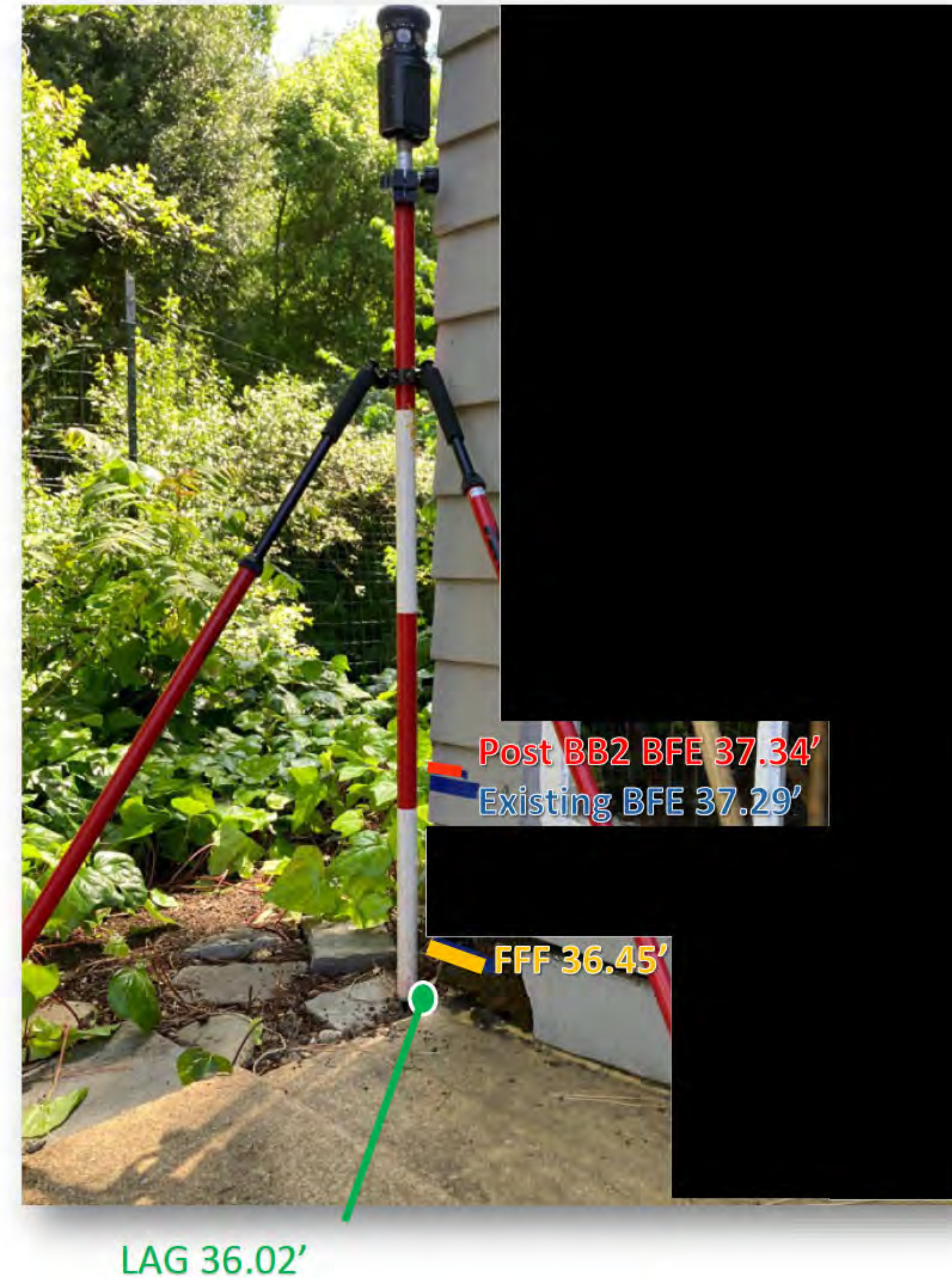


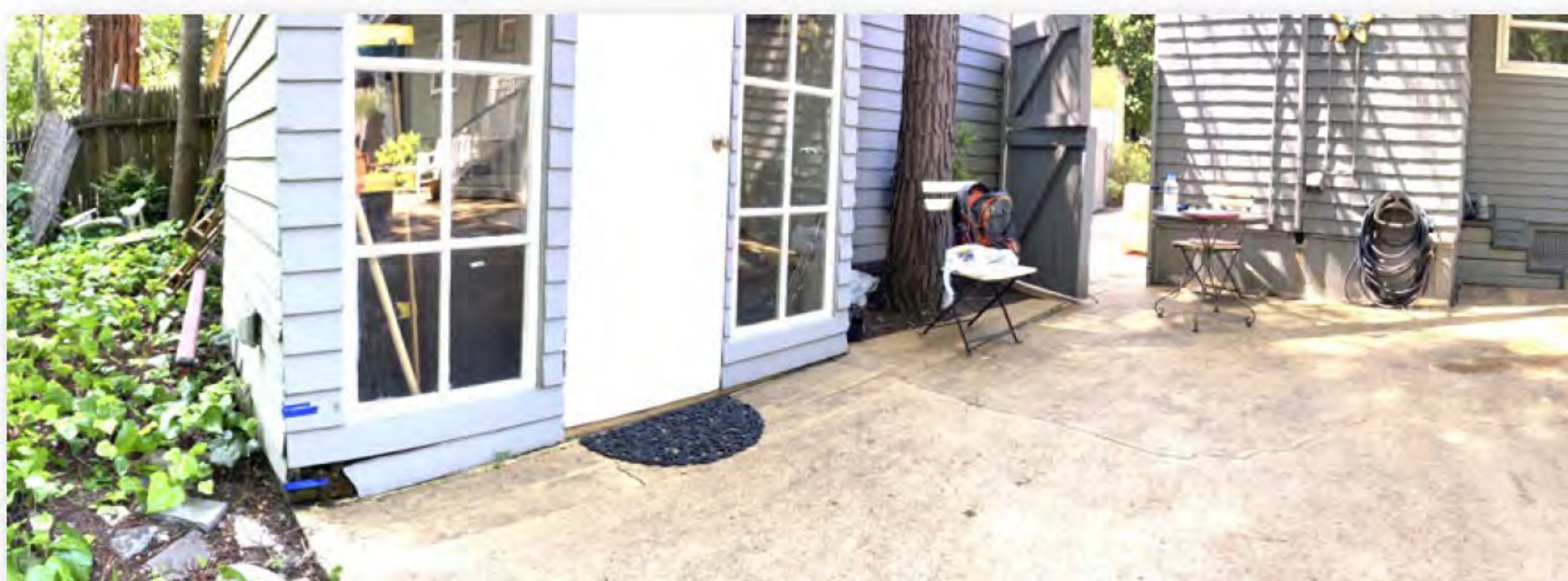
Utility piping

Mitigation includes: installing flood openings for crawlspace; elevating and securing utility piping in crawlspace.

Exhibit No. 19: 78 Sir Francis Drake, Ross - Garage



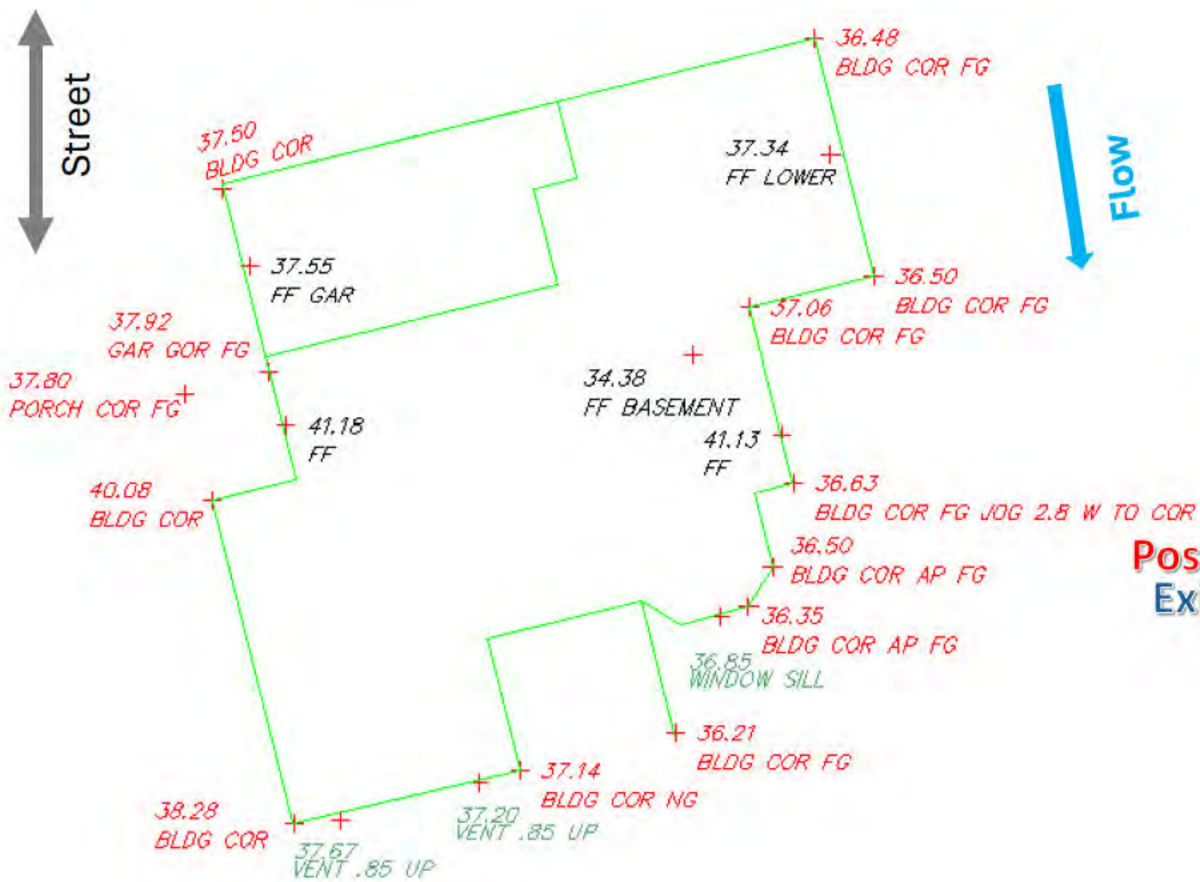


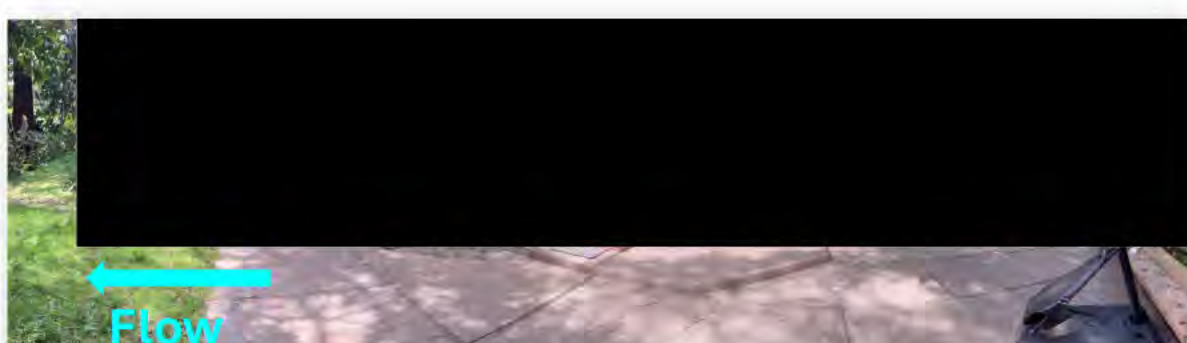


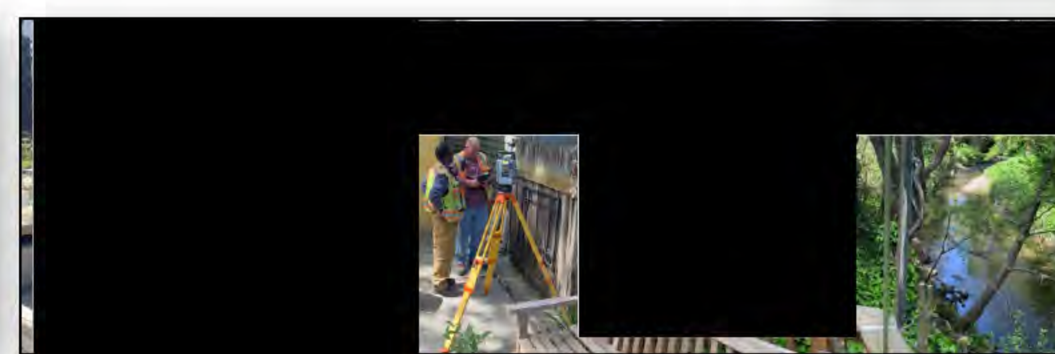
Garage

Mitigation includes installing flood openings for garage.

Exhibit No. 20: 74 Sir Francis Drake, Ross



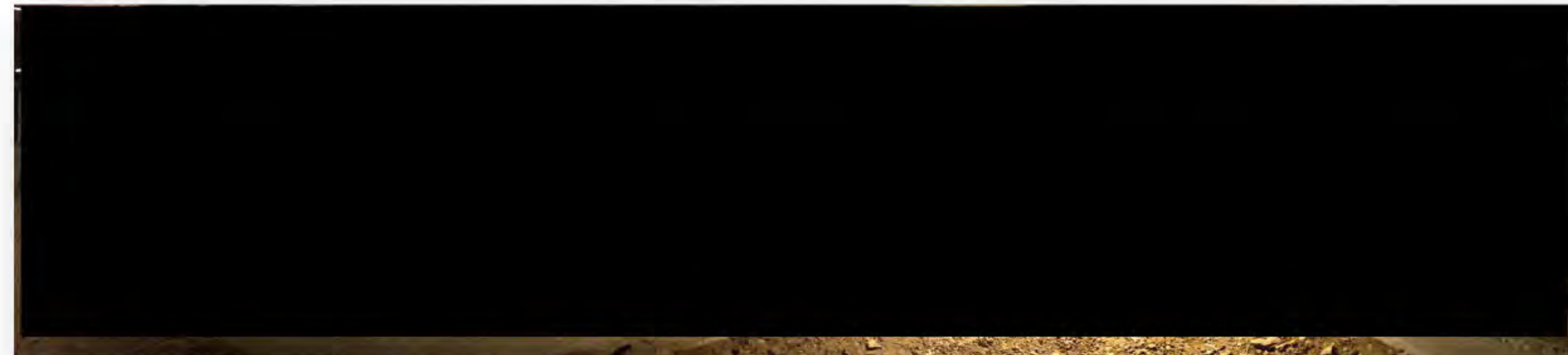




Mitigation includes: relocating HVAC unit in crawlspace to higher elevation; securing electrical/utility piping in crawlspace to underside of floor joists; installing flood opening in crawlspace and back of garage level; and anchoring building to foundation.

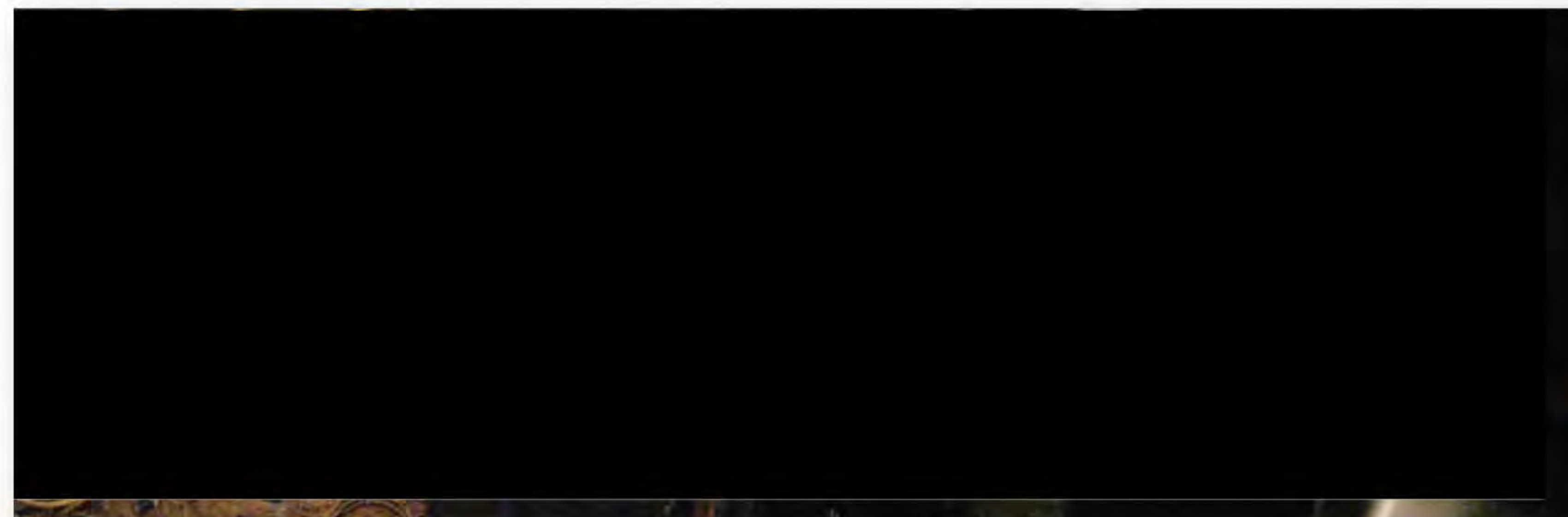
Note: Mitigation is consistent with enclosure used solely for parking of vehicles, building access, or storage. Town of Ross does not have records to indicate whether the lower back room at garage level is a permitted living space and bathroom.

Exhibit No. 20: 74 Sir Francis Drake, Ross

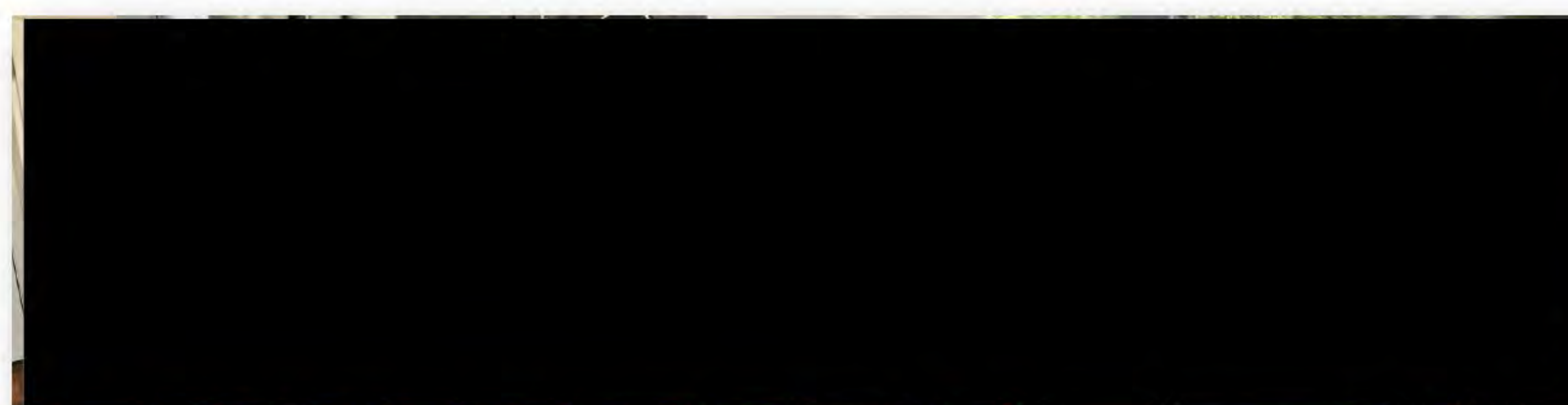


Electrical conduits and utility piping in crawlspace

Basement window

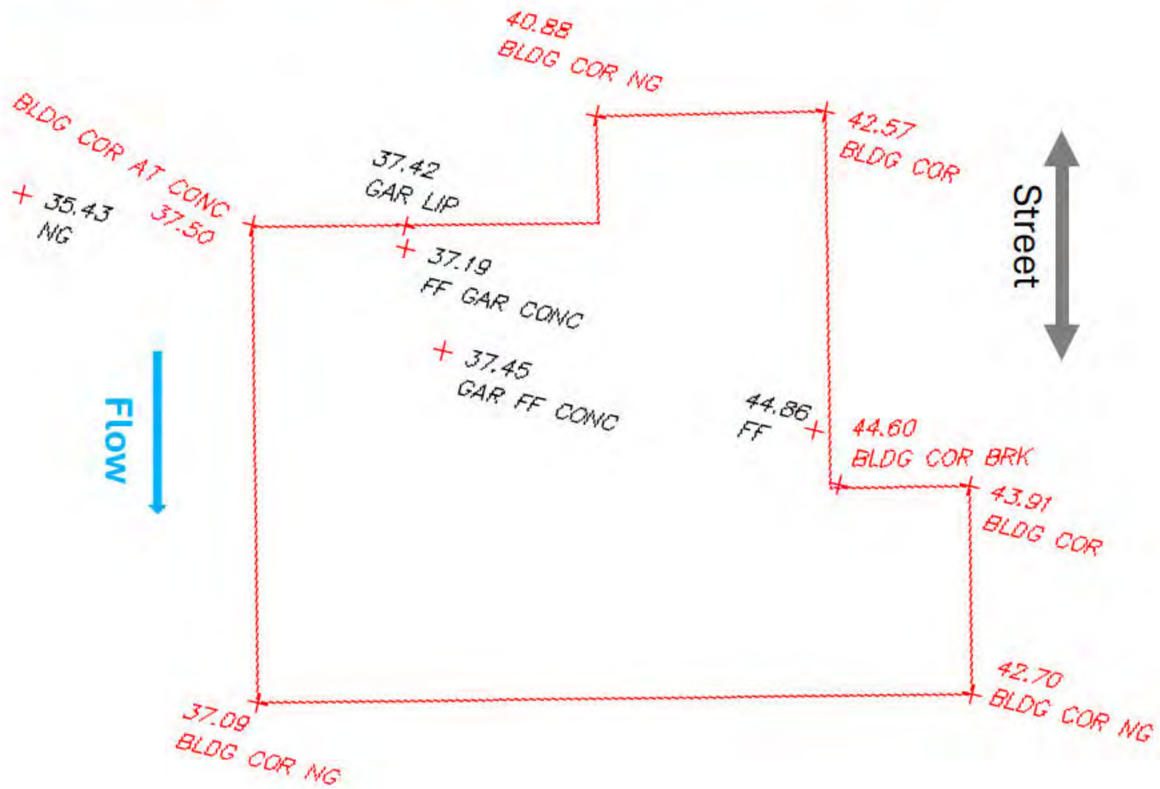


HVAC equipment

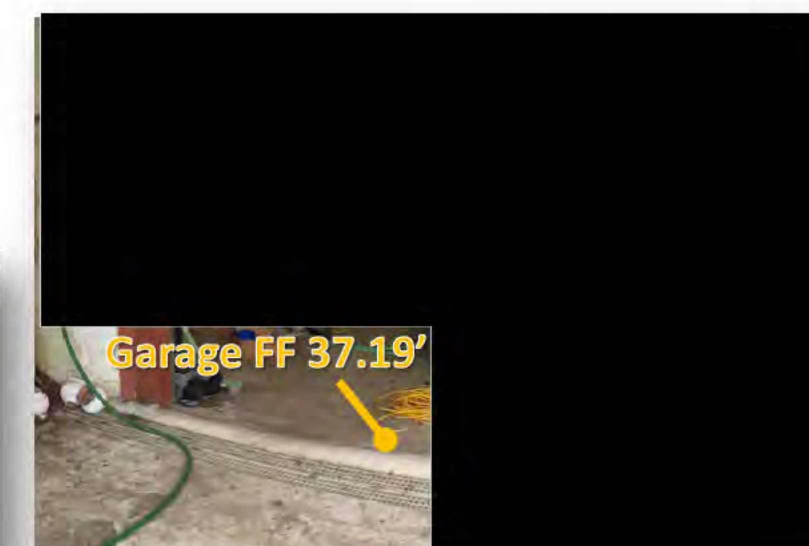


Lower back room
at garage level

Exhibit No. 21 - 20 Winship, Ross



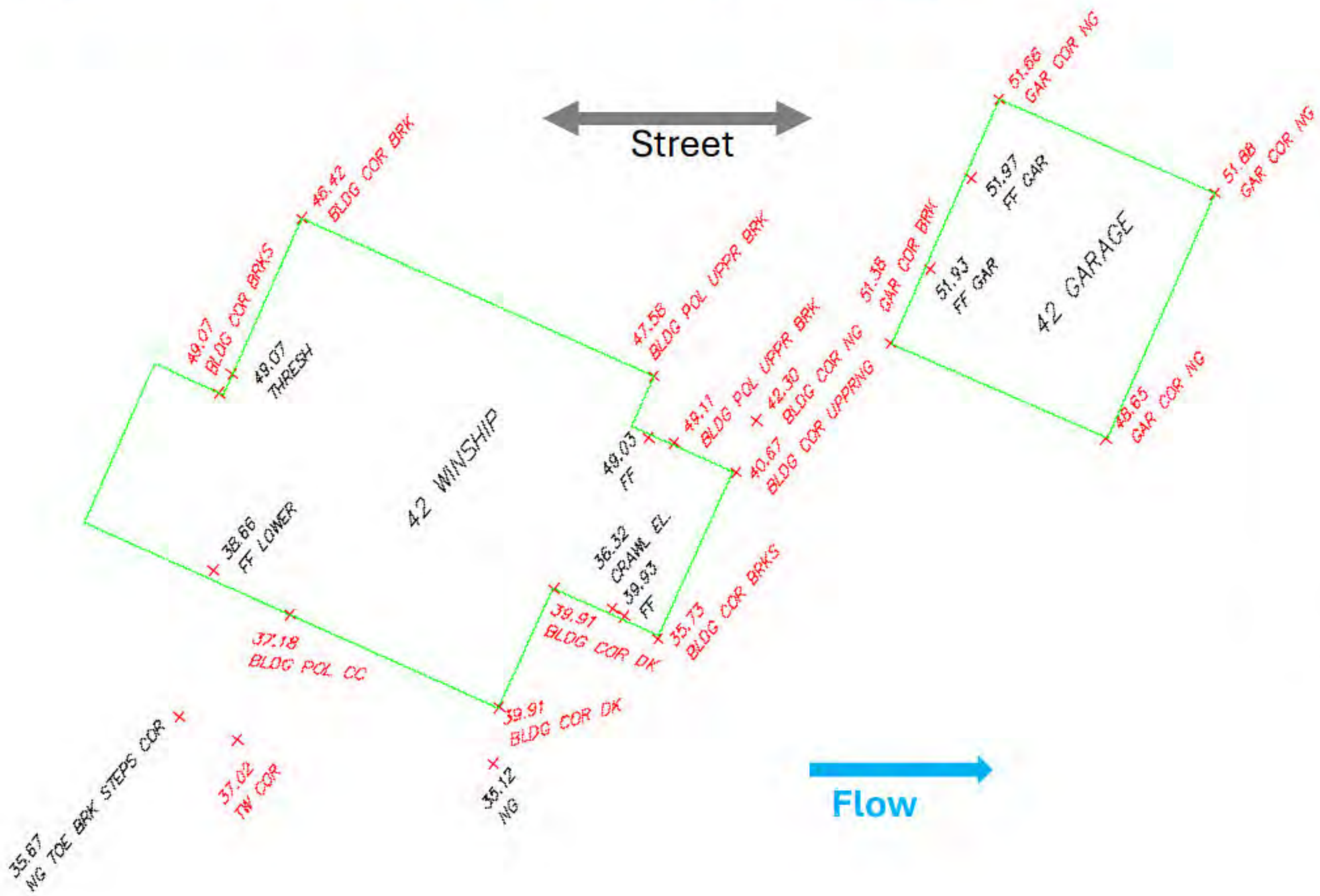
HVAC & water heater equipment

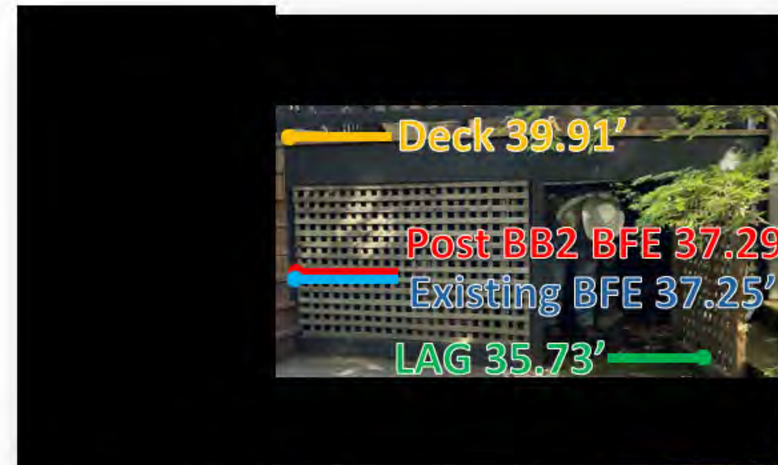


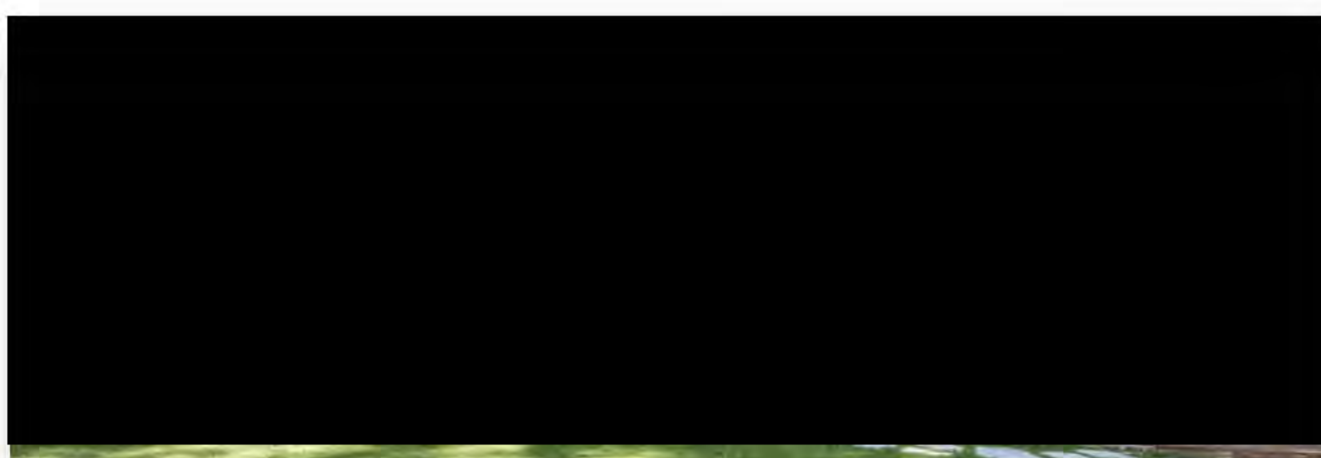
Garage

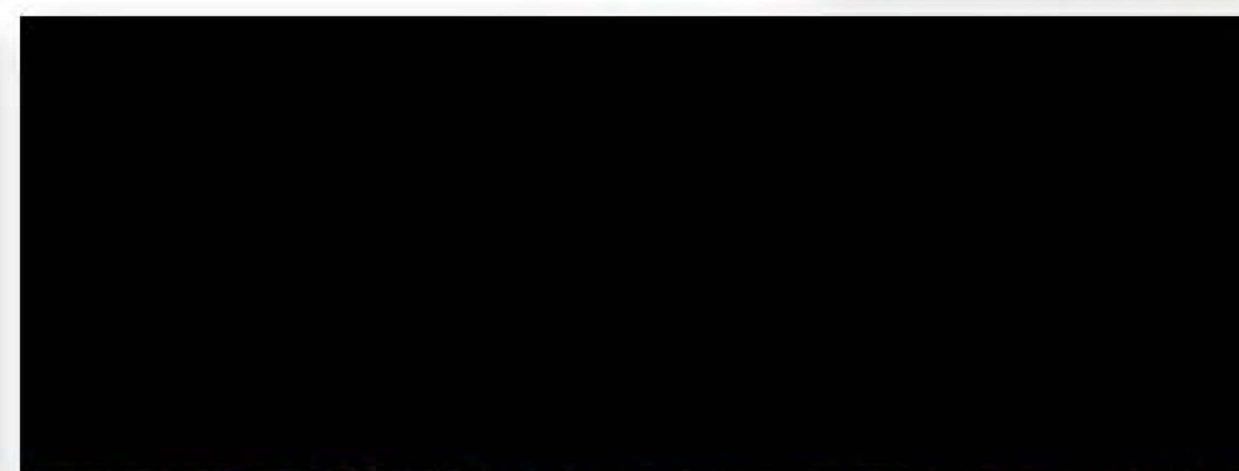
Mitigation includes: elevating HVAC and water heater equipment; installing flood openings in garage door and/or garage exterior walls.

Exhibit No. 22: 42 Winship, Ross





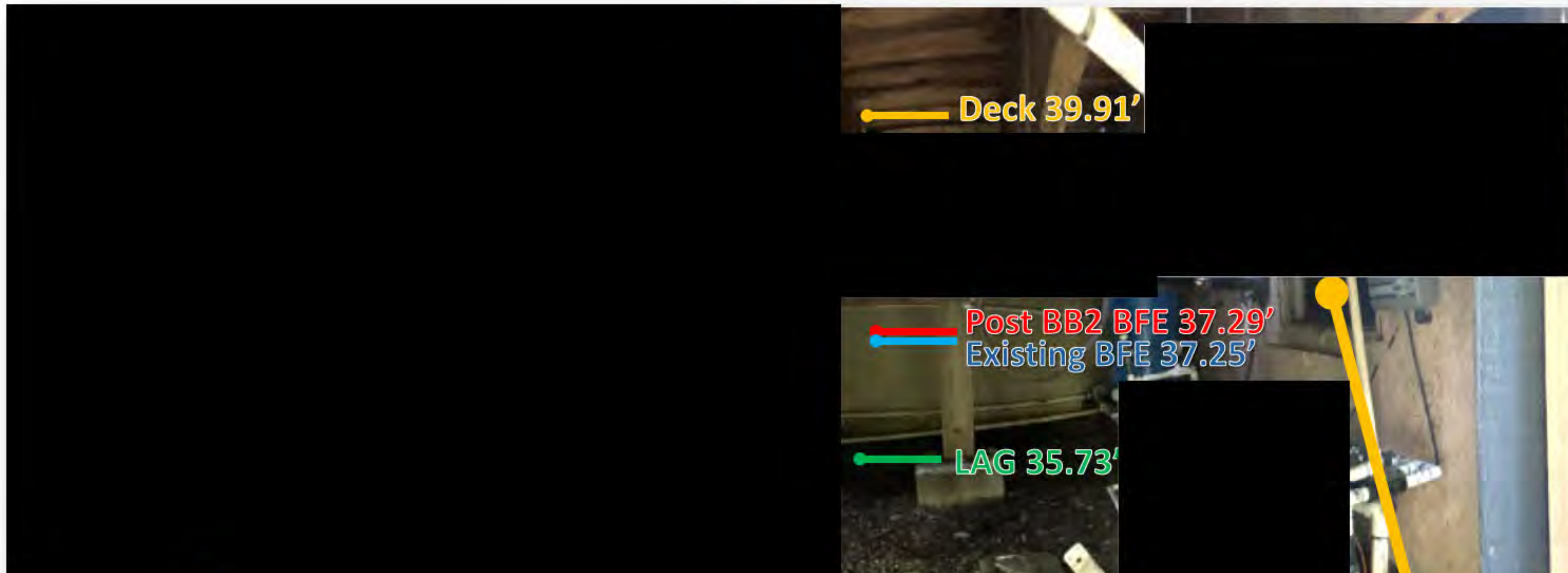




Mitigation includes: relocating fan equipment to higher elevation; elevating and securing utility piping to floor joists; anchoring tank to foundation; and installing flood openings for crawlspace.

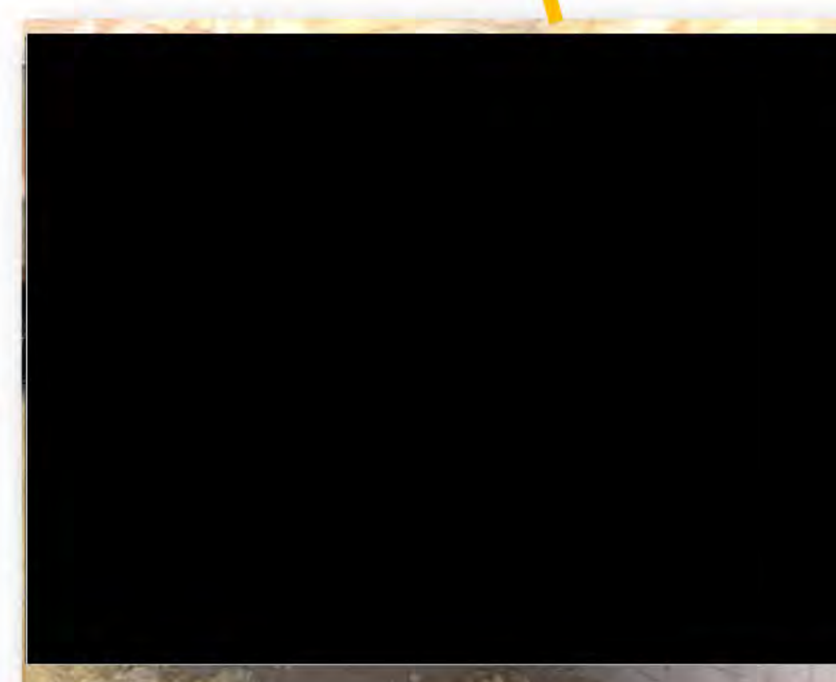
Exhibit No. 22: 42 Winship, Ross

Utility piping, electrical conduits, and tank



Fan equipment

Crawlspace



Attachment 1

Structural Engineering Evaluation of In-Stream Structures

July 9, 2025

An Bartlett
Marin County Flood Control & Water Conservation District
(415) 473- 3259
An.Bartlett@MarinCounty.gov

Re: **Structural Implications of BB2 Removal**

Martin/Martin, Inc. Project

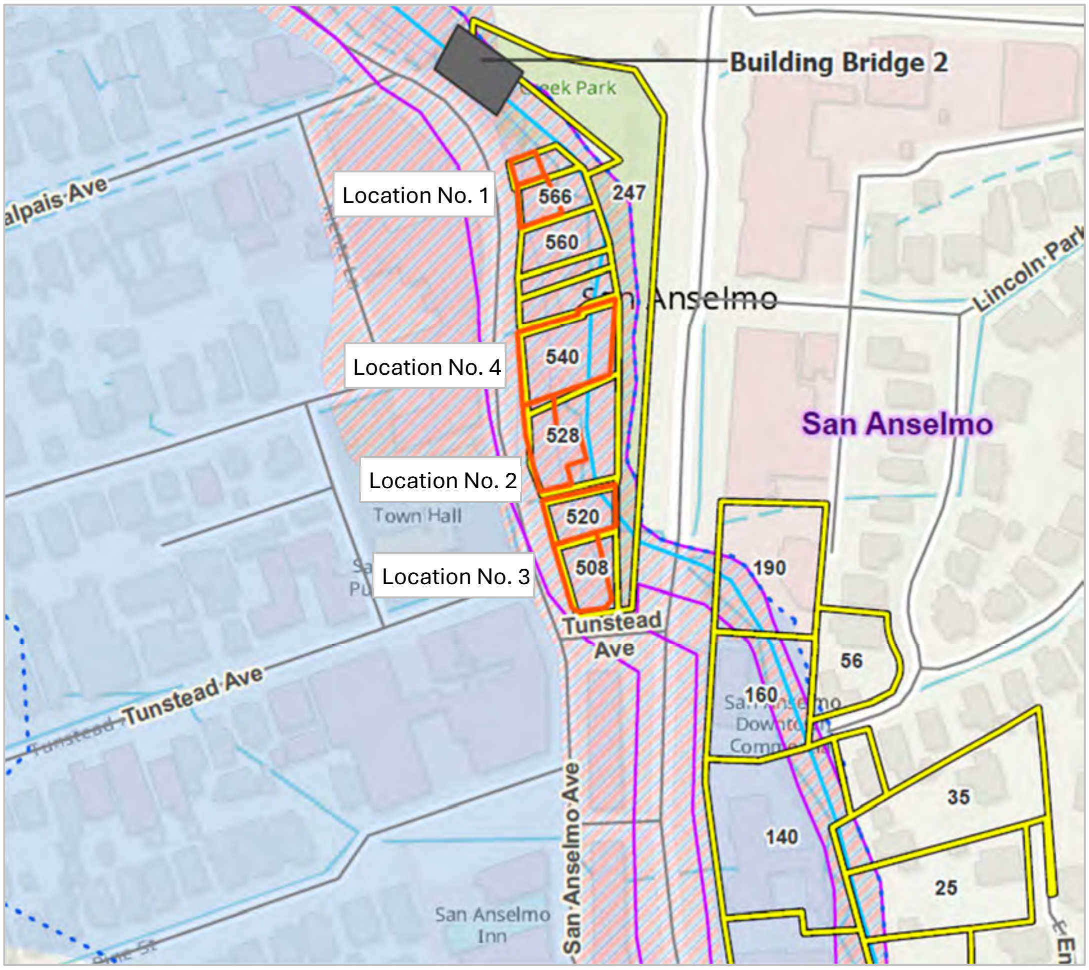
Background

As part of the San Anselmo Flood Risk Reduction (SAFRR) program, the removal of Building Bridge 2 (BB2) is expected to alter creek flow characteristics and increase hydraulic loading on certain structural elements within the San Anselmo Creek bed. Martin/Martin was retained to conduct a limited structural assessment focused on representative elements potentially impacted by the revised flood conditions.

Scope of Assessment:

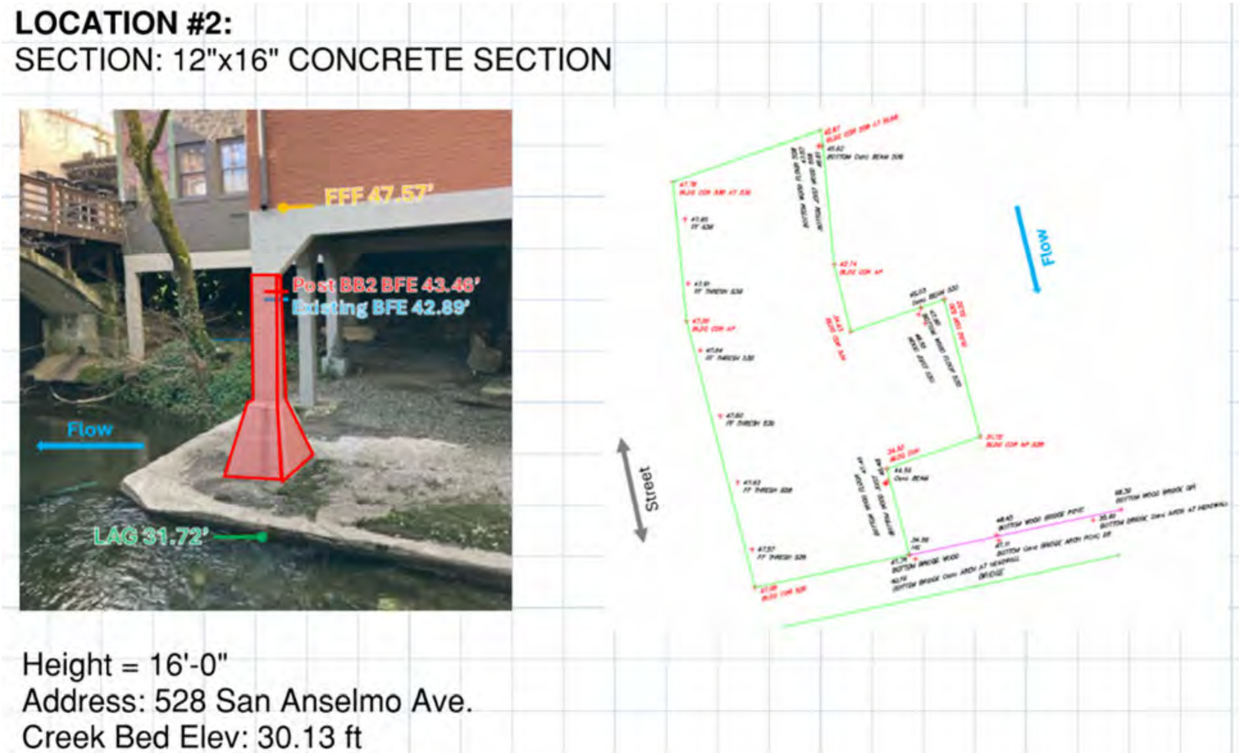
The following points outline the specific scope boundaries and limitations of our evaluation:

1. **Representative Elements Only**
   Our evaluation was limited to visual assessment and basic calculations on a select number of representative concrete columns and one concrete wing wall within the creek bed. We did not assess every column or structural condition along or within the alignment. Representative column locations are shown in the following figures.



Location Map

Location #1 Information for 16x16 Column



Location #2 Information for 12x16 Column

Location #3 Information for 20x20 Column

Location #4 Information for 7 ft Wing Wall

2. **Use of Flood Control District-Provided Flood Loads**
   Structural flood drag forces used in this assessment were determined using flood velocities provided by the Flood Control District and are shown in the following table. The Flood Control District directed us to use the "Modeled BB2 Project Conditions 100-year Channel Velocity" (shown in the blue column). These velocities were determined by Stetson Engineers, Inc. (Stetson). Stetson obtained the current FEMA effective HEC-RAS 1D steady-flow model and associated hydrological and topographical data from the FEMA Engineering Library to develop a corrected HEC-RAS 1-D steady-flow model. The model contained existing conditions and post-BB2 demolition conditions. The modeled water surface elevations and creek flow velocities associated with the 100-year flood, or Base Flood, for post-BB2 demolition were used.

   From the provided velocities, flood forces were calculated using procedures consistent with ASCE 7-22 Supplement 2, which introduces updated methodologies for determining flood loads.

#	Property Building	APN	Address	Modeled BB2 Project Conditions 100yr Channel Velocity (fps)
1	006-102-25a	006-102-25	574 SA Ave	6.62
7	006-102-31a	006-102-31	540 SA Ave	5.54
8	006-102-11a	006-102-11	528 SA Ave	4.47
10	006-102-09a	006-102-09	508 SA Ave	4.53

Provided Flood Velocity Table

3. **Foundations and Scour Not Assessed**
   We did not evaluate the condition, type, or capacity of the existing foundation systems, nor did we assess for potential scour or undermining that may occur due to increased creek flows. These conditions are critical to structural performance and are outside the scope of this evaluation.

   Scour, the erosion of soil around foundation elements due to high-velocity water flow, is a leading cause of structural failure in flood-prone environments. Shallow foundations, such as spread footings, are especially susceptible to scour, which can result in settlement or complete loss of support. While deep foundations like piles offer more resilience, they too can be compromised if erosion is significant or if undermining occurs around pile groups.

   At this time, the specific foundation types supporting the evaluated elements are unknown. No construction drawings or documentation exist to confirm whether the columns and wing wall are supported by shallow or deep foundations. A meaningful assessment of scour risk and foundation integrity would require both a geotechnical investigation and physical exposure (e.g., selective excavation or test pits) to verify the existing foundation depth, configuration, and material condition.

   Without this information, no conclusions can be made regarding the structural adequacy or vulnerability of the foundation systems under revised flood conditions.

4. **No Connection Analysis**
   The assessment did not evaluate top or bottom connections (e.g., between column and framing above or foundation below). Load transfer mechanisms and structural continuity have not been confirmed.

5. **Limited Conditions Assessment**
   The existing material conditions and concrete quality at the column locations were not formally assessed as part of this study. However, visual observations identified signs of deterioration at several locations, including exposed aggregate and surface cracking. For the purposes of analysis, a cracked concrete section was conservatively assumed, but no additional material degradation factors were incorporated into the calculations.

   To better characterize the structural performance of the creek structures, we recommend a more comprehensive evaluation of each column's condition. Expanding the assessment beyond the three representative cases studied in this report would provide a more accurate understanding of existing conditions and inform future repair or retrofit strategies.

Example of Concrete Spalling Not Evaluated in Report

6. **No Drawings or Testing**
   No original engineering drawings or construction documentation were available for review. No field testing (e.g., GPR scanning for rebar, concrete strength testing) has been performed. All assumptions were made based on visible geometry and assumed plain (unreinforced) concrete conditions. A further analysis was performed based on the minimum steel requirements per ACI 1963 which are noted in the following figure.

Requirement	Value
Min. longitudinal steel	1% of gross area
Max. longitudinal steel	8% of gross area
Max. tie spacing	Least of: - 16 × longitudinal bar dia. - 48 × tie bar dia. - Least column dimension

For both cases, the concrete compressive strength (f'c) was assumed to be 2500 psi in calculations. For the case including minimum reinforcing, the rebar was assumed to be grade 60.

The results of the minimum reinforcing steel cases are summarized in the following conclusions. Full calculations and results can be found in Appendix A.

Concrete Column Conclusions:

Column 1

COLUMN	16x16 C1		
ADDRESS	574 SA Ave.		
PARAMETER	ALTERNATIVES	VELOCITY (fps)	SUBMERGED HEIGHT (ft)
		MODELED 100 YR	MODELED 100 YR
		6.62	11.7
REINFORCEMENT	1% Vert, #3 Ties 10" OC	Acceptable	

Using the Flood Control District-supplied flood velocity of 6.62 feet per second, it was determined that the existing 16"x16" 'C1' column at 574 SA Avenue would not perform acceptably if constructed of plain (unreinforced) concrete. Flood loads imposed at this location on an unreinforced section fail to meet structural performance criteria.

However, when considering a reinforced column with a minimum of 1% vertical reinforcement and #3 ties spaced at 10 inches on center (consistent with the code requirements at the time of original construction), the structural performance improves. This configuration meets the acceptable performance threshold under the same loading conditions.

This evaluation confirms that while plain concrete is insufficient for resisting flood-induced loads, the inclusion of minimum code-required reinforcement renders the column acceptable. Reinforcement plays a vital role in ensuring structural integrity during extreme events, and its presence in the as-built condition is critical to the column's adequacy.

Column 2

COLUMN	12x16 C2		
ADDRESS	528 SA Ave.		
PARAMETER	ALTERNATIVES	VELOCITY (fps)	SUBMERGED HEIGHT (ft)
		MODELED 100 YR	MODELED 100 YR
		4.47	13.3
REINFORCEMENT	1% Vert, #3 Ties 10" OC	Acceptable	

Using the Flood Control District-supplied flood velocity of 4.47 feet per second, it was determined that the existing 12"x16" 'C2' column at 528 SA Avenue would not perform acceptably if constructed of plain (unreinforced) concrete. Flood loads imposed at this location on an unreinforced section fail to meet structural performance criteria.

However, when considering a reinforced column with a minimum of 1% vertical reinforcement and #3 ties spaced at 10 inches on center (consistent with the code requirements at the time of original construction), the structural performance improves. This configuration meets the acceptable performance threshold under the same loading conditions.

This evaluation confirms that while plain concrete is insufficient for resisting flood-induced loads, the inclusion of minimum code-required reinforcement renders the column acceptable. Reinforcement plays a vital role in ensuring structural integrity during extreme events, and its presence in the as-built condition is critical to the column's adequacy.

Column 3

COLUMN	20x20 C3		
ADDRESS	510 SA Ave		
PARAMETER	**ALTERNATIVES**	**VELOCITY (fps)**	**SUBMERGED HEIGHT (ft)**
		MODELED 100 YR	**MODELED 100 YR**
		4.53	13.95
REINFORCEMENT	1% Vert, #3 Ties 10" OC	Acceptable	

Using the Flood Control District-supplied flood velocity of 4.53 feet per second, it was determined that the existing 20”x20” ‘C3’ column at 510 SA Avenue would not perform acceptably if constructed of plain (unreinforced) concrete. A 20”x20” column was assumed based on photos and adjacent structures, as we could not access this site directly. Flood loads imposed at this location on an unreinforced section fail to meet structural performance criteria.

However, when considering a reinforced column with a minimum of 1% vertical reinforcement and #3 ties spaced at 10 inches on center (consistent with the code requirements at the time of original construction), the structural performance improves. This configuration meets the acceptable performance threshold under the same loading conditions.

This evaluation confirms that while plain concrete is insufficient for resisting flood-induced loads, the inclusion of minimum code-required reinforcement renders the column acceptable. Reinforcement plays a vital role in ensuring structural integrity during extreme events, and its presence in the as-built condition is critical to the column's adequacy.

Concrete Wing Wall Conclusions:

Wing Wall 1

WALL	W1		
ADDRESS	540 SA Ave		
PARAMETER	ALTERNATIVES	VELOCITY (fps)	SUBMERGED HEIGHT (ft)
		MODELED 100 YR	MODELED 100 YR
		5.54	14.1
REINFORCEMENT	1% Vert, #4 Horizontal 12" OC	Not Acceptable	

Using the Flood Control District-supplied flood velocity of 5.54 feet per second, it was determined that the existing 7' long, 10" wide 'W1' wing wall at 540 SA Avenue would not perform acceptably if constructed of plain (unreinforced) concrete. Flood loads imposed at this location on an unreinforced section fail to meet structural performance criteria.

When considering a reinforced wall with a minimum of 1% vertical reinforcement and #4 horizontal bars spaced at 12 inches on center (consistent with the code requirements at the time of original construction), the structural performance improves, but not enough for the given demands. This configuration still does not meet the acceptable structural performance threshold under the same loading conditions, so it is deemed *not acceptable*.

This evaluation confirms that even with the inclusion of minimum code-required reinforcement, the wall does not have adequate reinforcing to withstand the modeled 100-year flood loading. We recommend completing further exploration or analysis to address this inadequacy. This could include scanning the wall to determine the existing reinforcing layout or strengthening the wall via fiber reinforced polymer (FRP) as options to explore. Further recommendations and retrofit design are beyond the scope of this report.

Limitations:

This assessment is intended to provide a conceptual understanding of potential structural vulnerabilities under revised loading conditions and to offer high-level guidance regarding potential mitigation strategies. It is not intended as a comprehensive structural evaluation or certification of safety.

This report presents a limited structural assessment based on visual observations, assumed loading, and representative conditions only. As outlined throughout, no testing, excavation, or verification of hidden conditions (e.g., foundation type, reinforcement, or connection details) was performed. The findings are conceptual in nature and intended to inform preliminary understanding and potential mitigation strategies for selected structural elements along San Anselmo Creek.

Martin/Martin has not evaluated all potentially affected structures or components, and no conclusions are provided regarding their overall condition or performance. Any extrapolation of the findings in this report to other elements or properties must be made by the Flood Control District. Doing so requires acceptance of the inherent limitations of this assessment and the associated risks. If a broader understanding or greater certainty is required, additional site-specific investigation and analysis should be undertaken.

Sincerely,

Emily Guglielmo, PE, SE (California)

Principal

eguglielmo@martinmartin.com

<u>ATTACHMENTS:</u> Appendix A, Calculations

MARTIN/MARTIN
CONSULTING ENGINEERS

Structural Implications of BB2 Removal

Martin/Martin, Inc.

Appendix A: Structural Calculations

July 9, 2025

Index of Structural Calculations

A. Flood Analysis Calcs

MARTIN/MARTIN CONSULTING ENGINEERS

Title Flood Analysis Calculations

Description:

This spreadsheet details the ACI 318 - Ch 14 calculations for plain concrete columns and walls.

Design Properties (Chapter 19)

	f'c	2500	psi	*compressive strength of concrete*
	Ec	2850000		*modulus of elasticity for normal weight concrete*
	l	1		*lambda for normal weight concrete in accordance to 19.2.4*
	fr	375		*modulus of rupture*
	Exposure	W		*concrete in contact with water*
C1	S_m	682.67	in^3	*elastic section modulus*
C2	S_m	384	in^3	*elastic section modulus*
C3	S_m	1333.33	in^3	*elastic section modulus*
W4	S_m	240	in^3	*elastic section modulus*

Flexure (14.5.2)

C1	Mn	170666.67	lb-in	*flexural moment at the tension face (14.5.2.1a)*
C2	Mn	96000	lb-in	*flexural moment at the tension face (14.5.2.1a)*
C3	Mn	333333.33	lb-in	*flexural moment at the tension face (14.5.2.1a)*
W4	Mn	60000	lb-in	*flexural moment at the tension face (14.5.2.1a)*
C1	Mn	1450666.7	lb-in	*flexural moment at the compression face (14.5.2.1b)*
C2	Mn	816000	lb-in	*flexural moment at the compression face (14.5.2.1b)*
C3	Mn	2833333.3	lb-in	*flexural moment at the compression face (14.5.2.1b)*
W4	Mn	510000	lb-in	*flexural moment at the compression face (14.5.2.1b)*
C1	Mn	170666.67	lb-in	*lesser moment chosen (14.5.2.1)*
C2	Mn	96000	lb-in	*lesser moment chosen (14.5.2.1)*
C3	Mn	333333.33	lb-in	*lesser moment chosen (14.5.2.1)*
W4	Mn	60000	lb-in	*lesser moment chosen (14.5.2.1)*

Axial Compression (14.5.3)

C1	Ag	256	in^2	
	lc	16	in	
	h	142.8	in	
	Pn	383995.29	lbs	*axial compression (14.5.3.1)*
C2	Ag	192	in^2	
	lc	16	in	
	h	192	in	
	Pn	287998.05	lbs	*axial compression (14.5.3.1)*

Title Flood Analysis Calculations

C3	Ag	400	in^2	
	lc	20	in	
	h	288	in	
	Pn	599997.17	lbs	*axial compression (14.5.3.1)*
W1	Ag	120	in^2	
	lc	144	in	
	h	186	in	
	Pn	179894.64	lbs	*axial compression (14.5.3.1)*

Title Flood Analysis Calculations

Description:

This spreadsheet details the flood analysis calculations based on ASCE 7-22 Supplement 2 for the test cases at the San Anselmo Creek BB2.

Test Case	**W1**		*Wing Wall 1*
Address	540 SA Ave		
LAG	43.84	ft	*lowest available grade*
elev	29.72	ft	*creek bed elevation*
FEMA BFE	42.562	ft	*base flood elevation*
WSE Existing	43.186	ft	*FEMA model existing conditions, 100 yr*
WSE Project	43.813	ft	*FEMA model, project conditions, 100 yr*
V_{design}	5.54	ft/s	*design flood velocity, from BB2 project conditions*
b	10	in	*width of wall, perpendicular to flow direction*
l	12	in	*length of wall*
h_full	15.5	ft	*height of wall*
h	14.1	ft	*submerged height of wall above foundation, h = WSE Project - elev*
C_D	2		*drag coefficient for submerged objects [Table 5.4-1]*
C_{cx}	0		*debris damming closure ratio, [Figure 5.3-1]*
s_x	33.3	ft	*average clear spacing of column to adjacent*
s_y	-	ft	*clear spacing of columns parallel to flow*
z	12.842	ft	*depth below design stillwater flood elevation*
F_{drag}	699	lbs	$F_{drag} = (1/2)\rho C_d V^2 h(b+C_{cx}s)$
p_h	801.3408	psf	$p_h = \gamma_w z$
h/2	7.05	ft	*point where drag force is being applied*
Mu	4927.3898	lb-ft	
Pu(h/6)	1642.4633	lb-ft	*note 14.5.4.2, walls of solid rectangular cross section*
Mu < Pu(h/6)	Use Mu		
ϕ	0.6	lb-ft	*phi factor for unreinforced concrete (Table 21.2.1)*
Mn	5000	lb-ft	*nominal moment from ACI checks*

Mu < ϕMn	NG
DCR	1.64

By: AH
Date: 06/04/2025

Title Flood Analysis Calculations

Description:

This spreadsheet details the flood analysis calculations based on ASCE 7-22 Supplement 2 for the test cases at the San Anselmo Creek BB2.

River Properties

γ_w	62.4	lb/ft^3	
ρ	1.94	$lb\ s^2 / ft^4$	
Test Case	**C1**		*column 1*
Address	574 SA Ave		
LAG	32.81	ft	*lowest available grade*
elev	33.19	ft	*creek bed elevation*
FEMA BFE	43.374	ft	*base flood elevation*
WSE Existing	44.125	ft	*FEMA model existing conditions, 100 yr*
WSE Project	44.859	ft	*FEMA model, project conditions, 100 yr*
V_{design}	6.62	ft/s	*design flood velocity, from BB2 project conditions*
b	16	in	*width of column, perpendicular to flow direction*
l	16	in	*length of column*
h_full	11.9	ft	*height of column*
h	11.669	ft	*submerged height of column above foundation, h = WSE Project - elev*
C_D	2		*drag coefficient for submerged objects [Table 5.4-1]*
C_{cx}	0.7		*debris damming closure ratio, [Figure 5.3-1]*
s_x	5	ft	*average clear spacing of column to adjacent*
s_y	13.5	ft	*clear spacing of columns parallel to flow*
z	10.184	ft	*depth below design stillwater flood elevation*
$F_{drag,\ column}$	4795	lbs	$F_{drag} = (1/2)\rho C_d V^2 h(b+C_{cx}s)$
p_h	635.4816	psf	$p_h = \gamma_w z$
h/2	5.8345	ft	*point where drag force is being applied*
Mu	27977.0385	lb-ft	*ultimate moment from drag force*
ϕ	0.6	lb-ft	*phi factor for unreinforced concrete (Table 21.2.1)*
Mn	14222.2222	lb-ft	*nominal moment from ACI checks*

Mu < ϕMn	NG
DCR	3.28

Title Flood Analysis Calculations

Description:

This spreadsheet details the flood analysis calculations based on ASCE 7-22 Supplement 2 for the test cases at the San Anselmo Creek BB2.

Test Case	**C2**		*column 2*
Address	528 SA Ave		
LAG	31.72	ft	*lowest available grade*
elev	30.13	ft	*creek bed elevation*
FEMA BFE	42.284	ft	*base flood elevation*
WSE Existing	42.892	ft	*FEMA model existing conditions, 100 yr*
WSE Project	43.463	ft	*FEMA model, project conditions, 100 yr*
V_{design}	4.47	ft/s	*design flood velocity, from BB2 project conditions*
b	12	in	*width of column, perpendicular to flow direction*
l	16	in	*length of column*
h_full	16	ft	*height of column*
h	13.33	ft	*submerged height of column above foundation, h = WSE Project - elev*
C_D	1.6		*drag coefficient for submerged objects [Table 5.4-1]*
C_{cx}	0.67		*debris damming closure ratio, [Figure 5.3-1]*
s_x	11	ft	*average clear spacing of column to adjacent*
s_y	16	ft	*clear spacing of columns parallel to flow*
z	12.15	ft	*depth below design stillwater flood elevation*
F_{drag}	3461	lbs	$F_{drag} = (1/2)\rho C_d V^2 h(b+C_{cx}s)$
p_h	758.41	psf	$p_h = \gamma_w z$
h/2	6.67	ft	*point where drag force is being applied*
Mu	23070.5519	lb-ft	
ϕ	0.6	lb-ft	*phi factor for unreinforced concrete (Table 21.2.1)*
Mn	8000	lb-ft	*nominal moment from ACI checks*
Mu < ϕMn	NG		
DCR	4.81		

Title Flood Analysis Calculations

Description:

This spreadsheet details the flood analysis calculations based on ASCE 7-22 Supplement 2 for the test cases at the San Anselmo Creek BB2.

Test Case	**C3**		*column 3*
Address	510 SA Ave		
LAG	29.66	ft	*lowest available grade*
elev	29.66	ft	*creek bed elevation*
FEMA BFE	43.61	ft	*base flood elevation*
WSE Existing	43.06	ft	*FEMA model existing conditions, 100 yr*
WSE Project	43.61	ft	*FEMA model, project conditions, 100 yr*
V_{design}	4.53	ft/s	*design flood velocity, from BB2 project conditions for 508 SA Ave*
b	20	in	*width of column, perpendicular to flow direction*
l	20	in	*length of column*
h_full	17	ft	*height of column*
h	13.95	ft	*submerged height of column above foundation, h = WSE Project - elev*
C_D	2		*drag coefficient for submerged objects [Table 5.4-1]*
C_{cx}	0.38		*debris damming closure ratio, [Figure 5.3-1]*
s_x	18	ft	*average clear spacing of column to adjacent*
s_y	16	ft	*clear spacing of columns parallel to flow*
z	13.95	ft	*depth below design stillwater flood elevation*
F_{drag}	4724	lbs	$F_{drag} = (1/2)\rho C_d V^2 h(b+C_{cx}s)$
p_h	870.48	psf	$p_h = \gamma_w z$
h/2	6.98	ft	*point where drag force is being applied*
Mu	32951.5592	lb-ft	
ϕ	0.6	lb-ft	*phi factor for unreinforced concrete (Table 21.2.1)*
Mn	27777.7778	lb-ft	*nominal moment from ACI checks*

Mu < ϕMn	NG
DCR	1.98

B. Flood Analysis Models

C1 Minimum Reinforcing Model

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ALTAIR

File Name: C:\ ... ice\San Anselmo Flood Analysis\16x16.SCO

Summary

Status	Acceptable
Maximum	1.000
V & T Util	0.172
N vs M Util	0.590

Section Name
Concrete Section

Consultant
ABC Consultants Ltd.

American Building Standards
ACI 318-19, "Building Code Requirements for Structural Concrete"
ACI 318R-19, "Commentary for ACI 318-19"

Design Aids, Manuals, and Handbooks (For Reference Only)
The Reinforced Concrete Design Handbook, A Companion to ACI 318-19
"CRSI Design Guide on the ACI 318-19 Building Code Req. for Structural Concrete
"ACI Detailing Manual - 2020", ACI Committee 315, American Concrete Institute, 2020
"CRSI Manual of Standard Practice", Concrete Reinforcing Steel Institute, 2018

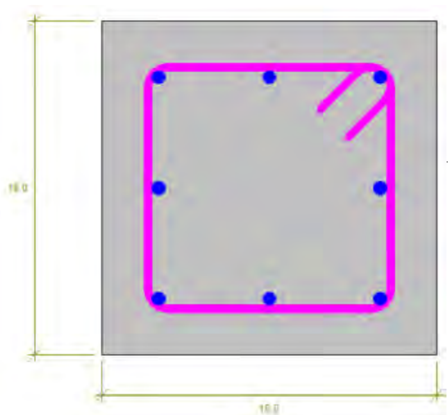
Section Dimensions
Rectangular Column
b = 16.0 in
h = 16.0 in

Quantities (approx.)
Concrete = 255 lb/ft
Steel = 10.4 lb/ft
Primary = 8.6 lb/ft
Secondary = 1.8 lb/ft

Material Properties
fc' = 2500 psi
fy (vert) = 60.0 ksi
fy (ties) = 60.0 ksi
Wc = 145 pcf
Ws = 500 pcf
Poisson's Ratio = 0.2
hagg = 0.75 in
Es = 29000 ksi
Ec = 2881 ksi
Gc = 1200 ksi
fr = 375 psi

Gross Properties
Zbar = 0.0 in
Ybar = 0.0 in
Ag = 256.0 sq.in.
Ig (y-y) = 5461.3 in4
Ig (z-z) = 5461.3 in4
Ashear (Y) = 213.3 sq.in.
Ashear (Z) = 213.3 sq.in.
Jg = 9213.0 in4

Effective Properties
Ae = 256.0 sq.in.
Ie (y-y) = 3822.9 in4
Ie (z-z) = 3822.9 in4
Ase (Y) = 213.3 sq.in.
Ase (Z) = 213.3 sq.in.
Je = 9213.0 in4



Vertical Bars
16" x 16" Column
8-#5 Vert
As = 2.48 sq.in.
Rho = 0.97 %
Tangential Splice

Ties
#3 Ties @ 10.0"
Legs (Z-Direction) = 2
Legs (Y-Direction) = 2

Miscellaneous
Clear Cover = 2.0 in

Slenderness Effects
k (y-y) = 2.0
k (z-z) = 2.0
Lu (y-y) = 180.0 in
Lu (z-z) = 180.0 in
kLu (y-y) = 360.0 in
kLu (z-z) = 360.0 in
Ncr (y-y) = -224.7 kips
Ncr (z-z) = -224.7 kips
EI (y-y) = 4xE6 kip*in2 = 0.25 xEcIgy
EI (z-z) = 4xE6 kip*in2 = 0.25 xEcIgz
BetaD = 0.6

Factored Input Loads

Load Case/Combo	N (kips)	T (k*ft)	Vz (kips)	My (k*ft)	Vy (kips)	Mz (k*ft)	Comment
1	-2.0	0.0	5.0	28.0	0.0	28.0	
2	0.0	0.0	0.0	0.0	5.0	28.0	

Factored Design Loads (with Magnified and/or Minimum Moments):

Load Case/Combo	Vz (kips)	My (k*ft)	Cm (y-y)	Vy (kips)	Mz (k*ft)	Cm (z-z)	Mres (k*ft)	Theta
1	5.0	28.3	1.0	0.0	28.3	1.0	40.0	135°

2	0.0	0.1	1.0	5.0	28.0	1.0	28.0	90º

N vs M Results

GLC	1	Nu = -2.0 kips	Mu = 40.0 k*ft	Mn = 77.1 k*ft
Status	Acceptable	ØNn(max) = -348.8 kips	ØMn = 67.7 k*ft	Mp = 87.1 k*ft
Utilization	0.590	Axial Util. = 0.006	Theta = 135 deg	
Maximum	1.000		Moment Util. = 0.590	

(Governing Load Case Utilizations)

Max. Axial Comp. Util.
LC = 1
Nu = -2.0 kips
ØNn(max) = -348.8 kips
Utilization = 0.006

Max. Axial Tens. Util.
Utilization = 0

Max. Resultant Mom. Util.
LC = 1
Mu = 40.0 k*ft
ØMn = 67.7 k*ft
Theta = 135 deg
Utilization = 0.590

Shear and Torsion Utilization		Shear Z-Direction	Shear Y-Direction	Torsion
GLC	2	bw = 16.0 in	bw = 16.0 in	ØTcr = 12.8 k*ft
Nu	0.0 kips	d = 13.31 in	d = 13.31 in	ØTth = 3.2 k*ft
Vy Util	0.172	As (Tens) = 0.93 sq.in.	As (Tens) = 0.93 sq.in.	Tu = 0.0 k*ft
Vz Util	0.000	Av = 0.22 sq.in.	Av = 0.22 sq.in.	ØTn = 9.5 k*ft
Torsion Util	0.000	Lambda = 1.00	Lambda = 1.00	ØTn,max = 20.9 k*ft
V and T Util	0.172	Mu (y-y) = 0.1 k*ft	Mu (z-z) = 28.0 k*ft	Ignore Torsional Effects
Crushing Util	0.063	Vuz = 0.0 kips	Vuy = 5.0 kips	
Status	Acceptable	ØVsz = 13.2 kips	ØVsy = 13.2 kips	
Utilization	0.172	ØVcz = 16.0 kips	ØVcy = 16.0 kips	
Maximum	1.000	ØVnz = 29.2 kips	ØVny = 29.2 kips	
		ØVnz,max = 79.9 kips	ØVny,max = 79.9 kips	

Tie Spacing for Shear/Torsion

Spacing	10.00 in
Maximum	16.00 in
Status	Acceptable

Maximum Shear/Torsion Capacity

GLC	2
Crushing Util	0.063
Maximum	1.000
Status	Acceptable

Tie Spacing

S	10.0 in
S (max)	10.0 in
Status	Acceptable

Tie Diameter

Diam.	0.375 in
Diam. (min)	0.375 in
Status	Acceptable

Vertical Steel Area		Status	As/Ag
As	2.48 sq.in.		0.97 %
As (min)	1.28 sq.in.	Acceptable	0.50 %
As (max)	10.24 sq.in.	Acceptable	4.00 %

Vertical Bar Splice Type
Tangential Splice
Status Acceptable

Vertical Bar Spacing

Ny	3 Specified
Ny (max)	4.9 Allowed
Nz	3 Specified
Nz (max)	4.9 Allowed
Status	Acceptable

Vertical Bar Diameter

db (vert)	0.625 in
db (min)	0.625 in
Status	Acceptable

Minimum Number of Vertical Bars

#Bars	8 Specified
#Bars	4 Required
Status	Acceptable

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Vertical Reinforcing

fy (min)	40.0 ksi
fy (vert)	60.0 ksi
fy (max)	100.0 ksi
Status	Acceptable

Horizontal Reinforcing

fy (min)	40.0 ksi
fy (horz)	60.0 ksi
fy (max)	100.0 ksi
Status	Acceptable

Concrete Strength

fc' (min)	2500.0 psi
fc'	2500.0 psi
fc' (max)	10000.0 psi
Status	Acceptable

Concrete Density

Wc (min)	90.0 pcf
Wc	145.0 pcf
Wc (max)	160.0 pcf
Status	Acceptable

American Reinforcing Bars

Index	Bar Designation	Diameter (in)	Area (sq.in.)
1	#2	0.25	0.05
2	#3	0.375	0.11
3	#4	0.50	0.20
4	#5	0.625	0.31
5	#6	0.75	0.44
6	#7	0.875	0.60
7	#8	1.00	0.79
8	#9	1.128	1.00
9	#10	1.27	1.27
10	#11	1.41	1.56
11	#14	1.693	2.25
12	#18	2.257	4.00

List of Messages

No Messages...

C2 Minimum Reinforcing Model

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File Name: C:\ ... ice\San Anselmo Flood Analysis\12x16.SCO

Section Name
Concrete Section

Consultant
ABC Consultants Ltd.

Summary

Status	Acceptable
Maximum	1.000
V & T Util	0.235
N vs M Util	0.849

American Building Standards
ACI 318-19, "Building Code Requirements for Structural Concrete"
ACI 318R-19, "Commentary for ACI 318-19"

Design Aids, Manuals, and Handbooks (For Reference Only)
The Reinforced Concrete Design Handbook, A Companion to ACI 318-19
"CRSI Design Guide on the ACI 318-19 Building Code Reg. for Structural Concrete
"ACI Detailing Manual - 2020", ACI Committee 315, American Concrete Institute, 2020
"CRSI Manual of Standard Practice", Concrete Reinforcing Steel Institute, 2018

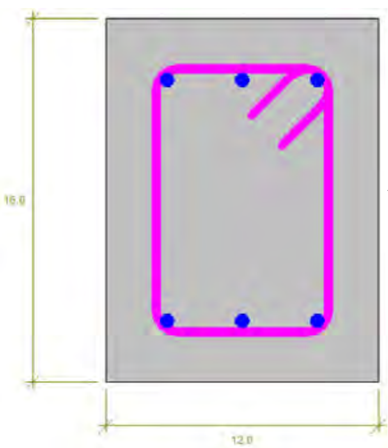
Section Dimensions
Rectangular Column
b = 12.0 in
h = 16.0 in

Quantities (approx.)
Concrete = 191 lb/ft
Steel = 8.0 lb/ft
Primary = 6.5 lb/ft
Secondary = 1.5 lb/ft

Material Properties
fc' = 2500 psi
fy (vert) = 60.0 ksi
fy (ties) = 60.0 ksi
Wc = 145 pcf
Ws = 500 pcf
Poisson's Ratio = 0.2
hagg = 0.75 in
Es = 29000 ksi
Ec = 2881 ksi
Gc = 1200 ksi
fr = 375 psi

Gross Properties
Zbar = 0.0 in
Ybar = 0.0 in
Ag = 192.0 sq.in.
Ig (y-y) = 4096.0 in4
Ig (z-z) = 2304.0 in4
Ashear (Y) = 160.0 sq.in.
Ashear (Z) = 160.0 sq.in.
Jg = 4989.4 in4

Effective Properties
Ae = 192.0 sq.in.
Ie (y-y) = 2867.2 in4
Ie (z-z) = 1612.8 in4
Ase (Y) = 160.0 sq.in.
Ase (Z) = 160.0 sq.in.
Je = 4989.4 in4



Vertical Bars
12" x 16" Column
6-#5 Vert
As = 1.86 sq.in.
Rho = 0.97 %
Tangential Splice

Ties
#3 Ties @ 10.0"
Legs (Z-Direction) = 2
Legs (Y-Direction) = 2

Miscellaneous
Clear Cover = 2.0 in

Slenderness Effects
k (y-y) = 2.0
k (z-z) = 2.0
Lu (y-y) = 180.0 in
Lu (z-z) = 180.0 in
kLu (y-y) = 360.0 in
kLu (z-z) = 360.0 in
Ncr (y-y) = -168.5 kips
Ncr (z-z) = -94.8 kips
EI (y-y) = 3xE6 kip*in2 = 0.25 xEcIgy
EI (z-z) = 2xE6 kip*in2 = 0.25 xEcIgz
BetaD = 0.6

Factored Input Loads

Load Case/Combo	N (kips)	T (k*ft)	Vz (kips)	My (k*ft)	Vy (kips)	Mz (k*ft)	Comment
1	-2.0	0.0	4.0	24.0	4.0	24.0	
2	0.0	0.0	0.0	0.0	4.0	24.0	

Factored Design Loads (with Magnified and/or Minimum Moments):

Load Case/Combo	Vz (kips)	My (k*ft)	Cm (y-y)	Vy (kips)	Mz (k*ft)	Cm (z-z)	Mres (k*ft)	Theta
1	4.0	24.3	1.0	4.0	24.5	1.0	34.5	135º

2	0.0	0.1	1.0	4.0	24.0	1.0	24.0	90º

N vs M Results

GLC	1
Status	Acceptable
Utilization	0.849
Maximum	1.000

Governing Load Case Utilizations

Nu = -2.0 kips
ØNn(max) = -261.6 kips
Axial Util. = 0.008

Mu = 34.5 k*ft
ØMn = 40.6 k*ft
Theta = 135 deg
Moment Util. = 0.849

Mn = 47.5 k*ft
Mp = 53.4 k*ft

Max. Axial Comp. Util.

LC = 1
Nu = -2.0 kips
ØNn(max) = -261.6 kips
Utilization = 0.008

Max. Axial Tens. Util.

Utilization = 0

Max. Resultant Mom. Util.

LC = 1
Mu = 34.5 k*ft
ØMn = 40.6 k*ft
Theta = 135 deg
Utilization = 0.849

Shear and Torsion Utilization

GLC	1
Nu	-2.0 kips
Vy Util	0.194
Vz Util	0.158
Torsion Util	0.000
V and T Util	0.235
Crushing Util	0.098
Status	Acceptable
Utilization	0.235
Maximum	1.000

Shear Z-Direction

bw = 12.0 in
d = 13.31 in
As (Tens) = 0.93 sq.in.
Av = 0.22 sq.in.
Lambda = 1.00
Mu (y-y) = 24.3 k*ft
Vuz = 4.0 kips
ØVsz = 13.2 kips
ØVcz = 12.2 kips
ØVnz = 25.4 kips
ØVnz,max = 60.1 kips

Shear Y-Direction

bw = 16.0 in
d = 9.31 in
As (Tens) = 0.62 sq.in.
Av = 0.22 sq.in.
Lambda = 1.00
Mu (z-z) = 24.5 k*ft
Vuy = 4.0 kips
ØVsy = 9.2 kips
ØVcy = 11.4 kips
ØVny = 20.6 kips
ØVny,max = 56.1 kips

Torsion

ØTcr = 8.4 k*ft
ØTth = 2.1 k*ft
Tu = 0.0 k*ft
ØTn = 6.2 k*ft
ØTn,max = 10.9 k*ft
Ignore Torsional Effects

Tie Spacing for Shear/Torsion

Spacing	10.00 in
Maximum	12.00 in
Status	Acceptable

Maximum Shear/Torsion Capacity

GLC	1
Crushing Util	0.098
Maximum	1.000
Status	Acceptable

Tie Spacing

S	10.0 in
S (max)	10.0 in
Status	Acceptable

Tie Diameter

Diam.	0.375 in
Diam. (min)	0.375 in
Status	Acceptable

Vertical Steel Area		**Status**	**As/Ag**
As	1.86 sq.in.		0.97 %
As (min)	0.96 sq.in.	Acceptable	0.50 %
As (max)	7.68 sq.in.	Acceptable	4.00 %

Vertical Bar Splice Type

Tangential Splice

Status	Acceptable

Vertical Bar Spacing

Ny	3 Specified
Ny (max)	3.4 Allowed
Nz	2 Specified
Nz (max)	4.9 Allowed
Status	Acceptable

Vertical Bar Diameter

db (vert)	0.625 in
db (min)	0.625 in
Status	Acceptable

Minimum Number of Vertical Bars

#Bars	6 Specified
#Bars	4 Required
Status	Acceptable

Vertical Reinforcing

fy (min)	40.0 ksi
fy (vert)	60.0 ksi
fy (max)	100.0 ksi
Status	Acceptable

Horizontal Reinforcing

fy (min)	40.0 ksi
fy (horz)	60.0 ksi
fy (max)	100.0 ksi
Status	Acceptable

Concrete Strength

fc' (min)	2500.0 psi
fc'	2500.0 psi
fc' (max)	10000.0 psi
Status	Acceptable

Concrete Density

Wc (min)	90.0 pcf
Wc	145.0 pcf
Wc (max)	160.0 pcf
Status	Acceptable

American Reinforcing Bars

Index	Bar Designation	Diameter (in)	Area (sq.in.)
1	#2	0.25	0.05
2	#3	0.375	0.11
3	#4	0.50	0.20
4	#5	0.625	0.31
5	#6	0.75	0.44
6	#7	0.875	0.60
7	#8	1.00	0.79
8	#9	1.128	1.00
9	#10	1.27	1.27
10	#11	1.41	1.56
11	#14	1.693	2.25
12	#18	2.257	4.00

List of Messages

No Messages...

C3 Minimum Reinforcing Model

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File Name: C:\ ... ice\San Anselmo Flood Analysis\20x20.SCO

Summary

Status	Acceptable
Maximum	1.000
V & T Util	0.078
N vs M Util	0.248

Section Name
Concrete Section

Consultant
ABC Consultants Ltd.

American Building Standards
ACI 318-19, "Building Code Requirements for Structural Concrete"
ACI 318R-19, "Commentary for ACI 318-19"

Design Aids, Manuals, and Handbooks (For Reference Only)
The Reinforced Concrete Design Handbook, A Companion to ACI 318-19
"CRSI Design Guide on the ACI 318-19 Building Code Reg. for Structural Concrete
"ACI Detailing Manual - 2020", ACI Committee 315, American Concrete Institute, 2020
"CRSI Manual of Standard Practice", Concrete Reinforcing Steel Institute, 2018

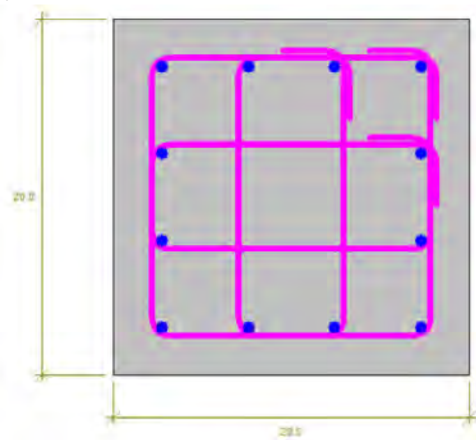
Section Dimensions
Rectangular Column
b = 20.0 in
h = 20.0 in

Quantities (approx.)
Concrete = 399 lb/ft
Steel = 18.7 lb/ft
Primary = 12.9 lb/ft
Secondary = 5.8 lb/ft

Material Properties
fc' = 2500 psi
fy (vert) = 60.0 ksi
fy (ties) = 60.0 ksi
Wc = 145 pcf
Ws = 500 pcf
Poisson's Ratio = 0.2
hagg = 0.75 in
Es = 29000 ksi
Ec = 2881 ksi
Gc = 1200 ksi
fr = 375 psi

Gross Properties
Zbar = 0.0 in
Ybar = 0.0 in
Ag = 400.0 sq.in.
Ig (y-y) = 13333 in4
Ig (z-z) = 13333 in4
Ashear (Y) = 333.3 sq.in.
Ashear (Z) = 333.3 sq.in.
Jg = 22493 in4

Effective Properties
Ae = 400.0 sq.in.
Ie (y-y) = 9333.3 in4
Ie (z-z) = 9333.3 in4
Ase (Y) = 333.3 sq.in.
Ase (Z) = 333.3 sq.in.
Je = 22493 in4



Vertical Bars
20" x 20" Column
12-#5 Vert
As = 3.72 sq.in.
Rho = 0.93 %
Tangential Splice

Ties
#3 Ties @ 10.0"
Legs (Z-Direction) = 4
Legs (Y-Direction) = 4

Miscellaneous
Clear Cover = 2.0 in

Slenderness Effects

k (y-y) = 2.0	kLu (y-y) = 576.0 in	EI (y-y) = 10xE6 kip*in2 = 0.25 xEcIgy
k (z-z) = 2.0	kLu (z-z) = 576.0 in	EI (z-z) = 10xE6 kip*in2 = 0.25 xEcIgz
Lu (y-y) = 288.0 in	Ncr (y-y) = -214.3 kips	BetaD = 0.6
Lu (z-z) = 288.0 in	Ncr (z-z) = -214.3 kips	

Factored Input Loads

Load Case/Combo	N (kips)	T (k*ft)	Vz (kips)	My (k*ft)	Vy (kips)	Mz (k*ft)	Comment
1	-2.0	0.0	4.7	32.9	0.0	0.0	
2	0.0	0.0	0.0	0.0	4.7	32.9	
3	-2.0	0.0	4.7	32.9	0.0	0.0	** Alt. LC # 1

Factored Design Loads (with Magnified and/or Minimum Moments):

Load Case/Combo	Vz (kips)	My (k*ft)	Cm (y-y)	Vy (kips)	Mz (k*ft)	Cm (z-z)	Mres (k*ft)	Theta

1	4.7	33.2	1.0	0.0	0.1	1.0	33.2	180º
2	0.0	0.1	1.0	4.7	32.9	1.0	32.9	90º
3	4.7	0.0	1.0	0.0	0.2	1.0	0.2	90º

N vs M Results

GLC	1
Status	Acceptable
Utilization	0.248
Maximum	1.000

Governing Load Case Utilizations

Nu = -2.0 kips
ØNn(max) = -523.3 kips
Axial Util. = 0.004

Mu = 33.2 k*ft
ØMn = 134.0 k*ft
Theta = 180 deg
Moment Util. = 0.248

Mn = 148.8 k*ft
Mp = 179.3 k*ft

Max. Axial Comp. Util.

LC = 1
Nu = -2.0 kips
ØNn(max) = -523.3 kips
Utilization = 0.004

Max. Axial Tens. Util.

Utilization = 0

Max. Resultant Mom. Util.

LC = 1
Mu = 33.2 k*ft
ØMn = 134.0 k*ft
Theta = 180 deg
Utilization = 0.248

Shear and Torsion Utilization

GLC	2
Nu	0.0 kips
Vy Util	0.078
Vz Util	0.000
Torsion Util	0.000
V and T Util	0.078
Crushing Util	0.036
Status	Acceptable
Utilization	0.078
Maximum	1.000

Shear Z-Direction

bw = 20.0 in
d = 17.31 in
As (Tens) = 1.24 sq.in.
Av = 0.44 sq.in.
Lambda = 1.00
Mu (y-y) = 0.1 k*ft
Vuz = 0.0 kips
ØVsz = 34.3 kips
ØVcz = 26.0 kips
ØVnz = 60.2 kips
ØVnz,max = 129.8 kips

Shear Y-Direction

bw = 20.0 in
d = 17.31 in
As (Tens) = 1.24 sq.in.
Av = 0.44 sq.in.
Lambda = 1.00
Mu (z-z) = 32.9 k*ft
Vuy = 4.7 kips
ØVsy = 34.3 kips
ØVcy = 26.0 kips
ØVny = 60.2 kips
ØVny,max = 129.8 kips

Torsion

ØTcr = 25.0 k*ft
ØTth = 6.3 k*ft
Tu = 0.0 k*ft
ØTn = 17.1 k*ft
ØTn,max = 50.7 k*ft
Ignore Torsional Effects

Tie Spacing for Shear/Torsion

Spacing	10.00 in
Maximum	20.00 in
Status	Acceptable

Maximum Shear/Torsion Capacity

GLC	2
Crushing Util	0.036
Maximum	1.000
Status	Acceptable

Tie Spacing

S	10.0 in
S (max)	10.0 in
Status	Acceptable

Tie Diameter

Diam.	0.375 in
Diam. (min)	0.375 in
Status	Acceptable

Vertical Steel Area		Status	As/Ag
As	3.72 sq.in.		0.93 %
As (min)	2.00 sq.in.	Acceptable	0.50 %
As (max)	16.00 sq.in.	Acceptable	4.00 %

Vertical Bar Splice Type

Tangential Splice

Status	Acceptable

Vertical Bar Spacing

Ny	4 Specified
Ny (max)	6.3 Allowed
Nz	4 Specified

Vertical Bar Diameter

db (vert)	0.625 in
db (min)	0.625 in
Status	Acceptable

Minimum Number of Vertical Bars

#Bars	12 Specified
#Bars	4 Required
Status	Acceptable

Nz (max)	6.3 Allowed
Status	Acceptable

Vertical Reinforcing

fy (min)	40.0 ksi
fy (vert)	60.0 ksi
fy (max)	100.0 ksi
Status	Acceptable

Horizontal Reinforcing

fy (min)	40.0 ksi
fy (horz)	60.0 ksi
fy (max)	100.0 ksi
Status	Acceptable

Concrete Strength

fc' (min)	2500.0 psi
fc'	2500.0 psi
fc' (max)	10000.0 psi
Status	Acceptable

Concrete Density

Wc (min)	90.0 pcf
Wc	145.0 pcf
Wc (max)	160.0 pcf
Status	Acceptable

American Reinforcing Bars

Index	Bar Designation	Diameter (in)	Area (sq.in.)
1	#2	0.25	0.05
2	#3	0.375	0.11
3	#4	0.50	0.20
4	#5	0.625	0.31
5	#6	0.75	0.44
6	#7	0.875	0.60
7	#8	1.00	0.79
8	#9	1.128	1.00
9	#10	1.27	1.27
10	#11	1.41	1.56
11	#14	1.693	2.25
12	#18	2.257	4.00

List of Messages

No Messages...

Wing Wall Minimum Reinforcing Model

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File Name: C:\ ... Flood Analysis\S-Concrete Wing Wall.SCO

Summary

Status	Unacceptable
Maximum	1.000
V (shear) Util	0.750
N vs M Util	2.944

Section Name
Concrete Section

Consultant
ABC Consultants Ltd.

American Building Standards
ACI 318-14, "Building Code Requirements for Structural Concrete"
ACI 318R-14, "Commentary for ACI 318-14"

Design Aids, Manuals, and Handbooks (For Reference Only)
The Reinforced Concrete Design Handbook, A Companion to ACI 318-14
"ACI Detailing Manual - 1994", ACI Committee 315, American Concrete Institute, 1994
"Manual of Standard Practice", Concrete Reinforcing Steel Institute, 2003

Section Dimensions
I-Shape
L1 = 84.0 in
T1 = 10.0 in

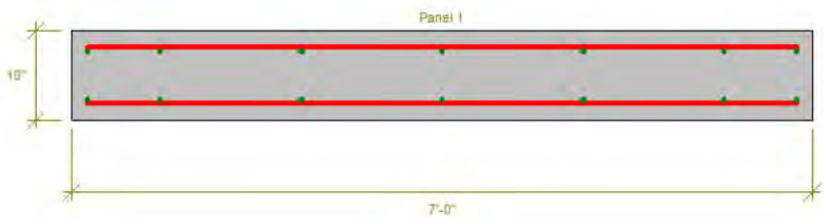
Material Properties
fc' = 2500 psi
fy (panel vert) = 60.0 ksi
fy (panel horz) = 60.0 ksi
fy (zone vert) = 60.0 ksi
fy (zone horz) = 60.0 ksi
Wc = 145 pcf
Ws = 500 pcf
Poisson's Ratio = 0.2
hagg = 0.75 in
Es = 29000 ksi
Ec = 2881 ksi
Gc = 1200 ksi
fr = 375 psi

Gross Properties
Zbar = 0.0 in
Ybar = 0.0 in
Ag = 840.0 sq.in.
Ig (y-y) = 7000.0 in4
Ig (z-z) = 493920 in4
Ashear (Y) = 700.0 sq.in.
Ashear (Z) = 700.0 sq.in.
Jg = 25899 in4

Effective Properties
Ae = 840.0 sq.in.
Ie (y-y) = 4900.0 in4
Ie (z-z) = 345744 in4
Ase (Y) = 700.0 sq.in.
Ase (Z) = 700.0 sq.in.
Je = 25899 in4

Quantities (approx.)
Concrete = 843 lb/ft
Steel = 19.0 lb/ft
Primary = 9.7 lb/ft
Secondary = 9.3 lb/ft

Panel 1
14-#4 @ 16.0" V.E.F
#4 @ 12.0" H.E.F.



Slenderness Effects
k (y-y) = 1.0
k (z-z) = 1.0
Lu (y-y) = 120.0 in
Lu (z-z) = 120.0 in
kLu (y-y) = 120.0 in
kLu (z-z) = 120.0 in
EI = 0.25 x EcIg
Ncr (y-y) = -2591.6 kips
Ncr (z-z) = -182865.2 kips

Factored Input Loads

Load Case/Combo	N (kips)	T (k*ft)	Vz (kips)	My (k*ft)	Vy (kips)	Mz (k*ft)	Load Type	Comment
1	0.0	0.0	0.0	0.0	35.0	168.0	Other	
2	0.0	0.0	35.0	168.0	0.0	0.0	Other	
3	0.0	0.0	35.0	168.0	0.0	0.0	Other	** Alt. LC # 2

Factored Design Loads (with Magnified and/or Minimum Moments)

Load Case/Combo	Vz (kips)	My (k*ft)	Cm (y-y)	Vy (kips)	Mz (k*ft)	Cm (z-z)	Mres (k*ft)	Theta
1	0.0	0.1	1.0	35.0	168.0	1.0	168.0	90°
2	35.0	168.0	1.0	0.0	0.1	1.0	168.0	180°
3	35.0	168.0	1.0	0.0	-0.1	1.0	168.0	180°

N vs M Results

GLC 2
Status Unacceptable Message 1
Utilization 2.944
Maximum 1.000

Governing Load Case Utilizations

Nu = 0.0 kips
ØNn(max) = -1012.5 kips
Axial Util. = 0.000

Mu = 168.0 k*ft
ØMn = 57.1 k*ft
Theta = 180 deg
Moment Util. = 2.944

Mn = 63.4 k*ft
Mp = 75.9 k*ft

Max. Axial Comp. Util.

Utilization = 0

Max. Axial Tens. Util.

Utilization = 0

Max. Resultant Mom. Util.

LC = 2
Mu = 168.0 k*ft
ØMn = 57.1 k*ft
Theta = 180 deg
Utilization = 2.944

Shear and Torsion Utilization

GLC 3
Status Acceptable
Utilization 0.750 = Uz + Uy
Maximum 1.000

Torsion Limit:

GLC = 1
Tu = 0.0 k*ft
T (limit) = 8.1 k*ft
Acceptable

Shear Z-Direction

Nu = 0.0 kips
Mu (y-y) = 168.0 k*ft
Vuz = 35.0 kips
Tu = 0.0 k*ft
bw = 84.0 in
d = 7.75 in
As (Tens) = 1.05 sq.in.
Av = 0.0 sq.in.
Lambda = 1.00
ØVsz = 0.0 kips
ØVcz = 46.6 kips
ØVnz = 46.6 kips
Util (Uz) = 0.750

Shear Y-Direction

Nu = 0.0 kips
Mu (z-z) = -0.1 k*ft
Vuy = 0.0 kips
Tu = 0.0 k*ft
bw = 10.0 in
d = 67.2 in
As (Tens) = 2.32 sq.in.
Av = 0.4 sq.in.
Lambda = 1.00
ØVsy = 100.8 kips
ØVcy = 83.2 kips
ØVny = 184.0 kips
Util (Uy) = 0.000

Panel 1 Reinforcing

#4 @ 16.0" V.E.F

Vert Steel Ratio	Vert Bar Spacing	Number of Curtains
Rho = 0.00250	S = 16.00 in	Curtains Specified = 2
Rho (min) = 0.00120	S (min) = 2.50 in	Curtains Required = 1
Rho (max) = 0.01000	S (max) = 18.00 in	Acceptable
Acceptable	Acceptable	

#4 @ 12.0" H.E.F

Horz Steel Ratio	Horz Bar Spacing	Clear Cover
Rho = 0.00333	S = 12.00 in	Cover Specified = 1.50 in
Rho (min) = 0.00200	S (min) = 2.00 in	Max Cover = 3.33 in
Acceptable	S (max) = 16.80 in	Acceptable
	Acceptable	

Panel Vertical Reinf. **Panel Horizontal Reinf.** **Zone Vertical Reinf.**

fy (min)	40.0 ksi	fy (min)	40.0 ksi	fy (min)	40.0 ksi
fy (vert)	60.0 ksi	fy (horz)	60.0 ksi	fy (vert)	60.0 ksi
fy (max)	80.0 ksi	fy (max)	60.0 ksi	fy (max)	80.0 ksi
Status	Acceptable	Status	Acceptable	Status	Acceptable

Concrete Strength		**Concrete Density**		**Zone Horizontal Reinf.**	
fc' (min)	2500.0 psi	Wc (min)	90.0 pcf	fy (min)	40.0 ksi
fc'	2500.0 psi	Wc	145.0 pcf	fy (horz)	60.0 ksi
fc' (max)	10000.0 psi	Wc (max)	160.0 pcf	fy (max)	100.0 ksi
Status	Acceptable	Status	Acceptable	Status	Acceptable

American Reinforcing Bars

Index	Bar Designation	Diameter (in)	Area (sq.in.)
1	#2	0.25	0.05
2	#3	0.375	0.11
3	#4	0.50	0.20
4	#5	0.625	0.31
5	#6	0.75	0.44
6	#7	0.875	0.60
7	#8	1.00	0.79
8	#9	1.128	1.00
9	#10	1.27	1.27
10	#11	1.41	1.56
11	#14	1.693	2.25
12	#18	2.257	4.00

Wall Dimensions

Lu (y-y) = 120.0 in, Lu (z-z) = 120.0 in, hw = 240.0 in

Panel 1 Thickness
T = 10.0 in
T (min) = 4.8 in
Acceptable

List of Messages

Message 1 Unacceptable Axial Load and Moment Utilization equals or exceeds Maximum.
Clauses 22.2 and 22.4 of ACI 318

End of Calculations