KELLER ENGINEERING

SANITARY DRAINPIPE CONDITION ASSESSMENT
CARLETON CONDOMINIUM CORPORATION NO. 145
OTTAWA ONTARIO

File # 1210306
May 2, 2022

Ottawa / Kingston / Calgary
www.kellerengineering.com

SANITARY DRAINPIPE CONDITION ASSESSMENT

1.0 TERMS OF REFERENCE

Keller Engineering conducted a drainpipe condition assessment at the Carleton Condominium Corporation No. 145 (CCC 145), located at 151 Bay St., in Ottawa, Ontario. Our mandate was to review the condition of the existing sanitary drain piping and provide recommendations on remedial repairs or required replacements.

2.0 LIMITATIONS

This report is based on, and limited to, verbal information supplied to Keller Engineering by the Property Manager and building superintendent, visual observations made during our inspections of the building, and pipe testing reports provided by Glencor Engineering. Only those items that can be observed and are reasonably obvious to Keller Engineering or have been otherwise identified by other parties and listed during this investigation are included in this report.

Drywall openings were made for access to perform ultrasonic pipe wall thickness testing on kitchen drain piping, however it is noted that large portions of building components were obstructed by interior finishes at the time of the inspection.

The work reflects Keller Engineering's best judgement in light of the information reviewed in the sanitary drainpipe ultrasonic thickness testing reports. There is no warranty expressed or implied by Keller Engineering that this assessment will uncover all potential deficiencies and risks of liabilities associated with the subject property. Keller Engineering believes, however, that the level of review carried out in this assessment is appropriate to meet the objectives as outlined in the Terms of Reference. We cannot guarantee the completeness or accuracy of information supplied by any third party.

This report has been prepared for the sole use of Carleton Condominium Corporation No. 145, and cannot be reproduced or otherwise used by any third party unless approval is obtained from Keller Engineering. No portion of this report may be used as a separate entity; it is written to be read in its entirety.

Keller Engineering is not a professional quantity surveyor, cost estimator, or construction contractor. Construction probable costs outlined below are budget figures only, based on the current market conditions, and are in present dollars. All estimated costs are before taxes. The actual costs of construction may vary considerably depending on the time of year when tendering is conducted, the actual detailed scope of work and the economic climate of the construction industry.

3.0 METHODOLOGY

Glencor Engineering performed ultrasonic pipe wall thickness testing on the exposed sanitary drain piping in the ceiling of the parking garage. The results of this testing are summarized in Keller Engineering's preliminary report dated November 24, 2021 which is included in Appendix A.

Based on the findings of the original testing, additional sanitary drainpipe thickness testing was performed throughout the rest of the building. The results of this testing are included in the Glencor Engineering inspection report 2103332 included in Appendix B.

4.0 INTRODUCTION

Carleton Condominium Corporation No. 145 (CCC 145) is a 13-storey condominium containing 142 residential suites that is located at 151 Bay Street, Ottawa Ontario. The building was constructed in 1975 and uses cast iron piping for the sanitary drain stacks and the primary shared piping in the parking garage. The suites have copper sanitary drain piping connecting each of the fixtures to the shared cast iron stacks.

Owners of several suites have reported re-occurring blockages in the copper to cast iron drainpipe connections which prompted CCC 145 to engage Keller Engineering to investigate the cause. Consultation with metallurgical engineering company, Glencor Engineering, brought up the possibility that the re-occurring blockages may be a symptom of the pipe reaching the end of its service life and the recommendation was made to further investigate the pipe condition.

To investigate the remaining service life of the sanitary drainpipe, an ultrasonic thickness testing study was performed on a sample of 153 locations in the parking garage in November 2021. The results of this testing determined that the sanitary drain piping in the parking garage had reached the end of its service life and replacement is required imminently. The shared sanitary piping in the parking garage is exposed to the most usage since all waste from the 11 floors above flow through it so it is expected to present the highest rate of deterioration. The results of this testing prompted further testing of the sanitary drain piping throughout the rest of the building to determine the remaining service life and any possible patterns of wear which could help determine a future replacement schedule.

5.0 FINDINGS

The following is a summary of the pipe thickness testing performed on the cast iron drain stacks and copper suite drain piping in washrooms and kitchens:

- The maximum cast iron pipe wall thickness loss detected was 44.8%
- 30% of the cast iron piping locations tested contained significant thinning
- The maximum copper drainpipe wall thickness loss detected was 22.2%
- The maximum copper vent pipe wall thickness loss detected was 25%
- 3% of the copper sanitary vent piping locations tested contained significant thinning

6.0 DISCUSSION & CONCLUSIONS

The ultrasonic probe measures the average thickness of the pipe wall over a small area. This means that a pipe wall thickness loss measurement of 50% can represent an area of 25% pipe wall loss, that contains localized pitting or cracking with 90% thickness loss. Since pipe failure is determined by any point of the pipe which has 100% thickness loss, the actual point of failure will likely occur well before 100% thickness loss is registered on the ultrasonic thickness measurements. As the piping ages, the rate of wear accelerates due to increased surface roughness and additional localized turbulence. Any pipe with a reading of over 25% pipe wall thickness loss has significant thinning and any pipe reading 50% pipe wall thickness loss is considered to be at risk of imminent failure.

Loss of pipe wall thickness occurs due to erosion, corrosion, and dealloying of the metal:

Erosion is mechanical wear in the pipes caused by water and debris flowing through them. This type of wear leads to general thinning of the pipes and is most prominent in locations where the pipe changes direction and the flowing water can be concentrated at a point of high turbulence.

Corrosion is a chemical process where the pipe material is converted from its base material into a less mechanically stable material, which can be eroded away such as rust forming on iron. This process can cause localized pitting of the material which can create pinhole leaks, especially in already thinned material.

De-alloying is preferential corrosion that occurs in cast iron, where the iron grains are corroded from the material, leaving behind a matrix of graphite flakes. Without the strength of the iron, the remaining material is brittle and can be subject to forming large longitudinal cracks in the pipe.

The results of the pipe thickness testing by Glencor Engineering indicate a significant degree of pipe thinning in the buildings cast iron sanitary drain stacks throughout the building. The measured thinning appeared intermittently which indicates that the deterioration of the pipe is more dependent on the material processed by the drains than by age of the pipe alone. The condition of this pipe indicates that the cast iron sanitary drain stacks have reached the end of their service life and replacement is required in the near future. No apparent patterns of deterioration were observed which could be used to plan an extended phased replacement approach.

The copper sanitary drainpipe and vent pipes showed intermittent thinning throughout the building. This is to be expected because these pipes serve individual suites, so their deterioration is likely to be very closely tied to the specific usage within the individual suite, or even the specific usage of individual fixtures. These systems do not appear to require full scale replacement at this time, however they are showing deterioration and their condition should continue to be monitored in the future.

7.0 RECOMMENDATIONS

Based on the findings of this report and the preliminary report attached in appendix A, we recommend the following work be performed:

- Complete replacement of the cast iron and copper sanitary drain piping in the parking garage (recommended in preliminary report).
- Complete replacement of the cast iron sanitary drain stacks serving the kitchens and washrooms throughout the building.

8.0 BUDGET COSTS

The following budget costs have been estimated for the recommended replacement work:

- Class D estimate for complete replacement of cast iron and copper sanitary drain piping in the parking garage is $300,000 (+/- 25%).
- Class D estimate for complete replacement of the cast iron sanitary drain stacks serving the kitchens and washrooms throughout the building is $4,260,000 (+/- 25%).

Trusting this meets with your present requirements, please feel free to contact us should you require further information.

Chris O'Brien, P.Eng

APPENDIX A

SANITARY DRAIN PIPING CONDITION ASSESSMENT PRELIMINARY REPORT

KELLER ENGINEERING

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2021 11 24 1210306

Carleton Condominium Corporation No. 145
% DES Services
2339 Ogilvie Road,
Ottawa, Ontario, K1J 9M7

Attn: Ms. Josee Deslongchamps

CCC 145 - SANITARY DRAIN PIPING CONDITION ASSESSMENT – PRELIMINARY REPORT

Dear Ms. Deslongchamps:

At your request, Keller Engineering coordinated with Glencor Engineering to perform a preliminary analysis of the drain piping at OCSCC 145, located at 151 Bay Street in Ottawa. The analysis included ultrasonic thickness testing of the cast iron and copper sanitary drain pipes at 153 locations in the parking garage. The purpose of the inspection is to determine the condition of the sanitary drain piping in this area, and to determine if further investigation of the buildings drain piping should be performed.

DOCUMENT REVIEW

Glencor Engineering inspection report 2110198 for ultrasonic thickness survey of drain piping in the parking garage at 151 Bay St, Dated November 2, 2021

FINDINGS

The following are our inspection findings:

- The maximum cast iron pipe wall thickness loss detected was 80.4%
- 78.4% of cast iron piping locations tested contained significant thinning
- 25.7% of cast iron piping locations tested could be expected to leak imminently
- The maximum copper pipe wall thickness loss detected was 57.1%
- 67.1% of copper piping locations tested contained significant thinning
- 13.9% of copper piping locations tested could be expected to leak imminently
- One pinhole perforation was detected during testing

DISCUSSION

The results of the sanitary pipe thickness testing performed by Glencor Engineering show that both the cast iron and the copper sanitary piping in the parking garage have significant thinning throughout and failure is imminent at multiple locations. The cast iron and copper sanitary piping in the parking garage has reached the end of its service life and piping replacement is required in the immediate future.

The ultrasonic probe measures the average thickness of the pipe wall over a small area. This means that a pipe wall thickness loss measurement of 50% can represent an area of 25% pipe wall loss, that contains localized pitting or cracking with 90% thickness loss. Since pipe failure is determined by any point of the pipe which has 100% thickness loss, the actual point of failure will likely occur well before 100% thickness loss is registered on the ultrasonic thickness measurements. As the piping ages, the rate of wear accelerates due to increased surface roughness and additional localized turbulence. Any reading over 50% pipe wall thickness loss is considered to be at risk of imminent failure.

Loss of pipe wall thickness is due to erosion, corrosion, and dealloying of the pipe. Erosion is mechanical wear in the pipes caused by water and debris flowing through them. This type of wear leads to general thinning of the pipes and is most prominent in locations where the pipe changes direction and the flowing water can be concentrated at a point of high turbulence. Corrosion is a chemical process where the pipe material is converted from its base material into a less mechanically stable material, which can be eroded away such as rust forming on iron. This process can cause localized pitting of the material which can create pinhole leaks, especially in already thinned material. De-alloying is preferential corrosion that occurs in cast iron, where the iron grains are corroded from the material, leaving behind a matrix of graphite flakes. Without the strength of the iron, the remaining material is brittle and can be subject to forming large longitudinal cracks in the pipe.

RECOMMENDATIONS

The testing results of the parking garage show the piping has deteriorated significant in this area, leaks are to be expected in the near term, and replacement of the pipes is required imminently.

Additional sanitary drainpipe thickness testing is required throughout the building to verify the condition of the existing piping in the rest of the building. This testing will help determine their condition and the remaining service life that can be expected.

We recommend the following:

- Complete replacement of the cast iron and copper sanitary drain piping in the parking garage.
- Ultrasonic thickness testing of the cast iron vertical stacks and copper drain piping serving the washrooms which are accessible through the 51 existing access hatches in the corridors located throughout the building.
- Ultrasonic thickness testing of the cast iron vertical stacks and copper drain piping in 9 locations serving the kitchens. This work will require drywall openings to access the kitchen piping in 9 suites, distributed between the lower, middle, and upper floors of the building.

Glencor provided a budget price to provide the additional recommended ultrasonic thickness testing of the 51 access hatches in the hallways and 9 access points in suite kitchens for a cost of $1,900.00+HST. This price does not include any cost for additional drywall openings and reinstatement, which will be required to access the kitchen sanitary stacks in 9 suites.

We trust that the above satisfies your current requirements. Please feel free to contact us if you have any questions regarding the above.

Sincerely,

Chris O'Brien, P.Eng.

APPENDIX A

GLENCOR ENGINEERING
DRAINPIPE THICKNESS TESTING REPORT
2110198

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Inspection Report 2110198

Ultrasonic Thickness Survey of
Drain Piping
at
151 Bay Street,
for
Keller Engineering,
Ottawa, Ontario

date: November 2, 2021

prepared by:

J.E. Martin
CGSB Level I
Ultrasonics

&

D.M.M. Twigg, P. Eng
CGSB Level II
Ultrasonics

Subject: Ultrasonic Thickness Survey of Drain Piping at 151 Bay Street, Ottawa, Ontario.

1.0 INTRODUCTION

On October 13 and 14, 2021 visits were made to 151 Bay Street in Ottawa, Ontario to perform an ultrasonic thickness survey of the copper and cast iron drain piping the parking garage. The intention of this survey was to use the parking garage piping to help determine of the drain piping throughout the building. Reportedly, there had been some failures of the cast iron piping and concerns were raised as to the condition of the drain piping throughout the building..

2.0 TEST

A Dakota DFX7+ ultrasonic flaw detector set in the thickness gauge mode, with a ½" 1.0 MHz, dual transducer probe and Sonotech Soundsafe gel as couplant were used to take thickness readings all around the circumference of the pipe at the locations selected.

An Olympus 36 DL Plus ultrasonic thickness gauge with a ¼", 7.5 MHz dual transducer probe and Sonotech Soundsafe gel as couplant were used to take thickness measurements at the selected locations on the copper DWV piping.

3.0 RESULTS OF THE TESTING

The results of the testing are summarized in the tables below. Readings in each location generally start on the top/front of the pipe and proceed counter clockwise around the pipe when facing the direction of flow. All readings are in inches and any readings of concern are in bold for ease of identification. Readings of immediate concern are in bold and underlined.

3.1 Table of Readings

Reading Numbers	Locations								
	Public Garage								
	4"			3"	6"			3"	6"
	1	2	3	4	5	6	7	8	9
1	0.271	0.244	0.192	**0.116**	**0.174**	0.244	0.159	**0.166**	0.200
2	**0.149**	0.242	**0.163**	**0.128**	0.385	0.241	0.213	**0.164**	0.203
3	**0.150**	**0.181**	**0.144**	**0.144**	0.382	0.225	0.229	**0.166**	0.197
4	**0.141**	**0.183**	0.204	**0.130**	0.270	0.213	0.218	**0.182**	**0.180**
5	0.239	0.234	**0.180**	**0.136**	0.279	0.214	0.220	**0.180**	**0.178**
6	0.210	0.235	0.218	-	**0.179**	0.214	0.219	**0.175**	0.242
7	**0.180**	**0.164**	**0.185**		0.250	0.207	0.222		0.246
8	0.229	**0.162**	**0.180**		0.262	0.300	0.227		0.244
9					0.271	0.237	0.220		0.239
10					0.285	0.236	**0.158**		0.229
11					0.304	0.232	0.237		0.225
12					0.309	0.239	0.234		0.225

Reading Numbers	Locations								
	Public Garage								
	8"	3"	8"	8"	3"	2" Cu DWV		3"	8"
	10	11	12	13	14	15	16	17	18
1	0.249	0.210	0.257	0.300	0.199	0.045	**0.024**	**0.149**	0.302
2	0.252	0.229	0.315	**0.133**	0.200	0.037	**0.025**	**0.154**	0.236
3	0.241	0.219	0.248	**0.194**	0.202	0.036	0.033	**Pinhole**	0.240
4	0.280	**0.176**	0.247	**0.197**	0.205	0.037	**0.029**	**0.145**	**0.219**
5	0.272	**0.173**	0.254	**0.187**	**0.180**			**0.134**	**0.166**
6	0.239	**0.181**	0.255	**0.202**	**0.177**			**0.142**	**0.229**
7	**0.229**		0.257	**0.206**					0.309
8	0.301		0.270	**0.116**					**0.230**
9	**0.228**		**0.181**	**0.187**					**0.229**
10	**0.224**		0.246	**0.188**					**0.230**
11	0.330		**0.144**	**0.196**					0.271
12	0.329		0.243	**0.193**					0.275
13	0.328		0.239	0.275					0.275
14	0.248		0.240	0.273					0.280

Reading Numbers	Locations								
	Public Garage								
	6"	4"							
	19	20	21	22	23	24	25	26	27
1	0.250	**0.175**	0.229	0.234	**0.167**	**0.161**	**0.177**	**0.160**	0.193
2	**0.162**	**0.174**	0.302	0.234	**0.164**	**0.157**	**0.174**	**0.159**	0.213
3	0.238	**0.174**	0.328	0.221	**0.160**	**0.152**	0.216	**0.160**	0.261
4	0.234	**0.175**	0.289	0.223	**0.154**	0.206	0.301	**0.158**	**0.161**
5	0.241	**0.176**	0.300	0.226	**0.152**	0.208	**0.162**	0.219	-
6	0.241	-	0.296	0.304	0.227	**0.151**	**0.164**	0.324	-
7	0.249	-	-	0.297	**0.178**	**0.159**	**0.168**	0.342	-
8	0.241	-	-	0.302	**0.161**	**0.153**	**0.169**	0.348	-
9	0.242								
10	0.244								
11	0.240								
12	0.245								

-Unable to get readings

Reading Numbers	Locations								
	Public Garage						Condo Garage		
	4"	4"	6"	4"		6"	4"		6"
	28	29	30	31	32	33	34	35	36
1	0.213	0.215	0.188	0.224	0.196	0.270	0.199	**0.181**	0.194
2	0.211	0.213	0.190	0.222	0.194	0.222	0.197	**0.177**	0.199
3	0.212	0.211	**0.165**	0.230	0.199	0.250	0.198	**0.180**	0.285
4	0.195	**0.159**	**0.176**	0.212	0.200	0.255	0.197	0.210	0.287
5	0.193	**0.157**	0.215	0.211	0.203	0.257	**0.169**	**0.181**	0.311
6	0.244	0.210	0.219	0.209	0.193	0.259	-	**0.182**	**0.187**
7	0.210	0.211	0.216	0.210	0.192	0.311	-	**0.184**	**0.184**
8	0.224	0.200	0.218	**0.171**	0.189	0.219	-	0.195	**0.183**
9			0.294			0.217			**0.186**
10			0.296			0.189			0.225
11			0.300			**0.187**			0.222
12			0.302			0.311			0.226

Reading Numbers	Locations								
	Condo Garage				Public Garage				
	4"				2" Cu DWV			$1^1/_4$" Cu DWV	
	37	38	39	40	41	42	43	44	45
1	**0.178**	0.239	**0.173**	0.265	0.038	0.032	0.036	**0.030**	0.040
2	**0.176**	0.228	**0.177**	0.219	0.037	0.037	0.042	0.042	0.039
3	**0.153**	0.229	**0.185**	0.213	0.040	0.040	**0.029**	0.040	0.032
4	**0.159**	0.232	0.188	0.216	0.035	0.036	**0.030**	0.039	**0.029**
5	0.221	0.216	0.189	0.212					
6	0.224	0.215	0.190	0.292					
7	0.224	0.217	0.285	0.202					
8	0.220	0.216	0.241	0.199					

Reading Numbers	Locations								
	Condo Garage								
	3"		6"	3"	6"	4"		3"	4"
	46	47	48	49	50	51	52	53	54
1	0.288	0.203	0.274	**0.146**	0.275	0.207	0.204	0.198	0.196
2	0.298	**0.155**	0.272	**0.155**	0.260	0.203	0.208	**0.174**	0.227
3	0.207	0.196	0.271	0.194	0.261	0.206	0.210	**0.167**	0.220
4	0.208	0.195	0.268	0.226	0.280	0.209	0.212	0.203	0.213
5	0.212	0.193	0.270	0.279	0.266	0.194	0.200	0.204	0.219
6	0.214	0.190	0.269	0.222	0.261	0.196	0.201	0.196	0.218
7			0.266		0.258	0.193	0.204		0.214
8			0.265		0.274	0.191	0.194		0.213
9			0.247		0.279				
10			0.244		0.286				
11			0.246		0.288				
12			0.259		0.277				

Reading Numbers	Locations								
	Condo Garage								
	3"	4"		6"	4"		6"	4"	
	55	56	57	58	59	60	61	62	63
1	0.203	0.220	0.320	0.319	0.221	0.194	0.190	**0.182**	**0.137**
2	0.231	0.221	0.320	**0.183**	0.198	0.194	**0.182**	0.199	**0.140**
3	0.234	0.230	0.308	0.368	0.195	**0.074**	**0.182**	0.198	0.204
4	0.228	**0.123**	0.306	0.353	0.197	0.319	**0.180**	**0.123**	**0.095**
5	0.236	**0.112**	0.250	0.361	0.213	**0.122**	**0.158**	0.302	0.211
6	0.194	0.348	0.191	**0.174**	0.215	**0.168**	**0.156**	0.195	**0.127**
7		0.360	0.189	0.323	0.198	0.214	**0.148**	0.192	0.219
8		0.250	0.332	0.362	0.212	0.211	**0.178**	0.216	**0.148**
9				0.384			0.191		
10				0.317			**0.185**		
11				0.222			0.195		
12				**0.148**			0.198		

Reading Numbers	Locations								
	Condo Garage								
	4"								
	64	65	66	67	68	69	70	71	72
1	**0.133**	0.195	**0.127**	0.190	**0.061**	0.197	**0.132**	0.198	**0.168**
2	**0.125**	0.198	0.210	**0.186**	0.235	0.201	**0.164**	0.196	**0.170**
3	**0.157**	**0.172**	**0.182**	**0.108**	0.228	**0.152**	**0.103**	**0.178**	**0.169**
4	**0.131**	**0.132**	**0.163**	**0.132**	0.230	**0.138**	**0.183**	**0.132**	**0.187**
5	**0.135**	0.325	0.344	**0.125**	0.231	0.190	**0.164**	**0.055**	0.191
6	**0.141**	**0.156**	0.187	**0.112**	0.222	**0.107**	**0.168**	**0.158**	**0.187**
7	**0.148**	**0.112**	0.132	**0.186**	0.222	**0.132**	0.194	0.192	**0.187**
8	**0.152**	**0.132**	0.168	0.193	0.192	**0.186**	**0.132**	**0.186**	**0.132**

Reading Numbers	Locations								
	Condo Garage								
	4"			3"					
	73	74	75	76	77	78	79	80	81
1	**0.121**	**0.160**	**0.186**	**0.137**	**0.187**	**0.122**	**0.186**	0.194	**0.176**
2	**0.138**	**0.168**	**0.183**	0.191	0.191	0.210	**0.174**	**0.162**	0.192
3	**0.136**	**0.183**	**0.136**	**0.180**	**0.185**	0.206	**0.177**	**0.134**	0.199
4	**0.185**	**0.167**	**0.122**	**0.131**	**0.176**	0.203	**0.162**	**0.166**	**0.139**
5	**0.060**	**0.121**	**0.102**	**0.049**	**0.126**	0.197	**0.080**	**0.163**	0.199
6	**0.162**	**0.172**	**0.125**	**0.136**	**0.170**	0.199	**0.160**	**0.186**	**0.180**
7	**0.183**	**0.180**	0.190						
8	0.191	**0.186**	**0.187**						

Reading Numbers	Locations								
	Public Garage								
	2" Cu DWV								
	82	83	84	85	86	87	88	89	90
1	0.051	0.050	0.044	0.041	0.046	0.052	0.036	**0.029**	0.040
2	0.040	0.044	0.039	0.040	0.038	0.039	**0.025**	0.033	0.038
3	0.042	0.036	0.053	0.044	0.050	0.041	**0.030**	0.034	0.036
4	0.050	0.044	0.042	0.042	0.049	0.045	0.032	0.036	0.032

Reading Numbers	Locations								
	Public Parking								
	2" Cu DWV								
	91	92	93	94	95	96	97	98	99
1	0.043	**0.031**	0.035	0.049	0.051	0.046	0.036	0.049	0.039
2	0.047	0.039	**0.030**	0.036	0.040	0.049	0.040	0.040	0.038
3	0.043	0.040	0.039	0.033	0.032	**0.028**	0.039	0.041	0.042
4	0.042	0.044	0.040	0.040	0.036	0.040	0.032	0.038	0.042

Reading Numbers	Locations								
	Public Parking								
	2" Cu DWV							$1^1/_4$" Cu DWV	
	100	101	102	103	104	105	106	107	108
1	0.048	0.039	0.036	0.036	**0.029**	0.051	0.048	**0.028**	0.033
2	0.040	0.047	0.034	0.039	**0.031**	0.047	0.049	0.031	**0.022**
3	**0.031**	0.044	0.041	0.042	0.033	0.045	0.041	**0.030**	0.036
4	**0.029**	0.042	0.040	0.036	**0.029**	0.042	0.042	**0.029**	0.034

Reading Numbers	Locations								
	Public Parking							Condo Parking	
	$1^1/_4$" Cu DWV							2" Cu DWV	
	109	110	111	112	113	114	115	116	117
1	0.039	0.034	0.034	0.036	0.040	0.040	**0.027**	**0.029**	0.037
2	0.032	**0.027**	0.037	0.034	0.039	0.039	0.031	**0.025**	**0.022**
3	**0.029**	**0.030**	0.035	0.033	0.036	**0.027**	0.039	0.036	**0.021**
4	0.036	**0.029**	0.039	0.032	0.037	0.032	0.040	0.033	**0.022**

Reading Numbers	Locations								
	Condo Parking								
	2" Cu DWV								
	118	119	120	121	122	123	124	125	126
1	**0.029**	**0.030**	0.042	**0.026**	**0.022**	0.039	0.037	**0.026**	0.043
2	**0.018**	**0.022**	**0.025**	**0.030**	**0.027**	**0.023**	0.035	**0.021**	**0.021**
3	**0.021**	**0.024**	**0.027**	**0.022**	**0.029**	**0.022**	**0.019**	**0.029**	**0.023**
4	**0.023**	**0.026**	**0.029**	**0.021**	**0.030**	**0.021**	**0.023**	**0.030**	**0.030**

Reading Numbers	Locations								
	Condo Parking								
	2" Cu DWV								
	127	128	129	130	131	132	133	134	135
1	0.032	0.040	0.033	0.042	**0.028**	0.047	**0.020**	0.039	0.040
2	0.036	**0.029**	**0.024**	0.040	**0.029**	**0.029**	**0.027**	0.042	0.041
3	0.039	0.037	**0.029**	0.049	**0.022**	**0.030**	**0.022**	**0.029**	**0.019**
4	0.037	0.039	**0.028**	0.037	**0.023**	**0.024**	**0.028**	**0.030**	**0.027**

Reading Numbers	Locations								
	Condo Parking								
	2" Cu DWV								
	136	137	138	139	140	141	142	143	144
1	**0.028**	0.040	0.037	0.036	0.039	0.033	**0.027**	**0.029**	0.033
2	**0.025**	**0.031**	**0.023**	**0.029**	0.032	**0.027**	**0.029**	0.032	**0.029**
3	0.032	**0.026**	**0.029**	0.040	**0.026**	**0.024**	**0.026**	0.035	0.036
4	0.038	**0.029**	0.032	0.041	**0.024**	**0.021**	**0.030**	0.036	0.034

Reading Numbers	Location								
	Condo Parking								
	2" Cu DWV								
	145	146	147	148	149	150	151	152	153
1	**0.021**	**0.023**	**0.022**	**0.029**	**0.029**	**0.027**	**0.026**	0.033	**0.025**
2	**0.030**	**0.026**	**0.022**	0.032	**0.031**	**0.027**	**0.029**	0.036	**0.029**
3	**0.029**	**0.029**	**0.019**	0.036	0.033	**0.025**	**0.027**	**0.028**	0.033
4	**0.020**	**0.030**	**0.021**	0.032	0.037	**0.029**	0.032	**0.029**	0.032

3.2 Calculations

3.2.1 Cast Iron Sanitary Drains

Thickness measurements on the 3" Cast Iron piping ranged from 0.049 inches to 0.298 inches. This suggests a nominal thickness of 0.250 inches for the 3" Cast Iron piping. Maximum wall loss detected would be 0.201 inches or ~80.4%.

Thickness measurements on the 4" Cast Iron piping ranged from 0.055 inches to 0.344 inches. This suggests a nominal thickness of 0.250 inches for the 4" Cast Iron piping. Maximum wall loss detected would be 0.195 inches or ~78.0%.

Thickness measurements on the 6" Cast Iron piping ranged from 0.148 inches to 0.384 inches. This suggests a nominal thickness of 0.250 inches for the 6" Cast Iron piping. Maximum wall loss detected would be 0.102 inches or ~40.8%.

Thickness measurements on the 8" Cast Iron piping ranged from 0.116 inches to 0.330 inches. This suggests a nominal thickness of 0.310 inches for the 8" Cast Iron piping. Maximum wall loss detected would be 0.194 inches or ~62.5%.

3.2.2 Copper Drains

Thickness measurements on the $1^1/_4$" Copper piping ranged from 0.022 inches to 0.042 inches. This suggests a nominal thickness of 0.040 inches for $1^1/_4$" Copper DWV piping. Maximum wall loss detected would be 0.018 inches or ~45.0%.

Thickness measurements on the 2" Copper piping ranged from 0.018 inches to 0.053 inches. This suggests a nominal thickness of 0.042 inches for 2" Copper DWV piping. Maximum wall loss detected would be 0.024 inches or ~57.1%.

4.0 DISCUSSION

Based on the survey performed, the sanitary drains through-out the parking garage have experienced significant deterioration with the maximum detected wall losses ranging from ~41 - ~80%. Thinning appears to be from a combination of pitting corrosion and under deposit corrosion with dealloying evident on the cast iron. Given the age of the building at ~ 43 years, this level of deterioration is understandable and in line with a roughly 50 year life-span, but it also suggests that the piping is reaching the end of its useful service life. Through-wall holes in the lines, coupled with obvious replaced sections indicative of former leaks are all pointing to a rapidly deteriorating piping system.

Cast iron piping typically suffers from a dealloying attack commonly called graphitic corrosion as it ages. This occurs when the ferrite grains in the cast iron are preferentially attacked, leaving behind a matrix of graphite flakes. The attack presents itself as a darkened area of material and is extremely brittle but generally does not show any difference in pipe dimension changes, except for a possibility of extreme variations in thickness measurements and high sound attenuation. This brittle material can then crack or flake out and causes the pipe to fail suddenly and catastrophically

without warning. Unfortunately, graphitization is quite common in cast iron piping systems and is usually referred to as aging. Failures are typically large, brittle, longitudinal cracks in the piping. Normally, when these brittle failures start to occur, it indicates that the cast iron has reached the end of its useful service life. Graphitization is also found in combination with significant pitting corrosion of the piping that produces small through-wall leaks that present as eruptions of reddish corrosion scale on the exterior of the pipe. This was noted in at least one (1) location during our survey. As well, the ultrasonic wave profiles viewed during the survey all seem to suggest that significant dealloying has occurred on numerous sections of piping in the parking garage. Fifty-eight (58) out of seventy-four (74) locations on the cast iron or ~78.4% contained significant thinning, while nineteen (19) out of seventy-four (74) locations or 25.7% could leak at any time.

The copper drains are also showing evidence of thinning with maximum wall losses of between ~45 - 57%. Interestingly enough some area show very little wear, while others are heavily thinned. This may be indicative of higher than normal flows, flushing clean the copper lines in some areas or simply replacement of the copper lines previously. It would be beneficial if the building could determine what piping has already been replaced to prevent replacing any new piping unnecessarily. Regardless a further fifty-three (53) out of seventy-nine (79) locations on the copper or ~67.1% contained significant thinning, while eleven (11) out of seventy-nine (79) locations or ~13.9% could leak at any time.

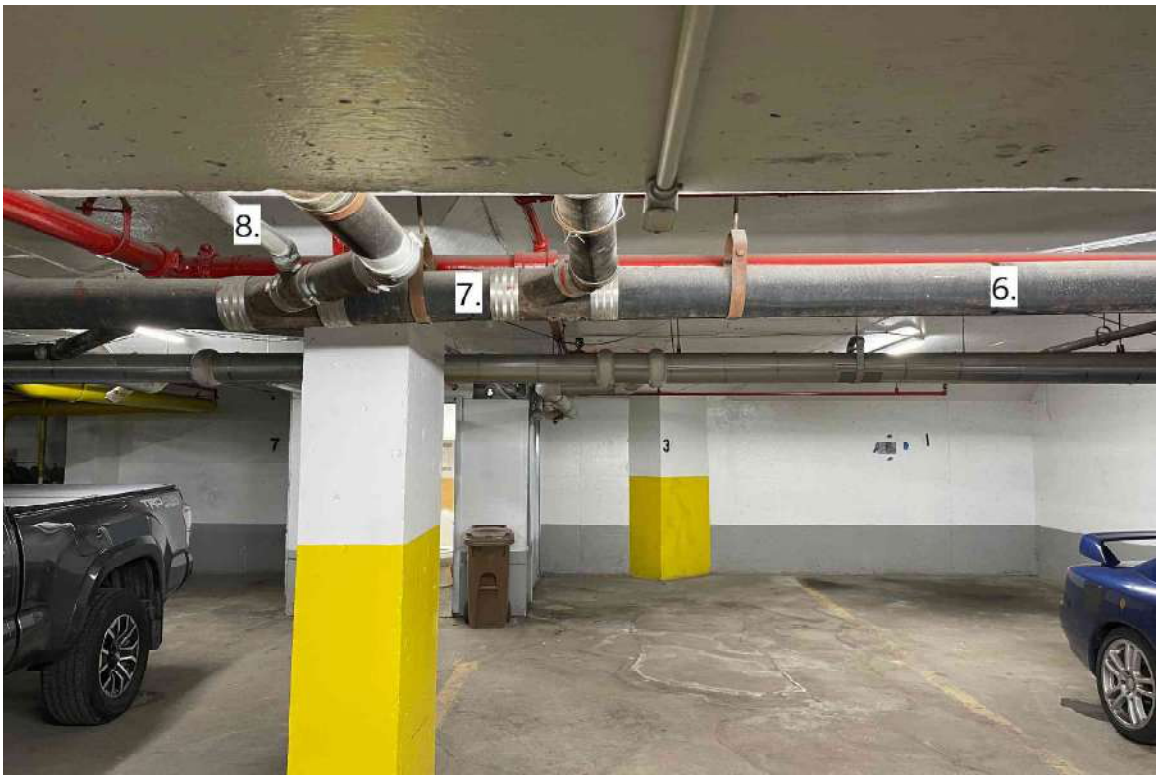
Based on the condition of the piping in the parking and the knowledge that failures are occurring on the floors, replacement of the cast iron drains should be considered. It may be prudent to attempt to determine how high up the building the heavy deterioration exists by sampling the drains on the lower, mid and upper levels and plan for replacement accordingly.

5.0 CONCLUSIONS

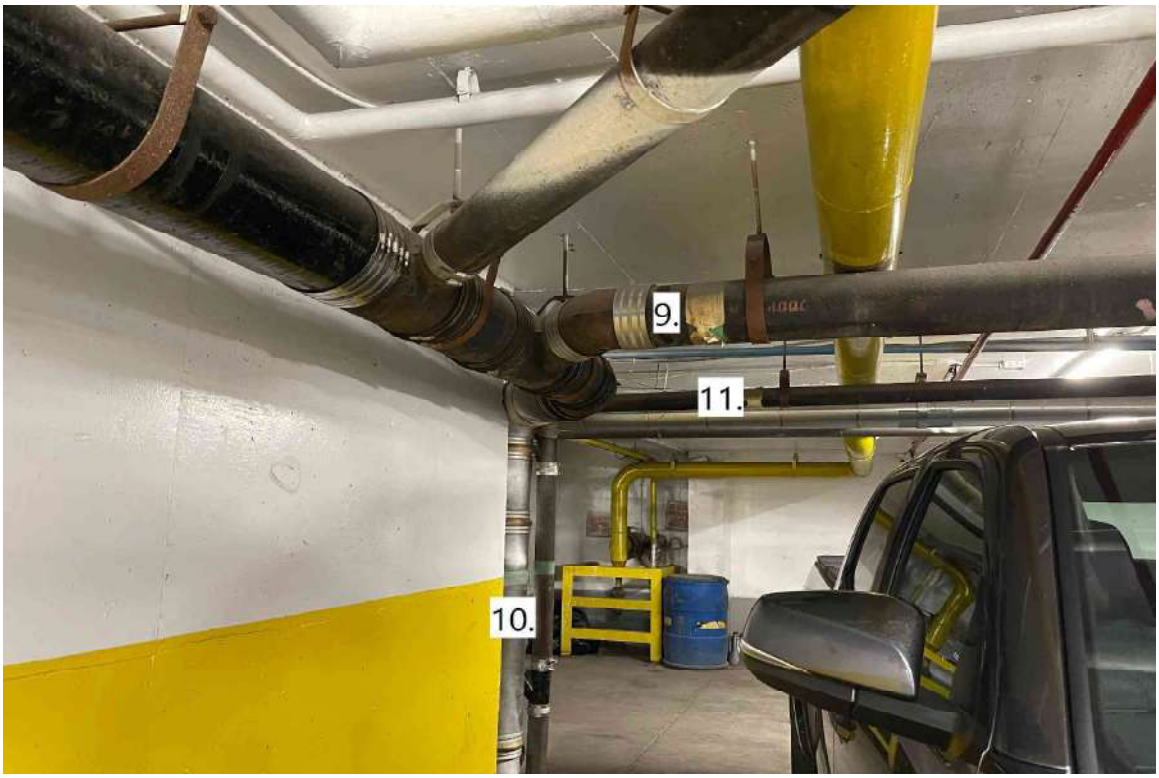
The sanitary piping in the Parking Garage of 151 Bay St in Ottawa, Ontario has experienced significant thinning in the form for underdeposit corrosion, pitting corrosion and graphitization with wall losses of greater of up to 80% of the nominal wall thickness were noted throughout the garage. Leaks and cracking could be expected at any time. This is indicating that the piping is reaching the end of its useful service life and should be replaced.

In addition, it would be advisable to try and determine the level of deterioration further up the building so that replacement of the sanitary drains can be planned to remove the worst sections first.

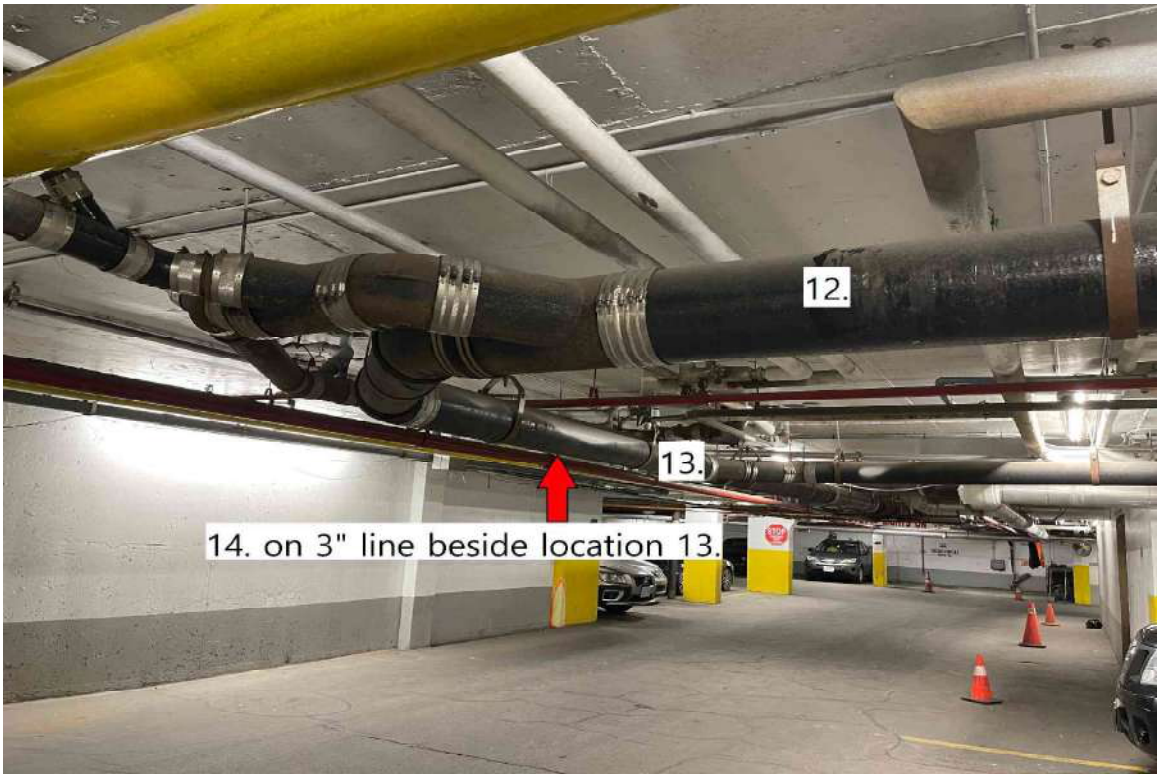
Photograph 1: Parking Garage 1 Entrance.



Photograph 2: Parking Garage Spot 3.

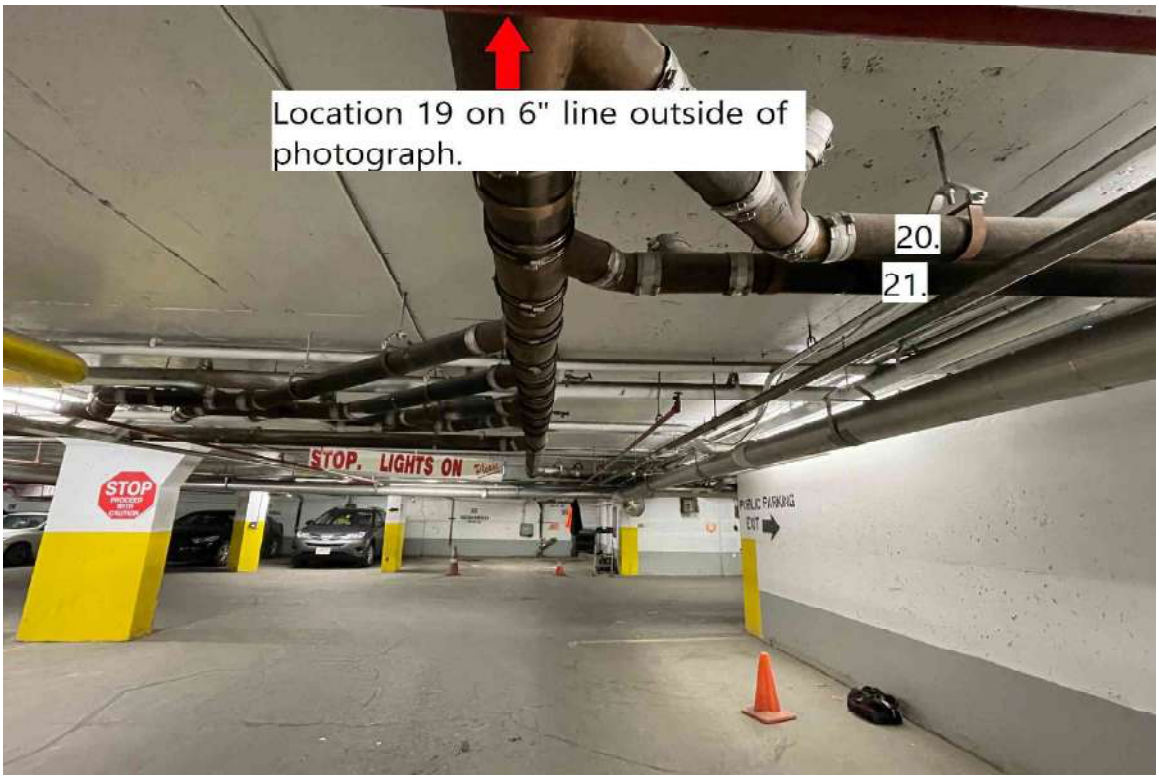


Photograph 3: Parking Garage Spot 7.

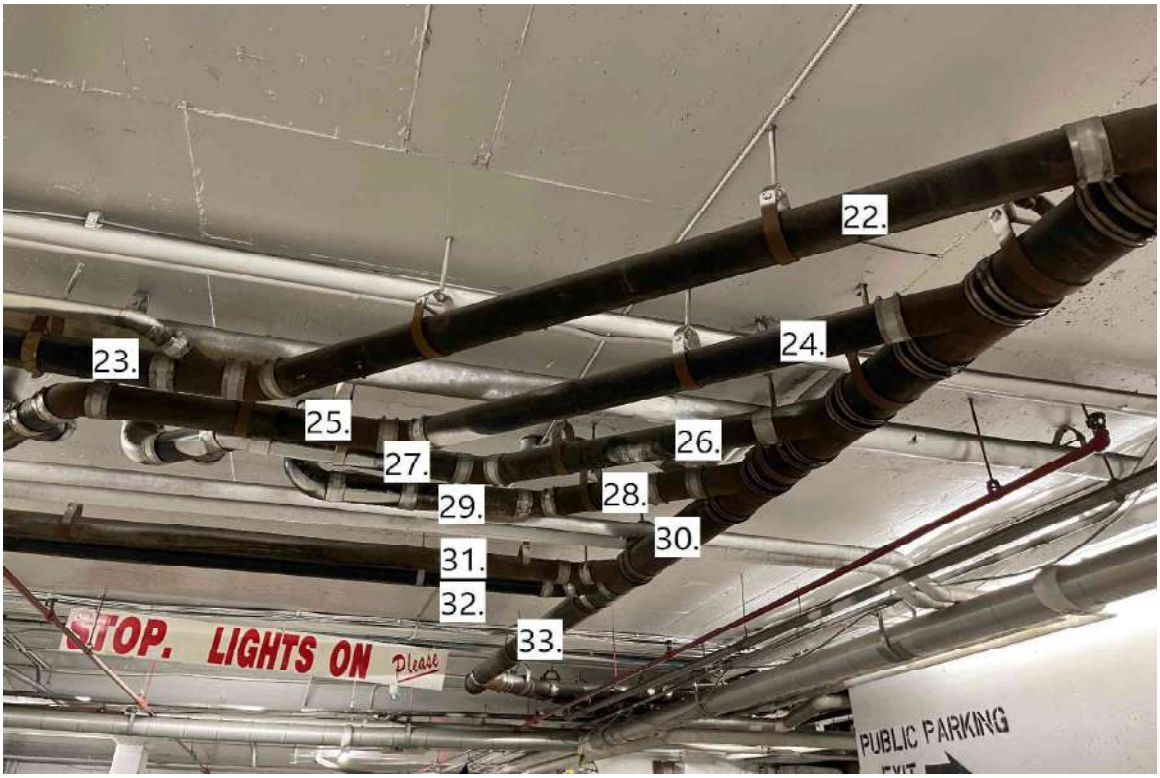


Photograph 4: Parking Garage Between Spot 8 & 9.

Photograph 5: Between Public Parking & Condo Garage.

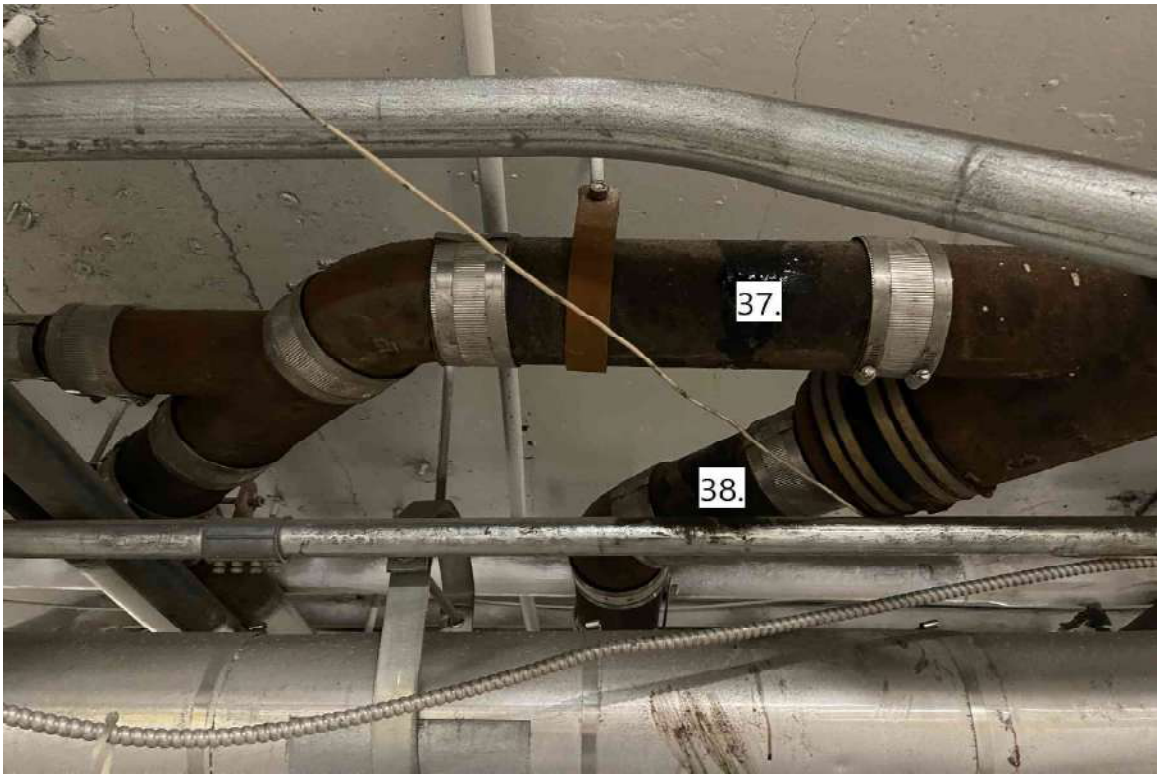


Photograph 6: Between Public Parking & Condo Garage.



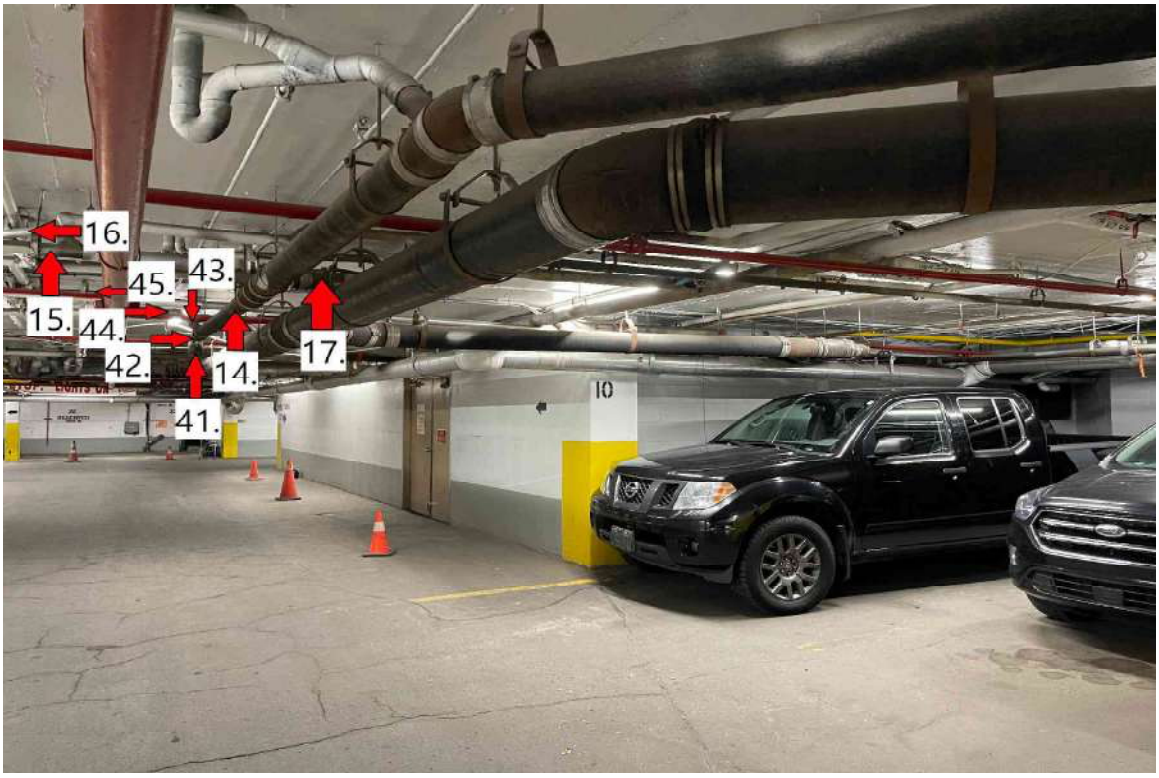
Photograph 7: Between Public Parking & Condo Garage.

Photograph 8: Condo Garage Entrance/Exit.

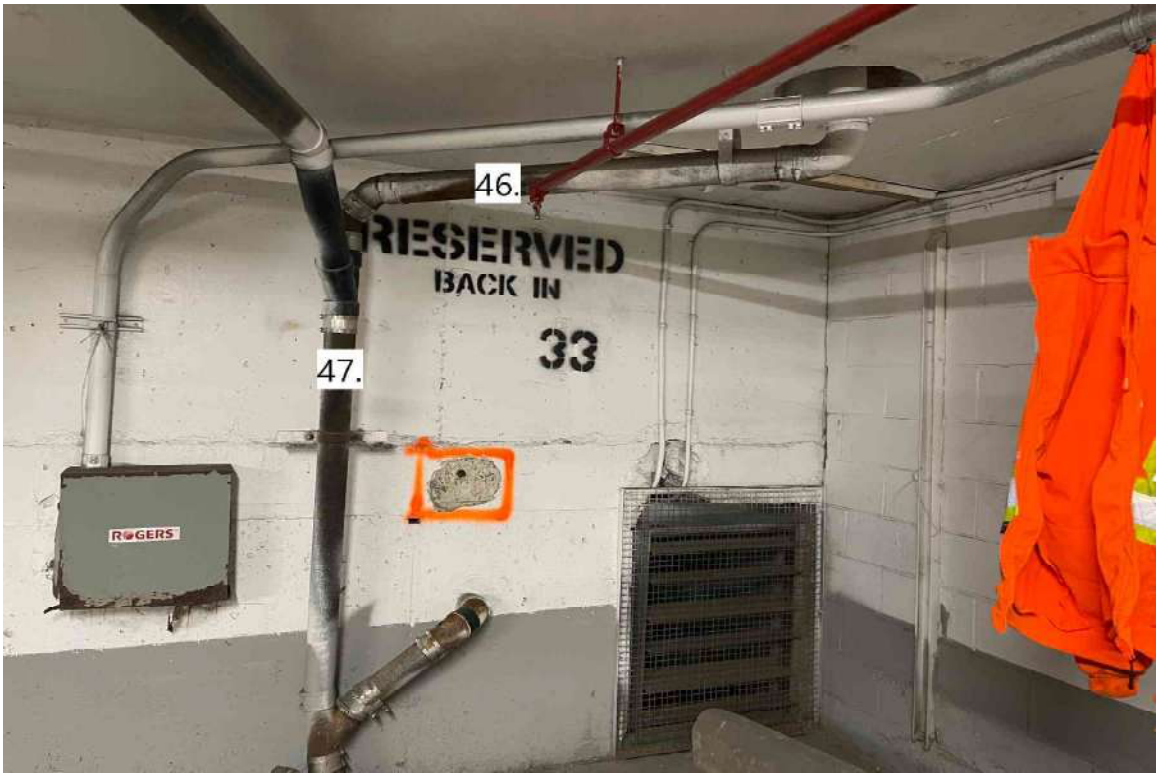


Photograph 9: Condo Garage Entrance/Exit.

Photograph 10: Condo Garage Entrance/Exit.

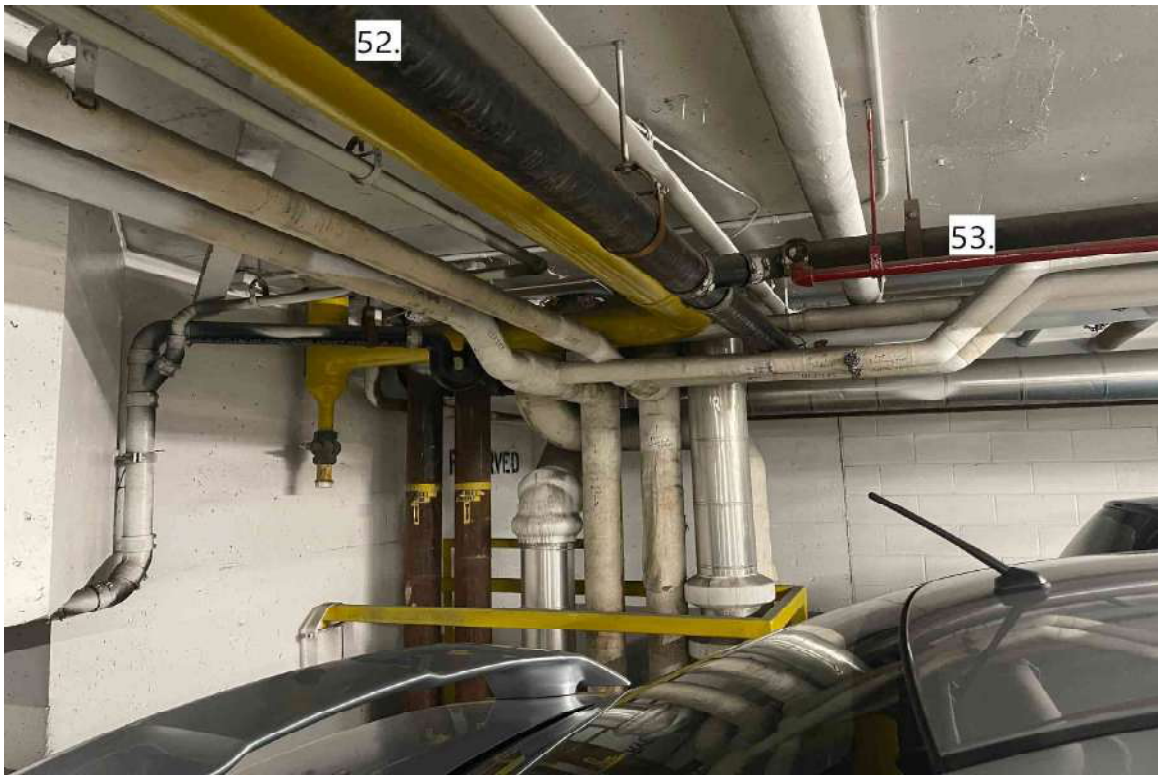


Photograph 11: Public Parking Garage.

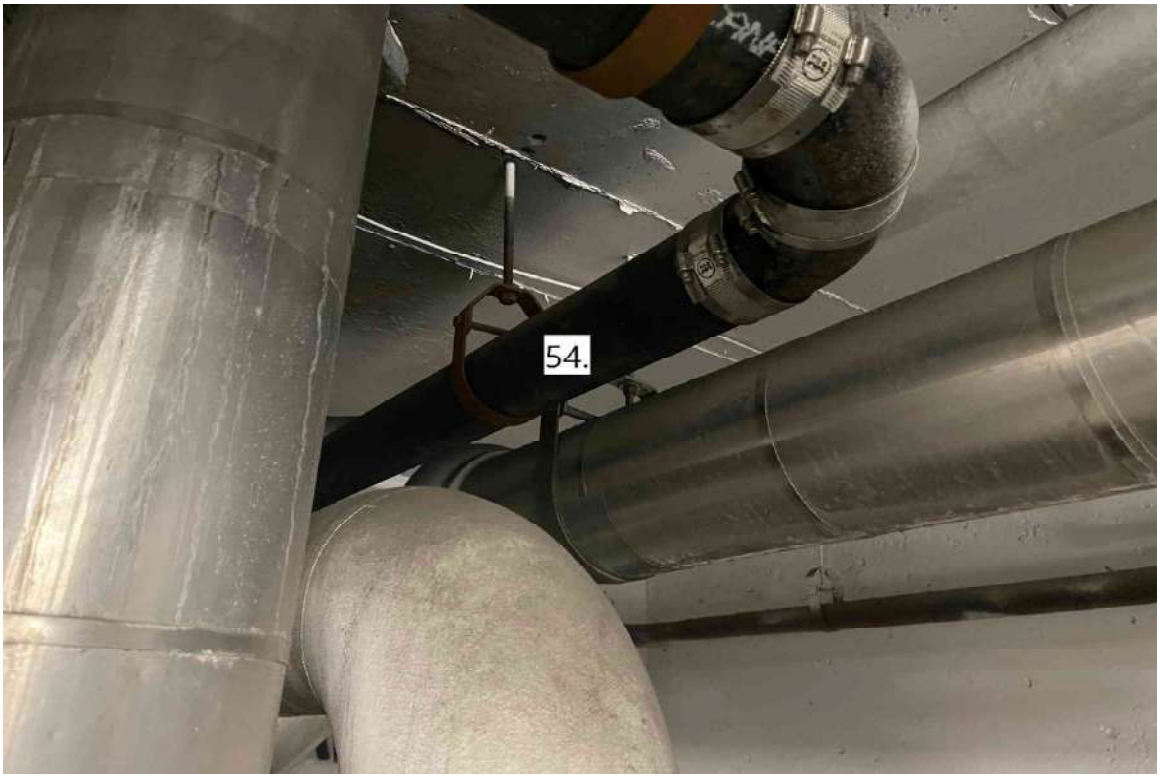


Photograph 12: Condo Garage Spot 33.

Photograph 13: Condo Garage Spot 14.

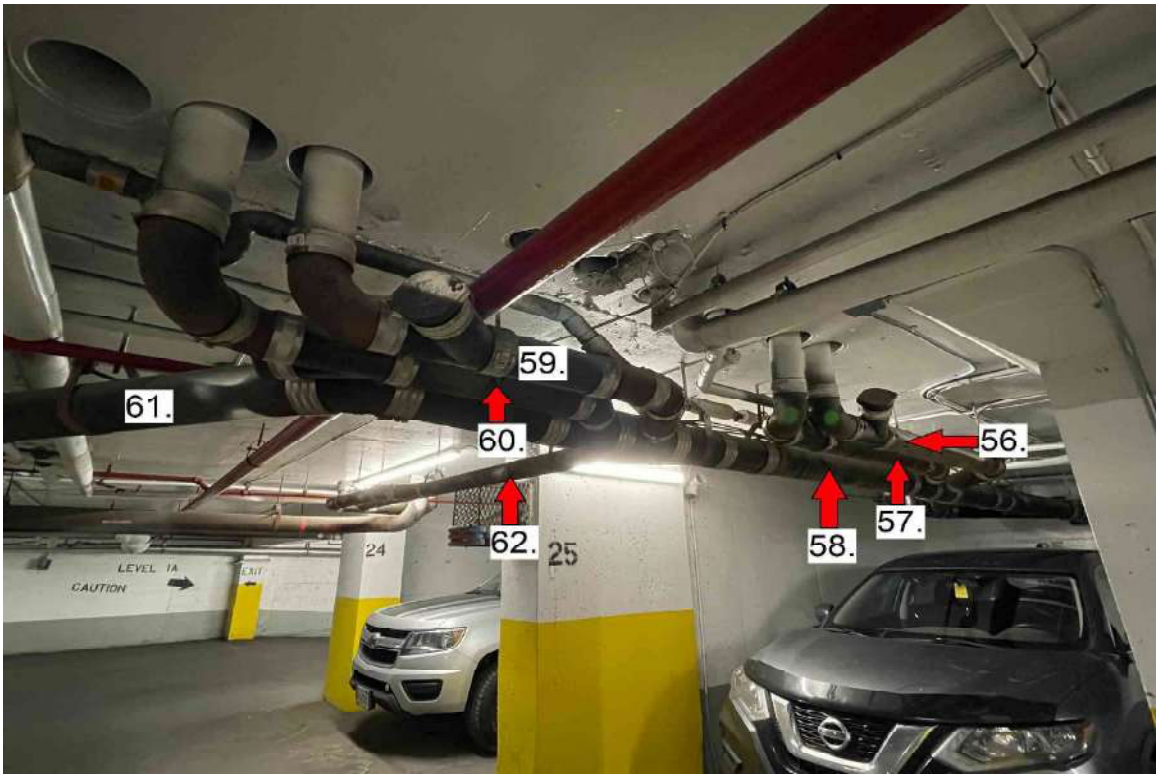


Photograph 14: Condo Garage beside Spot 14.

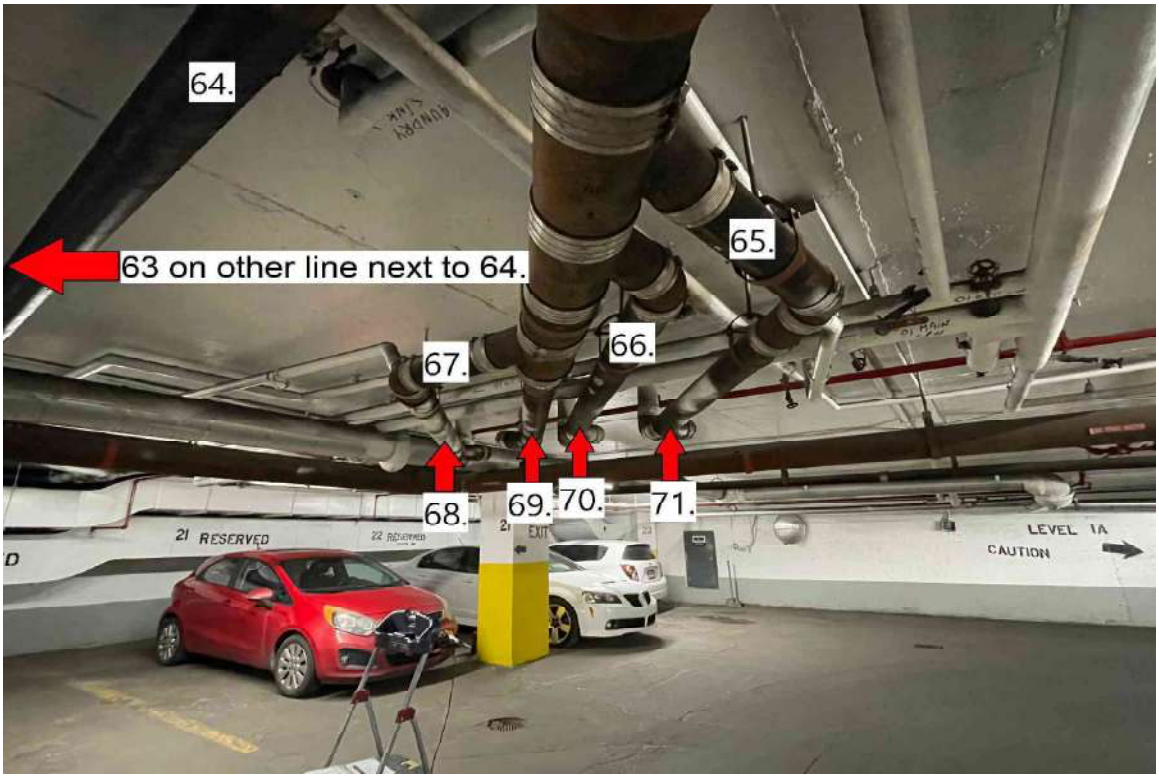


Photograph 15: Condo Garage Spot 19.

Photograph 16: Condo Garage beside Spot 14.



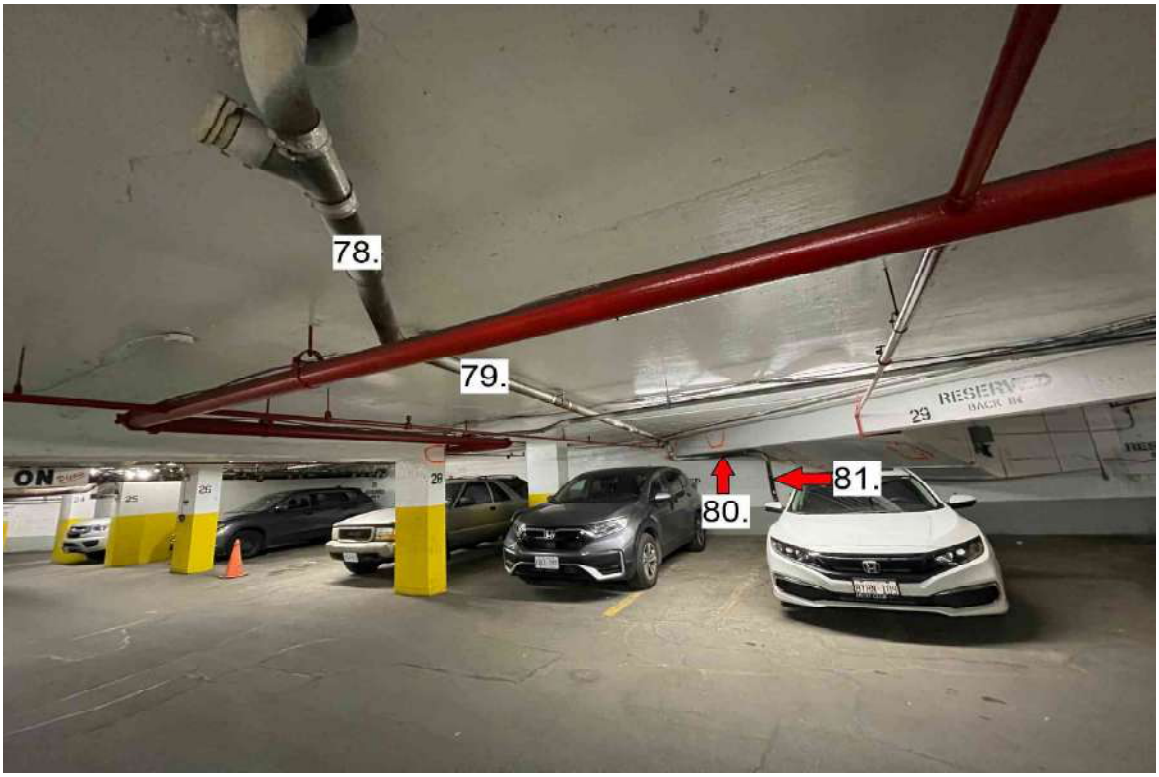
Photograph 17: Condo Garage Spot 25.



Photograph 18: Condo Garage Middle from Spots 21 & 25.

Photograph 19: Condo Garage Spot 20.

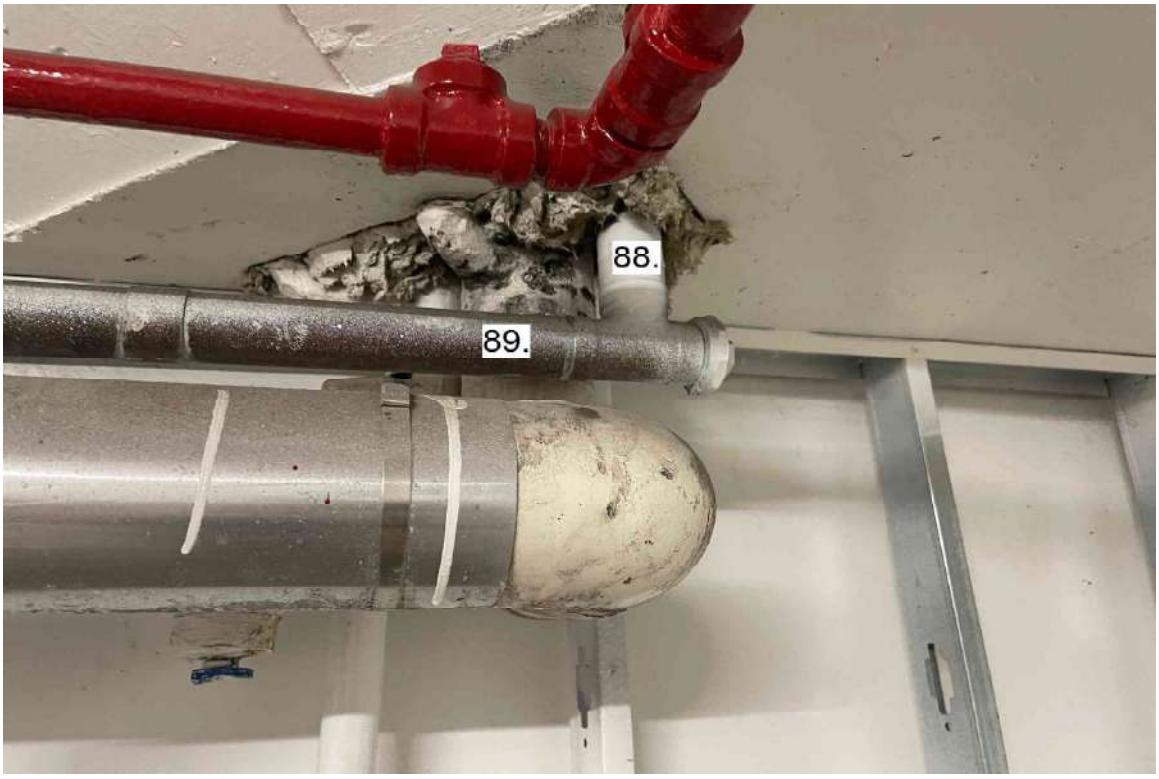
Photograph 20: Condo Garage Spot 19.



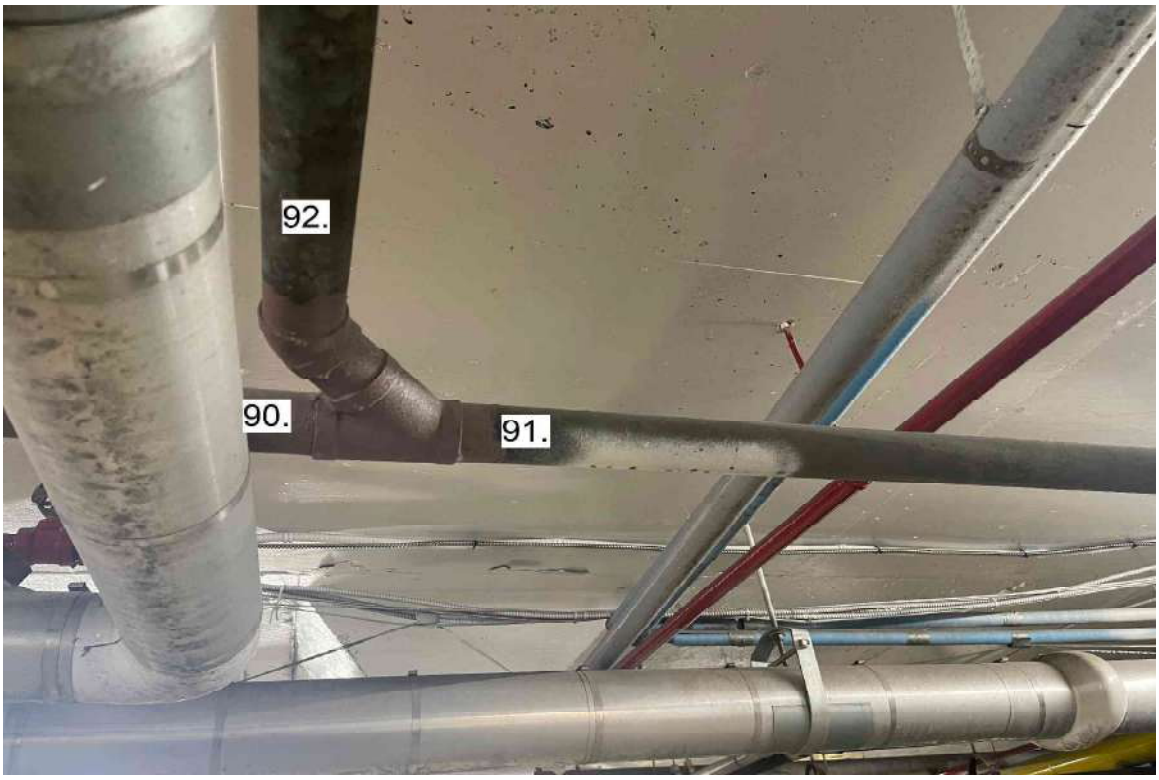
Photograph 21: Condo Garage Spot 29.

Photograph 22: Public Garage Spot 13.

Photograph 23: Public Garage Entrance/Exit.

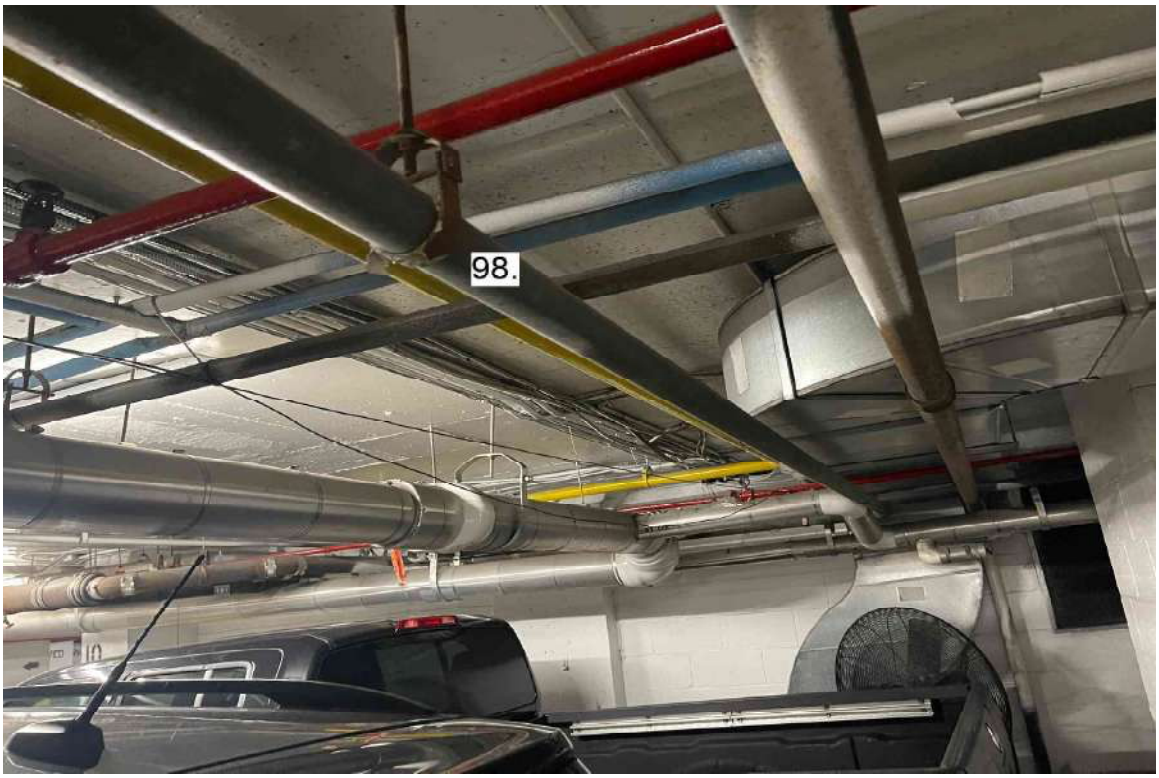


Photograph 24: Public Garage Spot 3.

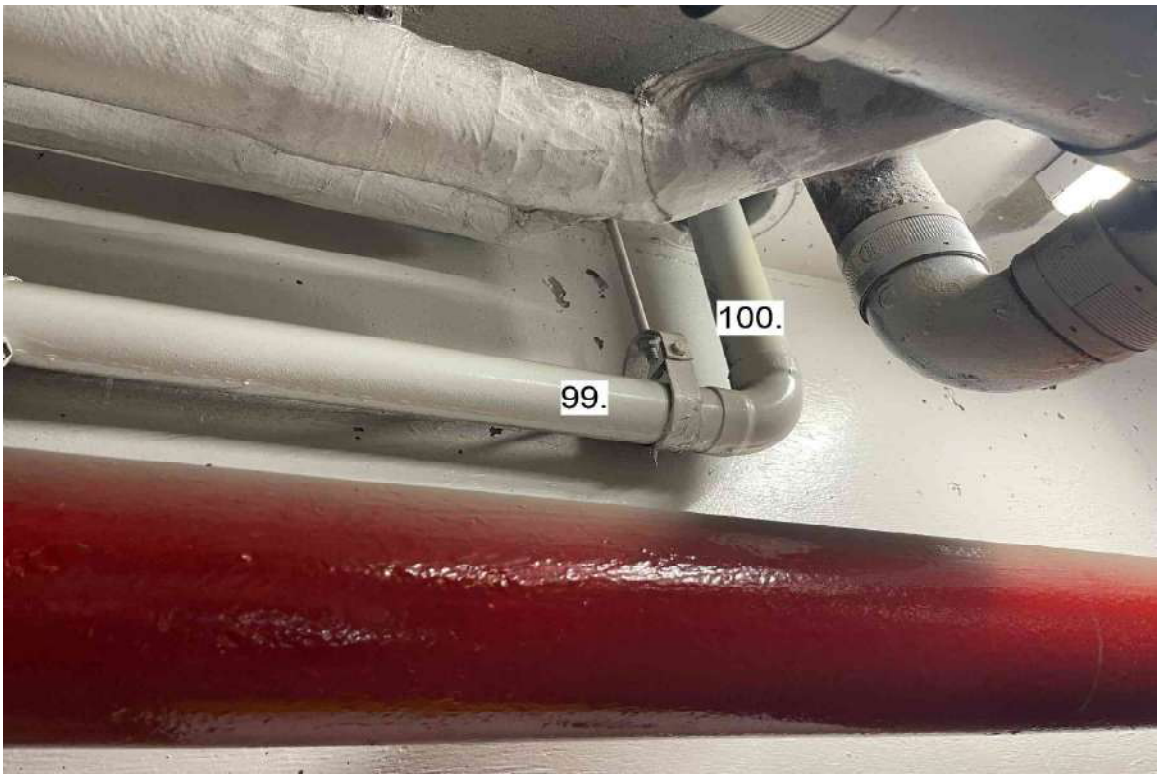


Photograph 25: Public Parking Spot 3.

Photograph 26: Public Parking Spot 7.



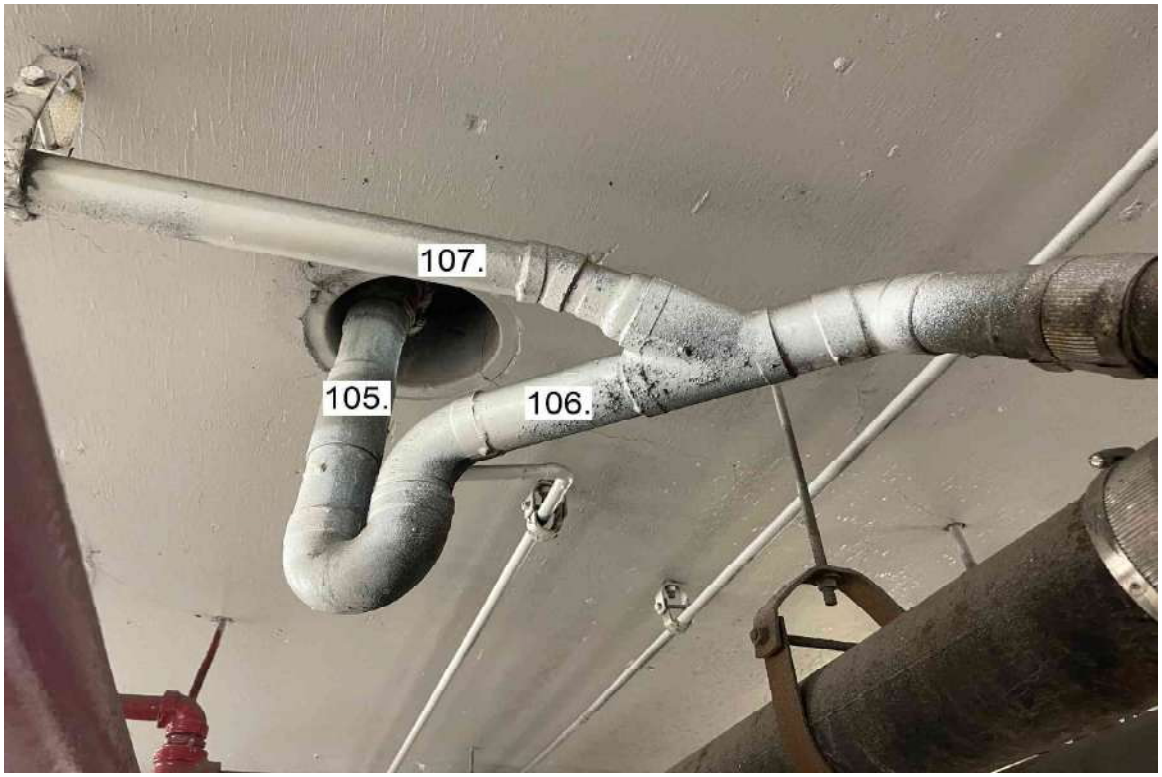
Photograph 27: Public Parking Spot 11.



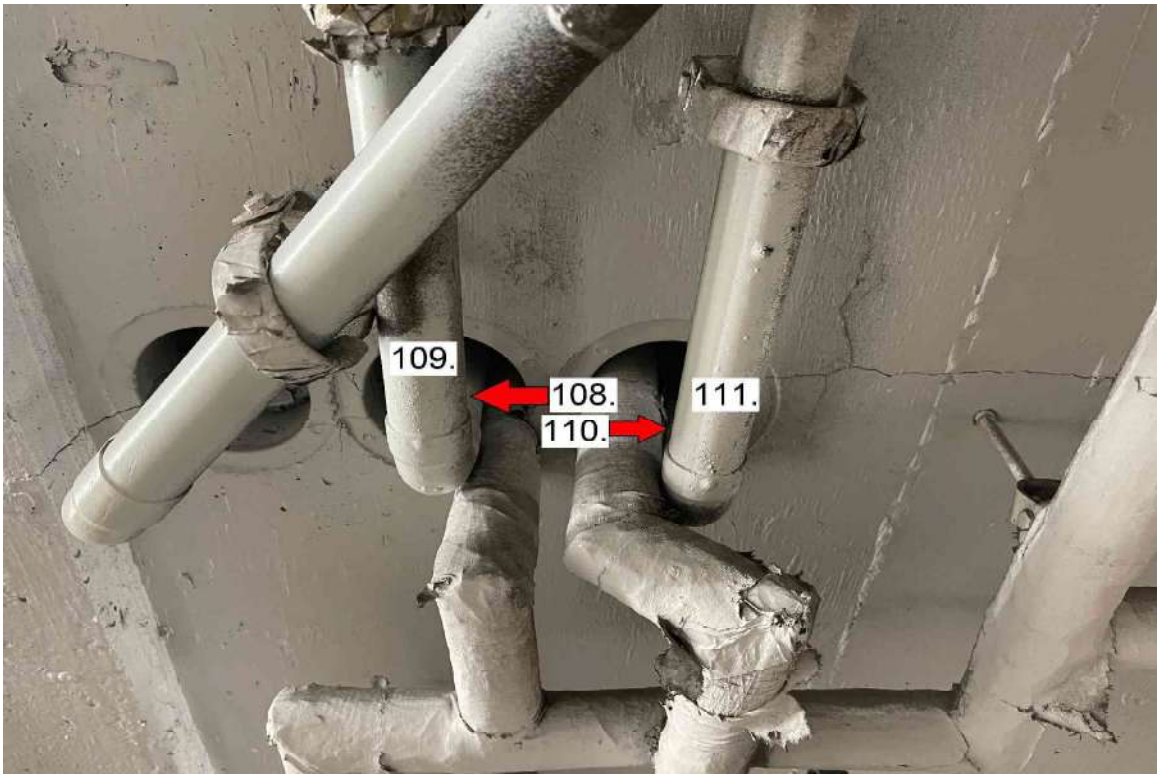
Photograph 28: Public Parking Pillar 6.

Photograph 29: Public Garage Pillar 9.

Photograph 30: Public Garage Beside locations 15 & 16.

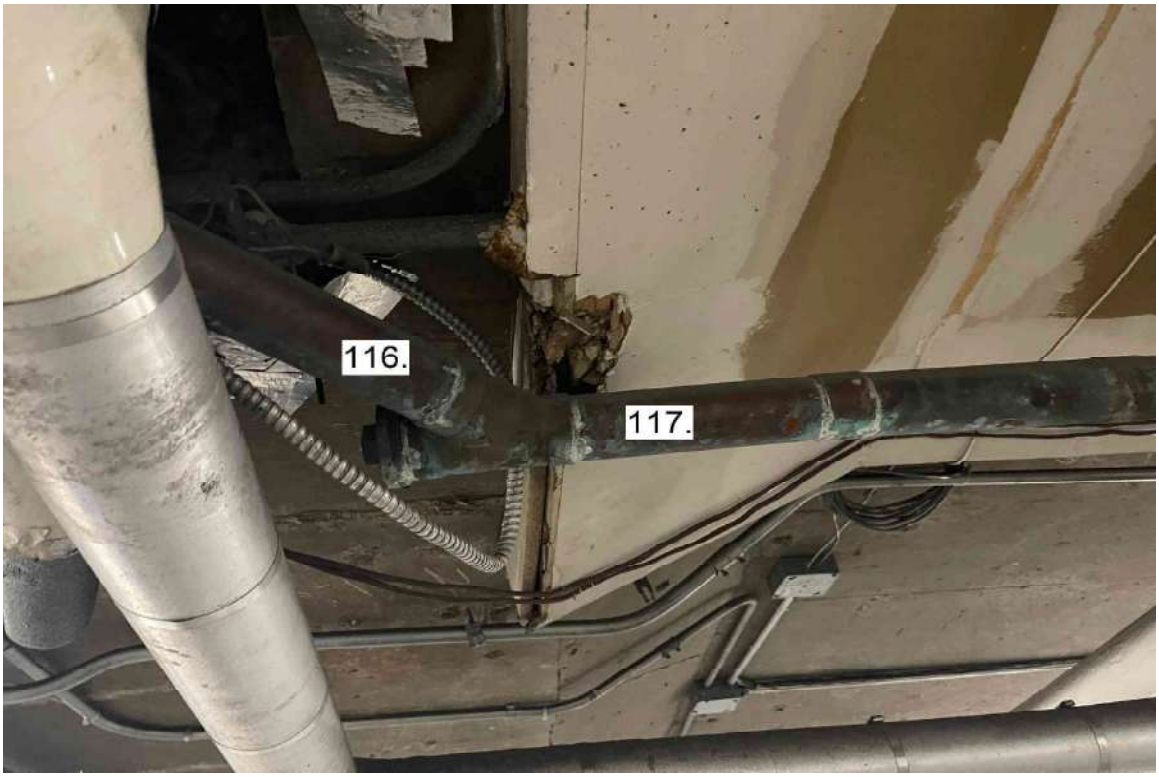


Photograph 31: Public Garage Across Spot 10.



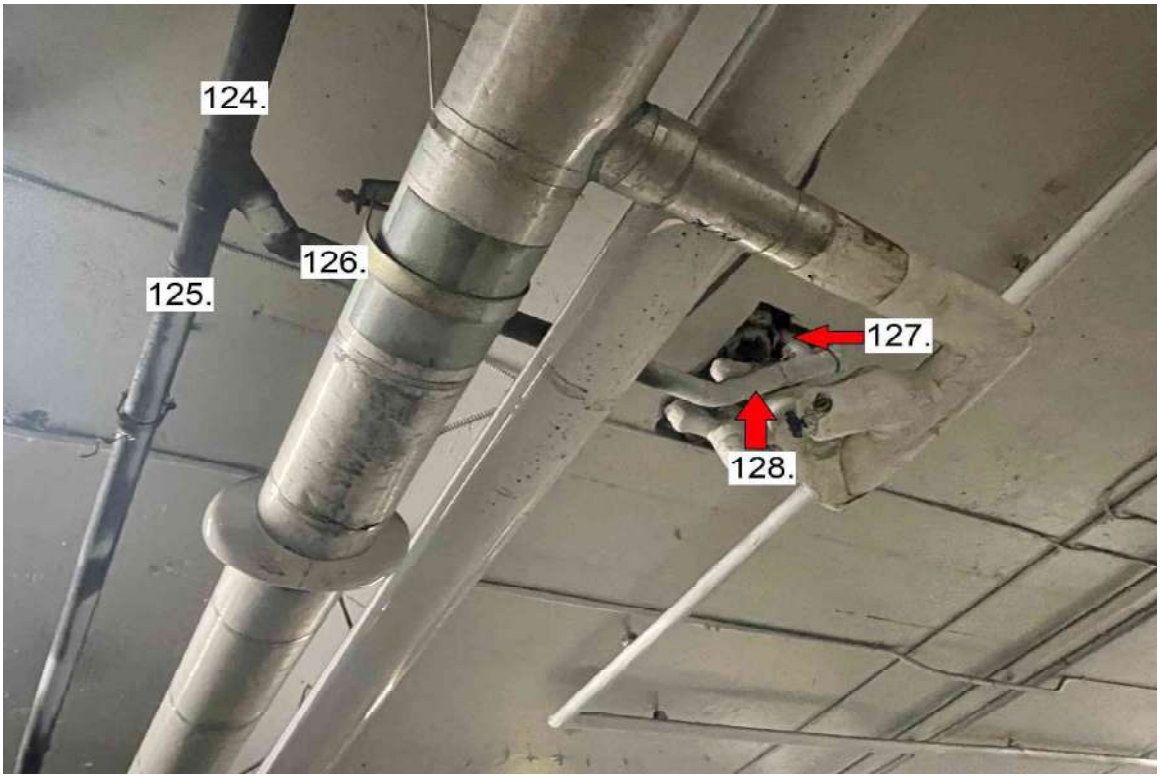
Photograph 32: Public Garage.

Photograph 33: Public Garage.

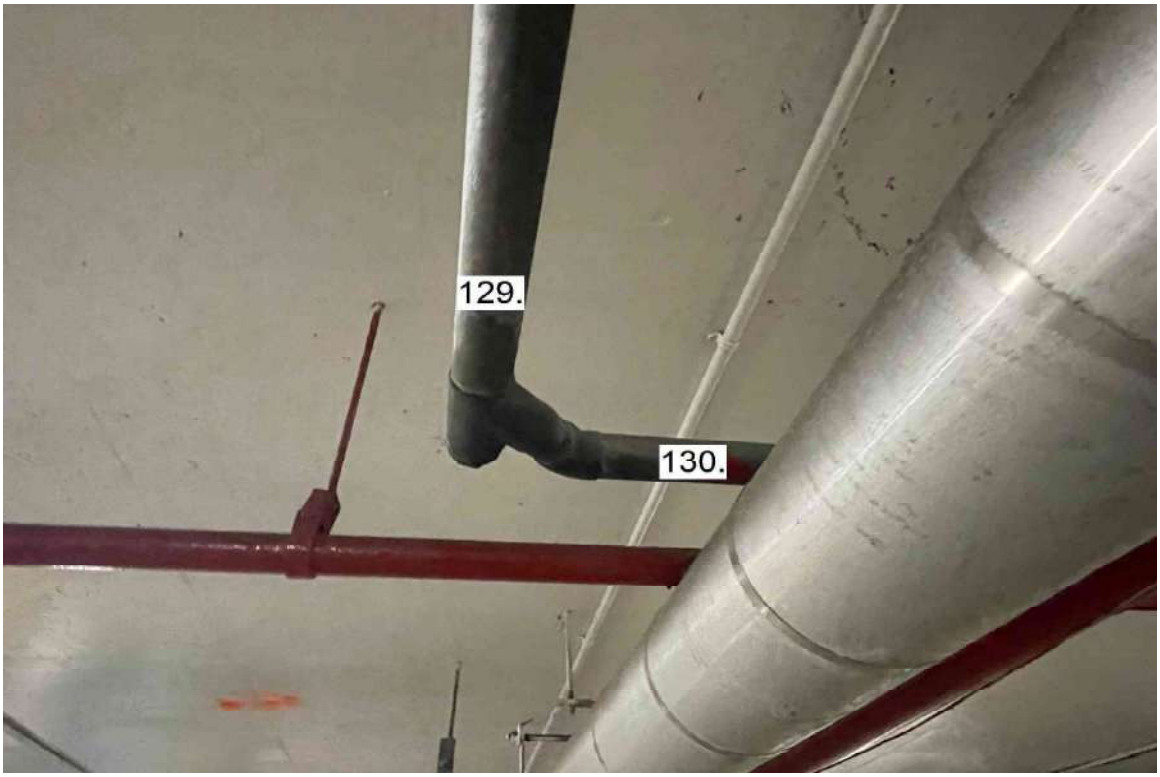


Photograph 34: Building Garage Entrance & Exit.

Photograph 35: Condo Garage Entrance & Exit.

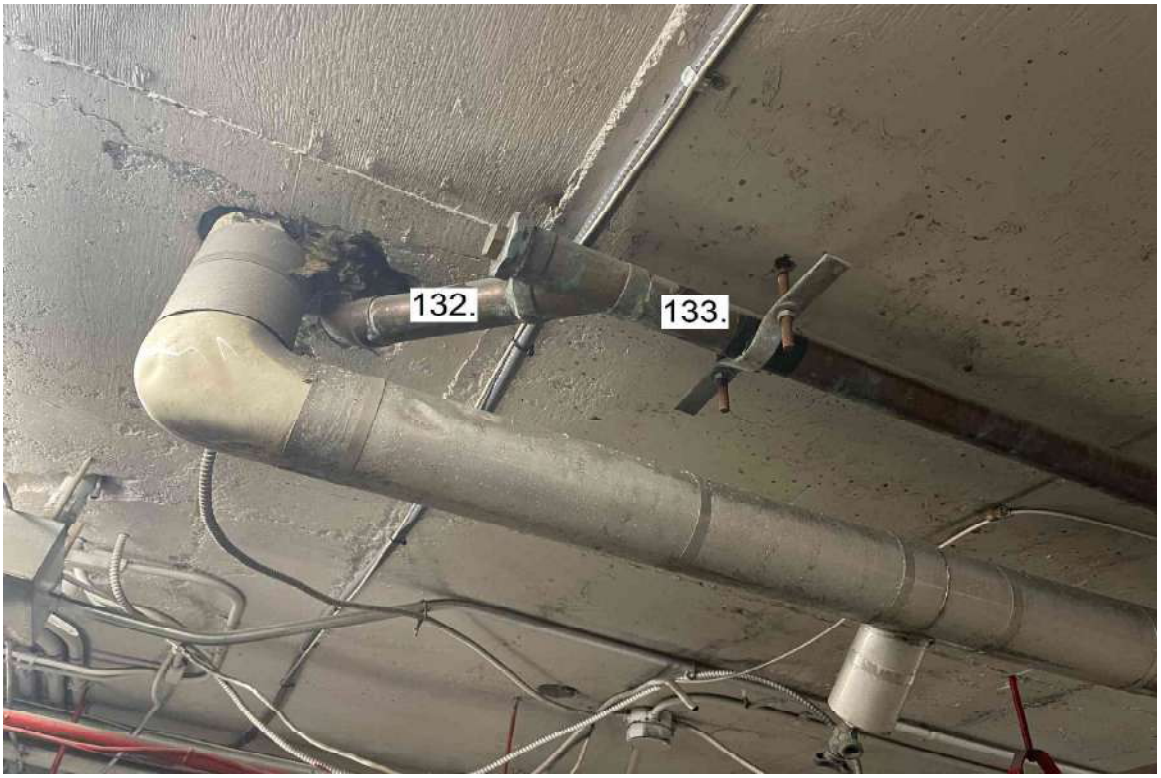


Photograph 36: Condo Garage Spot 31.

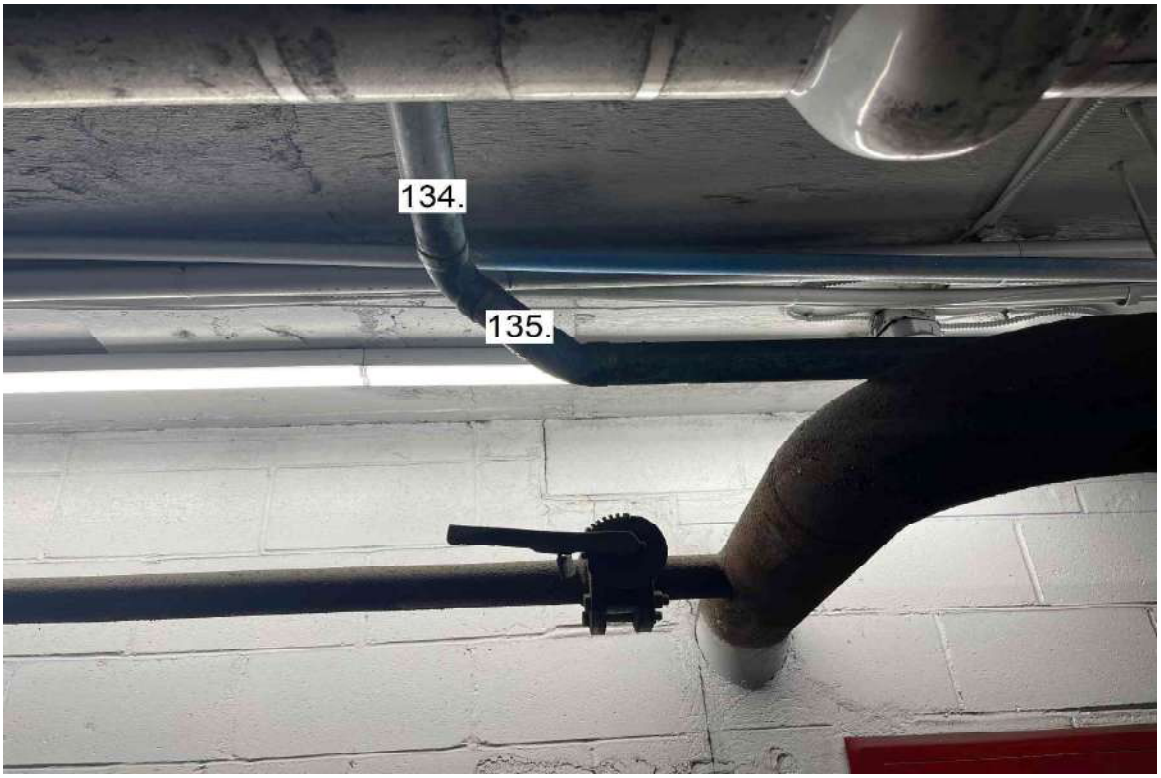


Photograph 37: Condo Garage Spot 30.

Photograph 38: Condo Garage Spot 30.



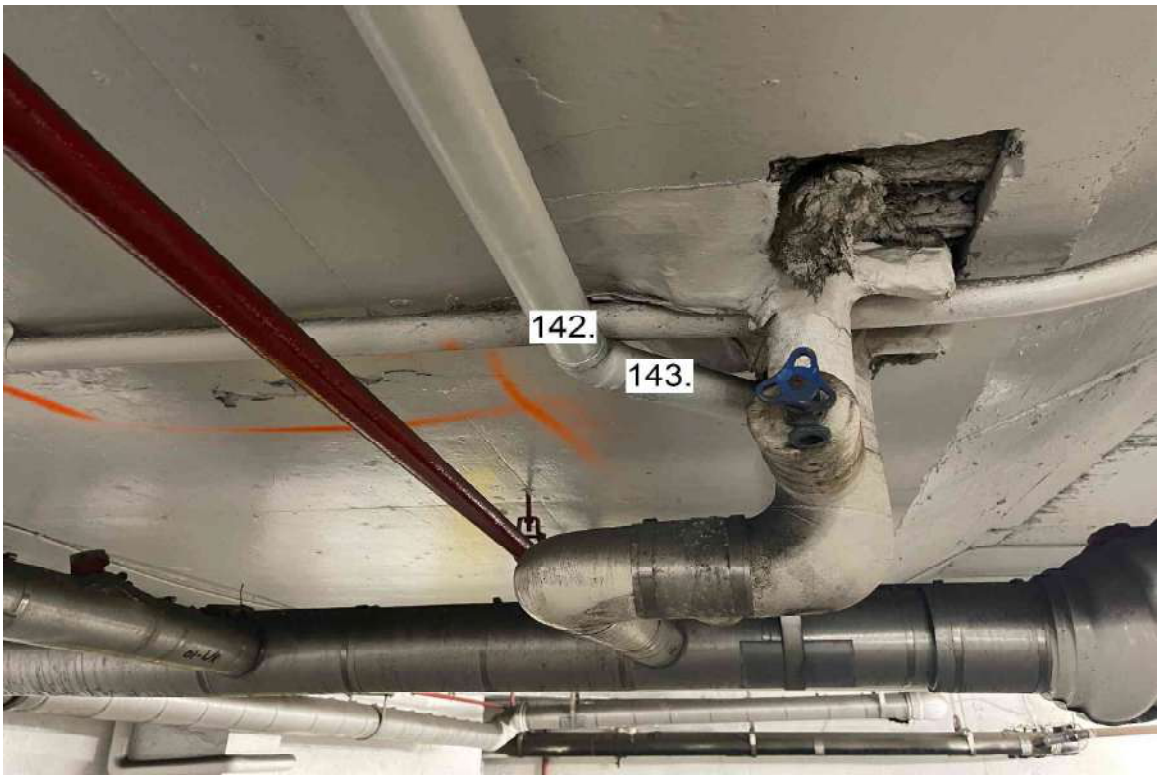
Photograph 39: Level 1 Parking Spot 29.



Photograph 40: Level 1 Parking Garage Elevator Door.

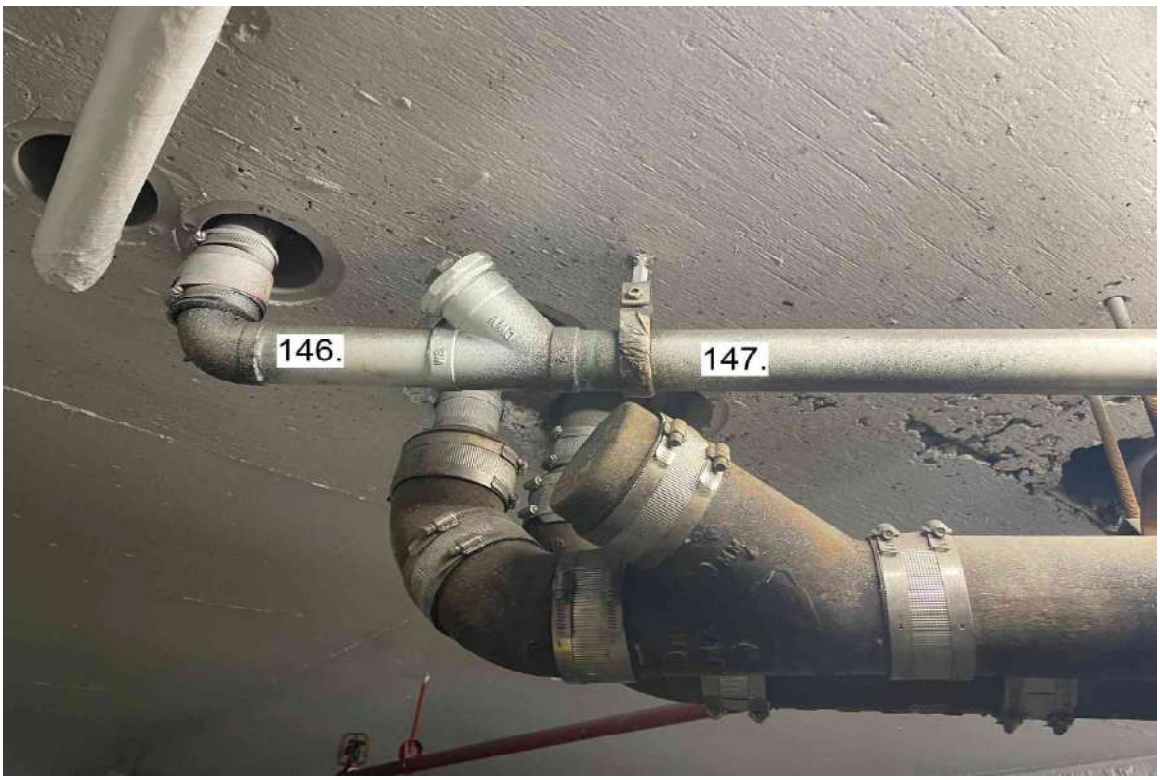
Photograph 41: Level 1 Garage Spot 20 & 21.

Photograph 42: Level 1 Garage Pillar 21.



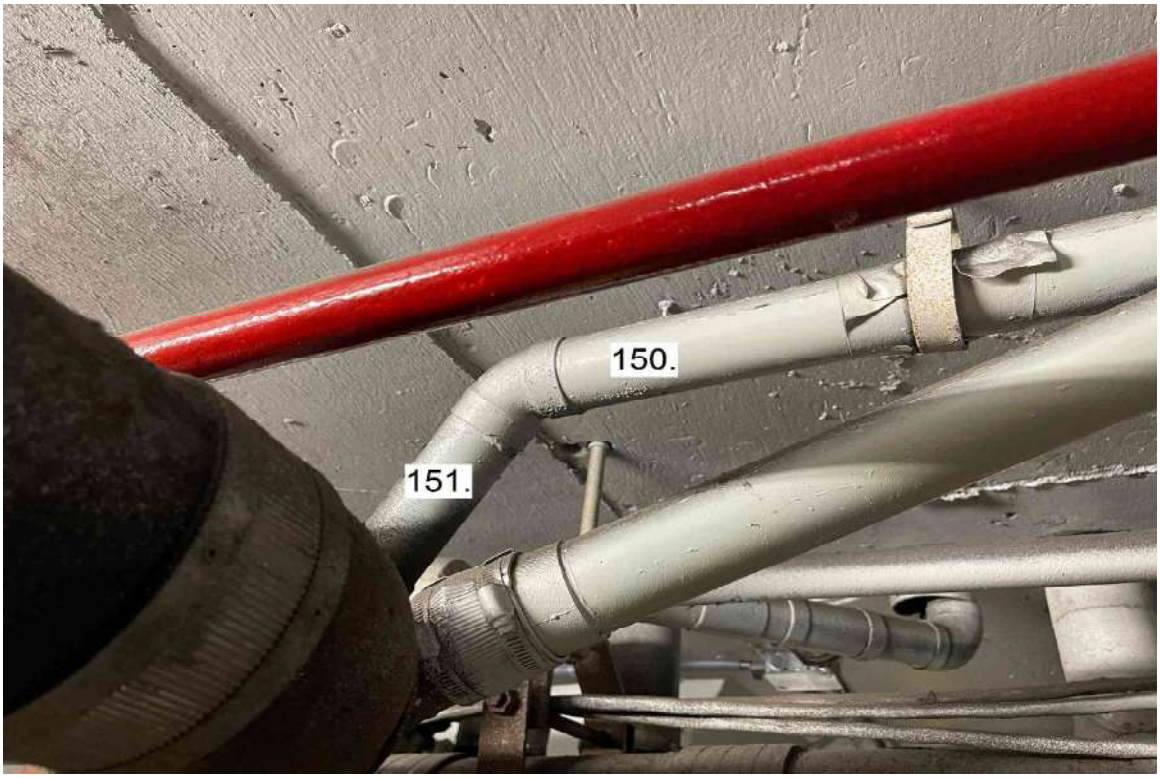
Photograph 43: Level 1 Garage Entrance/Exit Ramp.

Photograph 44: Level 1 Garage Spot 29.

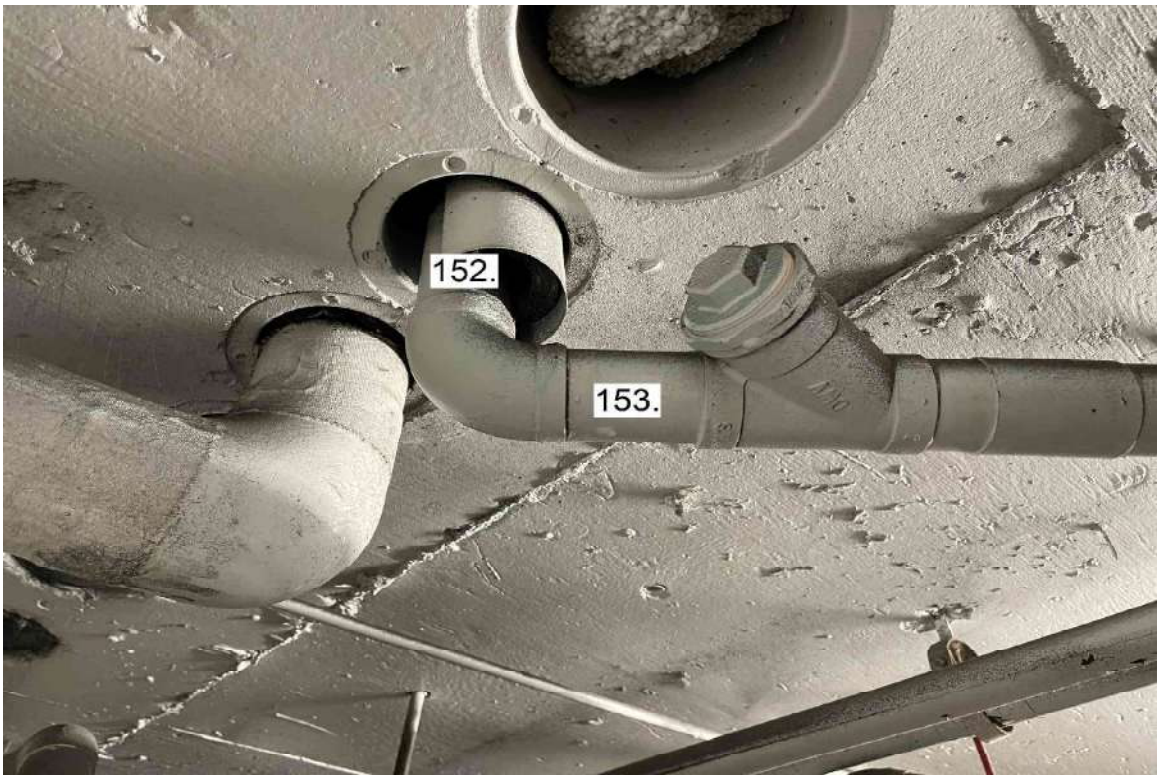


Photograph 45: Level 1 Garage Spot 29.

Photograph 46: Level 1 Garage Spot 29.



Photograph 47: Level 1 Garage Spot 29.



Photograph 48: Level 1 Garage Spot 30.

APPENDIX B

GLENCOR ENGINEERING
INSPECTION REPORT
2103332

glencor ENGINEERING LTD
20 GLENBROOK WAY • OTTAWA (NEPEAN), ONTARIO • K2G 0V2 • (613)596-1099
124 -21 ANTARES DR• OTTAWA (NEPEAN), ONTARIO • K2E 7T8 •glencor@on.aibn.com

Inspection Report 2103332

Ultrasonic Thickness Survey of
Kitchen and Bathroom
Sanitary Stacks
at
151 Bay Street,
for
Keller Engineering,
Ottawa, Ontario

date: March 14, 2022

prepared by:

J.E. Martin
CGSB 48.9712 UT-1
& ASNT-TC-1A UT-2

&

D.M.M. Twigg, P. Eng
CGSB 48.9712 UT-2
& ASNT-TC-1A UT-2

Subject: Ultrasonic Thickness Survey of Kitchen and Bathroom Sanitary Stacks at 151 Bay Street, Ottawa, Ontario.

1.0 INTRODUCTION

On Friday, March 4, 2022 a visit was made to 151 Bay Street in Ottawa, Ontario to perform an ultrasonic thickness survey of the kitchen and bathroom stacks in various units and hatches through-out the building. Reportedly, there had been some failures of the cast iron piping and concerns were raised as to the condition of the drain piping throughout the building.

2.0 TEST

A Dakota DFX7+ ultrasonic flaw detector set in the thickness gauge mode, with a ½" 1.0 MHz, dual transducer probe and Sonotech Soundsafe gel as couplant were used to take thickness readings all around the circumference of the pipe at the locations selected.

An Olympus 36 DL Plus ultrasonic thickness gauge with a ¼", 7.5 MHz dual transducer probe and Sonotech Soundsafe gel as couplant were used to take thickness measurements at the selected locations on the copper DWV piping.

3.0 RESULTS OF THE TESTING

The results of the testing are summarized in the tables below. Readings in each location generally start on the top/front of the pipe and proceed counter clockwise around the pipe when facing the direction of flow. All readings are in inches and any readings of concern are in bold for ease of identification. Readings of immediate concern are in bold and underlined.

3.1 Table of Readings

Reading Numbers	Locations									
	Unit 1110		Unit 1108		Unit 1105		Unit 707		Unit 701	
	Kitchen drain	San. Drain		Kitchen Drain	San. Drain	Vent	San. Drain	Vent	San. Drain	
	$1^1/_2$" DWV	3" CI		$1^1/_2$" DWV	3" CI	$1^1/_2$" DWV	3" CI	$1^1/_2$" DWV	3" CI	
	1	2	3	4	5	6	7	8	9	10
1	0.042	0.224	0.210	0.041	0.232	0.044	0.222	0.043	0.192	0.230
2	0.043	0.232	0.239	0.042	0.230	0.040	0.224	0.040	0.232	0.237
3	0.044	0.227	0.227	0.041	0.238	0.033	0.226	0.041	0.221	0.201
4	0.045	0.230	0.233	0.041	0.237	0.032	0.230	0.046	0.217	0.220
5		0.229	0.228		0.248		0.225		0.191	0.226
6		0.226	0.225		0.252		0.219		0.208	**0.171**

Reading Numbers	Locations								
	Unit 702			Unit 209		Unit 206		Unit 203	
	San. Drain	Vent		San. Drain					
	3" CI	$1^1/_2$" DWV		2" CI	3" CI	2" CI	3" CI	2" CI	
	11	12	13	14	15	16	17	18	19
1	0.230	0.042	0.042	**0.111**	**0.149**	0.211	**0.141**	0.222	0.222
2	0.226	0.042	0.041	0.181	**0.147**	0.191	0.206	0.212	0.230
3	0.207	0.041	0.043	0.201	**0.155**	0.201	0.225	0.217	0.237
4	0.204	0.042	0.044	-	0.207	0.207	0.205	0.215	0.249
5	0.221				**0.154**		0.209		
6	0.220				**0.142**		0.214		

- too difficult to obtain readings

Reading Numbers	Locations							
	14th Floor by Stairwell 14A		14th Floor by Unit 1408	14th Floor Bathroom Stack Unit 1406		12th Floor Hallway Bathroom Stack Unit 1201	11th Floor Hallway Bathroom Stack	
	San. Drain	Vent		San. Drain	Vent	San. Drain		Vent
	3" CI	$1^1/_4$" DWV		4" CI	$1^1/_4$" DWV	3" CI	4" CI	$1^1/_4$" DWV
	20	21	22	23	24	25	26	27
1	**0.160**	0.045	0.043	0.302	0.043	0.281	0.197	0.045
2	**0.159**	0.044	0.040	0.291	0.040	0.213	0.195	0.043
3	**0.151**	0.046	0.043	0.270	0.042	0.215	0.196	0.044
4	**0.153**	0.043	0.039	0.255	0.043	0.217	0.198	0.044
5	**0.160**			0.259		0.209	0.205	
6	**0.181**			0.250		0.211	0.206	
7				0.257			0.205	
8				0.270			0.219	

Reading Numbers	Locations									
	10th Floor Hallway Bathroom Unit 1001		9th Floor Hallway Bathroom Stack Units 903 & 902		Unit 901 Bathroom Stack		Unit 910 Bathroom Stack		Unit 806 Bathroom Stack	
	San Drain	Vent		San. Drain	San. Drain	Vent	San. Drain	Vent	San. Drain	Vent
	4" CI	1 1/4" DWV		4" CI		1 1/4" DWV	4" CI	1 1/4" DWV	4" CI	1 1/4" DWV
	28	29	30	31	32	33	34	35	36	37
1	0.286	0.042	**0.030**	0.277	**0.173**	0.041	0.266	0.042	0.270	0.042
2	0.284	0.040	0.035	0.236	**0.171**	0.040	0.247	0.044	0.263	0.045
3	0.268	0.033	0.039	0.234	0.280	0.043	**0.157**	0.040	0.239	0.044
4	0.192	0.039	0.040	0.283	0.191	0.039	0.252	0.041	0.244	0.043
5	0.193			0.282	0.234		0.249		0.259	
6	0.191			0.280	0.240		0.246		0.260	
7	0.264			0.281	**0.174**		0.240		0.257	
8	0.279			0.275	0.219		0.249		0.242	

Reading Numbers	Locations									
	8th Floor Bathroom Stack Unit 807		7th Floor Bathroom Stack Unit 706		7th Floor Bathroom Stack Unit 701		7th Floor Bathroom Stack Unit 707		6th Floor Bathroom Stack Unit 602	
	San. Drain	Vent	San Drain	Vent	San. Drain	Vent	San. Drain	Vent		San. Drain
	4" CI	1 1/4" DWV	4" CI	1 1/4" DWV	4" CI	1 1/4" DWV	4" CI	1 1/4" DWV		4" CI
	38	39	40	41	42	43	44	45	46	47
1	0.234	0.043	0.237	0.042	0.249	0.040	0.248	0.040	0.042	0.242
2	0.233	0.042	0.234	0.040	0.235	0.041	0.240	0.041	0.040	0.240
3	0.230	0.041	0.220	0.044	0.224	0.042	0.246	0.044	0.041	0.248
4	0.302	0.041	0.222	0.043	0.249	0.040	0.243	0.042	0.040	0.250
5	0.240		0.240		0.238		0.261			0.247
6	0.229		0.226		0.230		0.230			0.250
7	0.230		0.229		0.242		0.232			0.242
8	0.234		0.228		0.229		0.229			0.241

Reading Numbers	Locations									
	6th Floor Bathroom Stack Unit 606			6th Floor Bathroom Stack Unit 606	Unit 607-608	Unit 610	5th Floor Bathroom Stack Unit 510		5th Floor Bathroom Stack Unit 509	
	San. Drain	Vent		San. Drain	Toilet Drain	San. Drain		Vent	San. Drain	Vent
	4" CI	$1^1/_4$" DWV		4" CI	3" DWV	3" CI	4" CI	$1^1/_4$" DWV	3" CI	$1^1/_4$" DWV
	48	49	50	51	52	53	54	55	56	57
1	0.219	0.042	0.042	0.257	0.046	0.234	0.215	0.043	**0.173**	0.040
2	0.222	0.039	0.040	0.252	0.044	0.240	0.214	0.040	**0.179**	0.039
3	0.218	0.043	0.039	0.266	0.050	0.230	0.216	0.039	0.285	0.041
4	0.240	0.044	0.040	0.264	0.037	0.233	0.228	0.042	0.282	0.040
5	0.248			**0.172**	0.042	**0.146**	0.236		0.259	
6	0.250			**0.158**	0.046	**0.138**	0.238		0.255	
7	0.247			**0.160**			0.231			
8	0.250			**0.161**			**0.175**			

Reading Numbers	Locations								
	5th Floor Bathroom Stack Unit 506			5th Floor Bathroom Stack Unit 502	4th Floor Bathroom Stack Unit 402		4th Floor Bathroom Stack Unit 406		
	San. Drain	Vent			San. Drain		Vent	San. Drain	Vent
	4" CI	$1^1/_4$" DWV			4" CI		$1^1/_4$" DWV	4" CI	$1^1/_4$" DWV
	58	59	60	61	62	63	64	65	66
1	0.222	0.040	0.040	0.039	0.274	0.257	0.042	0.259	0.043
2	0.221	0.039	0.043	0.039	0.210	0.257	0.040	0.237	0.042
3	0.199	0.042	0.045	0.040	0.277	0.259	0.039	0.239	0.043
4	0.198	0.043	0.042	0.040	0.194	0.257	0.040	0.239	0.041
5	0.197				0.269	0.264		0.236	
6	0.200				0.265	0.273		0.249	
7	0.204				0.212	0.273		0.250	
8	0.207				0.225	0.271		0.251	

Reading Numbers	Locations									
	4th Floor Bathroom Stack Unit 410		3rd Floor Bathroom Stack Unit 307			3rd Floor Bathroom Stack Unit 302		3rd Floor Bathroom Stack Unit 302		
	San. Drain	Vent	San. Drain	Vent		San. Drain	Vent	San. Drain	Vent	San. Drain
	4" CI	1 1/4" DWV	3" CI	1 1/4" DWV	3" DWV	3" CI	1 1/4" DWV	4" CI	1 1/4" DWV	3" CI
	67	68	69	70	71	72	73	74	75	76
1	0.169	0.043	0.241	0.043	0.048	0.211	0.040	0.240	0.042	0.248
2	0.232	0.040	0.230	0.042	0.049	0.215	0.042	0.262	0.040	0.259
3	0.237	0.042	0.236	0.040	0.035	0.213	0.041	0.237	0.042	0.258
4	0.196	0.042	0.232	0.039	0.040	0.216	0.042	0.234	0.042	0.271
5	**0.179**		0.228		0.049	0.218		0.246		0.236
6	0.183		0.217		0.041	0.206		0.250		0.260
7	0.201							0.253		
8	0.246							0.240		

Reading Numbers	Locations						
	2nd Floor Bathroom Stack Unit 206			2nd Floor Bathroom Stack Unit 206		Ground Floor Bathroom Stack Unit 107	
	San. Drain	Vent		San. Drain	Vent	San. Drain	Vent
	4" CI	1 1/4" DWV		4" CI	3" DWV	4" CI	1 1/4" DWV
	77	78	79	80	81	82	83
1	0.194	0.041	0.044	0.234	0.038	**0.163**	0.039
2	0.192	0.042	0.040	0.224	0.040	**0.175**	0.040
3	0.196	0.039	0.042	0.223	0.037	0.274	0.041
4	0.210	0.043	0.039	0.222	0.042	0.282	0.039
5	0.207			0.225	0.044	**0.161**	
6	0.209			0.208	0.046	**0.159**	
7	0.195			0.226		0.210	
8	0.192			0.227		0.250	

3.2 Calculations

3.2.1 Sanitary Drain Piping

Thickness measurements on the 2" cast iron piping range from 0.111 inches to 0.249 inches. This suggests a nominal thickness of 0.190 inches for 2" cast iron piping. Maximum wall loss detected would be 0.079 inches or ~41.5%.

Thickness measurements on the 3" cast iron piping range from 0.138 inches to 0.281 inches. This suggests a nominal thickness of 0.250 inches for 3" cast iron piping. Maximum wall loss detected would be 0.112 inches or ~44.8%.

Thickness measurements on the 4" cast iron piping range from 0.157 inches to 0.302 inches. This suggests a nominal thickness of 0.250 inches for 4" cast iron piping. Maximum wall loss detected would be 0.093 inches or ~37.2%.

3.2.2 Vent Piping

Thickness measurements on the $1^1/_4$" copper piping range from 0.030 inches to 0.046 inches. This suggests a nominal thickness of 0.040 inches for $1^1/_4$" DWV copper piping. Maximum wall loss detected would be 0.010 inches or ~25.0%.

Thickness measurements on the $1^1/_2$" copper piping range from 0.032 inches to 0.046 inches. This suggests a nominal thickness of 0.042 inches for $1^1/_2$" DWV copper piping. Maximum wall loss detected would be 0.010 inches or ~23.8%.

3.2.3 Kitchen Drain

Thickness measurements on the $1^1/_2$" copper piping range from 0.041 inches to 0.045 inches. This suggests a nominal thickness of 0.042 inches for $1^1/_2$" DWV copper piping. Maximum wall loss detected would be 0.001 inches or ~2.3%.

3.2.4 Toilet Drain

Thickness measurements on the 3" copper piping range from 0.035 inches to 0.050 inches. This suggests a nominal thickness of 0.045 inches for 3" DWV copper piping. Maximum wall loss detected would be 0.010 inches or ~22.2%.

4.0 DISCUSSION

Based on the survey performed, the piping drain piping is showing wall losses ranging from ~2.3 - 44.8%. Most of the deterioration is noted on the cast iron drain piping, though the copper piping is showing wall losses of up to ~ 25% on one (1) section of vent piping.

Thinning, for the most part appears to be in the form of pitting corrosion, under deposit corrosion and dealloying of the cast iron. While the deterioration isn't as severe as in the parking garage, the thinning appears to be intermittent, but widespread with low readings noted on almost every floor sampled. This would seem to indicate that the material that has been processed by the drains plays a far greater role in the level of deterioration than the age of the lines. Unfortunately, this would also seem to indicate that there is no easy plan for replacement outside of the collection lines in the parking garage. In fact, it appears that sections on the floors have already been replaced either with newer sections of cast iron piping or XFR piping more recently. It is recommended that the sections of piping that have previously been replaced be determined so that future replacements can concentrate on the oldest and worst piping.

Significant thinning was discovered in Units on the 9th, 7th, 6th, 5th, 4th, 2nd & 1st Floors as well as the 14th Floor Hallway. This would seem to suggest that the units above the 10th Floor are in better condition, but that units from 9th Floor may or may not have thinning. For example, the Kitchen Stacks in Units 206 and 209 show thinning, but the Bathroom Stacks in Unit 206 do not. In reverse, the Bathroom Stacks in Unit 410 show thinning, but the Kitchen Stacks in Units 406 and 402 do not. Similarly, the Kitchen Stacks in Unit 701 show thinning but the Bathroom Stacks in Units 701, 706 & 707 do not. This is further evidence that the thinning is not consistent throughout the building, making it very difficult to plan for replacement.

The copper piping are also showing evidence of thinning with maximum wall losses of between ~2.3 - 25.0%. While as great a concern at this time, the piping should still be monitored to determine a rate of deterioration.

5.0 CONCLUSIONS

The piping tested at151 Bay St in Ottawa, Ontario has experienced significant thinning in the form for underdeposit corrosion, pitting corrosion and graphitization with wall losses ranging from ~2.3 - 44.8%. Unfortunately, except for the piping surveyed in the parking garage, the thinning appears to be intermittent throughout the building, though mainly contained below the 10th Floor. In addition, there appears to be replacement of several sections of piping, likely due to previous leaks. It should be determined what has been replaced previously so that a future replacement plan can avoid the sections of newer pipe that are likely still in good condition.

Photograph 1: 11th Floor Unit 1110.

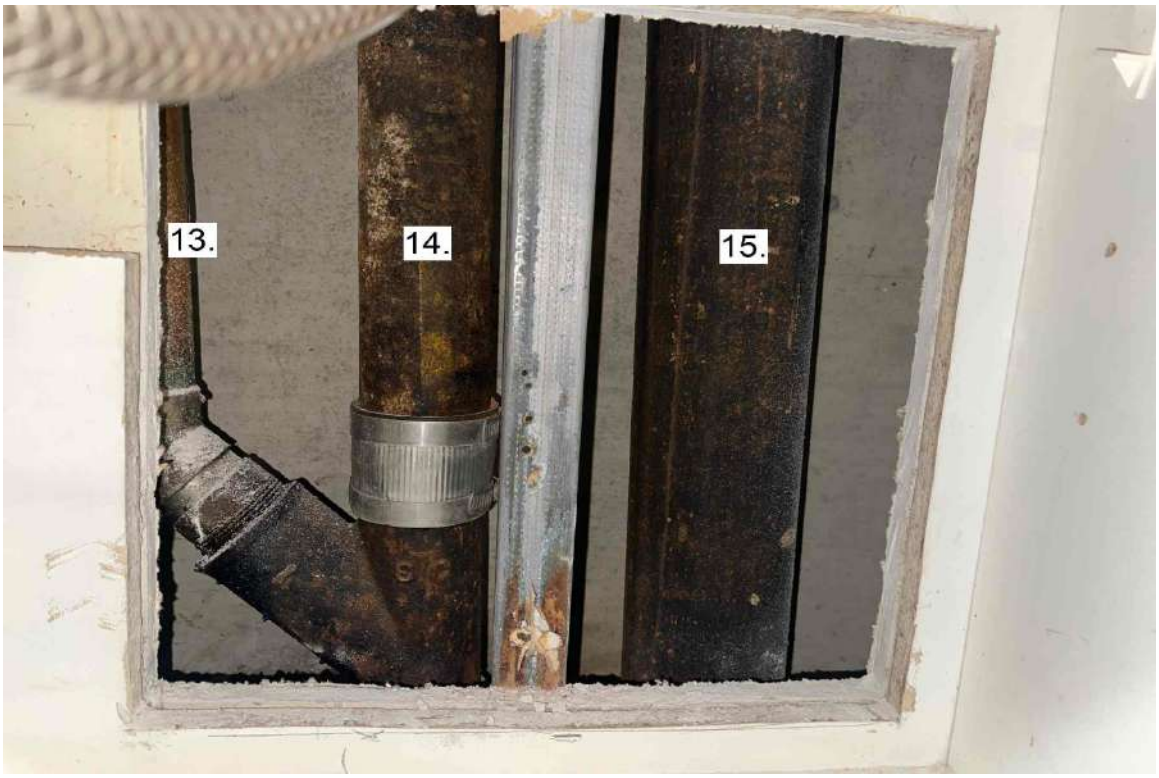
Photograph 2: 11th Floor Unit 1108.

Photograph 3: 11th Floor Unit 1105.

Photograph 4: 7th Floor Unit 707.

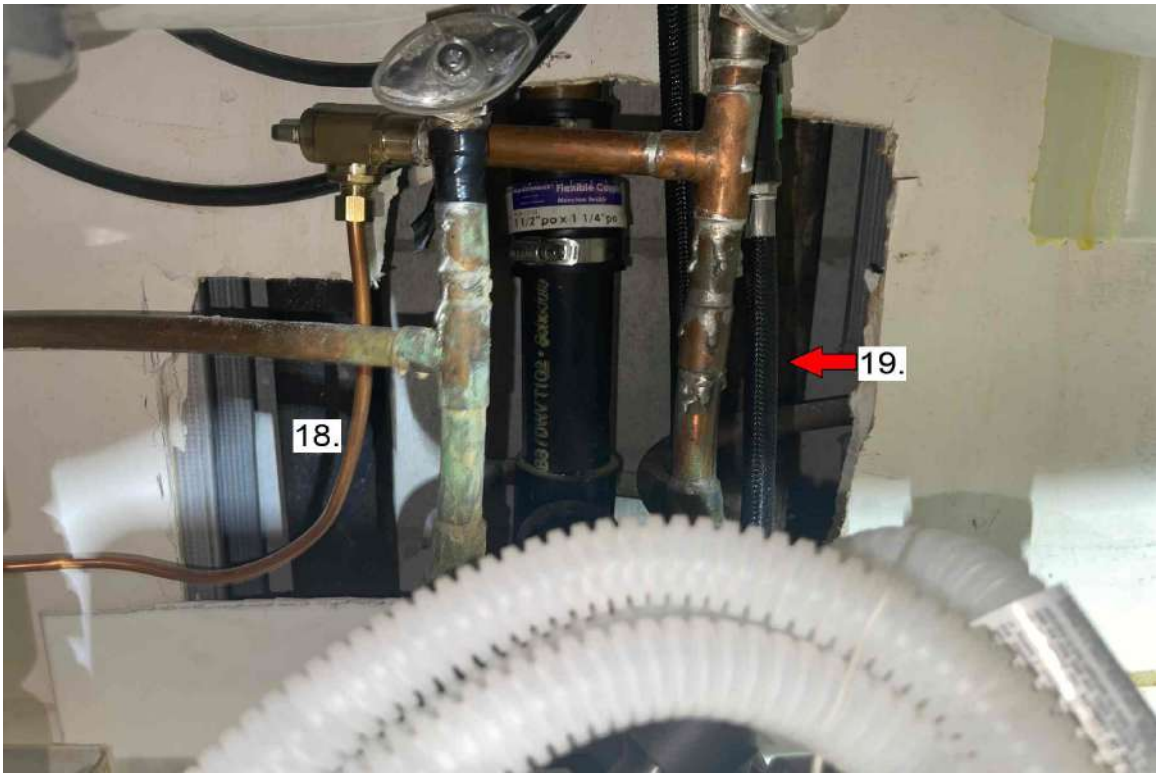
Photograph 5: 7th Floor Unit 701.

Photograph 6: 7th Floor Unit 702.



Photograph 7: 2nd Floor Unit 209.

Photograph 8: 2nd Floor Unit 206.



Photograph 9: 2nd Floor Unit 203.

Photograph 10: 14th Floor By Stairwell 14A.

Photograph 11: 14th Floor By Unit 1408.

Photograph 12: 14th Floor Bathroom Stack by 1406.

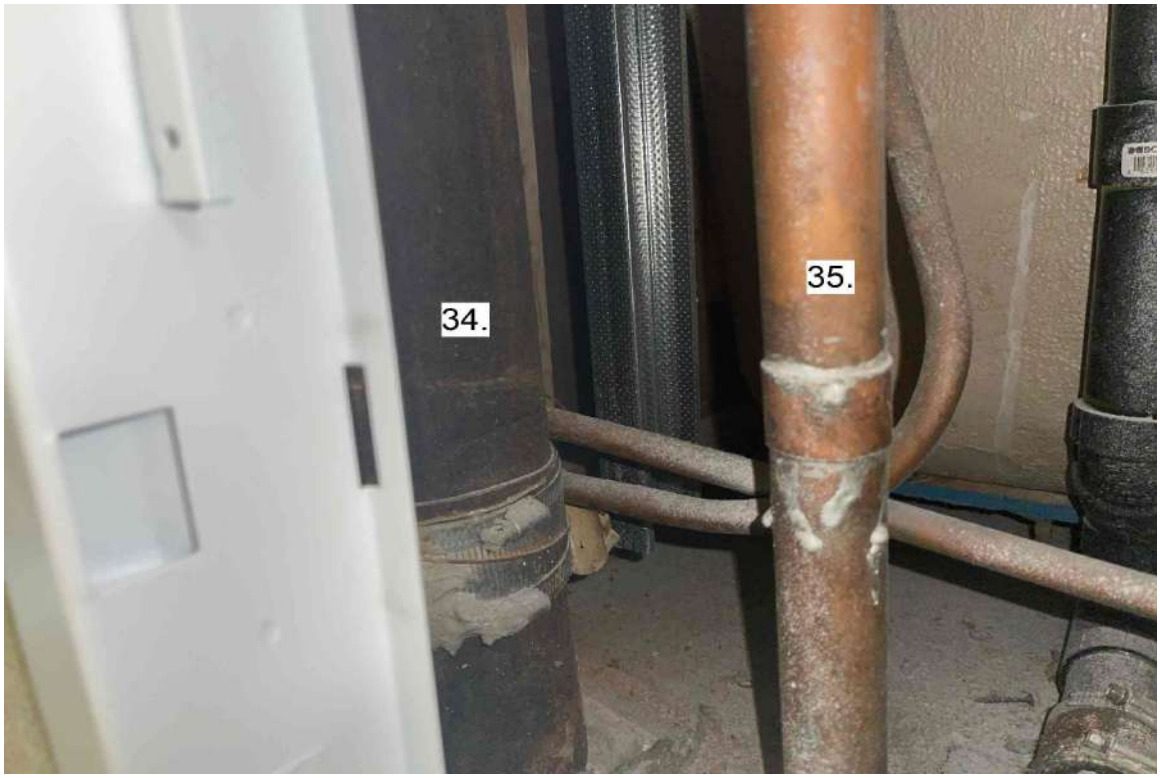
Photograph 13: 12th Floor Bathroom Stack Unit 1201.

Photograph 14: 11th Floor Bathroom Stack Unit 1101.

Photograph 15: 10th Floor Bathroom Stack Unit 1001.

Photograph 16: 9th Floor Bathroom Stacks Between Units 903 & 902.

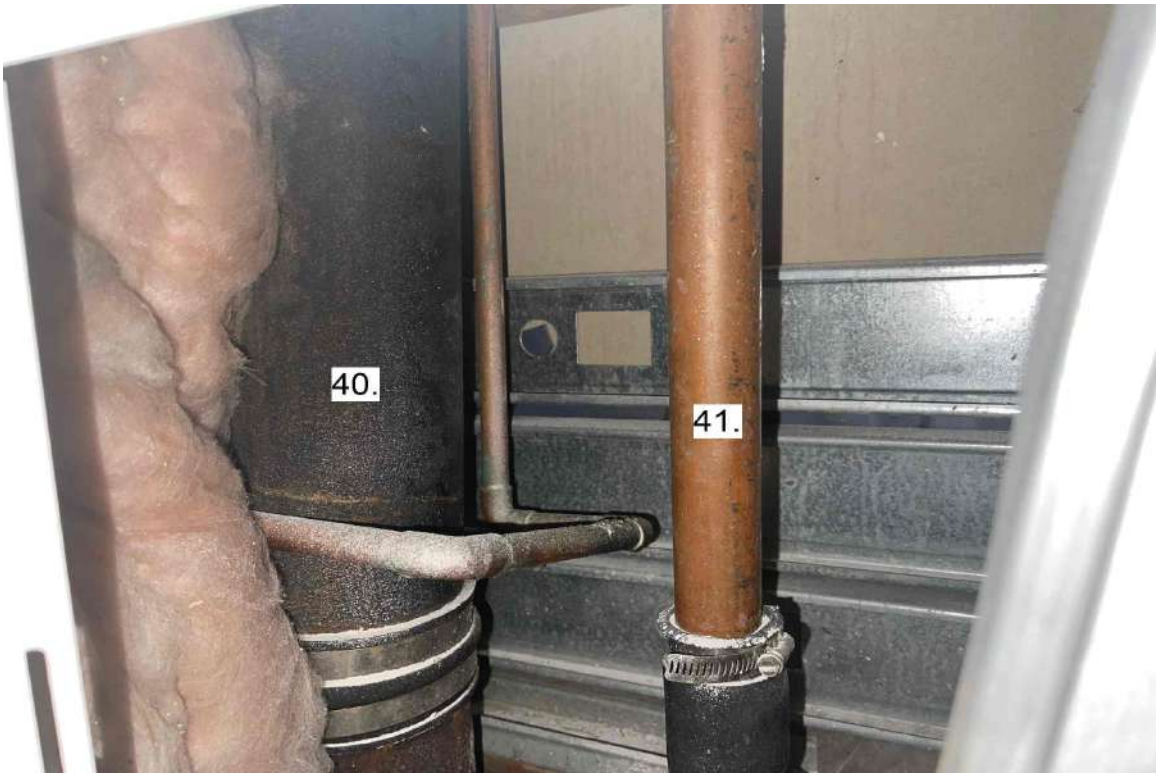
Photograph 17: 9th Floor Bathroom Stack Unit 901.



Photograph 18: 9th Floor Bathroom Stack Unit 910.

Photograph 19: 8th Floor Bathroom Stack Unit 806.

Photograph 20: 8th Floor Bathroom Stack Unit 807.



Photograph 21: 7th Floor Bathroom Stack Unit 706.

Photograph 22: 7th Floor Bathroom Stack Unit 701.

Photograph 23: 7th Floor Bathroom Stack Unit 707.

Photograph 24: 6th Floor Bathroom Stack Unit 602.

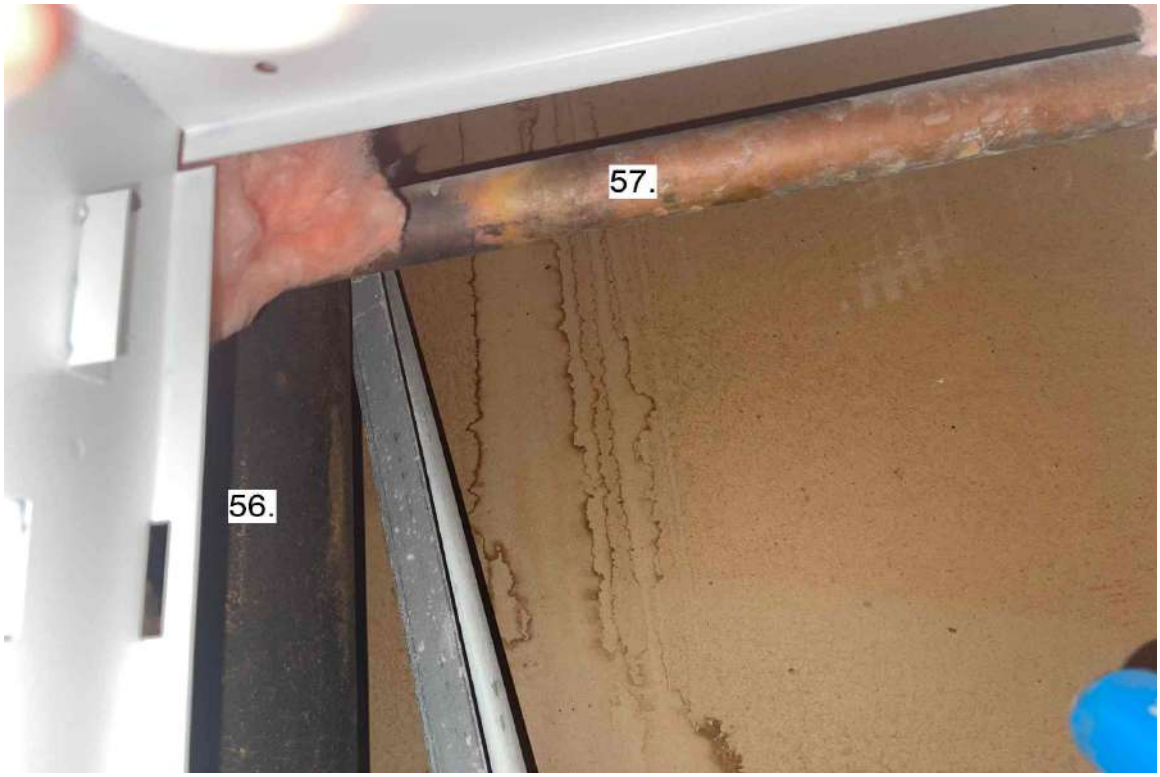
Photograph 25: 6th Floor Bathroom Stack Unit 606.

Photograph 26: 6th Floor Bathroom Stack Unit 601.

Photograph 27: 6th Floor Bathroom Stack Between Units 607 & 608.

Photograph 28: 6th Floor Bathroom Stack Unit 610.

Photograph 29: 5th Floor Bathroom Stack Unit 510.



Photograph 30: 5th Floor Bathroom Stack Unit 509.

Photograph 31: 5th Floor Bathroom Stack Unit 506.

Photograph 32: 5th Floor Bathroom Stack Unit 502.

Photograph 33: 4th Floor Bathroom Stack Unit 402.

Photograph 34: 4th Floor Bathroom Stack Unit 406.

Photograph 35: 4th Floor Bathroom Stack Unit 410.

Photograph 36: 3rd Floor Bathroom Stack Unit 307.

Photograph 37: 3rd Floor Bathroom Stack Unit 307.

Photograph 38: 3rd Floor Bathroom Stack Unit 302.

Photograph 39: 3rd Floor Bathroom Stack Unit 302.

Photograph 40: 3rd Floor Bathroom Stack unit 302.

Photograph 41: 2nd Floor Bathroom Stack Unit 206.

Photograph 42: 2nd Floor Bathroom Stack 1st Hatch Unit 206.

Photograph 43: 2nd Floor Bathroom Stack 2nd Hatch Unit 206.

Photograph 44: Ground Level Bathroom Stack Unit 107.