ENTUITIVE

1919, 1967 Riverside Drive, Ottawa
Riverside Hospital Campus
Rail Safety Report
December 2022

For Schlegel Villages Inc.

Authored by:

Jonathan Hendricks, P.Eng.

Julia Pannolino, P.Eng.

Our Project Number:

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INTRODUCTION

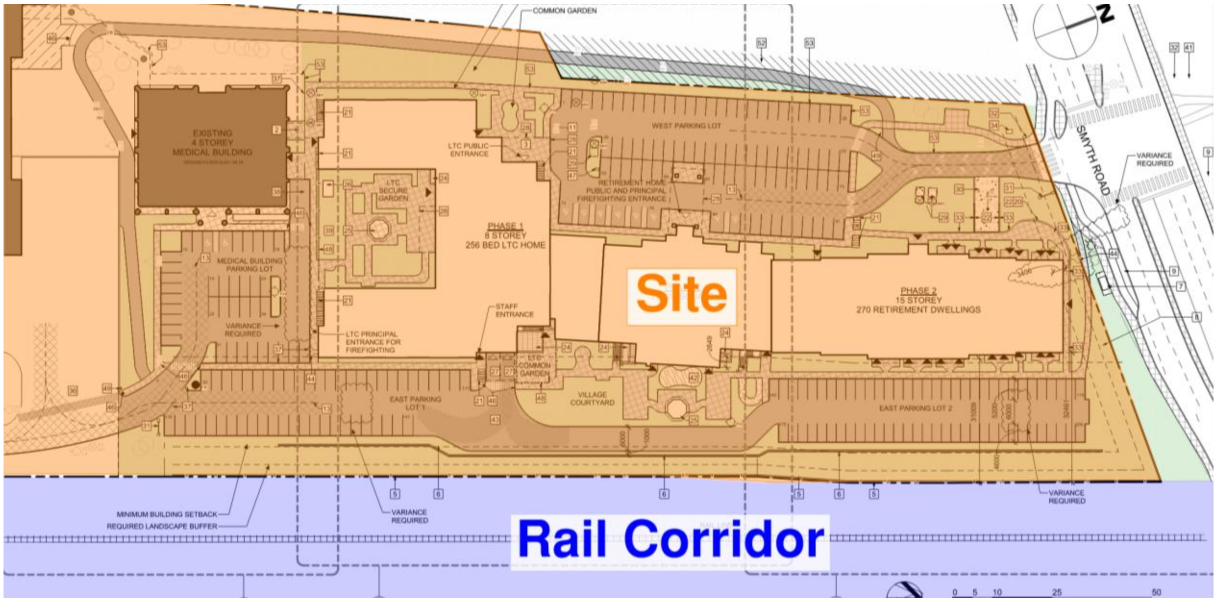
Entuitive was retained by Schlegel Villages Inc. to review the site-specific safety of the development being proposed at the Riverside Campus Hospital (1919, 1967 Riverside Drive), in Ottawa. The site is adjacent to an existing hospital at the intersection of Smyth Road and Riverside Drive. Immediately east of the site are lands is the Beachburg Rail corridor which are owned by CN Rail and CP Rail, but operated by VIA Rail.

This rail safety report reviews the site-specific safety risks for the development associated with the nearby rail corridor along with mitigating measures. The report is limited to the safety aspects associated with the proximity of the development to rail activity and does not address ground-borne and/or airborne (acoustic) vibration and stormwater which are all dealt with separately.

Focus Area

SITE

The site of the proposed development lies immediately west of the Beachburg Subdivision rail corridor. The development consists of an 8-storey long term care home, a 15-storey retirement home, a town square, and multiple parking lots. The development will be mixed-use with primarily residential units. The image below shows the site boundary in orange and the rail corridor in blue. The site and the rail corridor share a property line.



Site Plan

Relationship to the Rail

The site is located adjacent to a rail corridor. All rail information is shown in Appendix A.

Rail	
Rail Corridor	Beachburg Subdivision
Classification	Principle Main Line
Mileage at Site Location	1.8
No of Tracks	1 main line track
Speed	Max Freight: 30 mph Max Passenger: 35 mph
Alignment	Straight in the immediate vicinity
Elevation	Elevation varies. Rail is approx. 4.55m above grade of Phase 1, and approx. 2.93m above Phase 2.
Proposed Development	- Mixed-use, primarily residential - Direct adjacency between site and rail corridor

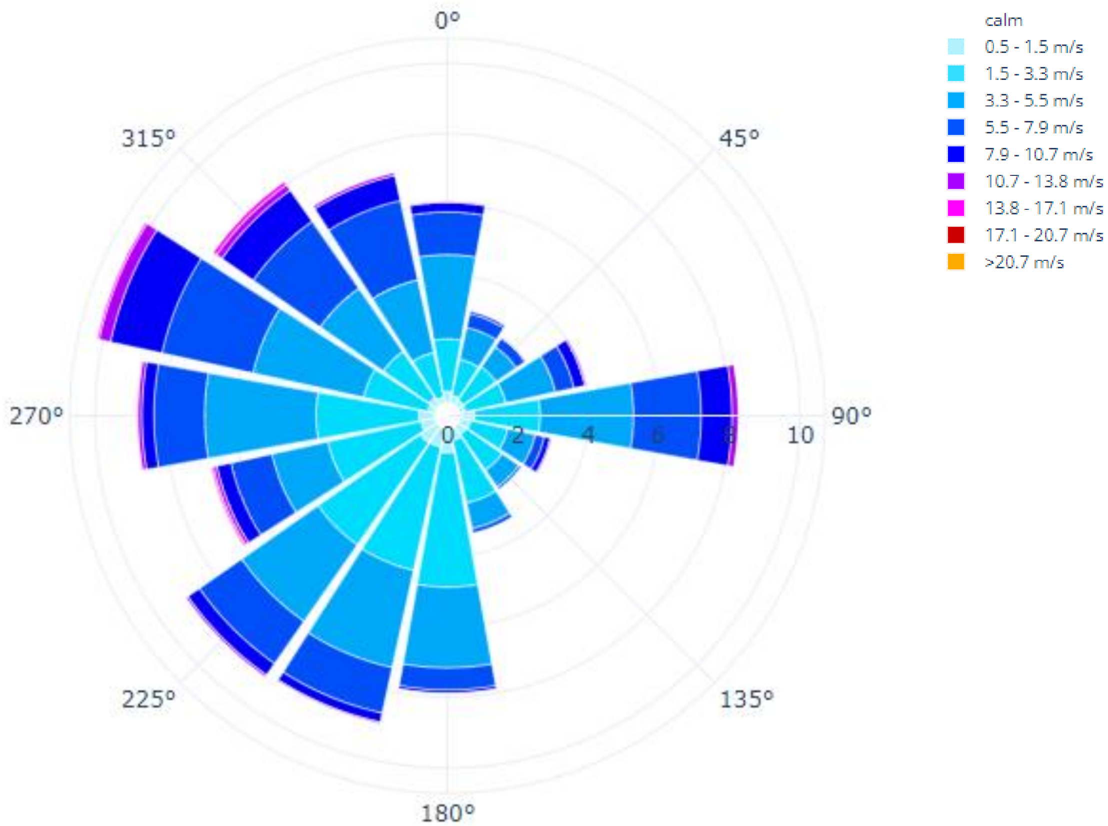
Safety Record of Rail Corridor

Based on data published by the Transportation Safety Board of Canada between the years of 2011-2021 and at mileage 0-11.8 of the Beachburg Subdivision, the frequency of events is as follows:

Period Start		2011
Period End		2021
Total Number of Events		7
Total Number of Incidents		4
Total Number of Accidents		3
Breakdown:		
	TRESPASSER	0
	CROSSING	1
	MAIN-TRACK TRAIN DERAILMENT	0
	MOVEMENT EXCEEDS LIMITS OF AUTHORITY	3
	DERAILMENT INVOLVING TRACK UNIT	2
	DERAILMENT INVOLVING TRACK UNIT (NO DAMAGE)	1

Weather

Based on the Wind Rose diagram for the years 2004-2018 shown below, the site location experiences winds mostly from the west direction. The data shown below was collected at Ottawa International Airport.



Wind Rose Diagram for Site Location

FCM/RAC PROXIMITY BASELINE REQUIREMENTS

New developments along the rail corridor should be designed and built to provide reasonable protection to the development against rail activities and accidents. The FCM (Federation of Canadian Municipalities)/RAC (Railway Association of Canada) guidelines set out requirements for:

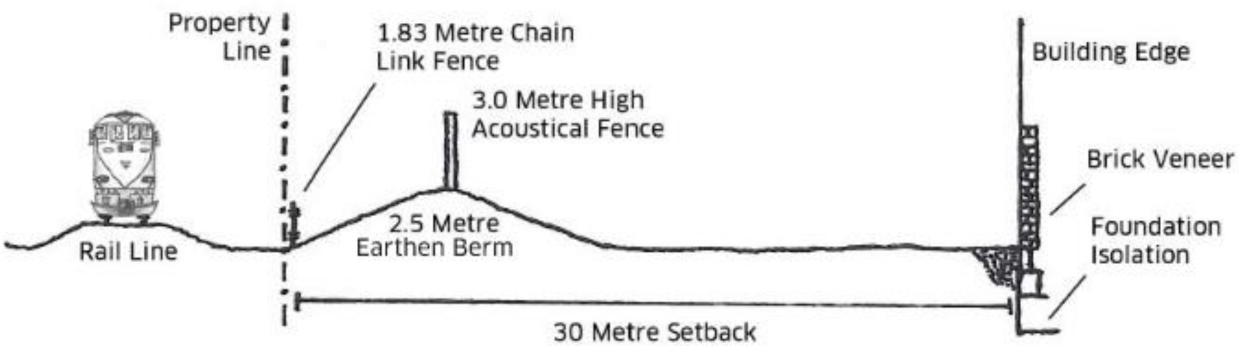
- Safety: Impact from a derailed train, fire, projectile elements, smoke
- Comfort: Noise and Vibration

This report deals primarily with Safety Issues.

The FCM/RAC Guidelines recommend the following setbacks:

Classification of line	Setback	Berm Height	Berm Slope
Freight Rail Yard	300m		
Principal Main Line	30m	2.5m	<= 2.5:1
Secondary Main Line	30m	2.0m	<= 2.5:1
Principal Branch Line	15m	2.0m	<= 2.5:1
Secondary Branch Line	15m	2.0m	<= 2.5:1
Spur Line	15m	0	

As stated in the FCM/RAC Guidelines (Section 3.3): “Setback distances must be measured from the mutual property line to the building face. This will ensure that the entire railway right-of-way is protected for potential rail expansion in the future.”



FCM/RAC Baseline Guideline

The FCM/RAC Guidelines (Section 3.3) indicate that “Appropriate uses within the setback area include public and private roads; parkland and other outdoor recreational space including backyards, swimming pools, and tennis courts; unenclosed gazebos; garages and other parking structures; and storage sheds.”

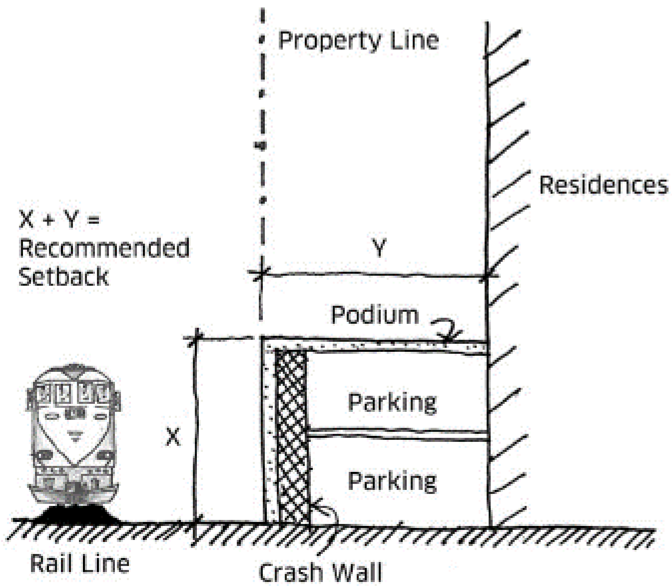
Chain Link Fence

To mitigate against the threat of trespasser incidents on the rail corridor the FCM/RAC Guidelines recommend a 1.83m high chain-link fence along the mutual property line entirely on the private side of the property line running continuously for the full width of the property.

Crash Wall to Protect Development

The FCM/RAC Guidelines (Section 3.3) note that the "Horizontal setback requirements may be substantially reduced with the construction of a crash wall". So, if the site-specific conditions do not allow for both a 30m setback and 2.5m high berm adjacent to a rail line the development can be protected instead by a robust crash wall.

With a crash wall "the setback distance may be measured as a combination of horizontal and vertical distances, as long as the horizontal and vertical value add up to the recommended setback" FCM/RAC Guidelines (Section 3.3).



Crash Wall Requirements

Crash walls are robust concrete structures designed to provide similar energy absorption capacities as the standard berm. The wall is to be designed to the standards established by AECOM looking at 4 derailment scenarios. (1) Freight train glancing blow (multiple car impact at deflection angle), (2) freight train direct impact (a single or pair of cars impacting the wall directly due to an accordion-type of derailment), (3) passenger train glancing blow and (4) passenger train direct impact.

In addition to being designed for the derailment scenarios set out above the crash wall shall have the following characteristics:

- Thickness of
  - 760mm if the wall is less than 7.6m from the centreline of the closest track
  - 450mm if the wall is greater than or equal to 7.6m from the centreline of the track.
- Height of:
  - 3.6m from top of rail if the wall is less than 3.6m from the centreline of track
  - 2.135m from top of rail if the wall is greater than or equal to 3.6m and less than 7.6m from the track
  - 2.135m from top of grade if the wall is greater than or equal to 7.6m from the centreline of rail
- The face of the crash wall shall be smooth and continuous and shall extend a minimum of 150mm beyond the face of the structure (such as a building column or bridge pier) parallel to the track
- Construction shall be solid and heavy, with separate precast blocks or stones not acceptable.

Importantly, there is a reasonableness criterion in the FCM/RAC Guidelines suggesting that the risk-mitigating measures need not be disproportional to the development. The Third Principle for mitigation design is "All mitigation measures should be designed to the highest possible urban design standards. Mitigation solutions, as developed through the Development Viability Assessment process, should not create an onerous, highly engineered condition that overwhelms the aesthetic quality of an environment." (FCM/RAC Guidelines Section 3.1).

ANALYSIS: ENERGY BALANCE METHOD

As per the AECOM guidelines (Development of Crash Wall Design Loads from Theoretical Train Impact) an energy balance was performed to study the travelling length in case of derailment. There are four loading cases as shown below:

1. Freight Train Load Case #1: derailment of nine freight train cars. For clear distances between the centerline of track equal to or greater than 2.6m for tangent tracks the impact angle can be taken as 3.5 degrees, which is the case for the site.

Freight Train Load Case 1 - Glancing Blow: nine cars weighing 143 tons (129 700 kg) each, impacting the wall at an angle, θ_G. The angle of impact will be a function of track curvature, and for tangent track may be taken as 3.5 degrees.

2. Freight Single Car Load Case #2: assuming only one car is derailed weighing 129,700 kg.

Freight Train Load Case 2 - Single Car Impact: single car weighing 143 tons (129 700 kg) impacting the wall as it undergoes rotation about its center. The angle of rotation at impact is defined in [9]:

$$\theta_r = \operatorname{asin}\left(\frac{d_{CL}}{8.5}\right) \qquad \text{(metric)}$$

Where d_{CL} is in feet (m). Where d_{CL} is greater than 28 feet (8.5 m), this load case need not be considered.

This loading case assumes a single car will be rotating around its center and should the clear distance d_{CL} exceed 8.5m then there is no need to include this loading case as the train car will not make contact with the safety barrier in this derailment scenario

3. Passenger train Load Case #3: derailment of one locomotive weighing 133,740 kg and seven bilevel coaches weighing 79,510 each.

Passenger Train Load Case 3 - Glancing Blow: eight cars weighing 74 tons (67120 kg) each impacting the wall at an angle, θ_G. The angle of impact will be a function of track curvature, and for tangent track may be taken as 3.5 degrees.

The AECOM guideline assumes eight cars; however, we have assumed seven passenger cars and one MP40 Locomotive to be conservative.

4. Passenger train Single Car Load Case #4: assuming one fully loaded bilevel coach is derailed weighing 79,510 kg.

Passenger Train Load Case 4 - Single Car Impact: single car weighing 74 tons (67120 kg) impacting the wall as it undergoes rotation about its center. The angle of rotation at impact is defined in [10]:

Where d_{CL} is in feet (m). Where d_{CL} is greater than 42'-6" (13 m), this load case need not be considered.

Similarly, this load case assumes a single car rotates around its center and should the clear distance d_{CL} exceed 13m then there is no need to include this loading case as the train car will not make contact with the safety barrier in this derailment scenario.

The angle of impact can be calculated as shown:

$$\theta_f = \text{asin}\left(\frac{d_{CL}}{13.0}\right) \qquad \text{(metric)}$$

Where d_{CL} is in feet (m). Where d_{CL} is greater than 42'-6" (13 m), this load case need not be considered.

Changing the train weight due to different rail services is permissible as per the AECOM Guideline.

Where a track is designed for dedicated service by a particular train consist, variations to the design trains may be permitted by the Railway.

The speed after derailment for glancing blow load cases can be calculated as shown:

$$v_G = \sqrt{v_o^2 + 2a\left(\frac{d_{CL} - 1.625}{\sin\theta_G}\right)} \ \text{[m/s]}$$

Where d_{CL} is the distance from the crash wall to the centerline of track in feet (m).
v_o is the track speed in ft/s (m/s)
a is the acceleration in ft/s², calculated as $-32(.25 + G)$
(in metric, acceleration is in m/s², calculated as $-9.8(.25 + G)$)
θ_G is the angle of impact defined in [4] or [5]
G is the grade in decimal unit of the groundline in the direction of travel defined by the angle of impact relative to the centerline of track; calculated as $\frac{\text{Groundline at wall} - \text{Base of Rail}}{d_{CL}/\sin\theta_G}$.

obtained from the above equation with $R = 0.25$.

The design force for the glancing blow load cases is:

$$F_G = \frac{\frac{1}{2}m(v_G \sin\theta_G)^2}{d_G} \qquad \text{(metric)}$$

Where m is the mass of the derailed cars in lbm (kg).
v_G is the impact speed in ft/s (m/s), defined in [3]
θ_G is the angle of impact defined in [4] or [5]
d_G is the deformation of the consist in the direction of the applied force, and $d_G = 10\sin\theta_G$, in feet ($d_G = 3.048\sin\theta_G$, in m)

Results of the Energy Balance Method Evaluation of Derailment Scenarios:

The table below shows the derailment scenarios set out in the guidelines and the maximum distance from the centreline of track where derailed trains come to an at-rest state. This analysis includes freight trains running at a maximum speed of 30mph and passenger trains running at a maximum speed of 35mph.

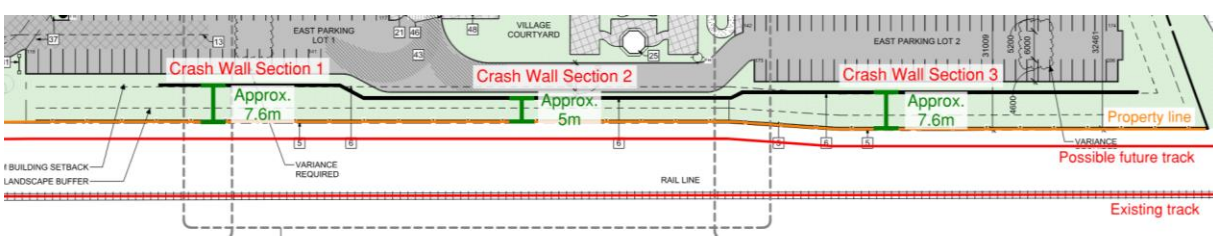
Scenario	Max distance perpendicular to the track at which the train comes to rest
1. Freight Train Multi-Car Glancing Blow	< 5m
2. Freight Train Single Car Direct Impact	< 8.5m
3. Passenger Train Multi-Car Glancing Blow	< 5.5m
4. Passenger Train Single Car Direct Impact	< 13m

The crash wall will be designed to allow for the rail authority to add tracks to the rail corridor in the future. Therefore, we are assuming that the property line could be 3.6m from the centreline of the future tracks. Due to the ample space between the property line and the proposed towers, we recommend that the crash wall be located at least 7.6m from the property line. In the areas where the 7.6m distance cannot be accommodated, the crash wall will be located 5m from the property line. The detailed location of the crash wall will be illustrated in the sections that follow.

The design impact forces were calculated and are summarized below. The Passenger Train Single Car Direct Impact is the governing force for all three crash wall sections and should be used when designing these sections of the crash wall.

Scenario	Impact Force (kN)		
	Crash wall section 1	Crash wall section 2	Crash wall section 3
1. Freight Train Multi-Car Glancing Blow	0	0	0
2. Freight Train Single Car Direct Impact	0	0	0
3. Passenger Train Multi-Car Glancing Blow	0	0	0
4. Passenger Train Single Car Direct Impact	265	382	265

The sections of the crash wall and their distance to the property line is illustrated below.



The governing impact force should be used in the design of the crash wall and based on AECOM design guidelines equation 6, and the impact force was applied over 3.1m horizontal length (as shown below) and at a height of 1.8m above the existing grade.

3.1.3 Length of action of impact force

The length of wall, l_G, along which the impact force should act was calculated from the length of deformation specified by the 2011 AECOM guidelines and the angle of impact as shown in Figure 4:

$$l_G = \frac{10}{\cos \theta_G} \quad [6]$$

$$l_G = \frac{3.048}{\cos \theta_G} \quad [6M]$$

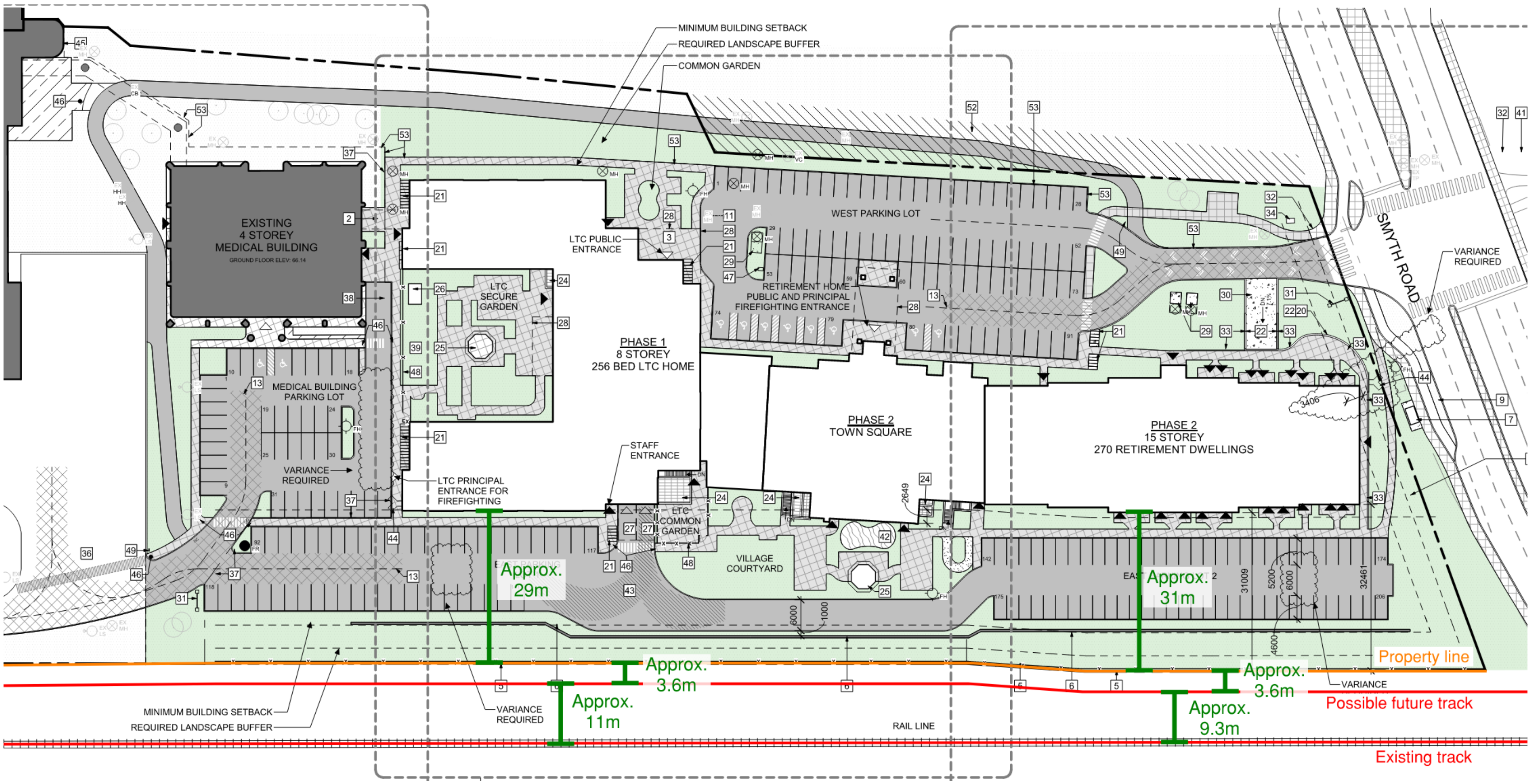
where l_G is in feet (m). For an angle of 3.5 degrees, the length along which the force acts is 10 feet (3.1 m). Due to the forward momentum of the train, it is likely that the length of impact along the wall is still being conservatively estimated.

EVALUATION AND MITIGATING MEASURES

Setbacks

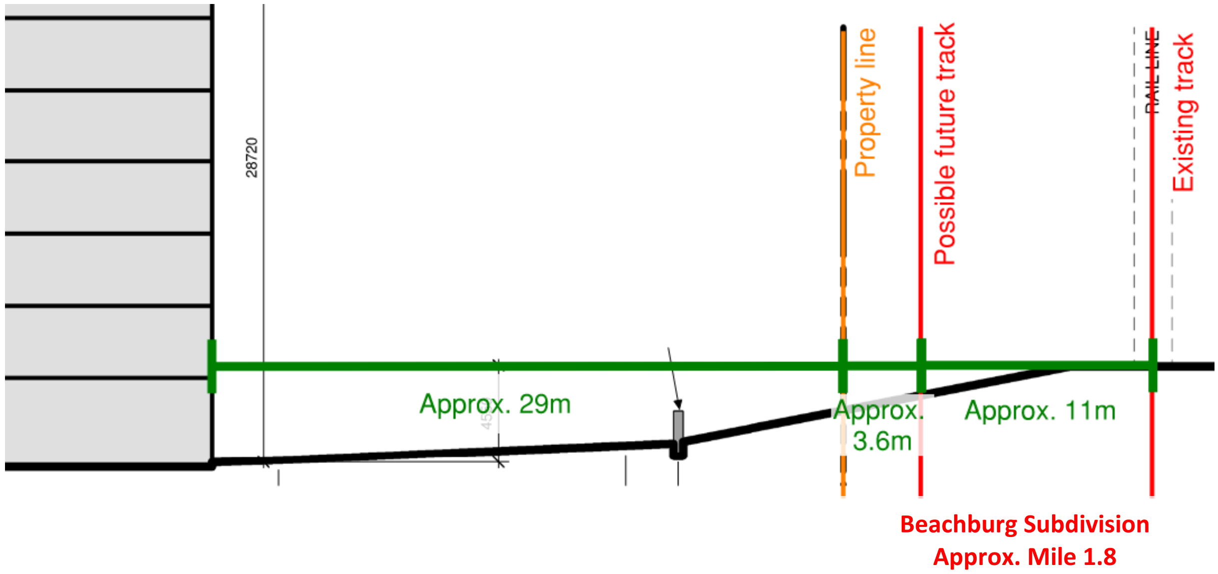
The setbacks to the sensitive-use areas of this site have been measured and are shown in the table and images that follow:

Phase	Setback Description	Distance (approximate)
Phase 1 8-Storey Long Term Care Home	Horizontal setback from property line to closest existing track	14.6m
	Horizontal setback from property line to closest possible future track	3.6m
	Horizontal setback from closest residential unit to closest existing track	43.6m
	Horizontal setback from closest residential unit to closest possible future track	32.6m
	Vertical setback from top of existing rail to closest residential unit	0m
	Vertical setback from top of possible future rail to closest residential unit	0m
	Combined horizontal and vertical setback from closest existing track to closest residential unit	43.6m
	Combined horizontal and vertical setback from closest possible future track to closest residential unit	32.6m
Phase 2 15-Storey Retirement Home	Horizontal setback from property line to closest existing track	12.9m
	Horizontal setback from property line to closest possible future track	3.6m
	Horizontal setback from closest residential unit to closest existing track	43.9m
	Horizontal setback from closest residential unit to closest possible future track	34.6m
	Vertical setback from top of existing rail to closest residential unit	0m
	Vertical setback from top of possible future rail to closest residential unit	0m
	Combined horizontal and vertical setback from closest existing track to closest residential unit	43.9m
	Combined horizontal and vertical setback from closest possible future track to closest residential unit	34.6m

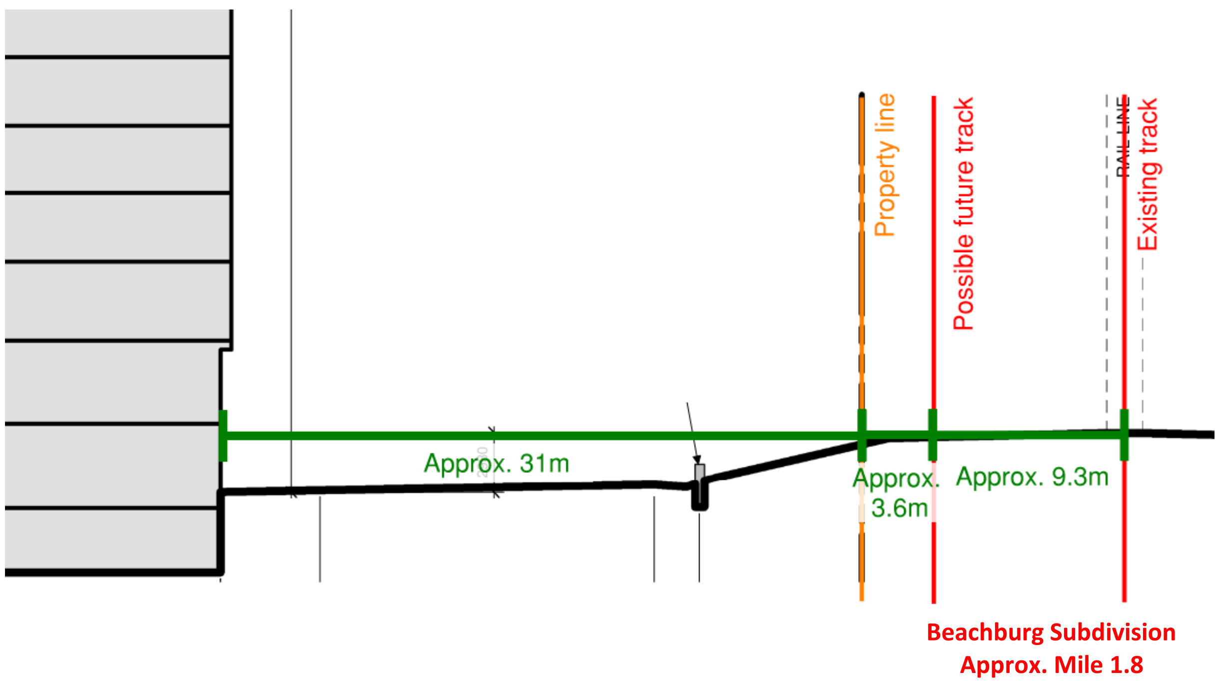


Beachburg Subdivision
Approx. Mile 1.8

Site Plan



Section view: Phase 1 – 8-Storey Long Term Care Home



Section view: Phase 2 – 15-Storey Retirement Home

The towers' residential floors do not meet the minimum requirements of <u>both</u> a 30m setback from the rail corridor and a 2.5m high berm. Since the berm would overly restrict the site plan layout of the site area, a crash wall is recommended as set out in the FCM/RAC Guidelines.

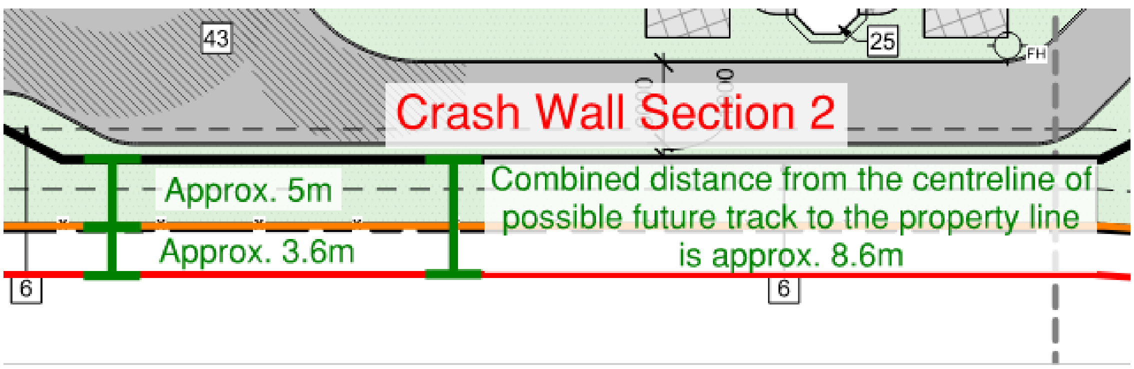
Crash wall

It is our recommendation that a crash wall be constructed between 5m and 7.6m from the eastern property line of the development site meeting the FCM/RAC Guidelines and the AECOM design procedures for the scenarios of derailment of trains from the rail corridor. The crash wall in combination with the setback distance from the rail corridor provides a reasonable and appropriate solution to mitigating the risks associated with the development's proximity to the rail corridor.

The crash wall will be designed to allow for tracks to be added to the rail corridor in the future. Since the wall will always be at least 7.6m from the centreline of future tracks, we recommend a crash wall with the following requirements:

- Height of 2.135m from top of grade, which meets the minimum requirements of the FCM/AECOM guidelines,
- The wall shall be a minimum of 450mm thick and be smooth and continuous,
- The applied impact load resulting from derailment will be at 1.8m from the top of rail, as per AECOM design guidelines,
- The wall shall be designed to incorporate both horizontal and vertical continuity reinforcement to distribute the impact loads of a derailed train.

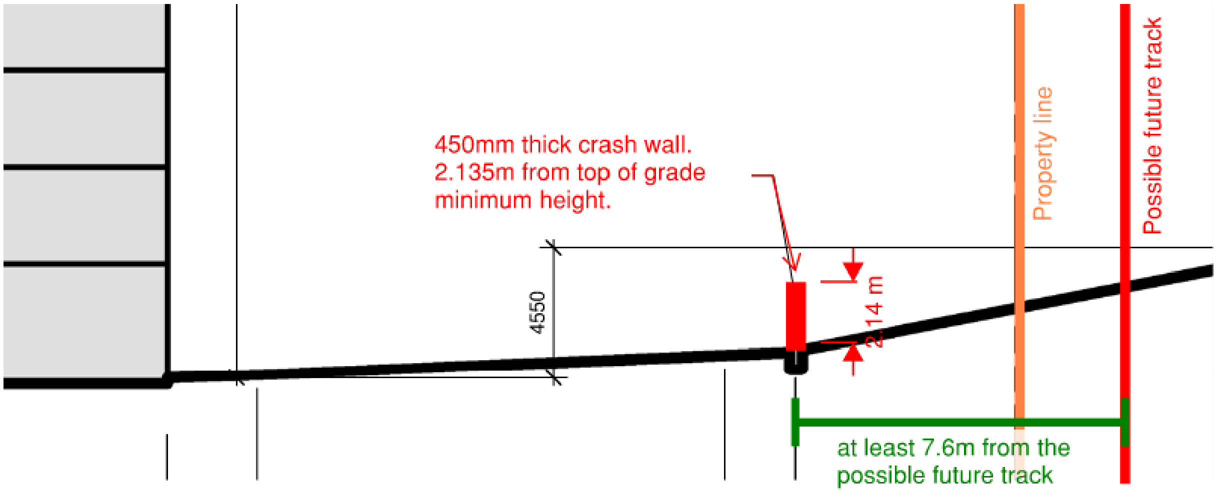
An illustration of the minimum setback to the centreline of a possible future track is shown below:



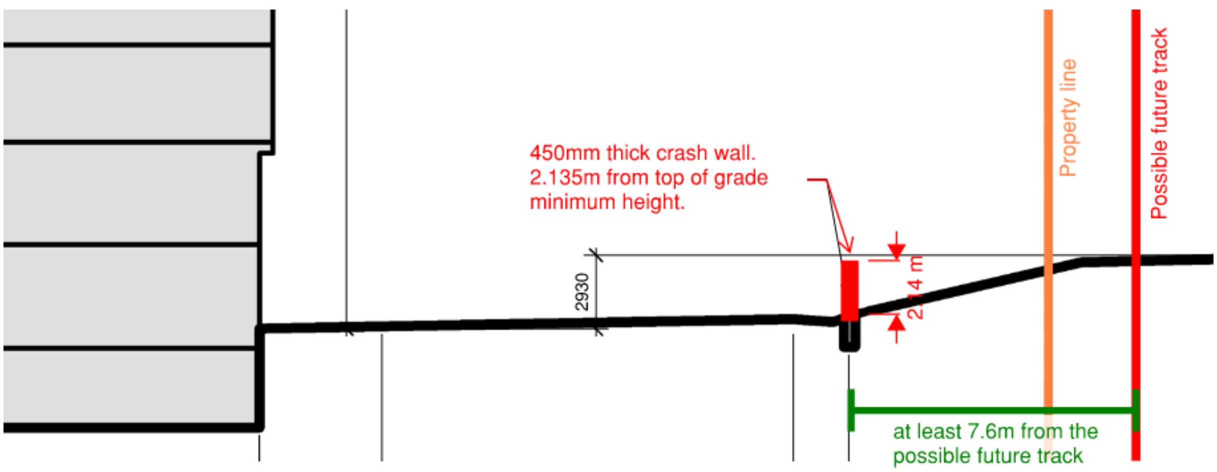
Structure Supporting the Building

The crash wall will be located between the eastern edge of the parking lot and the property line. The crash wall will be completely independent from the towers.

An example of the suggested crash wall is shown below:



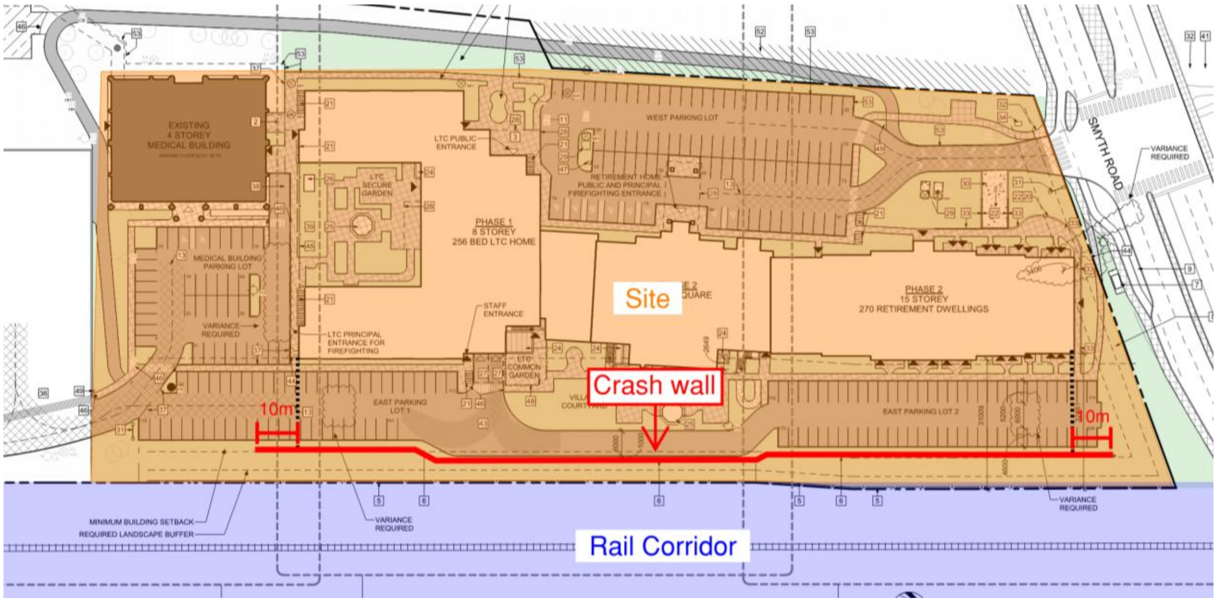
Suggested crash wall: Phase 1 – 8-Storey Long Term Care Home



Suggested crash wall: Phase 2 – 15-Storey Retirement Home

Crash wall Extent

The crash wall will run the length of the proposed towers, between 5m and 7.6m from the property line. The crash wall shall have a 10m extension at each end to prevent a train from derailing further away and entering the site.



Debris

The height of the crash wall at 2.135m from top of grade, reduces the risk of debris entering the site to a tolerable level and mitigates the risk from low flying debris. With the provision of the setback and the crash wall extent and height, the risk of debris is sufficiently mitigated to reasonable levels.

Fire

Given the height of the crash wall and the horizontal setback to the closest residential unit, there are no additional restrictions to the proposed development beyond Fire Code requirements associated with the construction materials or detailing for fire.

Smoke

As per the wind rose diagram provided, the predominant wind direction is from the west. With the site being located to the west of the tracks the prevailing winds carry smoke away from the proposed development. The prevailing wind direction coupled with the setbacks provided adequately mitigate the risk due to smoke per the FCM/RAC guidelines.

Trespassing/Fence Requirements

Adequate provisions to prevent the public from entering the rail corridor lands are recommended.

Since the crash wall will not be located at the property line, a fence (chain link or similar) with a minimum height of 1.83m above grade is required. An anti-trespassing fence will also be required for phases of construction prior to the crash wall being built.

Construction

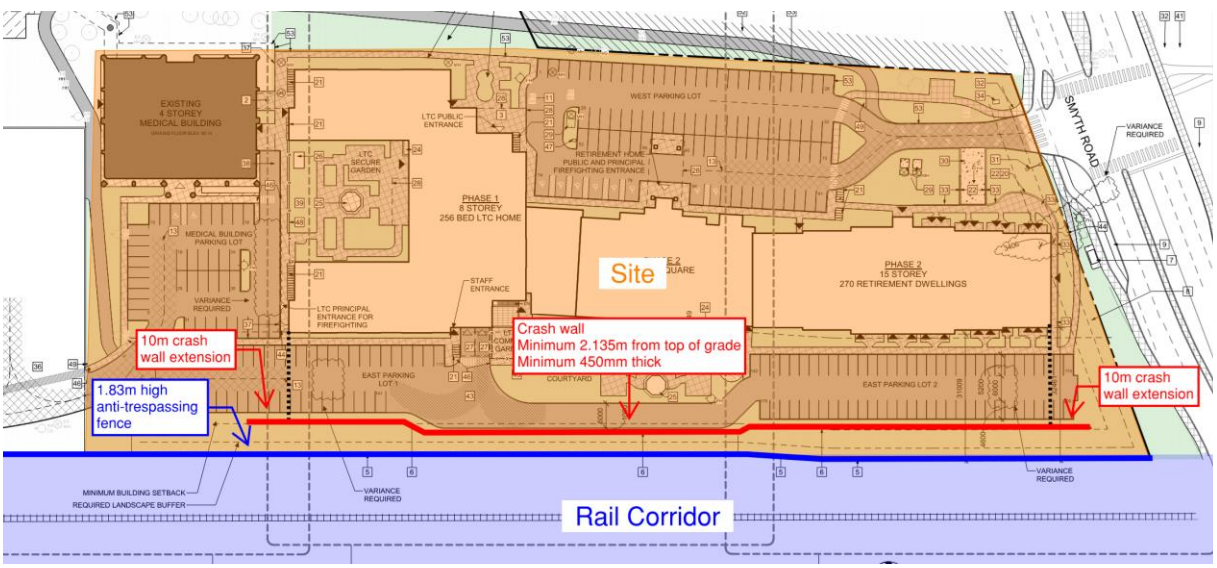
Any construction considerations will be dealt with separately with the contractor's input.

CONCLUSION

We have reviewed the site-specific safety aspects relating to the proposed development's proximity to the existing rail corridor and believe that the measures proposed above reasonably and appropriately mitigate the risks. The risk-mitigating measures include:

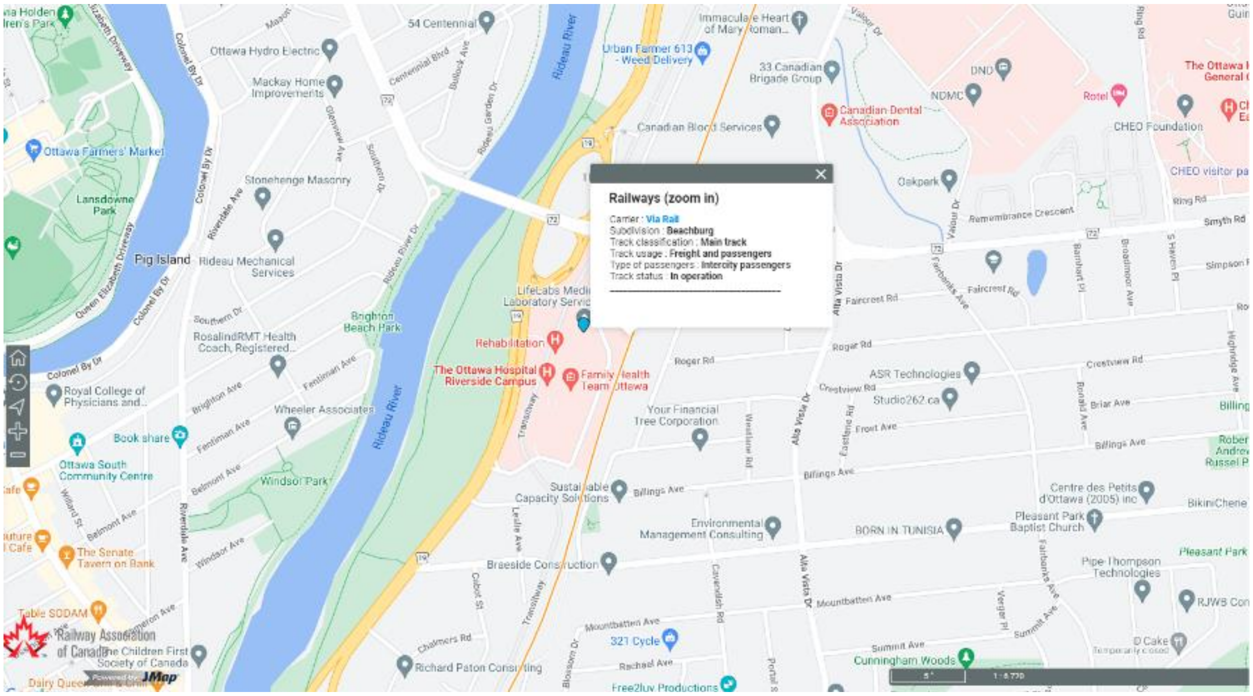
- Phase 1: combined vertical and horizontal setback is approximately 43.6m from the closest existing track to the closest residential unit and approximately 32.6m from the closest possible future track to the closest residential unit.
- Phase 2: combined vertical and horizontal setback is approximately 43.9m from the closest existing track to the closest residential unit and approximately 34.6m from the closest possible future track to the closest residential unit.
- Crash wall with a minimum height of 2.135m from top of grade and a minimum thickness of 450mm per the FCM/RAC and AECOM requirements. The structural design of the crash wall and details will be completed for the detailed submission.
- The crash wall shall extend the length of the proposed towers, with a 10m extension on each end.
- The crash wall will be completely independent from the towers.
- Crash wall to be built entirely on the development site.
- Anti-trespassing measures: a fence at least 1.83m high (measured from grade) will be located on the eastern property line and extend the length of the site.

An example of the proposed mitigating measures is shown below:

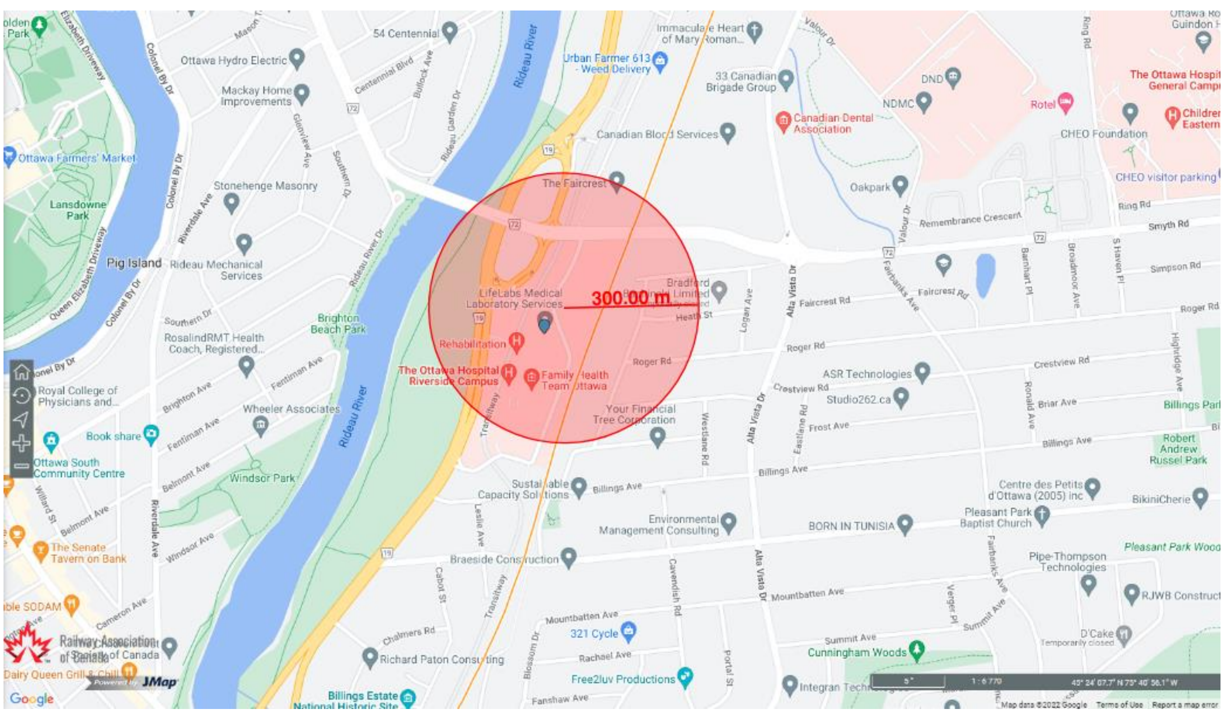


APPENDIX A: RAIL INFORMATION

Railway Association of Canada Track Information:



No rail yards within 300m radius of site location:



APPENDIX B: RISK ASSESSMENT MATRIX

Rail Safety Risk Assessment

No.	Hazard	Without Mitigating Measures: Frequency	Without Mitigating Measures: Severity	Without Mitigating Measures: Residual Risk	Without Mitigating Measures: Risk Classification	With Proposed Mitigating Measures: Frequency	With Proposed Mitigating Measures: Severity	With Proposed Mitigating Measures: Residual Risk	With Proposed Mitigating Measures: Risk Classification	Net change of Risk Classification	Comments
1	Derailment Freight - Flammable or Hazardous materials *Derailment of frieght train transporting flammable/hazardous material*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Crash wall and setback will mitigate risk of fire and explosion
2	Derailment Freight - Inert Glancing Blow *Multicar derailment of freight train adjacent to site*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Derailed freight train may ingress site; however due to the speed, the train will not reach the crash wall
3	Derailment Freight - Inert Direct Impact *Single freight car impact due to accordian style derailment*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Crash wall mitigates train ingress into site
4	Derailment Passenger - Glancing Blow *Multicar derailment of passenger train adjacent to site*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Derailed freight train may ingress site; however due to the speed, the train will not reach the crash wall
5	Derailment Passenger - Direct Impact *Single freight car impact due to accordian style derailment*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Crash wall mitigates train ingress into site
6	Excess Speed - Freight *Derailment of freight train travelling at speed in excess of track design speed*	2	5	10	Intolerable	1	3	3	Acceptable	-7	Crashwall mitigates train ingress into site
7	Excess Speed - Passenger *Derailment of passenger train travelling at speed in excess of track design speed*	2	5	10	Intolerable	1	3	3	Acceptable	-7	Crashwall mitigates train ingress into site
8	Airborn Debris - Freight *Top level sea-can of a double stacked intermodal freight car is launched due to a derailment*	2	4	8	Tolerable	2	3	6	Tolerable	-2	Crash wall will prevent impact from low flying debris, still possibility of debris over the wall. Setback will protect the sensitive-use areas
9	Groundborn Debris - Freight *As a result of derailment a sea-can or a part of the freight train become rolling or sliding debris along the ground*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Crashwall protects development from low flying debris
10	Airborn Debris - Passenger *During a derailment, parts of the passenger train become airborn projectiles*	2	4	8	Tolerable	2	3	6	Tolerable	-2	Crash wall will prevent impact from low flying debris, still possibility of debris over the wall. Setback will protect the sensitive-use areas
11	Groundborn Debris - Passenger *As a result of derailment a part of the passenger train become rolling or sliding debris along the ground*	2	4	8	Tolerable	2	2	4	Acceptable	-4	Crashwall protects development from low flying debris
12	Smoke/Exhaust *Ingestion of smoke or diesel exhaust into a building's HVAC systems*	2	4	8	Tolerable	2	2	4	Acceptable	-4	The setback distance to the residential towers will protect from smoke/exhaust. We recommend no air intakes on the east side of the towers
13	Trespassing *Ingress of non-authorised personel onto railway*	4	3	12	Intolerable	1	3	3	Acceptable	-9	An anti-trespassing fence will protect the entire length of the site
	Total Assessed Risk Score			112				53			

Risk Event Classification

Frequency of Event	Class	Severity of Event: Negligible	Marginal	Serious	Critical	Catastrophic
		1	2	3	4	5
Improbable	1	1	2	3	4	5
Remote	2	2	4	6	8	10
Occasional	3	3	6	9	12	15
Probable	4	4	8	12	16	20
Frequent	5	5	10	15	20	25

Risk Category

Risk	*(Frequency Class x Severity Class)*	Risk Assessment Category	Mitigation Measures Approach
Low	1 to 4	Acceptable	No further mitigation is required
Medium	6 to 9	Tolerable	Tolerable if ALARP* - mitigate to level that is reasonable
High	10 to 25	Intolerable	Risk shall be eliminated / reduced

*ALARP = As Low As Reasonably Practicable

Definition of Frequency Criteria

Frequency Rating	Description
1. Improbable	Extremely unlikely to occur
2. Remote	Unlikely to occur in rail lifecycle
3. Occasional	Likley to occur several times in rail lifecycle
4. Probable	Expected to occur
5. Frequent	Expected to occur continuous

Definition of Severity Criteria

Severity Rating	Consequence to Person/Public	Consequence to Environment
1. Negligible	Non-reportable injury	None
2. Marginal	Single minor injury	Reversible minor environmental impact
3. Serious	Single permanent partial or tempory total disabling injury; multiple minor injury	Reversible moderate environmental impact
4. Critical	Single fatality; Single permanent total disability; Multiple permanent partial or temporay total disabling injury	Reversible significant environmental impact
5. Catastrophic	Multiple fatalities: Multiple permanent total disabling injuries	rreversible significant environmental impac