NZTA Road Safety Barrier Design Workshop

Example of a road safety barrier design assignment

The following assignment is an example that uses the process and structure from Austroads Guide to Road Design Part 6. It is recommended to follow the same process, however, note that some of the site features and design decisions made may not be correct, or may not be relevant to your site. Use your own knowledge and judgement for your assignment.

Email your completed assignment to:

barrier.workshops@nzta.govt.nz

26 June 2024

Road Safety Barrier Design Assignment

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NZ TRANSPORT AGENCY

Name, contact details, course name & date etc.

Contents

1. Introduction: Road Safety Barrier Design Assignment **5**

2. Existing Site Condition **6**

2.1 Location 6

3. Road Safety Barrier Design Process **7**

3.1 Collect site information (Step 1) 8

3.2 Define the objectives of the proposed barrier (Step 2) 8

3.3 Define the minimum containment level for the proposed barrier (Step 3) 9

3.4 Identify barrier types that meet the objectives and the containment level (Step 4) 10

3.5 Select a barrier system and define its working width (Step 5) 11

3.6 Define the restraints on the lateral position of the barrier (Step 6) 11

3.7 Determine the longitudinal location of a road safety barrier (Step 7) 13

3.8 Evaluation of the selected barrier for the roadside (Step 8) 15

3.9 Evaluate the Strength of the Soil at the Proposed Barrier Location (Step 9) 15

3.10 Structural design of the Proposed Barrier (Step 10) 15

3.11 Detailed Installation refinements (Step 11) 15

3.12 Select End treatments to Longitudinal Barriers (Step 12) 16

3.13 Apply guidance for a barrier installation to meet specific requirements (Step 13) 17

3.14 Develop a plan to maintain the barrier (Step 14) 17

3.15 Confirm that the barrier meets the objectives (Step 15) 17

3.16 Documentation of the design (Step 16) 17

Tables

Table 1: TL-4 barrier working width, deflection and system width as per manufacturers' specifications (NZTA M23A, 2022) 16

Table 2: Different end terminals with their length and runout areas. 16

Figures

Figure 1: Intersection of Dairy Flat Highway and Coatesville-Riverhead Highway (Auckland Council, Geomaps) 6

Figure 2: Road safety barrier design process (Austroads AGRD06, 2022). 7

Figure 3: Aerial view of the site with contour of the existing ground with proposed stormwater system and retaining walls. (Auckland Council Geomaps). 8

Figure 4: Non-recoverable fill slope, stormwater system, retaining wall and grown vegetables as hazards on site. 9

Figure 5: Austroads Figure 6.2 for the barrier containment level selection. 10

Figure 6: Existing cross drainage discharge area with riprap and non-recoverable slopes with grown vegetables 10

Figure 7: Austroads Part 6, Table 6.5 11

Figure 8: Austroads Part 6: Figure 6.4, Absolute minimum distances between W-beam barriers and embankments (AGRD Part 6, 2022). 12

Figure 9: Existing cross section on Coatesville - Riverhead Highway. 13

Figure 10: Austroads AGRD Part 6, Table 6.10 for run-out lengths for barrier design. 14
Figure 11: Figure 6.15: Leading and trailing points of need for hazards extending long distances from the road. 14
Figure 12: Stormwater discharge area with riprap and grown vegetations. 15
Figure 13: Existing stormwater system and fill slope. 15
Figure 14: Proposed barrier site looking from Albany side of the T-intersection before the roundabout construction. 18
Figure 15: New roundabout under construction (Looking towards proposed barrier site from Albany side of the T-intersection along Dairy Flat Highway). 18
Figure 16: Existing driveway near the leading end terminals on Coatesville – Riverhead Highway. 18
Figure 17: Existing grown vegetation, cut slope and power poles on Coatesville - Riverhead Highway. 18
Figure 18: Newly built retaining wall, stormwater system and non-traversable slopes. 18
Figure 19: Existing broken sight rails along the Dairy Flat Highway after the T-intersection Silverdale leg. 18

Appendices

Appendix A. Site Photos

Appendix B. Site requirement and Design Iteration

Appendix C. Design Drawings (Plans and Typical Details)

Road Safety Barrier Design Assignment

Quality Assurance Information

Prepared for

Job Number

Prepared by

Reviewed by

1. Introduction: Road Safety Barrier Design Assignment

This report has been prepared as part of Road Safety Barrier Design Workshop for Waka Kotahi The date of the training is 10-12 September 2019.

During the preparation of this report and design calculations for a road safety barrier Austroads Guide to Road Design Part 6: Roadside Design Safety and Barriers, AGRD Part 6 Development, Waka Kotahi NZTA M23 and M23A, has been referred.

2. Existing Site Condition

2.1 Location

Dairy Flat Highway and Coatesville Riverhead Highway intersection is in the northern part of Auckland. The selected site, as part of RSB Barrier Design Workshop, is the intersection between Dairy Flat Highway (DFH) and Coatesville-Riverhead Highway (CRH) and it is along the Coatesville-Riverhead Highway approaching the roundabout and exiting on Dairy Flat Highway towards the northern leg of the intersection. The location is shown in the Figure 1 below.

Figure 1: Intersection of Dairy Flat Highway and Coatesville-Riverhead Highway (Auckland Council, Geomaps)

Dairy Flat Highway is once the State Highway 1 in New Zealand and the intersection was on the of the riskiest intersections in the country.

3. Road Safety Barrier Design Process

The Austroads Guide to Road Design, Part 6 has outlined the barrier design process and steps for the design are shown in the flow chart (Figure 2) below.

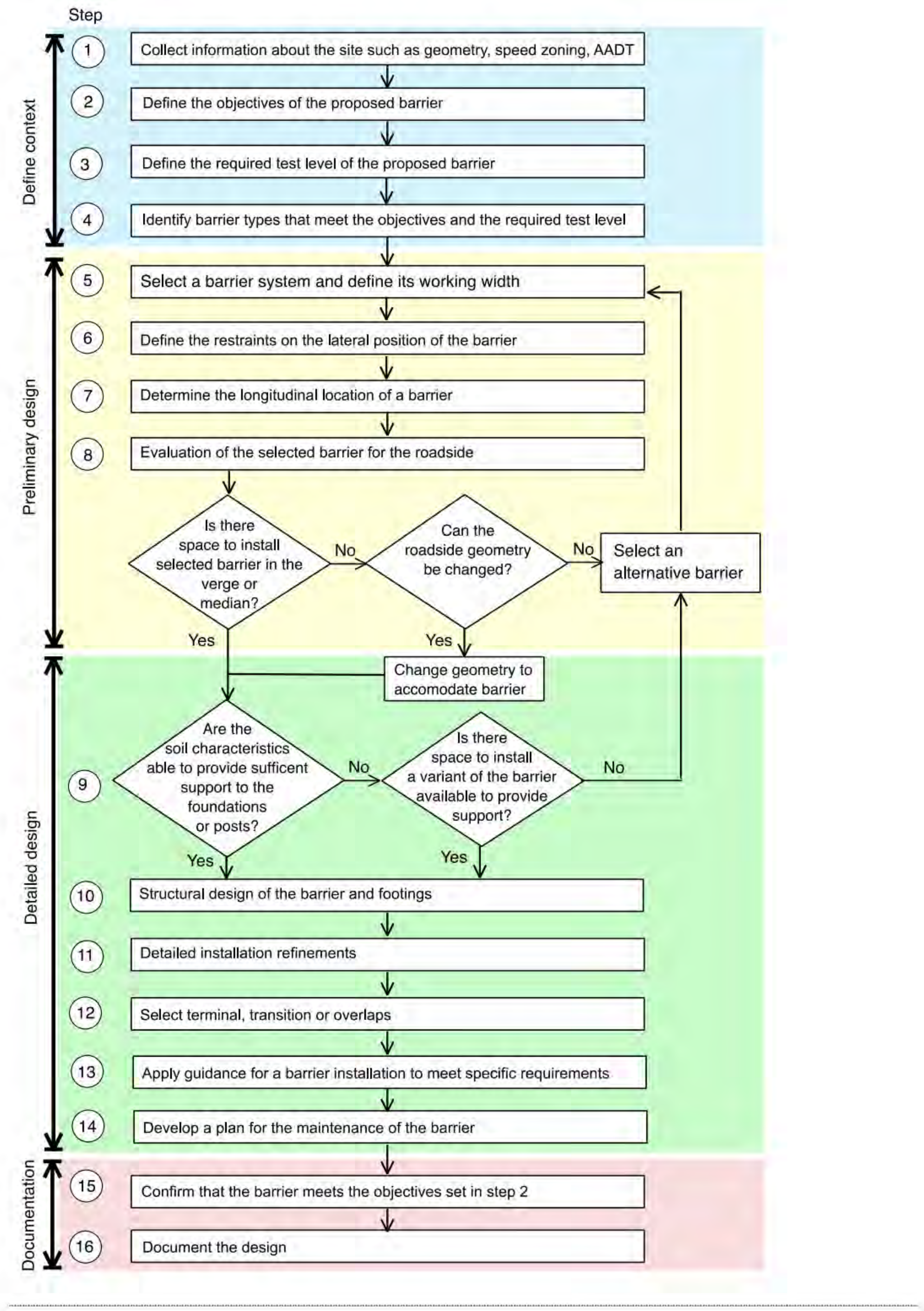


Figure 2: Road safety barrier design process (Austroads AGRD06, 2022).

3.1 Collect site information (Step 1)

DFH and CRH are both Arterial Road with the posted speed of 80km/h. DFH carries about *AADT 10,425* with 9% of the heavy vehicles and that of CRH carries about AADT 8,410 with 6% of the heavy vehicles (Source: NZTA ONRC, 2020).

The selected site is on the ridge and constrained (more explanation about site). The site is on steep terrain and ridges on both side of the road as shown in the Figure 2 below.

The northern approach of the road section is straight and descending from Dairy Flat Highway intersection towards the proposed site. Figure 3 shows the southern approach gently slopes towards the proposed site.

Posted speed on all approaches of the roundabout legs is 80km/hr and the design speed for this assignment purpose is considered as 90km/hr.

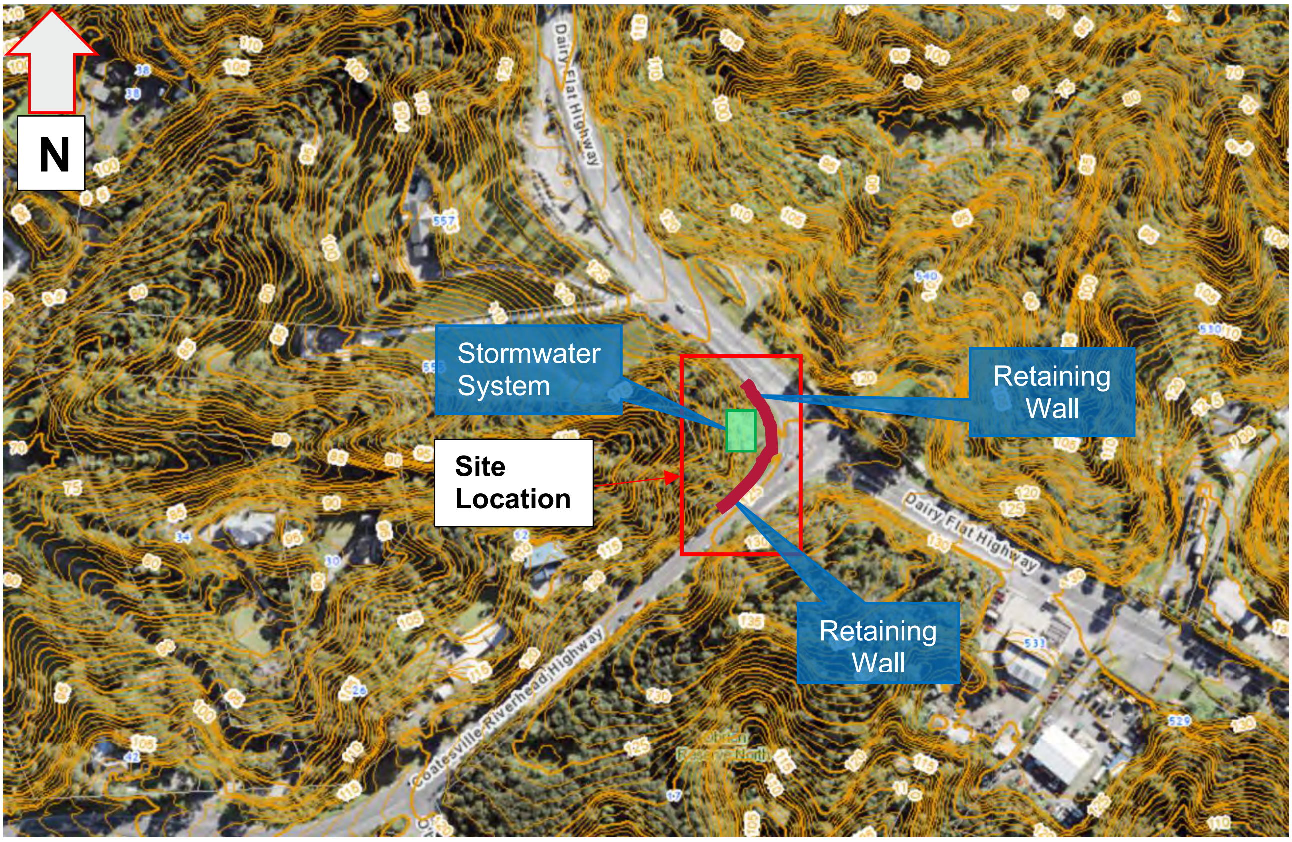


Figure 3: Aerial view of the site with contour of the existing ground with proposed stormwater system and retaining walls. (Auckland Council Geomaps).

There are two retaining walls and a stormwater system proposed on site as shown in Figure 3 above. Driveways are present on either side of the proposed barrier ends, one each on the CR Hwy and DF Hwy.

3.2 Define the objectives of the proposed barrier (Step 2)

The main hazards in the vicinity of the proposed barrier site are listed below and shown in the Figure 4.

- Steep non-recoverable slopes
- New Mechanically Stabilised Earth (MSE) Retaining Walls
- New Stormwater Treatment System

- Grown up trees and vegetations
- Existing powerpoles (powerlines undergrounded recently)

The primary objective of the proposed barrier is to protect errant vehicles during the possible crashes as the slopes are unrecoverable and the hazards present on sites are not forgiving in the event of the crashes. Also, the hazards are not removable. Only the existing powerlines are undergrounded.

The barriers are not designed to be favourable for motorcyclist users. This is because the route is not considered as a route by the motorcyclists. However, the intersection is widely used by cyclists as it is popular route for cyclists, especially along the Coatesville-Riverhead Highway.

Figure 4: Non-recoverable fill slope, stormwater system, retaining wall and grown vegetables as hazards on site.

3.3 Define the minimum containment level for the proposed barrier (Step 3)

The posted speed on either side of the roundabout is 80km/hr and the approach legs speed to the intersection are reduced due to the built-up environment such as traffic islands, kerb, and channel and one lane becoming two lanes while entering and exiting the roundabout. However, there are big drops, steep slope and retaining wall present on site as well as stormwater system, the containment level is assumed to be MASH TL-4 for the barrier design. The heavy vehicle volume is at least 6% through the roundabout. The Auckland Transport buses (AT Metro buses) also use the route along the Dairy Flat Highway getting to the Silverdale depot.

The Austroads guidance on the selection of barrier containment levels are given in the Figure 5 below.

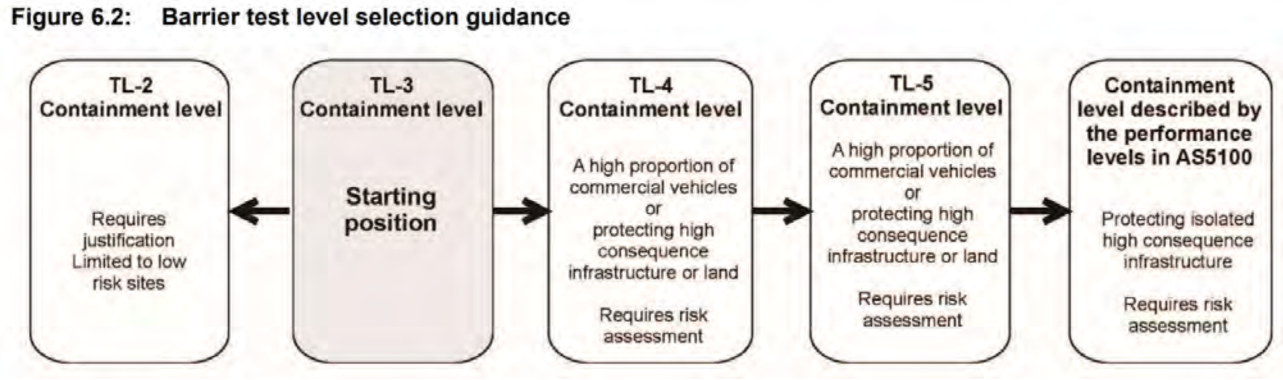


Figure 5: Austroads Figure 6.2 for the barrier containment level selection.

Figure 6: Existing cross drainage discharge area with riprap and non-recoverable slopes with grown vegetables

3.4 Identify barrier types that meet the objectives and the containment level (Step 4)

The test level selected for the barrier on the proposed site is **MASH TL-4**. MASH TL-4 barrier has been selected because of the steep slopes and the roadside hazards are not forgiving. MASH TL-4 has been preferred because of the higher heavy vehicle percentage along the route as well.

As per Waka Kotahi NZTA M23 and M23A guidelines for the barriers, there are various products that can be meeting the MASH TL-4 requirement. There are various suppliers in New Zealand and Auckland providing the required material during the construction.

The barrier site is in the rural environment and cyclists are not considered as part of the current design. However, the CRH route is used by recreational cyclists and there are no cycling infrastructures along the corridor and vicinity of the selected site. There are some retail shops near the site however there are very a smaller number of pedestrians using the section of the road.

The new NZ standard barrier allow to retrofit the motorcycle barriers as required and easily compatible with the suppliers readily available in New Zealand.

3.5 Select a barrier system and define its working width (Step 5)

The working widths are measured during the MASH compliance testing. AGRD Part, Table 6.3 provides the preliminary design width for various barrier systems. These values have been taken from TL-3 and TL-4 crash test reports and are acceptable for a preliminary design.

For design purpose the barrier system selected is Thriebeam System (TL-4). So, referring to the Table 6.3 in AGRD Part 6, for 2.0m post spacing, the working width is **2.8m**.

3.6 Define the restraints on the lateral position of the barrier (Step 6)

The lateral position of the proposed barrier determines the proposed length of the barrier. On the other hand, barrier itself is a roadside hazardous and placing the barrier closer to the traffic lane will provide lesser angle for vehicle during the impact and higher angle if the barrier is placed away from the road. However, more frequent impact can occur with the barrier close to the road making the maintenance of the barrier system costly.

The values for various elements of the barrier and its lateral position are provided below.

Offset to traffic lane

AGRD Part 6, Table 6.5 provides desirable offset for the barriers from the traffic lanes. The table is given below. The guideline shows that the desirable offset of the barrier from the traffic lane is 4.0m to 6.0m and minimum offset to be 3.0m.

Table 6.5: Offset from the traffic lanes for Normal Design Domain treatments

	Rural high speed [1,3]	Rural low speed	Urban freeways [3]	Urban roads [2]
Desirable	4.0 – 6.0 m	3.0 – 6.0 m	4.0 – 6.0 m	2.5 - 3.0 m
Minimum	3.0 m	2.5 m	3.0 m	1.0 m

Notes:

1 *Operating speed greater than or equal to 80 km/h*
2 *The offset may be governed by the required offset to kerbs*
3 *Adoption of barrier widths less than 3 m shall include assessment of desired operating practices, including emergency response, maintenance and police enforcement*
4 *Shoulder widths and barrier offset from traffic lane dimensions may differ. Refer Part 3 of the Guide (Austroads 2021d) for additional information regarding shoulder widths*

Figure 7: Austroads Part 6, Table 6.5

Due to the site constraints and space available, the proposed barrier location is **1.5m** away from the traffic lane (from white edgeline) with the barrier rail face aligned with the existing kerb face. The kerb and channel are present on the site along the proposed location of the barriers.

Minimum Lateral Distance of a Barrier from a Hazard

The desirable working width for the TL-4 barrier is 2.8m as given in the section 3.5 above. However, due to the site constraint and space available the working width present on site is 2.1m.

Austroads guideline (Figure 6.4, AGRD Part 6, 2022) for barriers suggests of having 1.0m (absolute minimum) distance between the face of the W-beam barriers and hinge of the embankments but the width available on site is **0.8m**.

Minimum Lateral Distance of a Barrier from an Embankment Hinge Point

The working widths are measured during the MASH compliance testing. AGRD Part, Table 6.3 provides the preliminary design width for various barrier systems. These values have been taken from TL-3 and TL-4 crash test reports and are acceptable for a preliminary design.

For design purpose the barrier system selected is Thriebeam System (TL-4). So, referring to the Table 6.3 in AGRD Part 6, for 2.0m post spacing, the working width is 2.8m. The absolute minimum distance between W-beam barriers and embankments is greater than 1.0m as per Austroads Part 6, Figure 6.4 (below).

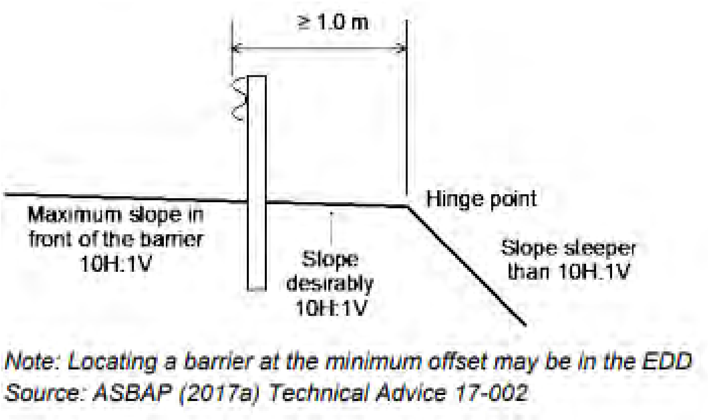


Figure 8: Austroads Part 6: Figure 6.4, Absolute minimum distances between W-beam barriers and embankments (AGRD Part 6, 2022).

Barrier Setback from kerbs

There are kerb and channel present on site where the barriers are proposed. The barriers face is proposed to run along the kerb face so that the barrier rails are at the same horizontal lines.

Flaring of Barriers and Terminals

The proposed barriers system both the barriers and terminals are not flared.

Figure 9: Existing cross section on Coatesville - Riverhead Highway.

3.7 Determine the longitudinal location of a road safety barrier (Step 7)

The proposed barrier length will be governed by the barrier stopping the errant vehicles before hitting the hazards and also hitting the barriers at the small angle and then deviating the errant vehicles away from the hazards before coming to stop. However, there are driveways present on site on either side of the barrier ends. This would eventually determine the length of the barrier proposed on site.

The Austroads Table 6.10 below provides the theoretical run-out length for barriers.

The selected site requires 67.0m of the run-out length based on the speed 90km/hr (posted speed is 80km/hr) and AADT between 5,000-10,000 for CRH Hwy and that of 80.0m for DF Hwy based on 90km/hr and AADT over 10,000.

For this assignment purpose, the run-out length is considered as 80.0m for both highways.

Therefore, $L_R = 80$

Table 6.10: Run-out lengths for barrier design

Operating speed (km/h)	Run-out length L_R (m) for AADT range			
	> 10 000	5 000–10 000	1 000–5 000	< 1 000
110	110	101	88	76
100	91	76	64	61
90	80	67	56	54
80	70	58	49	46
70	60	49	42	38
60	49	40	34	30
50	34	27	24	21

Note: The values are based on research and observations and are shorter than in previous editions of this Part.
Source: Adapted from AASHTO (2011a).

Figure 10: Austroads AGRD Part 6, Table 6.10 for run-out lengths for barrier design.

As per Section 6.9.2, in Austroads Part 6, when the hazard extends long distances perpendicular to the road, the equation 7 and 8 become,

$X_1 = 2L_R$

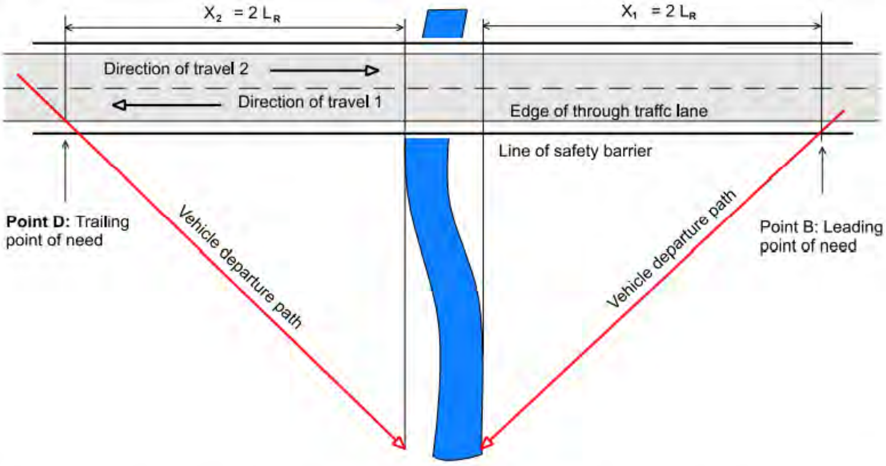
$X_2 = 2L_R$

Where,

X1 = the location of the leading point of need in advance of the hazards

X2 = the location of the trailing point of need in advance of the hazards based on traffic in direction 2

The figure below provides graphical representation of the leading point of need and trailing point of need.



Structures, including barriers, perpendicular to hazards such as rivers and streams shall be designed in accordance with AS5100 or the *Bridge Manual* (NZ Transport Agency 2013) as appropriate.

Figure 11: Figure 6.15: Leading and trailing points of need for hazards extending long distances from the road.

Therefore, $X_1 = X_2 = 2 \times 180 =$ **160m**

The total length of the hazard as per site condition is (measure the length from driveway in CRH Hwy to driveway in DF Hwy) = **170m**.

Hence the total length of need = 160 + 170 + 160 = **490m**.

However, the proposed site consists of two properties which are determining the length of the barrier on site. i.e., 12 Coatesville-Riverhead Hwy and other is 555 Dairy Flat Hwy. And the distance between the properties along the road (proposed barrier) is **185m**.

3.8 Evaluation of the selected barrier for the roadside (Step 8)

The barrier type and the requirement for the type of the barrier chosen is identified. No further iteration required for selection of barrier.

3.9 Evaluate the Strength of the Soil at the Proposed Barrier Location (Step 9)

The locations for the proposed barrier are new fill with the subgrade and all the pavement materials are new as well which provides the good foundation for the barriers. This will help the barriers to resist the impact from the vehicles and will fall under MASH protocol (AASHTO, 2016). The MASH protocol for the materials on the barrier foundations have similar soil bearing strength to NZTA M/4 basecourse compacted to NZTA B/2.

3.10 Structural design of the Proposed Barrier (Step 10)

The road safety barriers structure as per the manufacturers' specification will be used while designing the barrier system. And no ground beams are proposed at this stage of the barrier design. The barrier types proposed are compliant with NZTA M23: 2022 and NZTA M23A: 2022.

3.11 Detailed Installation refinements (Step 11)

The proposed barrier location is in constrained site and the steep embankment slopes are present immediately after the hinge point behind the barrier. The working width is not met as per the Austroads Part 6: Section 6.7 however there are no vertical hazards within the deflection zone of the barriers.

Figure 12: Stormwater discharge area with riprap and grown vegetations.

Figure 13: Existing stormwater system and fill slope.

There is stormwater system present on site crossing the roads and comes under the barrier foundation. The depth of barrier post foundation will be clashing with the cross-drainage present on CR Highway.

The barriers specified in the NZTA M23 Appendix A are considered during the design and the list of the barriers meet the NZTA design requirements.

The list of the barriers specified in the NZTA M23A are provided in Table 1 below with the working width, deflection and system width required for TL-4 barrier system.

Table 1: TL-4 barrier working width, deflection and system width as per manufacturers' specifications (NZTA M23A, 2022)

Barrier System	Working Width, m	System Deflection (MASH TL-4), m	System Width, mm
Ezy-Guard HC Thrie-beam barrier	2.46	1.77	245
Ramshield High Containment HC barrier	2.20	1.10	230
Sentry Thrie-beam barrier	2.80	1.53	200

The working width is not met as per specifications for all the barrier types however there are no vertical constraints for the barrier to restrict deflecting during the event of the hit by the errant vehicles.

The minimum length of the barrier required as per manufacturers' specifications ranges from 82m to 86m for the barriers stated in the Table 1 above. This length excludes the end terminals and any crash cushions and transitions.

The proposed barriers are in the straight sections in the approaches and departure of the rounadout and curved section in the north-western section of the roundabout. Also, no visibility issue for people getting in and out of the property on both end terminals due to the proposed barriers.

Barriers need to be nested if the posts are clashing with the utilities, especially underground stormwater system in this case.

3.12 Select End treatments to Longitudinal Barriers (Step 12)

The end terminals accepted by Waka Kotahi (WK) are listed in the NZTA M23A. The Table 2 below provides the lists of the end terminals approved by WK for use.

Table 2: Different end terminals with their length and runout areas.

TL-3 End terminals	Length, m	Runout areas, m x m
MSKT End terminal	14.29	6.0m wide x 18.5m long from point of redirection
MAX-Tension End terminal	16.77	6.0m wide x 18.5m long from point of redirection
SoftStop End terminal	15.48	6.0m wide x 18.5m long from point of redirection

The runout areas for the various end terminals are as provided in the Table 2 above. Due to the constraint site and space not, available it is hard to achieve the runout area required.

The proposed barriers are TL-4 and the end terminals are TL-3 so there will be requirement of transitions between the TL-3 and Thrie-beam and the NZTA M23A have listed the acceptable transition available to use. Also, most of the manufacturers / suppliers have their transition barrier pieces available to use.

Dairy Flat Highway and Coatesville Riverhead Highway are in the rural environment and walking and cycling have not been considered during the design. Both the roads also are not motorcyclist route, and no consideration has been given to providing motorcycle friendly barriers.

3.13 Apply guidance for a barrier installation to meet specific requirements (Step 13)

The new barrier is proposed along the Coatesville – Riverhead Highway and Dairy Flat Highway considering non-recoverable slopes on either side of the roads and there are other hazards on site requiring shielding so that the errant vehicles are redirected towards the traffic lane in the event of crash. The primary persons-at-risk are the occupants using the errant vehicles. Providing the barriers in the proposed location reduces the consequences after the crashes reducing the likelihood of death and serious injuries.

3.14 Develop a plan to maintain the barrier (Step 14)

Both the Dairy Flat Hwy and Coatesville-Riverhead Hwy have two lanes each direction approaching the roundabout and exiting the roundabout with lanes tapering on both sides. This allows space for site workers and equipment to carry out regular barrier maintenance and/or replacement works. Along DFH the opposite lanes are separated by the traffic islands so there will be minimal disruption to the traffic on other side lanes while working on barriers in one side.

The barriers and end terminals selected are readily available in market and approved by Waka Kotahi. There is open space available near the trailing end terminal of the barriers which could be used for materials and equipment storage during the construction and maintenance as required.

3.15 Confirm that the barrier meets the objectives (Step 15)

The Thrie Beam TL-4 barrier, along some parts of the Coatesville – Riverhead Highway and Dairy Flat Highway, are proposed to stop the errant vehicles getting off the road in the event of the crash happening. There are retaining walls on site as well as the steep non recoverable slopes with matures trees present on the slope. The stormwater system present on site also requires shielding in case there is a vehicle leaving the road and approaching the system.

Therefore, the proposed barriers should meet its objective redirecting the vehicle away from the hazards and keeping the vehicle within the traffic lane.

3.16 Documentation of the design (Step 16)

The barrier design consists of a report (this report) and site layout for the proposed barriers.

Site photos are provided in the **Appendix A.**

Couple of iterative process were carried out during the actual barrier design on this location to meet the site requirement. Some information about changes on the site conditions and actual design are described and presented in **Appendix B**. The final detailed design drawings are provided in the **Appendix C** of this report.

Appendix A. Site Photos

Note: Some of the site photos were taken druing the site visit and some are taken from the Google Street view.

Figure 14: Proposed barrier site looking from Albany side of the T-intersection before the roundabout construction.

Figure 15: New roundabout under construction (Looking towards proposed barrier site from Albany side of the T-intersection along Dairy Flat Highway).

Figure 16: Existing driveway near the leading end terminals on Coatesville – Riverhead Highway.

Figure 17: Existing grown vegetation, cut slope and power poles on Coatesville - Riverhead Highway.

Figure 18: Newly built retaining wall, stormwater system and non-traversable slopes.

Figure 19: Existing broken sight rails along the Dairy Flat Highway after the T-intersection Silverdale leg.

Appendix B. Site requirement and Design Iteration

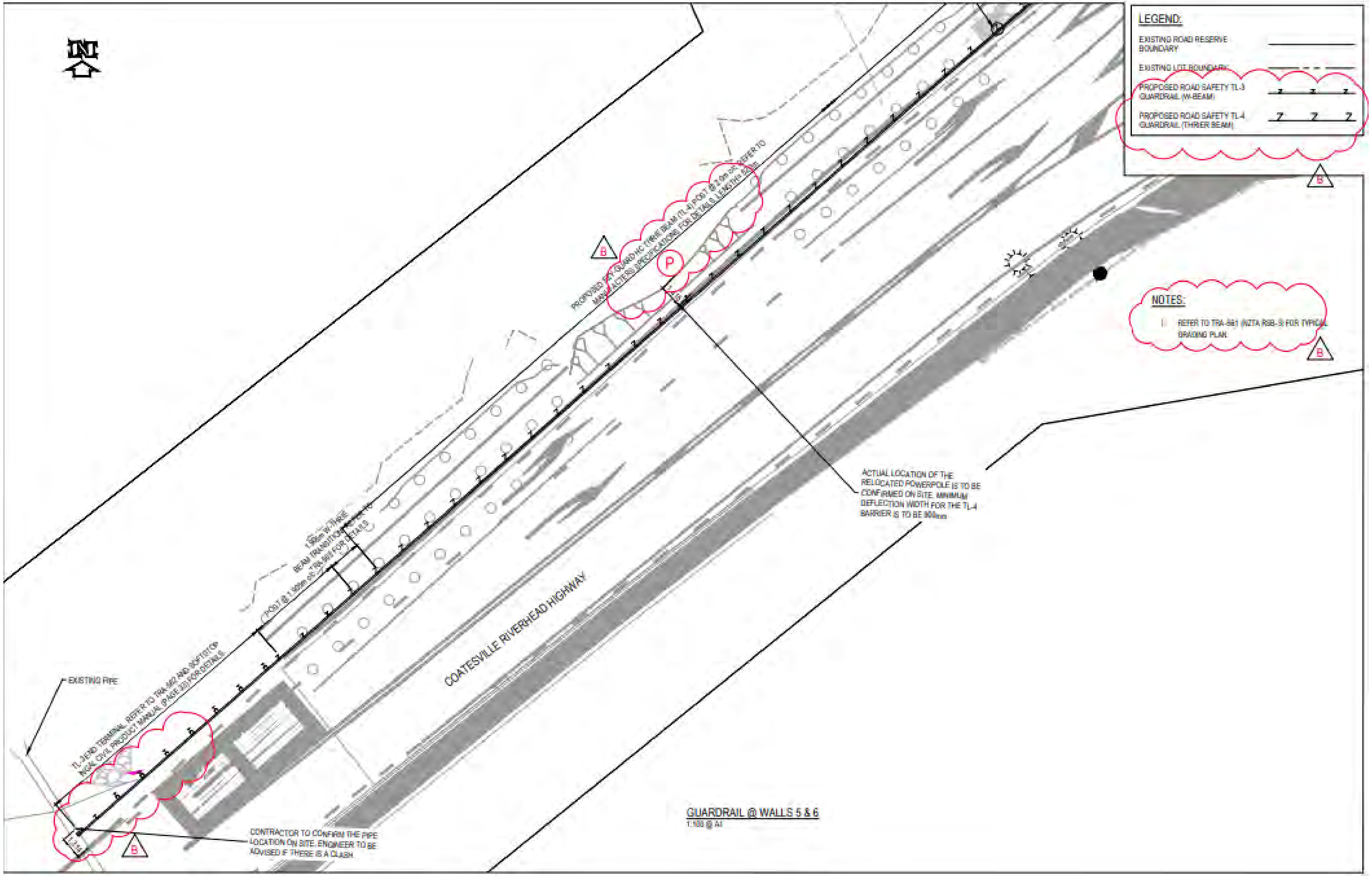
During the detailed design stage, the proposed barrier site requirement changed. This is due to the ground condition below the proposed retaining wall (Refer Drawing Sheet 2 and 3 in **Appendix C** below).

The area where the retaining wall 3 was proposed had massive historical landslide. No data available for the geotech works following the landslide. For that reason, the geotechnical engineers added ground improvements below the proposed retaining wall 3. At the sametime, the stormwater system changed to precast concrete rain garden system from standard rain garden.This led to provide opening requirement in the proposed barrier to allow maintenance vehicle. The opening was provided in the north-western corner of the roundabout. The width of opening was based on tracking requirement for maintenance vehicle to access the rain garden.

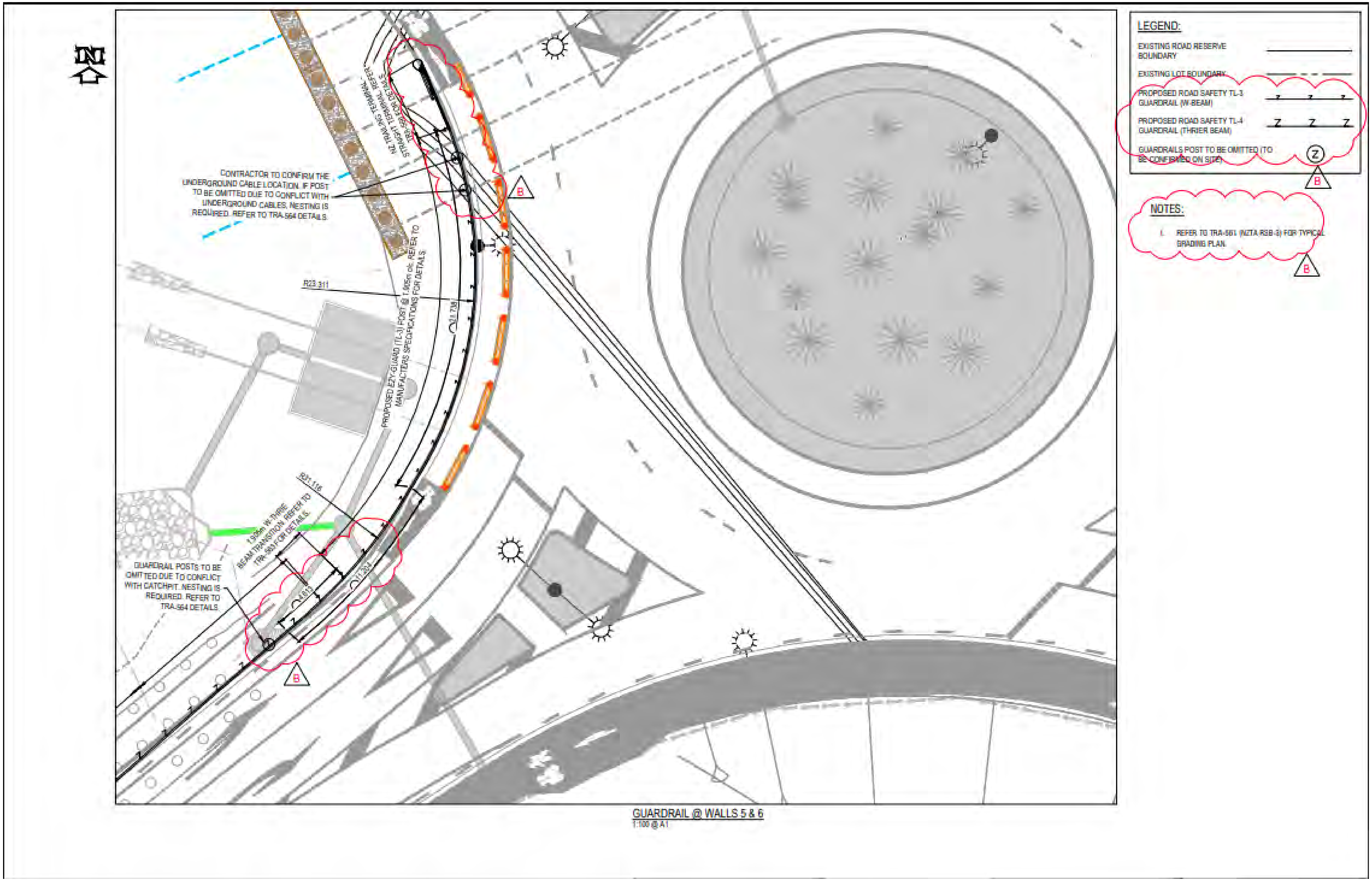
Some of the final design drawings are provided in the **Appendix C.**

Appendix C. Design Drawings (Plans and Typical Details)

1. Sheet 1 of 4



2. Sheet 2 of 4

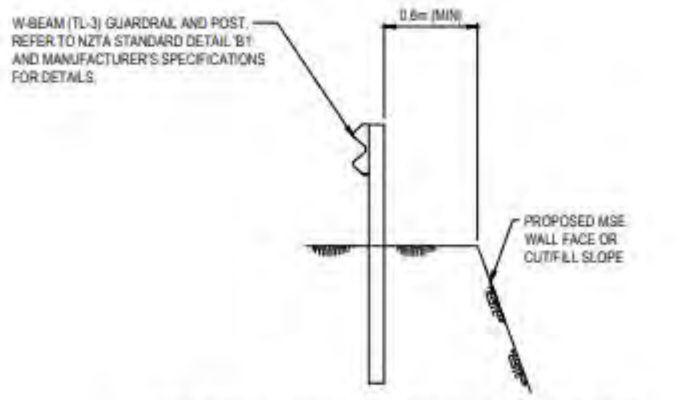


GUARDRAIL @ WALLS 5 & 6
1:100 @ A1

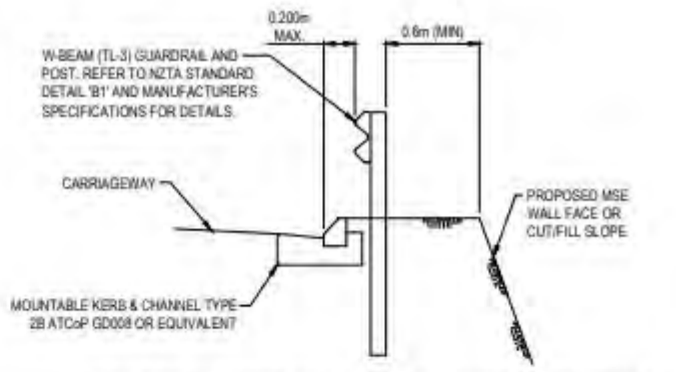
3. Sheet 3 of 4


DAIRY FLAT HIGHWAY
TL-3 END TERMINAL. REFER TO TRA-562 AND SOFTSTOP INGAL CIVIL PRODUCT MANUAL (PAGE 30) FOR DETAILS
1.905m W-THRIE BEAM TRANSITION. REFER TO TRA-563 FOR DETAILS
POST @ 1.905m c/c
PROPOSED CATCHPIT
GUARDRAIL POSTS TO BE OMITTED DUE TO CONFLICT WITH CATCHPIT. NESTING IS REQUIRED. REFER TO TRA-564 DETAILS
PROPOSED W-BEAM (TL-3) POST @ 1.905 c/c REFER TRA-560 FOR DETAILS
PROPOSED ANCHOR IS APPROXIMATELY MORE THAN 2.3m BELOW AT THIS LOCATION
PROPOSED CATCHPIT
TL-3 END TERMINAL. REFER TO TRA-562 AND SOFTSTOP INGAL CIVIL PRODUCT MANUAL (PAGE 33) FOR DETAILS
GUARDRAIL @ WALL 3
1:100 @ A1
N
LEGEND:
EXISTING ROAD RESERVE BOUNDARY
EXISTING LOT BOUNDARY
PROPOSED ROAD SAFETY TL-3 GUARDRAIL (W-BEAM)
GUARDRAIL POST TO BE OMITTED (TO BE CONFIRMED ON SITE)
NOTES:
1. REFER TO TRA-561 (NZTA RSB-3) FOR TYPICAL GRADING PLAN.

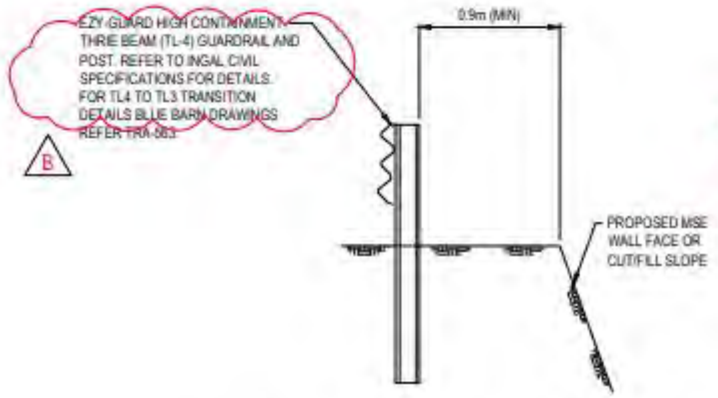
Sheet 4 of 4 – Typical Details



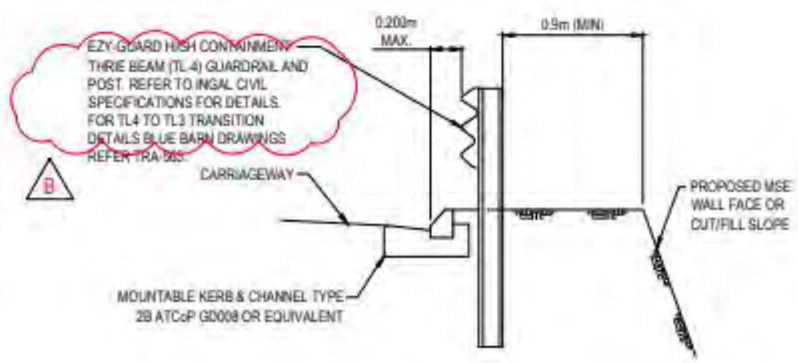
GUARDRAIL ASSEMBLY (W-BEAM) - ALONG SHOULDER
1:100 @ A1



GUARDRAIL ASSEMBLY (W-BEAM) - ALONG PROPOSED KERBLINE
1:100 @ A1



GUARDRAIL ASSEMBLY (THRIE BEAM) - ALONG SHOULDER
1:100 @ A1



GUARDRAIL ASSEMBLY (THRIE BEAM) - ALONG PROPOSED KERBLINE
1:100 @ A1