

# Highway Design Report

Preliminary / detailed design – geometric design, junction layout and cross-section

|             |                                                   |                   |                            |
|-------------|---------------------------------------------------|-------------------|----------------------------|
| Project     | A999 Example Junction Improvement, Fictional Town | Document no.      | RRD-SMP-XX-XX-RP-C-0001    |
| Client      | None – illustrative capability sample             | Revision / status | P02 / S3                   |
| Originator  | RoadRail Design (NRDMG Yapı Sistemleri A.Ş.)      | Date              | 09/10/2026                 |
| Discipline  | Highways – geometric design                       | Security          | Public – sample            |
| Prepared by | Senior Highway Engineer                           | Checked by        | Principal Highway Engineer |
| Approved by | Associate Director – Highways                     | Classification    | Report (RP)                |

| Rev | Date       | Status | Description                                                     | Prepared    | Checked       | Approved    |
|-----|------------|--------|-----------------------------------------------------------------|-------------|---------------|-------------|
| P01 | 14/09/2026 | S3     | First issue for review and comment                              | Snr Hwy Eng | Prin. Hwy Eng | Assoc. Dir. |
| P02 | 09/10/2026 | S3     | Updated following client review comments; departure D-001 added | Snr Hwy Eng | Prin. Hwy Eng | Assoc. Dir. |

**Illustrative sample.** This document describes a fictional scheme prepared solely to demonstrate RoadRail Design's report structure, technical approach and standards knowledge. Locations, data, chainages, survey information, traffic figures and collision records are invented. It is not a client project and must not be relied upon for design. References are to the Design Manual for Roads and Bridges (DMRB) documents current at the date of issue; the applicable version of each standard would be confirmed with the Overseeing Organisation on a live project.

## 1. Introduction

This report records the geometric design basis for the fictional **A999 Example Junction Improvement, Fictional Town**. It sets out the scheme description, design speed derivation, the CD 109 design criteria matrix, the junction and cross-section design, relaxations and departures from standard, design assumptions and the drawing register. It is intended to be read with the Departure from Standard application (RRD-SMP-XX-XX-RP-C-0002), the Road Safety Audit Stage 2 Response Report (RRD-SMP-XX-XX-RP-C-0003) and the Drainage Design Calculation Summary (RRD-SMP-XX-XX-CA-C-0001).

## 2. Scheme description

### 2.1 Existing situation

The existing A999 is a rural all-purpose single carriageway (nominal 6.7–7.0 m, no hard strips) subject to the national speed limit (60 mph). At the fictional B9999 Fictional Lane a simple priority T-junction serves Fictional Town to the north. The illustrative collision record (5 years) shows 7 personal injury collisions, 2 serious, of which 5 involved vehicles turning right into the minor road and being struck from behind or by overtaking vehicles. Forward visibility over the existing crest at Ch 1+180 is approximately 90 m.

### 2.2 Proposed scheme

- Online and partly offline realignment of the A999 between Ch 0+000 and Ch 1+350 (1.35 km) to a standard S2 single carriageway cross-section (CD 127).
- Conversion of the B9999 junction (Ch 0+560) to a **ghost island priority junction** with a protected right-turn lane in accordance with CD 123.
- Proposed reduction of the speed limit to 50 mph through the scheme extent, subject to a Traffic Regulation Order (TRO) by the highway authority.
- 3.0 m shared-use path on the northern verge between the junction and Fictional Town (CD 143 / CD 195).
- New positive drainage with attenuation and a vegetated SuDS swale before outfall (CG 501, CD 532); see RRD-SMP-XX-XX-CA-C-0001.
- Road restraint systems, signing, road markings and lighting at the junction (CD 377, TSRGD 2016, Traffic Signs Manual).

### 2.3 Traffic

Illustrative base-year (2026) AADT 11,400 vehicles with 9% HGV; design year (2041) AADT 13,600. Junction capacity was checked with a priority-junction capacity model; the design-year PM peak ratio of flow to capacity (RFC) on the right-turn movement is 0.62, below the 0.85 practical threshold.

## 3. Design standards

| Document                 | Title / application on this scheme                                            |
|--------------------------|-------------------------------------------------------------------------------|
| GG 101                   | Introduction to the DMRB – departures from standard process                   |
| GG 104                   | Requirements for safety risk assessment                                       |
| GG 119                   | Road safety audit (Stage 1, 2, 3 and 4)                                       |
| CD 109                   | Highway link design – design speed, SSD, horizontal and vertical alignment    |
| CD 123                   | Geometric design of at-grade priority and signal-controlled junctions         |
| CD 127                   | Cross-sections and headrooms                                                  |
| CD 143 / CD 195          | Designing for walking, cycling and horse-riding / designing for cycle traffic |
| CD 377                   | Requirements for road restraint systems                                       |
| CG 501 / CD 526 / CD 532 | Highway drainage design (see separate calculation summary)                    |
| TSRGD 2016 / TSM         | Traffic signs, road markings and Traffic Signs Manual chapters 3, 4 and 5     |

## 4. Design speed

Design speed has been derived in accordance with CD 109 Section 2 from the alignment constraint ( $A_c$ ) and layout constraint ( $L_c$ ) for the proposed alignment over a 2 km assessment length.

| Parameter                                        | Value                                                    | Basis                                                                       |
|--------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------|
| Bendiness, B                                     | 38 °/km                                                  | Sum of deflection angles over assessment length                             |
| Harmonic mean visibility, VISI                   | 230 m                                                    | Measured from proposed alignment model                                      |
| Alignment constraint, $A_c$ (single carriageway) | $12 - \text{VISI}/60 + 2B/45 = \mathbf{9.9 \text{ kph}}$ | CD 109 equation for single carriageways                                     |
| Layout constraint, $L_c$                         | 21 kph                                                   | 7.3 m carriageway, 1.0 m hard strips, 2.5 m verges, medium access frequency |
| Proposed mandatory speed limit                   | 50 mph                                                   | Subject to TRO                                                              |
| <b>Design speed adopted</b>                      | <b>85A kph</b>                                           | CD 109 design speed relationship for $A_c$ , $L_c$ and speed limit          |

## 5. Design criteria matrix (CD 109 / CD 123 / CD 127)

Desirable minimum values and values one step below are those of CD 109 Table 2.10 for an 85 kph design speed. SSD is measured from a driver's eye height of 1.05 m to an object height of 0.26 m. K values are expressed as curve length (m) per 1% algebraic change of gradient.

| Parameter                                                    | Desirable min / max  | One step below (relaxation) | Design value              | Location                    | Status                                |
|--------------------------------------------------------------|----------------------|-----------------------------|---------------------------|-----------------------------|---------------------------------------|
| Stopping sight distance (SSD)                                | 160 m                | 120 m                       | $\geq 165 \text{ m}$      | Ch 0+000-1+120, 1+240-1+350 | Compliant                             |
| SSD over crest VC3                                           | 160 m                | 120 m                       | 106 m                     | Ch 1+120-1+240              | <b>Departure D-001</b>                |
| Min. R without elimination of adverse camber and transitions | 1440 m               | -                           | HC1, HC2 below            | HC1, HC2                    | Superelevation + transitions provided |
| Min. R with superelevation of 5%                             | 1020 m               | -                           | 720 m (e = 3.5%)          | HC1 Ch 0+180-0+410          | Compliant ( $\geq 510 \text{ m}$ )    |
| Desirable min. R with superelevation of 7%                   | 510 m                | 360 m                       | 400 m (e = 6.4%)          | HC2 Ch 0+700-0+920          | <b>Relaxation R-01</b>                |
| Crest K value                                                | 55                   | 30                          | 60                        | VC1 Ch 0+180-0+420          | Compliant                             |
| Crest K value                                                | 55                   | 30                          | 24                        | VC3 Ch 1+120-1+240          | <b>Departure D-001</b>                |
| Sag K value                                                  | 20                   | -                           | 28                        | VC2 Ch 0+715-0+845          | Compliant                             |
| Maximum gradient (single carriageway)                        | 6% desirable max     | -                           | 3.2%                      | Ch 0+845-1+120              | Compliant                             |
| Minimum gradient, kerbed sections                            | 0.5%                 | -                           | 1.5%                      | Junction Ch 0+480-0+640     | Compliant                             |
| Superelevation, rural (max)                                  | 7%                   | -                           | 6.4%                      | HC2                         | Compliant                             |
| Full overtaking sight distance (FOD)                         | 410 m                | -                           | 28% of length $\geq$ FOD  | Ch 0+000-0+420              | Recorded                              |
| Junction visibility x / y distance (minor road)              | x = 4.5 m, y = 160 m | -                           | x = 4.5 m, y $\geq$ 175 m | B9999 arm                   | Compliant                             |
| Lane width / hard strip (S2)                                 | 3.65 m / 1.0 m       | -                           | 3.65 m / 1.0 m            | Throughout                  | Compliant                             |

| Parameter                 | Desirable min / max | One step below (relaxation) | Design value                  | Location   | Status    |
|---------------------------|---------------------|-----------------------------|-------------------------------|------------|-----------|
| Verge width               | ≥ 2.5 m             | -                           | 2.5 m S; 3.0 m path + 0.5 m N | Throughout | Compliant |
| Crossfall (normal camber) | 2.5%                | -                           | 2.5%                          | Straights  | Compliant |

Superelevation is calculated from  $S = V^2 / (2.828 \times R)$  with  $V = 85$  kph and is developed over the transition curves; for HC1 ( $R = 720$  m)  $S = 3.5\%$  and for HC2 ( $R = 400$  m)  $S = 6.4\%$ , within the 7% rural maximum. Vertical curve lengths: VC1  $L = 60 \times 4.0 = 240$  m; VC2  $L = 28 \times 4.7 = 132$  m; VC3  $L = 24 \times 5.0 = 120$  m.

## 6. Junction design (CD 123)

- Ghost island layout with 3.5 m right-turn lane, 3.65 m through lanes and hatched ghost island taper; turning length and deceleration length sized to the CD 123 values for an 85 kph major road design speed.
- Minor road (B9999) widened to 6.75 m with entry radius 15 m; tracked for a 16.5 m articulated vehicle and a 12 m rigid vehicle using swept-path analysis software.
- Junction located on straight (Ch 0+480-0+640) on a 1.5% gradient, clear of HC1 and HC2 and outside the influence of departure D-001 (crest at Ch 1+180, 620 m east).
- No overtaking through the ghost island (TSRGD hatching with warning line and double white line on approaches).

## 7. Cross-section (CD 127)

Standard rural single carriageway (S2): 2 × 3.65 m lanes, 1.0 m hard strips each side, 2.5 m southern verge and 3.5 m northern verge accommodating a 3.0 m shared-use path with 0.5 m buffer; kerbed only at the junction. Earthworks side slopes 1V:2.5H in cut and 1V:3H in fill (subject to geotechnical confirmation). Pavement construction is assumed at 620 mm (subgrade CBR 3% with capping).

## 8. Relaxations and departures summary

| Ref.  | Standard / clause                         | Description                                                                                  | Justification                                                                                                                                                         | Status                                                         |
|-------|-------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| R-01  | CD 109, horizontal curvature (Table 2.10) | $R = 400$ m at HC2, one step below desirable minimum radius (510 m) with 6.4% superelevation | Avoids land take from fictional Grade II listed farmstead curtilage; SSD on curve ≥ 165 m; no coincident relaxations; recorded in the design file in line with CD 109 | Recorded – within designer's remit                             |
| D-001 | CD 109, SSD and crest K (Table 2.10)      | Crest $K = 24$ and SSD = 106 m at VC3, below one step below desirable minimum                | Fixed vertical constraint from fictional gas main at Ch 1+195; improves on existing SSD of c. 90 m; mitigation proposed                                               | Submitted to Overseeing Organisation (RRD-SMP-XX-XX-RP-C-0002) |

No relaxations or departures are combined at the same location. A GG 104 safety risk assessment has been carried out for D-001 and is included in the departure application.

## 9. Assumptions and limitations

- Topographical survey (fictional) to OS National Grid / ODN; accuracy ±20 mm in level.
- Traffic data and collision history are illustrative and have not been validated.
- The 50 mph speed limit TRO will be promoted by the highway authority prior to opening.
- Statutory undertakers' apparatus is based on desktop records (PAS 128 survey category D); the intermediate-pressure gas main at Ch 1+195 is assumed to remain in place.
- Ground conditions assumed suitable for earthworks reuse; geotechnical design per CD 622 to follow.
- Outfall consent to Fictional Brook (ordinary watercourse) to be obtained from the Lead Local Flood Authority.
- Departure D-001 is assumed approved for the purposes of this issue; design to be reviewed if rejected.

## 10. Drawing register

| Drawing no.             | Title                                               | Scale              | Rev | Status |
|-------------------------|-----------------------------------------------------|--------------------|-----|--------|
| RRD-SMP-XX-XX-DR-C-0001 | Location plan and key plan                          | 1:10 000           | P02 | S3     |
| RRD-SMP-XX-XX-DR-C-0002 | General arrangement – sheet 1 of 2 (Ch 0+000-0+700) | 1:1000             | P02 | S3     |
| RRD-SMP-XX-XX-DR-C-0003 | General arrangement – sheet 2 of 2 (Ch 0+700-1+350) | 1:1000             | P02 | S3     |
| RRD-SMP-XX-XX-DR-C-0004 | Mainline plan and profile – sheet 1 of 2            | 1:1000 H / 1:100 V | P02 | S3     |

| Drawing no.             | Title                                                | Scale              | Rev | Status |
|-------------------------|------------------------------------------------------|--------------------|-----|--------|
| RRD-SMP-XX-XX-DR-C-0005 | Mainline plan and profile – sheet 2 of 2             | 1:1000 H / 1:100 V | P02 | S3     |
| RRD-SMP-XX-XX-DR-C-0006 | B9999 junction – general arrangement and setting out | 1:500              | P02 | S3     |
| RRD-SMP-XX-XX-DR-C-0007 | Visibility envelopes and SSD assessment              | 1:1000             | P02 | S3     |
| RRD-SMP-XX-XX-DR-C-0008 | Typical cross-sections                               | 1:50               | P01 | S3     |
| RRD-SMP-XX-XX-DR-C-0009 | Swept-path analysis – B9999 junction                 | 1:500              | P01 | S3     |
| RRD-SMP-XX-XX-DR-C-0010 | Road markings and traffic signs – sheet 1 of 2       | 1:500              | P01 | S3     |
| RRD-SMP-XX-XX-DR-C-0011 | Road restraint systems layout                        | 1:1000             | P01 | S3     |
| RRD-SMP-XX-XX-DR-C-0501 | Drainage general arrangement and long sections       | 1:1000             | P02 | S3     |

ISO 19650 naming: Originator (RRD) – Project (SMP) – Functional breakdown (XX) – Spatial breakdown (XX) – Form (RP report, DR drawing, CA calculation) – Role (C civil) – Number. Status S3 = suitable for review and comment; revision P = preliminary.

# Departure from Standard Application

D-001: Reduced stopping sight distance and crest K value at VC3 (Ch 1+120-1+240) – GG 101 format

|             |                                                   |                   |                            |
|-------------|---------------------------------------------------|-------------------|----------------------------|
| Project     | A999 Example Junction Improvement, Fictional Town | Document no.      | RRD-SMP-XX-XX-RP-C-0002    |
| Client      | None – illustrative capability sample             | Revision / status | P02 / S3                   |
| Originator  | RoadRail Design (NRDMG Yapı Sistemleri A.Ş.)      | Date              | 09/10/2026                 |
| Discipline  | Highways – geometric design                       | Security          | Public – sample            |
| Prepared by | Senior Highway Engineer                           | Checked by        | Principal Highway Engineer |
| Approved by | Associate Director – Highways                     | Classification    | Report (RP)                |

| Rev | Date       | Status | Description                                                          | Prepared    | Checked       | Approved    |
|-----|------------|--------|----------------------------------------------------------------------|-------------|---------------|-------------|
| P01 | 22/09/2026 | S3     | First issue to Overseeing Organisation for pre-submission review     | Snr Hwy Eng | Prin. Hwy Eng | Assoc. Dir. |
| P02 | 09/10/2026 | S3     | Mitigation and risk assessment updated after pre-submission comments | Snr Hwy Eng | Prin. Hwy Eng | Assoc. Dir. |

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## 1. Departure summary

|                            |                                                                                                                  |
|----------------------------|------------------------------------------------------------------------------------------------------------------|
| Departure reference        | D-001 (Overseeing Organisation reference: to be allocated)                                                       |
| Scheme                     | A999 Example Junction Improvement, Fictional Town (fictional)                                                    |
| Road / location            | A999 mainline eastbound and westbound, crest curve VC3, Ch 1+120-1+240 (vertex Ch 1+180)                         |
| Standard departed from     | CD 109 Highway link design – Table 2.10 design speed related parameters (stopping sight distance; crest K value) |
| Design speed / speed limit | 85A kph / 50 mph (proposed, subject to TRO)                                                                      |
| Requirement                | SSD desirable minimum 160 m (one step below 120 m); crest K desirable minimum 55 (one step below 30)             |
| Proposed provision         | Crest K = 24 (L = 120 m, A = 5.0%: +3.2% to –1.8%); SSD = 106 m in both directions                               |
| Departure type             | Departure from standard – provision below the relaxation range permitted by CD 109                               |
| Design stage               | Detailed design (pre-construction)                                                                               |
| Related documents          | RRD-SMP-XX-XX-RP-C-0001 Highway Design Report; DR-C-0005 Plan and profile; DR-C-0007 Visibility envelopes        |

## 2. Description of the departure

The proposed eastbound approach climbs at 3.2% from the sag VC2 to a crest at Ch 1+180 before descending at 1.8% to tie in with the existing A999 at Ch 1+350. The crest curve provides K = 24, giving a forward visibility envelope (eye height 1.05 m, object height 0.26 m) of 106 m in both directions. This is below the CD 109 one step below desirable minimum SSD of 120 m for 85 kph and therefore cannot be treated as a relaxation. The departure length is approximately 160 m including the approaches over which SSD is less than 120 m. The horizontal alignment through the crest is straight and no junctions, lay-bys or private accesses are located within the reduced-visibility length.

## 3. Reasons the standard cannot be met

The vertical profile is fixed at the crest by a (fictional) intermediate-pressure gas main crossing the A999 at Ch 1+195 with approximately 1.45 m cover to the existing road surface, and by the tie-in level at Ch 1+350. Lengthening the crest curve with unchanged grades lowers the road at the vertex by  $e = A \cdot L / 800$ :

| Option                   | Crest K | Curve length L | Middle ordinate e | Lowering at vertex vs proposed | Consequence                                                        |
|--------------------------|---------|----------------|-------------------|--------------------------------|--------------------------------------------------------------------|
| Proposed                 | 24      | 120 m          | 0.75 m            | -                              | Main protected by concrete slab; no diversion                      |
| One step below desirable | 30      | 150 m          | 0.94 m            | 0.19 m                         | Cover below gas operator's minimum; diversion required             |
| Desirable minimum        | 55      | 275 m          | 1.72 m            | 0.97 m                         | Diversion of main and lowering of tie-in; extends works 250 m east |

#### 4. Alternatives considered

| Option | Description                                                                     | Indicative cost (illustrative) | Programme                       | Assessment                                                                    |
|--------|---------------------------------------------------------------------------------|--------------------------------|---------------------------------|-------------------------------------------------------------------------------|
| A      | Full compliance (K = 55, SSD 160 m) with gas main diversion and extended tie-in | £1.60m additional              | +12-18 months (utility lead-in) | Disproportionate cost; additional land take and vegetation loss               |
| B      | Relaxation-level compliance (K = 30, SSD 120 m) with gas main diversion         | £0.45m additional              | +9-12 months                    | Cost and programme disproportionate to safety benefit (14 m SSD)              |
| C      | Proposed: K = 24, SSD 106 m with mitigation (Section 6)                         | £0.04m (mitigation)            | No change                       | <b>Preferred</b> - improves existing SSD (c. 90 m) by c. 18%                  |
| D      | Do minimum: retain existing crest profile (SSD c. 90 m)                         | Nil                            | No change                       | Rejected - lower safety performance than Option C                             |
| E      | Reduce speed limit to 40 mph through crest                                      | Low                            | TRO dependent                   | Rejected - inconsistent with rural road environment; poor compliance expected |

#### 5. Safety assessment

CD 109 desirable minimum SSD is based on a 2 s perception-reaction time and a deceleration of 0.25g; the one step below value corresponds to approximately 0.375g. Applying 2 s and 0.375g to the 106 m provided, a driver can stop from about **78 kph**. The illustrative 85th percentile approach speed at the crest is **80 kph** (comparable 50 mph rural sites, eastbound uphill), and the 3.2% uphill grade on the eastbound approach assists braking. The residual shortfall is therefore small and is addressed by the mitigation below.

The illustrative 5-year collision record for the existing crest shows no personal injury collisions attributable to forward visibility. The scheme's principal collision problem (right-turn collisions at the B9999 junction, 620 m west) is addressed by the ghost island and is unaffected by this departure.

#### 6. Proposed mitigation

- Double white line system (TSRGD diagram 1013.1) prohibiting overtaking over the crest, with warning line approaches.
- Raised retroreflective road studs on the centre line and edge lines through the departure length.
- High-friction-capable surface course: PSV and texture depth to the higher site category for an approach to a hazard (CD 236).
- No new accesses permitted within Ch 1+050-1+300; the existing field access at Ch 1+260 is relocated to Ch 1+320 with compliant visibility.
- Verge and hedge maintenance regime recorded in the Health and Safety File to keep the visibility envelope clear of vegetation.
- 50 mph speed limit (TRO) with repeater signing; speed and collision monitoring through Stage 4 RSA (12 and 36 months).

#### 7. Risk assessment (GG 104 approach)

Likelihood (L) and severity (S) are scored 1 (very low) to 5 (very high); risk R = L × S. Residual risk is assessed after mitigation. Risk is to be as low as reasonably practicable.

| No. | Hazard                                                        | Affected              | L | S | R  | Mitigation                                                  | L | S | Res. R |
|-----|---------------------------------------------------------------|-----------------------|---|---|----|-------------------------------------------------------------|---|---|--------|
| 1   | Driver fails to stop for stationary/slow vehicle beyond crest | Road users            | 3 | 4 | 12 | Double white lines, studs, high-PSV surfacing, 50 mph limit | 2 | 4 | 8      |
| 2   | Head-on collision from overtaking over crest                  | Road users            | 3 | 5 | 15 | Double white line system; continuous centre-line studs      | 1 | 5 | 5      |
| 3   | Turning vehicle at field access hidden by crest               | Road users, landowner | 3 | 4 | 12 | Access relocated to Ch 1+320 with full SSD                  | 1 | 4 | 4      |

| No. | Hazard                                           | Affected     | L | S | R  | Mitigation                                                         | L | S | Res. R |
|-----|--------------------------------------------------|--------------|---|---|----|--------------------------------------------------------------------|---|---|--------|
| 4   | Visibility envelope reduced by vegetation growth | Road users   | 3 | 3 | 9  | Maintenance regime in H&S File and maintenance manual              | 2 | 3 | 6      |
| 5   | Cyclist/pedestrian on carriageway beyond crest   | NMUs         | 2 | 5 | 10 | Shared-use path ends west of departure; route signed to quiet lane | 1 | 5 | 5      |
| 6   | Road worker exposure during maintenance at crest | Road workers | 2 | 4 | 8  | Advance signing per Chapter 8; works planned with lane closure     | 1 | 4 | 4      |

Overall residual risk is assessed as low to medium and lower than the do-minimum (existing) situation. The departure does not introduce a hazard to road workers or maintenance operations beyond those of a compliant alignment.

8. Maintenance and operational implications

Additional maintenance is limited to road stud replacement and twice-yearly verge vegetation cutting within the visibility envelope. No implications for winter service, inspection or structures. The gas main protection slab will be recorded in the as-built information and the Health and Safety File.

9. Designer's declaration

The design organisation confirms that the departure has been assessed against the alternatives above, that the safety risk has been assessed and reduced so far as reasonably practicable, and that no other relaxation or departure is combined with D-001 at this location.

| Role                                                         | Signature | Date       |
|--------------------------------------------------------------|-----------|------------|
| Prepared: Senior Highway Engineer                            |           | 09/10/2026 |
| Checked: Principal Highway Engineer                          |           | 09/10/2026 |
| Approved: Associate Director – Highways (design team leader) |           | 09/10/2026 |

For Overseeing Organisation use only

Decision: ☐ Approved ☐ Approved with conditions ☐ Rejected ☐ Further information required

Conditions / comments:

Name / role / date: – (left blank in sample)

# Road Safety Audit Stage 2 - Designer's Response

Road Safety Audit Response Report in accordance with GG 119 – completion of detailed design

|             |                                                   |                   |                            |
|-------------|---------------------------------------------------|-------------------|----------------------------|
| Project     | A999 Example Junction Improvement, Fictional Town | Document no.      | RRD-SMP-XX-XX-RP-C-0003    |
| Client      | None – illustrative capability sample             | Revision / status | P02 / S3                   |
| Originator  | RoadRail Design (NRDMG Yapı Sistemleri A.Ş.)      | Date              | 09/10/2026                 |
| Discipline  | Highways – road safety                            | Security          | Public – sample            |
| Prepared by | Senior Highway Engineer                           | Checked by        | Principal Highway Engineer |
| Approved by | Associate Director – Highways                     | Classification    | Report (RP)                |

| Rev | Date       | Status | Description                                                       | Prepared    | Checked       | Approved    |
|-----|------------|--------|-------------------------------------------------------------------|-------------|---------------|-------------|
| P01 | 30/09/2026 | S3     | Designer's responses to RSA Stage 2 report                        | Snr Hwy Eng | Prin. Hwy Eng | Assoc. Dir. |
| P02 | 09/10/2026 | S3     | Overseeing Organisation decisions and agreed actions incorporated | Snr Hwy Eng | Prin. Hwy Eng | Assoc. Dir. |

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## 1. Introduction

A Stage 2 Road Safety Audit (completion of detailed design) of the fictional A999 Example Junction Improvement was undertaken by an independent Road Safety Audit Team in accordance with GG 119. The audit considered the detailed design drawings at revision P01 (drawing register in RRD-SMP-XX-XX-RP-C-0001), the departure application D-001 and the illustrative collision data. The RSA Team identified **9 problems**.

This RSA Response Report records, for each problem, the design organisation's response and the Overseeing Organisation's decision, together with the agreed actions. Where a recommendation is not accepted, the reasons and the alternative measure are recorded in the exception report (Section 4). The RSA Team's findings are summarised; the full audit report remains the reference document.

| Item                           | Detail (illustrative)                                                                          |
|--------------------------------|------------------------------------------------------------------------------------------------|
| <b>RSA stage</b>               | Stage 2 – completion of detailed design                                                        |
| <b>RSA report reference</b>    | SMP-RSA2-R01 (fictional), dated 22/09/2026                                                     |
| <b>RSA Team</b>                | Independent RSA Team Leader and RSA Team Member (named in audit report; withheld in sample)    |
| <b>Site visit</b>              | Daylight and night-time visits, 16/09/2026 (fictional)                                         |
| <b>Overseeing Organisation</b> | Highway authority for the A999 (fictional)                                                     |
| <b>Response key</b>            | A = accepted; AA = accepted with alternative measure; NA = not accepted (see exception report) |

## 2. Problems, recommendations and responses

| No. | Location                          | Problem (summary)                                                                                                                    | RSA recommendation                                                                                         | Designer's response                                                                                                                                  | Res p. | OO decision / agreed action                                       |
|-----|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------|
| 2.1 | Ghost island, Ch 0+500-0 +620     | Ghost island hatching taper may be used for overtaking queued right-turners, risk of head-on collision.                              | Provide solid-edged hatching and extend double white line on approaches.                                   | Agreed. Hatching changed to TSRGD diagram 1040.4 (solid boundary); double white lines extended 60 m each approach.                                   | A      | Accepted. Revise DR-C-0010 to P02.                                |
| 2.2 | B9999 junction, nearside verge    | Proposed advance direction sign within the minor road visibility splay (x = 4.5 m, y = 160 m) obstructs view of approaching traffic. | Relocate sign outside visibility envelope.                                                                 | Agreed. Sign relocated 25 m east and mounted on passively safe posts outside splay.                                                                  | A      | Accepted. Revise DR-C-0010 and DR-C-0007.                         |
| 2.3 | Shared-use path crossing of B9999 | No dedicated crossing for pedestrians/cyclists on the minor arm; users may cross where turning vehicles are fast.                    | Provide an uncontrolled crossing with dropped kerbs, tactile paving and refuge set back from the give-way. | Agreed in part. Uncontrolled crossing with tactile paving set back 10 m; minor road width does not allow a 2.0 m refuge without reducing swept path. | AA     | Accepted with alternative (no refuge); see exception report E-01. |

| No. | Location                          | Problem (summary)                                                                                              | RSA recommendation                                                     | Designer's response                                                                                                                                                                             | Res p. | OO decision / agreed action                                 |
|-----|-----------------------------------|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------|
| 2.4 | HC2, Ch 0+700-0+920               | Relaxation R-01 radius with 6.4% superelevation; risk of loss of control in wet conditions on outside of bend. | Provide chevron signs and high-friction surfacing on the curve.        | Agreed in part. Chevrons (diagram 515.1) provided; surface course specified to higher site category PSV per CD 236. Proprietary high-friction surfacing not required on 400 m radius at 50 mph. | AA     | Accepted. Monitor at Stage 4.                               |
| 2.5 | Crest VC3, Ch 1+180               | Reduced SSD (departure D-001); risk of shunt collisions with slow agricultural vehicles beyond the crest.      | Consider warning signs and ensure no accesses within the crest length. | Agreed. Field access relocated to Ch 1+320; double white lines and studs per D-001 mitigation; no additional warning sign (avoid sign clutter).                                                 | A      | Accepted. Linked to D-001 decision.                         |
| 2.6 | Junction lighting, Ch 0+540       | Lighting column located 0.9 m behind kerb in 50 mph environment, unprotected.                                  | Use passively safe columns or protect with VRS.                        | Agreed. Passively safe columns (EN 12767 class 100 HE) specified; set back 1.5 m.                                                                                                               | A      | Accepted. Revise lighting drawings.                         |
| 2.7 | VRS terminal, embankment Ch 0+980 | Safety barrier terminal faces approaching traffic, risk of spearing/vaulting.                                  | Flare terminal away from carriageway or use energy-absorbing terminal. | Agreed. Terminal flared and an assessed P-class terminal specified in accordance with CD 377 and the RRRAP assessment.                                                                          | A      | Accepted. Revise DR-C-0011.                                 |
| 2.8 | Gully at bus stop, Ch 0+610       | Gully located within bus stop boarding area, risk of trip/wheel trap to passengers.                            | Relocate gully or use kerb-type drainage.                              | Agreed. Combined kerb drainage unit adopted through bus stop; gully spacing rechecked (CD 526).                                                                                                 | A      | Accepted. Revise DR-C-0501.                                 |
| 2.9 | Eastern tie-in, Ch 1+350          | Change from 7.3 m with hard strips to 6.7 m existing road may surprise drivers.                                | Extend the cross-section 200 m beyond the tie-in.                      | Not accepted. Extension is outside scheme boundary and land control. Taper lengthened to 1:50 with edge-line hatching and 'road narrows' sign (diagram 517).                                    | NA     | Designer's alternative accepted; see exception report E-02. |

### 3. Agreed actions

| Action | Problem(s)         | Action description                                                    | Owner (role)               | Deliverable         | Due        |
|--------|--------------------|-----------------------------------------------------------------------|----------------------------|---------------------|------------|
| AC-01  | 2.1, 2.2, 2.4, 2.9 | Revise road markings and signs drawings                               | Senior Highway Engineer    | DR-C-0010 P02       | 16/10/2026 |
| AC-02  | 2.2, 2.5           | Update visibility envelopes and confirm sign/access locations         | Senior Highway Engineer    | DR-C-0007 P03       | 16/10/2026 |
| AC-03  | 2.3                | Detail uncontrolled crossing and tactile paving                       | Highway Engineer           | DR-C-0006 P03       | 23/10/2026 |
| AC-04  | 2.6                | Specify passively safe lighting columns                               | Lighting Engineer          | Lighting layout P02 | 23/10/2026 |
| AC-05  | 2.7                | Revise VRS layout and RRRAP record                                    | Senior Highway Engineer    | DR-C-0011 P02       | 23/10/2026 |
| AC-06  | 2.8                | Revise drainage at bus stop; recheck spacing                          | Senior Drainage Engineer   | DR-C-0501 P03       | 23/10/2026 |
| AC-07  | All                | Issue revised drawings to RSA Team for information; brief Stage 3 RSA | Principal Highway Engineer | Transmittal         | 30/10/2026 |

### 4. Exception report

GG 119 requires that where the design organisation does not accept an RSA recommendation, the reasons and any alternative measure are recorded and agreed by the Overseeing Organisation.

| Ref. | Problem | Reason recommendation not (fully) accepted                                                                                        | Alternative measure                                                                                                          | OO position |
|------|---------|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-------------|
| E-01 | 2.3     | A 2.0 m refuge would reduce minor road entry width below that required for the 16.5 m articulated vehicle swept path (DR-C-0009). | Crossing set back 10 m from give-way line; tactile paving; enhanced crossing visibility ( $\geq$ SSD for 30 mph minor road). | Agreed      |
| E-02 | 2.9     | The extension lies outside the scheme boundary and the land within highway control; would require new consents.                   | 1:50 taper, edge-line hatching, 'road narrows' warning sign and road studs. To be reviewed at Stage 4 RSA.                   | Agreed      |

5. Sign-off

| Role                                               | Organisation                  | Signature | Date       |
|----------------------------------------------------|-------------------------------|-----------|------------|
| Design team leader (Associate Director – Highways) | RoadRail Design               |           | 09/10/2026 |
| Overseeing Organisation project sponsor            | Highway authority (fictional) |           | -          |
| RSA Team Leader (for information)                  | Independent RSA Team          | -         | -          |

Stage 3 RSA (completion of construction) will review the as-built scheme, and Stage 4 monitoring will use 12- and 36-month collision data, in accordance with GG 119.

# Drainage Design Calculation Summary

Highway surface water drainage – catchments, modified rational method, pipe sizing, attenuation and SuDS

|             |                                                   |                   |                             |
|-------------|---------------------------------------------------|-------------------|-----------------------------|
| Project     | A999 Example Junction Improvement, Fictional Town | Document no.      | RRD-SMP-XX-XX-CA-C-0001     |
| Client      | None – illustrative capability sample             | Revision / status | P02 / S3                    |
| Originator  | RoadRail Design (NRDMG Yapı Sistemleri A.Ş.)      | Date              | 09/10/2026                  |
| Discipline  | Highway drainage                                  | Security          | Public – sample             |
| Prepared by | Senior Drainage Engineer                          | Checked by        | Principal Drainage Engineer |
| Approved by | Associate Director – Highways                     | Classification    | Calculation (CA)            |

| Rev | Date       | Status | Description                                                                 | Prepared       | Checked          | Approved    |
|-----|------------|--------|-----------------------------------------------------------------------------|----------------|------------------|-------------|
| P01 | 14/09/2026 | S3     | First issue for review and comment                                          | Snr Drain. Eng | Prin. Drain. Eng | Assoc. Dir. |
| P02 | 09/10/2026 | S3     | Bus stop drainage revised (RSA 2.8); storage updated to +40% climate change | Snr Drain. Eng | Prin. Drain. Eng | Assoc. Dir. |

**Illustrative sample.** This document describes a fictional scheme prepared solely to demonstrate RoadRail Design's report structure, technical approach and standards knowledge. Locations, data, chainages, survey information, traffic figures and collision records are invented. It is not a client project and must not be relied upon for design. References are to the Design Manual for Roads and Bridges (DMRB) documents current at the date of issue; the applicable version of each standard would be confirmed with the Overseeing Organisation on a live project.

## 1. Scope

This summary records the surface water drainage design for the fictional A999 Example Junction Improvement (Ch 0+000–1+350 and the B9999 junction). The network collects carriageway, hard strip and footway runoff via gullies and combined kerb drainage units into a carrier pipe system, which discharges through a vortex flow control and an attenuation basin to a vegetated swale and then to the Fictional Brook (ordinary watercourse). Detailed network simulation will verify these hand calculations at the next stage. See drawing RRD-SMP-XX-XX-DR-C-0501.

## 2. Design criteria

| Criterion                                                       | Value adopted                                                           | Reference                          |
|-----------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------|
| Carrier pipes – no surcharge                                    | 1 in 1 year storm                                                       | CG 501                             |
| Network – no flooding of carriageway                            | 1 in 5 year storm (checked by simulation at next stage)                 | CG 501                             |
| Attenuation / exceedance                                        | 1 in 100 year + 40% climate change, no flooding beyond highway boundary | CG 501; LLFA requirement (assumed) |
| Gully spacing design storm / flow width                         | 1 in 1 year; flow width ≤ 1.0 m (within hard strip)                     | CD 526                             |
| Runoff method                                                   | Modified rational: $Q = 2.78 C_v C_r i A$ (l/s; i mm/h; A ha)           | Wallingford procedure              |
| Volumetric runoff coefficient $C_v$ / routing coefficient $C_r$ | 0.90 (paved) / 1.30                                                     | –                                  |
| Time of entry                                                   | 4 min                                                                   | –                                  |
| Pipe roughness (Colebrook-White) $k_s$                          | 0.6 mm (concrete / plastic, surface water)                              | –                                  |
| Minimum full-bore velocity / min. diameter                      | 1.0 m/s / 225 mm (project requirement)                                  | –                                  |
| Permitted discharge                                             | Greenfield mean annual flood $Q_{BAR}$ (IH124) for contributing area    | LLFA (assumed)                     |
| Water quality                                                   | HEWRAT assessment; vegetated treatment before outfall                   | LA 113; CD 532                     |

## 3. Catchments

| Catchment    | Description                                   | Chainage      | Impermeable area (ha) | Outlet   |
|--------------|-----------------------------------------------|---------------|-----------------------|----------|
| C1.1         | A999 mainline, both carriageways              | 0+000-0+130   | 0.18                  | S1.1     |
| C1.2         | A999 mainline, HC1 superelevated              | 0+130-0+290   | 0.21                  | S1.2     |
| C1.3         | A999 mainline incl. ghost island              | 0+290-0+560   | 0.24                  | S1.3     |
| C2.1         | B9999 minor arm and shared-use path           | B 0+000-0+220 | 0.16                  | S2.1     |
| C1.4         | A999 mainline east of junction incl. bus stop | 0+560-0+820   | 0.22                  | S1.4     |
| C1.5         | A999 mainline, HC2 to sag VC2                 | 0+820-0+980   | 0.19                  | S1.5     |
| C1.6         | Lay-by / maintenance access to basin          | 0+980         | 0.05                  | S1.6     |
| <b>Total</b> |                                               |               | <b>1.25</b>           | Basin B1 |

Mainline east of VC3 (Ch 1+180-1+350) drains to the existing system at the tie-in and is excluded. Rainfall intensities are illustrative values representative of FEH depth-duration-frequency data for a lowland UK site (SAAR 650 mm).

#### 4. Pipe sizing - modified rational method (1 in 1 year)

| Pipe | Length (m) | Gradient (1:x) | Area (ha) | Cum. area (ha) | T <sub>c</sub> (min) | i <sub>1yr</sub> (mm/h) | Q (l/s) | Dia. (mm) | V <sub>full</sub> (m/s) | Q <sub>cap</sub> (l/s) | Q/Q <sub>cap</sub> |
|------|------------|----------------|-----------|----------------|----------------------|-------------------------|---------|-----------|-------------------------|------------------------|--------------------|
| S1.1 | 65         | 150            | 0.18      | 0.18           | 5.0                  | 53.9                    | 31.6    | 225       | 1.06                    | 42.3                   | 0.75               |
| S1.2 | 72         | 180            | 0.21      | 0.39           | 6.0                  | 49.7                    | 63.1    | 300       | 1.17                    | 82.5                   | 0.76               |
| S1.3 | 80         | 200            | 0.24      | 0.63           | 7.1                  | 46.4                    | 95.1    | 375       | 1.28                    | 140.9                  | 0.68               |
| S2.1 | 60         | 120            | 0.16      | 0.16           | 4.8                  | 54.0                    | 28.1    | 225       | 1.19                    | 47.3                   | 0.59               |
| S1.4 | 75         | 220            | 0.22      | 1.01           | 8.0                  | 44.0                    | 144.7   | 450       | 1.36                    | 217.1                  | 0.67               |
| S1.5 | 68         | 250            | 0.19      | 1.20           | 8.9                  | 42.1                    | 164.3   | 450       | 1.28                    | 203.5                  | 0.81               |
| S1.6 | 40         | 300            | 0.05      | 1.25           | 9.5                  | 41.0                    | 166.5   | 450       | 1.17                    | 185.6                  | 0.90               |

T<sub>c</sub> = time of entry + time of flow (L/V<sub>full</sub>); intensity interpolated log-log at T<sub>c</sub>. Full-bore velocity from Colebrook-White. All pipes run below full-bore capacity in the 1 in 1 year storm and exceed the 1.0 m/s self-cleansing velocity. Minimum cover 1.2 m under carriageway.

#### 5. Gully spacing (CD 526)

Channel flow capacity at the design flow width is calculated for a triangular kerb/edge channel (Manning, n = 0.017, crossfall 2.5%), multiplied by the grating efficiency and divided by the runoff per metre of channel from a 5.15 m drained width at 50 mm/h. Adopted spacings are rounded down and capped at 40 m; spacing at sag VC2 and at the junction is reduced with double gullies at the low point.

| Long. gradient | Flow width (m) | Channel capacity (l/s) | Grating efficiency | Runoff (l/s per m) | Calc. spacing (m) | Adopted spacing (m) |
|----------------|----------------|------------------------|--------------------|--------------------|-------------------|---------------------|
| 0.5%           | 1.0            | 3.3                    | 0.80               | 0.0715             | 37                | 35                  |
| 1.0%           | 1.0            | 4.7                    | 0.80               | 0.0715             | 53                | 40                  |
| 1.5%           | 1.0            | 5.8                    | 0.80               | 0.0715             | 65                | 40                  |
| 2.0%           | 1.0            | 6.7                    | 0.80               | 0.0715             | 75                | 40                  |
| 3.2%           | 1.0            | 8.4                    | 0.80               | 0.0715             | 94                | 40                  |

#### 6. Greenfield runoff and attenuation

| Parameter                                                                                                                    | Value                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Method                                                                                                                       | IH124: $Q_{BAR} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$ (50 ha, pro-rata) |
| SAAR / SOIL (soil type 4)                                                                                                    | 650 mm / 0.45                                                                                         |
| Q <sub>BAR</sub> for 50 ha / per hectare                                                                                     | 201.4 l/s / 4.03 l/s/ha                                                                               |
| Contributing impermeable area                                                                                                | 1.25 ha                                                                                               |
| Greenfield Q <sub>1</sub> / Q <sub>BAR</sub> / Q <sub>30</sub> / Q <sub>100</sub> (growth factors 0.85 / 1.00 / 2.13 / 2.61) | 4.3 / 5.0 / 10.7 / 13.1 l/s                                                                           |
| <b>Limiting discharge adopted</b>                                                                                            | <b>5.0 l/s</b> (Q <sub>BAR</sub> for all events up to 1 in 100 year + 40%)                            |

  

| Duration (min) | i <sub>100</sub> (mm/h) | i <sub>100+40%</sub> (mm/h) | Inflow vol. (m³) | Outflow vol. (m³) | Storage (m³) |
|----------------|-------------------------|-----------------------------|------------------|-------------------|--------------|
| 15             | 102.0                   | 142.8                       | 402              | 5                 | 397          |
| 30             | 68.0                    | 95.2                        | 536              | 9                 | 526          |
| 60             | 42.0                    | 58.8                        | 662              | 18                | 643          |

| Duration (min) | $i_{100}$ (mm/h) | $i_{100+40\%}$ (mm/h) | Inflow vol. (m <sup>3</sup> ) | Outflow vol. (m <sup>3</sup> ) | Storage (m <sup>3</sup> ) |
|----------------|------------------|-----------------------|-------------------------------|--------------------------------|---------------------------|
| 120            | 26.0             | 36.4                  | 819                           | 36                             | 783                       |
| 240            | 15.5             | 21.7                  | 976                           | 73                             | 904                       |
| 360            | 11.5             | 16.1                  | 1087                          | 109                            | 978                       |
| 720            | 6.9              | 9.7                   | 1304                          | 218                            | 1087                      |
| 1440           | 4.0              | 5.7                   | 1531                          | 435                            | 1096                      |
| 2880           | 2.3              | 3.2                   | 1739                          | 870                            | 869                       |

Simplified mass balance assuming constant outflow at the limiting rate; network simulation using the flow control head-discharge curve will refine the volume at the next stage. Critical duration 1440 min.

| Attenuation summary                     |                                                                                                                                                     |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Required storage (1 in 100 yr + 40% CC) | <b>1096 m<sup>3</sup></b> at critical duration 1440 min                                                                                             |
| Storage provided                        | Basin B1: base 18 m × 59 m, side slopes 1:4, max. water depth 0.9 m + 0.3 m freeboard; 1221 m <sup>3</sup> below top water level (111% of required) |
| Flow control                            | Vortex flow control, design head 0.9 m, Q = 5.0 l/s; orifice not less than 75 mm equivalent to limit blockage risk                                  |
| Exceedance                              | Overland flow route along northern verge to basin; no property flooding                                                                             |

## 7. SuDS and water quality (CD 532, LA 113)

- Treatment train: gully pots (sediment), attenuation basin with permanent micro-pool, then a 120 m vegetated swale (CD 532) before outfall. Swale base 1.0 m, side slopes 1:4, longitudinal gradient 0.8%, check dams at 30 m centres.
- Swale velocity under the 1 in 1 year flow is below 0.3 m/s and residence time exceeds 9 minutes, supporting filtration and settlement of suspended solids.
- HEWRAT (LA 113) step 1 and 2 assessment for routine runoff (AADT 13,600) shows pass for soluble pollutants and sediment with the vegetated treatment in place (illustrative result). A spillage risk assessment gives an annual probability of a serious pollution incident well below the 1% threshold.
- Outfall headwall with flap valve to Fictional Brook; consent for works to an ordinary watercourse required from the LLFA.

## 8. Assumptions and limitations

- Rainfall, soil and growth-factor data are illustrative; on a live scheme FEH22 point data and the latest climate change allowances for the relevant management catchment would be used.
- Infiltration not relied upon (assumed clay, soil type 4); to be confirmed by BRE 365-type testing.
- Hand calculations to be verified by network simulation (1, 5, 30 and 100 + CC year storms) at the next design stage.
- Existing drainage at the eastern tie-in is assumed to have adequate capacity (survey to confirm).