

**REPUBLIC OF GHANA**



**MINISTRY OF ROADS AND HIGHWAYS**

**MANUAL FOR LOW VOLUME ROADS**

**PART A - POLICY, GEOMETRIC DESIGN  
AND ROAD SAFETY**

**2019**



## MESSAGE FROM THE MINISTER

**T**he mandate of the Ministry of Roads and Highways (MRH) is to provide a reliable and affordable road transport system that facilitates the socioeconomic development of Ghana. Effective and efficient road design, construction and maintenance is a *sine qua non* for achieving this. If high volume roads are the arteries and veins of the country, facilitating the free flow of the nation's socio-economic lifeblood, then low volume roads are the capillaries, extending that flow to the village level. Low volume roads facilitate travel that directly impacts public access to health, education and other essential services in rural areas, as well as the transport of goods that stimulates economic development at both the local and the national level.

MRH recognises the need for the practical application of sound research to its operations. For this reason, in 2014 it joined the African Community Access Partnership (AfCAP) under the Research for Community Access Partnership (ReCAP) funded by UK Aid through the Department for International Development (DFID). The Ministry has since then benefited immensely from global research on rural transport access and mobility. This design Manual is one result of, and a testament to, the Ministry's collaboration with AfCAP.

The Manual provides a basis for constructing, rehabilitating, or upgrading low volume roads in a manner that draws on international good practice, yet is relevant to the Ghanaian context. As such it constitutes an essential point of reference for students, or experienced practitioners with a professional interest in achieving value for money in the provision of such roads in Ghana. The Ministry will continue in such pursuits, in ensuring that the future of rural transport infrastructure remains sound through proper designs, construction and maintenance.

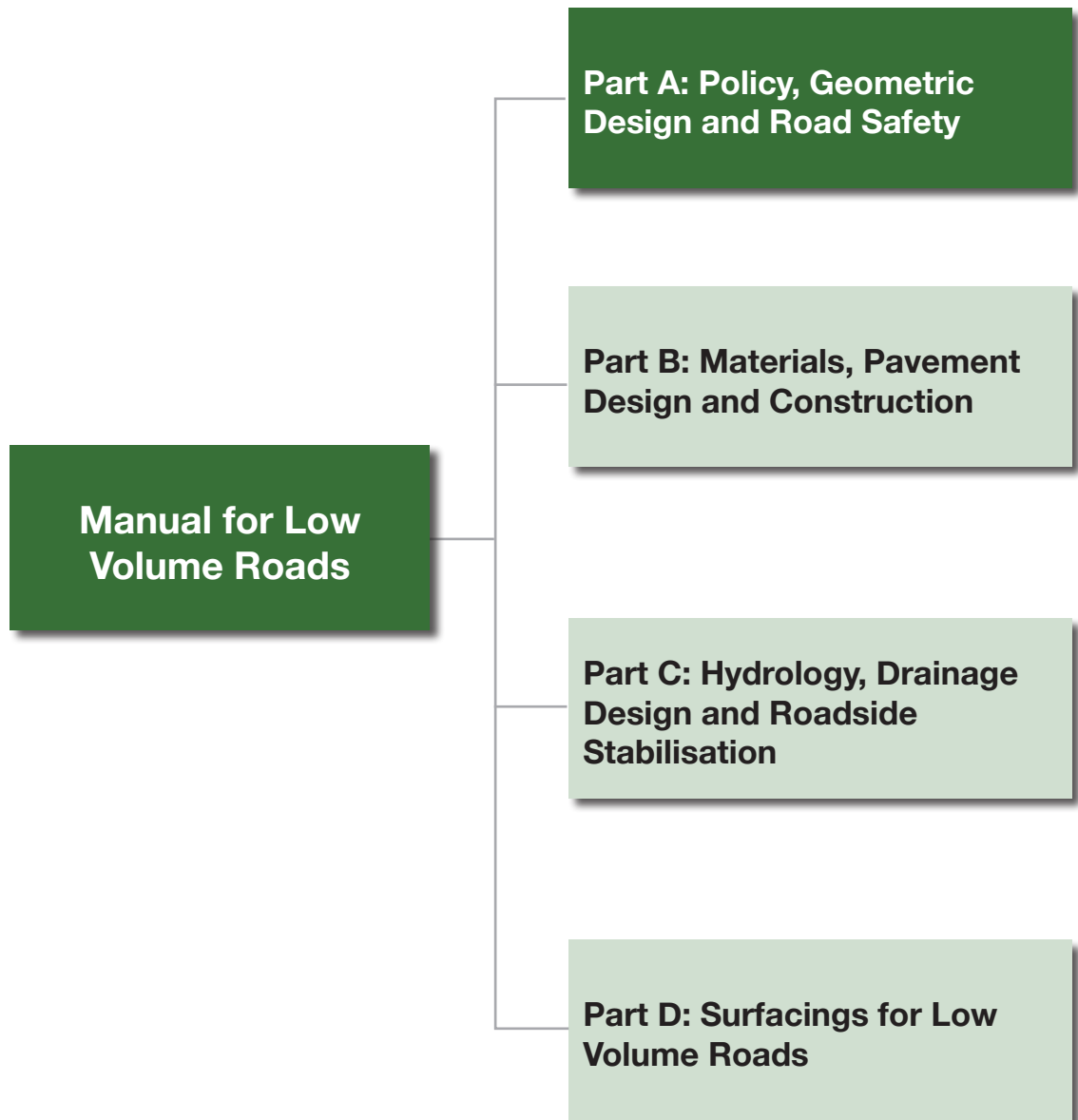
On behalf of the Government of Ghana I would like to thank UK Aid through DFID for its support to the Manual's preparation process. I would also like to thank the Project Management Unit of ReCAP and Civil Design Solutions for their role in managing the project.

I recommend this Manual, and am confident that it will provide the essential information and guidance needed for the sustainable provision of appropriate low volume roads that will meet Ghana's growing need for rural travel and transport.



**Hon. Kwasi Amoako-Atta,**  
Minister of Roads and Highways

**PART A**



## FOREWORD

The length of low volume roads in Ghana has since the year 2000 been increasing steadily, mainly as a result of changes in settlement patterns, increased agricultural activities and urban sprawl. This calls for a change in the approach to managing the network, with a focus on sustainability in line with the UN Sustainable Development Goals (SDGs).

A sizable proportion of all low volume roads in Ghana are managed by the Department of Feeder Roads (DFR), which accordingly has led the way in formulating standards, manuals and procedures for the design and construction of such roads. There was however no single consolidated design manual for low volume roads as DFR had in some cases relied on Ghana Highway Authority (GHA) standards, which are generally more appropriate for High Volume Roads. The Ministry recognises that the design of low volume roads requires unique attention, hence its support for the proposal by DFR to the Project Management Unit of the Research and Community Access Partnership (ReCAP) for the development of a design manual specifically for low volume roads.

This Manual has been through a robust process to ensure that it is fit for purpose. It draws on the expertise of both international and national specialists, and takes account of the latest relevant research findings, making every effort to ensure its relevance to the needs of our practitioners. A series of stakeholder workshops resulted in a range of perspectives being taken into account, from both the public and the private sector, and the initial complete draft has been subjected to a peer review. Nevertheless, it is recognised that there is no such thing as “perfect” guidance, so associated mechanisms are in place to ensure that sector performance continues to be monitored, and that further updates and improvements to the Manual can be made where necessary.

### Manual Updates

Significant changes to criteria, procedures or any other relevant issues related to new policies or revised laws of the land or those that are mandated by the Government of Ghana, GHA, DFR or EPA will be incorporated into the Manual from their date of effectiveness. Other minor changes that do not significantly affect the whole nature of the Manual will be accumulated and made periodically. When changes are made and approved, new versions incorporating the revision will be issued.

All suggestions to improve the Manual should be made in writing to the Director of the Department of Feeder Roads.

It is my fervent hope that you find this Manual useful and make every effort to make use of it.



**Ing. Edmund Offei-Annor,**  
Chief Director of Ministry of Roads and Highways

## PREFACE

**D**FR has over the past decades led in managing a significant proportion of low volume roads in Ghana. These roads are used by different types of vehicles and non-motorised transport for providing various services ranging from the provision of basic access to transporting agricultural produce. They generally carry fewer than 300 vehicles per day or one million equivalent standard axles over their design life.

DFR has used various standards and codes for the design of the different classes of roads under its jurisdiction. These include the American Association of State Highways and Transportation Officials (AASHTO) design manuals, Transport Research Laboratory (TRL) Overseas Road Notes, and Ghana Highway Authority (GHA) Design Manuals, among others.

The development of the aforementioned manuals drew on technologies and practices emanating from Europe and the USA some 50 years ago. While these “standard” approaches may still be appropriate for much of the main trunk and regional road network, they remain overly conservative, and hence unnecessarily expensive, for application on much of the country’s low volume roads.

The first significant attempt to provide an alternative to the use of the aforementioned standards and manuals was undertaken with the support of DFID around the millennium. This saw the production of design manuals, construction pocket hand books and other useful design tools tailored for low volume roads.

The commencement of African Community Access Partnership (AfCAP) project in Ghana in 2014 led DFR to prioritise the development of a design manual for low volume roads that will consolidate the different existing manuals, while drawing more fully on experience gained.

This Manual will assist in developing optimal designs that use locally occurring natural resources, encourage the use of labour-based construction methods where appropriate and ensure value for money. It is for use as a point of reference for engineering and allied practitioners alike and serves as an excellent guide for the design of low volume roads.

I am grateful to UK Aid working through DFID, to the Project Management Unit of ReCAP, to the consultants from Civil Design Solutions, and to the technical staff of DFR and MRH for the immense support they have provided in ensuring the coming into fruition of this Manual. It is my fervent hope that it will change the face of low volume road design in Ghana.



**Ing. Bernard Badu**

Director of the Department of Feeder Roads

## ABBREVIATIONS, ACRONYMS AND INITIALISMS

>	:	Greater than
<	:	Less than
%	:	Percentage
AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AfCAP	:	Africa Community Access Partnership
AI	:	Accessibility Indicator
AIDS	:	Acquired Immune Deficiency Syndrome or Acquired Immunodeficiency Syndrome
ARV	:	Antiretroviral
BDS	:	Bid Data Sheet
CBO	:	Community Based Organisation
CERSGIS	:	Centre for Remote Sensing & Geographic Information Services
CI	:	Complementary Intervention
CoST	:	An international Infrastructure Transparency Initiative
DEM	:	Digital Elevation Model
DFR	:	Department of Feeder Roads
DFID	:	UK Government' Department for International Development
DV	:	Design Vehicle
e.g.	:	For example (abbreviation for the Latin phrase <i>exempli gratia</i> )
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EMP	:	Environmental Management Plan
EOD	:	Environmentally Optimised Design
EPA	:	Environmental Protection Agency
esa	:	Equivalent Standard Axles
ESIA	:	Environmental and Social Impact Assessment
GEM	:	Growth through Effective road asset Management
GHA	:	Ghana Highway Authority
GIS	:	Geographic Information System
HDM 4	:	Highway Development and Management Model Version 4
HIV	:	Human Immunodeficiency Virus
HVR	:	High Volume Road
ICT	:	Information and Communication Technologies
IDS	:	Infrastructure Data Standard
i.e.	:	That is (abbreviation for the Latin phrase <i>id est</i> )
ILO	:	International Labour Organisation
IMT	:	Intermediate Means of Transport
IRAP	:	Integrated Rural Accessibility Planning
ITB	:	Instructions to Bidders

km	:	Kilometre
km <sup>2</sup>	:	Square kilometres
km/h	:	Kilometres per hour
KNUST	:	Kwame Nkrumah University of Science and Technology
LBC	:	Labour Based Construction
LIC	:	Labour Intensive Construction
LiDAR	:	Light Detection and Ranging method of 3D laser scanning
LOS	:	Level Of Service
LVR	:	Low Volume Road
m	:	metre
M	:	Million
M&E	:	Monitoring and Evaluation
MCA	:	Multi-Criteria Analysis
MC	:	Medium Curing
mm	:	millimetre
m/s	:	Metres per Second
MPBS	:	Maintenance Performance Budgeting System
MRH	:	Ministry of Roads and Highways
NGO	:	Non-Government Organisation
NMT	:	Non-Motorised Transport
NPV	:	Net Present Value
OC4IDS	:	Open Contracting for Infrastructure Data Standard
OCP	:	Open Contracting Partnership
PCU	:	Passenger Car Unit
Ref	:	Reference
RED	:	Roads Economic Decision Model
RFP	:	Request for Proposals
RRA	:	Rapid Rural Appraisal
RPM	:	Road Prioritisation Methodology
RTS	:	Road Transport Service
RSSI	:	Road Sector Sustainability Index
SMEs	:	Small and Medium Enterprises
ToR	:	Terms of Reference
UK	:	United Kingdom
USA	:	United States of America
vpd	:	Vehicles per day

## GLOSSARY OF TECHNICAL TERMS

### **Annual Average Daily Traffic**

The total volume of vehicle traffic on the road (in both directions) in one year divided by 365.

### **Base course**

The upper layer of the road pavement, located between the sub-base and the surfacing.

### **Camber**

The lateral slope of the cross-section of the carriageway and shoulder, constructed to drain surface water from the carriageway.

### **Carriageway**

The paved or unpaved surface of the road, excluding the shoulders, normally used by traffic

### **Complementary Interventions**

Actions that are implemented through a roads project which are targeted toward the communities that lie within the influence corridor of the road and are intended to optimise the benefits brought by the road and to extend the positive, and mitigate the negative, impacts of the project.

### **Crossfall**

The transverse gradient across the carriageway, normally expressed as a percentage.

### **Crown**

The highest point of the cross-section of a cambered carriageway, normally on the centre-line.

### **Cut**

Excavation in the natural ground with graded slope to accommodate the road

### **Cut slope**

The constructed inclined soil surface in a cut

### **Design speed**

The maximum safe speed that can be maintained over a specified section of road when conditions are so favourable that the design features of the road govern the speed.

### **Drain invert**

The lowest surface of the internal cross-section of a drain.

### **Drain inside slope**

The slope from the shoulder break point to the inside edge of the side drain invert.

### **Drain back slope (drain outside slope)**

The outer slope of the side drain with an appropriate angle to prevent soil from sliding into the ditch.

### **Earth road**

A road formed from the in situ soil material.

### **Embankment**

Constructed fill material below the pavement or gravel surface raising the road above the surrounding natural ground level.

### **Embankment slope**

The constructed, inclined surface on the side of the embankment.

### **Feeder Road**

Lowest level of road in the classified road network hierarchy with the function of linking traffic to and from rural areas, either directly to adjacent urban centres, or to the collector road network.

### **Formation width**

Full width of the road, including side drains, side cuts and embankments.

### **Gravel**

A naturally-occurring, weathered rock within a specific particle size range. In geology, gravel is any loose rock that is larger than 2 mm in its largest dimension and not more than 63 mm.



**Gravel road**

Road with a gravel layer as a surfacing material.

**Horizontal alignment**

Arrangement of a road in plan view showing a series of straight lines connected by curves.

**Kerb**

A raised border of stone, concrete or other rigid material formed at the edge of the roadway

**Labour-based construction**

Substitution of equipment with well-managed labour as the principal means of production where technically and economically feasible to produce the standard of construction as demanded by the specification and allowed by the available funding.

**Low Volume Road**

Road carrying up to about 300 vehicles (with 4 wheels or more) per day in the base year and less than about 1 million equivalent standard axles over its design life.

**Passability**

Typically assessed in terms of the number of months a road is deemed to be impassable, this relates to the ability of vehicles to travel along the road in light of its condition and the status of submersible cross-drainage structures.

**Pavement**

The part of a road designed to carry the weight of the traffic.

**Paved road**

A road that has a bitumen seal or a concrete riding surface

**Roadway**

Full width of the road, including shoulders and carriageway for use by traffic.

**Road centreline**

The longitudinal axis along the centre of the road.

**Road reserve (right-of-way)**

Strip of land legally awarded to the Road Authority in which the road is or will be situated and where no other work or construction may take place without permission from the Road Authority.

**Seal**

A term frequently used instead of “reseal” or “surface treatment”. Also used in the context of “double seal” and “sand seal” where sand is used instead of stone.

**Selected layer**

Pavement layer of selected gravel materials used to bring the subgrade support up to the required structural standard for placing the sub-base or base course.

**Shoulder**

Paved or unpaved width of the road between the edge of the carriageway and the shoulder breakpoint which provides side support for the pavement and space for vehicles to stop off the road or pass in an emergency.

**Shoulder breakpoint**

The outside edge of the road shoulder where the side slope of the drain starts.

**Site Investigation**

Collection of essential information on the soil and rock characteristics, topography, land use, natural environment, and socio-political environment necessary for the location, design and construction of a road.

**Sub-base**

The layer in the road pavement below the base course.

**Subgrade**

The native material underneath a constructed road pavement.

**Surface treatment**

A general term incorporating chip seals, micro surfacing, fog sprays or tack coats.

**Superelevation**

Inward tilt or transverse inclination given to the cross-section of a carriageway throughout the length of a horizontal curve to reduce the effects of centrifugal forces on a moving vehicle.

**Surfacing**

The top layer of the road with which traffic makes direct contact.

**Trafficability**

This relates to the ease with which a vehicle is able to travel along a road that presents challenges on account of its condition, but nevertheless remains passable. This may be assessed in terms of the proportion of the road length on which the carriageway is assessed as being in poor condition.

**Ultra-thin Reinforced Concrete Pavement (UTRCP)**

A layer of concrete, 50 mm thick, continuously reinforced with welded wire mesh.

**Unpaved road**

Earth or gravel road.

**Vertical alignment**

Longitudinal section of a road indicating the surface levels of the completed road along the carriageway centreline.

**Wearing course**

The upper layer of a road pavement on which the traffic runs and is expected to wear under the action of traffic.

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# 1. INTRODUCTION

## 1.1 Context and scope of the Manual

### 1.1.1 Purpose of the Manual

This Manual for Low Volume Roads (LVRs) promotes the rational, appropriate and affordable provision of LVRs in Ghana. In doing so it aims to make cost effective and sustainable use of local resources, reflecting local experience and advances in LVR technology gained in Ghana and elsewhere.

The Manual is fully adaptable for different clients and users. It has application for roads at both a national and a district level, administered respectively by the Ghana Highways Authority (GHA) and the Department of Feeder Roads (DFR), as well as by decentralised authorities. It caters for the full spectrum of interventions, from spot improvements to providing total rural road link designs. In the latter case, this could comprise different design options along the total road length.

The Manual is intended for use by roads practitioners responsible for the design and construction of low traffic earth, gravel or paved roads. It is appropriate for roads required to carry an average of up to about 300 vehicles per day in the base year, and less than about 1.0 million equivalent standard axles (Mesa) per traffic lane over their design life. The Manual complements the GHA design manuals for higher traffic roads and the Standard Specification for Road and Bridge Works (2007).

### 1.1.2 Contents of the Manual

The Manual is divided into four parts:

- Part A: Policy, Geometric Design and Road Safety
- Part B: Materials, Pavement Design and Construction
- Part C: Hydrology, Drainage and Roadside Stabilisation
- Part D: Surfacing for Low Volume Roads

Part A provides guidance for DFR and GHA staff, local authorities, Non-Governmental Organisations (NGOs) and local communities on how to:

- plan and prioritise road investments;
- determine appropriate geometric design standards in accordance with traffic using the road;
- identify and implement Complementary Interventions within road works contracts;
- select the optimal route for a road; and
- provide for the safety of road users.

### 1.1.3 Application of appropriate standards

In keeping with Ghana's policy environment, the application of appropriate design standards for LVRs aims to optimise construction and maintenance costs and meet the requirement to:

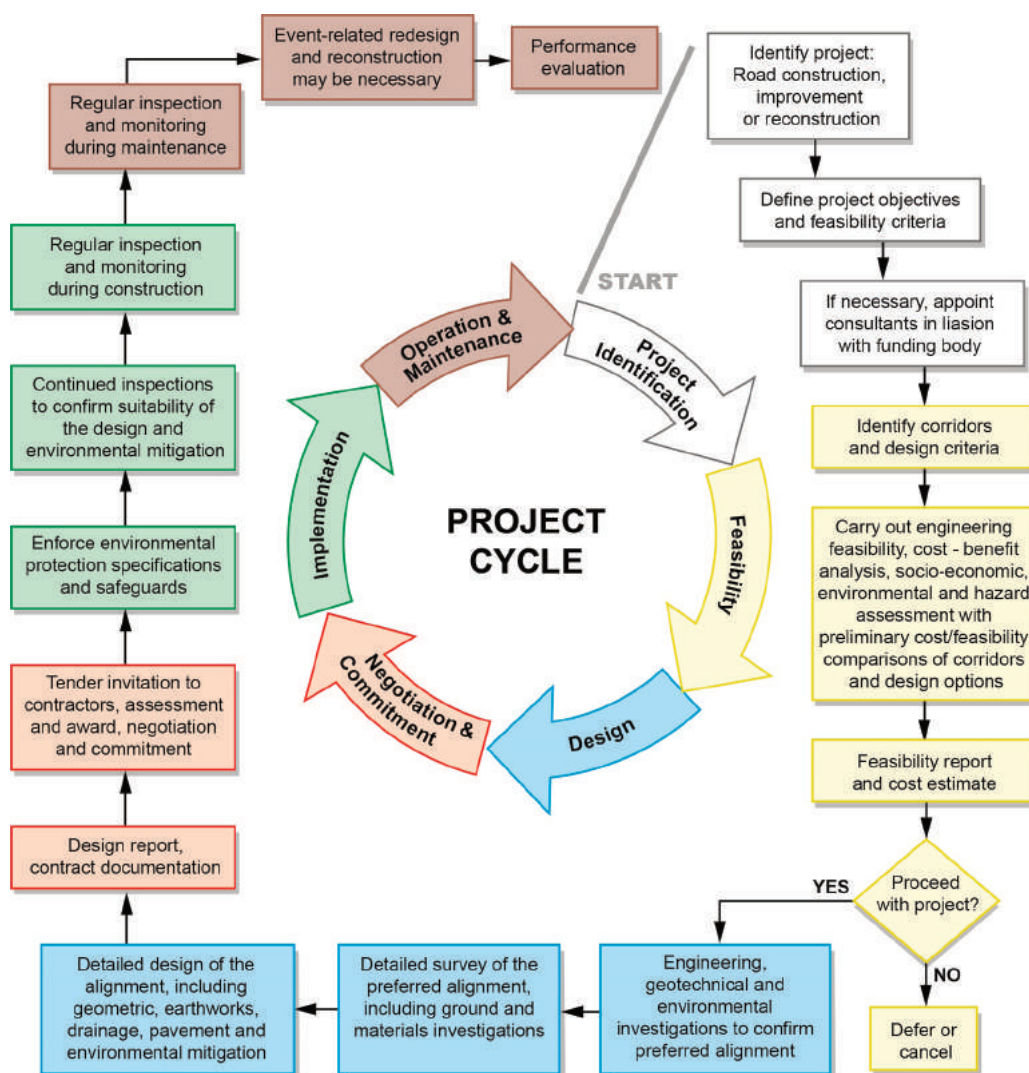
- improve the economic and social well-being of rural communities and their access to social and other services;
- lower road user costs and promote socio-economic development, poverty reduction, trade growth and wealth creation in rural areas;
- facilitate rural access in a manner that is available and relevant to the needs of disadvantaged and different ethnic groups in society; while
- protecting and managing non-renewable natural resources and reducing import dependency.

### 1.1.4 Clients for Low Volume Roads

The Client for the LVR works could be GHA, DFR, a local authority, an NGO, a community organisation, or a private company. Road works require a design, whether they are to be undertaken by a contractor, through an in-house capability or through a community contract. This design should meet national standards set for a particular type of road. The degree of sophistication of the design generally increases as the standard of the road increases. However, this does not mean that earth or gravel roads are any easier to design than a low volume paved road. The opposite may well be the case.

### 1.1.5 The procurement process and Project Cycle

Unless carried out in-house, the provision and maintenance of LVRs entails various instances of procurement, the process of creating and fulfilling contracts. Such contracts relate to the provision of the different services and goods needed to plan, appraise, design, supervise and execute the works while ensuring that related environmental and other safeguards are adhered to.



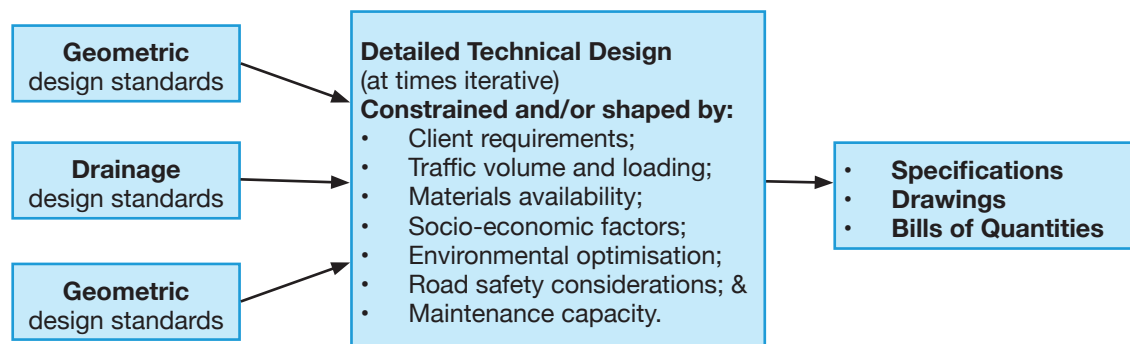
**Figure A.1.1 Step-by-step breakdown of stages of the Project Cycle**

In the case of a specific project, these functions are broken down into step-by-step procedures that contribute to the broader process of ensuring that established good practice is followed at all stages of the Project Cycle. Figure A.1.1 illustrates how each of these procedures, to which reference is made in this Manual, relate to each other and to that Project Cycle

Though not explicitly shown, there is implied associated lesson-learning at every stage, as Monitoring and Evaluation (M&E) functions identify scope for improvement.

### 1.1.6 The design process

The Road Design Engineer is normally supported by a team of individuals, with varying specialties, and equipped to deal with all aspects of the road design. The job of the design team is to provide a robust technical design (geometric, drainage and pavement), and to reflect this design in the Specifications, Drawings and the Bills of Quantities. The design team should include knowledge of the environmental and social development impacts of rural roads. The design process is illustrated in Figure A.1.2



**Figure A.1.2 Overview of the detailed design process**

The general approach to the design is guided by the Client and builds on information and data collected during the project pre-feasibility and feasibility stages. The Client normally has a budget allocated for the works. The general location of the route is known, as well as the preferred approach to the works, for example labour-based or equipment-based. The Client may have requirements on apportioning works and contract size, technical issues, social, environmental requirements and time constraints. The job of the road Design Engineer is to develop the project within and around these boundaries and limitations, whilst at the same time alerting the Client to issues and problems that may limit or require adjustment of expectations.

The approach to the design of LVRs follows the general principles of any good road design practice. There are, however, subtle but important differences from the traditional road design practice. This Manual provides the Design Engineer with the requisite tools to achieve an optimized design based on the financial, technical and other constraints that define the project.

Optimizing a road design requires a multi-dimensional understanding of all of the project elements. In this respect, the design elements become context specific. The design team may need to work outside their normal areas of expertise in order to understand implications of their recommendations or decisions on all other elements of the design.

The successful design of LVRs relies on:

- a Client who is open and responsive to innovation;
- a full understanding by the Design Engineer of the road environment;
- an ability to work within the demands of the road environment and to turn these to a design advantage;
- innovative and flexible thinking through the application of appropriate engineering solutions rather than following traditional thinking related to road design;
- recognition and management of risk; and
- prior certainty that the both the institutional and financial capacity are assured so that effective and sustainable routine and periodic maintenance is carried out following construction.

The Design Engineer is required to provide a road that meets the level of service expected by road users and local communities. Design engineers are traditionally conservative and build in factors of safety that cater for their perceptions of risk. This approach does not necessarily encourage innovation, uses scarce or inappropriate resources, and may result in high financial costs for the Client and the country. There is often a temptation to upgrade roads to a level of service not justified by economics or by road user requirements. Such an approach absorbs available resources and prevents extension of access. It is the role of the Design Engineer to represent the Client's and country's interests in a considered and professional manner.

The level of attention and engineering judgement required for optimal provision of LVRs is no different than that required for the provision of other roads. In many cases the required level of judgement is higher. The Design Engineer needs to draw on all of their engineering skills, judgement and local experience to develop appropriate designs without incurring unacceptable levels of risk.

## 1.2 Road network classification

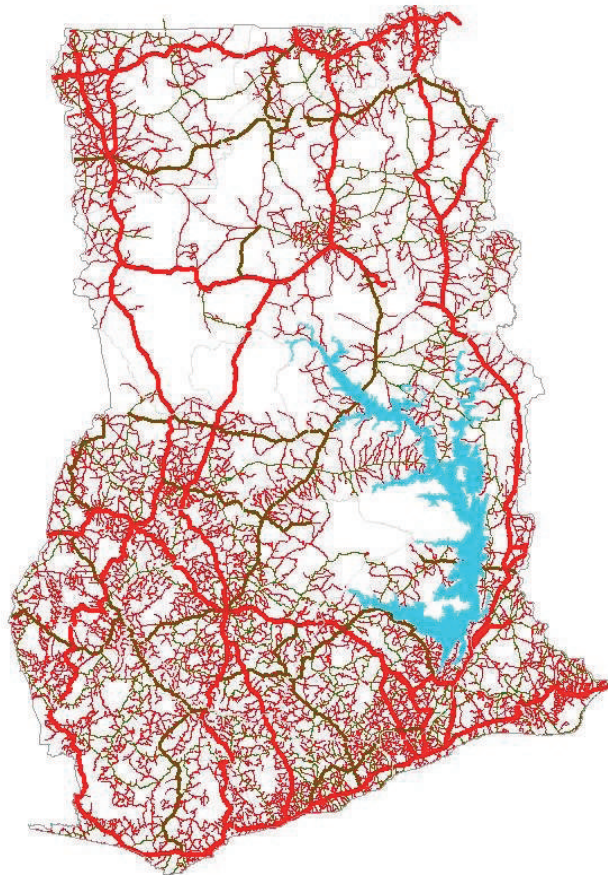
The total current road network in Ghana comprises approximately 71 000 km of road of which LVRs make up approximately 42 000 km. Figure A.1.3 presents a road map extract from the GIS database maintained by DFR, which includes all classified non-urban roads.

This map illustrates that LVRs are an essential component of the road system and are not limited to the Feeder Road category. Lower order roads such as informal tracks and agricultural access roads and some higher order roads including municipal, regional and national roads may also be LVRs. Their importance

and reach extend to all aspects of the economic and social development of rural communities and the country at large.

In 1999, the Ministry of Roads and Highways (MRH) introduced a new functional roads classification system that conforms to international norms. Under this system, and as defined in the Ghana Highway Authority (GHA) Road Maintenance Operation Manual (2003), each classified road is assigned to one of five classes:

- **National roads:** Roads linking the national capital to regional capitals. These are roads of strategic importance such as main arterial roads to neighbouring countries. They have the prefix 'N' followed by up to two digits e.g. N1, N11. These roads are the responsibility of the GHA.
- **Inter-Regional roads:** Roads providing inter-regional coherence. The proposed numbering system is the prefix 'IR' followed by up to two digits e.g. IR8, IR11. These roads are also the responsibility of the GHA.
- **Regional roads:** Roads linking district capitals to their respective Regional capitals, in addition to other nearest district capital, and major industrial, trade or tourist centres. The proposed numbering system is the prefix 'R' followed by up to three digits e.g. R124. These are also the responsibility of the GHA.
- **Metropolitan / Municipal roads:** Roads connecting local centres of importance to each other or connecting important centres to higher class roads. These are the responsibility of the Department of Urban Roads (DUR).
- **Feeder roads:** Roads connecting minor centres such as towns, villages, rural settlements and markets to other parts of the network. These are the responsibility of DFR.



**Figure A.1.3 Road map of Ghana**

Feeder roads generally carry relatively low volumes of traffic and make up a sizeable proportion of the road network in Ghana. They are further divided into three sub-categories:

- **Inter-District Feeder roads:** Connect two or more districts
- **Connector Feeder roads:** Connect to the road network at both ends, providing access to rural communities along the road itself
- **Access / Spur Feeder roads:** Connect to the road network at one end and terminate at a village or rural settlement at the other. These are generally short roads of limited economic importance.

LVRs are divided into four categories, Type 1 to Type 4. The hierarchy is based on traffic volume. Informal tracks are considered to be LVRs, but they are generally existing and do not necessarily conform to any

engineering standards. This Manual should be consulted when there is a need to upgrade a track to provide more reliable access by incorporating basic engineering standards.

Table A.1.1 shows the relationship between the functional classification of roads in Ghana, the road categories, the desirable level of service and the Average Annual Daily Traffic (AADT) volumes they generally carry. LVRs in Ghana are generally of Type 4 or below and meeting the criteria for the desirable levels of service C or D.

**Table A.1.1 Road classes in Ghana**

Road Functional Classification					Road Category	Desirable Level of Service	AADT (vpd)
				NATIONAL	Refer to GHA	A	>10,000
			INTER-REGIONAL		Refer to GHA		3,001 - 10,000
		REGIONAL		NATIONAL	Refer to GHA	B	1,001 - 3,000
					INTER-REGIONAL		Refer to GHA
FEEDER	METROPOLITAN MUNICIPAL			LOW VOLUME	Type 4	C	151 – 300
					Type 3		76 –150
			Type 2		≤75		
			Type 1/Track		D		≤15

The desirable LOS for roads is related to the road classification and is defined as follows:

**Level of Service A:** This is the highest level of service. Traffic is free flowing, with the volumes and types of traffic readily accommodated. Safety is a high priority. Design speed is very important and takes precedence over topographic constraints.

**Level of Service B:** Traffic may not flow smoothly in all situations. Safety is a high priority, but some safety controls may need to be enforced. Design speed is important, but topography may dictate some design changes and controls.

**Level of Service C:** The efficiency of traffic movement and flow is not a limiting factor. Traffic will be accommodated, but some design controls may need to be applied, such as for speed, sight distance, access control and road carriageway configuration. Safety provisions are adapted to lower and variable speed scenarios. The topography will dictate the alignment and the design speed.

**Level of Service D:** This level is geared to provision of basic access rather than efficiency. Design standards for water crossings may allow temporary service interruption and some entire roads may even be closed at times (such as during and immediately following heavy rain) to protect these assets. Other design standards for geometrics, surfacing and safety will reflect lower speed environments and basic access requirements.

For high volume roads it is seldom possible to achieve the desirable levels of service due to the high cost of construction. The highway designer is required to select an appropriate level of service based on acceptable levels of congestion and the available budget. Guidance is provided in the GHA design manuals.

For LVRs the LOS is not generally linked to congestion because traffic volumes are low. The appropriate LOS is linked to the average speed of travel that the road users expect to achieve on the road. In some cases, a high functional classification and high level of service might be given to a road despite carrying a low volume of traffic. This might be for strategic reasons, for example a road providing access to an international border post, or an inter-regional route where a high average speed of travel is desirable. In these cases, the geometric standards applying to a higher volume road may be adopted. However, in most cases the appropriate standards and LOS for a road are determined by the traffic volume, with a lower LOS expected on very low traffic roads.

### 1.3 Road reserve

The road reserve is provided to accommodate the roadway width as well as drainage and utility requirements. It serves to enhance safety, to improve the appearance of the road, to provide space for non-road travellers and to make provision for likely future upgrading and widening. Road reserves are managed using the Road Reservation Management Manual for Coordination. Though most commonly applied in the context of trunk and urban roads, this Manual also applies in the rural context. It provides information relating to road reserve width and must be referred to in relation to any activities undertaken within that road reserve.

Road reserve widths are measured equally either side of the road centre line. For example, a required road reserve width of 30 m will be measured 15 m either side of the road centre line. Road reserve widths applicable for the various types of LVRs are shown in Table A.1.2. In mountainous terrain where large cuts and fills are required, the total width can exceed the road reserve width.

**Table A.1.2 Road reserve widths for Low Volume Roads**

Geometric Standard	Total Width (m)
Type 4	60
Type 3	60
Type 2	30
Type 1/Track	15

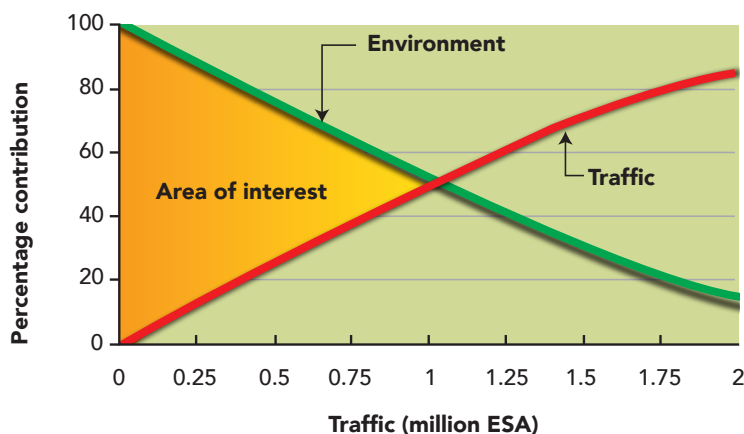
SOURCE: Road Reservation Management Manual for Coordination (1st Edition)

NOTE: subsequent to the development of the above Manual, the required road reserve width for Regional (Type 3) and Inter-Regional (Type 4) roads was amended from 55 m to 60 m

### 1.4 Definition of a Low Volume Road

For the purposes of this Manual a road is classified as “low volume” if:

- the average daily traffic in the base year is fewer than 300 motorised vehicles with four or more wheels; and
- the cumulative number of equivalent standard axles is less than 1.0 million per traffic lane over the design life.



**Figure A.1.4 The relative impact of Environment and Traffic on road performance**

The most important aspect of such roads is that their performance is more dependent on environmental influences than on traffic, as indicated in Figure A.1.4. This has important implications for many aspects of their design.

## 1.5 Sustainable road asset management

### 1.5.1 The road preservation pyramid

The design approach for LVRs is an integral part of the overall management of rural road assets by the responsible road agency. In addition to ensuring that the design developed is technically appropriate and affordable, the Design Engineer needs to bear in mind other factors affecting the sustainable provision of roads. These factors are represented by the building blocks of the Road Preservation Pyramid illustrated in Figure A.1.5.

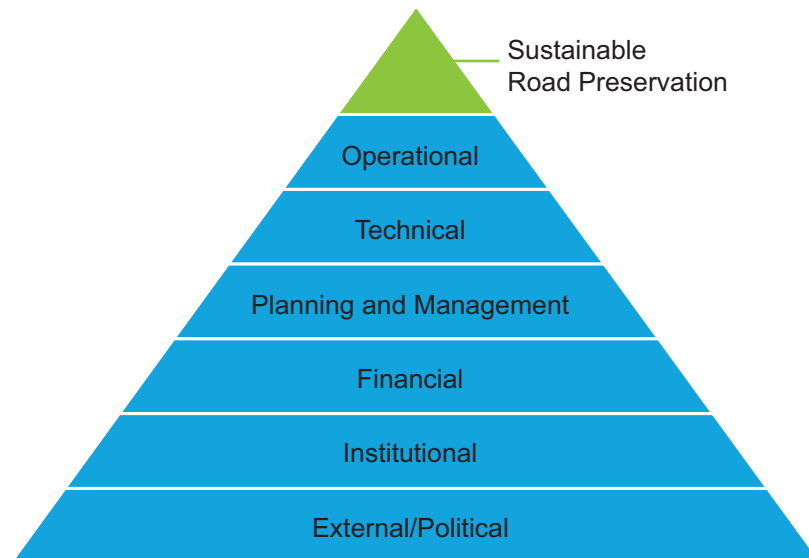


Figure A.1.5 The Road Preservation Pyramid

### 1.5.2 External factors

The “External” building block is the foundation of the Road Preservation Pyramid. It includes national policies for roads and stakeholder participation in road asset management. The demand for the sustainable provision of LVRs needs to be framed under a national policy driven by government and should be supported at the highest level. The cross-sectoral influence of LVRs and their role in underpinning other sectoral development strategies and poverty alleviation programs should be highlighted, quantified, and understood by policy makers. Road agencies should facilitate the process of identifying local requirements, alternatives and solutions to problems in order to ensure that the needs and expectations of road users and communities are understood and, where possible, met.

Opportunities should be provided for all stakeholders, including those representing private sector interests, professional bodies, academia and civil society organisations, to contribute to and potentially influence the evaluation and development of the agency’s procurement and asset management strategies. Accordingly, in keeping with applicable regulatory requirements and recognized good practice, data related to the road agency’s programs, targets, projects and contracts should routinely be made available to the public in a consistent, reliable and readily accessible format. Where there is demonstrable interest from all stakeholder groups, consideration may be given to the formation of an independent and professional Multi-Stakeholder Group that would facilitate the joint analysis of such data, with a view to identifying constructive measures that would help improve performance.

Government policies for the provision and maintenance of LVRs should complement national plans, policies and strategies and should be responsive to wider needs and demands, including:

- the social and economic goals of poverty alleviation and development;
- increasing rural accessibility; and
- protection of the environment.

Specific government policies for the rural road sector should support:

- sustainable funding for the maintenance of roads;
- commercial management practices in the road sector;
- the inclusion of design, construction and maintenance approaches for LVRs in tertiary civil engineering training curricula;



- targeted procurement practices that promote (where appropriate) the use of labour-based technology and the development of improved capacity within the domestic construction industry; and, ultimately
- demonstrable Value for Money in the procurement and maintenance of LVRs, achieved through improvements in economy, efficiency and effectiveness.

Roads agencies should maintain dialogue with political and public stakeholders in order to highlight the advantages of design approaches and alternative, often unfamiliar, solutions selected for LVR provision. The language used for advocacy should be carefully chosen to avoid negative terms such as “low standard”, “low cost” and “marginal”, because such terms may give the false impression that the proposed technical solution is not fit for purpose.

### 1.5.3 Policy

Government policy, national legislation and development planning considerations dictate the underlying principles of LVR design. In addition to those relating to purely technical issues they include environmental controls, road safety legislation, promotion where appropriate of the use of labour-based technologies to encourage local participation and skills development. Authorities may choose to place an emphasis on Complementary Interventions, as set out in Chapter A.3.

### 1.5.4 Legal framework

Some of the key documents that define the legal framework for the design of LVRs in Ghana are included in the list of references provided in Chapter A.8. They include the Environmental Impact Assessment Guidelines for the Transport Sector prepared in 2011 by the Environmental Protection Agency (EPA). This seeks to promote maintenance of the road corridor environment in at least the same condition as it was before the road construction project started. Engineering designs must make provision for protective and mitigation measures.

### 1.5.5 Institutional arrangements for roads

The institutional arrangements required for the sustainable management of roads include:

- the existence of appropriate asset management strategies supported by senior management of the road authority;
- an appropriate organisational structure with sufficient staff trained in the necessary core competencies for road management;
- ongoing training programs to address required asset management competencies
- performance indicators that can be used to measure the quality of the service provided.

### 1.5.6 Financial sustainability

The sustainable provision of low volume rural roads can be enhanced by ensuring that:

- roads are not upgraded to engineered standards unless both the funding and the institutional capacity are in place for routine and periodic maintenance requirements;
- designs are adopted that do not require excessive allocation of maintenance resources;
- annual valuation is carried out of road infrastructure assets;
- an effective costing framework is in place for determining unit costs of works;
- annual prioritised maintenance plans are prepared based on actual road condition data; and
- robust management systems are in place to account for the use of maintenance funds.

### 1.5.7 Technology choice

Good design of roads should be associated with good construction and maintenance. Sound workmanship and a culture of maintenance are important factors in achieving sustainable provision of LVRs. The technologies for the design, construction and maintenance of LVRs should:

- apply appropriate design standards and specifications that optimize the use of locally occurring materials and other resources;
- utilize equipment technology options that reduce undue reliance on heavy equipment imports;
- create genuine opportunities for employment, skills development and entrepreneurship;
- use types of contract that support the sustained development of viable domestic contractors and consultants; while
- ensuring the economic viability of rural road investments.

**Economic viability of LVRs**

LVRs have direct social benefits and their economic viability does not only depend on the volume of vehicle traffic using the road. Economic appraisal for LVRs should therefore:

- employ economic appraisal tools that can quantify social, economic and environmental costs and benefits; and
- ensure that investment decisions for LVRs are based on an assessment of whole life costs.

In the case of very LVRs where basic access is already provided, the next level of investment may only be justified by considering improved access as a public good, rather than on strict economic grounds. It thus becomes a matter of public policy whether the investment is made. Alternative investment options should be ranked using multi-criteria analysis, rather than in seeking to determine the economic viability of specific investments.

The design of LVRs should seek to minimise negative impacts on communities and the environment through:

- careful design of drainage systems to avoid channeling of water which might result in excessive erosion;
- rehabilitation of material borrow areas after construction;
- taking account of potential socio-cultural impacts on community cohesion; and
- optimizing resource management and promoting the recycling of non-renewable materials.

Road designs should be robust to the uncertainties and variability of climate and recognize the potential impacts of climate change.

**1.5.8 Management**

Road agencies need to develop an appropriate asset management system that contains:

- network definition (road and bridge inventory information);
- network condition (roads and bridges);
- network usage (traffic);
- financial/cost information on works activities; and
- storage, update, analysis and reporting of data collected.

For rural roads agencies this type of management system can be developed using simple spreadsheets. The system must allow for the preparation of prioritised annual maintenance and investment plans based on level of service standards agreed with sector stakeholders.

**1.5.9 Operations**

Sustainable road preservation relies on efficient operations including planning and scheduling of maintenance works, procurement of service providers and compliance with technical standards. The road agency should implement forms of contract that are appropriate to the type of works with a clearly presented scope of works and related specifications. Regular technical audits should be carried out on both road improvement and maintenance works. Strategic but non-core activities should be outsourced on a competitive basis to private companies.

**1.5.10 Road asset management performance assessment**

Road agencies should conduct regular assessments of their performance in road asset management. This can be done using the questionnaire developed under the ReCAP research project for “Economic Growth through Effective Road Asset Management” (GEM). The questionnaire assesses performance under each of the six building blocks of the Road Preservation Pyramid. Completion of the questionnaire results in the calculation of a single value that represents the performance of the road agency and its “maturity” in road asset management. This score is known as the Road Sector Sustainability Index (RSSI). The RSSI can be used to compare the performance of road agencies within the same country or internationally. The questionnaire also allows road agencies to identify weak areas in their road asset management which can be subsequently addressed to improve performance.

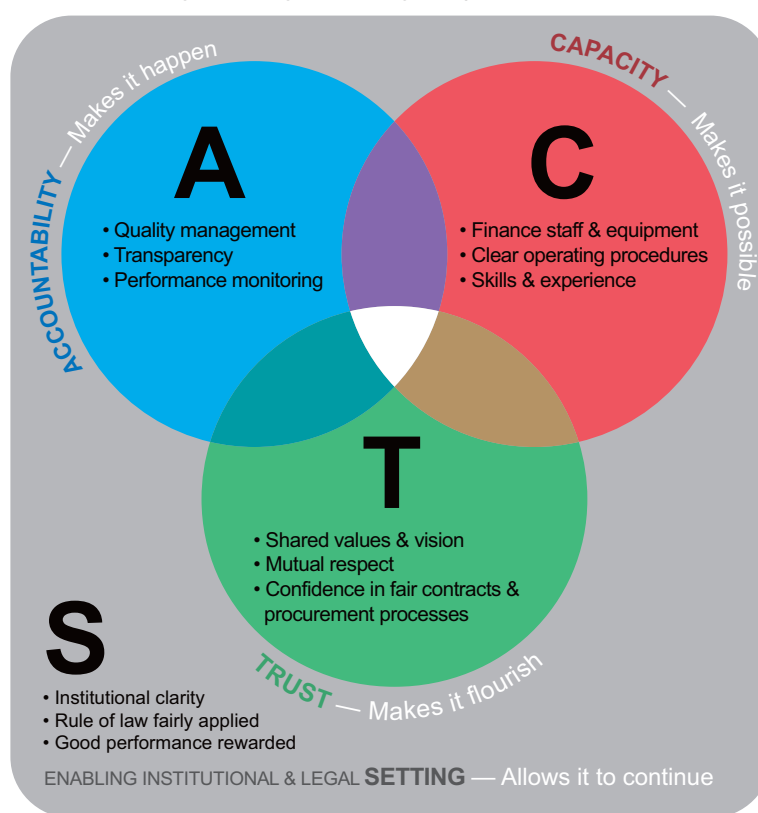
## 1.6 Good governance and transparency

The potential benefits of improved planning, design, construction and maintenance of LVRs resulting from use of this Manual will only be achieved if there is associated good governance and high professional standards in the sector. As in any county, the effectiveness of public infrastructure investment in Ghana is at times undermined through associated mismanagement giving rise to inefficiencies and associated corruption risks. LVRs are not immune from such risks and can at times be particularly prone to them on account in part of the high value but remote nature of the works. This can have a bearing both on the capacity of those responsible, and the ease with which they can be held to account.

### 1.6.1 Drivers of performance

From a strategic perspective, each aspect of performance in the provision of LVRs is, as illustrated in Figure A.1.6 dependent on:

- the requisite capacity to make it *possible*;
- associated accountability mechanisms to make it *happen*;
- trust in the fairness of the public procurement system to allow it to *flourish*; and
- an enabling institutional and legal setting to allow good performance to *continue* in the long term



**Figure A.1.6 Drivers of performance**

Each of these drivers can in turn be broken down further into its constituent elements. Where any one of those elements is absent or weak, that constitutes both:

- a management failing; and
- the introduction of a risk of corruption.

Looked at this way, Figure A.1.6 can serve to

- help map potential corruption risks;
- illustrate the need for a broad-based approach to improving sector performance;
- highlight the importance of trust, the absence of which results in time delays and increase costs; and
- identify constructive ways of bringing stakeholders together to work collaboratively in improving sector performance, rather than risk generating mutual distrust by simply adopting a narrow “anti-corruption” focus.

The white area in the middle of the Figure represents the “sweet spot”, a situation in which all the drivers of performance are in place. When this happens, it can result in a marked improvement in performance, whether at the level of a contract, a project, or a whole sector.

## 1.6.2

### Transparency

As illustrated above, transparency in public procurement can potentially lead to improved accountability, resulting in improved sector performance. To this end, some procuring entities choose to proactively disclose data about their projects. The Infrastructure Data Standard (IDS) for such proactive disclosure is summarised in Table A.1.3. Developed by the CoST Infrastructure Transparency Initiative to help promote transparency in public infrastructure procurement, the IDS is the infrastructure extension adopted by the Open Contracting Partnership (OCP).

**Table A.1.3 The CoST Infrastructure Data Standard for proactive disclosure**

Project phase	Project information	Contract phase	Contract information
Project Identification	Project reference number	Tender management	Procuring entity
	Project owner		Procuring entity contact details
	Sector, subsector		Procurement process
	Project name		Contract type
	Project Location		Contract status (current)
	Purpose		Number of firms tendering
	Project description		Cost estimate
Project Preparation	Project Scope (main output)		Contract administration entity
	Environmental impact		Contract title
	Land and settlement impact		Contract firm(s)
	Contact details		Contract price
	Funding sources		Contract scope of work
	Project Budget		Contract start date
	Project budget approval date		Contract duration
Project Completion	Project status (current)	Implementation	Variation to contract price
	Completion cost (projected)		Escalation of contract price
	Completion date (projected)		Variation to contract duration
	Scope at completion (projected)		Variation to contract scope
	Reasons for project changes		Reasons for price changes
	Reference to audit and evaluation reports		Reasons for scope and duration changes

SOURCE: CoST Infrastructure Data Standard, [www.infrastructuretransparency.org](http://www.infrastructuretransparency.org), 2017

The resulting combined standard that defines the format as well as the scope of such disclosure is known as the OC4IDS. This was launched in 2019 as a global standard.

## 2. PLANNING

### 2.1 General approach

The planning phase of a LVR project is the foundation on which the subsequent implementation phases are based. It is an activity that considers a wide range of options with the objective of providing an optimal, sustainable solution which satisfies the multiple needs of stakeholders at minimum life-cycle costs. The planning process should take full account of government policies and strategies in the road transport sub-sector.

In order to make the best possible use of scarce resources in the provision of new, or upgrading of existing LVRs, it is necessary to plan the road development activities in a comprehensive and coordinated manner. Such planning should be undertaken in a context-sensitive manner in which all dimensions of sustainability are addressed. This places more weight on multi-disciplinary planning in which teams of planners, engineers, environmentalists, and others work together with stakeholders to reach optimal solutions in the most cost-effective manner. Such an approach enhances the prospect of achieving the long-term sustainability of projects.

### 2.2 Activities in the planning process

The various activities typically undertaken in the planning process are outlined in Table A.2.1. The process comprises structured activities which start from the general and work towards the particular in relation to both data and project ideas.

**Table A.2.1 Activities in the planning process**

Project Stage	Activity	Typical Tools	Output
Identification	Selection	Policy resource analysis Master Plans Local/regional plans	Long list of projects
	Screening	Livelihoods analysis Integrated Rural Accessibility Planning	Shorter list of projects
Feasibility	Appraisal	Cost-benefit analysis <ul style="list-style-type: none"> <li>▪ consumer surplus approach (e.g. Roads Economic Decision model - RED)</li> <li>▪ producer surplus approach</li> <li>▪ compound ranking</li> <li>▪ Multi-Criteria Analysis (MCA)</li> </ul>	Short list of projects
	Prioritisation	Budget considerations, ranking by economic or socio-economic criteria.	Final list of projects

The main features of the planning and appraisal processes for new road projects are as follows:

**Selection:** This is a multi-sectoral and multi-disciplinary process which should generate a sufficient range of potential projects to ensure that no potentially worthwhile ones are excluded from consideration. Determined on the basis of an unconstrained resource analysis, the output is a longlist of projects that satisfy national road transport policy imperatives.

**Screening:** This defines the constraints within which specific planning solutions must be found. The output is a shorter list of projects that justify further, more detailed, analysis.

**Appraisal:** This evaluates the shorter list of projects in more detail by subjecting them to a detailed cost-benefit analysis for which various methods are available. The output is a final list of projects which satisfy a range of criteria - political, social, economic, environmental - at least cost.

**Prioritisation:** Ranks the “best” projects up to a cut-off point dictated by the available budget.

For existing roads which need to be rehabilitated or upgraded, it is not necessary to undertake the identification and feasibility phases. Rather, the focus is on the design, commitment and negotiation phases that lead to implementation.

## 2.3

## Planning for Low Volume Roads

The stages described in the planning and appraisal framework shown in Table A.2.1 are common to any type of road project. Some of the associated activities assume particular significance in the planning and appraisal of LVRs and call for more in-depth consideration of some issues than may arise from simply following conventional approaches. These are summarised in Table A.2.2.

**Table A.2.2 Project cycle and related planning activities**

Stage	Issues to be considered
<b>Project Identification</b> <ul style="list-style-type: none"> <li>▪ Project objectives</li> </ul>	<ul style="list-style-type: none"> <li>▪ Are the strategies being adopted supportive of government policy? (e.g. concerning skills development and appropriate choice of technology)</li> <li>▪ Are they relevant to the current and future needs of beneficiaries?</li> <li>▪ Do they take account of the multiple objectives and views of stakeholders?</li> <li>▪ Have effective communication channels with stakeholders been created?</li> <li>▪ Are they gender sensitive?</li> </ul>
<b>Feasibility</b> <ul style="list-style-type: none"> <li>▪ Design criteria</li> <li>▪ Cost-benefit analysis</li> <li>▪ Socio-economic assessment</li> <li>▪ Road safety assessment</li> <li>▪ Environmental assessment</li> <li>▪ Livelihoods</li> </ul>	<ul style="list-style-type: none"> <li>▪ Is there adequate participatory planning and consultation with public and private sector stakeholders?</li> <li>▪ Do the design criteria take full account of the specificities of LVRs, including non-motorised traffic?</li> <li>▪ Are appropriate evaluation tools being used?</li> <li>▪ Has a baseline environmental survey been undertaken?</li> <li>▪ Has a road safety audit been incorporated in the project?</li> </ul>
<b>Design</b> <ul style="list-style-type: none"> <li>▪ Design standards</li> <li>▪ Pavement/surfacing design</li> </ul>	<ul style="list-style-type: none"> <li>▪ Are the geometric, pavement design and surfacing standards technically appropriate?</li> <li>▪ Are they environmentally sound?</li> <li>▪ Are specifications and test methods appropriate to the use of local materials?</li> </ul>
<b>Negotiation &amp; commitment</b> <ul style="list-style-type: none"> <li>▪ Contract documentation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Do designs accommodate construction by labour-based methods where appropriate?</li> <li>▪ Do they include environmental protection measures?</li> <li>▪ Have tender documents been prepared and contract strategies adopted that facilitate the involvement of small contractors working in potentially remote locations?</li> </ul>
<b>Implementation</b> <ul style="list-style-type: none"> <li>▪ Construction</li> <li>▪ Inspection and monitoring</li> <li>▪ Environmental mitigation</li> <li>▪ Transparency and Accountability</li> </ul>	<ul style="list-style-type: none"> <li>▪ Have labour-based rather than equipment-based approaches to construction been adopted where feasible?</li> <li>▪ Are environmental mitigation measures contained in the contracts? Are they enforceable?</li> <li>▪ Have specific measures been included in the contract to cater for health and safety matters such as the risk of spreading HIV/AIDS?</li> <li>▪ Has the construction schedule considered the weather conditions with respect to the different activities, e.g. earthworks, unbound pavement materials, cement concrete and bituminous works with respect to dry and rainy seasons?</li> <li>▪ Is material information about project scope, costs and progress routinely disclosed by the Procuring Entity in order to facilitate improved accountability and build trust between stakeholders?</li> </ul>
<b>Operations &amp; maintenance</b> <ul style="list-style-type: none"> <li>▪ Performance evaluation</li> <li>▪ Maintenance operations</li> </ul>	<ul style="list-style-type: none"> <li>▪ Have the various indicators of socio-economic well-being been monitored and evaluated?</li> <li>▪ Are there adequate arrangements for community participation in road maintenance?</li> <li>▪ What are the lessons for the future?</li> </ul>

## 2.4 Planning tools

There are a number of tools that may be used to undertake rural accessibility planning. They include:

- Policy Analysis;
- Regional Development Plans;
- Livelihoods Framework;
- Integrated Planning Techniques;
- Multi-Criteria Analysis; and
- Network-Based Planning.

Aspects of each of the above tools are to varying degrees reflected in the Road Prioritisation Methodology (RPM).

### 2.4.1 Road Prioritisation Methodology

Developed by DFR with DFID support, this combines a proven bottom-up approach to the prioritisation of access needs with a robust economic model that caters for non-motorised as well as motorised traffic.

The participatory aspects of the RPM are centred on public meetings, starting at the local level, and culminating at the Regional level. At each stage, needs are identified and ranked, with the top-ranking proposals for access improvements being elevated for consideration at the next level.

The economic modelling associated with the RPM is well suited to LVRs, and particularly well adapted to commonly encountered situations where there are high volumes of non-motorised traffic, including bicycles and head-loading by pedestrians. Crucially, the tool takes account of modal shifts commonly associated with access improvements, as typically reflected in moves from head-loading to bicycles, from bicycles to motorbikes, from motorbikes to pickups and so on, as the improved road asset facilitates a shift towards more cost-effective forms of travel and transport. It is however important to note that while the RPM's underlying economic model is particularly strong at ranking alternative access investment options, it cannot be used to generate an Economic Internal Rate of Return (EIRR) for such investments.

### 2.4.2 Policy analysis

The objective of the policy analysis is to define, in general terms, the constraints within which specific planning solutions must be found. Constraints may relate to such factors as government policy on employment, provision of accessibility, income distribution and regional development as well as technical factors such as type of terrain and transport facilities, level of existing traffic, capacity and expertise of the local construction industry, and availability of finance.

### 2.4.3 Regional development plans

Regional development plans are used to determine priorities for future investments in infrastructure. These plans are not transport-specific but relate to all sectors and help to identify investment requirements and priorities over a defined period. It is at this stage that road projects for rehabilitation and upgrading will first be identified.

During the preparation of a regional development plan it is important that transport planners liaise closely with other sectors. In the rural context, particular priorities for such coordination typically include education, health and agriculture. It is also important that extensive consultation is undertaken with local communities and political leaders.

### 2.4.4 Livelihoods framework

“Livelihoods Analysis” is a useful approach to adopt in order to identify the ways in which any particular investment intervention will impact, benefit or disadvantage the local community. A rural livelihoods analysis provides a framework for understanding how any proposed changes will affect personal or community livelihoods in the longer term. It focuses directly on how the local community uses and develops its social, human, financial, natural and physical asset structure.

### 2.4.5 Integrated planning techniques

Regional Development Plans and the Sustainable Livelihoods Approach are both general multi-sectoral planning tools but the specific focus is not on transport interventions. Transport may or may not be one of the interventions for which a need is identified. However, there are a number of integrated planning techniques that specifically address transport issues. Their common thread is that planners need to address a range of issues in improving the accessibility of rural people to essential economic and social

services through a combination of improved infrastructure, improved transport services and the improved location of the services themselves.

Integrated Rural Accessibility Planning (IRAP) has been developed by the International Labour Organisation (ILO) and applied in several countries. The approach integrates rural households' mobility needs, the siting of essential social and economic services, and the provision of appropriate transport infrastructure. Communities are involved at all stages of the planning process. It is based on a thorough but easy to execute data collection system that seeks to rank the difficulty with which communities access various facilities.

In the IRAP approach, an Accessibility Indicator (AI) is calculated for various facilities in each community as follows:

$$AI = N \times (T - T_m) \times F$$

N = number of households

T = average travel time to a facility

T<sub>m</sub> = target travel time

F = frequency of travel

Typical facilities included are health, education, water and fuel. The AIs are ranked in descending order and interventions are prioritised in this way. Results of this process are discussed at a participatory workshop and interventions identified which most effectively reduce time and effort spent.

#### 2.4.6 Multi-Criteria Analysis

Multi-Criteria Analysis (MCA) provides a means of prioritising investments in rural roads through consideration of the current condition of each road link and its economic and social importance. For rural roads such data typically include:

- traffic on the road;
- the population served by the road;
- agricultural output of the area served by the road; and
- existing social facilities such as schools and clinics along the road.

The condition of each road link is assessed, and a score allocated. This is known as a "Condition Index". Roads in poor condition have a high Condition Index. Priority factors are then determined for traffic, population, agriculture and social facilities, with weightings applied to each factor depending on their importance. A "Priority Score" for each road link can be then calculated by multiplying the Condition Index by the traffic, agriculture, social and population priority factors. The equation is as follows:

$$\text{Priority Score} = \text{Condition Index} \times TF \times AF \times SF \times PF$$

TF = Traffic factor

AF = Agriculture production factor

SF = Social facilities factor

PF = Population factor.

The result of this analysis is that roads in poor condition but with high social and economic importance are selected first for maintenance or for improvement interventions.

The weights and points allocated to each factor should be determined in a participatory and transparent manner. This will help ensure that the outcome is acceptable to all stakeholders.

In the case of new roads, MCA can be applied to inform the process of route selection. This is described in detail Chapter A.3, which includes a case study and worked example.

#### 2.4.7 Network-based planning

Investments in LVRs have traditionally been evaluated on a link-by-link basis with less consideration given to the connectivity or accessibility contributions of links to the entire network. Network-based planning enables contributions from the various links to be considered in such a way that the travel needs of the people or the community in an area are met to the maximum extent possible in a collective manner at the lowest development cost.

Network-based planning is particularly useful where a "core road network" needs to be identified in situations where funding is available to maintain only part of the total road network. Such a core network



can include roads of different classes that are considered essential to ensuring acceptable levels of physical access to all communities. The extent of such a network can be reviewed periodically and will expand or contract depending on local circumstances.

Models such as HDM-4 can in theory be used for network-based planning purposes. In practice, however, the input data required is often not available, making such models inappropriate. Approaches that involve a high level of stakeholder consultation and a multi-criteria analysis are likely to be more effective for rural network planning purposes.

### 2.4.8 Stakeholder consultations

The objective of stakeholder consultation is to ensure that the road planning process is undertaken in an accountable and transparent manner. This is important for the overall benefit of the affected stakeholders and for the country at large. Consultations should be conducted throughout the project cycle and undertaken in such a manner as to allow full participation of the authorities and the public with the following typical aims:

- Establishing background information on the project from all possible sources;
- Identifying viable alternatives for the project;
- Taking on board the views of stakeholders at all stages of the project; and
- Reaching a consensus on the preferred choice of project(s).

Decisions on transport planning and prioritisation are often taken without considering the transport requirements of the people being affected by the investment. Insufficient consultation can lead to the inappropriate use of resources not only in terms of their usefulness to rural communities but also in terms of their impact on social and cultural traditions. To rectify this shortcoming, it is necessary that:

- local people are involved in the selection, design, planning and implementation of programmes and projects that will affect them;
- local perception, attitudes, values and knowledge are taken into account; and
- a continuous and comprehensive feedback process is made an integral part of all development activities.

#### Types of Stakeholders

Many people have an interest in road projects, and all interested groups need to be identified and consulted in the road selection process. The primary stakeholders are those people whose social and economic livelihoods will be directly affected by the project. These include:

- rural communities;
- farmers groups;
- market traders; and
- transport operators and road users.

It is important to ensure that women's needs are heard and addressed as part of the stakeholder consultations indicated above.

Some other interest groups are important in the decision-making process, even though their own lives may not be affected directly by the project. These include:

- Ghana Highways Authority;
- Department of Feeder Roads;
- District Administrations; and
- Local and national political leaders.

#### Consultation Techniques

There are several recognised participatory techniques for working with communities to determine their transport needs. These usually entail the use of trained facilitators to visually represent community livelihoods issues in order to help identify constraints and needs. Typical techniques include:

- Participatory Rural Appraisal (PRA); and
- Rapid Rural Appraisal (RRA).

Other methods include public hearings through political leaders, and direct community consultation. Workshops can, if well facilitated, be a good way of undertaking initial prioritisation exercises, delivering key messages and receiving feedback. It is important that all consultation techniques are well organised, that all the relevant stakeholders have been invited and that the deliberations take place in an interactive and transparent manner.

## 3. COMPLEMENTARY INTERVENTIONS

### 3.1 Context and application

This Chapter describes some concepts and practical issues relating to the planning, design and implementation of potential Complementary Interventions (CIs) on LVR projects.

CIs are:

- actions that can, if desired, be included in and implemented through the roads project or the road works contract;
- targeted toward the communities that lie within the road's corridor of influence and are affected by the road itself, by road users or by the road works; and
- intended to optimise the benefits brought by the road and to enhance its positive impacts. While the contract should already provide for mitigation of any negative impacts of road projects on local communities, CIs could potentially go further

Such interventions are neither:

- mandatory (they are included at the discretion of the client) nor
- designed to remove or replace the standard responsibilities of the contractor, client or other authorities or institutions.

The concept of CIs is motivated by opportunity. Put simply, they take advantage of the road project to build in aspects that will enhance or protect the social and environmental well-being of affected communities. Their relatively small scale means that their inclusion would not normally result in a disruption of the main contracted works programme.

The opportunity to take advantage of CIs will only be available during the period of the works when the contractor is on site. Any CI-related activities requiring access to Contractor's physical, human and financial resources that may not normally be readily available in the project area must be planned accordingly.

When a decision is taken to include a CI, this will have a cost consequence. This is normally borne by the client, though other arrangements could potentially be made. The extent to which the client wishes to include CIs within a project would be communicated to the design engineer through his or her terms of reference, or through a site instruction. This can be reflected in the bill of quantities.

CIs are demand-driven, reflecting the needs expressed by local communities. Appropriate responses to these needs will already to some extent be reflected in development plans drawn up at the district, regional and national level. Whether or not this is the case, the process of identifying potential opportunities for CIs will, during the feasibility stage, entail close consultation with relevant authorities, as well as with affected communities where appropriate. If CIs are to be included in the works, the relevant administrations must have agreed in principle the extent, type and approach for any inclusion of actions and initiatives. This is described in more details in Appendix A.4. In some cases, there may also be a requirement for the beneficiary community to make a contribution, whether financial or in kind.

With an outline framework agreed at the feasibility stage, the task of the design engineer is to reflect these desires and agreements in the works bidding documents and the eventual contract.

Following an outline description of the concept of CIs, examples are provided of the types of intervention that may be provided, and an explanation given as to how the detailed design and the bidding documents should be used to clearly define the requirements for implementation, measurement, and monitoring.

CIs can be grouped into three categories:

**Category I)** Management Interventions. These are simple actions that enhance the positive impact of the road project itself and are well within the normal skills of the road contractor. They may build on or extend the normal socio-environmental and safety obligations of the contractor.

**Category II)** Opportunity Interventions. These are actions that are beyond the scope of traditional road projects but are within the technical and management skills of the road works contractor.

**Category III)** Enhancement Interventions. These are actions that utilise the provisions of the contract but extend beyond the normal skills and experience of a road works contractor. These actions would normally be implemented by other parties with the relevant skills.

One of the main advantages of including CIs through a contractor already mobilised for a road project is that they can be completed more quickly, more efficiently and at a lower cost than if implemented

separately. This can improve the economic rate of return on the road investment while enhancing the prospects for local socio-economic growth, employment and empowerment.



**Figure A.3.1 Installation of water pump as a Complementary Intervention**

## 3.2 Planning, identification and implementation of CIs

The identification and development of CIs should take into account:

- current national, regional, district and sector policies;
- legal instruments; international conventions and treaties;
- guidelines and procedures relating to public consultation/participation; and
- local development planning and implementation.

### 3.2.1 Planning

CIs need to be considered early in the project cycle and be an integral part of project planning, from project identification to feasibility study. It is important that the client works closely with key stakeholders, including those who identify the need for the project and local government representatives in the project area. Together they are well placed to develop an outline plan for the inclusion of complementary interventions in the road project or programme. This should be to a sufficient level of detail to facilitate their ready further development during the feasibility study and detailed design stages.

The outline plan and budget for CIs, and an assessment of the potential short-term effects and longer-term impacts, should be included in the economic analysis of road projects. This is because, despite entailing additional initial investments, they may result in a net improvement in the economic rate of return of the road investment.

Key issues for consideration during the planning, feasibility and preliminary design stages of a project are described more fully in Appendix A.4.



**Figure A.3.2 Community participation in the planning process**

When approaching the design of CIs, it is necessary to identify interventions that:

- are demand driven;
- are agreed in principle by all of the relevant local and other authorities;
- will have a high level of participation and involvement from the local authorities and communities during implementation; and
- are matched with and complement actions within existing local plans, such as district development plans.

A high level of consultation with affected communities will also be needed during the detailed design of CIs. The design engineer will work through the client to ensure that the correct local procedures are adopted and that all necessary formalities are followed.

**Table A.3.1 Principles of participation**

Participation considerations
<p>In promoting consultations and participation the following should be noted:</p> <ul style="list-style-type: none"> <li>▪ Beneficiaries should not be viewed as a passive element. They should be active participants.</li> <li>▪ Situations should be avoided that override existing and legitimate decision-making processes and structures.</li> <li>▪ Due care and attention should be given to group decision-making processes that may reinforce existing power structures at the expense or exclusion of vulnerable groups.</li> </ul>

Decisions, prioritisation methods and approvals for planned initiatives would be introduced by the client and achieved through the client's interaction with relevant local authorities and communities. If identification and prioritisation are within the design consultant's mandate these should be carried out under the client's guidance using established participatory processes.

Though Ghana has a decentralisation policy and structure in place, challenges remains in operationalising it to enhance true grassroots participation in decision-making, while ensuring associated transparency and accountability. In the case of Feeder Roads, DFR's Road Prioritisation Methodology (RPM) provides an established mechanism for such participation. Though normally focussed purely on ranking priorities for improved rural access, the RPM entails a structured and respected approach to bottom-up participatory planning, as well as established associated methodologies for record-keeping. This could potentially be adapted to include consideration of potential for associated CIs.

In developing their own detailed methodology for identification and selection of complementary activities for each LVR project, the design consultant should draw not only on DFR's RPM, but also on other relevant participatory methodologies used by GHA, and in other sectors. Where the EPA requires an Environmental and Social Impact Assessment (ESIA) to be carried out, the associated community consultation could potentially serve as a further ready vehicle for identifying scope for CIs.

The design engineer should also be familiar with:

- existing local and regional development plans
- potential sources of complementary financing or resources that may available; and
- the willingness of local communities to make other contributions, including through current and potential future work by local NGOs and CBOs.

The consultant, with guidance from the client and key stakeholders, may be required to help establish and provide support to a 'Complementary Intervention Oversight Committee' at the different levels. These would become the main contact points for the design consultant and may assist in the community consultation and participatory decision-making processes. If the establishment of a separate committee is not required, a main contact point within the existing local administration would need to be nominated or identified through the client.

The participatory process will require a multi-disciplinary design team to ensure appropriate consideration of technical and financial aspects of the proposals identified, to develop appropriate designs and implementation mechanisms that meet the expressed needs of the communities, and to ensure adequate coverage in the construction contracts.

### 3.2.2 Identification and selection of CIs

In theory, CIs may include almost anything that can be implemented through a road works contract and which contributes to the socio-economic, environmental or safety of communities affected by the road. As summarised above, they are divided into three categories to help clarify the different types of activities and how they relate to the traditional role of the road works contractor or works contract.

#### Category I - Management interventions

The works contractor will already have clear-cut environmental, safety and employment obligations set out under the provisions of the works contract. These would be captured within the relevant design and implementation management documents. These include the ESIA and Environmental Management Plan (EMP). Management interventions add to and extend the normal obligations of the contractor. These could include interventions such as:

- items relating to improving road and resident access;
- reinstatement/improvement of areas used temporarily during construction; and/or
- provision of facilities and services disrupted by construction activities.

Such activities would generally be included as Bill of Quantity items (Measured Works) in the contract. In the case of small-scale activities, they could be included within other items.

#### Category II – Opportunity interventions

Opportunity interventions go beyond the normal scope of a road works contract but are within the technical and management skills of a road works contractor. Opportunity interventions would typically include:

- support for provision or repair of community infrastructure, such as a clearance of a market area; and
- provision of materials, labour or supplies for small community works, such as the rehabilitation or repair of community facilities (community buildings, hand pumps, irrigation infrastructure and the like);

Provision by the contractor of technical training to local government administrations and staff is also possible. The scope of such training could include:

- vehicle maintenance, financial management, road construction and maintenance; and
- building and/or sanitation management.

Similar technical support could also be provided to local enterprises and cooperatives. Such activities would be included as Bill of Quantity Items (Measured Works) in the contract or could be established through a separate or parallel agreement between the contractor and the Local Government Administrations or with an entity representing the community.

#### Category III – Enhancement interventions

Enhancement interventions extend beyond the skills and experience of a normal road contractor and would require specific arrangements through the contract with other skilled parties. Such parties may include local government offices, NGOs, private sector organisations, community-based organisations and cooperative societies that are better placed and skilled to implement the proposed interventions. The role of the contractor would be to manage the activity through the contract and provide physical support or, if necessary or appropriate, provide financing to the organisation implementing the activity. This would be included within the scope of monthly reporting, and associated payments sought through monthly Interim

Payment Certificates. Verification of activities would be undertaken by the supervising consultant or client. Examples of Category III activities include:

- awareness-raising and education campaigns;
- establishment of new or improved livelihoods options;
- building of facilities;
- life skills training; and
- provision of supplies and training to local service providers.

Such activities would be included as provisional sums in the contract.

CI's can cover a range of themes; for example, road safety, road corridor environment, road transport services, and community development. Appendix A.5 provides further details of CI's, set out by category and theme.

### 3.3 Contract provisions to support Complementary Interventions

The successful implementation of CI's requires clearly defined requirements and adequate provisions to be included in contract documents and at all stages of the project. The sub-sections that follow describe how the different contracts (for project design services, works, and supervision services respectively) may be used to address CI's.

### 3.4 Design services contract

During project planning, the client will need to determine the approximate budget and scope of the project, including the budget and scope for CI's. This then needs to be reflected in the Request for Proposals (RFP), in particular the terms of reference, for consulting services for the detailed design. The RFP should specifically include appropriate inputs of key personnel with the requisite skills to meet the requirements of the client with regards CI's.

**Table A.3.2 References to Complementary Interventions in the Request for Proposals**

The RFP should include:
<ul style="list-style-type: none"> <li>▪ Clearly defined and appropriate inputs for key personnel to be involved in developing CI's;</li> <li>▪ Reference to this Chapter or other guidance on identifying, selecting and designing CI's;</li> <li>▪ A requirement to organise a mobilisation workshop to draw all stakeholders together on site;</li> <li>▪ A requirement to review participatory decision-making practices and develop a project specific methodology that best reflects local decision-making structures, both formal and informal;</li> <li>▪ Clearly defined duties and responsibilities of the parties to the contract and any external organisations with respect to development of the CI's;</li> <li>▪ A requirement to review national, regional and local development plans in the development of CI's;</li> <li>▪ A requirement to include CI's in any further economic analysis;</li> <li>▪ A requirement to consult with local government and community representatives to enable them to participate effectively in the decision-making process when developing CI's;</li> <li>▪ A requirement to clearly define and specify requirements for CI's in the preparation of bidding documents.</li> <li>▪ A requirement to consult with local government and community representatives to enable them to participate effectively in the decision-making process when developing CI's;</li> <li>▪ A requirement to clearly define and specify requirements for CI's in the preparation of bidding documents.</li> </ul>
The RFP may require the consultant to provide guidance on:
<ul style="list-style-type: none"> <li>▪ How to decide which potential CI's will result in the most effective or efficient use of resources and how this can be measured;</li> <li>▪ How to ensure that the contractor does not become overburdened by CI's, that the proposed interventions are suitable to the scope of works, and that the necessary skills and experience are brought to bear by the contractor.</li> </ul>

The client may require the consultant to undertake some participatory process to assist with the development of the CI package. With regards to Category III interventions, it would generally be more efficient and appropriate for the client to undertake the identification and preliminary selection using the existing government structures and plans.

The development of Category I and II intervention packages are relatively straightforward as they fall within the skill area of a multi-disciplinary design team. However, the RFP still needs to be well developed and

thought out, as detailed in Table A.3.2. The feasibility study will have developed the preliminary options and budget/cost estimates for the CIs. The detailed design will require preparation of the finalised list of CIs, detailed designs and engineer's cost estimates.

### 3.5 Works contract

For the purposes of including CIs within works bidding documents (See Table A.3.3 for guidance), the key documents requiring attention are:

**Instructions to Bidders (ITB) and the Bid Data Sheet (BDS):** For a LVR project the client should include an additional item that will draw the attention of the bidder to any requirements for CIs.

**Standard Technical Specifications:** Defined in the 2007 Standard Specifications for Roads and Bridges, these include reference to some activities that could potentially constitute CIs. Other CIs should be included in the Particular Specifications.

**Particular Specifications:** This is where any detailed technical requirements and specifications, and implementation mechanisms specific to the designed set of CIs should be clearly defined for the project.

**Bills of Quantities or Schedules of Rates:** This should be linked by item number to the Standard Specifications and to the Particular Specifications. It is where the schedule of activities and estimated quantities for the CIs are set out for the bidder to price.

**Drawings:** Some standard detailed drawings, such as for the provision of side access, may be applied directly. Supplementary drawings, linked with the Particular Specifications, may also be required where new or special complementary approaches are included. In some such cases, a separate volume of associated drawings may be required. For Category III interventions reference should also be made to any standard drawings used by line ministries for infrastructure under their control.

**Conditions of Contract:** This includes standard provisions for execution of the contract and unless amended in the Conditions of Particular Application, these will apply. In some cases modification of some clauses may be required to reflect the desired approach. For example, where there is a targeted procurement policy to support small and medium enterprises and small-scale contractors then due consideration should be given to the clauses referring to Performance Security, Performance Program, Insurances, Cash Flow, Plant, Equipment & Workmanship, Payments, Retention and Advances, Price Adjustment and currency restrictions.

**Conditions of Particular Application:** This is where any Provisions in the General Conditions of Contract may be amended, as required, to make them more appropriate. This may apply to some of the CIs envisaged. Where assets are involved, the document should be clear on the responsibilities for asset transfer. Due consideration should also be given to strengthening clauses aimed at promoting sub-contracting/assignment, local employment and conditions (including for women), rights and insurances, and for strengthening CIs.

Important documents which are not part of the Works Contract are User Guides. These are guidelines to the design Consultant or the client organisation on the preparation of the Works Bidding documents and should ideally include specific reference to the provision of CIs.

The main issues for a contractor are to fully understand the scope of all of the works, including the CIs, and to be clear about associated mechanisms for measurement and payment.

The main issues for the client are to achieve the objectives of the intervention, to ensure value for money, and for these interventions not to require a disproportionate amount of supervision or monitoring.

**Table A.3.3 Works bidding/contract documents**

General Notes for Guidance	
Instructions to Bidders (ITB) and the Bid Data Sheet (BDS)	The ITB is generally a standard document which may vary depending on the procedures of different clients. For a LVR project, the client should include an additional item that will draw the attention of the bidder to the LVR approach. The BDS is linked to the ITB and provides specific project information.
Standard Specifications	These will define the scope of the technical requirements of the contract, including the type and quality of materials and equipment, the standards of workmanship. The Standard Specification for Road and Bridge Works includes the works to be undertaken, general obligations information on the format of Bill Items for the Bill of Quantities, on item coverage and the method of payment.

Particular Specifications	This is where any detailed technical requirements and specifications, and implementation mechanisms specific for the project, should be clearly defined. Particular technical specifications add further detail to complement or replace those stated in the Standard Technical Specifications. The particular technical specification should also include any specifications and limitations on the freedom of choice for the contracting company related to the execution of works.
Bill of Quantities	This should be linked by item number to the Standard Technical Specifications and to the Particular Specifications. It is where the schedule of activities and estimated quantities are set out for the bidder to price.
Drawings	Some standard detailed drawings may be applied directly for LVR works (e.g. cross-sections, standard culvert design and road signs). Supplementary drawings, linked with the Particular Specifications, may also be required where new, innovative or special approaches are included.
Conditions of Contract	This includes standard clauses or provisions for contracting requirements, obligations and legal commitments which, unless amended in the Conditions of Particular Application, will apply for the project. In some cases, modification of some clauses may be required. Modification may also be required to reflect the desired approach for the LVR works, as described below.
Conditions of Particular Application	This is where any Provisions in the General Conditions of Contract may be amended as required, to make them more appropriate to non-standard project requirements, including CIs.
User Guides	These documents will provide detailed guidelines to the design consultant on the preparation of the works bidding documents.

### 3.5.1

#### Options for inclusion of CIs in works contracts – measurement and payment

Many CIs will involve provision of work items, activities or services beyond the usual core activities associated with a traditional road works contract.

##### Bill of Quantity items (Measured Works)

Where the scope and detailed design of a CI is well defined and within the scope of activities normally expected of a road contractor (i.e. Category I and II interventions), the preferred option would be to include these activities as items within the Bill of Quantities for the contractor to price. This approach would apply to any extension. An example of typical entries is provided in Table A.3.4.

**Table A.3.4 Example Bill of Quantities entries**

No	Item Description	Unit	Quantity	Rate	Amount
1*	Clear and prepare hard standing for market, in accordance with Specification Ref: (.....) and Drawing: (.....)	m <sup>2</sup>	500		
2*	Rehabilitate school block in accordance with Specification Ref: (.....) and Drawing: (.....)	Item	1		

\* Relates to item in Standard Specifications or Particular Specification. Shaded area for bidder to price

##### Provisional Sums

In cases where the intervention is not fully developed and agreed, it is generally better to describe the activity briefly and to include a Provisional Sum item in the Bill of Quantities. Such cases could include the enhancement of a borrow pit to a small dam or fish pond, or provision of training that falls outside the scope of activity normally expected of the contractor.

What information is known could be included in the Particular Specifications or Drawings, with a requirement for the Contractor and/or Supervision Consultant to further develop and define the intervention. The Provisional Sum item can typically be described in one or two lines included in the Bill of Quantities. A cost estimate is inserted by the Client to cover the cost of these items.

The Provisional Sum is an estimated cost for the intervention based on the information available at the time of bidding document preparation. The actual cost of the intervention may change, with the final design



and price for the intervention being agreed between the parties to the contract once all the necessary information is available.

Provisional Sums are flexible and are used at the discretion of the Engineer.

When using provisional sums, provision must be made for the administration and management of these funds by the contractor, in the form of a % fee or adjustment to the provisional sum item.

An example of Provisional Sum entries in the Bill of Quantities is shown in Table A.3.5

**Table A.3.5 Example of Provisional Sum entries**

No	Item Description	Unit	Quantity	Rate	Amount
1*	Provision of road maintenance training to district staff	PS			125,000
	Allow percentage for administrative fee on provisional sum, item (...)	%	1		
2*	Provision of construction supplies to district administration	PS			75,000
	Allow percentage for administrative fee on provisional sum, item (...)	%	1		

\* Relates to item in Standard Specifications or Particular Specification. Shaded area for bidder to price

### Output-related Items

Output-related approaches are most applicable for procurement of supplies or services. Measurement and payment will normally be linked with stage outputs or deliverables, such as an activity report following a training programme. If the Terms of Reference (ToR) are complete for such an intervention then bill items can be included for the contractor to price, as in the example in Table A.3.6. If such information is not available to the contractor, then the intervention should be included as a Provisional Sum item and an estimated cost included in the Bill of Quantities by the client.

**Table A.3.6 Lump Sum item for completed output related to PS**

No	Item Description	Unit	Quantity	Rate	Amount
1*	Provide training materials and conduct training on community and schools road safety education in accordance with ToR.	Lump Sum	1		125,000

\*Relates to item in Standard Technical Specifications or Particular Specification. Shaded area for bidder to price

Any items for supplies or services that are outsourced to appropriate implementation partners will require a detailed ToR to be developed and included in the sub-contract agreement. Such sub-contractors may be nominated by the client or selected by the contractor as a 'domestic' sub-contractor, subject to client approval. These ToR will need to clearly define the scope of work, identify the beneficiaries to be reached and set out the detailed specifications if the sub-contract is for supplies. For a services sub-contract the projected person.month inputs and minimum staff requirements may be included. ToR should also include a payment schedule based either on inputs or, where possible, linked to deliverables.

### Schedule of rates

This is a particular form of pricing mechanism used where the activities or procurement items are known, but the quantities are not (See Table A.3.7). The schedule lists the items to be provided giving the unit of measure but not the quantities, or if quantities are included it is made clear that such quantities are nominal. The bidder will then submit a rate (rate only) against each item in the schedule.

**Table A.3.7 Example of Schedule of Rates where quantities are unknown**

No	Item Description	Unit	Quantity	Rate	Amount
1*	Provide animal drawn carts in accordance with Specification Ref: (.....) and Drawing: (.....)	No	1		Rate Only

\*Relates to item in Standard Technical Specifications or Particular Specification. Shaded area for bidder to price

If standard unit rates are known, then they can be inserted by the design engineer (See Table A.3.8) and will then normally form the basis of a nominated sub- contract. This could be used, for example, for the provision of school furniture from a nominated supplier, or a national procurement office, whose rates have already been agreed with the Ministry of Education. If such fixed rates are to be used they will generally include for contractor overheads and profit.

**Table A.3.8 Example of schedule of rates where quantities are known**

No	Item Description	Unit	Quantity	Rate	Amount
1*	Provide school desks in accordance with Specification Ref: (.....) and Drawing: (.....)	No	50	100	5000.00

\*Relates to item in Standard Technical Specifications or Particular Specification

### Dayworks

The dayworks schedule is intended for the pricing and payment for small scale incidental works and should not be relied on as a mechanism for the measurement of and payment for CIs.

### 3.5.2 The works contract evaluation

Although the CIs component of a road project may be a relatively small part of the construction budget, it must be included within the evaluation of the bid process. The aim should be to ensure that the contractor understands the CI requirements and has consulted with the relevant partners to provide considered and accurate price estimates.

### 3.6 Supervision consultant's contract

The RFP, and in particular the ToR, for consultancy services for construction supervision need to reflect the role of the Engineer in supervising the works and administering payments for the CIs.

As with the main engineering design, the supervision consultant will be required to review the agreed list and detailed designs of the CI, and to consult with the necessary stakeholders to ensure that priorities remain unchanged and that the interventions are still appropriate to the needs of the beneficiary communities.

The RFP must also take into account the need to further develop and negotiate detailed agreements for some of the interventions as the construction works progress, such as in the case of interventions relating to the reinstatement of temporary works areas. The Employer may also need to be involved in monitoring grievances and dispute resolution, should the need arise. In such cases, the Engineer shall provide the required assistance.

The supervision and monitoring of CIs may require specialist skills beyond those available within the normal engineering supervision team. The RFP should reflect this, and include:

- Clearly defined and appropriate roles for key personnel to be involved in monitoring and supervising CIs;
- Reference to this Chapter of the LVR design Manual or alternative guidance on designing and monitoring CIs;
- Clearly defined duties and responsibilities of the parties to the contract and any external organisations with respect to development and implementation of the CIs;
- Requirement to consult with and provide appropriate training to implementation partners to assist them in fulfilling any obligations as defined in agreements / sub-contracts for CIs;
- A requirement to include CIs in their progress meeting agendas and progress reports.

### 3.7 Targeted procurement

#### 3.7.1 Targeted procurement as a quasi-complementary intervention

Because the commercial considerations of a contractor are not necessarily well aligned with the results of higher-level socio-economic appraisal, or with other policy imperatives of government, the client may decide to adopt a targeted procurement approach. This is a process used to create a demand for the services or goods, or to secure the participation, of targeted enterprises and targeted labour in contracts in response to the objectives of a secondary procurement policy. Examples of targeted procurement could potentially entail the client stipulating requirements, targets, or rewards for:

- the employment of local labour; and/or
- the employment of women, and others from disadvantaged groups; and/or
- the engagement of small contractors.

The issue of employment and skills-development opportunities arising directly from the main works contract is not strictly speaking a complementary intervention as such, because it is inherent in, rather than being additional to, the main contract. However, it is included in this Chapter on account of its resonance with features of CIs in terms of its potential short-term effect, and longer-term impact, on the socio-economic outcomes of a road contract, whether for new construction, rehabilitation, or maintenance.

### 3.7.2 Choice of technology

Road works potentially provide an opportunity for temporary employment of local labour in the case of rehabilitation or new construction, and longer-term employment in the case of maintenance. The choice of technology, and of the associated management system adopted, is determined in part by the availability and cost of resources, in part by the capacity and outlook of contractors, and in part by applicable procurement policies. It is important in this regard to be clear about the difference between:

- “Labour-intensive” practices that, by using labour rather than machines wherever possible, seek to maximise employment opportunities;
- “Labour-based” practices that, by using labour when it is more cost-effective than machines, seek to optimise both value for money and socio-economic outcomes; and
- “Community-managed” practices that tend to be labour-intensive, focussed on meeting expressed needs at the community level, and implemented through community contracts.

Through feasibility studies, governments evaluate the optimum labour content of a works contract in economic rather than financial terms. Particularly in remote rural areas with high unemployment, this tends to favour the adoption of labour-based technology for many activities. By contrast, contractors typically evaluate the options in terms of financial costs and management requirements. Because labour-based operations are necessarily relatively management-intensive, this means, for instance, that most contractors would rather deploy one grader than 120 labours, even though the latter option could potentially result in better outcomes in terms of technical quality, value for money, skills development and socio-economic impact. Hence the decision by some clients to adopt a targeted procurement approach to encourage labour-based technology where there is a proven socio-economic case for doing so.

Such requirements or incentives would typically be reflected in both the procurement guidelines and the works contracts. Potential contractual mechanisms could for example include minimum targets for the percentage of labourers on specific activities employed from local communities. Payment for the relevant activities could reflect the extent to which the employment targets have been met. This should also be a topic for review at monthly site meetings.

More simply, an overall target could be set in terms of person.days worked by local residents, either as a total or as a percentage of the overall days worked. Again, payments to the contractor could then reflect the extent to which the target has been met.

When developing such clauses, or enhancing existing clauses, the following issues should be given due consideration:

- Boundaries for defining local labour – e.g. living within a designated number of kilometres from the project road; or living within certain administrative areas;
- Availability of skilled and semi-skilled labour within the project area, and within sections of the road project, taking account of seasonal variations;
- General health and physical condition of the locally available labour (especially in areas where there is significant out-migration for work, drought, food insecurity or endemic health issues);
- Social, religious or traditional barriers that may prevent some social groups from accessing labour opportunities and how these might be overcome;
- Incentives or penalties to be used to encourage the contractor to meet local employment targets;
- The need to guard against setting unreasonable targets that risk alienating contractors, rather than viewing them as partners; and
- Measurement, monitoring and recording mechanisms to accurately report on local employment.

The client will guide the design engineer on any special emphasis with regards the approach to be adopted. When a targeted procurement approach has been decided upon, the design consultant will need to carry out a labour survey during the detailed design stage to develop appropriate local employment contract clauses and targets that are realistically capable of being achieved.



**Figure A.3.3 Labour-based technology on a Low Volume Road**

Beyond the immediate works contract, the principles of CIs can be used to enhance access to employment opportunities for the wider community, particularly in cases where unemployment or under-employment are local issues. Such activities could include:

- crushing and screening rock for aggregate or hand screening gravels;
- making gabion baskets;
- seedling and sapling planting and subsequent maintenance; and
- cooking, cleaning, and managing work sites and camps.

### 3.7.3 Encouraging participation of marginalised groups

Every society has groups that are, for whatever reason, disadvantaged or at risk of being excluded from participation in employment. Often these groups can benefit most from temporary employment in road works projects.

Typically excluded groups include:

- Women in general and especially mothers with young children;
- The physically or mentally disadvantaged;
- Ethnic or religious minorities; and
- Those infected or affected by HIV/AIDS.

It has to be recognised that the labour required on the road site usually requires physically hard work and construction sites can be relatively dangerous places. It is not, therefore, appropriate to require contractors to employ physically or mentally disadvantaged people, though there are generally some jobs, for example at the works camp, that could be appropriate.

It should be possible for the design engineer to develop an understanding of the barriers to participation in employment by women and minority groups and find ways to help them access employment, without causing conflict or concern amongst the wider community.



**Figure A.3.4 Participation of women in road works on Low Volume Road**

In many areas, for example, barriers to women's participation in road works is caused by their own need to collect water, fire wood, animal fodder and look after the home and children. Measures that can be easily introduced to help women overcome such barriers include:

- Allowing women to form work groups and share the workload between them. This provides for flexible working hours for individual women and protection in numbers. This also allows them to share child care responsibilities through a rotating crèche or similar;
- Ensuring women work in areas where they feel safe and secure. Due consideration should be given to issues of isolation (e.g. distance from other work groups), appropriate areas or facilities for nature calls and distance from home/crèche; and
- Removal of time constraints preventing women from accessing employment opportunities. This can be done by, for example, providing firewood or alternative fuel or potable water through the contract. This would require the contractor to bring fuel or potable water to site for distribution. In some cases, this could also be used as part of payment for work done (by men as well as women). Importantly, it should only be a relatively minor part of payment.

### 3.7.4 Labour standards

Legal requirements relating to employment of temporary workers in Ghana are defined by Part X of the Labour Act 2003. Under the works contract, these requirements are inherent in the over-riding requirement for parties to comply with all applicable laws. Nevertheless, in the interests of clarity and accountability it is considered good practice to explicitly include key provisions within works contracts. Table A.3.9 summarises such provisions, recognised internationally as Core Labour Standards.

**Table A.3.9 Contract clauses reflecting labour standards**

Objectives of typical contract clauses reflecting labour standards
<ul style="list-style-type: none"> <li>▪ Minimum wage rates per unit of time or unit of work are adhered to;</li> <li>▪ Equal pay for equal work;</li> <li>▪ Equal access to employment opportunities (taking into account local traditions, with respect to male / female jobs, for example);</li> <li>▪ Effective monitoring and recording of work done and wages paid (transparency);</li> <li>▪ Health and safety of employees and affected communities (due attention to sanitation, waste disposal, disease control and prevention, first aid and emergency health care, accident management and reporting);</li> <li>▪ Safe and appropriate temporary accommodation and recreational facilities;</li> <li>▪ Effective grievance procedures for temporary employees;</li> <li>▪ Limitations on use of child labour (according to local laws, regulations and customary practices);</li> <li>▪ Use of ILO guidelines and regulation if it is an internationally funded contract.</li> </ul>

### 3.7.5 Supporting small scale contractors

Targeted procurement often seeks to promote the development of local small scale and emergent contractors and enterprises, as part of a strategy to stimulate entrepreneurship, skills development, and local employment. This can be achieved in two ways:

#### Utilising bidding documents aimed at SMEs

Smaller scale works contracts are more forgiving to the emergent contractor and protect the client from high levels of financial risk.

When contracting work to small scale contractors, small enterprises or community-based organisations that are not so used to undertaking road related works, the following issues need to be considered and a position agreed with the client:

- It should be understood that emergent contractors may lack contract experience. The client and supervisor may need to be flexible in some instances where full compliance with normal contract provisions would have an unnecessarily negative impact on bidding, the performance of the contract or the viability of the contractor.
- Ensuring the requirements of the contract, allocation of responsibilities, technical and performance standards, payment terms and conditions are clearly understood by the tenderer/contractor. The project could include elements of contract management and supervision support, technical assistance and/or management training.
- Cash flow: It is unlikely that small sub-contractors will have sufficient cash or resources to start the activity without some form of advance payment (in cash or in kind) and it is likely that they would need more frequent payments, possibly every two weeks rather than monthly.

- **Advances:** The advance amount, repayment conditions, and regular payments need to be defined in a payment schedule in the agreement. Advance guarantees used on larger contracts may not be appropriate or even possible for small scale works.
- **Performance guarantees and bonds:** It is mandatory to include performance guarantees for the works. Where small scale enterprises are sub-contracted, the guarantees entered into by the main contractor will cater for the SME subcontractor. Where SME are contracted directly, the provisions set out in the respective model tender/contract documents should be appropriate for the size of the contract/contractor and to local constraints.
- **Performance Programme:** The period of the works should also take account of the likely size of the contractor, the choice of technology, and the resources that can realistically be deployed and effectively managed.

#### **Utilising Sub-Contracting clauses**

By requiring the main contractor to engage the services of small-scale enterprises, risk is carried by the main contractor who has qualified and met the minimum criteria set by the client. The client may set a minimum percentage or type of works that should be sub-contracted to small scale enterprises. In doing so the client needs to recognise the risk that is carried by the contractor and to ensure that the performance programme and payment clauses reflect the fact that the works contract has a capacity-building component.

### **3.7.6 Further guidance**

Part 7 of the international standard for construction procurement, ISO 10845 (2010), provides further specific guidance on targeted procurement.

## **3.8 Management, monitoring and enforcement**

In general, the CI aspects of the contract should be managed, monitored and enforced using the normal provisions of the contract documents.

CIs should be included in the contractor's detailed work plan and the payment schedule. Progress and performance should be reported through the monthly site meetings and progress reports. It may be appropriate to prepare specific reports for local communities and their leaders on the progress of CIs in their area. The frequency of such reports would depend on the nature and scale of CIs being implemented in that area, which should be determined during the detailed design stage and uses provisions made in the reporting sections of the works and supervision contracts.

While it is the Contractor's responsibility to manage and implement the CIs according to the contract, it is the Engineer's responsibility to ensure CIs are monitored regularly and to verify that technical and performance standards are being consistently met by the contractor.

Monitoring and enforcement should be closely linked to the Contractor's payments. It is essential that measurement and payment for CIs and any incentives or penalties are clearly defined in the works contract.

Payment for sections of the road should only be fully made once all aspects of the contract have been completed in that section. This includes completion of environmental mitigation measures and the CIs, to the required standards. This should be reflected in the payment schedule. When processing payment requests for CIs it can be helpful to make use of forms that make provision for retaining a certain amount from the contractor's payment to ensure that sufficient funds are available to the client to complete the mitigation measures/CIs should the contractor fail to do so.

Where the CIs involve small scale contractors or community groups, it may be appropriate to include an element of community-based monitoring. In such cases a mechanism should be established by which the affected communities are clearly informed about what is to be done and by whom, and to monitor implementation by all parties to the CI agreements. This can be done through formal monitoring groups, or by putting up information on a notice board that allows all members of the community to see what should be happening.

It is important to be clear that the role of community monitoring should never be to make technical judgements, but rather to ask questions related to any apparent discrepancies between what has been agreed, and what they observe. It may be necessary in this regard for basic training to be provided, and simple protocols established for community monitoring and subsequent reporting back to the supervision consultant's team.

## 4. PRINCIPLES OF ROUTE SELECTION

### 4.1 Introduction

The Environmental Assessment Regulations (LI 1652) were promulgated in 1999 to give comprehensive legal cover to Environmental Impact Assessment (EIA) procedures in Ghana. These stipulate that all development activities likely to adversely impact the environment are subject to Environmental Assessment. In 2011, the Environmental Protection Agency (EPA) issued a document entitled “Environmental Impact Assessment Guidelines for the Transport Sector”. This document sets out clear guidelines for the need and content of EIAs in all transport sub-sectors. New road construction projects, regardless of road category, are subject to mandatory EIA. The guidelines define the environmental assessments to be undertaken as part of planning/pre-feasibility study, feasibility study/preliminary design, detailed design and construction. During pre-feasibility and feasibility study stages it is necessary to consider the full range of potential environmental impacts, as listed in the EPA guideline.

Ghana has the sixth highest density of roads on the continent and its road network is well established compared to most of the rest of Africa. Nevertheless, public investment in LVRs continues, including though a programme to provide improved access to cocoa-growing communities. And new roads have also been constructed in recent decades to facilitate the growth in the mining and other sectors. So while the construction of new roads is not a national priority, some continued investment in the expansion of the rural road network can be anticipated. This is expected to be focused on upgrades and improvements, as well as localised extensions and link roads to expand and integrate the network. Wherever possible, maximum use should be made of existing tracks in any such network expansion. There may however be cases where new alignments need to be identified through virgin ground.

Route selection for any new road construction can be divided broadly into two stages:

- Definition of the corridor within which route options are identified and selected; and
- Selection and design of the preferred alignment within the corridor.

### 4.2 Route corridor identification

A route corridor is defined as a linear area of terrain that needs to be studied in order to be able to identify route options within it. There are no minimum or maximum dimensions to its width, as this is determined usually by the geographical structure of the existing road network, the intended road purpose or category, the topography and the envisaged constraints imposed by social and environmental factors.

The data resources available for identifying a route corridor in Ghana include:

- Published digital 1:50,000 scale topographical maps. Topographical data can be obtained at a range of scales from the Centre for Remote Sensing and Geographic Information Systems (CERSGIS);
- Geological maps published at a scale of 1:250,000 from the 1960s. Recently published geological data is available at smaller scales, such as 1:1 million;
- Maps showing areas of conservation status. These can be obtained from the Wildlife Division of the Forestry Commission in Accra;
- Satellite imagery to assist in the mapping of land use, drainage systems and topographical constraints, as well as the location of villages, towns and other infrastructure;
- Site reconnaissance and site investigations;
- Local information; and
- National and regional development plans.

### 4.3 Identification of alignment

Road authorities are usually required to identify at least three possible alternative alignment options within the corridor which:

- connect the stated start and end points via any specified intermediate points;
- maximise connectivity with the existing road network;
- avoid environmentally sensitive areas;
- avoid any adverse impacts on settlements and housing areas;
- satisfy local community desires and concerns;
- avoid areas requiring complex and expensive engineering solutions; and

- allow the alignment to be determined in keeping with the geometric standards of the proposed class of road.

## 4.4

**Recommended approach**

The approach to environmental assessment established by the EPA is a useful way of structuring the selection of route corridors, the identification of route options and the selection and design of the final alignment. Depending upon location in the country, a range of factors need to be covered. Most of these are included in Table A.4.1. The relative importance of these criteria is dependent upon regional and site-specific circumstances.

**Table A.4.1 Typical route selection criteria**

Selection criteria
Maximum use of existing alignments
Minimum route length
Minimum construction cost
Minimum maintenance cost (where persistent geo-hazards require ongoing investment)
Minimum cumulative rise and fall
Minimum length of steep gradients
Minimum length of reduced horizontal standard due to topographic and other constraints
Minimum number and span of required bridges (though ordinarily covered in cost)
Ease of construction and required construction technology
Minimal environmental, social impact and cultural constraints, including the need to avoid cemeteries and sacred sites
Socio-economic benefits to be accrued
Minimal unfavourable geological conditions and slope geo-hazards
Sufficient freeboard above flood levels (whether coastal or riverine)
Availability of construction materials

Maximum use should be made of desk study data sources, including published topographical and geological mapping, environmental datasets and satellite imagery. Digital elevation data can be downloaded from internet sources and these can assist in route selection and alignment design, especially in steep terrain. The preferred route option is usually identified using desk studies and field investigations that are undertaken to a sufficient level of detail to allow confident comparisons to be made. The specific criteria used to select the preferred alignment may vary from project to project. It should be noted that construction cost will be influenced by a wide range of cost drivers, including route length, subgrade suitability, bridges, earthworks (including excavations in rolling terrain and embankments in flood-prone terrain), haulage costs for borrow and spoil disposal, and the need to mitigate geohazards, including flooding, erosion and landslides. These costs can be difficult to determine without detailed investigations and, particularly for LVRs, it is advisable not to consider route options that will require expensive and complex engineering mitigation.

Table A.4.2 contains some of the more important generic recommendations for route selection.



**Table A.4.2 Some generic recommendations for route selection**

Principles of route selection	
1.	The route should be as direct as possible (within the bounds of the geometric standards for the particular class of road), thereby minimising road user transport costs and probably minimising construction and maintenance costs as well.
2.	The route should not be so close to public facilities that it causes unnecessary disturbance. Cultural sites such as cemeteries, places of worship, archaeological and historical monuments should be specifically protected. Although a road is designed to facilitate access to hospitals and schools, it should be located at a reasonable distance away for safety and to reduce noise.
3.	Where the proposed location interferes with utility lines (e.g. overhead transmission cables and water supply lines), the decision between changing the proposed route and moving the utility line should be based on a study of the feasibility and the relative economics.
4.	The route should, as far as possible, be located along edges of properties rather than through them to minimise interference to agriculture and other activities and to avoid the need for frequent crossing of the road by the local people.
5.	The location should be such as to avoid unnecessary and expensive destruction of trees.
6.	The route should be 'integrated' with the surrounding landscape as far as possible. Normally, it is necessary to study the environmental impact of the road and ensure that its adverse effects are kept to the minimum.
7.	Where possible, marshy and low-lying areas and places having poor drainage and weak materials should be avoided.
8.	When feasible the preferred alignment should be one that permits a balancing of cut and fill to minimise borrow, spoil and haul.
9.	Ideally, the route should be as close as possible to sources of borrow materials and should minimise haulage of materials over long distances.
10.	Where the route follows the corridor of a railway line or river, frequent crossings of the railway or river should be avoided.
11.	Problematic and erosion-susceptible soils should also be avoided as much as possible.
12.	Areas prone to flooding and areas likely to be unstable due to toe-erosion by rivers should be avoided.

Fieldwork generally provides the greatest source of data necessary for route selection, with reconnaissance surveys allowing key factors and constraints to be identified. Drone surveys can provide useful supplementary terrain interpretation, especially when supplied with the software capable of deriving digital topographic mapping data. Geological and hydrological studies will allow difficult ground and flood-prone areas to be identified while environmental and social surveys will help identify and evaluate the various benefits and impacts associated with each route option.

## 4.5 Multi-Criteria Analysis (MCA)

### 4.5.1 Role of MCA

In some cases, the choice of route option and alignment might be obvious, especially where environmental, topographical and geohazard factors play only minor roles in decision-making. However, there may be instances where multiple factors need to be assessed, sometimes with conflicting implications for route selection. Certain factors, such as route length or environmental impact, may be judged to be more important than others, and this will vary from location to location, depending on circumstances. Multi-Criteria Analysis (MCA) is often used to assist in the route selection process. It allows each factor to be systematically assessed in either a quantitative or semi-quantitative way, and then combines scores to

reach an overall preferred route. It is usual to apply a weighting to each factor, depending on its agreed significance. For example, a route that is 20% longer than its alternatives may nevertheless be the preferred option if it minimises the need to acquire agricultural land or impinge on an area of forest.

Route selection for LVRs in Ghana may not need to adopt the MCA approach if it is clear from the outset which option is preferred, whether on length, cost or environmental grounds. However, the MCA approach requires the decision-maker to examine all relevant criteria and constraints and to adopt a process of stakeholder engagement in determining which factors are more important than others in arriving at the final route selection. The MCA approach is therefore a useful way of ensuring that all factors are considered in the case of new road construction, and where road improvement projects require some realignment. The remainder of this section provides background into the use of the MCA approach.

The following steps are required in the application of MCA for route selection:

1. List all criteria that are relevant to route selection. These include engineering, social, environmental, economic and planning considerations
2. Determine how each criterion is to be assessed
3. Rank each option according to each criterion
4. Apply a weighting to each criterion according to its perceived importance
5. Multiply rank x weighting for each criterion for each option and sum for each option to determine preferred route.

#### 4.5.2

#### List of criteria

Table A.4.3 lists some of the criteria that might typically be assessed in an MCA for route selection. Through consultation, it is important to engage with all potentially-affected stakeholders in order to ensure that the list of criteria is fully-inclusive of all concerns.

**Table A.4.3 Common criteria for consideration in MCA and route selection in general**

Primary Criteria	Secondary Criteria	Basis of Assessment
Engineering	<b>Road length</b>	km
	<b>Terrain.</b> Elevation, steepness and complexity of topography	Height, relief (m) slope angle (°)
	<b>Earthworks.</b> Need for major or continuous cuts and fills	m <sup>3</sup>
	<b>Drainage.</b> Number and spans of river crossings	Number and spans (m)
	<b>Materials.</b> Subgrade conditions and availability of construction materials	Good, moderate, poor
	<b>Geo-hazards.</b> Potential exposure to flooding, landslides	High, moderate, low
	<b>Cost.</b> Outline cost estimate associated with each option	\$ or local currency
Social	<b>Community access.</b> For example, changes to rural accessibility to public transport, education, employment, markets and health facilities	Good, moderate, low
	<b>Resettlement.</b> Need to rehouse families as a result of construction	Numbers affected and demographics
	<b>Severance.</b> Are communities split into sub-areas by the route option or are they separated from farmland for example	Numbers affected
	<b>Cultural heritage.</b> Are sites of cultural and religious importance affected by the route?	Numbers affected
	<b>Road safety.</b> Are pedestrians and road users at risk from traffic accidents?	Yes, no, numbers
	<b>Pollution.</b> Could road runoff or fuel and oil spillages affect habitats and could air pollution and noise affect public health?	Yes, no, number of locations, ecological severity

Primary Criteria	Secondary Criteria	Basis of Assessment
Environmental	<b>Ecology.</b> Are there any areas of important bio-diversity (gazetted or otherwise) impacted or at potential risk?	Yes, no, number and areas, ecological severity
	<b>Water.</b> Are there any water bodies at potential risk of pollution and are there any potable water supplies that could be affected?	Yes, no, number and importance, population potentially affected
	<b>Agricultural land.</b> Are there areas of prime agricultural land that will be removed?	Yes, no, area (km <sup>2</sup> )
	<b>Landscape.</b> Are there areas of high landscape value at potential risk, including in areas of tourism?	Yes, no
	<b>Erosion.</b> Are there any soils along the route option particularly prone to erosion?	Length (km)
Economic	<b>Viability</b>	Qualitative, NPV, EIRR, Cost-Benefit Analysis
Planning	<b>Sustainability.</b> Does the route satisfy regional and local sustainable development goals?	Yes, no, not applicable

### 4.5.3 Methods of assessment

Table A.4.3 also indicates how each criterion might be assessed. The method of assessment should be as objective as possible, maximising quantification, and subject to stakeholder consultation to ensure that all parties are satisfied with the method adopted.

### 4.5.4 Identifying the preferred option

In order to identify the preferred option through the use of MCA, it is necessary to carry out the following simple calculation:

- Rank each option for each criterion. The worst option is given the highest rank (e.g. where there are three options the longest length is given a rank of 3) then other ranks are determined on a pro-rata basis.
- For each option, multiply the criterion rank by its importance weighting.
- Sum all the products of rank and weighting.
- The option with the lowest sum is the preferred one.

For example, take the case where there are three route options: A, B and C. For ease of explanation only three criteria are considered: length, estimated cost and number of families to be rehoused. Length is considered the least important as this is a LVR and travel times are not an issue. Cost is more important than length, but the number of families to be relocated is considered by far the most important criterion. The weightings for these criteria are therefore assigned accordingly:

- Length: 1;
- Cost 3; and
- Number of families to be relocated: 6.

This weighting is not linear and can only be finalised through collective discussion and agreement with local communities. Table A.4.4 shows the MCA carried out for this case. Option A has the lowest sum of Rank x Weighting and is the preferred option.

**Table A.4.4 Hypothetical MCA application for illustration purposes**

Route Option	Criterion			Rank (pro-rata'd)			Rank x Weighting			Sum (R x W)
	Length (km)	Cost (\$)	Families relocated	Length	Cost	No. of families relocated	Length	Cost	Families relocated	
A	50	1.2 M	1	3	3	$1/7 \times 3 = 0.43$	$3 \times 1 = 3$	$3 \times 3 = 9$	$0.43 \times 6 = 2.58$	<b>14.58</b>
B	40	0.9 M	5	$40/50 \times 3 = 2.4$	$0.9/1.2 \times 3 = 2.25$	$5/7 \times 3 = 2.14$	$2.4 \times 1 = 2.4$	$2.25 \times 3 = 6.75$	$2.14 \times 6 = 12.84$	<b>21.99</b>
C	35	0.75 M	7	$35/50 \times 3 = 2.1$	$0.75/1.2 \times 3 = 1.88$	$= 3$	$2.1 \times 1 = 2.1$	$1.88 \times 3 = 5.64$	$3 \times 6 = 18$	<b>25.74</b>

#### 4.5.5

#### MCA case study

In order to illustrate use of the MCA approach in more detail, a practical example is taken from the Nimba Mountains in Liberia, to the east of Sierra Leone. MCA was used to help select the preferred route for a new haul road between mine sites. Given the significance of the Nimba Mountains for floral and faunal biodiversity, environmental considerations were considered among the most important. The following methodology was adopted:

- The project area was mapped in detail by environmental and biological specialists to delineate areas of high biodiversity (Level 1) that should be avoided entirely, and areas of intermediate biodiversity (Level 2) that should be avoided to the greatest extent possible.
- The Light Detection and Ranging (LiDAR) method of 3D laser scanning was commissioned and a Digital Elevation Model (DEM) produced with 2m contour intervals.
- Five route options were developed by manually plotting their approximate centre lines onto paper contour maps, taking account of maximum allowable gradient and minimum permissible curve radius. These routes were then digitised, and highway design software used to develop each route into a preliminary design. Earthworks quantities were calculated for each, based on cross-sections at 20m intervals.
- A range of Engineering, Environmental and Social Impact factors were taken into account as detailed in Table A.4.5.
- Each factor was quantified for each route option and the route option with the worst-case condition, for example greatest Level 1 land take, greatest cost, longest length, was assigned a rank of 5. The other route options were then assigned ranks proportionally according to their value for each factor. Each factor was given a weighting according to its perceived importance. For example, the total land take in Level 1 environmental areas was given the maximum weighting of 10, while cost and route length were given weightings of 6 and 5 respectively.
- By multiplying the rank and the weighting for each factor and then summing the total, an aggregate score is obtained for each route option and the route with the lowest score is the preferred option.

As shown in the Table, Option 2A has the lowest aggregate score, and was therefore the preferred option.

Table A.4.5 MCA case study: rankings, weightings and scores used in route selection

ENGINEERING					ENVIRONMENTAL					SOCIAL IMPACT				
Factor	Route	Rank	Weighting	Score	Factor	Route	Rank	Weighting	Score	Factor	Route	Rank	Weighting	Score
Cost	1	3.7	6	22.3	Level 1 areas	1	5	10	50.0	Areas of farmland removed	1	3.4	6	20.6
	2	4.2	6	24.9		2	1.4	10	14.3		2	3.9	6	23.6
	2A	3.7	6	22.4		2A	0.9	10	8.6		2A	3.9	6	23.6
	3	5	6	30		3	1.3	10	13.3		3	5	6	30.0
	3A	4.8	6	28.8		3A	0.8	10	8.2		3A	5	6	30.0
Length	1	3.5	5	17.4	Level 2 areas	1	2.8	5	13.8	Temporary dwellings removed	1	3	2	6
	2	3.4	5	17.0		2	2.9	5	14.3		2	0	2	0
	2A	3.4	5	17.2		2A	2.7	5	13.7		2A	0	2	0
	3	5	5	25.0		3	4.9	5	24.6		3	0	2	0
	3A	5	5	25.0		3A	5	5	25.0		3A	0	2	0
Compaction issues	1	3.5	2	6.9	Length above or through Level 1	1	5	5	25	Cultural heritage sites affected	1	0	8	0
	2	2.3	2	4.7		2	3.3	5	16.5		2	0	8	0
	2A	2.6	2	5.3		2A	2.1	5	10.5		2A	0	8	0
	3	5	2	10.0		3	2	5	9.8		3	0	8	0
	3A	4.1	2	8.2		3A	2	5	9.8		3A	0	8	0
Mass haul	1	3.5	2	6.9	Excess of cut to be spoiled	1	3.8	5	18.9	Need for borrow areas	1	0	4	0
	2	2.3	2	4.7		2	4.9	5	24.7		2	0	4	0
	2A	2.6	2	5.3		2A	4.4	5	22.2		2A	0	4	0
	3	5	2	10.0		3	4.2	5	21.2		3	0	4	0
	3A	4.1	2	8.2		3A	5	5	25.0		3A	0	4	0
Geohazards	1	5	5	25.0	Number of stream crossings	1	4.3	3	12.9	Total length of route	1	3.5	3	10.4
	2	5	5	25.0		2	2.5	3	7.4		2	3.4	3	10.2
	2A	5	5	25.0		2A	2.5	3	7.4		2A	3.4	3	10.3
	3	3	5	15.0		3	5	3	15.0		3	5	3	15.0
	3A	3	5	15.0		3A	5	3	15.0		3A	5	3	15.0
Mine facilities crossed	1	0	5	0	TOTAL OF ALL SCORES	1	78.54	131.15	26.58	OVERALL RANKING	1	236	4	
	2	0.1	5	0.4		2	76.61	87.33	23.58		2	188	2	
	2A	0.1	5	0.3		2A	75.41	72.57	23.58		2A	172	1	
	3	5	5	25.0		3	115	98.85	30		3	244	5	
	3A	3.6	5	17.9		3A	103.01	98	30		3	231	3	

SOURCE: Based on analysis carried out by URS, now AECOM LTD for ArcelorMittal Liberia Ltd

## 5. TRAFFIC

### 5.1 Introduction

The anticipated amount and type of traffic is one of the most important factors affecting the design of LVRs. It determines geometric features such as road widths and alignments as well as the design of the road pavement structure itself. The effect of traffic on the choice of road pavement is covered in Part B of the Manual.

The types of traffic using LVRs in Ghana vary significantly and include both motorised and non-motorised traffic involving a wide spectrum of road users from pedestrians to motorcycle taxis to large commercial vehicles. Appropriate traffic surveys are required to provide the information necessary for both geometric and pavement design. Traffic counts for LVRs should include motorised and non-motorised traffic including pedestrians.

### 5.2 Traffic counts

The estimate of the initial traffic volumes, both motorised and non-motorised, should be the Average Annual Daily Traffic volume (AADT) currently using the route. This is determined from traffic count surveys. A recommended approach to designing motorised traffic count survey forms is illustrated in Appendix A.1. Such a form can be used to capture additional data (such as whether or not a vehicle is loaded) which can contribute to the data set needed for economic appraisal purposes. Further such data can readily be provided by the enumerator on the reverse of the form, thus increasing the value derived from the counting process. Available as a simple spreadsheet, such a form can be adjusted to cater for specific circumstances including the likely traffic mix, and the type of count being conducted.

Types of traffic count may include:

- seven consecutive days counts, including at least one (1) market day;
- twelve-hour volume counts during the daytime including peak periods (usually 6.00am to 6.00pm);
- separate counts taken for all seasons of the year, but avoiding unusual events such as public holidays, ceremonies or severe weather;
- In the case for proposed paved roads the categorisation of vehicles into groups or classes; and
- separate counts undertaken for both directions of travel.

Where there is no information available on a factor to convert 12-hour traffic counts to 24-hour Average Daily Traffic volume (ADT), an hourly factor of 1.33 can be applied, i.e.

$$ADT = 12 \text{ hour count} \times 1.33 \quad \text{Equation 1}$$

Other survey methods used to determine traffic volumes and loading for pavement design purposes are covered in Part B of the Manual.

### 5.3 Estimating design traffic

Design traffic volume (AADT) used for geometric design purposes is generally determined as being the projected future traffic volume expected to be using the facility half way through its design life or design period. The design period to be used for LVRs is generally 15 years thus 7 years is used for estimating design traffic volumes for geometric design purposes.

The process by which the design traffic volumes and hence the traffic class is determined for geometric design purposes is illustrated in Figure A.5.1.

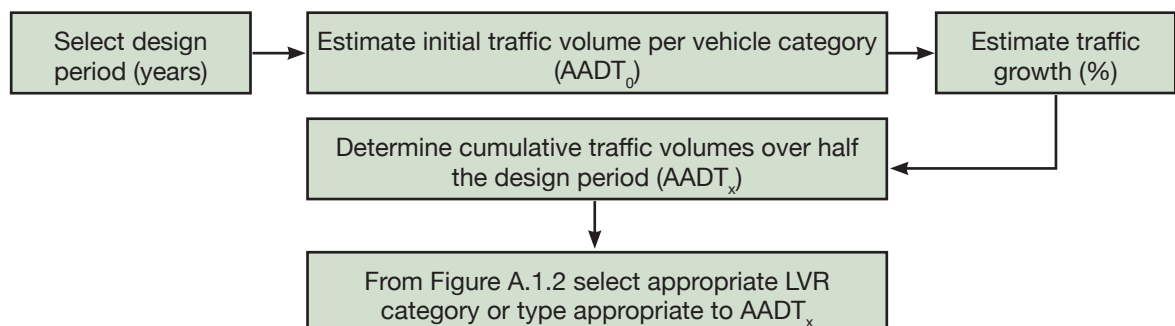


Figure A.5.1 Procedure to determine geometric Design Traffic Class

In order to determine the cumulative number of vehicles over the design period of the road, the following steps are required:

- Determine the initial traffic volume *in both directions* ( $AADT_0$ ) using the results of a traffic survey and any other recent traffic count information that is available. For paved roads, the corresponding daily *one-directional* traffic volumes for each type of vehicle is required e.g. car, bus, types of truck, and truck-trailers.
- In the case of existing unpaved roads of poor standard which are to be either rehabilitated, upgraded or paved, there can be a rapid increase in traffic. This will typically include diverted traffic as well as some new traffic above and beyond a normal steady growth rate. The diverted traffic depends on the characteristics of the local road network and often the trade-off between a faster more comfortable ride and additional distance. Estimates of this effect are best derived from local experience in similar circumstances.
- Estimate the annual traffic growth rate in terms of percentage (%).
- Determine the projected future traffic volume in *both directions* for the mid-life year of the road ( $AADT_x$ ). This can be determined by using Equation A.5.1 or by selecting the value from Table A.4.1 based on a mid-life of 7 years.

$$AADT_x = AADT_0 (1 + i)^x \quad \text{Equation 2}$$

Where “i” = annual traffic growth rate expressed as a decimal fraction.

“x” = number of years to mid-life of the design period.

**Worked example:**

The design traffic volume ( $AADT_x$ ) required for an LVR with a selected design period of 15 years, an initial  $AADT_0$  of 100 vehicles, and estimated traffic growth rate of 5% is determined as follows:

$$AADT_7 = 100 \times (1 + 0.05)^7 = 141 \text{ cumulative vehicles.}$$

Table A.4.1 may be used to obtain the same result.

**Table A.5.1 Mid-life (7 years) AADT for various initial AADTs and various growth rates**

Initial $AADT_0$ (vpd)	$AADT_7$ (vpd)										
	Traffic Growth Rate (%)										
	2	3	4	5	6	7	8	9	10	12	15
15	17	18	20	21	23	24	26	27	29	33	40
25	29	31	33	35	38	40	43	46	49	55	67
50	57	61	66	70	75	80	86	91	97	111	133
75	86	92	99	106	113	120	129	137	146	166	200
100	115	123	132	141	150	161	171	183	195	221	266
125	144	154	164	176	188	201	214	229	244	276	333
150	172	184	197	211	226	241	257	274	292	332	399
175	201	215	230	246	263	281	300	320	341	387	466
200	230	246	263	281	301	321	343	366	390	442	532
225	258	277	296	317	338	361	386	411	438	497	599
250	287	307	329	352	376	401	428	457	487	553	665
275	316	338	362	387	413	442	471	503	536	608	732
300	345	369	395	422	451	482	514	548	585	663	798
325	373	400	428	457	489	522	557	594	633	718	865
350	402	430	461	492	526	562	600	640	682	774	931

## 5.4 Traffic volume and traffic growth

Roads need to provide an acceptable level of service for many years, so the traffic level used in the design process must take account of traffic growth. In general, it is expected that spur roads (those that do not have 'through' traffic) will have lower traffic growth rates than the higher classes of road. However, each situation should be treated on its own merits taking into account any expected future developments.

For the purpose of geometric design, it is the daily traffic that is important. The use of mid-life AADTs reduces the risk of under-design that may occur if the initial traffic is used and of over-design if projected traffic at the end of the design life is used.

Normally a general growth rate is assumed or is provided by government, based on a combination of criteria including actual traffic counts, and the rate of growth in the number of registered vehicles in operation. However, local development plans may indicate higher growth rates in some places.

Where there is no existing road, estimating the initial traffic is difficult and estimating future traffic even more so. However, in many cases where a new road is proposed there is likely to be pedestrian and other non-motorised traffic and therefore some information on the likely vehicular traffic after the road is constructed.

In some cases, an economic evaluation may have been carried out to justify the road in the first place. This will have provided an estimate of the amount of goods transported by pedestrians and bicycles and the likely amount that will be carried by vehicles. In the unlikely event that there is no information available, the lowest class of engineered road (Type 1) should be designed. Historical growth rates of similar roads in any specific area should be considered as a proxy if available.

Four categories are defined for LVRs, Types 1, 2, 3 and 4, each being applicable over a specific traffic range. These ranges are quite wide and little difficulty should normally be experienced in assigning a suitable standard to a new road project. Where the expected traffic is near to a traffic boundary, the higher category of LVR should be adopted.

## 5.5 The Design Vehicle

For geometric design purposes the physical dimensions of vehicles are important. A truck requires more space than a motorcycle or a car, irrespective of whether the truck is loaded.

The way that vehicle size influences the geometric design of LVRs and HVRs is fundamentally different. When the volume of traffic is high, the road space occupied by different types of vehicle is an essential element in designing for capacity (i.e. the number of vehicles that the road can carry in a unit of time - vehicles per hour or per day). For example, at the highest traffic levels, when congestion becomes important, traffic volume dictates how many traffic lanes need to be provided.

For LVRs the volume of traffic as such is not sufficiently high to give rise to congestion issues. Congestion can, however, result from the disparity in speed between the variety of vehicles and other road users. The key issue here is thus traffic composition rather than traffic capacity. Nevertheless, it is the size of the largest vehicles that uses the road that dictates many aspects of geometric design. Such vehicles must be able to pass each other safely and to negotiate all aspects of the horizontal and vertical alignment. Trucks of different sizes are usually used to determine different standards; the driver of a large 6-axle truck would not expect to be able to drive on roads of the lowest standards.

In some countries the truck population in rural areas is predominantly composed of one or two types and sizes of vehicle. This makes it relatively easy to select a typical vehicle for setting geometric standards. Conversely, some countries have a wide variety of truck sizes. This makes it more difficult to select a suitable truck size for geometric design purposes.

It is prudent to be conservative in choosing the design vehicle for each class of road so that the maximum number of vehicle types can use them. Four distinctive design vehicles and their characteristics, based on AASHTO standards, used to develop the various design standards for the LVR categories are shown in Table A.5.2.



**Table A.5.2 Design Vehicle characteristics**

LVR Category	Design vehicle	Height (m)	Width (m)	Length (m)	Front overhang (m)	Rear overhang (m)	Wheel base (m)	Minimum design turning radius (m)
Type 1	Passenger Car (P)	2.0	1.8	4.7	0.75	1.2	2.9	7.3
Type 2	Single unit bus (BUS)	4.1	2.6	12.1	2.1	2.4	7.6	12.8
Type 3	Single unit truck (SU)	4.1	2.6	9.1	1.2	1.8	6.1	12.8
Type 4	Truck and semi- trailer (WB-40)	4.1	2.6	15.2	1.2	1.8	12.2	5.8

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

## 5.6 Traffic composition – proportion of heavy vehicles

The proportion of heavy vehicles in a typical traffic stream on LVRs in Ghana can be quite high. Design standards Type 2, Type 3 and Type 4 include a modification to cater for this.

- For Type 2 roads, if the number of large vehicles, defined as 3-axled (or more) trucks, exceeds 10 then a Type 3 should be used.
- For Type 3 roads, if the number of large vehicles is greater than 25, a Type 4 should be used.
- For Type 4 roads, if the number of large vehicles is greater than 40, the width of the paved surface is increased to 7.0 m and the shoulders reduced to 1.0 m. If there are more than 80 large vehicles, then the design standards for high volume road classes (as defined in Section A.1.2) should be used instead of Type 4.

Recommendations regarding the influence of heavy vehicles on design standards can also be found below each of the geometric design summary tables in Appendix A.2.

## 5.7 Traffic composition - use of Passenger Car Units (PCUs)

In order to quantify traffic for normal capacity design the concept of equivalent PCUs is often used. For example, a typical medium goods carrying vehicle requires about 2.5 times as much road space as a typical car hence it is equivalent to 2.5 PCUs. A motorcycle requires less than half the space of a car and is therefore equivalent to 0.25 PCU's.

The PCU concept was not originally intended for use in the geometric design of LVRs but is useful where traffic congestion is likely to be a problem. However, vehicles that move slowly cause congestion problems because of their speed rather than due to their size. In effect, they can be considered to occupy more road space than would be expected from their size alone.

Where the number of slow-moving vehicles, both motorised and non-motorised, is significant, the road standard should be improved to reduce congestion and retain the level of service appropriate to the traffic level of the motorised vehicles. This is best achieved by widening the shoulders. Where there is a high volume of non-motorised traffic and two- and/or three-wheeled motorised vehicles, defined as exceeding 300 PCUs per day, this can be expected to have a negative impact on traffic flow and road shoulder widening is recommended. The PCU concept is also useful for identifying the need for additional facilities or safety features where the numbers of pedestrians and slow-moving vehicles are high. Table A. 5.3 shows PCU conversion factors recommended for Ghana.

**Table A.5.3 PCU conversion factors**

Vehicle	PCU value
Pedestrian	0.15
Bicycle	0.2
Motorcycle	0.25
Bicycle with trailer	0.35
Motorcycle with trailer	0.45
3-wheeled vehicle	0.5
Animal drawn cart	0.7
Light goods vehicle	1.0
Bullock cart	2.0
Bus	2.0
Medium goods vehicle	2.5
Heavy goods vehicle	3.5
All based on a passenger car = 1.0	

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

**Worked example:**

A traffic count on an existing LVR to be upgraded revealed that 120 pedestrians, 80 bicycles, 60 motorcycles, 10 passenger cars, 2 buses, and 8 medium goods vehicles are expected to use the road in year 7. The passenger car unit equivalent (PCU) required for the design is determined as follows:

*Non-motorised transport, 2- and 3-wheeled motorised vehicles design PCU*

$$= [(120 \times 0.15) + (80 \times 0.2) + (60 \times 0.25)] = 49 \text{ PCUs per day.}$$

$$\text{Motorised } (\geq 4\text{-wheeled}) \text{ traffic design PCU} = (10 \times 1.0) + (2 \times 2.0) + (8 \times 2.5) = 25 \text{ PCUs per day.}$$

## 6. GEOMETRIC DESIGN

### 6.1 Introduction

Geometric design is the process whereby the layout of the road through the terrain is designed to meet the needs of all road users. Geometric standards are intended to meet two important objectives: to provide acceptable levels of safety and comfort for drivers through the provision of adequate sight distances, coefficients of friction, and road space for manoeuvres; and to minimise earthworks in order to reduce construction costs.

Geometric design covers the determination of road width, crossfall, horizontal and vertical alignments and sight lines, and the transverse profile or cross-section. The cross-sectional profile includes the design of the side drains, embankment heights, and side slopes, and is a vital part of geometric design. The cross-section essentially adapts the pavement to the road environment and is part of the drainage design. For example, wide paved shoulders and high camber or crossfall can significantly improve the operating environment for the pavement layers by minimising the ingress of surface water. Sub-surface water is a problem in low-lying flood-prone areas and in road cuttings. The height of embankment and the depth and type of drainage ditch have significant effects.

### 6.2 Design standards and their application

#### 6.2.1 Purpose of national standards

A national standard is not a specification, although it could and often is, incorporated into specifications and contract documents. Rather, a standard defines specific characteristics that should be achieved at all times, and nationwide. Amongst other things this helps ensure consistency across the country. For geometric standards, this means that road users know exactly what to expect, so that drivers are not surprised by unexpected changes in standard. The standards should guarantee a particular level of service, which is important for reasons of safety.

#### 6.2.2 Low Volume Road design scenarios

There are three design situations, namely:

- Upgrading from a lower class of road to a higher class;
- Designing a road to replace an existing track; and
- Designing a completely new road where none existed before.

Each of these scenarios is now addressed in turn. Further guidance on route selection and alignment design is provided in Chapter A.4.

##### Upgrading an existing road

Under this scenario, the basic alignments already exist, but the standards of the existing road are those of a lower class than that intended for the upgrade. The existing road alignment will need to be checked for compliance in terms of the new standard and may require a wider cross-section, higher design speeds, and therefore larger horizontal and vertical curvature standards. Hand held GPS equipment may be used to establish the existing horizontal alignment on site. In flat and rolling terrain, larger horizontal curve radii are usually achieved by means of minor realignments at the curves. Larger vertical curve lengths are usually more difficult to achieve but, depending on the terrain, can be attained through additional fill rather than deeper cutting. In more severe mountainous terrain, it may be necessary to make substantial realignments to avoid deep cuts. For example, following a contour more closely can serve to avoid a steep hill with inadequate sight distances over a crest.

Challenges occur in mountainous terrain when substantial widening is required. Under these circumstances it is not always possible to meet the standards of the new road class and therefore adequate warning signs need to be employed to alert drivers to the lower standards. Traffic calming measures should also be considered to reduce speed.

In general, however, the main improvements, apart from overall widening, are essentially spot improvements and do not require sophisticated design methods.

An alternative strategy for rehabilitating an old existing LVR or upgrading a track, is to go one step further and to accept much of the existing alignment. This does not include areas where road safety may be an issue, and for which specifically engineered measures, such as appropriate traffic calming or road widening

at blind crest curves may be required. Accepting the existing alignment may result in variable cross-section widths and travel speeds but will not incur significant earthworks costs. For such a strategy to be acceptable there are a number of qualifying conditions:

- The road is unlikely to change its function over its design life;
- The road is likely to be used mostly by local people and seldom by other users not familiar with the characteristics of the alignment; and
- Problem areas such as very tight curves, or steep grades, or other potentially hazardous locations are addressed through sound engineering solutions.

A design-by-eye approach may be adopted in such circumstances, but this calls for considerable experience and skill and should only be used under the guidance and supervision of an experienced Engineer. In mountainous and escarpment terrain the design-by-eye approach has an important role to play because an experienced Engineer is required to first identify where a route corridor should be located before the alignment can be designed within it using conventional approaches. Design-by-eye typically requires the use of remote sensing and walkover surveys to identify the basics of the preferred route before it can be designed.

An old earth road may sometimes be wider than required for the class of road determined on the basis of traffic. It may already have adequate side drains and reasonable crown height. In such a situation it may be less expensive to adopt the existing wider standard by choosing a higher road class than strictly necessary. Each case should be evaluated, and the most economical solution selected.

#### **Designing a road to replace an existing track**

In this case the existing geometric standards may be very much lower than those required. Substantial re-alignment may therefore be necessary, especially in rolling and mountainous terrain. However, the basic route selection will already have been carried out by virtue of the fact that there is an existing track and the main points constraining the alignment will already be defined. A hand-held GPS device may be used to establish the existing horizontal alignment on site. Although required re-alignments may be substantial, an experienced Engineer could in many cases adopt a design-by-eye approach. However, it is anticipated that, in general, the designs will be done with the help of computer-aided design programs based on accurate topographical and other survey data.

#### **Designing a new road**

Designing a geometric alignment for an entirely new road where none existed before is a considerably more complex process because of the different route alignments that are possible and the relative lack of information available at the beginning of the process. In many cases a pre-feasibility study will be necessary to identify possible corridors for the road and to decide whether the project is likely to be viable. This is followed by a feasibility study to determine the best routes within the best corridors and, finally, a detailed design study based on the route selected. The level of detail in this process depends critically on the class of road being designed and the terrain through which it will pass. Errors at this stage can be costly and, once the road is built, can also impose serious burdens in the future if the road requires excessive maintenance.

The principles of route selection as described in Chapter A.4 draw on data derived from various forms of surveys and field investigations. When analysed, these provide information about all the likely technical engineering issues related to the new road as well as insights into related social and environmental issues.

The final design is inevitably a compromise between many competing factors and there is not necessarily an assured way of resolving all of them to everyone's satisfaction. Engineering judgement and sound participatory processes are required in order to arrive at an alignment that is acceptable to all parties including those whose expressed view did not necessarily prevail.

### **6.2.3**

#### **Topographic survey**

It is recommended that some form of topographical survey be obtained or undertaken prior to any geometric design. The extent to which the topographic survey is required depends on the steepness and complexity of the terrain and the extent to which both the horizontal and vertical alignments are required to deviate from the existing alignment to conform with the (revised) geometric design criteria, as well as the need to mitigate traffic safety hotspots. If the project also involves carriageway widening, as most do, then topographic surveys will be required to allow the design of this widening, in conjunction with the geometric design and a sufficiently accurate ground model. Drone-flown surveys are increasingly used to undertake more sophisticated surveys and should be considered when the need arises as these types of surveys can be extremely cost effective. Alternatively, digital elevation models produced by the Shuttle Radar

Topography Mission (SRTM) and other platforms can be acquired from the internet which can be used for road planning and design purposes where a high degree of accuracy is not essential.

Where the drainage assessment identifies flood potential at low-lying points on the road it is necessary to draw on the results of the topographic survey when designing any raised sections of vertical alignment. It is important to ensure that in such circumstances the site inspection team includes highway and drainage specialists, as well as geological expertise related to rolling and mountainous terrain. The topographic survey must also be sufficiently detailed and broad enough in its geographical extent to allow the road improvement to be properly designed. Where the road passes through flat or rolling terrain and there are few geometric constraints to consider, the design can be based on simple elevational and road width adjustments making use of a simple surveyed strip map and standard cross-sections. A centre line survey using a standard hand-held GPS device may be adequate for this purpose.

## 6.3 Principal factors affecting geometric standards

### 6.3.1 Introduction

The principal factors that affect the appropriate geometric design of a road and which should be considered are:

- cost and level of service;
- traffic volume and composition;
- topography and terrain;
- roadside population (open country or populated areas);
- pavement type;
- soil type and climate;
- safety considerations;
- construction technology;
- administrative or functional classification;
- environmental considerations; and
- manmade features.

Since these factors can differ for every road, the geometric design of every road could, in principle, be different. This is impractical, and it is therefore normal practice to identify the main factors and to design a fixed number of geometric standards to cope with the range of values of these key factors. For LVRs in Ghana, four basic categories are defined based on traffic volume as described in detail in Section A.1.2. These are then modified, sometimes quite considerably, to cater for the other key factors. The most important of these are:

- traffic composition (including pedestrians and non-motorised vehicles);
- topography and terrain;
- roadside activity; and
- pavement type (paved or unpaved).

Varying standards of geometric design do not exist to cater specifically for climate and soil type. However, these factors are taken into account in the design of the drainage features of the road. Part C of the Manual details drainage design and shows how these affect the road cross-section and hence the geometric design.

The designer therefore has a very wide range of standards from which to choose, ensuring that a suitable standard is available for almost all situations. However, there may be cases where it is impossible to meet any of the standards, for instance in extremely severe terrain conditions. Under such circumstances the standards must be relaxed, and road users warned of the reduction through the provision of suitable permanent signage.

### 6.3.2 Cost and level of service

The cost of a road is usually the most critical factor in determining the design standards. It is also the most difficult factor to include in the setting of the design standards. The standard of a road is essentially an index of its level of service. 'Level of service' is a rather imprecise term that can mean different things to different people. However, it is generally accepted that its main components include: speed of travel, safety, comfort, trafficability, passability, and ease of driving, stopping and parking.

The chosen level of service is directly associated with traffic volume, so is not treated as a separate variable. The standards for levels of service simply increase from the lowest road class to the highest, remaining relatively constant within each class.

### 6.3.3 Traffic volume and composition

Details pertaining to traffic volume, traffic composition, and the design vehicle are described in Chapter A.5.

### 6.3.4 Topography and terrain

Topography and terrain are major factors in determining the physical location, alignment, sight distances, cross-section and other design elements. As a result of the considerable effect this has on road costs it is not economical to apply the same standards in all terrains. In flat terrain the topography may have little influence on the location of the alignment, but it would still impact design elements such as drainage. In mountainous terrain the route alignment and certain design features are entirely governed by the topography.

The geometric design elements of a road depend on the transverse terrain of the land through which the road traverses. Transverse terrains are typically categorized as being either Flat, Rolling, or Mountainous. These terrain classifications are not always consistently defined, and assessments are necessarily somewhat subjective. Mountainous terrain would however typically entail a road traversing side slopes between about 25% and 60%, i.e. between about 15° and 30°.

It is important to note that the terrain classification is a terrain feature and not a characteristic of the route alignment selected. It is a very broad classification that does not necessarily indicate difficult conditions or steep alignments. For example, a road in mountainous terrain may follow contour lines closely or be constructed in a river valley. In neither case is it inevitable that the alignment will be unduly difficult and the road relatively expensive, though that probability is higher in mountainous terrain. The following information is particularly relevant to LVR design in more difficult terrain.

#### Rolling terrain

An important aspect of geometric design concerns the ability of vehicles to ascend steep hills. Roads that need to be designed for very heavy vehicles or for animal drawn carts require specific standards to address this, for example, special climbing lanes. Fortunately, the technology of trucks has improved greatly over the years and, provided they are not grossly overloaded (which is a separate problem) or poorly maintained, they do not usually require special treatment. On the other hand, animal drawn vehicles are unable to ascend moderate gradients let alone steep climbs, so catering for them in rolling and mountainous terrain may not always be possible.

Climbing lanes cannot be justified on LVRs, nor can the provision of very low maximum gradients. The maximum gradients allowable for different road classes are shown in the Tables in Appendix A.2.

#### Mountainous terrain

In mountainous areas, the geometric standards for LVRs take account of the constraints imposed by the difficulty and stability of the terrain. The design standard may need to be reduced locally in order to cope with exceptionally difficult terrain conditions.

Every effort should be made to design the road so that the maximum gradient does not exceed the standards shown in Appendix A.2, however where higher gradients cannot be avoided, they should be restricted in length. It is recommended that gradients greater than 12% should not be longer than 250 m and relief gradients should also be provided as indicated in the tables. Horizontal curve radii of as little as 13 m may be unavoidable.

### 6.3.5 Roadside population

In any area having a reasonable sized population, or where markets and other business activities take place, the geometric design of the road needs to be modified to ensure good access and to enhance safety. This is done by providing:

- a wider road cross-section;
- lay-bys for passenger vehicles to pick up or deposit passengers;
- roadside parking areas; and
- traffic calming measures.

The additional road width depends on the status of the populated area through which the road is passing. If it is highly populated, an extra paved carriageway, or shoulder, of 3.5 m width is required in each direction

for parking and for passenger pick-up, and a 2.5 m pedestrian footpath is also recommended. Lesser populated areas require narrower shoulder widths of 2.5 m, but no additional footpath, although one could easily be provided if required. In addition, the main running surface should generally be paved at least 7.0 m wide. The pavement structure of the widening should be identical to the pavement of the running surface.

### 6.3.6 Pavement type

For a similar quality of travel there is a difference between the geometric design standards required for an unpaved road and a paved road. This is because of the very different traction and friction properties of the two types of surfaces. Higher geometric standards are generally required for unpaved roads.

### 6.3.7 Soil type and climate

Soil type affects the ideal geometric design, principally in terms of cross-section rather than in terms of the width of the running surface or road curvature. With some problem soils the cross-section can be adjusted to minimise the severity of the problem by minimising the speed of water flow, minimising the likelihood of excessive water inundation or penetration into the carriageway, and/ or moving problem areas further away from the carriageway. These aspects are dealt with under pavement design in Part B of the Manual and under drainage design in Part C.

Ideally, maximum gradients and road slopes for unpaved roads should also depend on soil types. However, this is usually impracticable because in most climatic regions almost any slope causes problems for unpaved roads. Recent research has demonstrated that gravel-surfaced roads are unsustainable in many more situations than had previously been acknowledged. This can also apply to earth roads. Consequently, every effort is being made to introduce or to develop more sustainable forms of surfacing for use where unpaved roads deteriorate too quickly. Such surfacing cannot usually be justified for long stretches of road where they are not essential, hence the concepts of spot improvements and environmentally optimised design (EOD) are being developed and refined.

### 6.3.8 Safety

Experience has shown that simply adopting design standards from developed countries will not necessarily result in acceptable levels of safety on rural roads. The main reasons for this include: the completely different mix of traffic, including relatively old, slow-moving and often overloaded vehicles; the large number of pedestrians, animal drawn carts and, possibly, motorcycle-based forms of transport; poor driver behaviour; and poor enforcement of regulations. In such an environment, methods to improve safety through engineering design assume paramount importance.

Although little research has been published on rural road safety in Ghana, the following factors related to road geometry are known to be important:

- Vehicle speed
- Horizontal curvature
- Vertical curvature
- Width of shoulders.

These factors are all inter-related and part of geometric design. In addition, safety is also affected by:

- traffic level and vehicle composition;
- inappropriate public transport pick-up/drop-off areas;
- poor road surface condition (e.g. potholes);
- dust (poor visibility); and
- slippery unpaved road surfaces.

These last three factors are related to pavement materials and structural design covered in Part B of the Manual.

Conflicts between motorised vehicles and pedestrians constitute a major safety risk on many rural roads where separation is generally not economically possible. The document *Ensuring Basic Access for Rural Communities* (World Bank, 2001) considers there to be sound safety-related arguments for keeping traffic speeds low in mixed traffic environments rather than aiming for higher design speeds, as would be the case for major roads. The use of wider shoulders is also suggested, and associated segregation measures recommended. These considerations have been incorporated into this Manual.

Traffic levels on a LVR and the mix of traffic using it are both considered to have an important bearing on safety. A considerable number of conflict situations can arise when the number of PCUs of nonmotorised

traffic, motorcycles and 3-wheeled motorised vehicles is large, even when the number of 2 (or more)-axle motorised vehicles is quite low. The proportion of heavy vehicles on LVRs in Ghana can be high, leading to the risk of more serious conflict situations. Though the overall traffic class standards are based on the number of 2 (or more)-axle motorised vehicles, additional safety features are based on:

- the number of PCUs of non-motorised traffic, motorcycles and 3-wheeled motorised vehicles; and
- The proportion of heavy vehicles in the motorised stream.

Pedestrians (and draft animals) find it very uncomfortable to walk on poorly graded gravel shoulders containing much coarse material. They usually choose to walk on a paved running surface, if available, despite the greatly increased safety risk. Thus, provision of a wider unsurfaced shoulder does not necessarily ensure greater safety. On the approaches to market villages, where the pedestrian traffic increases greatly on market days, provision of a separate footpath can be the best solution provided that the soil and topography is suitable.

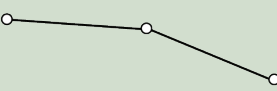

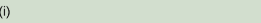

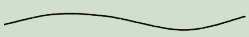
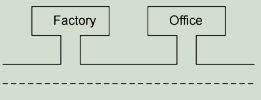
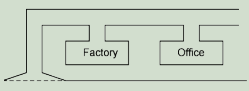


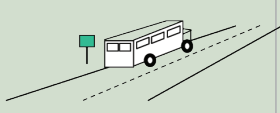
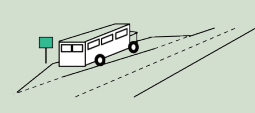






A checklist of engineering design features that affect road safety is given in Figure A.6.1. Not all are suitable for rural roads but the general philosophy of design for safety is emphasised. Further guidance on road safety measures is given in Chapter A.7.

The following factors should be considered when designing for safety:

- Wherever possible, non-motorised traffic should be segregated by physical barriers, such as raised kerbs (through villages and peri-urban areas).
- Designs should include features to reduce speeds in areas of significant pedestrian activity, particularly at crossing points. Traffic calming measures may need to be applied.
- To minimize the effect of a driver who has lost control and left the road, the following steps should be taken.
  - Steep open side-drains should be avoided since these increase the likelihood of vehicles overturning.
  - Trees should not be planted immediately adjacent to the road.
- Due to their high costs of installation and maintenance, guard-rails should only be introduced at sites of known accident risk.
- Junctions and access points should be located where full safe stopping sight distances are available.

Reference should be made to Chapter A.7 for further information and detail on the various physical measures which can be employed towards improving road safety, including road signage, traffic calming devices, and barriers.



	Undesirable	Desirable	Principle applied
<b>Route location</b>			Major routes should bypass towns and villages
<b>Road geometry</b>	(i)  (ii) 		Gently-curving roads have lowest accident rates
<b>Roadside access</b>			Prohibit direct frontal access to major routes and use service roads
			Use lay-bys or widened shoulders to allow villagers to sell local produce
			Use lay-bys for buses and taxis to avoid restriction and improve visibility
<b>Segregate motorised and non-motorised traffic</b>			Seal shoulder and provide rumble divider when pedestrian or animal traffic is significant
			Construct projected footway for pedestrians and animals on bridges
			Fence through villages and provide pedestrian crossings

SOURCE: ERA Manual for Low Volume Roads, 2016

**Figure A.6.1 Examples of effects of engineering design on road safety**

**6.3.9 Construction technology**

Particularly in areas where labour is abundant, scope usually exists to optimise the use of labour rather than rely predominantly on the use of heavy equipment for road construction. In such a situation, the choice of technology could potentially affect the manner in which standards are applied, especially in rolling and mountainous areas. This is because economic haul distance using wheelbarrows is typically limited to about 250 m, and for tractor-trailer units to about 8 km. Depending on the availability of labour, and of the institutional capacity needed to manage it effectively, this may place restrictions on progress in terms of earthworks volumes. In order to maintain the required levels of linear progress, it may in such circumstances be necessary to adjust the application of the standard where possible by:

- minimising cut and fill; and
- balancing earthworks through transverse rather than longitudinal haulage.

The result will typically be an alignment that more closely follows the existing terrain.

The design standards in rolling and mountainous terrain are always lower than in flat terrain but this reduction in standards need not necessarily be greater where labour-based methods are used. Following the contour lines more closely makes the road longer but the gradients can be less severe. Every effort should be made to preserve the same standards in the particular terrain encountered irrespective of construction method.

### 6.3.10 Administrative function

It is sometimes necessary to take account of the administrative or functional classification of roads in determining the design standards. This is because a certain standard may be expected by the road agency for each functional class of road irrespective of the current levels of traffic. Generally, the hierarchy of administrative classification broadly reflects the traffic levels observed but anomalies are common where, for example, traffic can be lower on a road higher in the hierarchy. It is recommended that the standards selected should be appropriate to the task or traffic level of the road in question but a minimum standard for each administrative class can also be adopted if it is policy to do so.

### 6.3.11 Environmental considerations

The location and design of the road can give rise to both (short term) effects and (longer term) impacts on the environment. Such effects and impacts are generally negative, but through careful design can sometimes be positive. In practice, the major concerns to be addressed typically include dust pollution from unpaved roads, quarry operations to extract surfacing gravels, and environmental degradation arising from logging activities due to increased access to remote areas. Environmental impact assessments should be carried out for every road design.

### 6.3.12 Manmade features

Manmade features such as agricultural, industrial, commercial, residential and recreational developments can place significant constraints on the choice of road alignment. Care should be taken to avoid the unnecessary destruction, demolition or severance of valuable properties. The road alignment should fit within any development planning scheme for the area. Information regarding land use and other physical features should be obtained from physical planners or the local authorities in order to coordinate the project with other planned land use.

## 6.4 Design speed and geometry

### 6.4.1 Definitions

Design speed is defined as the maximum (85th percentile) safe speed that can be maintained over a specified section of road when conditions are so favourable that the design features of the road govern the speed. Design speed is used as an index that essentially defines the geometric standard of a road, linking many of the factors that determine the road's level of service. These include traffic level, terrain, pavement type, road safety, population density and road function, to ensure that a driver is presented with a consistent speed environment.

The concept of design speed is most useful because it allows the key elements of geometric design to be selected for each standard of road in a consistent and logical way. For example, design speed is relatively low in mountainous terrain to reflect the necessary reduction in standards required to keep road costs reasonable. The speed is higher in rolling terrain and highest of all in flat terrain.

In practice the speed of motorised vehicles on many roads in flat and rolling terrain is only constrained by the road geometry over relatively short sections. But it is important that the level of constraint is consistent for each geometric standard and set of conditions.

In view of the mixed traffic that occupies the rural roads of Ghana and the cost benefit of selecting lower design speeds, it is prudent to select values of design speed towards the lower end of the internationally acceptable ranges. The recommended values, for both surface types, are shown in Table A.6.1.

Where changes in design speed are required because of a change in terrain, these should be made over distances that enable drivers to change speed gradually. Such changes should never be more than one design step at a time, and the length of the sections with intermediate standards (if there is more than one change) should be long enough for drivers to realise there has been a change before another change in the same direction is encountered (i.e. considerably more than one single bend). Where this is not possible, warning signs should be provided to alert drivers to the changes.

Table A.6.1 Design speeds

Road Class/ LVR Category Flat		Design Speed (km/h)			
		Flat	Rolling	Mountainous	Populated Areas
Type 1/Track	Unpaved	50	40	20	40
Type 2	Unpaved	50	40	20	40
	Paved	60	50	30	50
Type 3	Unpaved	60	50	30	50
	Paved	70	60	30	50
Type 4	Unpaved	60	50	30	50
	Paved	70	60	30	50

SOURCE: Modified from Ghana MRH Design Standards for DFR, 2009

### 6.4.2 Safe stopping sight distance

In order to ensure that the design speed is safe, the geometric properties of the road must meet certain minimum and maximum values. This ensures that drivers can see far enough ahead to carry out normal manoeuvres such as overtaking another vehicle or stopping if there is an object in the road.

The distance a vehicle requires to stop safely is called the stopping sight distance. It mainly affects the shape of the road on the crest of a hill (vertical curvature) but if there are objects near the edge of the road that restrict a driver's vision on approaching a bend, then it also affects the horizontal curvature.

The driver must be able to see any obstacle in the road hence the stopping sight distance depends on the size of the object and the height of the driver's eye above the road surface. The driver needs time to react and time is required for the braking action of the vehicle to slow the vehicle down, hence stopping sight distance is extremely dependent on the speed of the vehicle. The surfacing material and the characteristics of the road surface also affect the braking time so the values for unpaved roads differ from those of paved roads, although the differences are small for design speeds below 60km/h.

The stopping distance also depends on the longitudinal gradient of the road. It is harder to stop on a downhill gradient than on a flat road because a component of the weight of the vehicle acts down the gradient in the opposite direction to the frictional forces that are attempting to stop the vehicle.

Full adherence to the required sight distances is essential for safety reasons. On the inside of horizontal curves, it may be necessary to remove trees, buildings or other obstacles to obtain the necessary sight distances. If this cannot be done, the alignment must be changed. In rare cases where it is not possible and a change in design speed is necessary, adequate permanent signage must be provided. Recommended stopping sight distances are shown in Table A.6.2.

Table A.6.2 Stopping sight distance (flat terrain)

Design Speed (km/h)	20	30	40	50	60	70
Stopping Sight Distance (m)	20	30	50	60	80	100

SOURCE: Modified from Ghana MRH Design Standards for DFR, 2009

NOTE: In rolling and mountainous terrain these distances should be increased by 10%.

### 6.4.3 Safe stopping sight distance for single lane roads (meeting sight distance)

For single lane roads, adequate sight distances must be provided to allow the drivers of vehicles travelling in the opposite direction to see each other, and to stop safely if necessary. This distance is normally set at twice the stopping sight distance (as defined in Table A.6.2) for a vehicle that is stopping to avoid a stationary object in the road. An extra safety margin of 20-30 m is also sometimes added.

Although a vehicle is a much larger object than is usually considered when calculating stopping distances, these added safety margins are used partly due to the very severe consequences of a head-on collision, and partly because it is difficult to judge the an approaching vehicle's speed, which could be considerably

greater than the design speed. However, single lane roads will have a relatively low design speed, so meeting sight distances should not be too difficult to achieve.

#### 6.4.4 Intersection sight distance

Intersection sight distance is similar to stopping sight distance except that the object being viewed is another vehicle that may be entering the road from a side road or crossing the road at an intersection. The required safe sight distance in metres is considered to be approximately 3 times the vehicle speed in km/h. For example, the safe intersection sight distance required to an intersection for a vehicle travelling at 60 km/h is equal to  $60 \times 3 = 180$  m. The sight triangles for drivers approaching an intersection are illustrated in Figure A.6.2

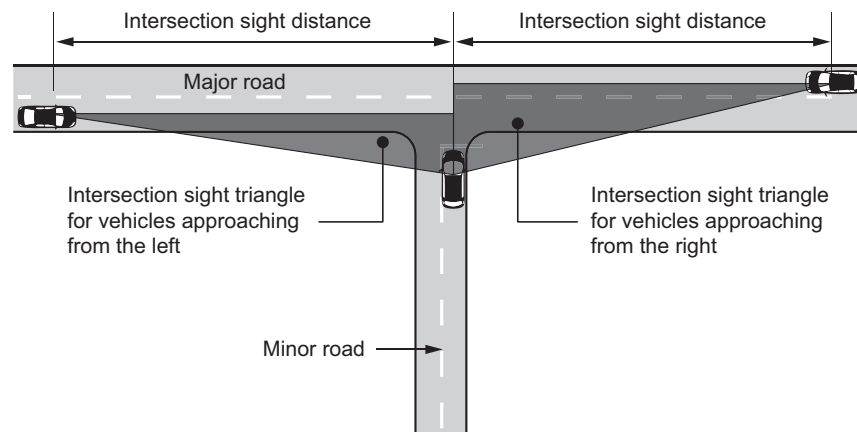


Figure A.6.2 Intersection sight triangles

#### 6.4.5 Passing sight distances

Factors affecting the safe sight distances required for overtaking are more complicated because they vary according to the capability of a vehicle to accelerate and the length and speed of the vehicle being overtaken. Assumptions are usually made about the speed differential between the vehicle being overtaken and the overtaking vehicle, but many road authorities have simply based their standards on empirical evidence. Current standards for the design of passing sight distance are based on percentage time spent following. This is because when vehicles are unable to overtake slow leading vehicles, groups of closely spaced vehicles form on the road, separated by large gaps, and the level of service deteriorates.

For single lane roads, overtaking manoeuvres are not always possible and passing manoeuvres ideally take place only at the designated passing places. On 2-lane roads, recommended passing sight distances are provided in Table A.6.3.

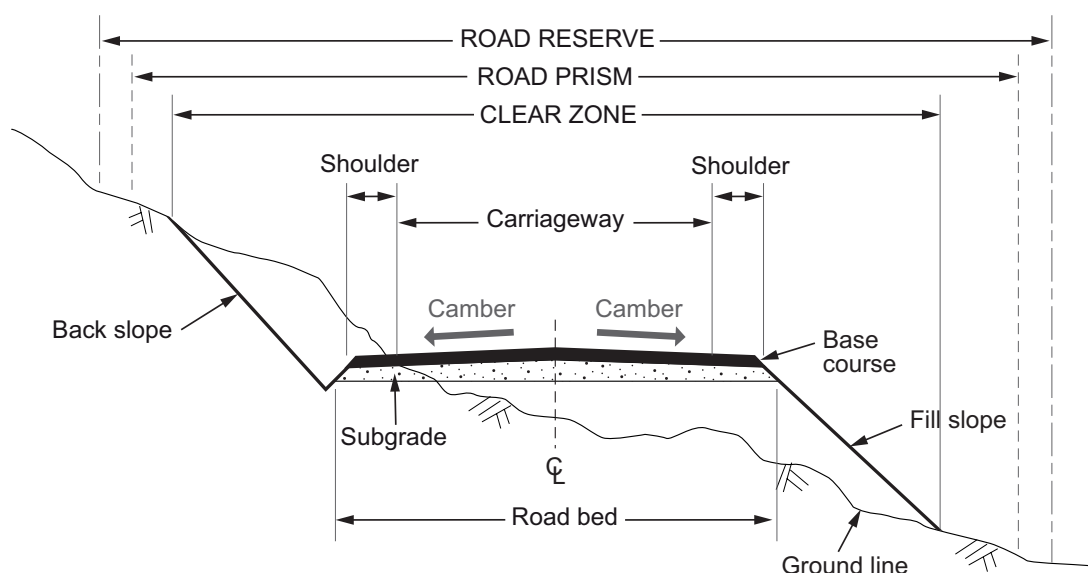
Table A.6.3 Recommended passing sight distances

Design Speed (km/h)	20	30	40	50	60	70
Full Overtaking Sight Distance (m)	115	170	230	290	350	420

### 6.5 Cross-sections

#### 6.5.1 Basic requirements

The cross-section of a road is essentially a geometric design feature. It is also intimately related to drainage issues as well as slope stability and erosion problems in rolling and mountainous areas. The cross-section includes the shape and size of the running surface, shoulders, the side slopes of embankments, side slopes to drainage ditches, the side drains themselves; and slopes to the batter. Figure A.6.3 shows the elements of a typical road cross-section. Recommended road cross-section configurations, dimensions and slopes for the various types of LVRs can be found in Appendix A.2.



**Figure A.6.3 Elements of a typical road cross-section**

Some aspects of cross-sectional design are concerned with drainage. Further details concerning this aspect are addressed in Part C of the Manual.

The cross-section of a road may need to vary over a route, but it is essential that any changes take place gradually over a transition length. Abrupt and isolated changes lead to increased hazards and reduced traffic capacity.

A common situation arises at bridge and water crossing points where the existing structure is narrower than desired. In such situations adequate warning signs must be erected to alert approaching drivers.

### 6.5.2 Width standards

Road width (running surface and shoulders) is one of the most important geometric properties since its value is very strongly related to cost and safety. The tables and typical cross-sections in Appendix A.2 show the standard road widths for each category of LVR.

In Ghana, LVRs which carry traffic volumes of AADT  $\leq 15$  vpd (Type 1) are effectively single lane roads. For LVRs with an AADT  $\leq 75$  vpd (Type 2) the traffic is considered to be less than 5 vehicles per hour in each direction. Vehicles will invariably travel down the centre of the road unless another vehicle is seen approaching. In this case, two vehicles can normally pass each other safely with the exception of larger vehicles which may need to slow down to walking pace. If there are significant numbers of these larger vehicles, then the road width recommended for traffic Type 3 should be used. Similarly, for Type 3 and Type 4 LVRs the same principle applies. Although provision for passing is made easier, if there is an excessive number of larger vehicles in the traffic stream the level of service is compromised.

Traffic volumes on Ghana's feeder roads, particularly Type 1 and Type 2 LVRs, are typically quite low and the roads generally do not require shoulders. However, for Type 3 and Type 4 LVRs, with the exception of gravel roads, shoulders are recommended particularly if the proportion of heavy vehicles is high. The width of gravel roads shown in the tables includes the theoretical widths of the shoulder as the surfacing of gravel or earth for these roads spreads across the whole surface to the edge of the road, reducing the significance of the distinction between the edge of the carriage and the start of the shoulder. Recommendations regarding widths of shoulders are given in Section 6.5.4.

Where spot improvements are made that involve a short length of paved surfacing (such as on a steep incline) then the width used should be that shown in the respective tables for paved roads. This includes the width of the shoulders.

### 6.5.3 Single lane roads and passing places

The recommended minimum carriageway width for single-lane roads is 3.0 m. Passing places may be required, depending on the traffic level. Provision for other traffic and pedestrians must be introduced through the adoption of wider shoulders if the numbers of other road users exceed specified levels. The increased width should allow two vehicles to pass at slow speed and hence depends on the design vehicle.

Passing places should normally be provided every 300 m to 500 m depending on the terrain and geometric conditions. Care is required to ensure adequate sight distances and the ease of reversing to the nearest

passing place, if required. Passing places should be built at the most economic locations rather than at precise intervals provided that the distance between them does not exceed the recommended maximum. Ideally, the next passing place should be visible from its neighbour.

The length of passing places is dictated by the maximum length of vehicle expected to use the road. In most cases, a length of 25 m (including tapers) for a passing place is sufficient for feeder roads.

The width of the passing places depends upon the width of the road itself. Enough overall width should be provided for two design vehicles to pass each other safely at low speed. Therefore, a total trafficable minimum width of 6.3 m is required (providing a minimum of 1.1 m between passing vehicles). Allowing for vehicle overhang when entering the passing bay, a total road width of 7.0 m is recommended at passing places.

#### 6.5.4

#### Shoulders

The shoulders of a road must fulfil the following functions:

- Provide sufficient structural support to the edges of the road;
- Allow wide vehicles to pass one another without causing damage to the road edge;
- Provide safe room for temporarily stopped or broken-down vehicles;
- Allow pedestrians, cyclists and other vulnerable road users to travel in safety;
- Allow water to drain from within the pavement layers; and
- Reduce the extent to which water flowing off the surface can penetrate into the pavement (often done by extending a seal over the shoulder).

Shoulders, paved or unpaved, have an important structural function and act as edge supports to contain the running carriageway without which the road may move laterally and deform. Therefore, there is a minimum width of shoulder that is required to perform this function. Depending on the properties of the material and the traffic, this can range from 0.5 to 1.5 m.

Shoulders perform an important traffic-carrying function for non-motorised vehicles and pedestrians. Additional shoulder widths are recommended should there be a high volume of non-motorised transport and 2- and 3-wheeled vehicles (defined as more than 300 PCUs per day on average).

When the road passes through denser areas of population, additional width is provided for parking and for other roadside activities. This widening may be considered to be shoulder widening although the need to provide access to shops and market areas means that the construction is usually of an extra carriageway.

In the case of paved roads, the shoulders may be gravel or paved, although the latter is recommended. Paved shoulders encourage non-motorised traffic to use the shoulders rather than the carriageway. On the approaches to villages and towns the local traffic builds up quite quickly and therefore consideration should be given to extending paved shoulders for considerable distances each side of the town or village. No standard guidance can be given, and each situation should be assessed on its merits.

Shoulders of unpaved roads should be constructed with the same material as the carriageway and have the same crossfall as the carriageway. In the case of paved roads where the shoulders are gravel, it is recommended that the crossfall of the shoulder be 1.5 to 2.0% steeper than that of the carriageway.

Shoulder widths in mountainous terrain are generally reduced to minimise the cost of earthworks. Usually the design of the overall cross-section in such terrain will include significant drainage and erosion control features and the shoulder will form an important component of this.

#### 6.5.5

#### Camber and crossfall

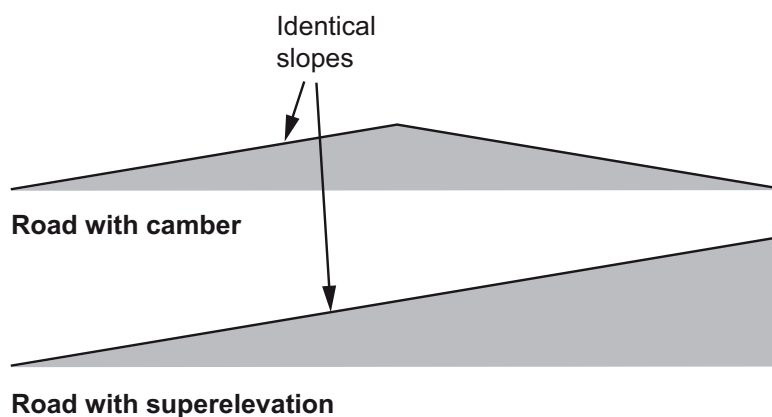
Camber is essential to facilitate surface drainage. Ponding of water on a road surface quickly leads to deterioration. Camber on a paved LVR should be 3%. In exceptional circumstances this may be reduced to 2.5% in the case of asphalt and 2.0% in the case of concrete if the quality of both the associated compaction and the eventual surface profile can be reliably assured.

Drainage is less efficient on rough surfaces and therefore the camber needs to be higher on unpaved roads. However, if the soil or gravel is susceptible to erosion, high values of camber can cause erosion problems. Steep camber can also cause driving problems but, on the lower standard rural roads where traffic is low, and where the road is a single carriageway, vehicles will generally travel in the middle of the road. Therefore, high levels of camber are not as much of a problem for drivers. In Ghana, unpaved rural roads are generally constructed using a camber of 6%, though this optimum camber is not always maintained over time.

### 6.5.6 Superelevation

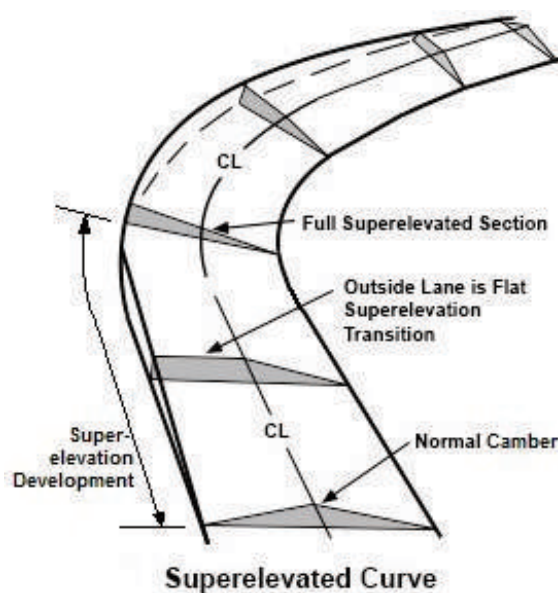
On low traffic feeder roads vehicles tend to use the inside half of the road on curves to avoid the effects of the adverse camber, so superelevation is generally not necessary. Furthermore, the use of superelevation means that rain water is required to travel over the full width of the carriageway, which in the case of unpaved roads can lead to excessive erosion of the road surface. It is, however, recommended that superelevation be applied where appropriate to all paved LVRs and unpaved secondary roads.

For paved LVRs the removal of adverse camber results in an effective superelevation of 3% (see Figure A.6.4). This is used to determine the minimum horizontal radius of curvature at such locations. However, where a large radius curve is difficult to achieve, superelevation of up to 8% can be used with a resulting decrease in the horizontal radius of curvature. Minimum radii for the various geometric standards and design speeds are shown in the tables provided in Appendix A.2.



**Figure A.6.4 Camber and superelevation**

The change from normal camber on straight sections of road to a super-elevated section should be made gradually (Figure A. 6.5). The length over which superelevation is developed is known as the superelevation development length and is dependent on design speed. Two-thirds of the superelevation development should be provided for on the tangent before the start of the curve. The remainder of the development is contained within the curve. The rate of change of road slope should be distributed uniformly throughout the length of the transition development.



**Figure A.6.5 Development of superelevation**

Recommended superelevation development lengths are provided in Table A.6.4.

**Table A.6.4 Superelevation development lengths**

Design speed (km/h)	Development length (m)
30	25
40	30
50	40
60	55
70	72
80	92

SOURCE: ERA Manual for Low Volume Roads, 2016

### Example

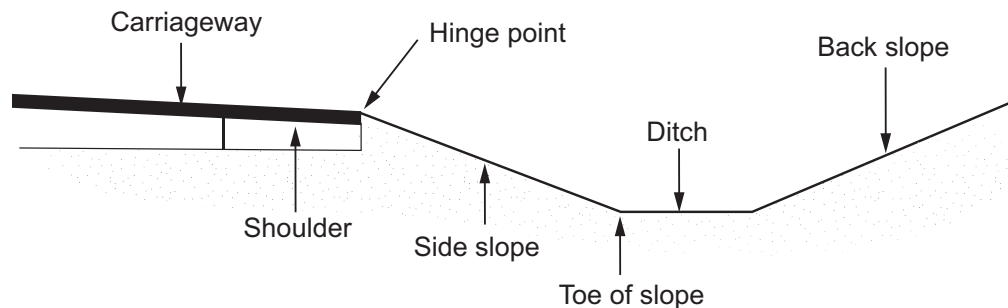
A new paved road designed to a 60 km/h design speed, which is to be constructed with a camber of 3% and a horizontal curve superelevation of 6% will require a superelevation development length of 55 m. The rate of change in road slope per linear metre of road over the development length can be calculated as follows:

$$\begin{aligned} \text{Road slope change (\%/m)} &= (\text{superelevation slope} - \text{camber slope}) / \text{development length} \\ &= (6\% - (-3\%)) / 55 \text{ m} = 0.16\% \text{ per m} \end{aligned}$$

## 6.5.7

### Side slopes and embankments

Side slopes should be designed to ensure the stability of the roadway and to provide a reasonable opportunity for recovery if a vehicle is out of control and leaves the carriageway. In addition, the position of the side drain invert should be a reasonable distance away from the road. This minimises the risk of infiltration of water into the road pavement structure if the drain should ever be full of water. Figure A.5.6 illustrates the road edge and defines the various elements.



**Figure A.6.6 Details of the road edge**

The side slope is defined as 'recoverable' when drivers can recover control of their vehicles should they encroach over the edge of the shoulder. Side slopes of 1:3 or flatter are recoverable. Research has shown that rounding at the hinge point and at the toe of the slope is also beneficial.

A non-recoverable slope is defined as one that is traversable but gives rise to situations in which most drivers will be unable to stop safely or return to the roadway easily. Vehicles on such slopes can be expected to reach the bottom of the slope. A slope that is steeper than 1:3 generally falls into this category.

The selection of side slope and back slope is often constrained by geotechnical considerations concerning embankment height, height of cuts, drainage considerations, and stability of slopes. These aspects are addressed in Part C of the Manual. Where slope stability problems are likely to occur, slope configuration and treatment should be based on expert advice. Basic topography, road reserve limits, and economic considerations also play an important role.

Flatter side slopes are recommended for low road embankments and where expansive clay is used in the embankment (Table A.6.5). On low embankments the cost of providing flatter side slopes is more affordable than on high embankments, and less land take is required.



**Table A.6.5 Recommended side slopes for standard cross-sections for traffic safety**

Material	Height of slope (m)	Side slope	Safety classification
<b>All standard fill materials</b>	0 - 1.0	1V:4H	Recoverable
	1.0 - 2.0	1V:3H <sup>(2)</sup>	Marginal
	2.0 - 3.0	1V:3H	Marginal
	>3.0	1V:1.5H <sup>(3)</sup>	Critical
<b>Expansive clays</b> <sup>(1)</sup>	0 - 2.0	1V:6H	Recoverable
	>2.0	1V:4H	Recoverable

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

NOTES:

1. The use of expansive clays on road formation is only recommended on very low traffic unpaved roads.
2. 1V:4H side slope is recommended for secondary roads.
3. For fill slopes safety barriers should be provided on embankments >3 m high with slopes steeper than 1V:3H.

### 6.5.8 Clear zones

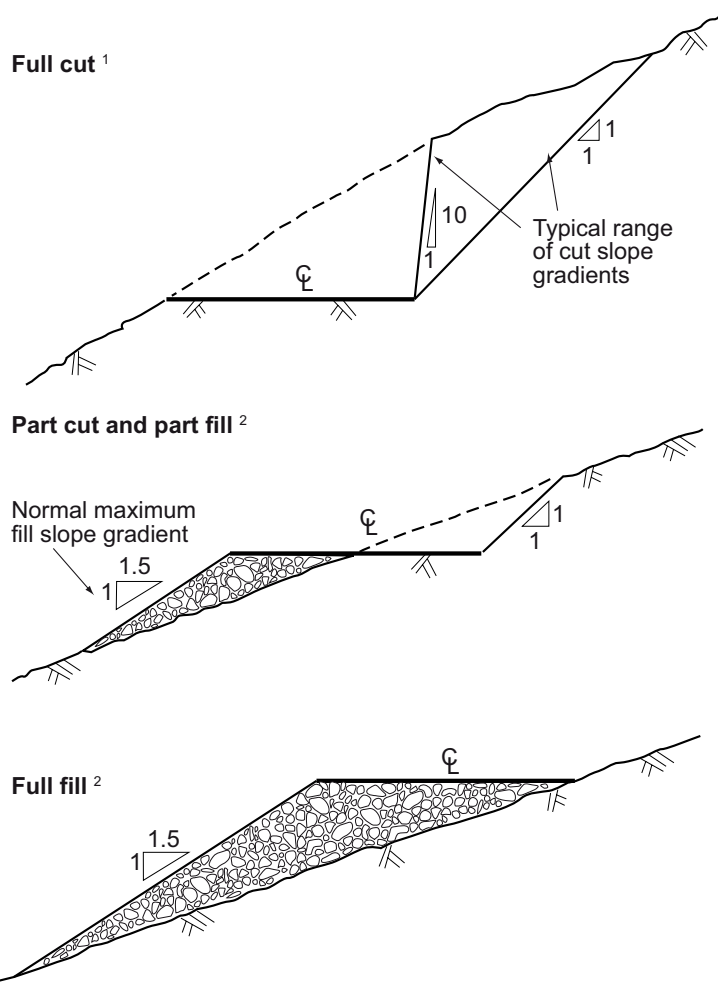
Many accidents are made more severe because of obstacles that an out-of-control vehicle may collide with. The concept of clear zones identifies these obstacles and attempts to eliminate such hazards.

The most common hazards are road signage, and the headwalls of drainage culverts. The clear zone defined for high volume roads is substantial (15 m is typical) but for LVRs this is impractical. Ideally it should extend at least to the toe of the embankment and should always be greater than 1.5 m from the edge of the carriageway. At existing culverts and bridges the clear zone should not be less than the carriageway width. If this criterion cannot be met, the structure should be widened. New drainage culverts must be designed with a 1.5 m clearance from the edge of the shoulder. Horizontal clearance to road signs and marker posts must also be an absolute minimum of 1.5 m from the edge of the carriageway. Vertical clearances between the top of the road surface to overhead structures, such as overpass bridges, must be at least 5 m as an absolute minimum.

### 6.5.9 Choice of cross-section in rolling and mountainous terrain

For new road construction in rolling or mountainous terrain there are essentially three main choices of cross-section. As shown in Figure A.6.7, there are: full cut, part cut/part fill, and full fill.

In practice the vertical and horizontal alignment constraints impose a significant control on the choice of cross-section at any given location. Ideally, a balance of cut and fill, either in the same cross-section or within economic haul distance, is desirable on economic and environmental grounds where side slopes are up to about 25°. Where side slopes are 30° or more the cost implications of constructing the road on fill become increasingly significant and full cut becomes the most economic option, as shown in Table A.6.6. The reason for this is that fill slopes become difficult to construct on side slopes much above 25°, when the use of expensive retaining walls and reinforced fill is necessary. Full cut is the cheapest option on increasingly steep slopes, even when spoil haulage and safe disposal are taken into account. Another advantage with a full cut cross-section is that there is little need for subgrade compaction. On labour-based LVR projects this can be an important consideration. Table Figure A.6.7 summarises some of the main advantages and disadvantages associated with the three main options.



<sup>1</sup> May require cut slope protection or stabilisation above the road.  
<sup>2</sup> Will require below-road retaining wall on slopes steeper than 25° unless rock fill or reinforced fill is used.

**Figure A.6.7 The three main cross-section options**

**Table A.6.6 Cost comparison for full cut, half cut-half fill and full fill cross-sections**

Natural slope angle (degrees)	Approximate cost units per metre run of road		
	Full cut	Half cut, half fill	Full fill
10	15	5	12
20	43	16	39
30	77	170	437
40	204	319	559
50	305	505	n/a

SOURCE: Modified from Hearn, 2011

NOTE: High full fill costs for natural slopes >30° are due to retaining wall requirements

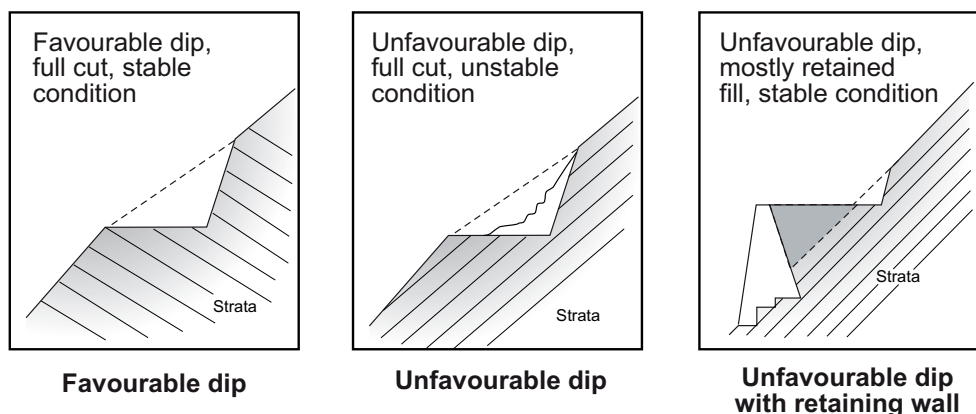
**Table A.6.7 Advantages and disadvantages with types of cross-sections**

Type of section	Advantages	Disadvantages
<b>Full cut</b>	<ul style="list-style-type: none"> <li>▪ Road formation requires minimum compaction because it is formed entirely in natural ground.<sup>1</sup></li> <li>▪ No requirement for fill slope placement or compaction.</li> <li>▪ Potential source of fill material for use elsewhere along the road.</li> <li>▪ Potential source of rock, if present, for masonry, aggregate and drainage backfill.</li> <li>▪ Usually the only practical solution if existing ground slope &gt; 50°.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Greater height of cut may lead to greater instability and/or erosion.</li> <li>▪ May result in large volumes of spoil requiring safe disposal.</li> </ul>
<b>Part cut and part fill</b>	<ul style="list-style-type: none"> <li>▪ Volume of spoil minimised if balanced cut/fill can be obtained.</li> <li>▪ Minimum impact on landscape.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Requirement for fill placement and compaction.</li> <li>▪ May require below-road retaining wall or reinforced fill to avoid excessive area of fill if existing ground slope &gt; 25°.</li> </ul>
<b>Full fill (including wall-retained fill)</b>	<ul style="list-style-type: none"> <li>▪ Usually the only practical solution when traversing re-entrants or water courses.</li> <li>▪ Usually the only practical solution (with fill retaining structure) on steep rock slopes if jointing is unfavourable to stability</li> </ul>	<ul style="list-style-type: none"> <li>▪ Requirement for significant fill import, ground preparation (including benching), placement and compaction.</li> <li>▪ Will require below-road retaining wall or reinforced fill to avoid excessive fill area if existing ground slope &gt; 25°.</li> <li>▪ Impracticable if existing ground slope &gt; 40°.</li> </ul>

SOURCE: Modified from Hearn 2011

NOTE: Transported soils and some low-density residual soils (Section A.3.1) exposed in the subgrade of some full cut sections will require compaction and possibly replacement.

Depending upon the geological conditions, full cut cross-sections can provoke slope instability through the removal of slope support. This applies to both new road construction and the widening of existing roads and is the case for slopes formed in both rock and soil. Where the strata or the main jointing patterns in the rock can be seen to be dipping into the slope (“favourable dip” in Figure A.6.8), the excavation of the cut slope is unlikely to trigger large-scale sliding. Where the strata dip is unfavourable then excavation can be expected to trigger slope instability problems. The extent of such risks depends upon the strength of the rock along its joints, which is a function of tightness, the degree of weathering and water pressures. These factors should be considered if a full cut cross-section is selected.



**Figure A.6.8 Unfavourable and favourable rock strata and jointing patterns**

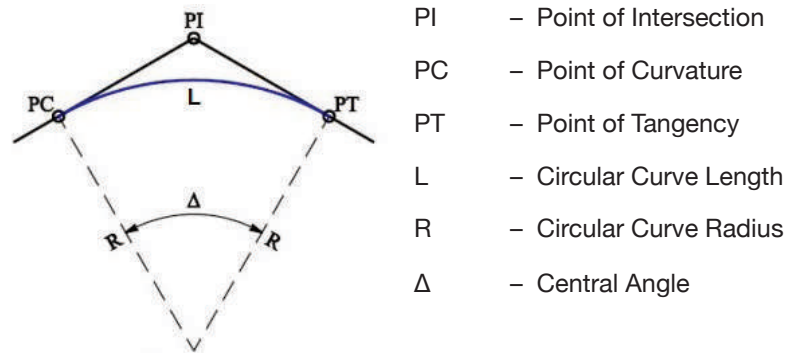
The same situation occurs in soil slopes. Where the soils are inherently loose and weak, where they have previously failed and where water tables are high, full cut excavation usually leads to slope problems. The alternative involves retained fill or reinforced fill, both of which are expensive and both of which can be difficult to construct in confined spaces and where foundations are weak. When faced with dilemmas

such as these, it is advisable to consult a specialist engineering geologist or geotechnical engineer. Where the geological conditions are so extreme that expensive technical solutions are required, it may be more economic in both the short and long term to change the road alignment.

## 6.6 Horizontal alignment

### 6.6.1 Components of horizontal alignment

The horizontal alignment consists of a series of straight sections (tangents) connected to circular curves. Long tangents, generally in excess of 4 km, should be avoided as this usually leads to excessive speeding. The horizontal curves are designed to ensure that vehicles can negotiate them safely. The alignment design should avoid sharp changes in curvature, thereby achieving a safe uniform driving speed. The standard components of a simple horizontal circular curve are illustrated in Figure A.6.9.



**Figure A.6.9 Elements of a simple horizontal curve**

In order for a vehicle to move in a circular path an inward radial force is required to provide the necessary centripetal acceleration or, in other words, to counteract the centrifugal force. This radial force is provided by the sideways friction between the tyres and the road surface assisted by the crossfall or superelevation.

For all paved roads and higher order unpaved roads there are also constraints on the maximum crossfall or superelevation slopes, which translate directly into minimum values of horizontal radii of curvature. The recommended minimum radii based on design speed are shown in Table A.6.8.

**Table A.6.8 Minimum horizontal radii of curvature**

Design Speed (km/h)	Maximum Superelevation (%)	Minimum Radius (m)
20	-	-
30	3	40
40	4	70
50	5	105
60	6	150
70	7	200

### 6.6.2 Curve length

For reasons of safety and ease of driving, curves near the minimum for the design speed should not be used at the following locations:

- On high fills, because the lack of surrounding features reduces a driver's perception of the alignment;
- At or near vertical curves (tops and bottoms of hills) because the unexpected bend can be extremely dangerous, especially at night;
- At the end of long tangents or a series of gentle curves, because actual speeds will exceed design speeds; and
- At or near intersections and approaches to bridges or other water crossing structures.

The horizontal alignment should maximise the length of road where adequate sight distances facilitate safe overtaking. Overtaking is difficult on curves of any radius and hence the length of curved road should be minimised. This requires curve radii to be relatively close (but not too close) to the minimum for the design speed to maximise the length of straight sections. This view is currently accepted as good practice for roads except in very flat terrain, but care should be exercised to ensure the curves are not too tight.

For small changes of direction, it is often desirable to use a large radius of curvature. This improves the appearance and reduces the tendency for drivers to take risks. In addition, it reduces the length of the road segment and therefore the cost of the road provided that no extra cut or fill is required.

The recommended lengths for horizontal curves based on design speed are shown in Table A.6.9.

**Table A.6.9 Recommended minimum length of horizontal curves**

Design Speed (km/h)	20	30	40	50	60	70
Minimum Curve Length (m)	40	50	70	80	100	120

SOURCE: Modified from MRH Design Standards for DFR, 2009

### 6.6.3 Curve widening

Widening of the carriageway where the horizontal curve is tight is sometimes necessary to ensure that the rear wheels of the largest vehicles remain on the road when negotiating the curve; and, on two lane roads, to ensure that the front overhang of the vehicle does not encroach on the opposite lane. Widening is therefore also important for safety reasons.

Vehicles need to remain centred in their lane to reduce the likelihood of colliding with an oncoming vehicle or driving on the shoulder. Sight distances should be maintained as addressed previously. The levels of widening shown in Table A.6.10 are recommended except for roads carrying the lowest levels of traffic (AADT  $\leq 15$ ). Widening should be applied on the inside of the curve and introduced gradually.

**Table A.6.10 Widening recommendations**

	Single Lane Roads				2-Lane Roads				
	$\leq 20$	21-30	31-40	41-60	$\leq 20$	21-50	51-150	151-300	301-400
Curve radius (m)	$\leq 20$	21-30	31-40	41-60	$\leq 20$	21-50	51-150	151-300	301-400
Increase in width (m)	<sup>(1)</sup>	1.0	0.75	0.5	<sup>(1)</sup>	1.5	1.0	0.75	0.5

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

NOTE:

1. See Section A.6.7.4 dealing with hairpin stacks

## 6.7 Vertical alignment

The two major elements of vertical alignment are the gradient, which is related to vehicle performance and level of service; and the vertical curvature, which is governed by safe sight distances and driver comfort criteria.

The vertical alignment of a road can appear more complicated than the horizontal alignment due to the inclusion of the algebraic difference in gradient (G %) between the uphill and downhill sides. In addition, the vertical curve is parabolic rather than circular.

The required sight distance for safety is the basic stopping sight distance.

### 6.7.1 Gradient

Where possible, gradients should be kept as low as possible, but 0.5% is considered to be the absolute minimum to assist with the longitudinal drainage. Two-wheel drive trucks can generally cope with gradients of 15%, except when heavily laden. International rural road standards have a general recommended limit of 12% for small heavily laden trucks, but this can be increased to 15% for short sections (< 250 m) in areas of difficult terrain.

For driving consistency, and hence safety, in terrains other than mountainous, limiting values of gradient are also often specified. In flat and rolling terrain a maximum gradient of 7% and 10% respectively is appropriate for LVRs.

Where truck speeds are reduced to an unreasonable level as a result of climbing excessively long lengths of steep gradients, climbing lanes can be considered. However, as the inconvenience of slow-moving vehicles is more pronounced on roads carrying high volumes of traffic, climbing lanes are not normally appropriate for LVRs.

Regional experience indicates that, on account of gravel loss, unpaved road sections in excess of 6% gradient are often unsustainable in the medium to long term. It is expected that the use of alternative surfacings will become more common in Ghana to provide a more sustainable solution in critical areas such as on steep sections. Therefore, criteria need to be developed to identify the critical areas where alternative surfacings are to be recommended. The recommended maximum gradients based on design speed are shown in Table A.6.11.

**Table A.6.11 Recommended Maximum Gradient**

Design Speed (km/h)	≤30	40	50	60	70
Maximum Gradient (%)	10	7	6	5	4

SOURCE: Modified from Ghana MRH Design Standards for DFR, 2009

### 6.7.2 Crest curves

The minimum length of the curve (L) over the crest of the hill between the points of maximum gradient on either side is related to gradient and to the stopping sight distance and therefore to the design speed. Note that although drivers would like to overtake on hills, the required sight distance for safe passing on crests is much too large to be economical on LVRs.

The minimum length of the curve is defined by  $L=KG$ , where K is a factor derived from the stopping sight distance, and G is the algebraic difference in grade (%). Minimum values of K are provided in Table A.6.12 and minimum curve lengths in Table A.6.14.

**Table A.6.12 Minimum values of K for Crest Curves**

Design Speed (km/h)	40	50	60	70	70
Minimum K	4	8	14	30	4

SOURCE: Modified from MRH Design Standards for DFR, 2009

#### Example

The minimum length of crest curve required for a road with a design speed of 40 km/hr on a steep uphill stretch of 10% followed by a downhill stretch of the same slope =  $4 \times (+10\% - (-10\%)) = 80$  m. The minimum curve length of 35 m (for 40 km/h) can be adopted in extreme cases.

### 6.7.3 Sag curves

Sag curves are the opposite of crest curves in that vehicles first travel downhill and then uphill (through a dip). In daylight the sight distance is normally adequate for safety and the design criterion is based on minimising the discomforting forces that act upon the driver and passengers when the direction of travel changes from downhill to uphill. On rural roads such considerations are somewhat less important than road safety issues. However, at night the problem on sag curves relates to whether the illumination provided by headlights is sufficient for the driver to see the road far enough ahead. This is influenced by the height of the headlights above the road and the angle of the beams.

The curve lengths for feeder roads may be based on driver comfort criterion as the driving speed at night is assumed to be low and therefore sight distance is not considered a significant influence. For secondary roads however, where travel speeds are expected to be higher, the determination of curve length is based on headlight illumination sight distance. Minimum values of K are provided for in Table A.6.13 and minimum curve lengths in Table A.6.14 .

**Table A.6.13 Minimum values of K for sag curves**

Design Speed (km/h)	40	50	60	70	70
Minimum K	5	7	10	18	4

SOURCE: Modified from MRH Design Standards for DFR, 2009

**Example**

The minimum length of sag curve required for a road with a design speed of 60 km/h on a steep downhill stretch of 10% followed by an uphill stretch of the same slope

=  $10 \times (+10\% - (-10\%)) = 200$  m. The minimum curve length of 50 m (for 60 km/h) can be adopted in extreme cases.

**Table A.6.14 Minimum vertical curve length**

Design Speed (km/h)	40	50	60	70	70
Minimum vertical curve length (m)	35	40	50	70	4

SOURCE: Modified from MRH Design Standards for DFR, 2009

#### 6.7.4 Hairpin stacks

Climbing sections on mountainous roads are often best designed using hairpin stacks. The advantages are that the most favourable site for ascending the mountain can be selected and a more direct and therefore shorter route will often be possible. However, there are several limitations. For example, the limited space available to construct cut and fill slopes necessitates either a reduction in geometric standards or more expensive retaining structures. For LVRs the former solution should be adopted. Furthermore, a lack of suitable sites for disposal of spoil and access difficulties for plant can pose difficulties during construction.

If there are problems of slope instability, they may extend from one loop to another and so the advantage of attempting to choose the most stable section of the mountain is lost. This issue is dealt with in Part C of the Manual.

Storm water run-off becomes very concentrated on hairpin stacks, so although the number of drainage structures and erosion controls may be reduced, their capacity needs to be increased. The risk associated with failure of the drainage system is therefore correspondingly high and minimising this risk adds to the cost. If the topography allows, some of the problems of stacked hairpins can be reduced by creating several stacks that are offset from each other and staggered across the slope so that not immediately above or below each other. This reduces drainage problems and limits the danger of instability to fewer hairpin loops.

The key aspect of the geometric design of hairpin stacks is that the curves should be as flat as possible, and the tangents should be used to achieve the ascent. This is because vehicle traction is much more efficient when the vehicle is travelling in a straight line. The maximum gradient through the hairpin curve itself should be 4% for AADT >75 vpd and up to 6% for AADT <75 vpd.

Considerable curve widening is required where the curve radius is small to ensure that large vehicles can negotiate the bends (Table A.6.10). Widening is also required for safety reasons and, if space allows, to provide a refuge area if a vehicle breaks down. For LVRs it is recommended that the curve radius at the centre line of the road should be an absolute minimum of 13 m and the road should be at least 8 m wide.

## 6.8 Harmonisation of horizontal and vertical alignment

### 6.8.1 Situations to avoid

When considering the horizontal alignment of a road, the designer must ensure that the other elements of the design are complementary to each other. It is therefore important to note that there are a number of design situations that could produce unsatisfactory combinations of elements despite the fact that the design standards have been followed. Such designs could provide surprises for drivers by presenting them with unfamiliar conditions that constitute a safety risk.

Avoiding such design risks is more important for classes of road where design speeds are higher and traffic volumes are much greater and, consequently, any accidents resulting from poor design are likely to be more severe and more frequent. However, in many cases, avoidance of such designs does not necessarily impose a significant cost penalty and therefore the principles outlined below should be applied to roads of all classes.

### Reverse curves

This is a horizontal curve followed immediately by a curve in the opposite direction. This configuration makes it difficult for the driver to keep the vehicle on its intended side of the road. In the case of paved LVRs, it is also difficult to accommodate the required superelevation development within the space available.

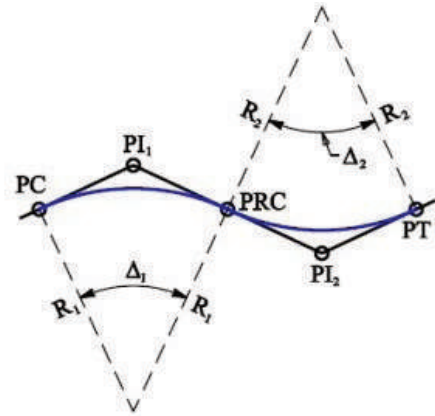


Figure A.6.10 Reverse curve to be avoided

### Broken back curves

This occurs when two horizontal curves in the same direction are connected by a short connecting tangent. Drivers do not usually anticipate that they will encounter two successive curves close to each other in the same direction. In the case of paved LVRs, it is difficult to accommodate superelevation development within the space available in the situation where curve radii differ.

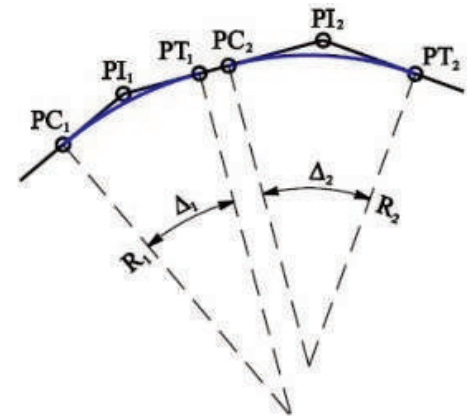


Figure A.6.11 Broken back curve to be avoided

### Compound curves

This is a horizontal curve connected to another of different radius. Drivers do not usually expect to be confronted by a change in radius, and therefore in design speed. If the change is too great, some drivers are likely to be travelling too fast when entering the tighter part of the compound curve from the larger one. Compound curves should be avoided where curves are sharp and where the difference in radii is large. Thus, in any compound curve the smaller radius should not be less than 67% of the larger one.

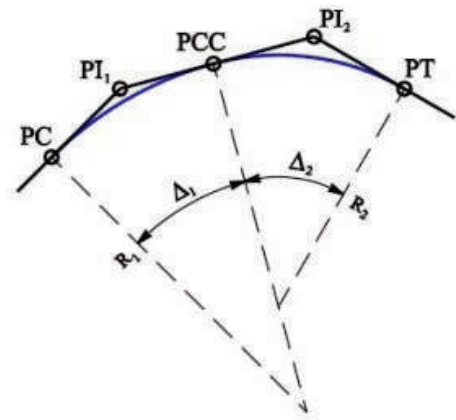


Figure A.6.12 Compound curve to be avoided

### Isolated curves

An isolated horizontal curve close to the minimum radius connected by long straight sections is inherently unsafe. Irrespective of the design speed, actual speeds on long straight sections will be relatively high, so a curve of minimum radius could require a significant reduction in speed for some vehicles. It is good practice to avoid the use of minimum standards in such situations. An added bonus is that, provided no extra cutting or filling is required, the use of a larger radius of curvature results in a shorter and less expensive road. Curve widening can help to diminish this risk if a higher radius curve cannot be used.

### Long curves

Drivers can negotiate a short curve relatively safely at speeds in excess of the design speed, but they cannot do so if the curve is long. A large radius should therefore be used in such situations.



### 6.8.2 Balance

There are several competing factors in providing the optimum horizontal alignment. Small radii curves maximise the length of straight sections and optimise overtaking opportunities. This should be the controlling factor where the terrain is such that overtaking opportunities are infrequent.

In more gentle terrain where overtaking is less of a problem and vehicles generally travel at speeds higher than the design speed, the use of larger radius curves is preferred for the reasons outlined previously. In summary, engineering choice plays a part in the final design which is essentially a balance between competing requirements.

### 6.8.3 Phasing

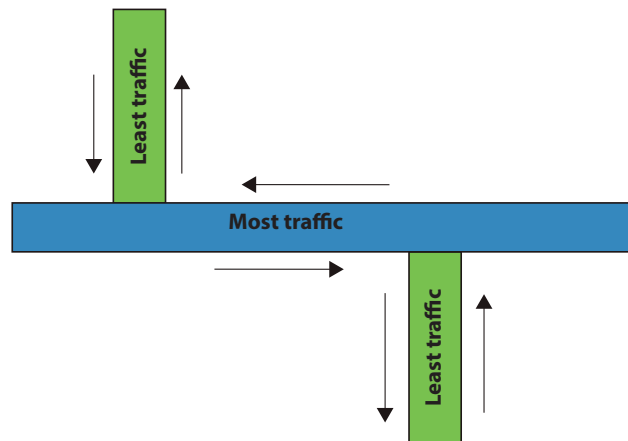
The horizontal and vertical alignment should not be designed independently. Inappropriate combinations of horizontal and vertical curves can result in hazards being concealed, giving rise to risks. Examples of poor phasing include:

- A sharp horizontal curve following a pronounced crest curve where the unexpected bend can be hazardous, especially at night. The solutions to this are to separate the curves, to use a more gentle horizontal curve, or to begin the horizontal curve well before the summit of the crest curve.
- Both ends of the vertical curve lie on the horizontal curve. If both ends of a crest curve lie on a sharp horizontal curve the radius of the horizontal curve may appear to the driver to decrease abruptly over the length of the crest curve. If the vertical curve is a sag curve the radius of the horizontal curve will appear to decrease. The solution is to make both ends of each curve coincide or to separate them completely.
- A vertical curve overlaps both ends of a sharp horizontal curve. This creates a hazard because a vehicle has to turn sharply while the sight distance is reduced on the vertical curve. The solution is to make both ends of each curve coincide or to separate them completely.

## 6.9 Junctions and intersections

Road accidents are most likely to occur at junctions and intersections. Hence, where possible, a safe environment should be created by ensuring that good sight distances provided particularly under night driving conditions. The following principles should be considered when locating and designing an intersection:

- Intersections should not be located on high embankments, near to bridges or structures, on small radius curves, or on super-elevated curves.
- To ensure good visibility, vegetation should be permanently cleared from the area surrounding the junction.
- Intersections should not be located on moderate to steep gradients or at the bottom of sag curves, where vehicle acceleration and deceleration distances are compromised. A maximum gradient of 3% is recommended, though 6% may be adopted in more difficult terrain.
- The ideal intersecting angle of connecting roads should be 90°, as this provides maximum visibility in both directions. However visibility is not seriously compromised provided the angle exceeds 70°.
- Where two roads have to cross each other, a simple cross junction is adequate for LVRs. However, where possible, it is preferable to provide two staggered T-junctions as illustrated in Figure A.6.13. The most heavily trafficked road is retained as the through route whilst the minor road is split so that traffic has to enter the major road by making a left turn onto the major road and then a right turn to re-enter the minor road. The number of possible manoeuvres where the traffic from the minor road has to cross the traffic stream on the major road are then reduced by 50%. The entry points of the two arms of the minor road should be spaced at least 40m apart.



SOURCE: ERA Manual for Low Volume Roads, 2016

Figure A.6.13 Preferred intersection design

## 6.10 Selecting the geometric design standards

### 6.10.1 Procedure

The following steps and flow diagram (Figure A.6.14) show how the appropriate geometric standards for LVRs are selected. The references referred to in each step should be consulted for further details.

**Step 1 (Section 5.3):** Determine the design traffic volumes in terms of motorised and non-motorised traffic as well as the proportion of heavy vehicles. This step is not specific to the geometric design and will usually have been done by the time it is necessary to determine the geometric characteristics of the road.

**Step 2 (Section 5.6):** Determine the design heavy traffic volume thresholds. This later influences the category of LVR selected using the total motorised traffic volume in Step 4 to compensate where necessary for excessively high proportions of heavy vehicles expected in the traffic stream.

**Step 3 (Section 5.7):** Determine the passenger car equivalency (PCU) of expected non-motorised traffic and 2- and 3-wheeled motorised vehicles. The numbers and characteristics of all the other road users are to be considered, and therefore it is here that the road layout may need to be altered and additional width provided for safety, and to improve serviceability for all road users by reducing the risk of congestion caused by slow moving traffic. The impact that excessive PCUs of nonmotorised transport and 2- and 3-wheeled motorised vehicles have on selecting the road geometric characteristics for design purposes is assessed in Step 10.

**Step 4 (Section 1.2):** Using Table A.1.1, select the appropriate category of LVR to be used based on the previously determined total design motorised traffic volumes adjusted for excessive heavy vehicle volumes where appropriate from Step 2.

**Step 5 (Sub-Section 6.3.4):** Determine the terrain class. This is either classed as being flat, rolling, or mountainous and has influence on the road geometric characteristics.

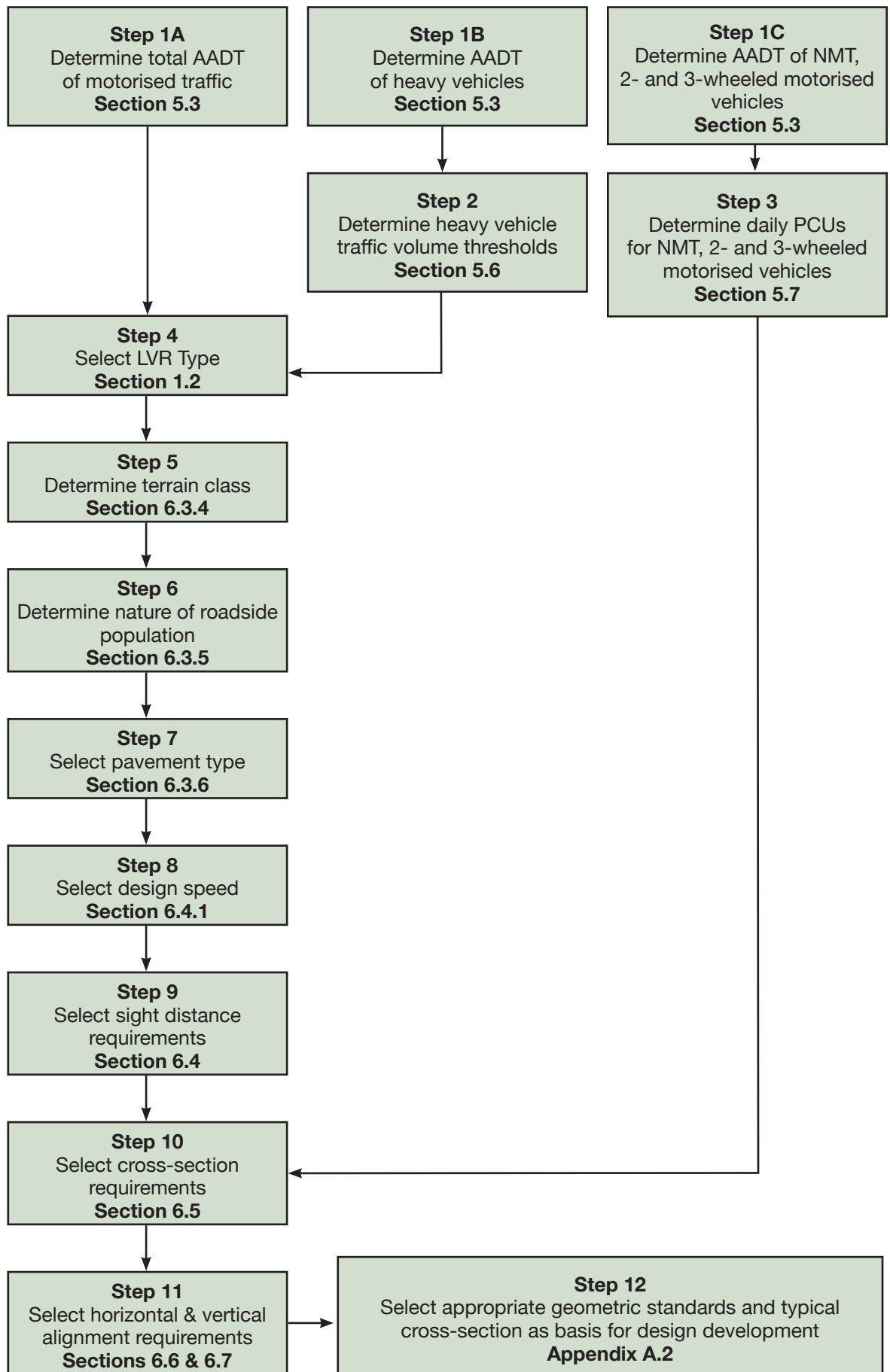


Figure A.6.14 Procedure for selecting geometric design standards

**Step 6 (Sub-Section 6.3.5):** Determine whether the road passes through populated areas, such as towns, villages, market areas, or open country. This has an influence on the selection of the geometric features of the road. Populated areas may require parking areas, lay-bys, bus bays, and areas for traders.

**Step 7 (Sub-Section 6.3.6):** Determine whether the road is expected to be paved within the design period. This has an impact on the selection of the geometric criteria used for design. For most road classes there are options for road pavement type. The adoption of an Environmentally Optimised Design (EOD) policy will mean that different parts of the road may be designed with a different pavement or surfacing. The choice of road pavement type is described in Part B of the Manual.

**Step 8 (Sub-Section 6.4.1):** Select the design speed for the road. The majority of road geometric standards are based on the design speed and this has the greatest influence on the selection of the road geometric standards.

**Step 9 (Section 6.4):** Select the minimum sight distance requirements to be used for design purposes for stopping, for intersections, and for passing.

**Step 10 (Section 6.5):** Determine the widths of the carriageway, shoulders, roadside ditches and clear zones, as well as the cross-sectional slopes of the carriageway, shoulders, sides and embankments. Increase the shoulder width if the expected number of non-motorised PCUs exceeds 300 per day. At this stage additional factors which affect the geometric standards should be considered, such as additional road safety features and the construction technology to be employed.

**Step 11 (Sections 6.6 and 6.7):** Select the minimum road alignment curvature requirements to be used for design purposes for both horizontal and vertical alignment.

**Step 12 (Appendix A.2):** Using the category of LVR determined in Step 4, along with the decision whether to pave the road from Step 7, select the appropriate geometric design standards and characteristics summarized in the tables and typical cross-sections in Appendix A.2. It should be noted that the tables and cross-sections contain only the most relevant information on geometric standards and therefore the Chapters leading up to the selection process should be consulted for further guidance and information.

### 6.10.2 Matrix of standards

The four basic types of LVR as summarised in Table A.1.1 have been expanded to accommodate the various factors which influence the design standards. This includes terrain, roadside population, and whether the road is to be paved. This resulted in the development of seven distinct design standards as follows:

- Type 1 unpaved LVRs (AADT <15)
- Type 2 unpaved LVRs (AADT <75)
- Type 2 paved LVRs (AADT <75)
- Type 3 unpaved LVRs (AADT 75-150)
- Type 3 paved LVRs (AADT 75-150)
- Type 4 unpaved LVRs (AADT 151-300)
- Type 4 paved LVRs (AADT 151-300)

Geometric design standards for these seven categories of LVR are summarised in Appendix A.2.

### 6.10.3 Completion of the design process

The completion of the design process is the preparation of a trial alignment to be used as a check to ensure that all the standards have been met. If not, alternative alignments should be tried. In extreme conditions it may not be possible to adhere to all of the standards at all points along the road. In such cases engineering judgement or additional technical advice may be needed.

The pre-feasibility study should have shown that the costs of the road are likely to be acceptable in relation to the budget and the economic benefits of the road. However, at the design stage it may be found that the engineering problems are more expensive to solve than anticipated. If the costs are high the feasibility of the project may need to be reviewed.

## 7. ROAD SAFETY

### 7.1 Introduction

The road accident statistics in Ghana, in common with many other countries in Africa, show that death and serious injury rates from road accidents are 30 to 50 times higher than in Western countries. Beyond the grief and anguish this imposes on a considerable proportion of the population, such a high level of road accidents has significant demonstrable economic consequences for the country, constituting a very significant drain on the economy. Every effort should therefore be made to reduce the number of serious and fatal accidents, including by raising awareness and educating the general public in road safety.

Key principles of design that can considerably improve the safety of LVRs include:

- Designing for all road users. This includes non-motorised vehicles and pedestrians, and has implications for most aspects of road design, including cross-sectional features previously addressed.
- Providing a clear and consistent message to the driver. Road layouts should be easily and immediately understood by road users and should not present them with any sudden surprises. This should also ensure that demands are not placed upon the road user which are beyond his or her ability to manage.
- Encouraging appropriate speeds and behaviour by design. Traffic speed can be influenced by altering the appearance of the road, for example by providing clear visual clues such as changing the shoulder treatment or installing prominent signage.
- Adopting designs that reduce the risk of conflicts between types of road user. Examples include staggering junctions, and using guardrails to channel pedestrians to safer crossing points.
- Creating a forgiving road environment that accommodates driver error or vehicle failure to the extent that this is possible without significantly increasing costs.

The geometric design of roads plays an important role in achieving a safe road environment. This is highlighted throughout the Manual through the following:

- Road and shoulder widths are adequate to accommodate pedestrians and other forms of non-motorised transport.
- Moderate design speeds are used for elements of road alignment.
- Parking places and lay-bys are included for public transport vehicles in populated areas.
- Account has been taken of reduced friction on unpaved roads.
- Acceptable road slopes for drainage of road surface and out-of-control vehicle recovery have been recommended.
- Adequate sight distances have been provided.

Further steps that could be taken to improve safety include:

- traffic calming measures to reduce speeds in populated area;
- road markings and signage;
- segregating non-motorised and motorised vehicles in populated areas;
- providing crash barriers at dangerous locations; and
- carrying out a professional safety audit at the design stage.

### 7.2 Traffic signs

#### 7.2.1 Introduction

Clear and efficient signage is an essential part of the road system. Road users depend on signs for information and guidance, and road Authorities rely on signage for traffic control and regulation, and for road safety.

The physical layout of the road must sometimes be supplemented by effective traffic signing to inform and to warn drivers of any unexpected changes in the driving conditions. Some of the common situations are mentioned below, but each situation is unique, and the severity of any particular situation can vary considerably. For cost effectiveness, signs should be restricted to situations where there is a real need to inform road users. It is recommended that the judgement of an experienced road safety expert is brought to bear at the design stage.

For an existing road that is to be upgraded, the hazardous locations should be identified at an early stage and, ideally, should be corrected in the new design. If this is not possible, then suitable permanent road

signs should be installed. Temporary signage should be used when roadworks are being carried out, or where significant road defects have been identified but not yet addressed.

There are three general classifications of traffic signs:

- Regulatory Signs. These indicate legal requirements for traffic movement and are essential for all roads.
- Warning Signs. These indicate conditions ahead that may be hazardous to road users.
- Information Signs. These convey information of use to the road user.

In 2006, a review of the Ministry of Transportation's sign standards was undertaken by the Transport Sector Program Support (TSPS) Road Safety Sub-Component. The report entitled Draft Review of the Ministry of Transportation's Signs and Markings Standards (2007) was prepared with the aim of establishing the country's approach to traffic signs and markings. Ghana had a mixture of signs, so the report attempted to reconcile these, while identifying the need for a definitive national traffic signs manual that would standardise all the traffic signs and markings.

Further information and details pertaining to the Ghanaian road traffic signs and road markings can be found in the above-mentioned report, as well as the Ghana Highway Code (1974), and Ministry of Roads and Highways Standard Details, Road Signs and Markings for Urban and Trunk Roads (1991).

## 7.2.2 Regulatory signs

Regulatory signs are a range of signs used to control the actions of road users in the interest of safety. They indicate or reinforce traffic laws, regulations or requirements which apply either at all times or at specified times or places upon a public road facility. They include traffic flow control signs that regulate the movement of traffic, command signs that tell drivers what to do under a given set of circumstances, and prohibition signs that indicate what is not allowed. It is an offence for road users to disregard any of these signs. The signs are displayed as white discs with a red border and black message symbol or word. Temporary versions of the signs have a yellow background.

The most commonly used regulatory sign is the speed limit sign which indicates the maximum speed permitted on a road or over a particular section of the road. A general speed limit is applicable on all roads and does not have to be displayed by a road traffic sign. Other examples of regulatory signs generally required on LVRs include vehicle restrictions such as for weight, length and width.

## 7.2.3 Warning signs

Warning signs are used to alert drivers to dangers or potential hazards that are not clearly visible from a safe distance ahead. They are usually found some distance before the hazard to allow the driver sufficient of time to react. The signs are displayed as white triangles with a red border and black message symbol or word. Temporary versions of the signs have a yellow background. Hazard marker plates are rectangular red and white plates (or red and yellow for temporary versions) that are positioned at the hazard itself, for example, at bridges or drifts, on sharp bends or at an obstruction at the edge of the road.

The most common use for warning signs is to indicate situations where the geometric standards for a particular class of road have been changed along a short section of road. This is usually caused by a constraint of some kind that has prevented the standard from being applied continuously and therefore causes an unexpected and potentially dangerous situation. Examples include a sharp bend, a sudden narrowing of the road, an unexpectedly steep gradient, and an unexpected school crossing. There are many further examples and engineering judgement is required.

A common situation occurs in populated areas where traffic calming measures have been introduced. Speed humps are a particular problem because they are often not sufficiently visible from a reasonable distance, and sometimes they have been badly designed and provide more of a jolt to the vehicle than intended. It is therefore good practice to provide warning signs for these, especially on roads that are likely to be used by traffic unfamiliar to the area.

An important consideration on unpaved roads is that the road markings that are generally used on paved roads to improve safety cannot be applied to unpaved roads. This means that if drivers need to be warned of a hazard that is traditionally done by means of road markings this will have to be done by means of traffic signs.

## 7.2.4 Information and guidance signs

Information signs provide information about the road ahead so that road users can plan their road and lane usage accordingly. Guidance signs provide information about the route and include distances and directions to key destinations, as well as details of traffic lane arrangements ahead.

Information and guidance signs are less vital on the lower classes of road frequented primarily by local residents. However, for road classes where the AADT exceeds 75 vpd on which a considerable proportion of drivers will not be local, information signs are desirable. Though in populated areas they can help improve safety by reducing the need for drivers to stop to ask questions of pedestrians, this effect is only marginal, especially if the road standards applicable for populated areas have been applied. Information signs are thus largely a matter of convenience, and part of the provision of a particular level of service to the traveller.

### 7.3 Road markings

Road markings are traffic signs painted onto paved road surfaces, and consist primarily of centre lines, lane lines, no overtaking lines and edge lines. As with traffic signs, these too are classified into Regulatory, Warning, Information and Guidance markings. They have the same meanings as the traffic signs, and road users should react accordingly. Surface markings are painted in white or yellow according to the message they convey.

Other pavement markings such as 'stop', pedestrian crossings and various word and symbol markings may supplement pavement line markings. In cases where a warning is deemed necessary for safety reasons, but road markings cannot be used, road signs must be used instead.

The extent to which there is a need for road markings, signs and other road furniture depends on the traffic volume, the type of road, and the degree of traffic control required for safe and efficient operation. Road markings are generally not justified on LVRs, however on a paved, two lane road, a centre line is desirable. Such a road is not likely to have been built unless the traffic justifies it and hence, for safety reasons, a centre line is recommended. The main elements are:

- traffic signs provide essential information to drivers for their safe and efficient manoeuvring on the road;
- road markings to delineate the carriageway centre line and edges to clarify the paths that vehicles should follow; and
- marker posts to indicate the alignment of the road ahead and, when equipped with reflectors, provide optical guidance at night.

#### 7.3.1 Object markers

Physical obstructions in or near the carriageway should be removed in order to provide the appropriate clear zone. Where removal is impractical, such objects should be adequately marked by painting or through the use of other high-visibility material.

#### 7.3.2 Road studs

Reflective road studs should be provided on all paved roads. Typically, these are used to improve guidance at night, particularly where road markings become ineffective, or where rainy or misty conditions are a common occurrence. If budget limitations so dictate, their use can be confined to sharp radius bends where the road edge and lane demarcations may be obscured during darkness or abnormal weather conditions. It is recommended that no fewer than three road studs should be visible to a driver at any one time to define a specific line.

Road studs are to be provided to demarcate the road edges and/or road centre line, the latter being the minimum provision. Road studs should be positioned in the centre of the gaps between dashed road lane markings or 50 mm away from the inside of the road edge. Where painted road edge lines are provided, the road studs should be positioned 50 mm away from the outside of the painted road edge line and in line with the centre line studs.

The recommended spacing of road studs is provided in Table A.7.1. Under certain extraordinary conditions, the spacing of road studs may be reduced to the intermediate spacings as indicated. Typically, this would be where visibility is at risk of being obscured by rain or mist. Under abnormal conditions such as in areas prone to heavy rain or fog, the spacings may be reduced even further as indicated.

**Table A.7.1 Recommended longitudinal road stud spacing**

Environment	Normal (m)	Intermediate (m)	Abnormal (m)
Rural	24	12	6
Urban	18	9	3

### 7.3.3

#### Marker posts

There are two types of marker posts in use namely guideposts and kilometre posts.

Guideposts are used to indicate the alignment of the road ahead and make drivers aware of potential hazards such as abrupt changes in shoulder width and alignment or approaches to structures. On unpaved roads they are often the only option for warning drivers of such hazards. Their use is strongly recommended. They should be painted white and include a panel of retro-reflective material.

Kilometre posts are a requirement for higher order roads and are therefore normally only required on roads where the AADT exceeds 150 vpd.

## 7.4

### Traffic calming

#### 7.4.1

##### Introduction

The seriousness of road accidents increases dramatically with speed and hence very significant improvements to road safety are possible if traffic can be slowed down. This process is called traffic calming. All such methods have their advantages and disadvantages and the effectiveness of the methods also depends on aspects of road user behaviour.

The effect of any traffic calming measure on all the road users should be carefully considered before they are installed. Some are not appropriate for unpaved roads, and others unsuitable if large buses are part of the traffic stream. Some are very harsh on bicycles, motorcycles and motorcycle taxis, and others are totally unsuitable when there is any animal drawn transport.

Some research has been carried out on traffic calming, albeit for higher order roads. This can be found in the Ministry of Transportation's Traffic Calming Measures Design Guideline (Version 2 – February 2008). It should be noted that this Manual does not replace the Traffic Calming Measures Design Guideline which should be referred to for the implementation of traffic calming measures.

Three types of traffic calming measures are recommended:

- Vertical deflection (road humps, rumble strips and jiggle bars);
- Horizontal deflection (raised islands and road narrowing / staggering); and
- Visual deflection (gateways, pre-warnings and village treatment).

Further information and details on the type, size, shape and application of the traffic calming devices can be found in the Traffic Calming Measures Design Guideline.

#### 7.4.2

##### Speed humps and speed cushions

Speed humps are probably the most familiar measures used to slow traffic on paved roads. They are essentially raised sections installed across the road extending uniformly from one side of the road to the other. Unlike rumble strips, speed reduction humps are quite high and, if they are designed badly, they can cause considerable vehicle damage. They are often used very effectively in villages but are generally unpopular with road users. The locations of speed humps should be discussed with local communities to identify the specific locations where pedestrians use the roads and where vehicles use inappropriately high speeds. Examples of speed humps are shown in Figure A.7.1.



Figure A.7.1 Speed humps

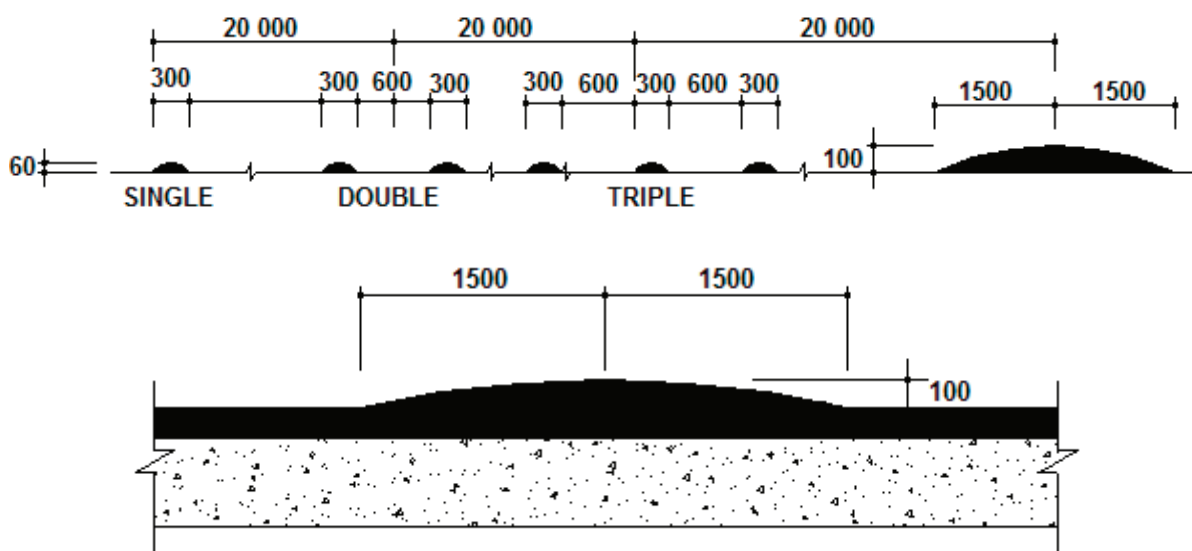


The following should be considered when adopting this form of traffic calming measure:

- On new roads or roads being upgraded, speed humps or cushions should be included as a standard part of the design.
- On existing roads where there are currently no speed humps, they should be provided where the need is identified.
- Speed humps should cover the full width of the road, with due regard to drainage requirements in order to avoid associated ponding.
- Stripes should be painted on speed humps using reflective road paint to make them visible, particularly at night.
- Speed humps should be well maintained. Stripes should be repainted when the paint becomes worn.
- Advance warning of speed humps should be provided preferably using a road sign situated 50 m before the hump. Marker posts should be installed alongside the hump indicating the actual location of the hump. Marker posts should be fitted with reflectors so that they can be seen at night.
- The use of speed humps should be avoided on slopes.

### Speed humps

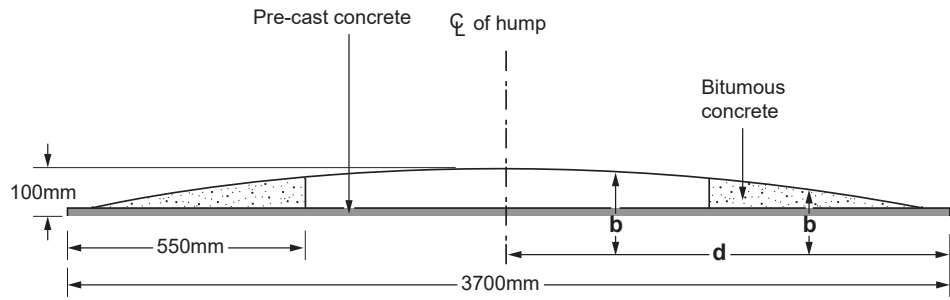
**Standard hump:** This is the most common type of speed hump used to reduce speed on both paved and unpaved roads. On paved roads, the hump is generally constructed of asphalt or concrete and combined with rumble strips. The rumble strips provide advanced warning to drivers of the hump ahead. On unpaved roads, the hump is constructed of the same material as the wearing course, however without the advance rumble strips. It is recommended that this type of hump be used on lower speed roads such as on the feeder road system. Further details of the hump and rumble strips are shown in Figure A.7.2.



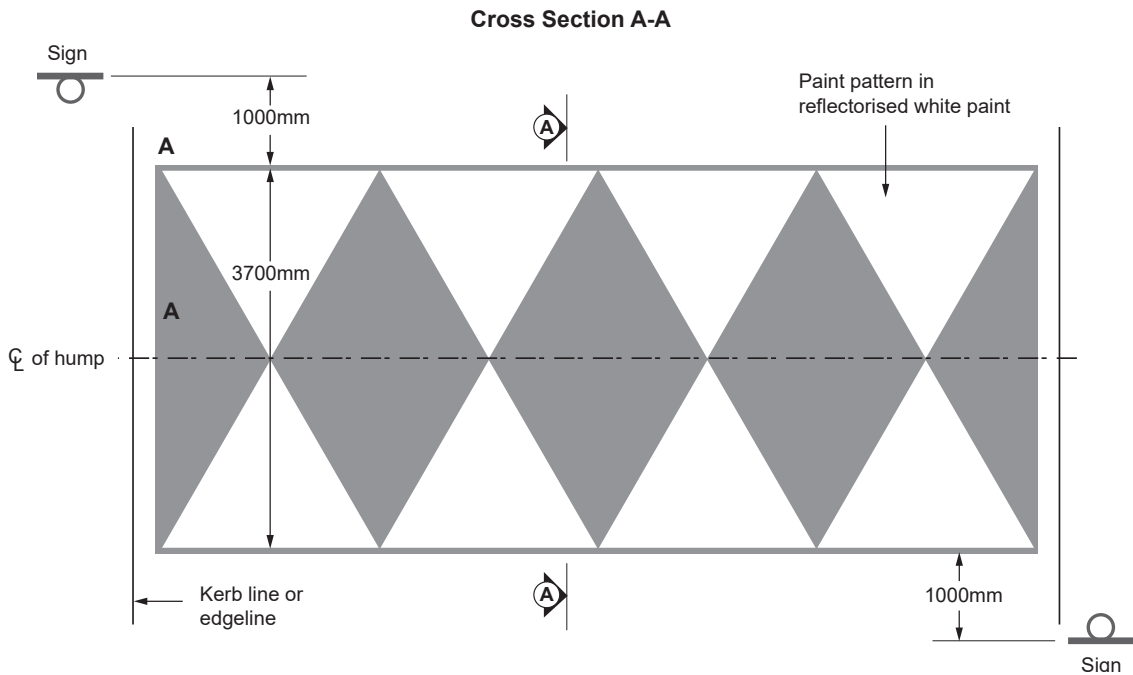
NOTE: Dimensions in mm

**Figure A.7.2** Details of the standard hump / rumble strips combination

**Watts profile hump:** This type of speed hump, although longer than the standard speed hump, is designed to provide a more comfortable ride for passengers and the least damaging effect on vehicles in addition to reducing speed. The Watts profile hump is appropriate to paved roads and is generally constructed using asphalt or concrete. If the hump is constructed of concrete it should be reinforced with a layer of steel mesh for increased durability and to control cracking. It is recommended that this type of hump be used on higher speed roads such as on the secondary and primary road systems. Details of the Watts profile hump are shown in Figure A.7.3.



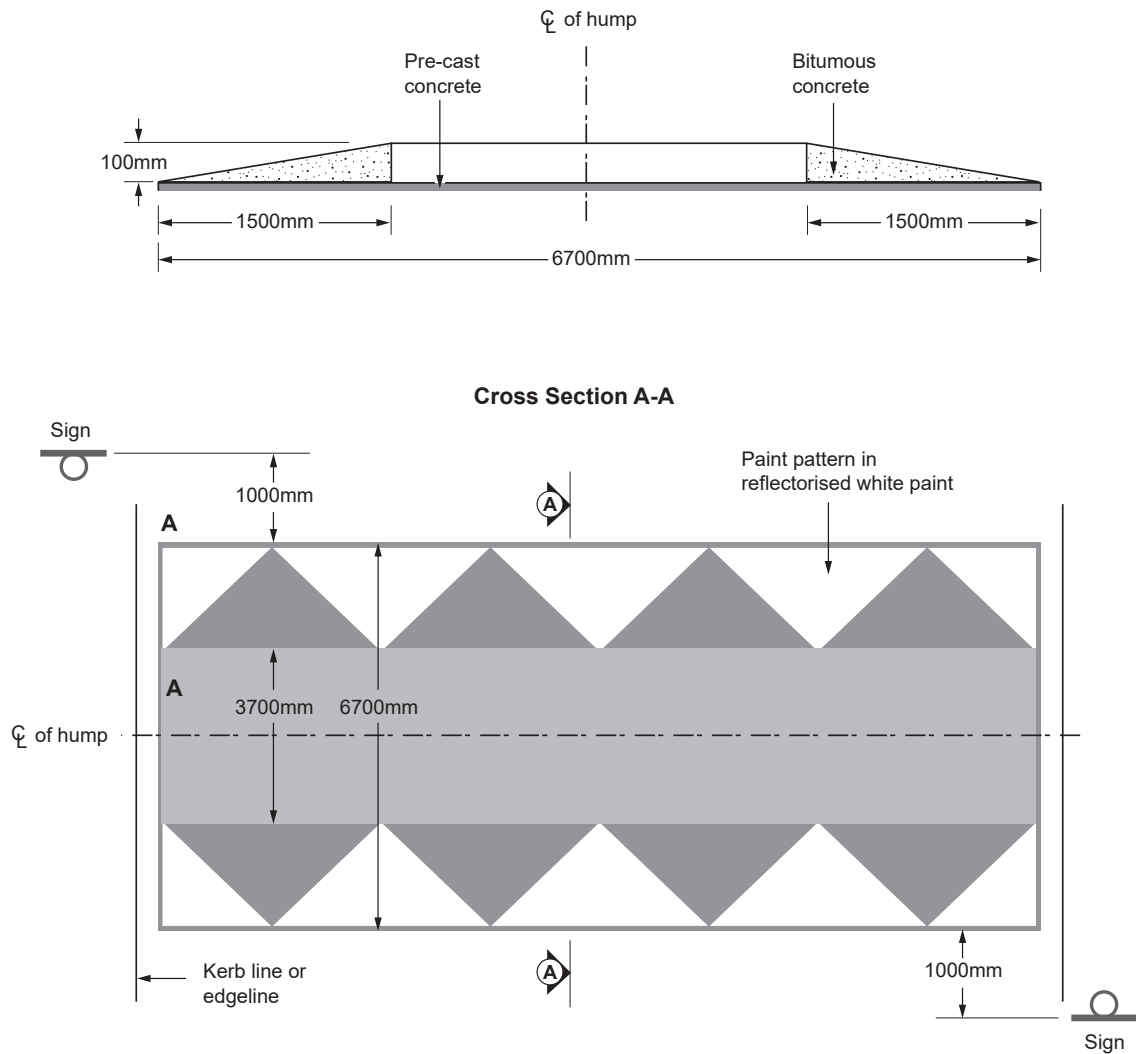
<b>d (mm)</b>	0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
<b>b (mm)</b>	100	100	99	97	95	93	90	86	81	76	71	65	58	51	43	34	25	16	5



SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

**Figure A.7.3 Details of the Watts profile hump**

**Flat-top hump:** When speed humps are used to reduce speeds ahead of pedestrian crossing points, it is increasing common practice to combine the pedestrian crossing and speed hump. The flat-topped hump is typically used in this application. This type of hump is only appropriate to paved roads and consists of a flat top portion with a ramp on either side. If the hump is constructed using concrete, it should be reinforced with a layer of steel mesh. Details of the flat-top hump are shown in Figure A.7.4.

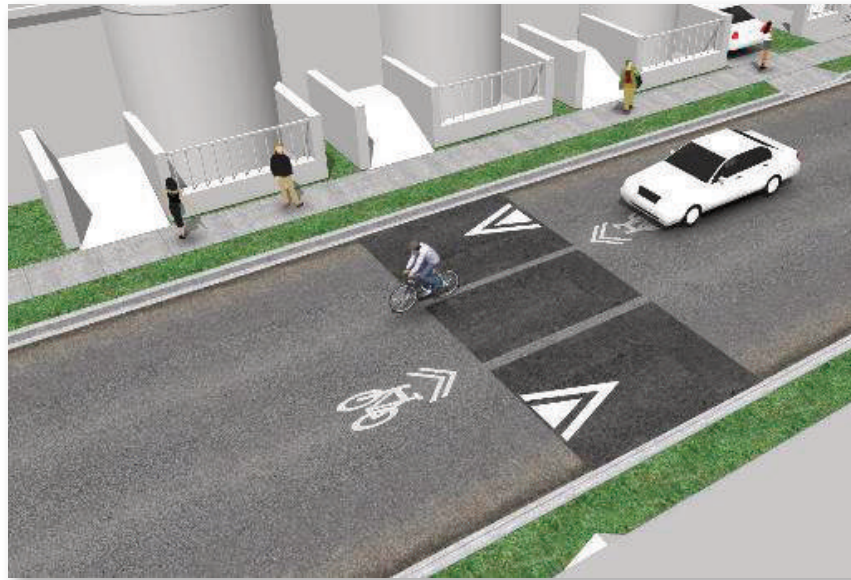


SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

**Figure A.7.4 Details of a flat-top hump**

**Speed cushions:** Speed cushions are based on a similar principle to the speed hump however they are only applicable to paved road. The hump is not continuous across the road. The width of a two-lane road is usually covered by two or three cushions with gaps between them. The idea is that large vehicles will not be able to pass without at least one wheel running over one of the humps, but bicycles and motorcycles can pass between them without interference.

A speed cushion is shown in Figure A.7.5.



**Figure A.7.5** Speed cushions

### 7.4.3

#### Rumble strips

Rumble strips are applicable to paved roads only. They are formed of artificial road texture that causes tyre noise and vehicle vibration if the vehicle is travelling too fast. They are generally used across paved roads where they are uncomfortable to drive across at speed and are effective in alerting road users and slowing down the traffic. They are particularly effective when used in combination with road humps, typically at the approaches to villages. Examples of rumble strips are shown in Figure A.7.6

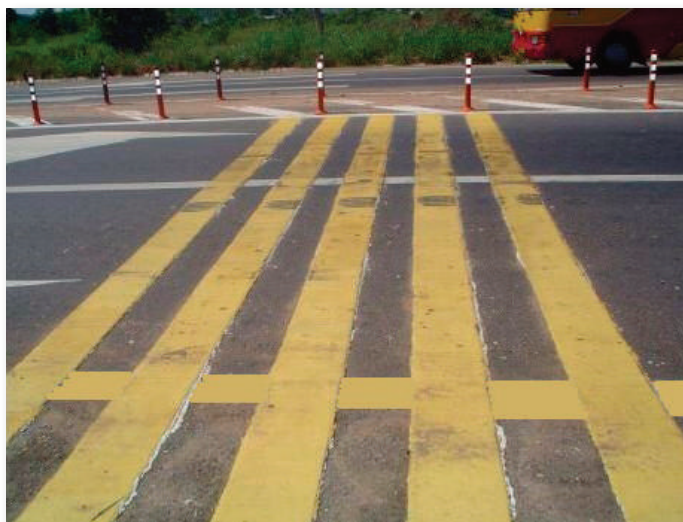


**Figure A.7.6** Rumble strips

### 7.4.4

#### Jiggle bars

Applicable to paved roads only, jiggle bars are similar to rumble strips. The noise generated by a vehicle passing over the strips is the main factor in causing vehicles to slow down. Jiggle bars are spaced closer together than rumble strips. An application of jiggle bars is shown in Figure A.7.7.



**Figure A.7.7 Jiggle bars**

#### 7.4.5 Speed bumps

Speed bumps are similar to speed humps, but have a more abrupt design. They consist of a portion of raised pavement typically between 10 cm and 15 cm high, and about 75 cm long. Unlike speed humps, which result in a rocking motion for a passing vehicle, speed bumps can produce a severe jolt even at moderate speeds, potentially resulting in damage to the vehicle and/or loss of control. Such risks, which are particularly marked in the case of motorcycles, mean that their use is generally limited to private roads, and car parks. They are not recommended for use on public roads.

#### 7.4.6 Road islands

These are generally used in built-up areas on paved sections of road. The provision of raised islands in the centre of the road carriageway may be used to separate two-way traffic, restrict overtaking, separate motorised traffic from vulnerable road users, and to provide refuge for pedestrians crossing the road. They can also be used at approaches to built-up areas to make it clear to road users that they are approaching a populated area.

#### 7.4.7 Road narrowing / staggering

This particularly applies to 2-lane paved roads and is designed to produce artificial congestion by reducing the width of the road over a very short distance at intervals.

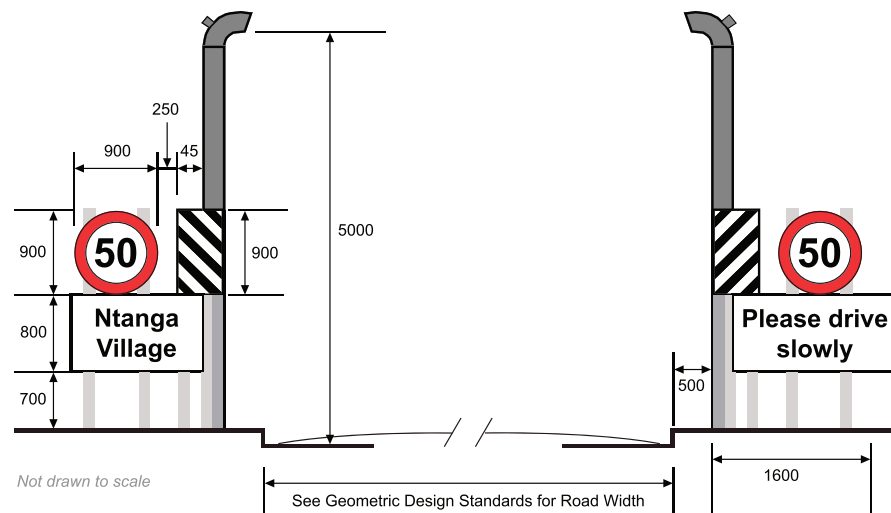


**Figure A.7.8 Road narrowing**

The road width can be reduced from the centre of the road through the installation of centre islands, reduced from the roadside using road edge islands, or both. The narrowing can be constructed using raised kerbed islands or road markings. Road staggering can be introduced by installing roadside islands on alternate sides of the road. In both cases the space available for traffic is reduced which will encourage drivers to slow down. An example of road narrowing is shown in Figure A.7.8

### 7.4.8 Town gates (gateways)

These are generally used on paved trafficked roads to make a clear entrance to an area with a lower speed limit. This form of traffic calming is introduced visually to road users through provision of adequate signage, centre islands, humps and jiggle bars to encourage drivers to slow down when approaching a village or small settlement. The village name is sometimes also displayed here. This application can be used on unpaved roads in the form of signage only. Design details for a gateway are provided in Figure A.7.9, and an example shown in Figure A.7.10.



SOURCE: ERA Manual for Low Volume Roads, 2016

**Figure A.7.9 Typical gateway details**



**Figure A.7.10 Gateway**

### 7.4.9 Pre-warnings

The purpose of pre-warnings is to alert road users to the presence of a hazard, settlement or speed restriction ahead so that they are aware of the need to slow down. These can simply be warning signs fitted with supplementary plates indicating relevant information. Pre-warnings can also be supplemented with rumble strips.

### 7.4.10 Pedestrian crossings

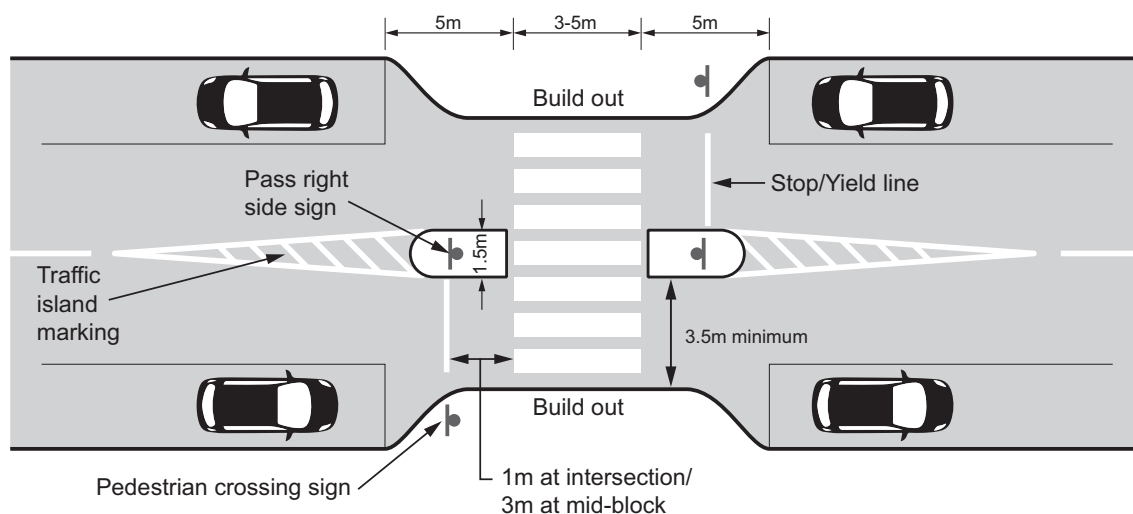
Applicable to paved roads, pedestrian crossings can be placed where large numbers of pedestrians cross the road, or in places such as outside schools where there is a special need for protection of vulnerable road users. Also known as zebra crossings, these may be provided at road intersections or between

intersections also known as “mid-block”. Pedestrian crossings should always be associated with speed reducers such as humps, centre islands and road narrowing.

It is recommended that centre islands, kerbed or painted, be installed where pedestrian crossings traverse more than two lanes, in order to provide refuge for pedestrians. These may be combined with flat top humps as previously described. Furthermore, kerbed build-outs should be provided where there is roadside parking.

Pedestrian crossings shall be preceded by a STOP line marking when used at a traffic signal-controlled crossing or intersection, or by a YIELD line marking when used at a sign-controlled crossing or intersection. STOP and YIELD lines shall be positioned at least 1 m away from the pedestrian crossing at road intersections and recommended to be at least 3 m away for mid-block pedestrian crossings.

Pedestrian counts and pedestrian crossing behaviour should always precede the design of traffic calming projects to ensure that the most appropriate application and location is selected. A typical layout of a pedestrian crossing is illustrated in Figure A.7.11 and examples are provided in Figure A.7.12.



**Figure A.7.11** Typical pedestrian crossing details



**Figure A.7.12** Pedestrian crossings

#### 7.4.11 Village treatment

This concept of traffic calming has been introduced in other African countries and has been proven successful, though is most applicable to paved roads. The objective of the village treatment is to create a perception that the village is a low-speed environment and to encourage drivers to reduce speed. This is achieved using a combination of multiple traffic calming measures, pedestrian sidewalks and bus bays.

The same application can be used on unpaved roads with the exception that the traffic calming component would consist of earth or gravel speed humps as opposed to that described below. Typically, the road through the village is treated as being in three zones, namely:

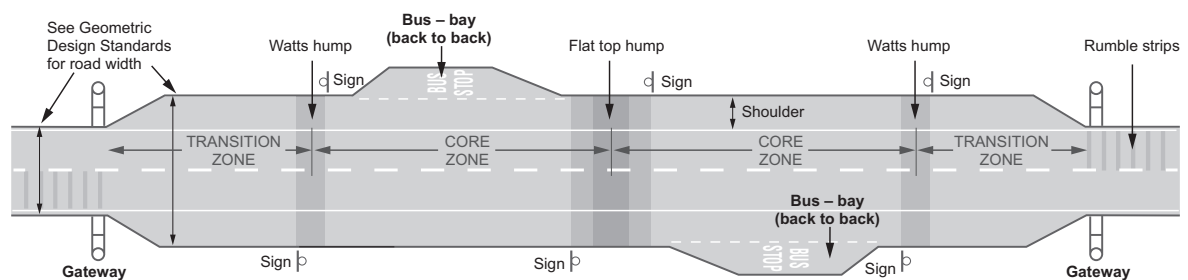
- the approach zone;
- the transition zone; and
- the core zone.

**Approach zone:** This is the section of road prior to entry into the village, where the driver needs to be made aware that the open road speed is no longer appropriate. In this section speed should be reduced typically from 70 km/h down to 50 km/h, before entering the village. The village entry should be marked by a gateway as described below.

**Transition zone:** This is the section of road between the village entrance, or gateway, and the core zone of the village. The target speed and posted speed limit in this zone would be typically 50 km/h. The first road hump or humps in a series of humps will be located in this zone. In this context, with adequate advance warning provided by the approach zone and Gateway, road humps are deemed to be safe.

**Core zone:** This is the section identified as being in the centre of the village, where most of vehicle/pedestrian conflict is expected to take place. This is normally where many shops or trade stalls are located with bus bays and other pedestrian generating activity. The target speed, and posted speed limit, should typically be 40 km/h. Road humps would normally be provided within this zone with advisory speed limits of 20 km/h in order to enforce the lower speed environment required.

A typical treatment, showing the three zones outlined above, is illustrated in Figure A.7.13



SOURCE: ERA Manual for Low Volume Roads, 2016

NOTES:

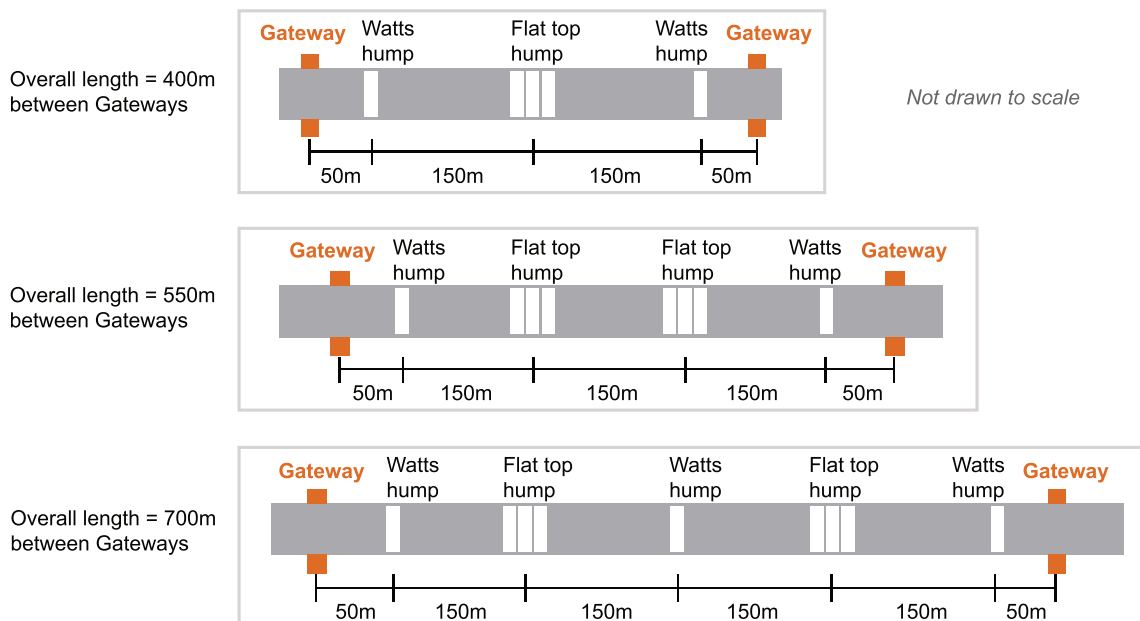
1. Layout not to scale
2. Road cross-section dimensions to suit conditions and traffic regulations

**Figure A.7.13 Village treatment - typical layout**

The elements which make up the village treatment are as follows:

1. **The gateway:** See details provided in sub-section A.7.4.8.
2. **Rumble strips:** See details provided in sub-section A.7.4.3.
3. **Speed humps:** See details provided in sub-section A.7.4.2. The recommended spacing and combination of speed humps is shown in Figure A.7.14





SOURCE: ERA Manual for Low Volume Roads, 2016

**Figure A.7.14 Typical spacing and combination of road humps**

4. **Pedestrian crossings:** See details provided in sub-section A. 7.4.10.
5. **Traffic signs and road markings:** These are used to provide warning information to motorists at all elements of the village treatment, such as at entry to the gateway, at the start and exit of the core zone, and in advance of speed humps, while also advising speeds.
6. **Lay-bys or bus bays:** These should generally be provided in the core section of the village and should be in pairs. They should be located back-to-back, so that when there is a vehicle in each bay, they should be facing away from each other. This is so that passengers leaving the vehicle and then crossing the road will be behind a vehicle parked on the opposite side, and will not be crossing in front of it. Typical details of lay-bys or bus bays can be found in the Standard Details, Road Signs and Markings for Urban and Trunk Roads Manual (Ministry of Roads and Highways, 1991).
7. **Pedestrian routes:** The aim should be to identify the major pedestrian routes within the village, to determine at what point they join the road, and whether any realignment is necessary to ensure that pedestrians are led to appropriate crossing places. The main pedestrian route within a village should always join the road within the core zone.

## 7.5 Safety barriers

### 7.5.1 Overview

Safety barriers are expensive and seldom justified on LVRs. The geometric design of such roads should generally eliminate the need for such barriers. They may however be required in highly dangerous situations, for example, on excessively sharp bends on mountainous roads that cannot be made safe by other means.

The types of safety barriers and their application vary, the most commonly used being raised kerbed islands, wooden or steel posts, steel guardrails, and concrete barriers. Raised kerbed islands are generally applicable to paved roads and commonly used for segregating motorised and non-motorised traffic. Wooden and steel posts are the cheapest form of barrier but generally not the most effective. Steel guardrails are one of the most effective types of safety barrier and most commonly used. They are cheaper to install than concrete barriers, but in the long term their repair and maintenance can be more expensive.

### 7.5.2 Segregating vulnerable road users

Where possible, non-motorised vehicles and pedestrians using a road should be physically separated from the motorised vehicles. If the terrain and local conditions are suitable, a cost-effective solution can be to construct of parallel off-road pathways wide enough for non-motorised transportation. Any such layout

must be carefully considered to ensure that it will be used as intended, and care must be taken to ensure sufficient connections between the roadway and the pathway to enable access in either direction.

### 7.5.3 Crash barriers

Crash barriers are designed to physically prevent vehicles from crossing them. They are an essential feature of high-speed roads to prevent vehicles travelling in opposite directions from colliding with each other head-on. On LVRs their primary function is to prevent vehicles from leaving the road at dangerous locations. Good geometric design should prevent drivers from experiencing unexpected situations where they might be in danger of losing control, but sometimes crash barriers are required. However, they are expensive to install, and they must be installed properly otherwise they are not likely to be fit for purpose. They are rarely used on LVRs but could justifiably be used in some circumstances such as on roads where AADT's exceed 150 vehicles per day.

## 7.6 Motorcycle safety on LVRs

### 7.6.1 Introduction

Until recently, safety has been only a minor consideration in the management of low volume rural roads in Ghana, due to the low number of vehicles using these roads. However, in recent years the number of vehicles, most notably motorcycles, in rural areas has increased rapidly.

There is no doubt that motorcycles are a dangerous mode of transport compared with other motorised means. Having only two wheels in contact with the ground, their small size, and lack of protection, makes them more susceptible to loss of control and puts drivers and their passengers at greater risk of serious injury.

Injuries suffered in crashes involving motorcycles on rural roads are more severe than those involving other modes. Poor road user behaviour, generally as a result of a lack of training and a lack of law enforcement in rural areas, is the most common contributory factor in motorcycle crashes on rural roads.

Speed is widely recognized as a key risk factor in road traffic crashes for all forms of transport. On LVRs, motorcycle speeds are often not high, however speed-related motorcycle crashes do often occur. This is generally due to inappropriate speed for the surrounding environment, for example failing to slow down when passing through settlements or on stretches of road where sight lines are short. However, some element of road design and condition also contributes to over half of all motorcycle crashes on rural roads.

#### Safety Improvements

Over and above the typical safety measures generally applied to the rural road network, the following measures should be considered in the design and construction of roads to ensure motorcycle safety:

- Encourage appropriate speeds through the use of speed humps in areas where speeds must be reduced for the safety and where there are high numbers of pedestrians, such as village centres, outside schools and close to market places.
- Minimise the use of sharp horizontal bends and increase the road width when they cannot be avoided.
- Ensure the road is wide enough for a motorcycle to pass a four-wheeled vehicle safely without being forced to leave the road. A minimum carriageway width of 3.8 m excluding shoulders is recommended. Adequate road width is of critical importance for road safety.
- Provide shoulders on both sides of the road for use by motorcycles. A minimum width of 0.5 m is recommended.
- Ensure that road shoulders are regularly maintained to ensure a safe riding surface. The shoulders, as with the main carriageway, should be free from vegetation, potholes, corrugation, rutting, loose gravel, or oversized material. Surfaces that become slippery when wet are also constitute a risk, as can occur as a result of bleeding of paved bituminous surfaces.
- Ensure where possible that the slope of the shoulder matches that of the main carriageway. It is recommended that unpaved shoulders should have a minimum camber of 4% slope.
- Consider paving the road in situations where the fact that a road is unpaved contributes to risk. Examples include stretches of road that becomes very slippery when wet, or in an area where dust can obscure vision.
- Ensure the surrounding environment is 'forgiving', for example by avoiding steeply-angled side-slopes and deep side drains at the edge of the carriageway. Slopes flatter than 1:4 are considered to be 'recoverable' for motorcycles.

- Ensure the roadside is free of large hard objects, such as big rocks and trees, from within 5 m of the edge, and within 10 m from the road edge on the outside of curves.
- Use road signs or marker posts to warn of hazards. In high-risk areas, when budget allows, guard rails may be used to protect road users from a roadside hazard.
- Demarcate the edges of bridges and drifts using bollards or masonry blocks on both sides, so that their location is known when they are covered with water. The bollards should be fitted with reflectors for night-time driving. Guard rail protection is also recommended on each side.
- Provide sufficient sight lines on the approach to bridges and drifts. In addition, warning signs are recommended where a bridge or drift is narrower than the approaching road carriageway.

*SOURCE: Advice for Motorcycle Safety on Low-Volume Rural Roads, Tanzania, 2016*

## 7.7 Safety audits

The subject of road safety is remarkably complex in that, while many unsafe practices are readily identified, there are also many situations where it is difficult to identify what is likely to be unsafe, especially if the project is a new road and one is working from drawings. The history of road safety includes many examples of ideas and approaches that were expected to improve road safety but often had no discernible effect or even made things worse. The problem has always been a shortfall of the reliable data needed to guide policy development. There is no substitute for a systematic method of recording the characteristics of road accidents, reliably storing such data over time and then analysing when sufficient robust data is available for reliable conclusions to be drawn.

After data collection, professional road safety auditing is the next priority, and should be regularly undertaken on every road project, particularly for road projects in populated areas.

A rudimentary road safety audit checklist, based on that from HD 19/15 of the UK Highways Manual Volume 5 Section 2 Part 2, can be found in Appendix A.3. This provides some basic guidance as to some of the elements which should be considered when undertaking a road safety audit.

## 8. REFERENCES

Reference material used in the compilation of this part of the manual included the following:

- Ghana. Road Reservation Management: Manual for Coordination. Undated First Edition.
- Ghana. Ministry of Roads and Transportation. Highway Code. 1974
- Ghana. Ministry of Roads and Highways. Standard Details, Road Signs and Markings for Urban and Trunk Roads. 1991
- Ghana Highway Authority. Road Design Guide. 1991.
- World Bank Technical Paper 496. Ensuring Basic Access for Rural Communities. 2001.
- Ghana. Ministry of Employment and Social Welfare. Labour Act 651. 2003.
- Ghana Highway Authority. Road Maintenance Operation Manual. Road Condition Survey (Revised manual). 2003
- Ghana. Department of Feeder Roads. Guidance Notes for the Design of Rural Feeder Roads. 2004.
- Ghana. Ministry of Transportation. Standard Specification for Road and Bridge Works. 2007
- Ghana. Ministry of Transportation. Draft Review of the Ministry of Transportation's Signs and Markings Standards. 2007.
- Ghana. Ministry of Roads and Highways. Design Standards for the Department of Feeder Roads. 2009.
- ISO 10845 International Standard for Construction Procurement. Part 7: Targeted Procurement. 2010.
- Ghana. Environmental Protection Agency. Environmental Impact Assessment Guidelines for the Transport Sector. 2011
- Ghana. Ministry of Local Government and Rural Development. Practitioner's guide to Rural Road Improvement and Maintenance. 2014.
- Ethiopian Roads Authority. Manual for Low Volume Roads. 2016.
- Tanzania. Advice for Motorcycle Safety on Low-Volume Rural Roads. 2016

# APPENDIX A.1: Traffic Count Survey Form

**Traffic Count Form (back)**

**NOTES FOR COMPLETION:**  
 1. Boxes with darker shading **MUST** be completed. Key data from front of form required in case single sided copies made  
 2. Boxes with paler shading **SHOULD** be completed when relevant reliable information is available

Region:  District:  Location:  (Km Chaiage)

Link Number:  Link Name:  Date of traffic count:  Date of approval:

Interviewer:  Enumerator:  Date of interview:  Approved by:

Sketch map [if needed to clarify the location of count point]

FACTOR	Comment (if any)
Market Day	
Funeral	
Wedding	
Construction	
Other (specify on right)	

**Socio-Economic characteristics of road link (additional comments on travel, transport and access to health, education and other services)**

Main reason for travel/transport:

Facilities being accessed (travel):

Typical goods carried (transport):

Comment on road function: YES NO

Serving local residents; Link road for through traffic

S	L	SL	Public Transport?	YES	NO	[add details of public transport if known]												
SUN	MON	TUE	WED	THU	FRI	SAT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Traffic patterns: ["P" indicates peak days / months]

Seasonal Accessibility: ["X" indicates impassable to 2wd, "L" indicates limited passability to 2 wd]

Any other comments [Including any additional information about typical origin, destination, or loads]

**Traffic Count Form (front)**



Region: \_\_\_\_\_  
 Link Number: \_\_\_\_\_  
 Description of Count Point: \_\_\_\_\_

NOTES FOR COMPLETION: 1. Responsible Officer to complete all shaded boxes  
 2. Enumerator to conduct traffic count as instructed  
 3. When instructed to do so, Enumerator to provide further details overlaid in interview  
 4. Responsible officer to check and sign that all data and meta data is complete and genuine

District: \_\_\_\_\_ Date: \_\_\_\_\_  
 Link Name: \_\_\_\_\_ Location: \_\_\_\_\_  
 Season: \_\_\_\_\_ Enumerator: \_\_\_\_\_  
 (km Chainage)

Responsible Officer: \_\_\_\_\_

[X] UNLOADED (start marking from bottom of area)  
 LOADED (start marking from top of area)

Starting time:	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	COUNT	FACTOR	TOTAL	

## Appendix A.2: Geometric Design Standards and Road Cross-Sections

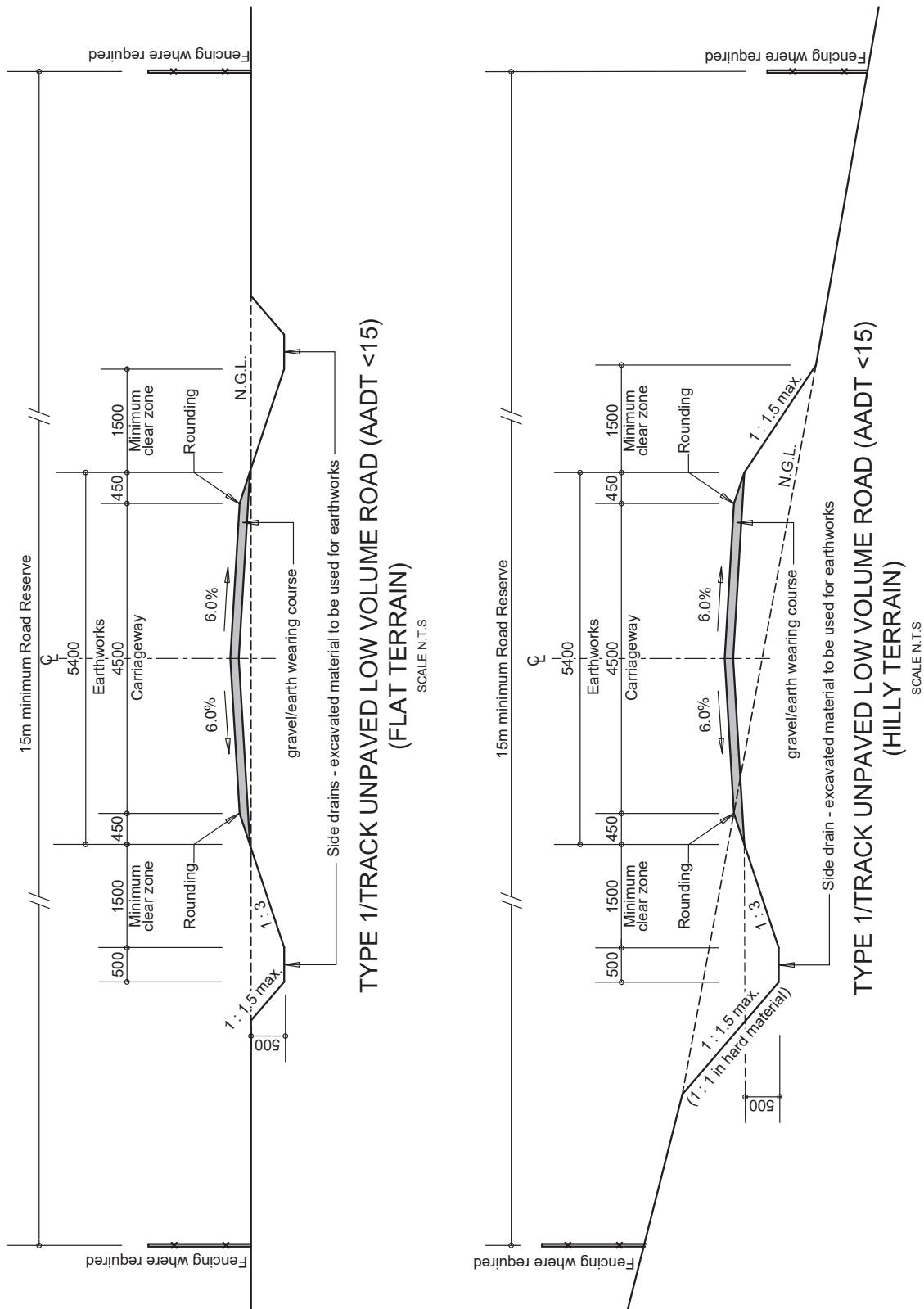
### Geometric design standards for Type 1 Track/Unpaved roads (AADT <15)

Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Desirable speed	km/h	50	40	20 <sup>(3)</sup>	40
Road Reserve width	m	15	15	15	15
Road width	m	4.5	4.5	4.5 <sup>(3)</sup>	7.0
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	6	7	10	7
Maximum gradient	%	7 <sup>(4)</sup>	10 <sup>(4)</sup>	12 <sup>(4)</sup>	10
Normal camber	%	6	6	6	6
Minimum stopping sight distance	m	60	50	20	50
Full overtaking sight distance	m	290	230	115	230
Minimum horizontal radius for camber = 6%	m	100	60	15	60
Minimum length of horizontal curve	m	80	70	40	70
Minimum crest vertical curve	K	8	4	Use min. L	4
Minimum sag vertical curve	K	7	5	Use min. L	5
Minimum vertical curve length	m	40	35	30	35

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

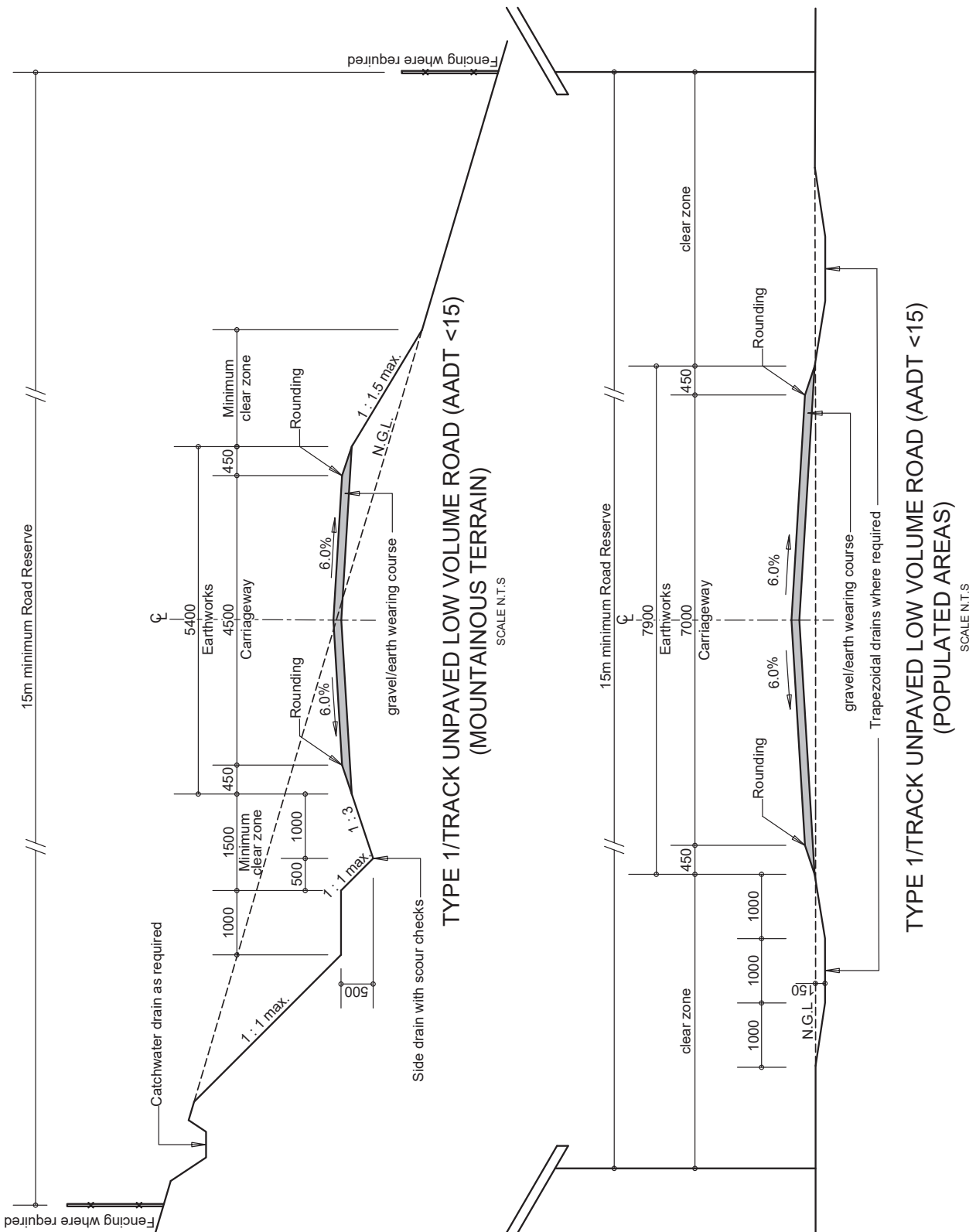
#### NOTES:

1. If the number of large vehicles is >10, then Type 2 should be used.
2. On hairpin stacks the minimum radius may be reduced to 13m.
3. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
4. Length not to exceed 250m and relief gradient required (<6% for minimum of 250m).



Typical cross-section: Type 1 Track, Unpaved (AADT <15): Flat terrain, and Hilly terrain





Typical cross-section: Type 1 Track Unpaved (AADT <15): Mountainous terrain, and Populated areas

### Geometric design standards for Type 2 Unpaved roads (AADT <75)

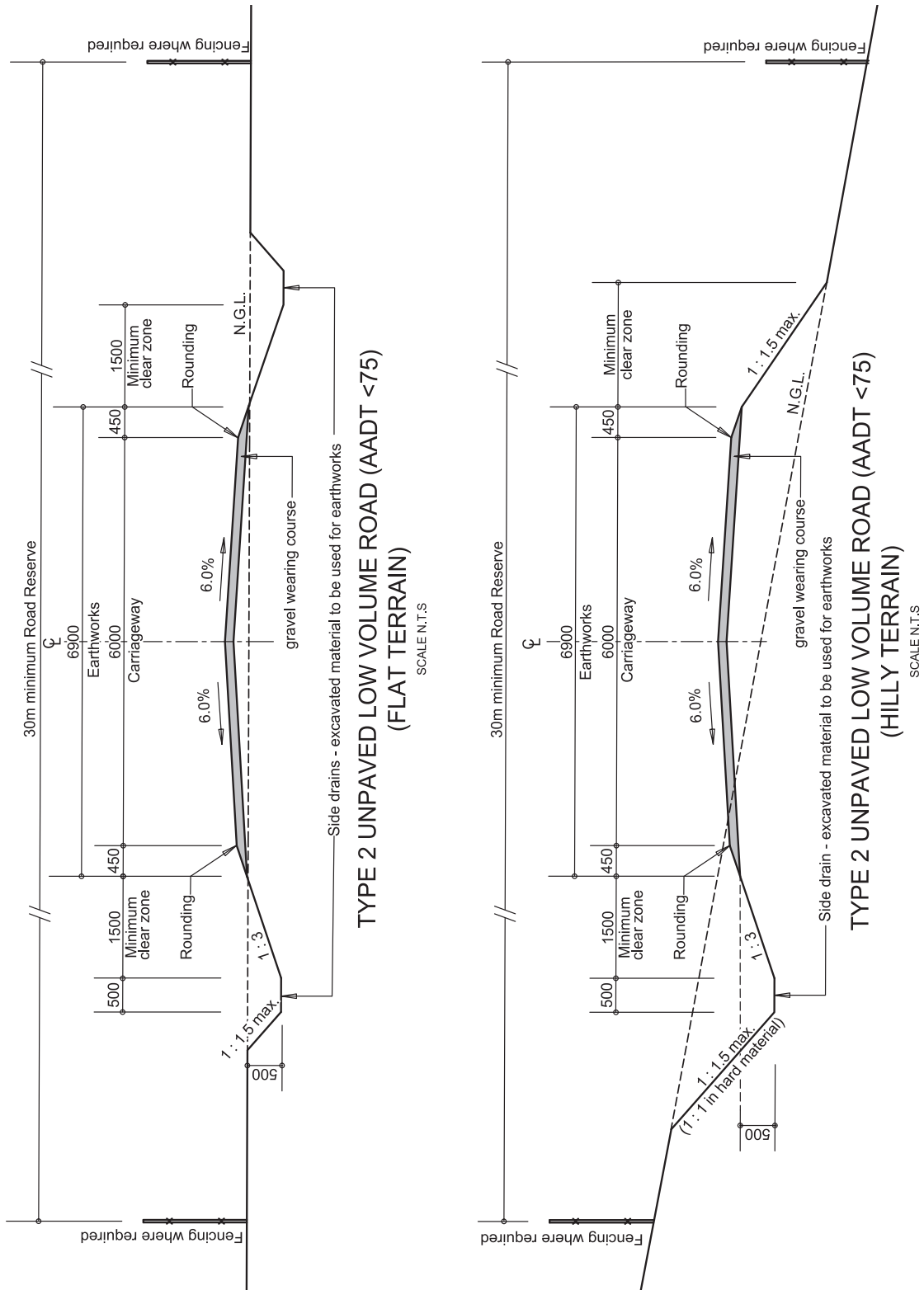
Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Design speed	km/h	50	40	20 <sup>(2)</sup>	40
Road Reserve width	m	30	30	30	30
Road width	m	6.0	6.0	6.0 <sup>(2)</sup>	7.0 <sup>(4)</sup>
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	6	7	10	7
Maximum gradient	%	7	10	12	10
Normal camber	%	6	6	6	6
Minimum stopping sight distance	m	60	50	20	50
Full overtaking sight distance	m	290	230	115	230
Minimum horizontal radius for camber = 6%	m	100	60	15	60
Minimum length of horizontal curve	m	80	70	40	70
Minimum crest vertical curve	K	8	4	Use min. L	4
Minimum sag vertical curve	K	7	5	Use min. L	5
Minimum vertical curve length	m	40	35	30	35

Sources:

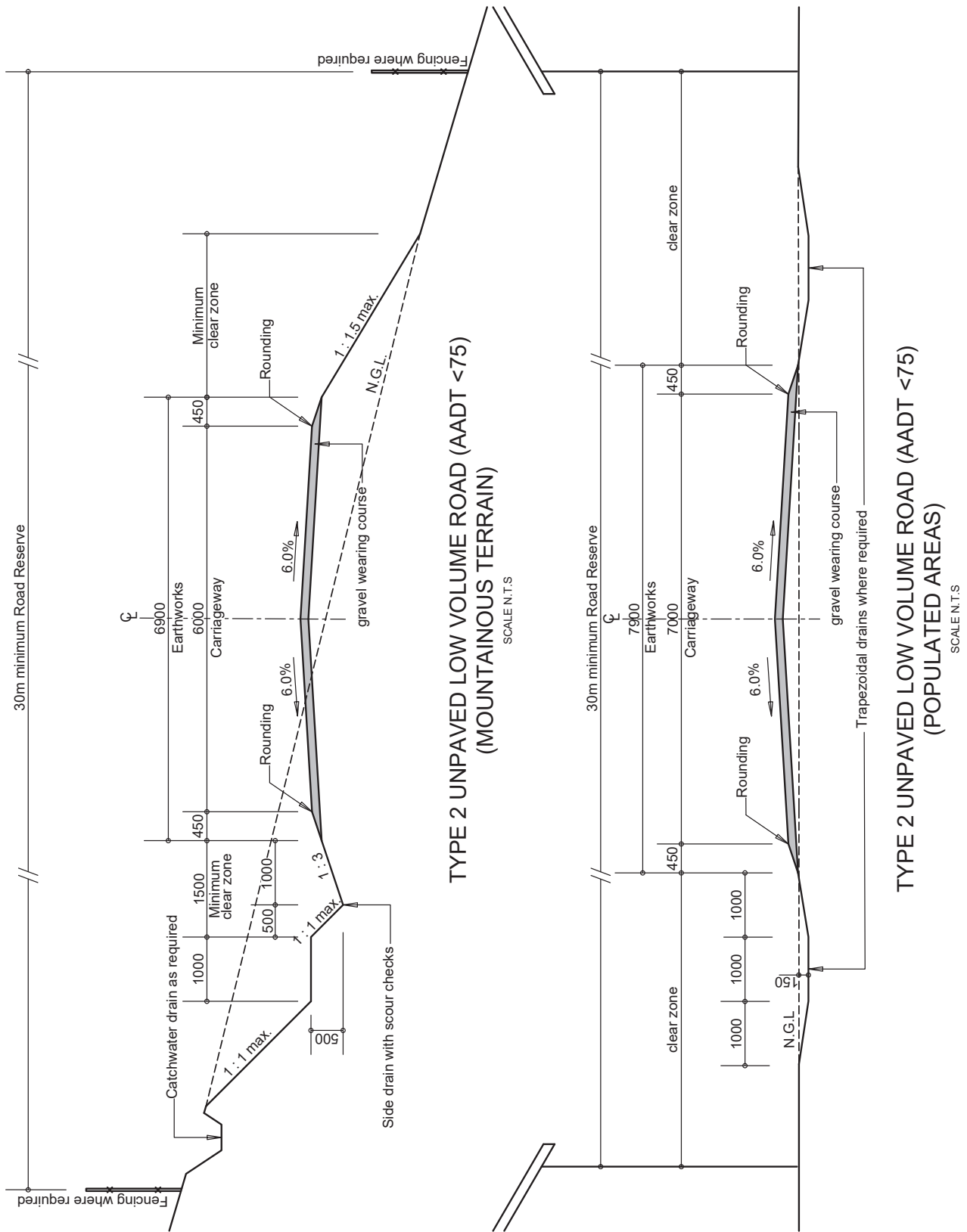
- Modified from ERA Manual for Low Volume Roads, 2016
- Ministry of Local Government and Rural Development. Practitioners Guide to Rural Road Improvement and Maintenance, 2014

NOTES:

1. If the number of large vehicles is >20, then Type 3 should be used.
2. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
3. Parking lanes and footpaths may be required.



Typical cross-section: Type 2 Unpaved (AADT <75): Flat terrain, and Hilly terrain



Typical cross-section: Type 2 Unpaved (AADT <75): Mountainous terrain, and Populated areas

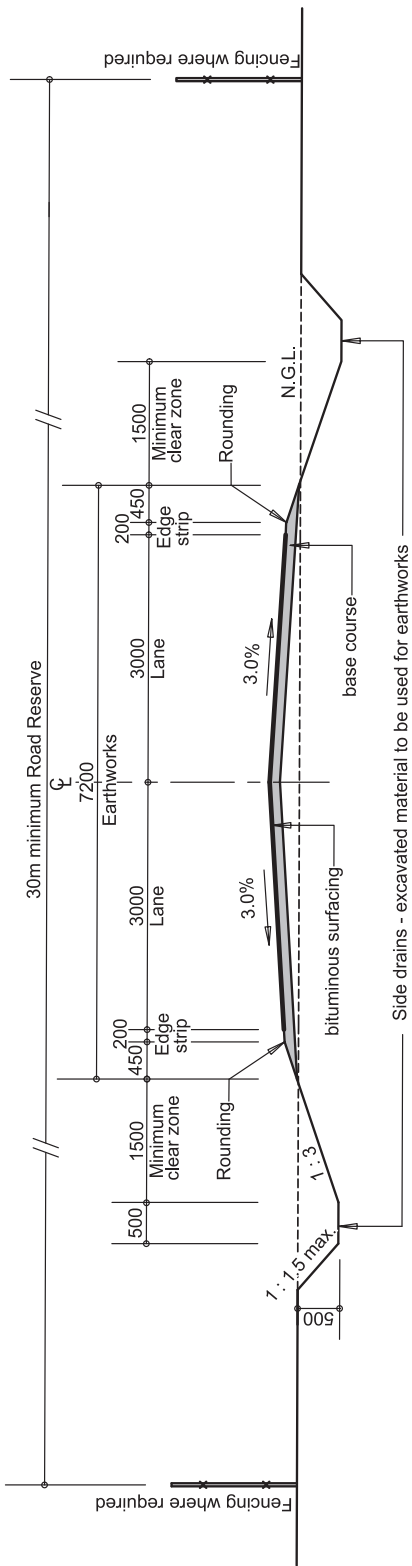
### Geometric design standards for Type 2 Paved roads (AADT <75)

Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Design speed	km/h	60	50	30 <sup>(2)</sup>	50
Road Reserve width	m	30	30	30	30
Surfaced width	m	6.0	6.0	6.0 <sup>(2)</sup>	7.0
Shoulder width	m	0.2	0.2	0.0	0.5 <sup>(3,4)</sup>
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	5	6	10	6
Maximum gradient	%	8	9	12 <sup>(5)</sup>	6
Normal camber	%	3	3	3	3
Maximum desirable superelevation	%	6	5	3	5
Minimum stopping sight distance	m	80	60	30	60
Full overtaking sight distance	m	350	290	230	290
Minimum horizontal radius for superelevation= 3%	m	180	115	40	115
Minimum horizontal radius for superelevation= 4%	m	170	110	-	110
Minimum horizontal radius for superelevation= 5%	m	160	105	-	105
Minimum horizontal radius for superelevation= 6%	m	150	-	-	-
Minimum length of horizontal curve	m	100	80	50	80
Minimum crest vertical curve	K	14	8	Use min. L	8
Minimum sag vertical curve	K	10	7	Use min. L	7
Minimum vertical curve length	m	50	40	30	40

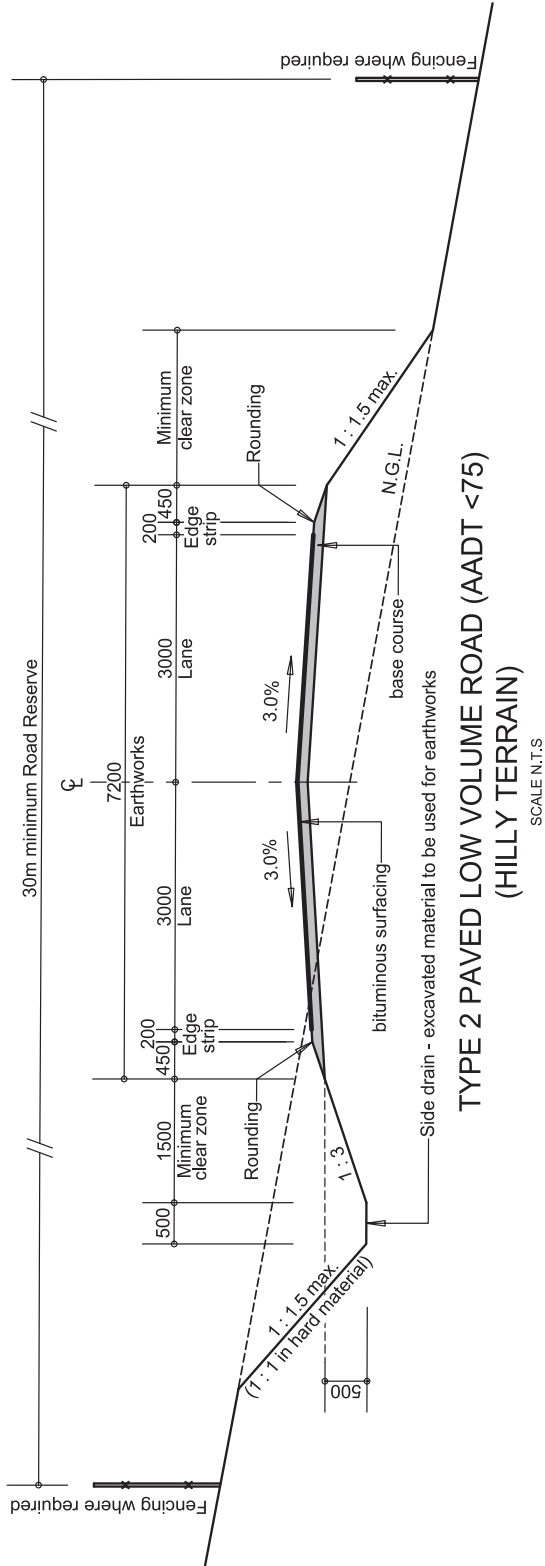
SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

NOTES:

1. If the number of large vehicles >20, then Type 3 should be used.
2. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
3. Parking lanes and footpaths may be required.
4. Increase shoulder widths for NMT and 2- and 3-wheeled motorised traffic > 300 PCUs per day.
5. Length not to exceed 250m and relief gradients required (<6% for minimum of 250m).

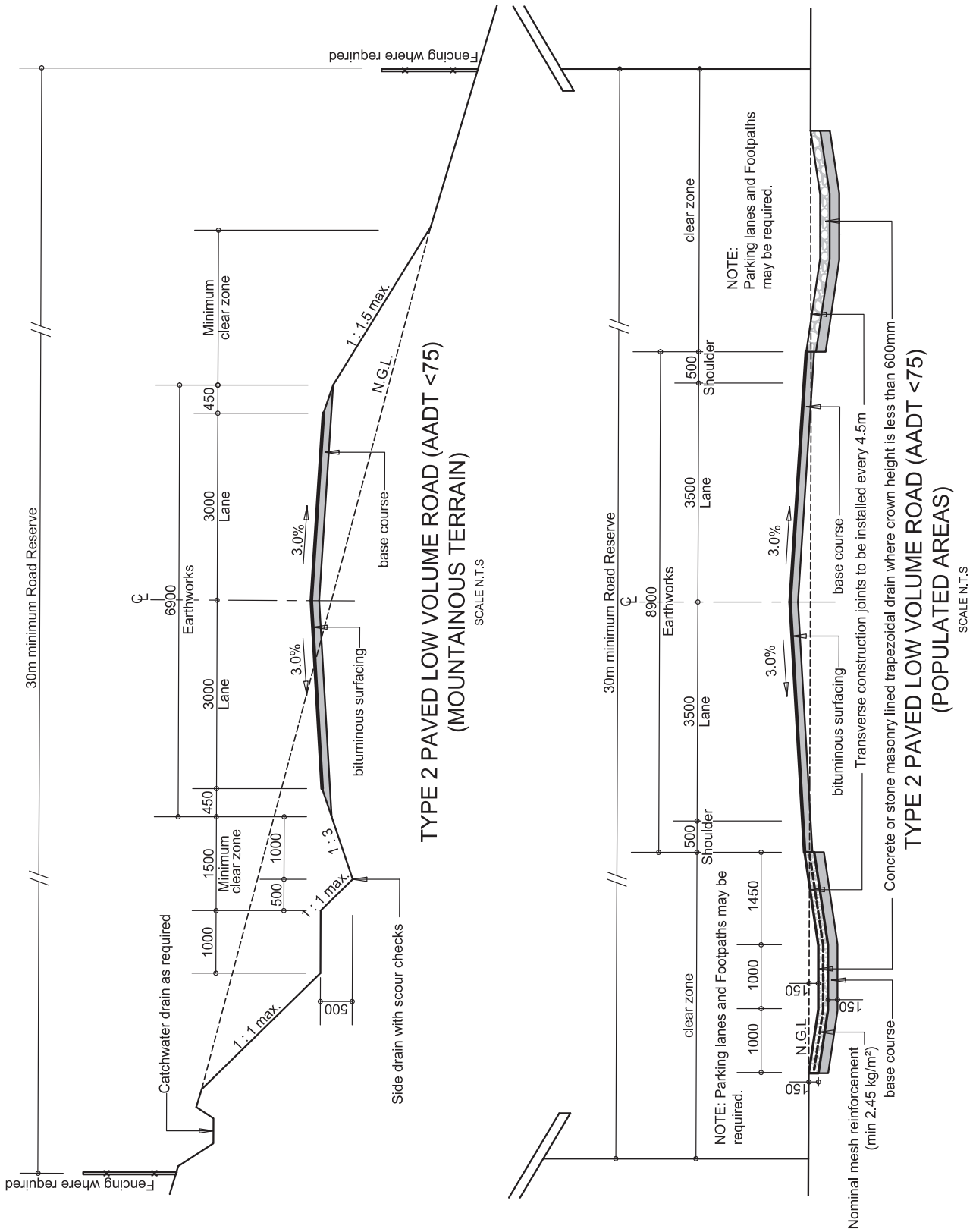


**TYPE 2 PAVED LOW VOLUME ROAD (AADT <75)**  
**(FLAT TERRAIN)**  
SCALE N.T.S.



**TYPE 2 PAVED LOW VOLUME ROAD (AADT <75)**  
**(HILLY TERRAIN)**  
SCALE N.T.S.

**Typical cross-section: Type 2 Paved Roads (AADT <75): Flat terrain, and Hilly terrain**



Typical cross-section: Type 2 Paved (AADT <75): Mountainous, and Populated, areas

### Geometric design standards for Type 3 Unpaved roads (AADT 75-150)

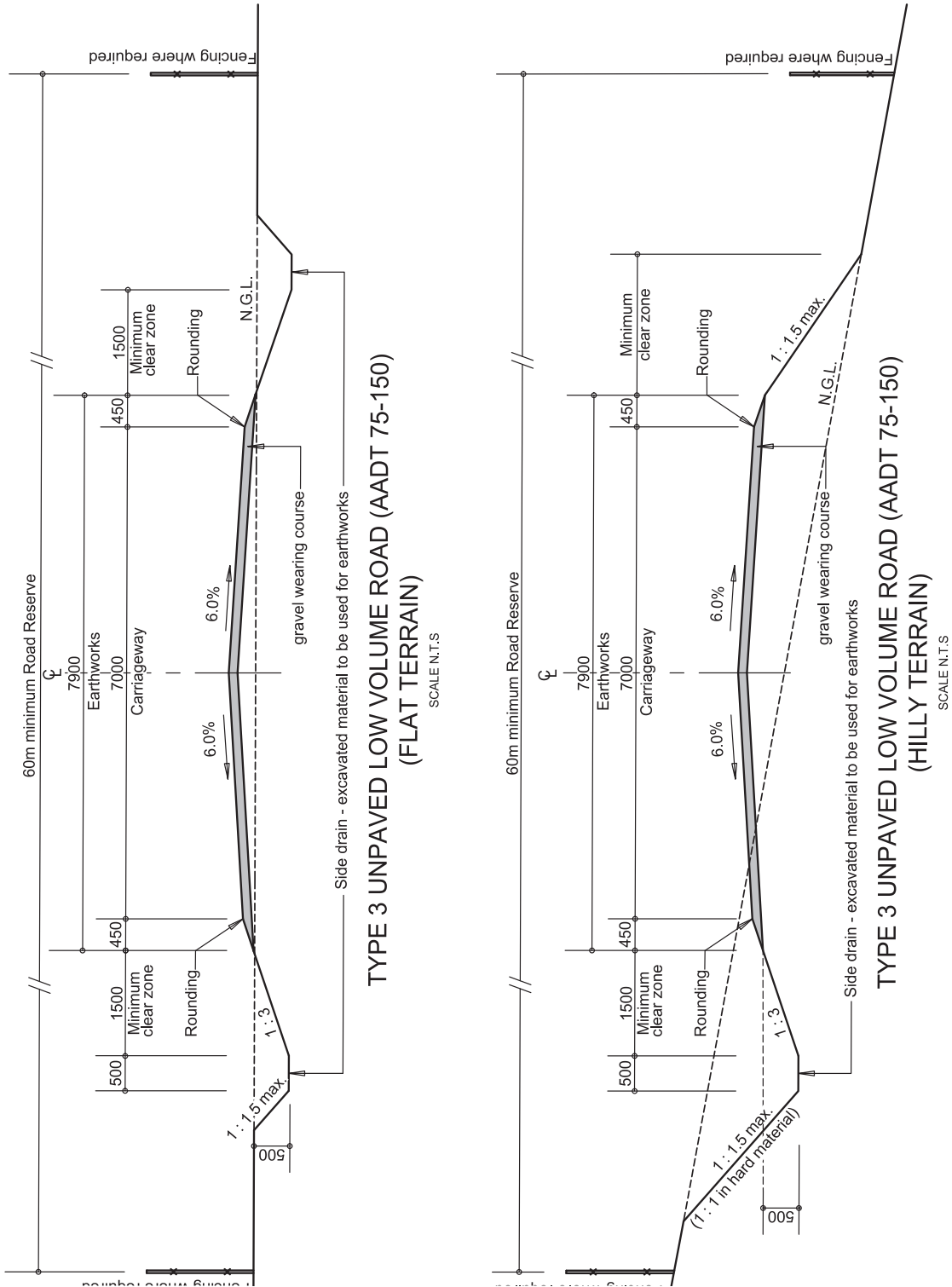
Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Design speed	km/h	60	50	30 <sup>(2)</sup>	50
Road Reserve width	m	60	60	60	60
Road width	m	7.0	7.0	7.0 <sup>(2)</sup>	7.0 <sup>(3)</sup>
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	5	6	10	6
Maximum gradient	%	7	10	12	10
Normal camber	%	6 <sup>(4)</sup>	6 <sup>(4)</sup>	6 <sup>(4)</sup>	6 <sup>(4)</sup>
Minimum stopping sight distance	m	80	60	30	60
Full overtaking sight distance	m	350	290	170	290
Minimum horizontal radius for camber = 6%	m	150	100	35	100
Minimum length of horizontal curve	m	100	80	50	80
Minimum crest vertical curve	K	14	8	Use min. L	8
Minimum sag vertical curve	K	10	7	Use min. L	7
Minimum vertical curve length	m	50	40	30	40

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

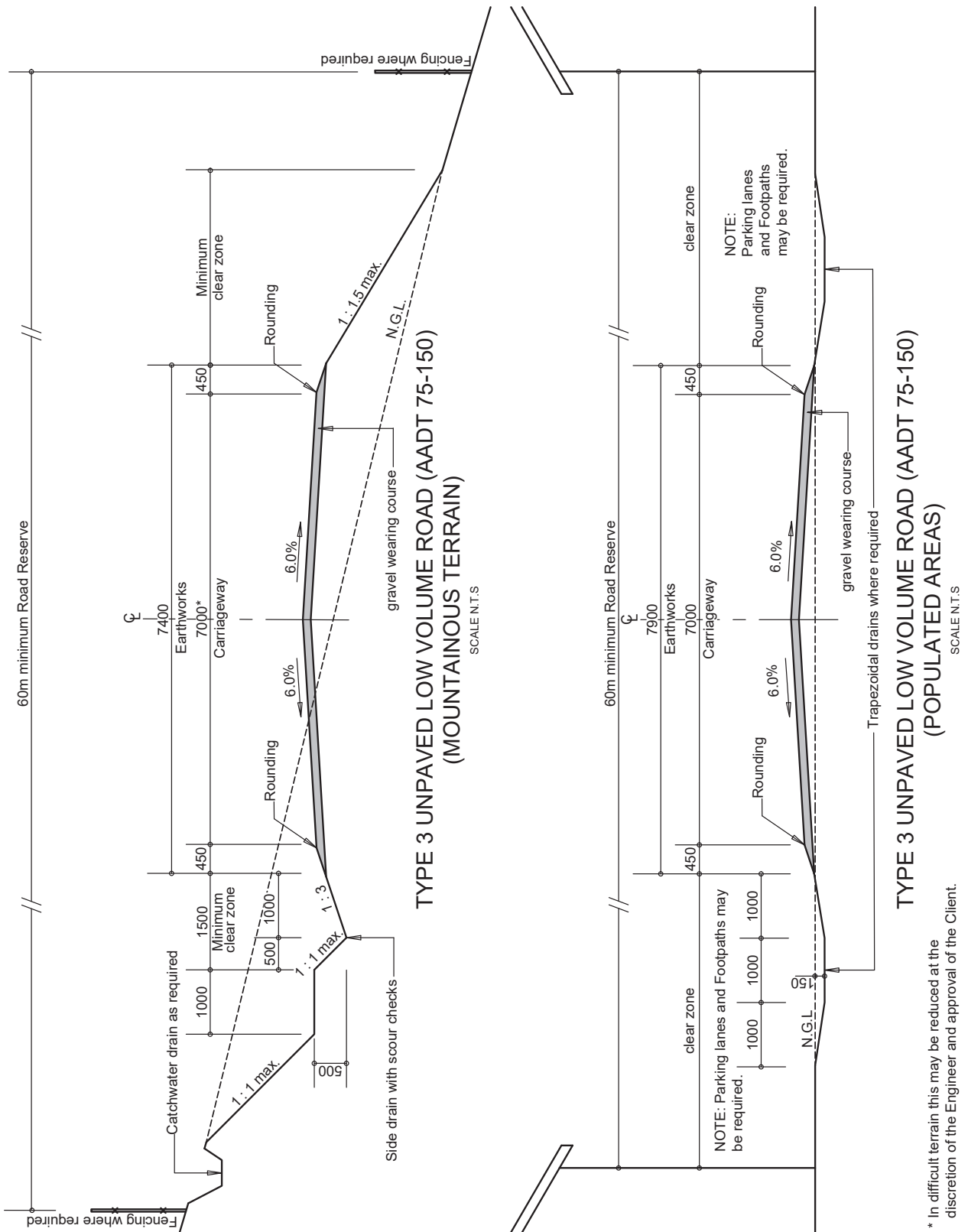
#### NOTES:

1. If the number of large vehicles is >30, then Type 4 should be used.
2. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
3. Parking lanes and footpaths may be required.
4. Crossfall can be reduced to 4% where warranted (e.g. poor gravel (for safety), low rainfall)





Typical cross-section: Type 3 Unpaved (AADT 75-150): Flat terrain, and Hilly terrain



Typical cross-section: Type 3 Unpaved (AADT 75-150): Mountainous terrain, and Populated areas

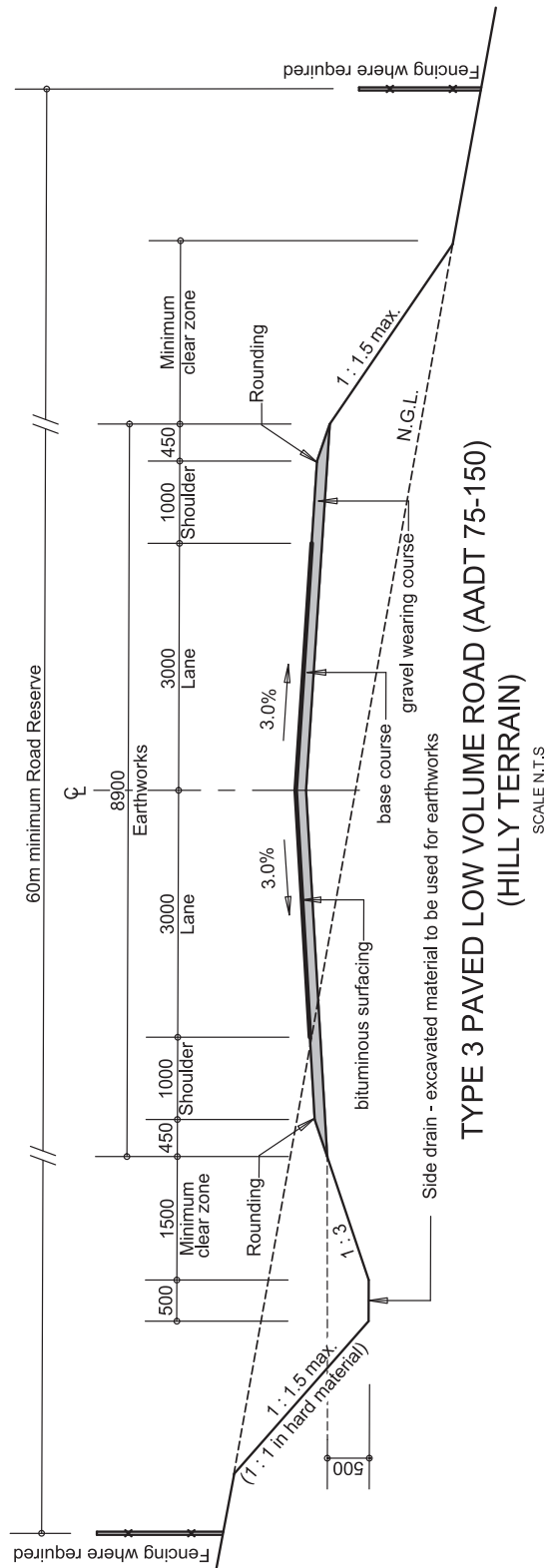
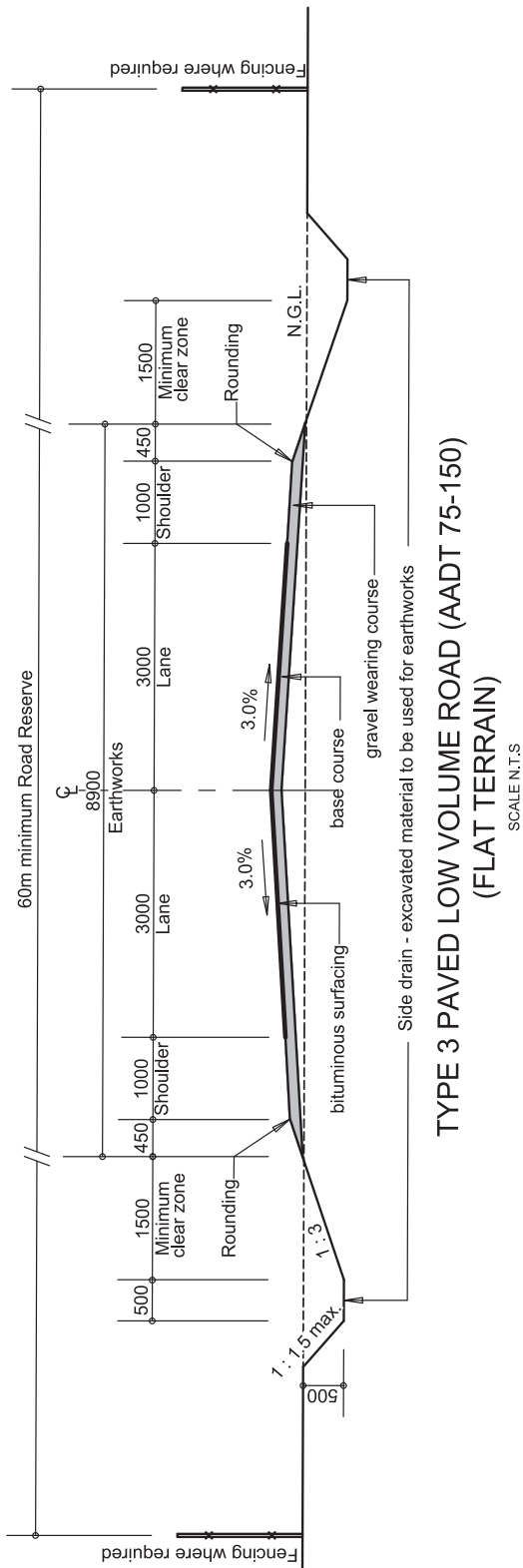
### Geometric design standards for Type 3 Paved roads (AADT 75-150)

Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Design speed	km/h	70	60	30 <sup>(2)</sup>	50
Road Reserve width	m	60	60	60	60
Surfaced width	m	6.0	6.0	6.0 <sup>(2)</sup>	7.0
Shoulder width	m	1.0	1.0	0.5	1.0 <sup>(3,4)</sup>
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	4	5	10	6
Maximum gradient	%	8	9	12 <sup>(5,6)</sup>	9
Normal camber	%	3	3	3	3
Maximum desirable superelevation	%	7	6	3	5
Minimum stopping sight distance	m	100	80	30	60
Full overtaking sight distance	m	420	350	170	290
Minimum horizontal radius for superelevation= 3%	m	245	180	40	115
Minimum horizontal radius for superelevation= 4%	m	230	170	-	110
Minimum horizontal radius for superelevation= 5%	m	215	160	-	105
Minimum horizontal radius for superelevation= 6%	m	205	150	-	-
Minimum horizontal radius for superelevation= 7%	m	200	-	-	-
Minimum length of horizontal curve	m	120	100	50	80
Minimum crest vertical curve	K	30	14	Use min. L	8
Minimum sag vertical curve	K	18	10	Use min. L	7
Minimum vertical curve length	m	70	50	30	40

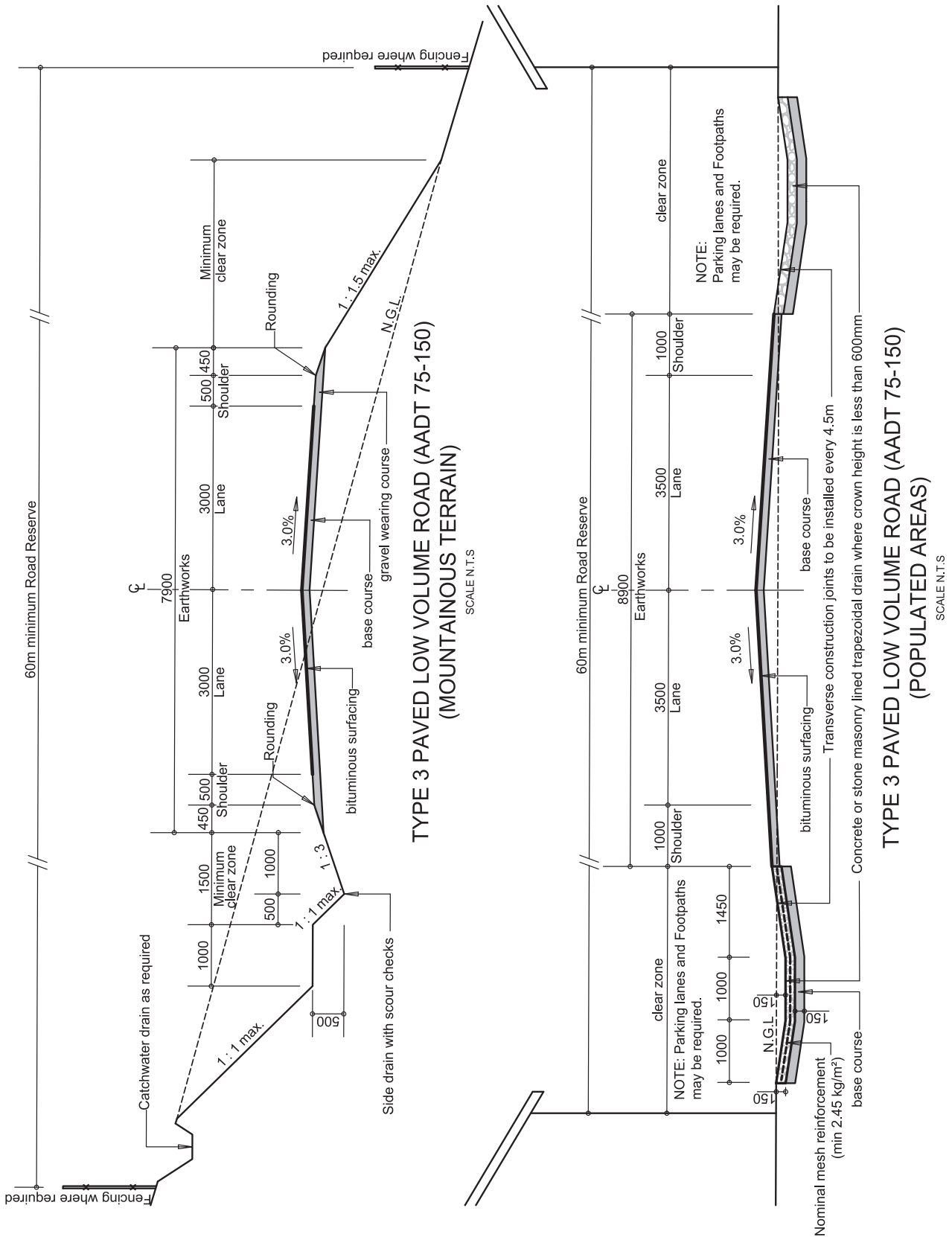
SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

#### NOTES:

1. If the number of large vehicles is >30, then Type 4 should be used.
2. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
3. Increase shoulder widths for NMT and 2- and 3-wheeled motorised traffic > 300 PCUs per day.
4. Parking lanes and footpaths may be required.
5. Length not to exceed 250m and relief gradients required (<6% for minimum of 250m).
6. If the number of large vehicles <20 this can be increased (to 15%).



Typical cross-section: Type 3 Paved (AADT 75-150): Flat terrain, and Hilly terrain



Typical cross-section: Type 3 Paved (AADT 75-150): Mountainous terrain, and Populated areas

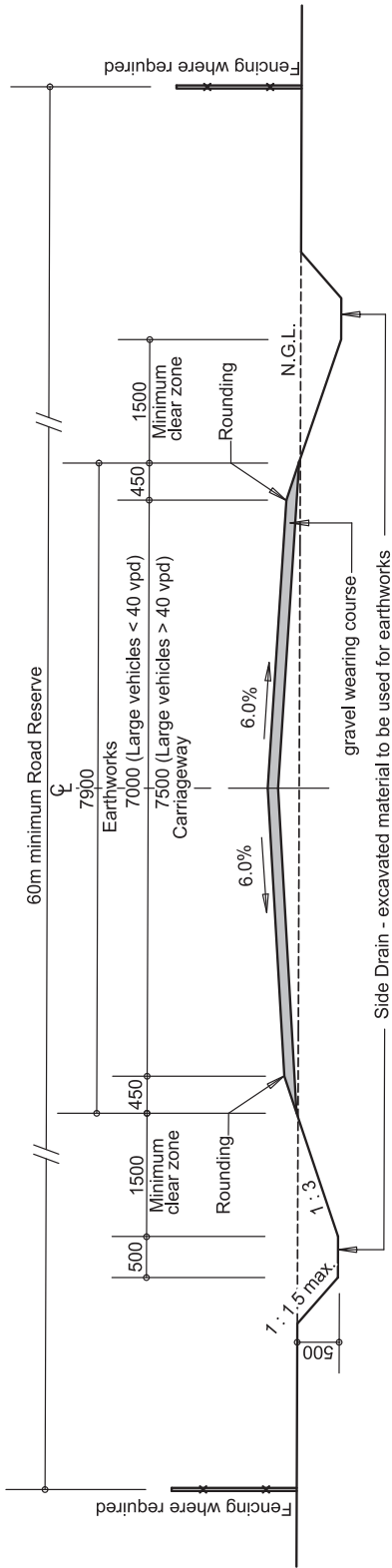
### Geometric design standards for Type 4 Unpaved roads (AADT 150-300)

Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Design speed	km/h	60	50	30 <sup>(2)</sup>	50
Road Reserve width	m	60	60	60	60
Road width	m	7.0 <sup>(3)</sup>	7.0 <sup>(3)</sup>	7.0 <sup>(2)</sup>	7.0 <sup>(3,4)</sup>
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	5	6	10	6
Maximum gradient	%	6	9	9	6
Normal camber	%	6 <sup>(5)</sup>	6 <sup>(5)</sup>	6 <sup>(5)</sup>	6 <sup>(5)</sup>
Maximum desirable superelevation	%	6	5	3	5
Minimum stopping sight distance	m	80	60	30	60
Full overtaking sight distance	m	350	290	170	290
Minimum horizontal radius for superelevation= 6%	m	150	100	35	100
Minimum length of horizontal curve	m	100	80	50	80
Minimum crest vertical curve	K	14	8	Use min. L	8
Minimum sag vertical curve	K	10	7	Use min. L	7
Minimum vertical curve length	m	50	40	30	40

SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

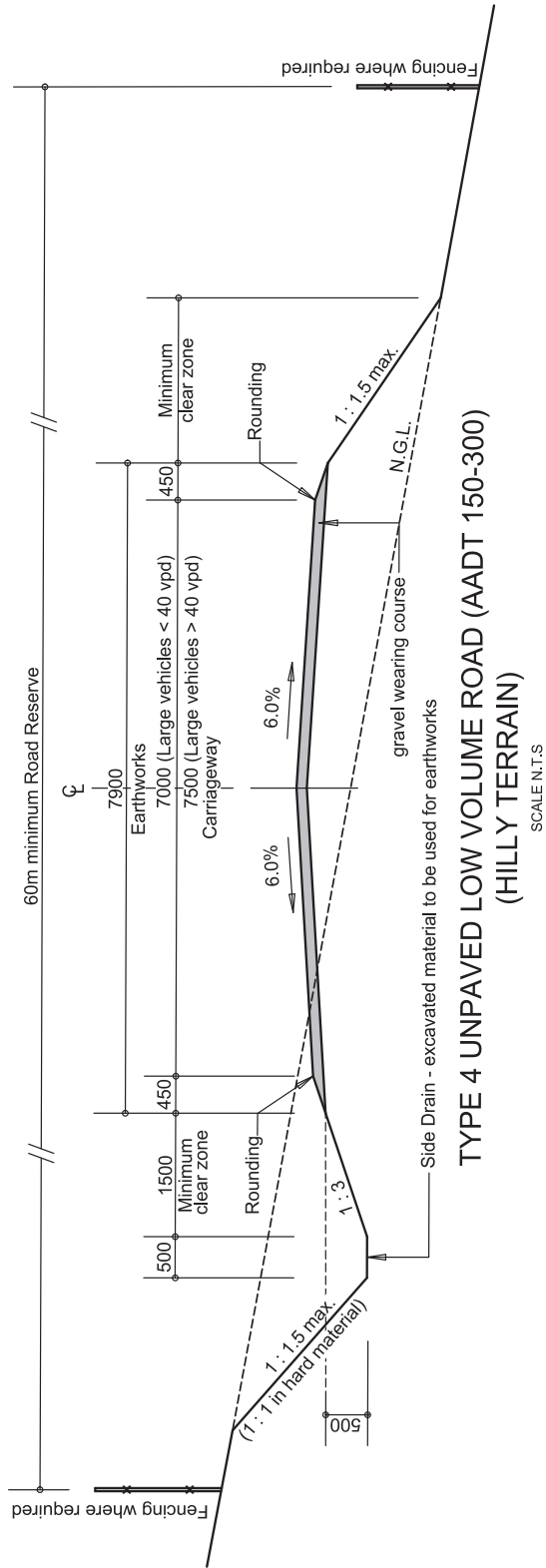
#### NOTES:

1. If the number of large vehicles is >80, then the road classes for high volume traffic (GHA) should be used.
2. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
3. If the number of large vehicles >40 then this should be increased to 7.5m.
4. Parking lanes and footpaths may be required.
5. Crossfall can be reduced to 4% where warranted (e.g. poor gravel (for safety), low rainfall)



**TYPE 4 UNPAVED LOW VOLUME ROAD (AADT 150-300)**  
**(FLAT TERRAIN)**

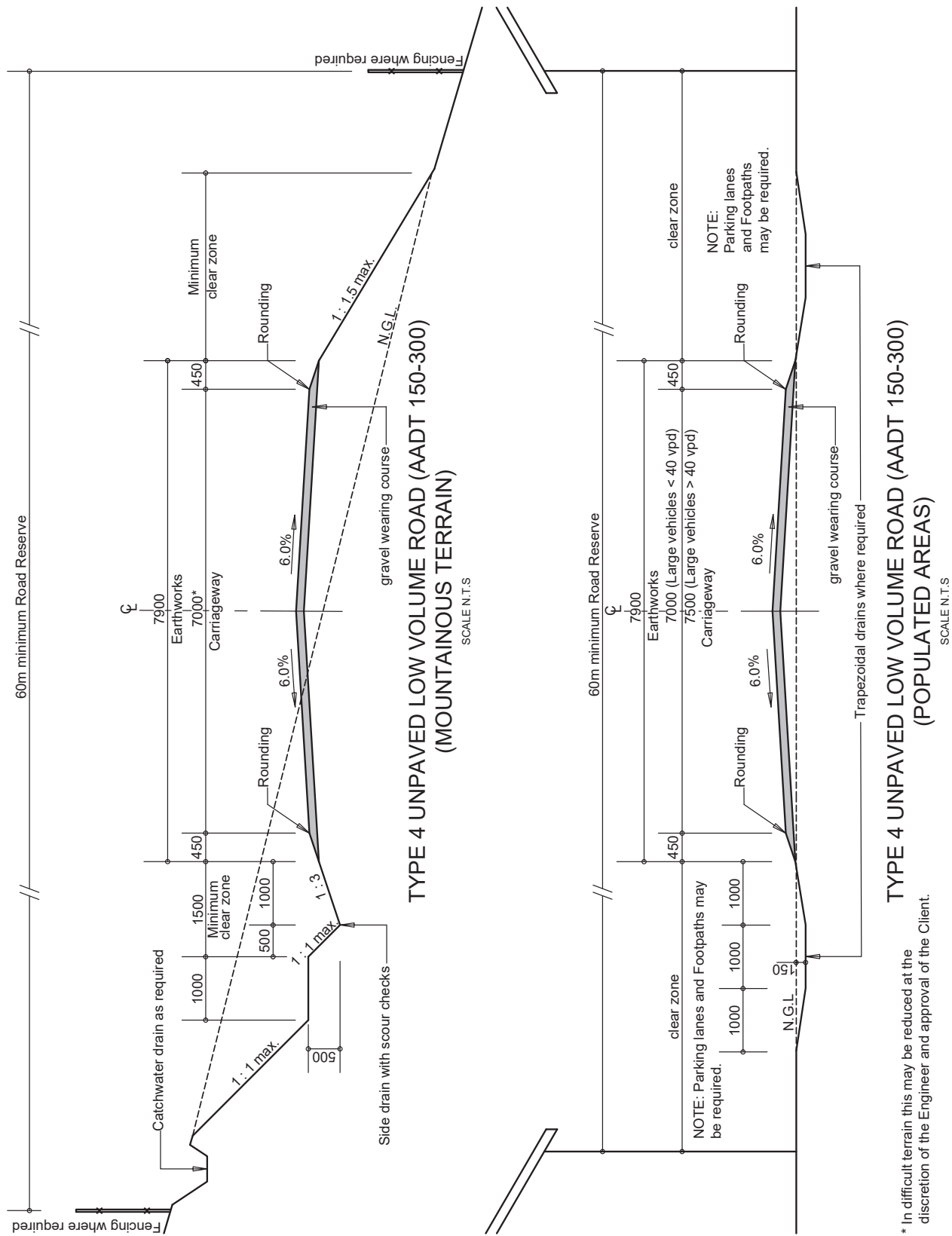
SCALE N.T.S



**TYPE 4 UNPAVED LOW VOLUME ROAD (AADT 150-300)**  
**(HILLY TERRAIN)**

SCALE N.T.S

**Typical cross-section: Type 4 Unpaved (AADT 150-300): Flat terrain, and Hilly terrain**



Typical cross-section: Type 4 Unpaved (AADT 150-300): Mountainous terrain, and Populated areas



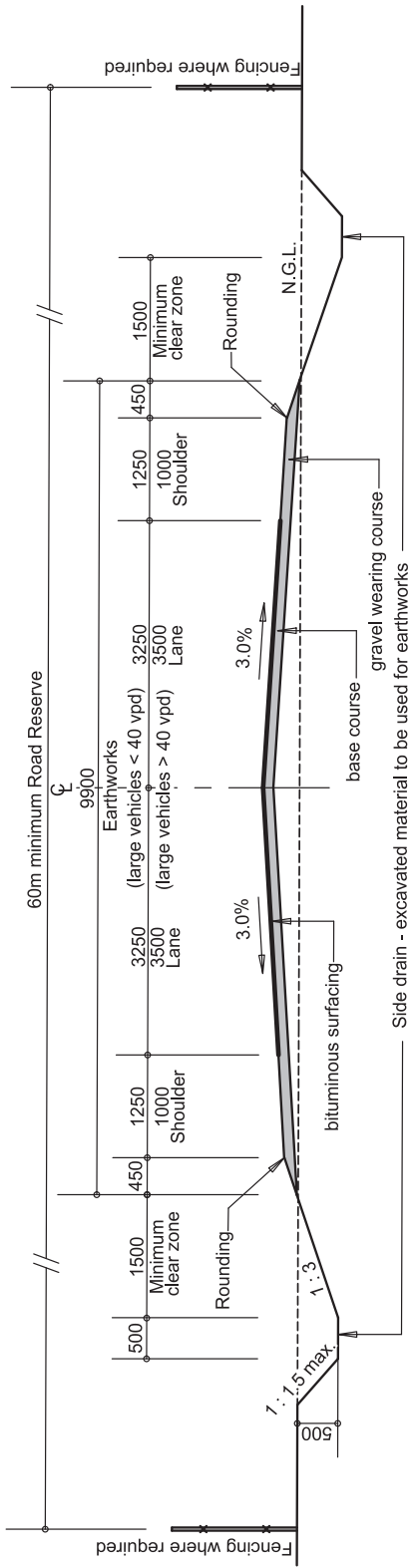
### Geometric design standards for Type 4 Paved Roads (AADT 150-300)

Design Element	Unit	Flat	Hilly	Mountain	Populated areas
Design speed	km/h	70	60	30 <sup>(2)</sup>	50
Road Reserve width	m	60	60	60	60
Surfaced width	m	6.5 <sup>(3)</sup>	6.5 <sup>(3)</sup>	6.5 <sup>(2)</sup>	7.0 <sup>(3)</sup>
Shoulder width	m	1.25 <sup>(3)</sup>	1.25 <sup>(3)</sup>	0.5	1.25 <sup>(4,5)</sup>
Minimum gradient	%	0.5	0.5	0.5	0.5
Maximum desirable gradient	%	4	5	10	6
Maximum gradient	%	6	8	10 <sup>(6)</sup>	9
Normal camber	%	3	3	3	3
Maximum desirable superelevation	%	7	6	3	5
Minimum stopping sight distance	m	100	80	30	60
Full overtaking sight distance	m	420	350	170	290
Minimum horizontal radius for superelevation= 3%	m	245	180	40	115
Minimum horizontal radius for superelevation= 4%	m	230	170	-	110
Minimum horizontal radius for superelevation= 5%	m	215	160	-	105
Minimum horizontal radius for superelevation= 6%	m	205	150	-	-
Minimum horizontal radius for superelevation= 7%	m	200	-	-	-
Minimum length of horizontal curve	m	120	100	50	80
Minimum crest vertical curve	K	30	14	Use min. L	8
Minimum sag vertical curve	K	18	10	Use min. L	7
Minimum vertical curve length	m	70	50	30	40

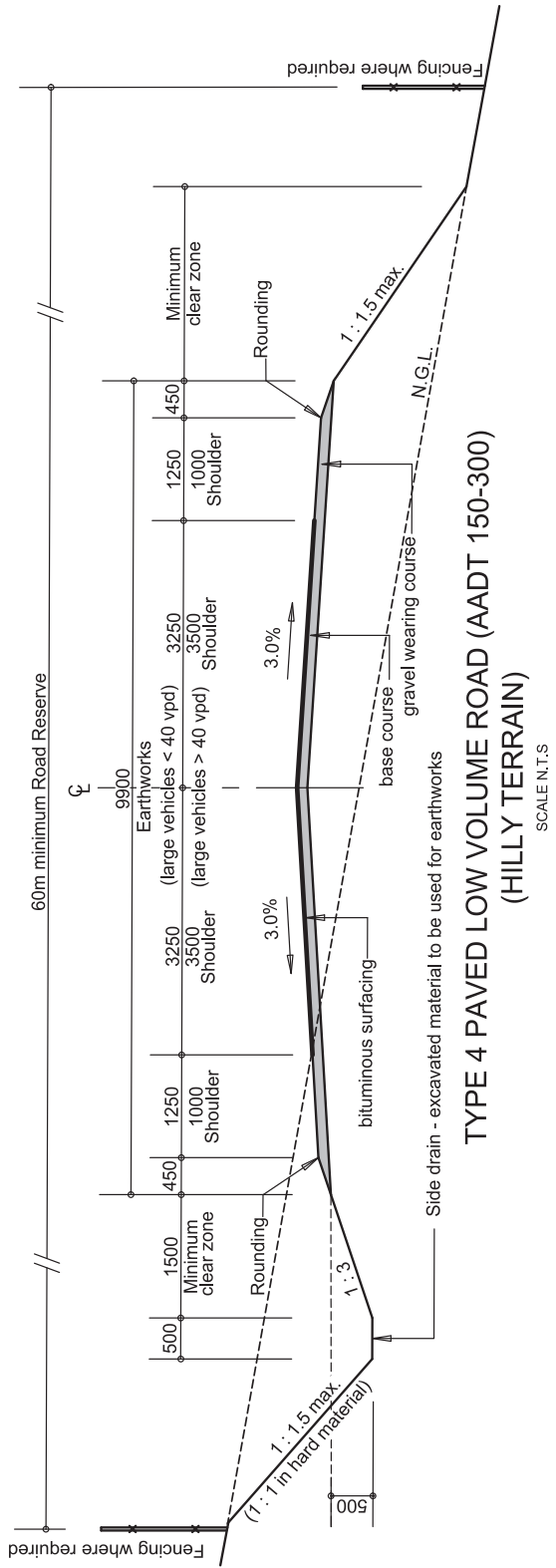
SOURCE: Modified from ERA Manual for Low Volume Roads, 2016

#### NOTES:

1. If the number of large vehicles is >80, then the road classes for high volume traffic (GHA) should be used.
2. In difficult terrain this may be reduced at the discretion of the Engineer and approval of the client.
3. If the number of large vehicles is >40 this should be increased to 7.0m and shoulders reduced to 1.0m.
4. Increase shoulder widths for NMT and 2- and 3-wheeled motorised traffic > 300 PCUs per day.
5. Parking lanes and footpaths may be required.
6. Length not to exceed 250m and relief gradients required (<6% for minimum of 250m).

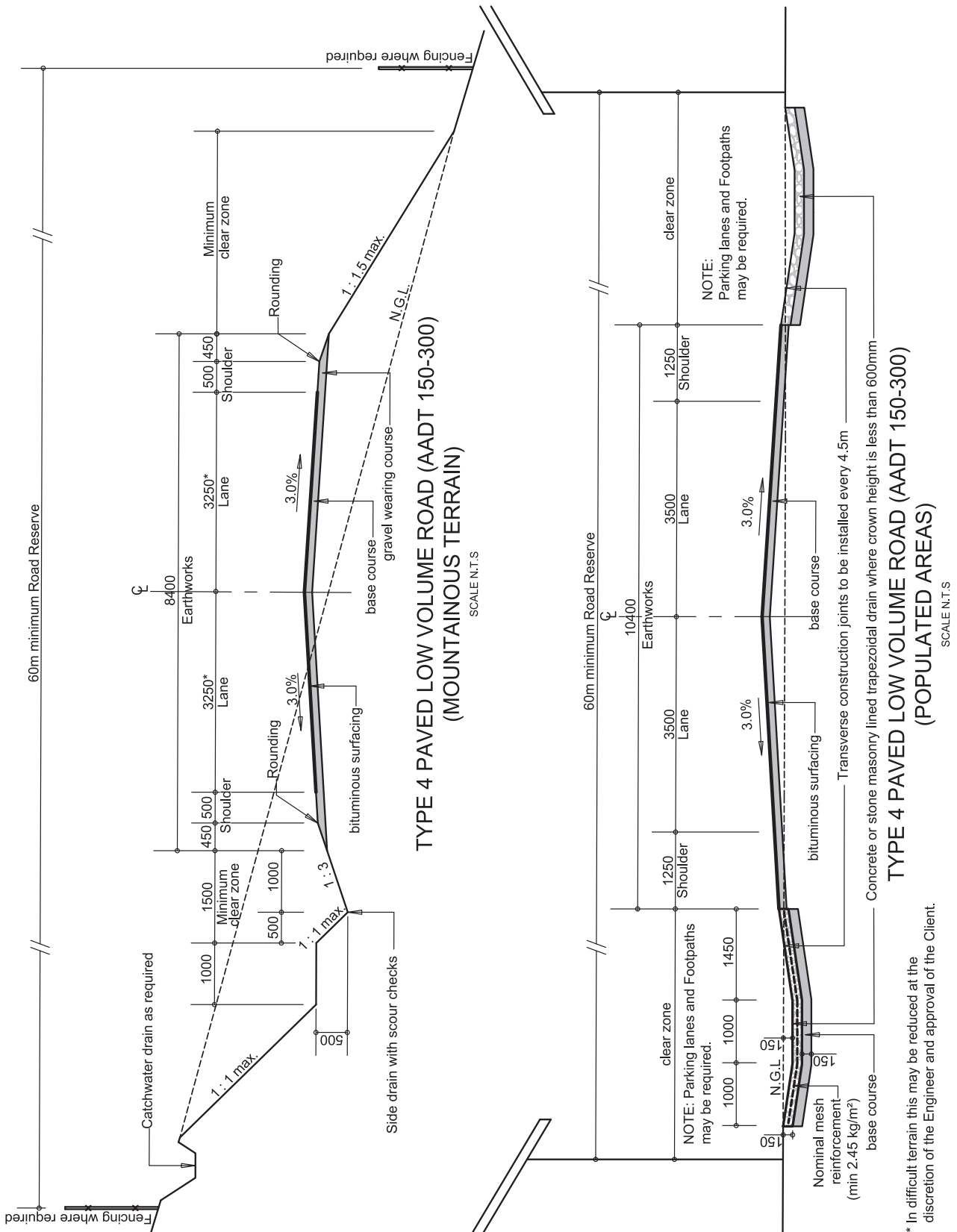


**TYPE 4 PAVED LOW VOLUME ROAD (AADT 150-300)**  
(FLAT TERRAIN)  
SCALE N.T.S



**TYPE 4 PAVED LOW VOLUME ROAD (AADT 150-300)**  
(HILLY TERRAIN)  
SCALE N.T.S

**Typical cross-section: Type 4 Paved (AADT 150-300): Flat terrain, and Hilly terrain**



Typical cross-section: Type 4 Paved (AADT 150-300): Mountainous terrain, and Populated areas

## Appendix A.3: Road Safety Audit Checklist

The following checklists draw on recognised good practice and should be applied as follows:

Stage A checklist: On completion of Design

Stage B checklist: On completion of Construction

Stage C checklist: For ongoing Monitoring

STAGE A Road Safety Audit Checklist - Completion of Design	
Item	Potential Issues
Departures from Standards	What are the road safety implications of any approved Departures from Standards or Relaxations?
	Are these strategic decisions within the scope of the Road Safety Audit?
Cross-sections	How safely do the cross-sections accommodate drainage, signage, pedestrian and cycle routes?
	Could the scheme result in the provision of adverse camber?
Drainage	Do drainage facilities (e.g. gully spacing, gully locations, flat spots, crossfall, ditches) appear to be adequate?
	Is surface water likely to drain across the carriageway and increase the risk of aquaplaning under storm conditions?
	Could excessive water drain across the highway from adjacent land?
Landscaping	Could areas of landscaping conflict with sight lines?
	Could vegetation encroach onto carriageway or obscure signs or sight lines?
Public Utility Services	Are boxes, pillars, posts and cabinets located in safe positions away from locations that may have a high potential of errant vehicle strikes? Do they interfere with visibility?
	Has sufficient clearance of overhead cables been provided?
Lay-bys	Could lay-bys be confused with junctions?
	Is the lay-by located in a safe location? (e.g. away from vertical crests or tight horizontal bends with limited visibility)
	Could parked vehicles obscure sight lines?
	Are lay-bys adequately signed?
Access	Can all accesses be used safely?
	Can multiple accesses be linked into one service road?
	Are there any conflicts between turning and parked vehicles?
	Is adequate visibility provided to/from accesses?
	Do all accesses appear safe for their intended use?
Local Alignment	Are horizontal and vertical alignments consistent with required visibility? Any "hidden dips"?
	Will sight lines be obstructed by permanent and temporary features e.g. bridge abutments, signage, parked vehicles etc?
New/Existing Road Interface	Will the proposed scheme be consistent with the standard of provision on adjacent lengths of road and if not, is this made obvious to the road user?
	Does interface occur near any potential hazard, i.e. crest, bend, after steep gradient?
	Where road environment changes (e.g. urban to rural, restricted to unrestricted) is the transition made obvious by appropriate signage and road markings?

STAGE A Road Safety Audit Checklist - Completion of Design	
Item	Potential Issues
Junctions	Are there any unusual features that affect road safety?
	Are any junctions sited on crests?
	Are sight lines adequate on and through junction approaches and from the minor arm?
	Are visibility splays adequate and clear of obstructions such as street furniture and landscaping?
	Are parking or stopping zones for buses, taxis and public utilities vehicles situated within the junction area? Are they located outside visibility splays?
	Is the junction signing adequate, consistent with adjacent signing and easily understood?
	Have the appropriate warning signs been provided?
	Are signs appropriately located, minimise potential strike risk, and are of the appropriate size for approach speeds?
	Are traffic signs mounted to appropriate heights and orientated correctly to ensure correct visibility and reflectivity?
Non-Motorized User (NMU) Provision	Have pedestrian and cycle routes been provided where required?
	Is specific provision required for special and vulnerable groups? (i.e. the young, older users, mobility and visually impaired)
	Are tactile paving, flush curbs and guard railing proposed? Is it specified correctly and in the best location?
	Are these routes clear of obstructions such as signposts, lamp columns etc?
	Are accesses to and from adjacent land/properties safe to use?
	Are facilities required for Non-Motorized Users (NMUs) at junctions, crossings etc.
	Are crossing facilities designed and placed to attract maximum use?
	Is there sufficient visibility and signage for both motorists and for pedestrians/cyclists?
Traffic Signs and Road Markings	Will signposts be appropriately located and/or protected?
	Are any road markings proposed at this stage appropriate?
	Do the signs and road markings conform to national standards, policy or regulation?
	Are road signs and markings appropriate to the location, easy to understand, and uncluttered?
	Are signposts passively safe?
	Is the sign reflectivity provided correct?

STAGE B Road Safety Audit Checklist - Completion of Construction	
Item	Potential Issues
Departures from Standards	Are there any adverse road safety implications of any Departures from Standard granted since the Stage 2 Road Safety Audit?
Drainage	Does drainage of roads, cycle routes and footpaths appear adequate?
Landscaping	Could vegetation obscure signs or sight lines?
Public Utility Services	Are boxes, pillars, posts and cabinets located in safe positions away from locations that may have a high potential for errant vehicle strikes? Do they interfere with visibility?
Access	Has adequate visibility been provided to/from accesses?
Local Alignment	Are the sight lines clear of obstruction?
New/Existing Road Interface	Is there a need for additional signs and/or road markings?
Junctions	Are all visibility splays clear of obstructions?
	Is signage adequate?
	Do the carriageway markings clearly define routes and priorities?
Non-Motorized User (NMU) Provision	Has adequate visibility and signage been provided for pedestrian and cyclist crossings?
Traffic Signs and Road Markings	Have appropriate signs and/or markings been installed in respect to national standards, policy or regulation?
	Are the visibility, locations and legibility of all signs (during daylight and darkness) adequate?
	Are signposts passively safe?
	Will signposts impede the safe and convenient passage of pedestrians and cyclists?
	Have additional warning signs been provided where necessary?
	Are all road markings/studs clear and appropriate for their location?
	Have all superseded road markings and studs been removed adequately?

### STAGE C Road Safety Audit Checklist - Monitoring

During the first year a roadway improvement scheme is open to traffic, a check should be kept on the number of personal injury collisions that occur, so that any serious problems can be identified, and remedial work arranged quickly. Stage 4 collision monitoring reports should be prepared using 12 months and 36 months collision data from the time the scheme became operational. These reports shall be submitted to the Overseeing Organisation. The collision records shall be analysed in detail to identify:

- (a) Locations at which personal injury collisions have occurred,
- (b) Personal injury collisions that appear to arise from similar causes or show common factors.

The analysis should include identification of changes in the incident population in terms of number, types, and other collision variables, and comparisons should be made with control data. Where the Highway Improvement Scheme is an on-line improvement then the collision record before the scheme was built should be compared with the situation after opening. The collision data should be analysed to identify the influence of problems and recommendations identified at previous audit stages, and any Exception Reports.

If collision records are not sufficiently comprehensive for detailed analysis, the police should be contacted to ascertain the availability of statements and report forms, which could aid the 36-month data analysis.

The collision monitoring reports should identify any road safety problems indicated by the data analysis and observations during any site visits undertaken. The reports should make recommendations for remedial action.

*SOURCE: Developed from HD 19/15 of the UK Highways Manual Volume 5 Section 2 Part 2*

## Appendix A.4: Key CI issues to consider, by project stage

### A.

#### Key issues to consider during early planning stages

CIs need to be treated as an integral part of the planning process, in much the same way as environmental and social safeguards are. Provision for them should be included in the long and medium-term budgets to prevent them being removed due to inadequate budgeting or fund allocation.

The client should consult with key stakeholders during project identification stages. Key stakeholders at the early planning stage could include those who identified the need for the project and representatives from local administrations. The outcome of the consultations should be an outline or indicative plan for inclusion of complementary interventions in the road project/programme.

It is the responsibility of the client to decide on the extent of CIs that are to be considered during feasibility study and to prepare the outline plan. The outline plan should describe the category, type and scale of the potential CIs to be developed further.

Road projects, by their nature, can cover relatively long distances, cross multiple local administrative boundaries, and affect a number of different communities. Identification of CIs is not therefore a simple task of consulting one community to identify their development needs and priorities. It potentially requires consultation and negotiation with many community groups, each with their own internal structures and cultures, needs and priorities. There is an associated risk that each group will think that another is being allocated a better 'share' than they are.

The key stakeholders can be expected to have a deeper understanding of the beneficiary communities than the client. They should therefore be well placed to provide guidance on the most locally acceptable means for engaging with local communities and appropriate participatory decision-making methods.

In developing an outline plan the client should consider and provide guidance on the following issues:

- Is the client interested in including CIs in the project?
- What category of CIs are appropriate, bearing in mind the cost/budget, timeframe, scope and complexity of the project?
- How should the physical boundaries of where CIs can be implemented (the area of influence of the road project) be defined?
- What sum, or proportion of the road project budget, may be set aside for CIs?
- How should the level of willingness of local authorities and communities to participate in development and implementation of CIs be determined?
- Who, at the local level, could best assist the client and its service providers to develop and implement the CIs? Is there a need to establish 'Complementary Intervention Oversight Committees' or could existing committees or administrators take on this role?
- What are the best methods for raising awareness of the opportunities for, and identification and prioritisation of, CIs? Is it better to hold large meetings or a greater number of small meetings with different groups? Which language(s) should be used? Who should the participants and key speakers be? Should information be presented in writing, pictures, or some other form? Which analysis and decision-making tools are most appropriate? How should different needs identification and prioritisation results be consolidated?
- What may be the best method for identifying and selecting the proposed CIs? Should a committee be formed from representatives from Regional and district levels to determine the short list? Or should each district present its short list to the consultant/client for consideration?
- Can key stakeholders, based on current local development plans and initial consultation with local authorities within the project area, develop an indicative list of potential CIs?
- What additional funding or resources may be available from other sources to allocate to CIs?
- To what level does the participation process need to extend? This partly depends on the budget and category of intervention agreed on for the specific project. It will also depend on the number and size of communities that live along the road.
- How is each community defined? What is the formal and informal structure for decision-making purposes? Who are the key stakeholders, i.e. those likely to influence the decisions made and/or the likelihood of successful and sustainable implementation?
- How can it be ensured that vulnerable and/or excluded groups within a community are included in the participation process? Examples potentially include women, the elderly, children, the physically and mentally disadvantaged, and those from ethnic, religious or other minorities.



## B. Key issues to consider during feasibility study and preliminary design

During the Feasibility Study for a new road, the consultant, with guidance from the client and key stakeholders, takes on the responsibility to further investigate the options, and develop preliminary designs and cost estimates, for CIs, based on the outline plan previously prepared.

The investigations at this stage are aimed at developing the CIs to a sufficient level of detail to enable reasonably accurate cost estimates to be prepared and likely (short-term) effects and (longer-term) impacts to be assessed. CIs are to be included as an integral part of the options analysis and economic analysis of the road project. Despite giving rise to additional costs, they may well raise the economic rate of return of the road investment.

The feasibility study consultant will, in keeping with a detailed participation strategy, need to continue and expand upon the consultations already undertaken. Initial communication should raise awareness of key features of the road project with the local communities. Information to be provided should include:

- the approximate project timeframe;
- potential route options (the final route selection may mean some communities do not fall within the road project corridor);
- the nature of the works; and
- potential for CIs.

Following on from the awareness-raising programme, the client or its representative should work closely with the local authorities and communities to identify and prioritise the potential CIs.

The detailed participation strategy will need to define how decision-making may be devolved to the local level, whilst maintaining an overview and consistency of approach along the road project. It will need to clearly define decision-making methodologies and allocate responsibilities for decision-making at all levels.

The outcome of the identification and prioritisation process should be a list of potential interventions. Ideally, this should be presented as an impact analysis table, with each intervention having an estimated cost, an estimate of the number of people affected and the extent of that impact (both positive and negative) on different groups of people, as well as an attempt at quantifying the benefits. The location of each potential CI and its intended beneficiaries should be clearly defined.

A preliminary or outline design will also be necessary at this stage to enable more accurate cost estimates to be derived for each potential CI. The consultant should at that time identify any sources of additional financing or resources that can be used to implement them. This could include funds coming from the Client through the road project contract, financing promised from other sectors or local authorities, contributions of labour or materials promised from local authorities and contributions in kind (such as materials or labour) offered by local communities.

In line with guidance given by the client, the local authorities should review the list of proposed interventions and select those which they propose for inclusion in the project. This is a difficult task and needs to take account of expressed priority needs of residents in an equitable manner, while working within budget constraints. In order to minimise the potential for conflict and complaint, the decision-making process adopted should be transparent and ideally communicated and agreed in advance.

Due consideration needs to be given by local authorities to the client regarding the following:

- How to divide the CI resources between different communities along the road.
- How to divide the CI resources among the different categories of CI. This could either be defined in the policy, or be project-specific.
- If interventions are to be demand driven, how to determine whose demands are more important. Should the views of each group, or the potential benefits of each type of intervention be given equal weight, or are there development policies that prioritise certain social groups or types of intervention?
- How to coordinate ideas of local communities with development plans of local authorities and higher-level sector organisations (line ministries)?

It is likely that the final selection of CIs will be an iterative process, to ensure ownership at all necessary levels. Conflict management between different groups of one community, between adjacent communities, between different sectors and authorities should be resolved by the appropriate Regional or higher authorities.

The feasibility report should capture the selection methodology, analysis of potential complementary interventions and recommendations for those to be selected for inclusion in the project, along with an outline budget.

## Appendix A.5: Examples of CIs by category and theme

### Theme: Road and site safety

Category 1 Management Interventions	Category 2 Opportunity Interventions	Category 3 Enhancement Interventions
<ul style="list-style-type: none"> <li>Provide illumination/ additional marking in dangerous areas</li> <li>Extend provision or maintenance of access to specific services and facilities for pedestrians and IMTs</li> <li>Provide road safety education to employees</li> <li>Provide access to first aid training for community representatives and to facilities in emergency</li> <li>Rigorously enforce speed limits of equipment and plant</li> </ul>	<ul style="list-style-type: none"> <li>Distribute reflective strips for pedestrian, NMT and IMT road users.</li> <li>Provide boards warning community of construction and road hazards</li> <li>Provide refresher/first aid training for local health officials</li> </ul>	<ul style="list-style-type: none"> <li>Road safety awareness: schools/community road safety education campaigns – Community theatre, TV and radio etc</li> <li>Provide Road Safety equipment, teaching aids or additional equipment</li> </ul>

### Theme: Transport services

Category 1 Management Interventions	Category 2 Opportunity Interventions	Category 3 Enhancement Interventions
<ul style="list-style-type: none"> <li>Ensure adequate physical access for Pedestrian, NMT, IMT and normal RTS is maintained</li> <li>Provide adequate bus- bays and shelter</li> </ul>	<ul style="list-style-type: none"> <li>Supply IMT to cooperatives/ associations</li> <li>Provide IMT maintenance training to cooperatives</li> <li>Provide technical skills training to local transport service operators</li> <li>Make available mechanical workshops for IMT/RTS repairs</li> </ul>	<ul style="list-style-type: none"> <li>Provide awareness training on options for rural transport services</li> <li>Provide seed financing for establishment of rotating funds for supply and maintenance of IMT</li> <li>Provide animal husbandry training</li> </ul>

### Theme: Support service sectors

Category 1 Management Interventions	Category 2 Opportunity Interventions	Category 3 Enhancement Interventions
<ul style="list-style-type: none"> <li>Provide vehicles and temporary emergency/ first aid services for local communities whose access to mainline services is hindered by the construction works</li> <li>Supply local health centres with ARVs, and other drugs relating to communicable disease control</li> </ul>	<ul style="list-style-type: none"> <li>Provide HIV/AIDS testing and counselling services along the road corridor for construction workers and local communities</li> <li>Distribute first aid supplies to health posts</li> <li>Assist with the repair, rehabilitation or maintenance of health and education facilities centres (including hospices &amp; orphanages)</li> </ul>	<ul style="list-style-type: none"> <li>Provide classroom furniture (desks and chairs)</li> <li>Promote use of ICT in schools through improved electrical and communications installations, and provision of computers.</li> <li>Provide mosquito nets and mattresses to orphanages, hospices and nurseries</li> <li>Provide support to initiatives supporting community education and awareness (health, safety, livelihoods and income-generation)</li> <li>Provide water supply/construct sanitation facilities for roadside communities</li> </ul>

**Theme:** Community development

Category 1 Management Interventions	Category 2 Opportunity Interventions	Category 3 Enhancement Interventions
<ul style="list-style-type: none"> <li>Maximise employment opportunities for local communities, including women – provide crèche and other support facilities</li> </ul>	<ul style="list-style-type: none"> <li>Provide advisory services to local administration with regards construction, rehabilitation or maintenance of community infrastructure</li> <li>Provide ground water recharge schemes, water harvesting or small micro-irrigation schemes</li> <li>Provide materials, equipment and training to support establishment and development of local SMEs</li> <li>Supply materials, equipment, labour, etc for community projects (e.g. pipes, cement, steel, timber, wiring, tractors, excavators, skilled labourers)</li> </ul>	<ul style="list-style-type: none"> <li>Provide office furniture, accommodation and sanitation facilities for community facilities</li> <li>Skills enhancement. Train casual and other local labourers (e.g. in better livestock management; agricultural methods etc)</li> <li>Provide life skills training (e.g. literacy, numeracy, basic accounting, kitchen gardening, sanitation and hygiene) to local community groups and SMEs</li> </ul>

**Theme:** Road corridor environment (including climate change adaptation measures)

Category 1 Management Interventions	Category 2 Opportunity Interventions	Category 3 Enhancement Interventions
<ul style="list-style-type: none"> <li>Provide temporary and permanent accesses to homes, tracks and paths</li> <li>Provide water and hand sprinkler systems to local communities to control dust on road sections near their properties as needed</li> <li>Reinstate diversion roads – consider transferring ownership for use by IMTs (particularly in busy/dangerous areas)</li> <li>Reinstate temporary work areas – e.g. provide designs for conversion of borrow pits to dams or fish ponds</li> <li>Provide opportunity for community to claim spoiled materials including wood from grubbing, topsoil or oversize aggregate</li> <li>Provide additional soil protection and road/structure erosion protection in vulnerable areas</li> </ul>	<ul style="list-style-type: none"> <li>Plant productive (e.g. fruit, nuts, fuel) trees and plants along roadside and in reinstatement of borrow areas</li> <li>Establish landfill/waste management sites, utilising borrow and quarry areas where appropriate, or areas designated by local authorities</li> <li>Repair areas suffering from previous erosion or siltation damage</li> <li>Improve access to the new road through improvements to related tracks, footbridges and footpaths</li> <li>Improve access from the road to local community facilities</li> <li>Provide road maintenance training e.g. to lengthpersons, or other technical training to local administrations/SMEs</li> <li>Rehabilitate/repair community/village assets such as roads, market areas, meeting areas, sanitation/ water supply facilities, drainage systems, etc.</li> </ul>	<ul style="list-style-type: none"> <li>Establish nurseries for supply of trees and shrubs for bio-engineering, fruit orchards, wood lots etc.</li> <li>Provide protective tubing for saplings, covers for seedlings and water supply</li> <li>Extend productive planting to other areas identified by local community</li> <li>Support programmes to eradicate invasive plant species</li> <li>Supply fingerlings (juvenile fish) for borrow areas upgraded to fish ponds</li> <li>Build community/village assets – school rooms, health or veterinary posts, storage facilities, training/meeting rooms etc</li> <li>Utilise road drainage systems to provide water-harvesting facilities</li> </ul>

**Theme:** Research, demonstration and training

Category 1 Management Interventions	Category 2 Opportunity Interventions	Category 3 Enhancement Interventions
<ul style="list-style-type: none"> <li>▪ Include Road Authority personnel on contractor's team for professional training/experience</li> <li>▪ Include trial/demonstration sections for new technical options</li> </ul>	<ul style="list-style-type: none"> <li>▪ Investigate different approaches to CI design and implementation to improve future provision and contract conditions</li> <li>▪ Provide technical training to local mechanics, electricians, plumbers, carpenters, masons, etc. (e.g. through employment and maintenance at camp /work sites)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Provide technical and management advice and training to local authorities and administrations on key issues</li> </ul>

