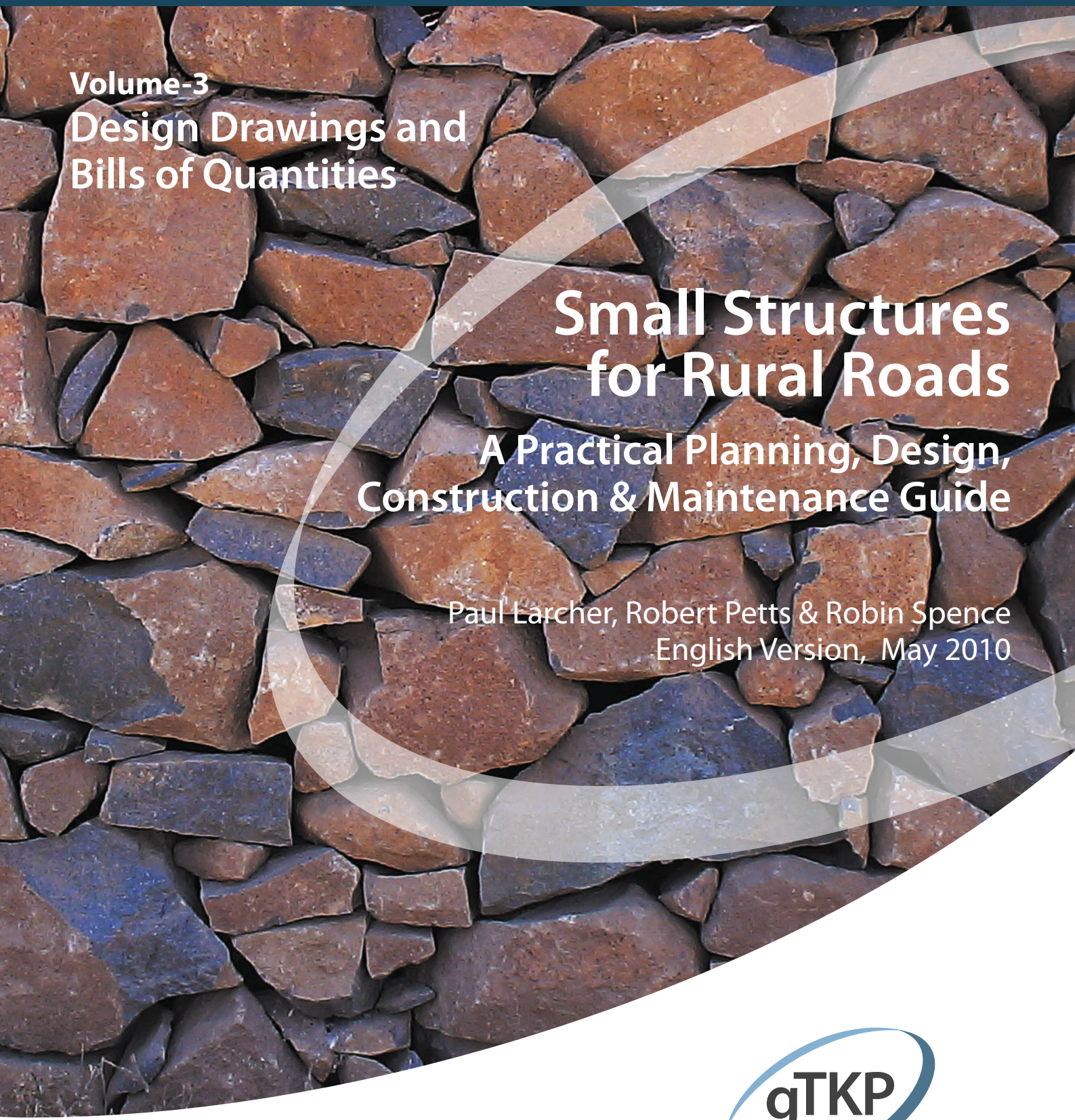


Volume-3
Design Drawings and Bills of Quantities

Small Structures for Rural Roads

A Practical Planning, Design, Construction & Maintenance Guide

Paul Larcher, Robert Petts & Robin Spence
English Version, May 2010

gTKP

global Transport Knowledge Partnership

committed to sustainable transport

Acknowledgements

The initial funding for the research and drafting of this guideline was provided by DFID (Department for International Development) through their Knowledge and Research (KaR) programme. The guideline has benefited from constructive advice and guidance from a large number of different people, too numerous to mention, for which the authors are very grateful. The following people have contributed in detail to the work; Andreas Beusch, Michael Broadbent, Able Chiteshe, Jasper Cook, Simon Done, Robert Geddes, Colin Gourley, Kingstone Gongera, Heng Kackada, Tesfaye Kunbi, Kamal Pande, David Salter, Dave Stiedl, Julie Turner. The diagrams have been drawn by Patricia Petts. The authors are grateful to Simon Done, John Howe, Intech Associates and TRL for contributing a number of photographs for the guideline.

The original draft document (2005) was an output from a project funded by the UK Department for International Development (DFID) for the benefit of low-income countries. This current edition (2010) was updated and edited by TRL Ltd in association with Intech Associates, OtB Engineering (International) Ltd and KACE (Cambodia) through the DFID-South East Asia Community Access Programme (SEACAP). The document has been reviewed and finalised by the Global Transport Knowledge Partnership (gTKP) under management of the International Road Federation (IRF) with contributions from the Asian Development Bank and the Africa Community Access Programme (AFCAP).

The aim of this document is to provide guidance to planners, designers and practitioners of rural roads in developing and transition counties. It is based on proven techniques and experience and should be the basis of introduction of low cost but durable construction practices in environments experiencing severe resource restrictions. It is intended that rural road practitioners and professionals will be able to utilise and adapt the knowledge in this document to introduce more appropriate, affordable and sustainable techniques, standards and specifications into everyday practice, academic curricula and training, and contribute to rural poverty reduction.

We also thank the following organizations for their contributions:

DFID Department for International Development

INTERNATIONAL ROAD FEDERATION
FEDERATION ROUTIERE INTERNATIONALE

ADB

SEACAP
AFCAP

Table of Contents

Published in separate volumes:

Introduction

This is the third volume of the guideline covering the design, construction and maintenance of road structures on low volume roads. A broad introduction to the guideline is provided in Volume 1. The guideline covers a wide range of drainage structures from drifts to small bridges (Chapter 4 in the design manual, Volume 1, describes the characteristics of these structures). These structures vary in complexity and are ranked in order of increasing complexity as follows:

- Drifts
- Simple culverts
- Vented fords
- Large bore culverts
- Small bridges

This volume of the guideline contains standard designs and bills of quantities for low cost structures. It is hoped that by standardisation of these designs, which have been checked technically:

- economies of scale will lead to an improvement in cost and quality;
- speed of construction will be increased as labourers, supervisors and engineers will be more familiar with the design;
- approval procedures will be simplified.

The guideline has been written as a design guide, to complement design codes and standards from the relevant Ministry or Roads Authority. However, experience has shown that in many areas national design standards are not applicable to the small cost structures on Low Volume Rural Roads (LVRR) covered by this guideline. It is therefore envisaged that this document will be recognised by road authorities as a useful tool and that, by following the advice and information contained in the guide, engineers and technicians will be able to design, construct and maintain acceptable and durable structures.

Steps in the design process for road drainage structures are often missed or neglected. Volumes 1 and 2 therefore explain the steps that should be carried out and the reasons for undertaking them. They also explain the type and detail of information required and how it should be used to undertake a design.

The designs contained in this volume are standard designs and may therefore not be fully applicable for all structures. Small modifications to the drawings may be required for individual circumstances. Before using these designs, engineers and technicians should consult Volume 1 and 2, to ensure that the drawings are suitable for specific water crossing locations.

Volume 4 contains the drawings at full scale 'A3' format. The drawings in this Volume 3 are reduced in size and are for reference only and cannot be 'scaled'.

How to use this Guideline

This volume of the guideline should be read in conjunction with Volume 1 and 2. There is a logical sequence of work that should be undertaken in the selection and design of any road structure. The preliminary design section (Volume 1) is laid out in sequence with each chapter covering one aspect of the process shown in the diagram in Figure 1.1 below. The detailed design process is described in Volume 2. The two initial tasks which should be carried out are to identify the problem (Chapter 2) and determine the design criteria (Chapter 3) for the structure. The initial design data may then be collected (Chapter 2) to enable the preliminary design to be carried out. Preliminary design, shaded yellow in the flow diagram in Figure 1.1 involves 4 different stages which may be performed a number of times before a design solution is proposed. It is suggested that a review of structural options (Chapter 4) is initially undertaken followed by an appraisal of a potential construction site (Chapter 5). The water flow characteristics of the watercourse (Chapter 6) should then be considered before a selection of the most appropriate structure is made (Chapter 4). It is likely that the preliminary design loop will need to be followed a number of times to review different potential structures and construction sites.

Following completion of the preliminary design the proposed design solution should be checked to ensure that it complies with the design criteria. Detailed design of the structure can then be undertaken (Chapter 8 – Volume 2). This requires reference to be made to chapters covering site selection and appraisal (Chapter 5) and watercourse characteristics (Chapter 6). It is also necessary to review the options for available construction materials (Chapter 7) that may be available.

The designs referenced in this volume (and reproduced at full scale in Volume 4) may be incorporated at the detailed design stage. Structure designers should ensure that the designs meet all the design criteria, or make the necessary modifications. The proforma bills of quantities will aid the calculation of the cost of the structure. Following the preparation of the design drawings it will be necessary to refer to the guidance in the chapters on construction and maintenance to ensure that no issues will arise that cannot be satisfactorily accommodated in the expected construction and maintenance regimes.

Volume 4 contains the standard drawings reproduced at full 'A3' size. In this Volume 3 they have been reduced to 'A4' size for convenience and the scales will be accordingly distorted.

The Volume 4 drawings at 'A3' size have been prepared to a scale noted at the bottom right hand corner of each drawing sheet (some inserts are drawn at a larger scale, where this occurs the scale will be listed under the insert drawing title). Some dimensions are shown on the drawings. If a dimension is not shown on the drawing an approximation may be obtained by measuring the dimension on the drawing with a ruler and applying the correct scale factor.

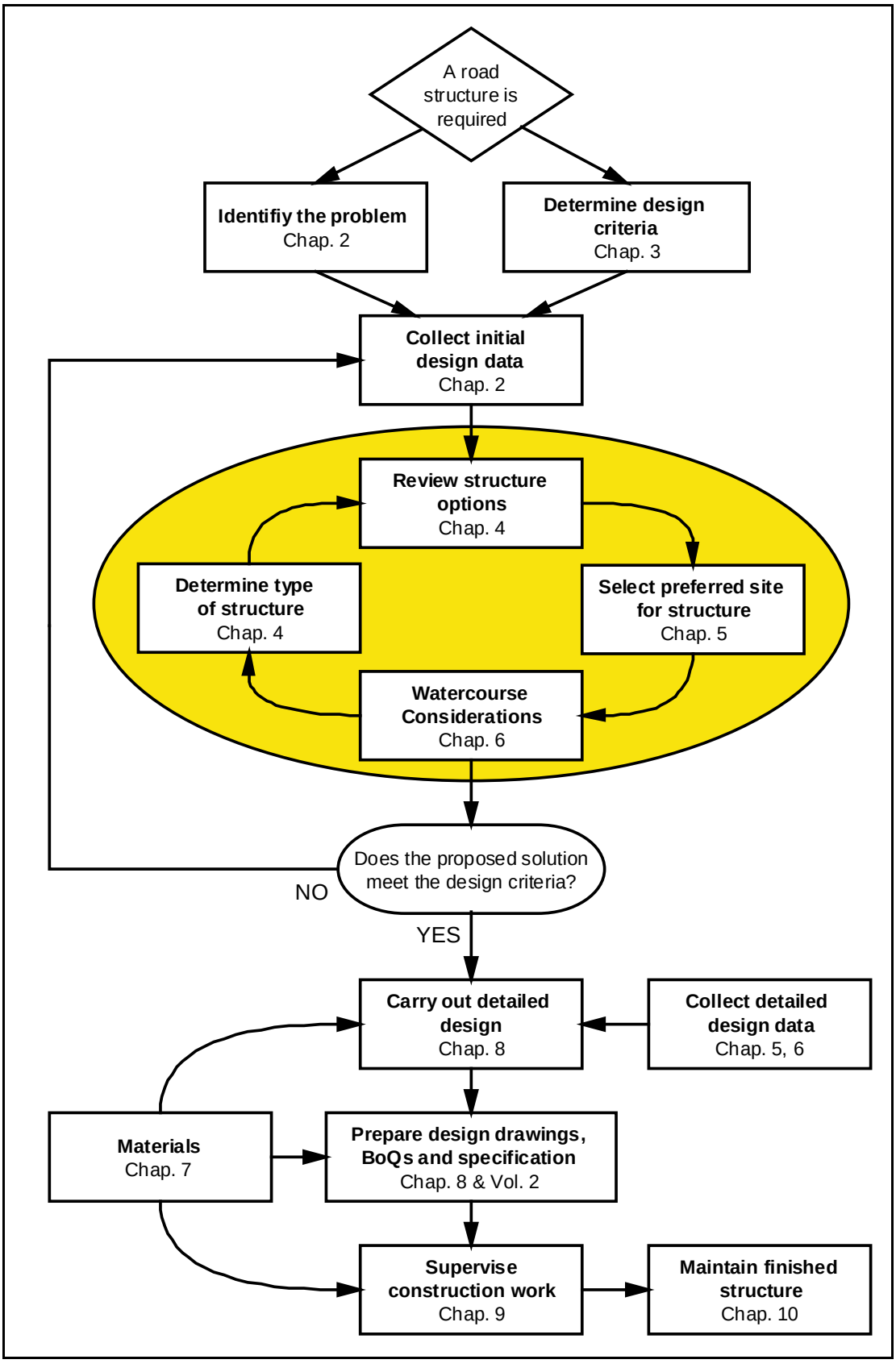
Example:
If the dimension of a structure on a drawing is 12mm and the scale is 1:50 the actual dimension will be 600mm.

12mm x 50 = 600mm

The box on the drawing indicates the scale and the text "at A3" paper size. Note that the scaling will not apply to the reduced drawings in this Volume 3. Likewise, if the 'A3' drawing is increased or decreased in size (e.g. on a photocopier) it will no longer be possible to calculate the dimensions of the structure by taking measurement on the drawing.

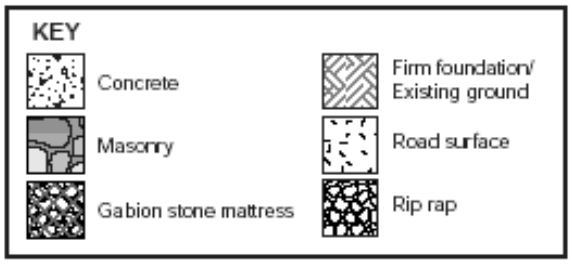
NOTE: Photocopiers can often distort drawings when they make copies. This distortion will not be apparent unless accurate measurements are taken from the drawing. Drawings which have been photocopied should not be used to measure unmarked dimensions as their accuracy cannot be guaranteed. The drawings contained in the text in this Volume 3 are for reference only and are not scalable.

Figure 1.1 Flow diagram of the planning, design and construction process



Each drawing has a page of notes which relate to the use of the particular drawing. There may also be some notes about assumptions that have been made when preparing the bill of quantities. The notes below apply to all the drawings.

1. Drawings that are used for construction should include a location map and description to assist maintenance and inspection teams to find the structure.
2. Each drawing contains a key to indicate different materials. An example of a complete key is shown below. The stone shown in different shading patterns is only indicative and may not be representative of the actual stone sizes in the structure. The diagonal shading "Firm foundation/existing ground" is widely used on the drawings. Areas shaded in this style include:



   a. Ground undisturbed by the construction work which provides a suitable foundation for construction
   b. Areas which have poor quality ground which has been excavated and replaced by good quality material to provide a suitable foundation for construction
   c. Existing ground backfilled after construction
   d. Lean concrete or gravel blinding layers
3. Masonry has been shown as a construction material on many of the drawings. Where masonry is shown any of the masonry types listed below may be used subject to the requirements of Chapter 7 (Materials) and any applicable material specifications:
   a. Random stone masonry
   b. Dressed stone masonry
   c. Bricks
   d. Blocks
4. It may be possible for some structures to change the material type shown on the drawings. In some cases an alternative material is shown on the drawings however, designers should refer to Volume 1 and 2 before making any material substitutions.

The objective of the bills of quantities is to provide an estimate of the construction cost of the structure. The following notes apply to all the bills of quantities:

1. The drawings provided in this manual are general arrangements. Exact quantities will be dependent on the specific characteristics of the site for the structure. Designers should make modifications where required.
2. The quantity of excavation required for specific structures is very difficult to estimate for different structures. Difficulty of excavation can also vary dramatically between construction sites. The figures provided for quantity of excavation and labour requirements should only be used as a rough guide.
3. Suggested labour work rates are provided for the different construction tasks. These rates are based on surveys and analysis carried out in different areas of the world by the ASIST programme of the ILO. They are provided as a guide and should be modified based on local or personal experience.
4. Before work can start at any construction site preliminary work must be carried out to facilitate the construction. This may include the establishment of a work compound for storing materials, labourers accommodation etc. A bill of quantities for preliminary cost items that should be considered for all structures is provided below. The preliminary items that are required for a specific structure should be added to the structure's bill of quantities to calculate the full cost of the structure.

Worker productivity

In the absence of local data the following productivity standards may be useful in estimating the resources and time required for each activity.

Site preparation	
Site clearance (bush clearing, tree felling, etc.)	100 – 350m^2 / worker day
Removal of tree stumps	1 / worker day
Material excavation and movement	
Soil excavation (and stockpiling alongside)	2 - 5m^3 / worker day
Loose rock collection	2.5m^3 / worker day
Rock (fractured) excavation (solid rock will require drilling and blasting/splitting)	0.8m^3 / worker day
Loading	8.5m^3 / worker day
Haulage by wheelbarrow	
0 - 20m	8.5m^3 / worker day
20 - 40m	7.0m^3 / worker day
40 - 60m	6.5m^3 / worker day
60 - 80m	5.5m^3 / worker day
80 - 100m	5.0m^3 / worker day
100 - 150m	4.5m^3 / worker day
Pipe installation	
Install only 600 or 900mm diameter culvert lines (including excavation and backfill)	0.8 - 1.2 lin.m / worker day
Masonry and concrete work	
Mix and place concrete	1.0m^3 / worker day
Erect masonry work	1.0m^3 / worker day

Productivity depends on a number of factors, including worker fitness, nutrition, experience and motivation, site organisation, tool quality and condition, and climate. Individual small structure sites do not allow much scope for improvement of performance with experience, due to the short time spans involved for individual activities. New workers under training will also be less productive. Poor quality and condition handtools can affect productivity by up to 25%.

Aggregate and cement quantities for concrete

Class of concrete	Expected 28 day strength N/mm^2	Mix cement/ fine aggregate/ coarse aggregate	Material required for 1m^3 finished concrete		
			Cement bags (kg)	Fine (m^3)	Coarse (m^3)
Lean	-	1:4:8	3.3 (166)	0.47	0.94
Mass	15	1:3:6	4.3 (215)	0.46	0.92
Grade 20	20	1:2:4	6.0 (300)	0.42	0.84
Grade 25	25	1:1.5:3	7.3 (365)	0.38	0.76

Bill of Quantities - Preliminary works

Preliminaries	Unit	Quantity	Rate	Cost
Site Compound				
Set up and remove temporary site compound	lump sum			
Water supply	lump sum / m^3			
Sanitation facilities	lump sum			
Provide site office	lump sum			
Provide workshop	lump sum			
Provide store	lump sum			
Provide labourers temporary accommodation	lump sum	(No. of labourers)		
Staffing				
Recruitment of labourers	lump sum			
Store keeper	No./day			
Day watchmen	No./day			
Night watchmen	No./day			
Labourers protective clothing				
Traffic Control				
Provide temporary deviation for public traffic	lump sum / day			
Provide temporary signage and traffic control	lump sum / day			
Existing Structure				
Demolish old structure	lump sum			
Remove from site and dispose of old structure	m^3			
Site preparation				
Temporary site access	lump sum			
Site clearance (bush clearing, tree felling)	m^2			
Removal of tree stumps	No.			
Construction work				
Temporary support to foundations				
De-watering of foundations				
Temporary diversion of watercourse				
Temporary support to superstructure				
Work completion				
Remove surplus material				
Clear and tidy site				
		Preliminaries Total		

Gabion drift - Drawing number 1.1

Applicability of the design

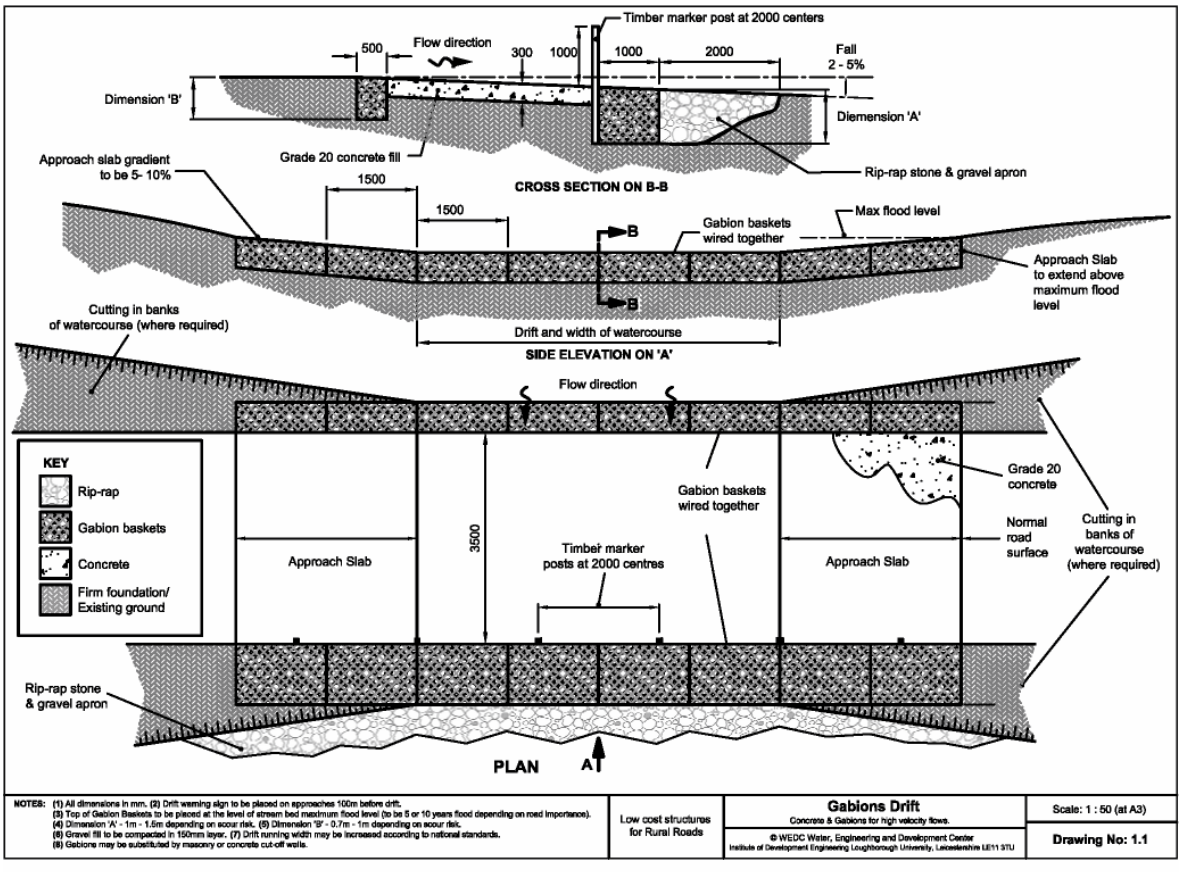
- Suitable for all drift sites
- May be used for high velocity flows

Notes about the Drawing and Bill of Quantities

1. It is recommended that dimension 'A' is constructed at 1.5m and dimension 'B' is constructed at 1m unless low flows are expected.
2. Gabion basket wire; 10% extra wire should be allowed for laps.

Preliminaries	Unit	Quantity	Rate	Cost
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding				
Cement	50 kg bag			
Sand	m3			
Aggregates	m3			
2. Grade 20 concrete				
Cement	50 kg bag			
Sand	m3			
Aggregates	m3			
3. Painted timber marker posts	No.			
4. Timber for concrete formwork	m2			
5. Wire mesh for gabion baskets	m2			
6. Tying wire for gabions	m			
7. Drift warning sign and posts	No.			
		Materials Total		
Labour	**Unit**	**Quantity**	**Man day / unit**	**Days**
1. Concrete drift and approach slabs				
Excavation of riverbed	m3			
Mix, place and compact blinding concrete	m3			
Fix marker posts	No.			
Erect and dismantle rough formwork	m2			
Mix, place and compact concrete slabs	m3			
2. Gabion cut off walls				
Excavate riverbed	m3			
Assemble place and join gabion baskets in river bed	m2			
Collect stones	m3			
Fill gabion baskets	m3			
Close and tie off wire baskets	m2			

3. Rip rap protection				
Collect stones	m3			
Place stones in riverbed	m3			
4. Sundries				
Excavation of watercourse banks, where required (estimated)	m3			
Erect drift warning signs	No.			
	Total no. man days			
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport				
Delivery of materials	km			
Supervision vehicle	km			
2. Hand-tools	lump sum			
3. Equipment costs				
Hire/depreciation cost	hr			
Running costs	hr			
4. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		
Cost Summary	**Cost**			
Preliminaries				
Materials				
Labour				
Other Costs				
Total construction cost				



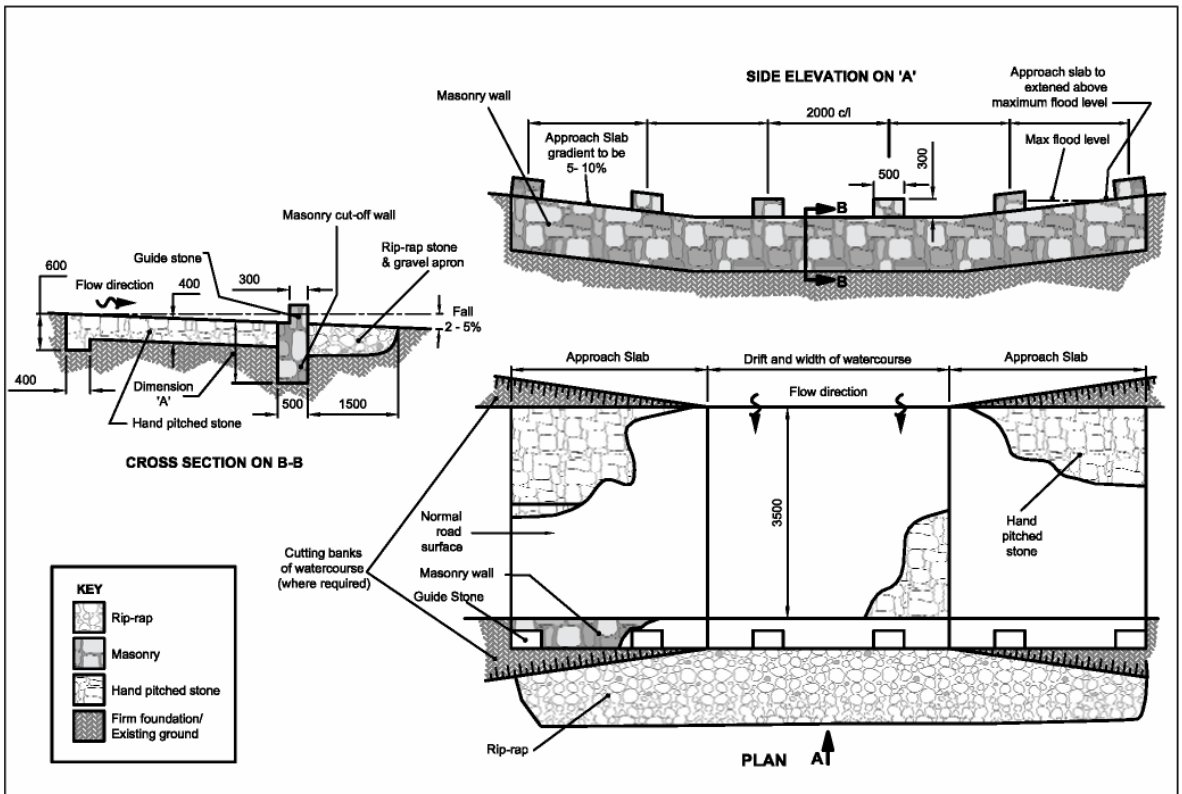
NOTES: (1) All dimensions in mm. (2) Drift warning sign to be placed on approaches 100m before drift. (3) Top of Gabion Baskets to be placed at the level of stream bed maximum flood level (to be 5 or 10 years flood depending on road importance). (4) Dimension 'A' - 1m - 1.5m depending on scour risk. (5) Dimension 'B' - 0.7m - 1m depending on scour risk. (6) Gravel fill to be compacted in 150mm layer. (7) Drift running width may be increased according to national standards. (8) Gabions may be substituted by masonry or concrete cut-off walls.

Low cost structures for Rural Roads

Gabions Drift
Concrete & Gabions for high velocity flows.
© WEDC Water, Engineering and Development Center
Institute of Development Engineering Loughborough University, Leicestershire LE11 3TU

Scale: 1 : 50 (at A3)

Drawing No: 1.1



NOTES: (1) All dimensions in mm. (2) Dimension 'A' - 1m - 1.5m depending on scour risk. (3) Rip-rap downstream protection may be substituted for hand pitched stone, reinforced with vegetation. (4) Guide stone to be painted white. (5) Maximum flood level to be 5 or 10 years flood depending on road importance. (6) Drift warning sign to be placed on approaches 100m before drift. (7) Top of drift to be at existing stream bed level (8) Drift running width may be increased according to national standards.

Low cost structures for Rural Roads

Pitched Stone Drift
Natural stone & gravel for occasional small and low velocity flows.
© WEDC Water, Engineering and Development Center
Institute of Development Engineering Loughborough University, Leicestershire LE11 3TU

Scale: 1 : 50 (at A3)

Drawing No: 1.2

Pitched stone drift - Drawing number 1.2

Applicability of the design

- Suitable for occasional small and low velocity flows
- Minimal requirements for cement

Notes about the Drawing and Bill of Quantities

1. Hand pitched stones should be placed on their edge to ensure a good interlock between adjacent stones
2. It is recommended that dimension 'A' is constructed at 1.5m unless a low flow risk and low flows are expected.

Preliminaries	Unit	Quantity	Rate	Cost
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
2. Stone masonry				
Stone	m^3			
Cement	50 kg bag			
Sand	m^3			
3. Hand pitched stone	No.			
4. Drift warning sign and posts	No.			
		Materials Total		
Labour	**Unit**	**Quantity**	**Man day / unit**	**Days**
1. Masonry cut off wall				
Excavation of riverbed	m^3			
Mix, place and compact blinding concrete	m^3			
Construct masonry wall including guide stones	m^3			
2. Hand pitched stone				
Excavate riverbed	m^3			
Place stones	m^3			
3. Rip rap protection				
Collect stones	m^3			
Place stones in riverbed	m^3			

4. Sundries				
Excavation of watercourse banks, where required (estimated)	m^3			
Erect drift warning signs	No.			
		Total no. man days		
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport				
Delivery of materials	km			
Supervision vehicle	km			
2. Hand-tools	lump sum			
3. Equipment costs				
Hire/depreciation cost	hr			
Running costs	hr			
4. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		
Cost Summary	**Cost**			
Preliminaries				
Materials				
Labour				
Other Costs				
Total construction cost				

Masonry drift - Drawing number 1.3

Applicability of the design

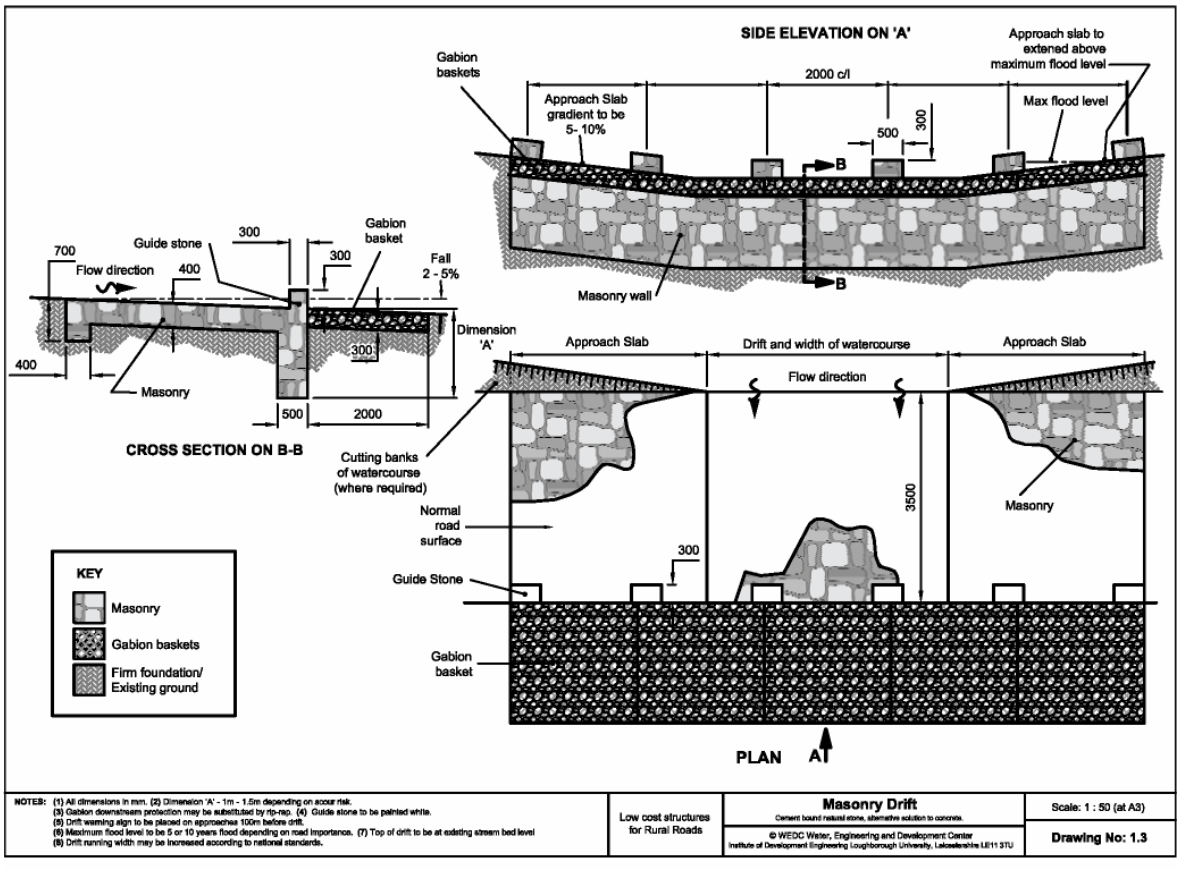
- Suitable for all drift sites
- Reduces the current requirements when compared to Drawing 1.1

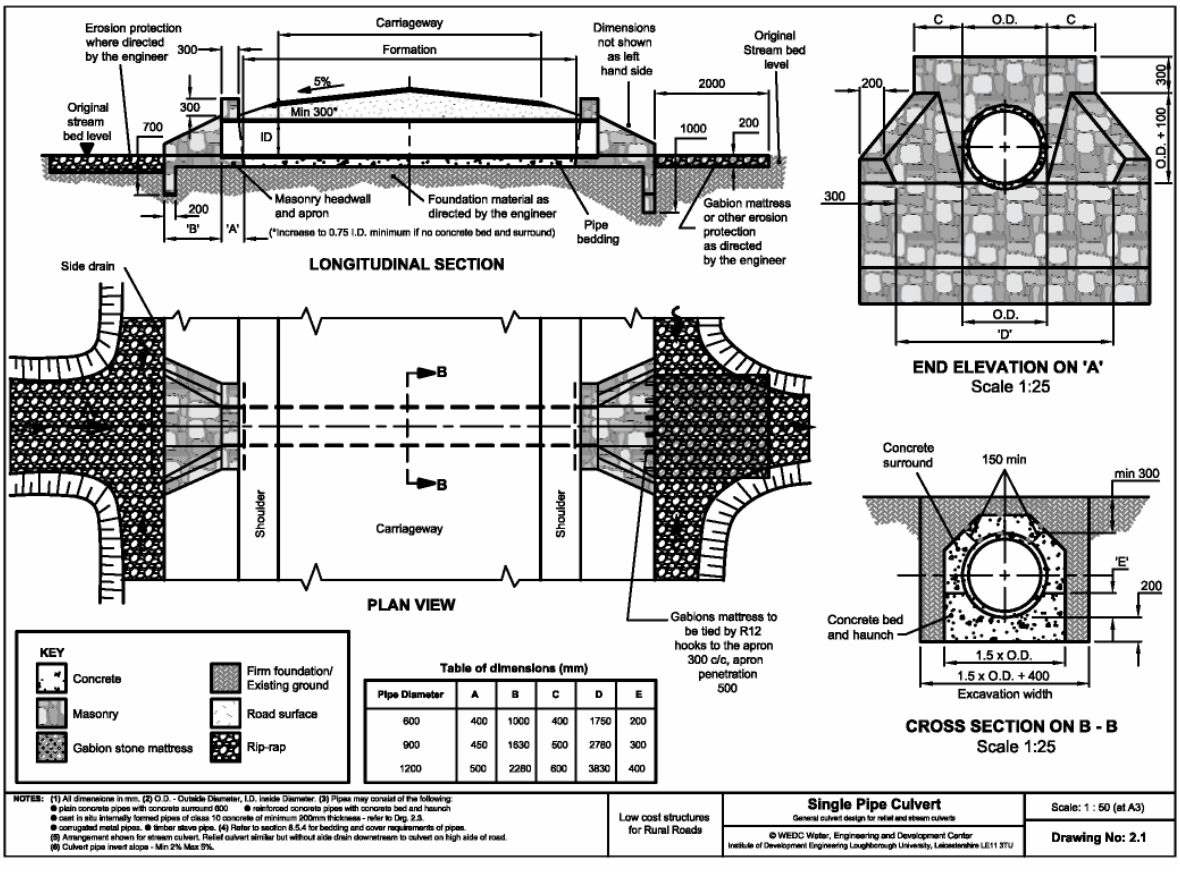
Notes about the Drawing and Bill of Quantities

1. It is recommended that dimension 'A' is constructed at 1.5m unless a low flow risk and low flows are expected.
2. Gabion baskets: 10% extra wire should be allowed for laps.

Preliminaries	Unit	Quantity	Rate	Cost
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
2. Stone masonry				
Stone	m^3			
Cement	50 kg bag			
Sand	m^3			
3. Wire mesh for gabion baskets	m^2			
4. Tieing wire for gabion baskets	M			
5. Drift warning sign and posts	No.			
		Materials Total		
Labour	**Unit**	**Quantity**	**Man day / unit**	**Days**
1. Masonry cut off wall, drift and approach slabs				
Excavation of riverbed	m^3			
Mix, place and compact blinding concrete	m^3			
Construct masonry walls, slab and guide stones	m^3			
2. Gabion protection				
Excavate riverbed	m^3			
Assemble place and join gabion baskets in river bed	m^2			
Collect stone	m^3			
Fill gabion baskets	m^3			
Close and tie off wire baskets	m^2			
3. Rip rap protection				
Collect stones	m^3			

Place stones in riverbed	m^3			
4. Sundries				
Excavation of watercourse banks, where required (estimated)	m^3			
Erect drift warning signs	No.			
			Total no. man days	
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport				
Delivery of materials	km			
Supervision vehicle	km			
2. Hand-tools and equipment	lump sum			
3. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		
Cost Summary	**Cost**			
Preliminaries				
Materials				
Labour				
Other Costs				
Total construction cost				


SIDE ELEVATION ON 'A'
Gabion baskets
Approach slab to extened above maximum flood level
2000 c/l
Approach Slab gradient to be 5- 10%
Max flood level
500
300
B
Masonry wall
Guide stone
300
Gabion basket
700
Flow direction
400
300
Fall 2 - 5%
Dimension 'A'
400
Masonry
300
500
2000
CROSS SECTION ON B-B
Approach Slab
Drift and width of watercourse
Approach Slab
Flow direction
Cutting banks of watercourse (where required)
Normal road surface
3500
Masonry
300
Guide Stone
Gabion basket
KEY
Masonry
Gabion baskets
Firm foundation/ Existing ground
PLAN
NOTES: (1) All dimensions in mm. (2) Dimension 'A' - 1m - 1.5m depending on accer risk.
(3) Gabion downstream protection may be substituted by rip-rap. (4) Guide stone to be painted white.
(5) Drift warning sign to be placed on approaches 100m before drift.
(6) Maximum flood level to be 5 or 10 years flood depending on road importance. (7) Top of drift to be at existing stream bed level
(8) Drift running width may be increased according to national standards.
Low cost structures for Rural Roads
Masonry Drift
Cement bound natural stone, alternative solution to concrete.
© WEDC Water, Engineering and Development Center
Institute of Development Engineering Loughborough University, Leicestershire LE11 3TU
Scale: 1 : 50 (at A3)
Drawing No: 1.3


Erosion protection where directed by the engineer
300
Carriageway
Formation
5%
Min 300*
Dimensions not shown as left hand side
Original Stream bed level
2000
Original stream bed level
300
700
ID
1000
200
200
'B'
'A'
Masonry headwall and apron
Foundation material as directed by the engineer
(*increase to 0.75 I.D. minimum if no concrete bed and surround)
Pipe bedding
Gabion mattress or other erosion protection as directed by the engineer
LONGITUDINAL SECTION
Side drain
B
B
Shoulder
Carriageway
Shoulder
PLAN VIEW
Gabions mattress to be tied by R12 hooks to the apron 300 c/c, apron penetration 500
KEY
Concrete
Masonry
Gabion stone mattress
Firm foundation/ Existing ground
Road surface
Rip-rap
Table of dimensions (mm)
Pipe Diameter | A | B | C | D | E
600 | 400 | 1000 | 400 | 1750 | 200
900 | 450 | 1630 | 500 | 2780 | 300
1200 | 500 | 2280 | 600 | 3830 | 400
C
O.D.
C
200
300
O.D. + 100
300
O.D.
'D'
END ELEVATION ON 'A'
Scale 1:25
Concrete surround
150 min
min 300
'E'
200
Concrete bed and haunch
1.5 x O.D.
1.5 x O.D. + 400
Excavation width
CROSS SECTION ON B - B
Scale 1:25
NOTES: (1) All dimensions in mm. (2) O.D. - Outside Diameter, I.D. Inside Diameter. (3) Pipes may consist of the following:
● plain concrete pipes with concrete surround 600 ● reinforced concrete pipes with concrete bed and haunch
● cast in situ internally formed pipes of class 10 concrete of minimum 200mm thickness - refer to Dg. 2.3.
● corrugated metal pipes. ● timber stave pipe. (4) Refer to section 8.5.4 for bedding and cover requirements of pipes.
(5) Arrangement shown for stream culvert. Relief culvert similar but without side drain downstream to culvert on high side of road.
(6) Culvert pipe invert slope - Min 2% Max 5%.
Low cost structures for Rural Roads
Single Pipe Culvert
General culvert design for relief and stream culverts
© WEDC Water, Engineering and Development Center
Institute of Development Engineering Loughborough University, Leicestershire LE11 3TU
Scale: 1 : 50 (at A3)
Drawing No: 2.1

Single pipe culvert - Drawing number 2.1

Applicability of the design

- Standard culvert arrangement for use as stream or relief culvert on all sites
- Design may be used with any precast pipe material
- Drawing also applicable to cast in situ concrete pipes when it is read with Drawing 2.3.

Notes about the Drawing and Bill of Quantities

1. Drawing shows a 600mm diameter culvert which will be suitable for the majority of sites. Drawing has table of dimensions A-O which should be used for 900mm and 1200mm diameter culverts.
2. Drawing should be read with the following other drawings for specific applications:
    - Twin barrel culvert Drawing 2.2
    - Drop inlet Drawing 2.3
    - Cast in situ pipe Drawing 2.3

Preliminaries	Unit	Quantity	Rate	Cost
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding, pipe bed and haunch				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
2. Stone masonry				
Stone	m^3			
Cement	50 kg bag			
Sand	m^3			
3. Culvert pipe				
Selected pipe material	m			
4. Mass concrete for pipe surround				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
5. Wire mesh for gabion baskets	m^2			
6. Tieing wire for gabion baskets	m			
		Materials Total		
Labour	**Unit**	**Quantity**	**Man day / unit**	**Days**
1. Placing of the culvert pipe				
Excavation of watercourse/ road	m^3			
Mix, place, compact culvert bedding and haunch	m^3			

Fix culvert pipes in place	m			
2. Masonry culvert headwalls, wingwalls, aprons and cut off walls				
Construct cut off walls and aprons	m^3			
Fix reinforcement hooks in downstream apron to secure gabion protection	No.			
Construct wingwalls and headwalls	m^3			
3. Pipe surround				
Mix, place, compact concrete pipe surround	m^3			
4. Gabion downstream protection				
Excavate riverbed	m^3			
Assemble place and join gabion baskets in river bed	m^2			
Collect stones	m^3			
Fill gabion baskets	m^3			
Close and tie off wire baskets	m^2			
5. Sundries				
Backfill and compact fill around culvert in 300mm layers	m^3			
		Total no. man days		
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport	km			
Delivery of materials	km			
Supervision vehicle	lump sum			
2. Hand-tools and equipment				
3. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		

Cost Summary	**Cost**	
Preliminaries		
Materials		
Labour		
Other Costs		
Total construction cost		

Alternative culvert arrangements:

Twin barrel culvert - Drawing number 2.2

Applicability of the design

- For large volume flows where 1 pipe does not provide sufficient flow capacity
- Design may be used with any precast pipe material

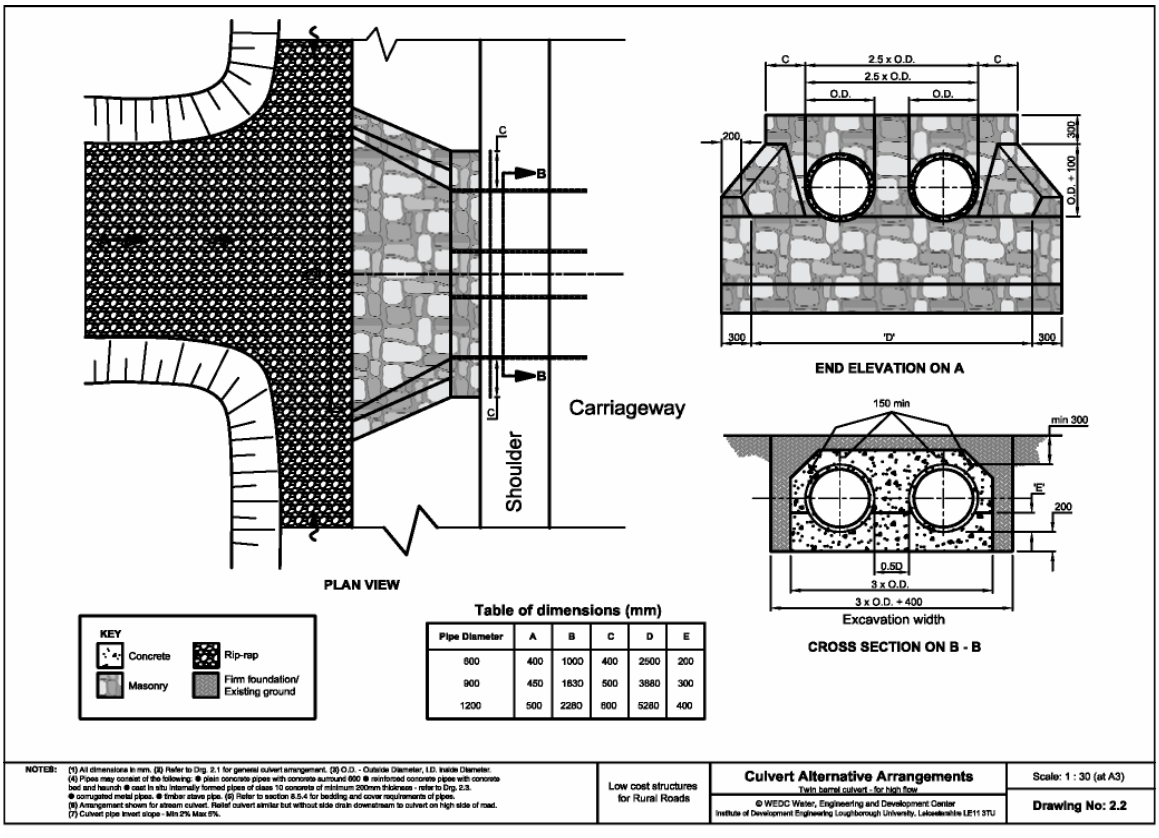
Notes about the Drawing and Bill of Quantities

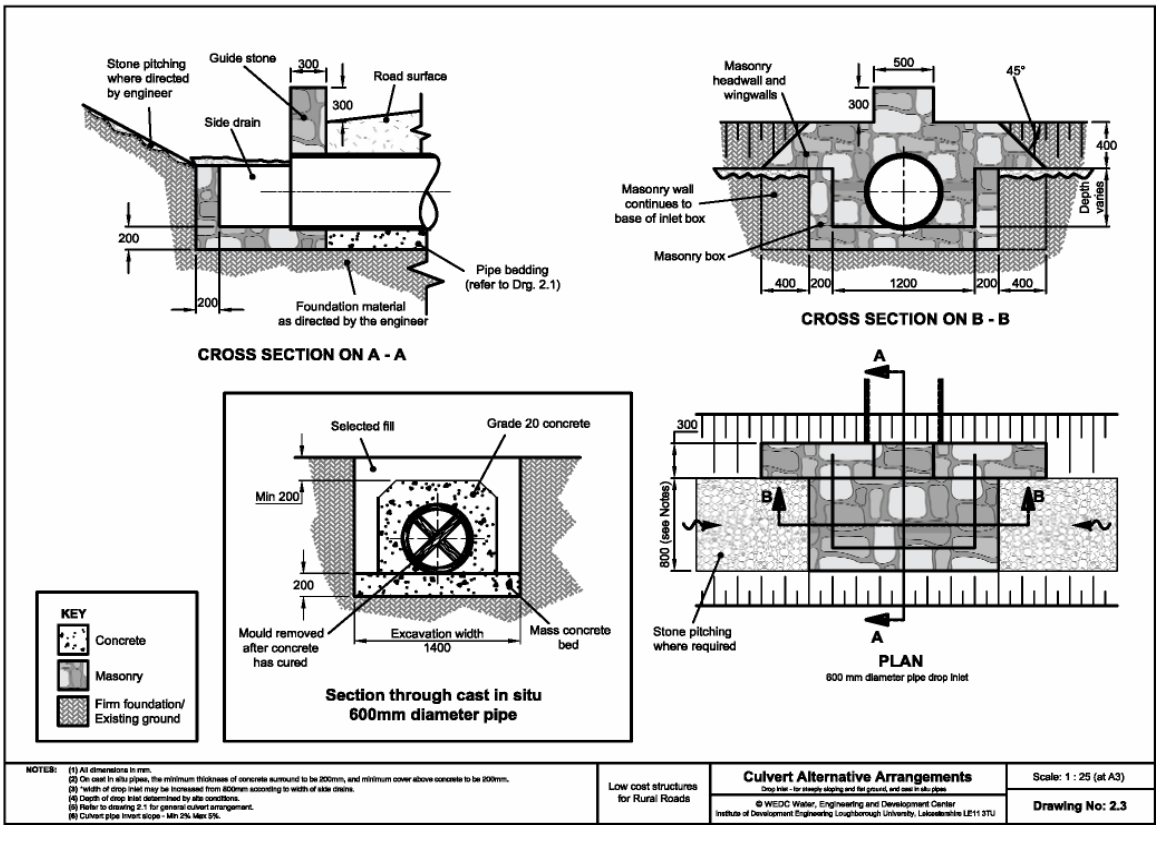
1. Drawing should be read in conjunction with Drawing 2.1 for general culvert arrangements.
2. Drawing shows 600mm diameter pipes. Table of dimensions A should be used for 900mm and 1200mm diameter pipes.

Preliminaries	Unit	Quantity	Rate	Cost
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding and pipe beds and haunches				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
2. Stone masonry				
Stone	m^3			
Cement	50 kg bag			
Sand	m^3			
3. Culvert pipes				
Selected pipe material	m			
4. Mass concrete for pipe surrounds				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
5. Wire mesh for gabion baskets	m^2			
6. Tie-wire for gabion baskets	m			
		Materials Total		

Labour	Unit	Quantity	Man day / unit	Days
1. Placing of the culvert pipes				
Excavation of watercourse/ road	m^3			
Mix, place and compact culvert bedding and haunches	m^3			
Fix culvert pipes in place	m			
2. Masonry culvert headwalls, wingwalls, aprons and cut off walls				
Construct cut off walls and aprons	m^3			
Fix reinforcement hooks in downstream apron to secure gabion protection	No.			
Construct wingwalls and headwalls	m^3			
3. Pipe surround				
Mix, place and compact concrete pipe surrounds	m^3			
4. Gabion downstream protection				
Excavate riverbed	m^3			
Assemble place and join gabion baskets in river bed	m^2			
Collect stones	m^3			
Fill gabion baskets	m^3			
Close and tie off wire baskets	m^2			
5. Sundries				
Backfill and compact fill around culvert pipes in 300mm layers	m^3			
		Total no. man days		
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport	km			
Delivery of materials	km			
Supervision vehicle	lump sum			
2. Hand-tools and equipment				
3. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		

Cost Summary	Cost		
Preliminaries			
Materials			
Labour			
Other Costs			
Total construction cost			


C
B
Carriageway
Shoulder
PLAN VIEW
KEY
Concrete
Masonry
Rip-rap
Firm foundation/
Existing ground
2.5 x O.D.
O.D.
200
300
O.D. + 100
'D'
END ELEVATION ON A
150 min
min 300
200
0.5D
3 x O.D.
3 x O.D. + 400
Excavation width
CROSS SECTION ON B - B
Table of dimensions (mm)
Pipe Diameter | A | B | C | D | E
600 | 400 | 1000 | 400 | 2500 | 200
900 | 450 | 1630 | 500 | 3880 | 300
1200 | 500 | 2280 | 600 | 5280 | 400
NOTES: (1) All dimensions in mm. (2) Refer to Drg. 2.1 for general culvert arrangement. (3) O.D. - Outside Diameter, I.D. Inside Diameter.
(4) Pipes may consist of the following: ● plain concrete pipes with concrete surround 600 ● reinforced concrete pipes with concrete bed and haunch ● cast in situ internally formed pipes of class 10 concrete of minimum 200mm thickness - refer to Drg. 2.3.
● corrugated metal pipes. ● timber stave pipe. (5) Refer to section 8.5.4 for bedding and cover requirements of pipes.
(6) Arrangement shown for stream culvert. Relief culvert similar but without side drain downstream to culvert on high side of road.
(7) Culvert pipe invert slope - Min 2% Max 5%.
Low cost structures for Rural Roads
Culvert Alternative Arrangements
Twin barrel culvert - for high flow
© WEDC Water, Engineering and Development Center
Institute of Development Engineering Loughborough University, Leicestershire LE11 3TU
Scale: 1 : 30 (at A3)
Drawing No: 2.2


Stone pitching
where directed
by engineer
Guide stone
300
Road surface
300
Side drain
200
200
Pipe bedding
(refer to Drg. 2.1)
Foundation material
as directed by the engineer
CROSS SECTION ON A - A
Masonry
headwall and
wingwalls
500
45°
300
400
Masonry wall
continues to
base of inlet box
Depth
varies
Masonry box
400
200
1200
200
400
CROSS SECTION ON B - B
Selected fill
Grade 20 concrete
Min 200
200
Mould removed
after concrete
has cured
Excavation width
1400
Mass concrete
bed
Section through cast in situ
600mm diameter pipe
A
300
B
B
800 (see Notes)
A
Stone pitching
where required
PLAN
600 mm diameter pipe drop inlet
KEY
Concrete
Masonry
Firm foundation/
Existing ground
NOTES: (1) All dimensions in mm.
(2) On cast in situ pipes, the minimum thickness of concrete surround to be 200mm, and minimum cover above concrete to be 200mm.
(3) *width of drop inlet may be increased from 600mm according to width of side drains.
(4) Depth of drop inlet determined by site conditions.
(5) Refer to drawing 2.1 for general culvert arrangement.
(6) Culvert pipe invert slope - Min 2% Max 5%.
Low cost structures for Rural Roads
Culvert Alternative Arrangements
Drop Inlet - for steeply sloping and flat ground, and cast in situ pipes
© WEDC Water, Engineering and Development Center
Institute of Development Engineering Loughborough University, Leicestershire LE11 3TU
Scale: 1 : 25 (at A3)
Drawing No: 2.3

Alternative culvert arrangements:

Drop inlet and cast insitu pipes -Drawing number 2.3

Applicability of the design

Drop inlet

- For culverts on intermediate sloping ground (refer to structure design section in Volume 1.)
- For relief culverts on long gradients

Cast in situ pipes

- General arrangement for cast in situ pipes

Notes about the Drawing and Bill of Quantities

1. Drawing should be read in conjunction with Drawing 2.1 for general culvert arrangement
2. Drop inlet
   a. Width of inlet pit should be constructed to correspond to the width of side drain.
   b. Depth of inlet pit will depend on slope of each specific site.
3. Cast in situ pipes
   Drawing shows circular timber formwork. Other formwork configurations may be used eg. steel, arches or sections of a circle.

Drop inlet – Bill of Quantities

Preliminaries	Unit	Quantity	Rate	Cost
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding and pipe bed and haunch				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
2. Stone masonry				
Stone	m^3			
Cement	50 kg bag			
Sand	m^3			
3. Culvert pipe				
Selected pipe material	m			
4. Mass concrete for pipe surround				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
5. Wire mesh for gabion baskets	m^2			
6. Tie wire for gabion baskets	m			
		Materials Total		

Labour	Unit	Quantity	Man day / unit	Days
1. Placing of the culvert pipe (drawing 2.1)				
Excavation of watercourse/ road	m^3			
Mix, place and compact culvert bedding and haunch	m^3			
Fix culvert pipes in place	m			
2. Masonry culvert headwalls, wingwalls, aprons and cut off walls (drawing 2.1)				
Construct cut off wall and apron	m^3			
Fix reinforcement hooks in downstream apron to secure gabion protection	No.			
Construct wingwalls and headwalls	m^3			
3. Drop inlet (drawing 2.3)				
Excavate drain for drop inlet	m^3			
Construct masonry drop inlet	m^3			
3. Pipe surround (drawing 2.1)				
Mix, place and compact concrete pipe surround	m^3			
4. Gabion downstream protection (drawing 2.1)				
Excavate riverbed	m^3			
Assemble place and join gabion baskets in river bed	m^2			
Collect stones	m^3			
Fill gabion baskets	m^3			
Close and tie off wire baskets	m^2			
5. Sundries				
Backfill and compact fill around culvert and drop inlet in 300mm layers	m^3			
			Total no. man days	
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport	km			
Delivery of materials	km			
Supervision vehicle	lump sum			
2. Hand-tools and equipment				
3. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		
Cost Summary	**Cost**			
Preliminaries				

Materials				
Labour				
Other Costs				
Total construction cost				

Cast in situ – Bill of Quantities

Preliminaries	**Unit**	**Quantity**	**Rate**	**Cost**
See previous sheet				
		Preliminaries Total		
Materials	**Unit**	**Quantity**	**Rate**	**Cost**
1. Lean Concrete for blinding				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
2. Stone masonry				
Stone	m^3			
Cement	50 kg bag			
Sand	m^3			
3. Mass concrete for base of pipe				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
4. Class 20 concrete for pipe surround				
Cement	50 kg bag			
Sand	m^3			
Aggregates	m^3			
5. Wire mesh for gabion baskets	m^2			
6. Tieing wire for gabion baskets	m			
		Materials Total		
Labour	**Unit**	**Quantity**	**Man day / unit**	**Days**
1. Placing of the culvert pipe				
Excavation of watercourse/ road	m^3			
Mix, place and compact blinding concrete	m^3			
Mix, place and compact mass concrete bed				
2. Masonry culvert headwalls, wingwalls, aprons and cut off walls				
Construct cut off walls and aprons	m^3			
Fix reinforcement hooks in downstream apron to secure gabion protection	No.			
Construct wingwalls and headwalls	m^3			
3. In situ pipe				

Fix pipe formwork in place	lump sum			
Mix, place and compact class 20 concrete pipe surround	m^3			
Remove pipe formwork after 3 days	lump sum			
4. Gabion downstream protection				
Excavate riverbed	m^3			
Assemble place and join gabion baskets in river bed	m^2			
Collect stones	m^3			
Fill gabion baskets	m^3			
Close and tie off wire baskets	m^2			
5. Sundries				
Backfill and compact fill around culvert in 300mm layers	m^3			
	Total no. man days			
Labour cost per day		**Total labour cost**		
Other Costs	**Unit**	**Quantity**	**Rate**	**Cost**
1. Transport	km			
Delivery of materials	km			
Supervision vehicle	Lump sum			
2. Hand-tools and equipment (including depreciation cost of pipe formwork)				
3. Staff allowances				
Supervisor	Man / day			
Artisan	Man / day			
		Total Other Costs		
Cost Summary	**Cost**			
Preliminaries				
Materials				
Labour				
Other Costs				
Total construction cost				