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A COST-EFFECTIVE SITE-SPECIFIC STRUCTURAL INVENTORY AND DECISION MAKING: HOW TO ACHIEVE IN ROAD REHABILITATION PROJECT

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Abstract *: **The deterioration of road bridges and culverts that mainly called road structure is a common incident worldwide due to various phenomena that significantly affect Asset management. There is a significant backlog in Asset maintenance, rehabilitation, or upgrade worldwide from literature, and asset Owners are fumbling for funding to line up these backlogs and ensure safety and mitigate risks with a systematic process; operation and maintenance, developing, upgrading or disposing of. An efficient structure inventory is a pivotal part of Asset management that could help rich data establish the governance approach. Besides, an adequate inventory assists asset owner (the government agency) in identifying the Life Cycle Cost (LCCA), prioritisation, optimisation costs (Benefit-Cost ratio), and performance to achieve a sustainable approach. The study object is to bring a perfect case example from Uiar – Yevlakh Road Rehabilitation Project, Azerbaijan for academic and practitioner how to assess and find the Structural adequacy, design standard, appropriateness, hydrological condition, protection designs, aesthetics, and many more. Besides, it could assist in design economical, functional, durable structures for the project. The study found that adopting this methodology could suit other similar road development projects, where the author used and successfully completed inventory for small scale to large scale projects. The study concludes that due to the lack of timely inventory measures, deterioration often causes severe structural damage, a little opportunity for a structural engineer to revitalise, and warrant untimely expensive repair or replacement of the whole structures. The findings will help comprehend quality decision-making in cost for asset owners to collecting enrich data for assets in the selection, optimisation and ranking the following examples, and adopting the case and samples (detailed in this study). The closing discussion will also offer some potential tonics for the data collection shortcomings or literature gaps.***

Keywords- Structure Inventory, Decision Making, Asset Management, Operation and Maintenance, Hydraulic and Hydrological

I. INTRODUCTION

Accurate data and inventory is essential content or records for the respective project and country that influence time, cost, resources and research for any country in the way forward. This study brings a case that underlined such example collected from Azerbaijan, where authors had the opportunity directly involved in the project. "Road Trans Service" Department (RTSD) engaged Bangladesh Consultants Ltd (BCL) through a contract on 21 July 2005 to provide the consultancy services for the design review, preconstruction work and for construction supervision of the project. The project comprises the reconstruction and upgrading of the existing Ujar to Yevlakh 2-lane road to a standard 2-land road with 3.75 m lane, 3.0 m shoulder and 0.75m margin for placing Guardrail on both sides of the road from Ujar up to 44.5 km to the west. The last 8.5 km toward Yevlakh is proposed to be a dual carriageway (4-lane divided with 5 m median). The project's design was originally prepared in 2002, but the project did not proceed at that time. IDB through discussion with the newly constituted "Road Trans Service" Department (RTSD) agreed to finance the project on the following principles:

- The road's reconstruction starts from Ujar to Yevlakh Bypass east junction (i.e. the 46 km section from station 170+500 to station 216+500).
- The remaining portion of the road (7 km section) will be jointly co-financed by OPEC Fund and the Government as agreed in May 2003.

It was intended to base the new construction as far as possible on the original designs and documents, but the Consultants required to amend where it was warranted due to possible changes in conditions, traffic forecast and technical standards. The ultimate objective was to prepare proper documents, select good contractor and render proper supervision by a qualified consultant to ensure the project's

successful implementation. The author was engaged and worked as a highway design engineer in this design review stage.

Figure 1: Location of Ujar – Yevlakh Road Project, Source: Project Folder

The team's structural engineers were responsible for reviewing the previous consultant's design for rehabilitation and new construction of structures and bridges. This was to be followed by incorporating modification and improvement to the original designs, developing new designs where needed. The basic target is to deliver an economical, functional and durable structural solution for the project.

II. METHODOLOGY

Keeping this objective in mind, the activities for reviewing of existing design and further investigations and analysis had been done. After desk study of the existing design drawings, the Consultants carried out field investigations, which included:

- Visual inspection for deterioration and damage of structures,
- Measurement of the basic dimensions for the bridge and the culverts
- Photographic recording of the bridges and the culverts.

A total of 69 drainage structures, both box and pipe culverts and five bridges, were investigated, and their structural and hydrological conditions recorded in formatted inventory sheets. These inventory sheets of the structures with condition and recommendations have been presented as ***Table-2.*** Additionally, exploratory soil boring was carried out at Kura River Bridge Site, and other major bridge locations. The project was detailed design by Kocks Consultants. The desk study of the existing design documents revealed no design details and analysis; hence, the design adequacy could not be checked. The design review Consultants (BCL) had to conclude the design review based on hydrological condition, appropriateness of the type to the specific locations, site investigations, and further client requirements. Findings of the Previous design review are summarised below:

Evaluation of Bridges and Culverts

The main objective of the evaluation of the existing structures was to establish the optimum requirement of repair and strengthening to make it to contribute efficiently for effective road transportation after they have been improved.

Determination of the bridge rehabilitation priority consists of many factors and elements. The comprehensive evaluation had preferably determined the priority based on the engineering and structural factors such as the degree of bridge defect and characteristics of traffic and other road users.

The following conditions and methods worked out prioritisation of bridge/culvert replacement and rehabilitation for all inspected bridges/culvert on the project roads.

All the inspected bridges/culverts on the project road were compared with the same criteria,

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- Replacement or rehabilitation priority were determined from the viewpoint of engineering inspection such as degree of defect, function and type of the bridge/culvert, volume and type of traffic

Recommendation Criteria

On the basis of the evaluation of the existing structures, recommendations for necessary improvement had been prepared. Recommendations comprised Rehabilitation and Reconstruction.

Rehabilitation Works of Bridge and Culvert

i) Observed Common Defects of Structures

Structural and operational defects of existing bridges and culverts so far investigated were as follows:

1) Structural defects

- Deterioration of a major structural member
- Cracking of concrete girder and or beam
- Damaged, corrode and deteriorated steel girders
- Damaged bearing
- Deformation and settlement of substructure
- Scour of foundation

2) Operational defects

- Inadequate bridge/culvert width
- Damaged expansion joint
- Inadequate bridge/culvert safety guard rails,
- Approach guardrail

ii) **Rehabilitation Concept**

The rehabilitation method appropriate to the cause and type of defects at each bridge and culvert had been determined, taking

into account the overall structural condition, cost and maintenance requirement, protection against bed scouring and bank erosion.

Besides, rehabilitation works had been considered with special emphasis on the following aspects.

- Local constructional materials & local custom
- Minimum traffic disruption during construction

Rehabilitation of structures had recommended when

- Major structural components are in good condition
- Satisfies geometric requirements
- Modifications required to satisfy design requirements do not affect the major structural components

Reconstruction

Reconstruction of structures proposed on the existing alignment where existing structures required replacement due to definite structural and operational defects. The following criteria took into consideration to be replaced the structures immediately:

- The lifetime had been expired
- The major components had been seriously damaged and impossible to rehabilitate
- The waterway opening was too small
- The carriageway was too narrow

Once the demand for reconstruction was established, the proposed structure's design had been prepared with a similar consideration of the new structure.

Selection of Bridge/culvert Type

In the design of new bridge/culvert structures, it was important to undertake comprehensive studies and analysis to select the most appropriate type of bridge structure, i.e. the superstructure and substructure members. The basic and important factors which were considered in selecting the bridge type were:

- Geological/Geotechnical conditions
- Hydraulic conditions
- Global flooding pattern
- Environmental conditions
- Availability of materials
- Construction time and cost
- Available construction technology
- Requirement of maintenance

Structural Components

The structural components of the new Bridge structures for which the detail design developed include the following:

a) Decking with pre-stressed I Girder
b) Bearing for the decking.
c) Piers.
d) Abutments with wing walls.
e) Foundation for abutments and piers.

The components broadly grouped as below:

- Superstructure; all elements above bridge bearings,
- Sub-structure; all elements above the ground but up to bearing, and
- Foundation; elements below the Sub-structure.

Investigations and Surveys

The activities carried out to form the design basis of the project works are briefly:

A. Topographic Survey
B. Traffic Study
C. Pavement and Sub-soil Investigation
D. Hydrological Investigation
E. Pavement Investigation
F. Materials/Quarry Investigation
G. Socioeconomic Survey for land Acquisition, Utility and Resettlement

In the following section have detailed these activities that were essential to complete the detailed inventory for road and road-related structures;

A. ***Topographic Survey***

The scope of works required a detailed topographic survey of the 8.5km of 4-lane section and verified survey control points of the existing design documents. But in the absence of survey control points of the existing survey data, the consultants had also to carry out detailed Topographic Surveys of 44.5km 2-lane road section. The topographic surveys have been carried out using Total Station, Electronic Survey Equipment.

i. Survey Control Points (Benchmark)

Prior to carrying out the topographical surveys, benchmark monuments were established at regular intervals and at suitable locations along the road's full length for both horizontal and vertical control (X, Y, Z). X, Y coordinates of these monuments were determined by traversing and by GPS survey. Elevations (Z VALUES) of these control monuments were determined by level survey and tied into the existing National Datum and Benchmark of Azerbaijan. The monuments have been constructed at safe and secured locations to be maintained throughout the construction period. Each monument had been marked with reference number, elevation and coordinates, which sketches were presented in the project detail drawings.

ii. Detailed Topographical Survey

A corridor of respectively 40m and 60m was surveyed in 2-lne and 4-lane sections, while the wider strip was surveyed to realign or construct new approaches. Within the corridor, all infrastructures, including roads, buildings, water channels, electric power line, telephone line and cables, gas and water pipelines, irrigation installations, etc., were surveyed. Even trees, poles, marker posts, posters were surveyed and located on the map. Cross-section surveys were done at every 25m intervals

Utilities Relocation survey was done for wider areas to prepare an appropriate plan for relocating the affected utilities like electricity line, telephone line, gas line and water pipes.

iii. Survey Processing and Digital Terrain Model

All these survey data were downloaded to the computer and processed using AutoCAD Land Desktop and Civil CAD design software to create a digital terrain model (DTM), which formed the base of designing horizontal alignment, vertical profile and cross-sections of the road. Drawing production and volume calculations have also been done by software using the DTM.

B. Traffic Study

As a counter-checking of the existing design report's traffic data, traffic was counted for a short period of 2 days. Traffic count sheets were included in the project's main report as an annex. Computed Annual Average Daily Traffic Volume (AADT) was found reasonably corresponding the forecast AADT of the existing report. Equivalent Standard Axle Loading (ESAL) was estimated from the AADT up to 30 years and found greater than previous values. Forecast ESAL of the year 2018 and 2026 were found respectively 11.0 million and 20 million, which are greater than those of existing. Due to the work's late commencement, the new design life was up to 2026, and the design traffic was 20m Equivalent Standard Axle (ESA).

C. Pavement and Alignment Soil Investigations

Besides reviewing existing data of pavement and soils investigations, the Consultants had carried out some essential investigations, which included:

- Pavement condition survey
- Pavement structures stratification
- Grading of pavement materials in 4-lane section
- Embankment and alignment soils investigation at bridge approaches, and 4-lane section.

i. Pavement Condition Survey

36.2 km of overlay sections, which were scattered between km 0+000 and km 43+000, had been visually condition surveyed and assessed to determine its present serviceability status. Existing pavement surfaces had been found badly distressed. The severity and extent of major distress like depression, rut, cracks, edge failure etc., had been visually examined, measured and photographed.

Figure 2: 70 mm deep rutting along wheel track, km 1+600, Source: from the project file

Figure 3: Cracked and undulated surface at Km 25, Source: from the project file

The depression/rut depth was found varying from 25 to 70 mm, with an average of 50 mm. The surface was badly cracked and undulated. The crack widths measured and found greater than 3 mm, with an average of 10 mm. The cracked surface represents about 30 to 50 % of the paved area. The riding quality was inferior. A comfortable ride at a speed greater than 40 km/hr was practically impossible. The standard pavement crown diminished in almost all stretches. With respect to the International Roughness Index (IRI) having scale 0 ~ 10, the existing pavement surface had an estimated IRI > 7.

Figure 4: 3 ~ 15 mm wide crocodile cracks at km 7+700, Source: from the project file

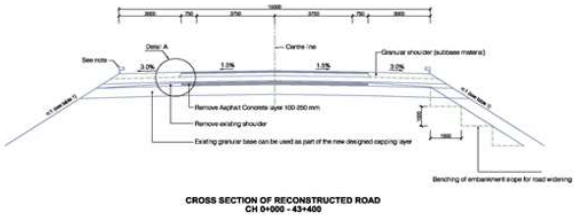
Figure 5: Shoulder erosion and edge failure at km 8+200, Source: from the project file

In a rating of 0 to 5 (0 being the worst and 5 being the best) the present serviceability index of the existing pavement condition had an estimated value of less than 2.5. So the pavement of all overlay sections had reached to its terminal serviceability condition, which badly warrants reconstruction instead of overlaying.

ii. Embankment and Alignment Soils Investigation

The existing embankment and the natural ground of the proposed realignment of the 4-lane road section investigated. Samples were collected by digging a pit to a depth of 1000 to 1300mm depth at an interval of 500m both from the embankment, the proposed alignment for 4-lane road and new bridge approaches. Total 35 samples were collected and tested for Classification, Moisture-density relation tests and CBR. Sampling and tests had been done as per ASTM and AASHTO Specifications. Existing embankment and new alignment soils were generally lean clay with traces of sand. Liquid limit of these samples varied from 24.5 to 37, PI varied from 8.1 to 17.3, and that of CBR varied from 3% to 47%. The geotechnical report of the embankment and the natural ground in the area did not indicate unsuitable parameters except the presence of high salt content.

iii. Typical Pavement Cross Sections



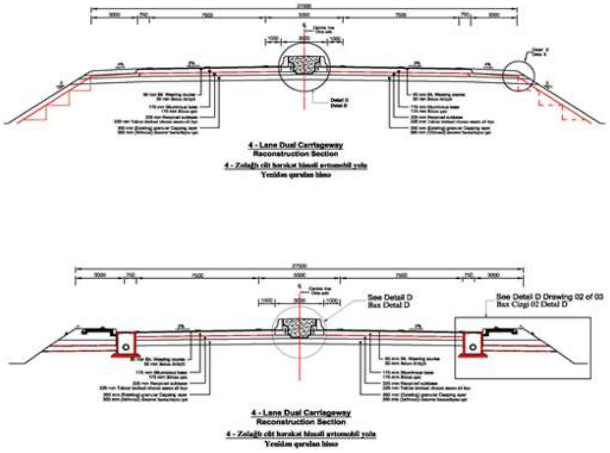


Figure 6: Typical Pavement Cross Sections to identify the structural length adequacy.

The document analysis was conducted among all detailed design drawings for various components and project reports to ensure constructability, appropriateness, cost-effectiveness, as well as to ensure correct documents were prepared for tenderers. From the review of the main bridges, the following were summaries as part of the review process in ***Table-1***.

D. Hydrological/Drainage Investigation

An overall review of the hydraulic and drainage design for the Ujar – Yevlakh Road Rehabilitation Project (UYRRP) had made mainly to:

- Check required waterway opening through the bridge/culvert so that it is not endangered by erosion or scouring during heavy rainfall;
- Identify the type and extent of protection works to be undertaken for bridges and culverts.

Checked the cross-drainage's waterway opening (bridge/culvert) of the road recommended by the Kocks Consult during September – October 2002 and found that all the structures were hydraulically adequate except the 5.6 m bridge over the canal at km 2.269. The waterway opening of the 5.6 m bridge at km 2.269 should be increased for proper drainage. The Roadside drains had also been checked and observed that roadside drains proposed by Kocks were not adequate. Therefore, attention was given to design road drains, especially for the new bridge approaches at km 18.77, 33.95, 43.94 and 47.8 and urban area of Yevlakh from km 44.5 to 45.5. Hydrological/Drainage Investigation at site for each road cross-drainage structure was carried out during 25 to 28

September 2005. It found that all the drainage structures were adequate in hydrological consideration except the 5.6 m bridge at km 2.269. The project road traverses through a mostly open area having a longitudinal gradient and cross fall. Rain also falls minimum in the area (maximum 300mm annually) at that time. Roadside drains were not warranted along the road to cater to surface runoff except urban area and high bridges' approaches. An appropriate type of roadside drains was to be provided in bridge approaches and in the urban area where surface runoff is likely to be obstructed.

5.6m Bridge at Km 2.269

This bridge was located over about 10m wide irrigation canal. Water depth was observed as 2.0m, which rises to 4.0m during monsoon resulting in high flow velocity. A scour hole was observed downstream of the bridge, indicating the inadequate waterway opening of the existing bridge. Details of Hydrological investigation of this bridge site, as well other bridges and culverts were checked and reviewed also,

Table-1: Review summary for Project Structure (Bridges and Culverts)

Structure No. and location	Kocks Consultant's Report		BCL Comments and Recommendations
	Condition of structures	Recommendations and Design	Comments and Recommendations
Bridge no. 14 at km 2+269	5.6m simply supported bridge, the condition was bad, width is less and recommended for a 5x4.5m box culvert	As 5x2.5m box culvert	Big scour hole exists at the down stream, and the canal width was about 10m. The previous design was not adequate and needs more opening for water flow.
Bridge no. 15 at km 18+760 over Turanchay river	Simply supported 3 span bridge, piers and abutments were not reinforced. Construction quality was insufficient.	As 3x18m bridge	Due to equal span length, both piers could obstruct flow and influence scour due to backflow of water. Need design modification with longer mid-span.
Bridge no. 16 at km 33+967 across Nametahadskij canal	Single span bridge with T shaped RC slab. Bearing capacity of abutments and superstructure was insufficient.	As 18m long new bridge with concrete lining on the canal bed	Satisfying hydrological conditions marginally but canal bed lining is not the appropriate solution, which changes the natural course of the vicinity's flow and impact. Needs modification with longer span and nominal slope protection.
Bridge no. 17 at km 43+870 over the river Kura	Simply supported 267m long 8-span bridge,	Rehabilitation of the deck	Rehabilitation of the deck was ok but considering increased traffic load RTSD requirement was to construct a new bridge to downstream.
Bridge no. 18 at km 47+800 across Yevlakh-Aghdam	51m long 3 span bridge	49m long 3-span new bridge with span arrangement of 12+25+12m	Double lane broad gauge rail line crosses under the bridge. 25m midspan was not adequate to provide necessary horizontal clearance. Moreover, the bridge location was within the 4-lane road section. A new bridge with longer mid-span for sufficient clearance could be designed.
Drainage Structures			
Box Culvert	There are 13 box culverts.	4 additional box culverts and repair/rehabilitation of all 13 box culverts	Constructions of 4 additional culverts are for cattle pass and to cater drainage, which was ok. 6 of the existing box culverts had no base, and structural condition of all 13 box culverts was poor and inadequate—recommended for replacement.
Pipe Culvert	There are 56 pipe culverts.	6 of these to be replaced and others to be rehabilitated	Condition of 14 had been assessed to be rehabilitated, and the rest 42 need replacement.

i. Hydraulic Design of the existing 5.6 m Bridge at km 2.269

Design discharge of the canal at the bridge location calculated by the following Manning's formula:

$Q=AX\ ^{1}/_{n}XR^{0.67}$ x $S^{0.33}$

Where: Q - Design discharge (m^3/Sec);
A – Flow area of the canal section (m^2);
N – Manning's roughness coefficient;
R – Hydraulic radius (m);
$R = {}^{A}/_{p}$; (p → Perimeter (m));
S → Slope of canal flow line;
After putting the value of n=0.025, A=24m^2 (from cross-section of canal), R=24/13=1.85m and S=0.0001, we have got
Q = 69 m^3/sec.

Assuming the maximum allowable flow velocity is 2 m/sec.
A = Q/V = 69/2 = 34.5 m^2
If h = 4.5 m, then b = 7.67 m (width of opening)

Considering the canal's flow condition and for the above discharge, a drainage structure of 8m waterway opening is recommended.

Kock's recommended a 5m wide box culvert with 2.5m hight, which was inadequate.

ii. Road Side Drain

Roadside drains were required on the major new bridges km 18.77, 33.95, 43.94 and 47.8 and within Yevlakh City area from km 44.5 to 45.5. Considering maximum rainfall of 1.15mm per minute roadside drain of 300mm diameter pipe with 1.0m diameter catch pit placed at 50m intervals is recommended. In case of high approach road with steep gradient surface runoff shall be guided along edge of pavement using raised kerb and 400 mm wide outlet drain.

iii. Slope Protection

All the drainage structures except the bridge at km 2.269 was adequate in hydrological consideration, and no sign of significant bank erosion was observed at those structure locations. However, to protect the embankment slope around the bridge abutment from rain-cuts, the following nominal protection works had done for the 260 m Kura Bridge at km 439; 20 m bridge at km 33.95 and RoB at km 47.8.

Protection of Sloping Area around the Bridge Abutment:

- Embankment slopes prepared to design level and grade with proper compaction
- 100 mm thick filter layer of 50 mm downgraded stone chips placed on compacted slopes
- Concrete blocks of size 350mmx350mmx250mm (manufactured by cement, sand and gravel) closely placed on the filter layer

Protection of Falling apron:

- Prepare the apron area with proper grading, levelling and compaction,
- 100 mm thick filter layer of 50mm downgraded stone chips placed on the compacted area
- Concrete blocks of size 400mmx400mmx400mmx250mm (also manufactured by cement, sand and gravel) closely placed on filter layer,
- Details of slope protection work were prepared in Detail Structural Design Drawings,

Bridges and Culverts design consideration

Design of the structures carried out according to the requirements of AASHTO – 96, Standard Specifications for Highway Bridges and/or BS5400. Materials for use in the construction of the bridge had generally been specified to comply with AASHTO and/or ASTM.

The superstructure design loads consist of dead load, superimposed dead load, live load, Impact effect, Wind Load, Longitudinal Forces, Stream Flow Pressure, Seismic Forces, and restraint moments due to creep and shrinkage and differential settlement. The substructure had been designed to support all dead loads from the superstructure, live loads, wind loads, braking force, bearing friction, earth pressure including surcharge and other loads according to AASHTO.

- **Dead load**

Total weight of the bridge/culvert structure including the carriageway, sidewalks, guardrails etc, had been considered as dead load. The differential settlement had also been considered as a dead load. For the calculation of dead load weight, the material unit weights specified in Section 3.3 of the AASHTO Standards adopted as follows:

Superstructure Concrete	23.5 kN/m^3
Substructure Concrete	23.5 kN/m^3
Superstructure Dead Load	23.5 kN/m^3
50 mm Surfacing	22.0 kN/m^3

The impact of permanent differential settlement of the foundations on the structure due to dead and superimposed dead loads has been considered.

The impacts of shrinkage and creep had been considered and evaluated for the following:

a) Calculation of differential shrinkage and creep stresses in composite construction.
b) Calculation of pre-stressing losses in pre-stressed concrete construction.
c) Calculation of long term deflections of concrete structures.

- **Live load**

The AASHTO lane loads or HS20-44 highway live loading equivalent to the truck-trailer, related impact effects, longitudinal forces due to traction/braking, and the AASHTO footpath loading have been considered the design.

III. RESULT AND ANALYSIS

Form the above design analysis, detail drawings, reports, code and standard, project contracts requirement; the author had an excellent understanding regarding project proposed road templates in various SLK (straight line kilometre). The availability of useful project data and information was not so difficult—the structural inventory to make for cost-effective, site-specific, and context-sensitive approaches. During the site inspection, measuring tape, a camera with sufficient memories, safety gears, torch, shovels, prodder, sub-surface utility information, and much relevant information was taken with the team while left the main office.

It was acknowledged how much information needed should be carried on the site; otherwise impossible to go and forth since the site was not close to the project office during the design review stage. A thorough road alignment video was captured during this site inspection to eliminate any missing or unforeseen during the visit quickly. It was an excellent knowledge sharing, having experienced engineers among the team with lovely weather, sightseeing, nature, spectacular weather and geology. After the site inspection, a detail structural inventory table was prepared from the site information. The detailed inventory was collated in Table -2

Table-2: Review of Hydrological and Structural condition of existing drainage structures (Culverts and Bridges)

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs	Recommendation
1	0+004	0e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
2	1+190	1e	RCC Pipe	1250Ø	Adequate	Poor		Replace by 1250 Ø new RCC Pipe
3	1+643	2e	RCC Pipe	1250Ø	Adequate	Fair		Retain with extension at both sides of the STR.
4	2+098	3e	RCC Pipe	1250Ø	Adequate	Poor		Replace by 1250 Ø new RCC Pipe
5	2+431	4e	RCC Pipe	1250Ø	Adequate	Poor		Replace by 1250 Ø new RCC Pipe
6	2+996	5e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at one side of the STR.

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs	Recommendation
7	3+579	6e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
8	4+107	7e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
9	4+505	8e	RCC Pipe	1000Ø	Adequate	Poor		Replace by 1000 Ø new RCC Pipe
10	5+420	9n			Hyd. Req.			Propose 2000 x 2000 new Box Culvert
11	5+952	10e	RCC Pipe	2x1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
12	6+264	11e	Box Culvert	3000x2000	AUP	Fair		Retain but major rehabilitation works for wing wall, apron, and vegetation, bed deposition clearance to be required
13	6+441	12e	Box Culvert	2000x1500	Adequate	Poor		Replace by 2000 x 2000 new Box Culvert
14	6+783	13e	Box Culvert	3000x2000	Adequate	Poor		Replace by 2000 x 2000 new Box Culvert

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs		Recommendation
15	6+858	14n			Hyd. Req.				Propose 2000 x 2000 new Box Culvert
16	7+548	15e	RCC Pipe	2x1000Ø	Adequate	Poor			Replace by 2 x 1000 Ø new RCC Pipe
17	7+835	16e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
18	8+287	17e	RCC Pipe	1000Ø	Adequate	Fair	Not Avaialbe	Not Avaialbe	Retain with extension at both sides of the STR.
19	9+344	18e	RCC Pipe	1000Ø	Adequate	Fair	Not Avaialbe	Not Avaialbe	Retain with extension at both sides of the STR.
20	9+518	19n			Hyd. Req.				Propose 2000 x 2000 new Box Culvert
21	9+829	20e	Box Culvert	2000x2000	Adequate	Fair			Retain with extension at both sides of the STR.
22	10+380	21e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
23	11+272	22e	RCC Pipe	2x1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
24	12+403	23e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs		Recommendation
25	12+568	24e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
26	13+680	25e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
27	14+058	26e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
28	14+274	27e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
29	14+476	28e	Box Culvert	2000x3000	Adequate	Fair			Retain with extension at both sides of the STR.
30	14+810	29e	RCC Pipe	1000Ø	AUP	Fair			Retain with extension at both sides of the STR.
31	15+150	30e	RCC Pipe	2x1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs	Recommendation
32	15+267	31e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
33	15+843	32e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
34	16+580	33e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
35	18+559	34e	RCC Pipe	1000Ø	Adequate	Poor		Replace by 1000 Ø new RCC Pipe
36	19+024	35e	RCC Pipe	1250Ø	Adequate	Fair		Retain with extension at both sides of the STR.
37	19+629	36e	Box Culvert	2000x2000	Adequate	Fair		Retain with extension at both sides of the STR.
38	20+365	37e	Box Culvert	2000x2000	Adequate	Fair		Retain with extension at both sides of the STR.

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs	Recommendation
39	20+932	38e	RCC Pipe	1000Ø	Adequate	Poor		Replace by 1000 Ø new RCC Pipe
40	21+212	39e	RCC Pipe	1250Ø	Adequate	Poor		Replace by 1250 Ø new RCC Pipe
41	21+376	40e	RCC Pipe	1000Ø	Adequate	Poor		Replace by 1000 Ø new RCC Pipe
42	21+584	41e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
43	23+018	42e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.
44	23+179	43e	Box Culvert	2000x2000	Adequate	Fair		Retain with extension at both sides of the STR. Also for AUP
45	24+022	44e	RCC Pipe	1000Ø	Adequate	Fair		Retain with extension at both sides of the STR.

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs		Recommendation
46	24+950	45e	RCC Pipe	1000Ø	Adequate	Poor			Replace by 1000 Ø new RCC Pipe
47	25+511	46e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
48	26+131	47e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
49	26+273	48e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
50	27+515	49n			Hyd. Req.				Proposed 2000 x 2000 new Box Culvert, Also for AUP
51	29+641	50e	Box Culvert	2000x2000	Adequate	Poor			Replace by 1000 Ø new RCC Pipe
52	31+548	51e	Box Culvert	2000x2000	Adequate	Poor	Not Available	Not Available	Replace by 2000 x 2000 new Box Culvert
53	34+128	52e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs		Recommendation
54	34+518	53e	Box Culvert	2000x2000	Adequate	Fair			Retain with extension at both sides of the STR.
55	34+664	54e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
56	35+267	55e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
57	35+951	56e	RCC Pipe	1000Ø	Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
58	36+789	57e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
59	37+202	58e	RCC Pipe	1000Ø	Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
60	37+651	59e	RCC Pipe	1000Ø	Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
61	38+210	60e	RCC Pipe	1000Ø	Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
62	38+279	61e	RCC Pipe	1000Ø	Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
63	38+910	62e	RCC Pipe	1000Ø	Adequate	Poor			Replace by 1000 Ø new RCC Pipe
64	39+260	63e	RCC Pipe	3x1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.

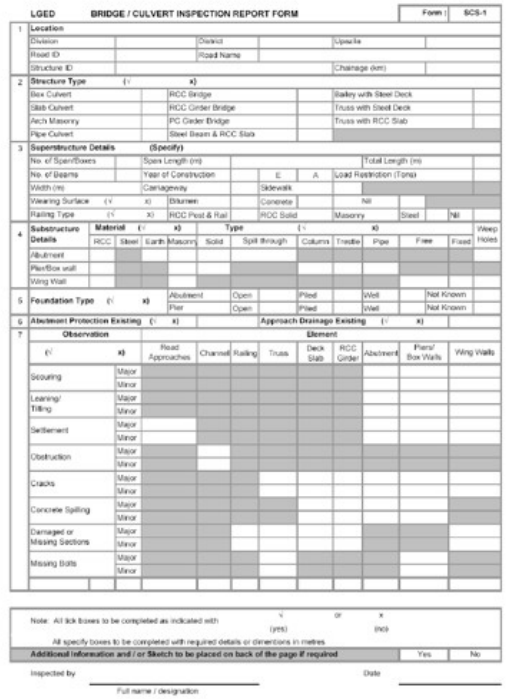
Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs		Recommendation
65	39+874	64e	RCC Pipe	1000Ø	Adequate	Poor	Not Available	Not Available	Replace by 1000 Ø new RCC Pipe
66	40+494	65e	RCC Pipe	1000Ø	Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
67	40+730	66e	RCC Pipe	2x1000Ø	Adequate	Poor	Not Available	Not Available	Replace by 1000 Ø new RCC Pipe
68	44+631	67e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
69	50+117	68e	Box Culvert		Adequate	Fair	Not Available	Not Available	Retain with extension at both sides of the STR.
70	51+336	69e	RCC Pipe	1000Ø	Adequate	Fair		Not Available	Retain with extension at both sides of the STR.
71	51+454	70e	Box Culvert		Adequate	Fair			Retain with extension at both sides of the STR.
72	51+632	71e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.
73	51+770	72e	RCC Pipe	1000Ø	Adequate	Fair			Retain with extension at both sides of the STR.

REVIEW REPORT OF EXISTING STRUCTURES (BRIDGE)

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs		Recommendation
1	2+269	Br 14	Bridge	5600 (1 Span)	*Inadequate	Poor			Superstructure consists of precast RCC slab on concrete Abutment. Replace by 2x4000x5000 New Box culvert
									
2	18+774	Br 15	Bridge	52000 (3 Span)	Adequate	Poor			Superstructure consists of precast RCC slab on concrete Abutment and Pier. Replace by 1x50 m Bridge
									
3	33+951	Br 16	Bridge	17500 (1 Span)	Adequate	Poor			Superstructure consists of precast RCC T shaped slab on concrete Abutment and Pier. Replace by 20 m Bridge
									
4	43+940	Br 17	Bridge	260000 (8 Span)	**Adequate	Fair			Superstructure consists of precast RCC T shaped slab on concrete Abutment and Pier. For Road Geometric requirement it

Serial No.	Chainage (Km)	STR. No.	STR Type	STR Size (mm)	Hydor Condi.	STR Condi.	Photographs	Recommendation
								needs to be replaced by 260m bridge Along with S/P works by CC blocks.
5	47+801	Br 18	Bridge	51000 (3 Span)	Adequate	Poor		Superstructure consist of precast RCC T shaped slab on concrete Abutment and Pier. For Road Geometric requirement its needs to be the replacement by 50m bridge
6	47+875	Br 18A	Bridge	38000 (2 Span)	Adequate	Good		Superstructure consists of precast RCC T shaped slab on concrete Abutment and Pier. To be Retain
*5.6 m bridge is located over 10m wide drainage canal. This bridge is inadequate in hydrological consideration. A scour hole has formed at d/s of the bridge. So it should be replaced by 2x(4000x5000).								
* * In hydrological consideration 260m bridge over Kura River is adequate, but geometrically it is insufficient for projected traffic. Hence it should be replaced by 260m new bridge. The new bridge should be at 20m L/S of the existing bridge. Slope protection by CC BLOCKS should be required.								

The above culverts and structures' inventory determined by combining the culverts and bridges available information, drawings, and project-specific requirements. Different projects encountered different types of bridges and culverts with historical importance, which may vary from this project based on the project's nature: duplication, reconstruction, rehabilitation, revitalisation. The study tried to explain how the site team can conduct an efficient inspection with having correct expatriates. The study collated various data collection forms during the literature review for the practitioner and academic to prepare a site-specific or project-specific form based on the clients' requirements or projects scope and deliverables. The inspection team must liaise with the clients' asset management team, whether any available forms for the relevant tasks, to better integrate and cost-effective outcomes for clients to keep enriching data. The following figures are the sample forms have listed here for better understanding and preparation, the relevant authorities may be inquired for the further updated forms;



LGED BRIDGE / CULVERT INSPECTION REPORT FORM Form : SCS-1

1 Location
Division | District | Upazila
Road ID | Road Name
Structure ID | Chainage (km)

2 Structure Type (√ x)
Box Culvert | RCC Bridge | Bailey with Steel Deck
Slab Culvert | RCC Girder Bridge | Truss with Steel Deck
Arch Masonry | PC Girder Bridge | Truss with RCC Slab
Pipe Culvert | Steel Beam & RCC Slab

3 Superstructure Details (Specify)
No. of Span/Boxes | Span Length (m) | Total Length (m)
No. of Beams | Year of Construction | E | A | Load Restriction (Tons)
Width (m) | Carriageway | Sidewalk
Wearing Surface (√ x) | (√) Bitumen | Concrete | Nil
Railing Type (√ x) | RCC Post & Rail | RCC Solid | Masonry | Steel | Nil

4 Substructure Details Material (√ x) Type (√ x) Weep Holes
RCC | Steel | Earth | Masonry | Solid | Spill through | Column | Trestle | Pipe | Piles | Fixed
Abutment
Pier/Box wall
Wing Wall

5 Foundation Type (√ x) Abutment Open Piled Well Not Known
Pier Open Piled Well Not Known

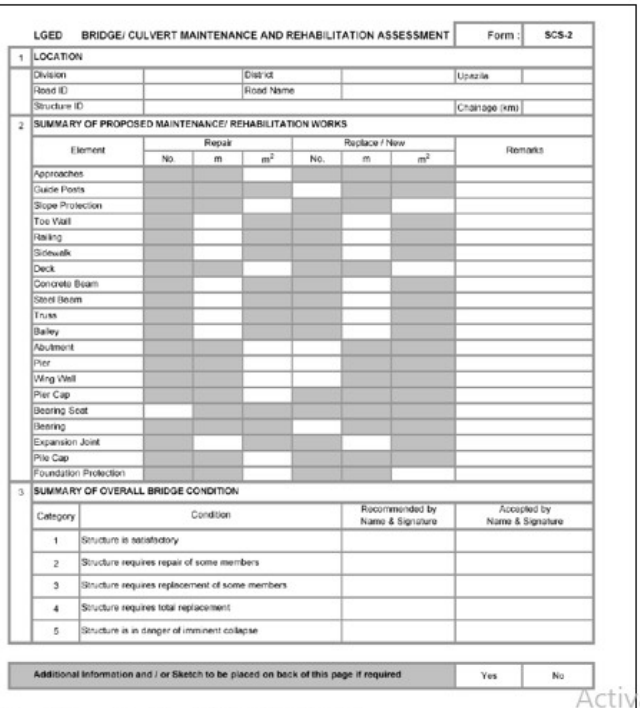
6 Abutment Protection Existing (√ x) Approach Drainage Existing (√ x)

7 Observation (√ x) Element: Road Approaches | Channel | Railing | Truss | Deck Slab | RCC Girder | Abutment | Piers/ Box Walls | Wing Walls
Scouring — Major / Minor
Leaning/ Tilting — Major / Minor
Settlement — Major / Minor
Obstruction — Major / Minor
Cracks — Major / Minor
Concrete Spilling — Major / Minor
Damaged or Missing Sections — Major / Minor
Missing Bolts — Major / Minor

Note: All tick boxes to be completed as indicated with √ (yes) or x (no)
All specify boxes to be completed with required details or dimensions in metres
Additional Information and / or Sketch to be placed on back of the page if required | Yes | No

Inspected by ____ Date ____
Full name / designation

Figure 7: Inspection Form 01 of 02 (LGED, 2010)



LGED BRIDGE/ CULVERT MAINTENANCE AND REHABILITATION ASSESSMENT Form : SCS-2

1 LOCATION
Division | District | Upazila
Road ID | Road Name
Structure ID | Chainage (km)

2 SUMMARY OF PROPOSED MAINTENANCE/ REHABILITATION WORKS

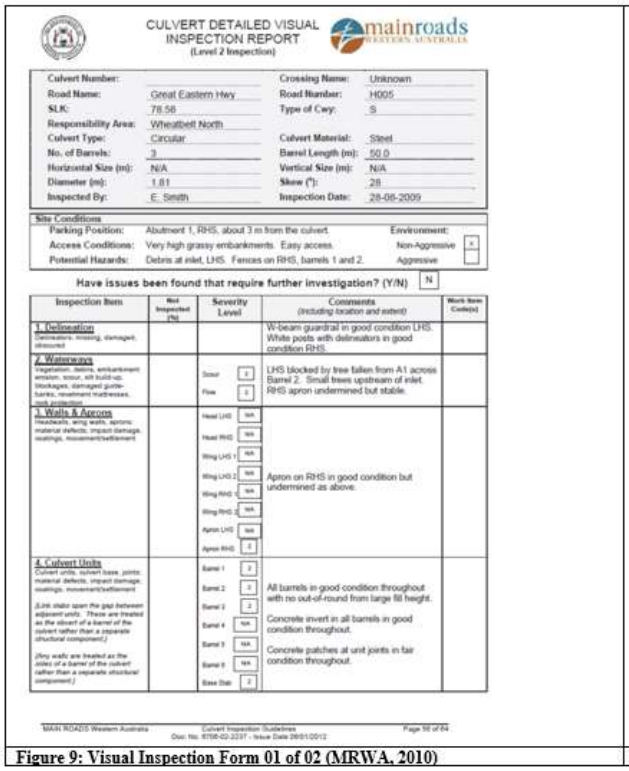
Element	Repair No.	Repair m	Repair m^2	Replace / New No.	Replace / New m	Replace / New m^2	Remarks
Approaches							
Guide Posts							
Slope Protection							
Toe Wall							
Railing							
Sidewalk							
Deck							
Concrete Beam							
Steel Beam							
Truss							
Bailey							
Abutment							
Pier							
Wing Wall							
Pier Cap							
Bearing Seat							
Bearing							
Expansion Joint							
Pile Cap							
Foundation Protection							

3 SUMMARY OF OVERALL BRIDGE CONDITION

Category	Condition	Recommended by Name & Signature	Accepted by Name & Signature
1	Structure is satisfactory		
2	Structure requires repair of some members		
3	Structure requires replacement of some members		
4	Structure requires total replacement		
5	Structure is in danger of imminent collapse		

Additional Information and / or Sketch to be placed on back of this page if required | Yes | No

Figure 8: Inspection Form 02 of 02 (LGED, 2010)



CULVERT DETAILED VISUAL INSPECTION REPORT
(Level 2 Inspection)

mainroads WESTERN AUSTRALIA

Culvert Number:		Crossing Name:	Unknown
Road Name:	Great Eastern Hwy	Road Number:	H005
SLK:	78.56	Type of Cwy:	S
Responsibility Area:	Wheatbelt North		
Culvert Type:	Circular	Culvert Material:	Steel
No. of Barrels:	3	Barrel Length (m):	50.0
Horizontal Size (m):	N/A	Vertical Size (m):	N/A
Diameter (m):	1.81	Skew (°):	28
Inspected By:	E. Smith	Inspection Date:	28-08-2009

Site Conditions

Parking Position:	Abutment 1, RHS, about 3 m from the culvert.	Environment:	
Access Conditions:	Very high grassy embankments. Easy access.	Non-Aggressive	x
Potential Hazards:	Debris at inlet, LHS. Fences on RHS, barrels 1 and 2.	Aggressive	

Have issues been found that require further investigation? (Y/N) N

Inspection Item	Not Inspected (%)	Severity Level	Comments (including location and extent)	Work Item Code(s)
1. Delineation Delineators: missing, damaged, obscured			W-beam guardrail in good condition LHS. White posts with delineators in good condition RHS.	
2. Waterways Vegetation, debris, embankment erosion, scour, silt build-up, blockages, damaged gutter-banks, revetment mattresses, rock protection		Scour 1 Flow 2	LHS blocked by tree fallen from A1 across Barrel 2. Small trees upstream of inlet. RHS apron undermined but stable.	
3. Walls & Aprons Headwalls, wing walls, aprons: material defects, impact damage, scalings, movement/settlement		Head LHS NA Head RHS NA Wing LHS 1 NA Wing LHS 2 NA Wing RHS 1 NA Wing RHS 2 NA Apron LHS NA Apron RHS 2	Apron on RHS in good condition but undermined as above.	
4. Culvert Units Culvert units, culvert base, joints: material defects, impact damage, scalings, movement/settlement (Link slabs span the gap between adjacent units. These are treated as the invert of a barrel of the culvert rather than a separate structural component.) (Dry walls are treated as the sides of a barrel of the culvert rather than a separate structural component.)		Barrel 1 2 Barrel 2 2 Barrel 3 2 Barrel 4 NA Barrel 5 NA Barrel 6 NA Base Slab 2	All barrels in good condition throughout with no out-of-round from large fill height. Concrete invert in all barrels in good condition throughout. Concrete patches at unit joints in fair condition throughout.	

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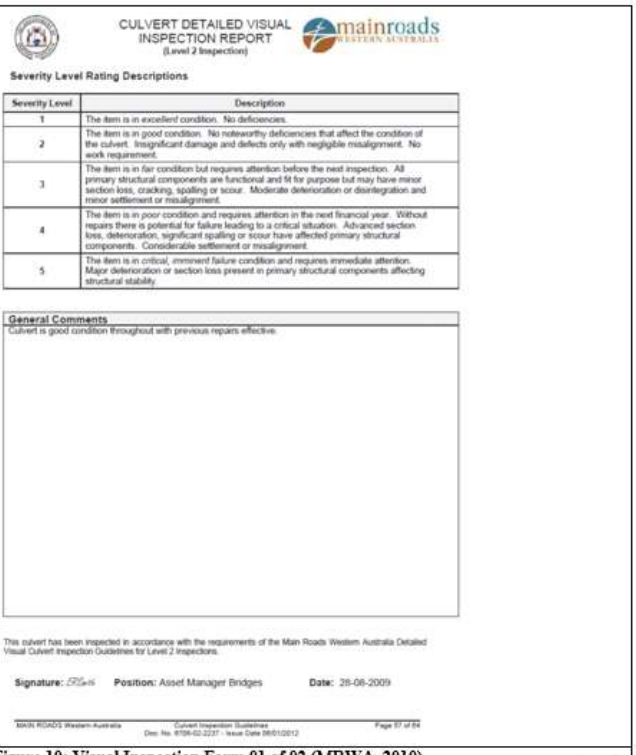
Figure 9: Visual Inspection Form 01 of 02 (MRWA, 2010)



CULVERT DETAILED VISUAL INSPECTION REPORT
(Level 2 Inspection)

mainroads WESTERN AUSTRALIA

Severity Level Rating Descriptions

Severity Level	Description
1	The item is in *excellent* condition. No deficiencies.
2	The item is in good condition. No noteworthy deficiencies that affect the condition of the culvert. Insignificant damage and defects only with negligible misalignment. No work requirement.
3	The item is in fair condition but requires attention before the next inspection. All primary structural components are functional and fit for purpose but may have minor section loss, cracking, spalling or scour. Moderate deterioration or disintegration and minor settlement or misalignment.
4	The item is in poor condition and requires attention in the next financial year. Without repairs there is potential for failure leading to a critical situation. Advanced section loss, deterioration, significant spalling or scour have affected primary structural components. Considerable settlement or misalignment.
5	The item is in *critical, imminent* failure condition and requires immediate attention. Major deterioration or section loss present in primary structural components affecting structural stability.

General Comments
Culvert is good condition throughout with previous repairs effective.

This culvert has been inspected in accordance with the requirements of the Main Roads Western Australia Detailed Visual Culvert Inspection Guidelines for Level 2 Inspections.

Signature: [signature] Position: Asset Manager Bridges Date: 28-08-2009

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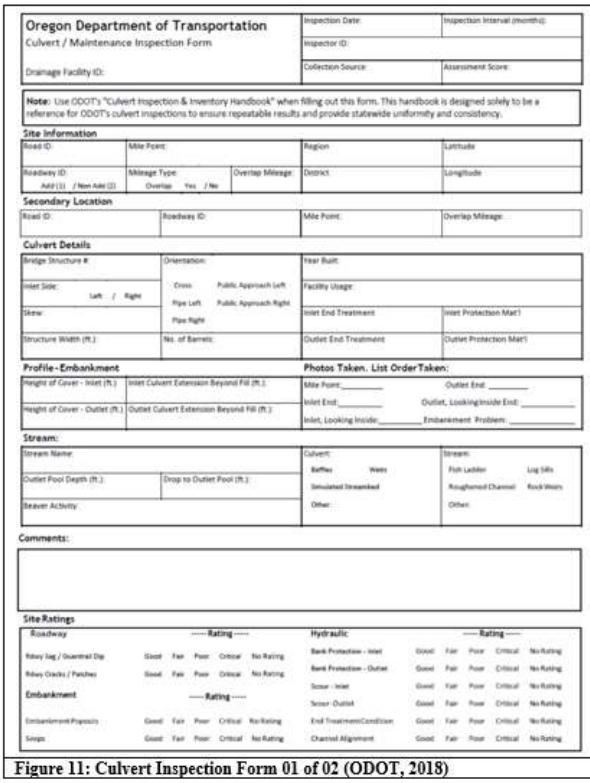
Figure 10: Visual Inspection Form 01 of 02 (MRWA, 2010)



Oregon Department of Transportation
Culvert / Maintenance Inspection Form

Inspection Date | Inspection Interval (months)
Inspector ID
Drainage Facility ID: | Collection Source | Assessment Score

Note: Use ODOT's "Culvert Inspection & Inventory Handbook" when filling out this form. This handbook is designed solely to be a reference for ODOT's culvert inspections to ensure repeatable results and provide statewide uniformity and consistency.

Site Information
Road ID | Mile Point | Region | Latitude
Roadway ID: Add'l (1) / Non Add (2) | Mileage Type: Overlap Yes / No | Overlap Mileage | District | Longitude

Secondary Location
Road ID | Roadway ID | Mile Point | Overlap Mileage

Culvert Details
Bridge Structure # | Orientation: Cross, Pipe Left, Pipe Right, Public Approach Left, Public Approach Right | Year Built
Facility Usage
Inlet Side: Left / Right | Inlet End Treatment | Inlet Protection Mat'l
Skew | Outlet End Treatment | Outlet Protection Mat'l
Structure Width (ft.) | No. of Barrels

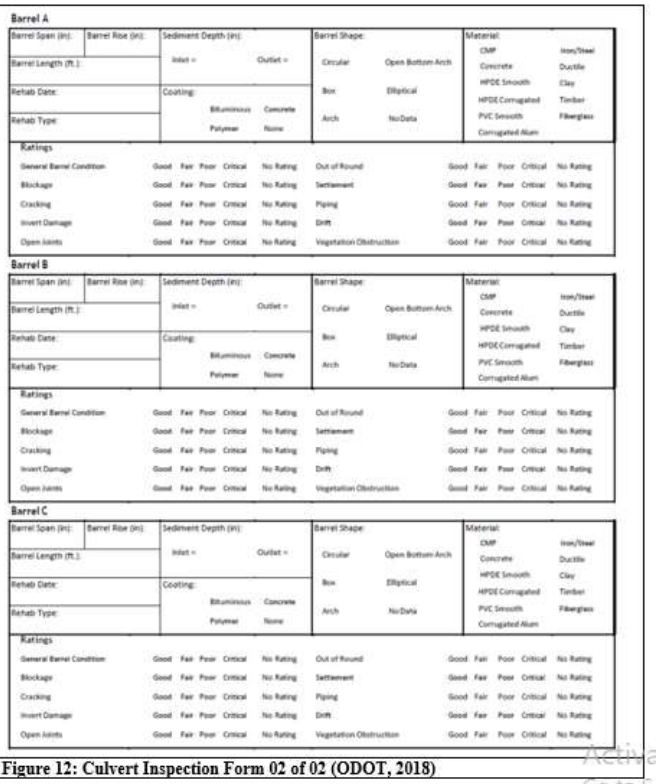
Profile - Embankment
Photos Taken. List Order Taken:
Height of Cover - Inlet (ft.) | Inlet Culvert Extension Beyond Fill (ft.) | Mile Point | Outlet End
Height of Cover - Outlet (ft.) | Outlet Culvert Extension Beyond Fill (ft.) | Inlet End | Outlet, Looking Inside End
Inlet, Looking Inside | Embankment Problem

Stream:
Stream Name
Outlet Pool Depth (ft.) | Drop to Outlet Pool (ft.)
Beaver Activity
Culvert: Baffles, Weirs, Simulated Streambed | Stream: Fish Ladder, Log Sills, Roughened Channel, Rock Weirs, Other

Comments:

Site Ratings
Roadway ----- Rating ----- Hydraulic ----- Rating -----
Rdwy Sag / Guardrail Dip — Good Fair Poor Critical No Rating
Rdwy Cracks / Patches — Good Fair Poor Critical No Rating
Bank Protection - Inlet — Good Fair Poor Critical No Rating
Bank Protection - Outlet — Good Fair Poor Critical No Rating
Scour - Inlet — Good Fair Poor Critical No Rating
Scour - Outlet — Good Fair Poor Critical No Rating
End Treatment Condition — Good Fair Poor Critical No Rating
Channel Alignment — Good Fair Poor Critical No Rating
Embankment ----- Rating -----
Embankment Protects — Good Fair Poor Critical No Rating
Seeps — Good Fair Poor Critical No Rating

Figure 11: Culvert Inspection Form 01 of 02 (ODOT, 2018)



Barrel A

Barrel Span (in):	Barrel Rise (in):	Sediment Depth (in): Inlet = Outlet =	Barrel Shape: Circular, Open Bottom Arch, Box, Elliptical, Arch, No Data	Material: CMP, Iron/Steel, Concrete, Ductile, HPDE Smooth, Clay, HPDE Corrugated, Timber, PVC Smooth, Fiberglass, Corrugated Alum	
Barrel Length (ft.):					
Rehab Date:		Coating: Bituminous, Concrete, Polymer, None			
Rehab Type:					

Ratings

General Barrel Condition	Good	Fair	Poor	Critical	No Rating	Out of Round	Good	Fair	Poor	Critical	No Rating
Blockage	Good	Fair	Poor	Critical	No Rating	Settlement	Good	Fair	Poor	Critical	No Rating
Cracking	Good	Fair	Poor	Critical	No Rating	Piping	Good	Fair	Poor	Critical	No Rating
Invert Damage	Good	Fair	Poor	Critical	No Rating	Drift	Good	Fair	Poor	Critical	No Rating
Open Joints	Good	Fair	Poor	Critical	No Rating	Vegetation Obstruction	Good	Fair	Poor	Critical	No Rating

Barrel B

Barrel Span (in):	Barrel Rise (in):	Sediment Depth (in): Inlet = Outlet =	Barrel Shape: Circular, Open Bottom Arch, Box, Elliptical, Arch, No Data	Material: CMP, Iron/Steel, Concrete, Ductile, HPDE Smooth, Clay, HPDE Corrugated, Timber, PVC Smooth, Fiberglass, Corrugated Alum	
Barrel Length (ft.):					
Rehab Date:		Coating: Bituminous, Concrete, Polymer, None			
Rehab Type:					

Ratings

General Barrel Condition	Good	Fair	Poor	Critical	No Rating	Out of Round	Good	Fair	Poor	Critical	No Rating
Blockage	Good	Fair	Poor	Critical	No Rating	Settlement	Good	Fair	Poor	Critical	No Rating
Cracking	Good	Fair	Poor	Critical	No Rating	Piping	Good	Fair	Poor	Critical	No Rating
Invert Damage	Good	Fair	Poor	Critical	No Rating	Drift	Good	Fair	Poor	Critical	No Rating
Open Joints	Good	Fair	Poor	Critical	No Rating	Vegetation Obstruction	Good	Fair	Poor	Critical	No Rating

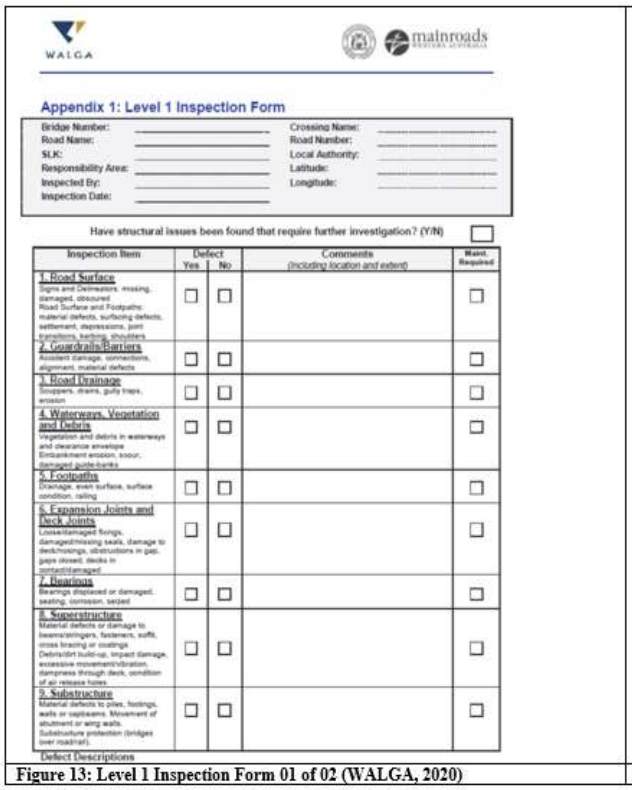
Barrel C

Barrel Span (in):	Barrel Rise (in):	Sediment Depth (in): Inlet = Outlet =	Barrel Shape: Circular, Open Bottom Arch, Box, Elliptical, Arch, No Data	Material: CMP, Iron/Steel, Concrete, Ductile, HPDE Smooth, Clay, HPDE Corrugated, Timber, PVC Smooth, Fiberglass, Corrugated Alum	
Barrel Length (ft.):					
Rehab Date:		Coating: Bituminous, Concrete, Polymer, None			
Rehab Type:					

Ratings

General Barrel Condition	Good	Fair	Poor	Critical	No Rating	Out of Round	Good	Fair	Poor	Critical	No Rating
Blockage	Good	Fair	Poor	Critical	No Rating	Settlement	Good	Fair	Poor	Critical	No Rating
Cracking	Good	Fair	Poor	Critical	No Rating	Piping	Good	Fair	Poor	Critical	No Rating
Invert Damage	Good	Fair	Poor	Critical	No Rating	Drift	Good	Fair	Poor	Critical	No Rating
Open Joints	Good	Fair	Poor	Critical	No Rating	Vegetation Obstruction	Good	Fair	Poor	Critical	No Rating

Figure 12: Culvert Inspection Form 02 of 02 (ODOT, 2018)



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Appendix 1: Level 1 Inspection Form

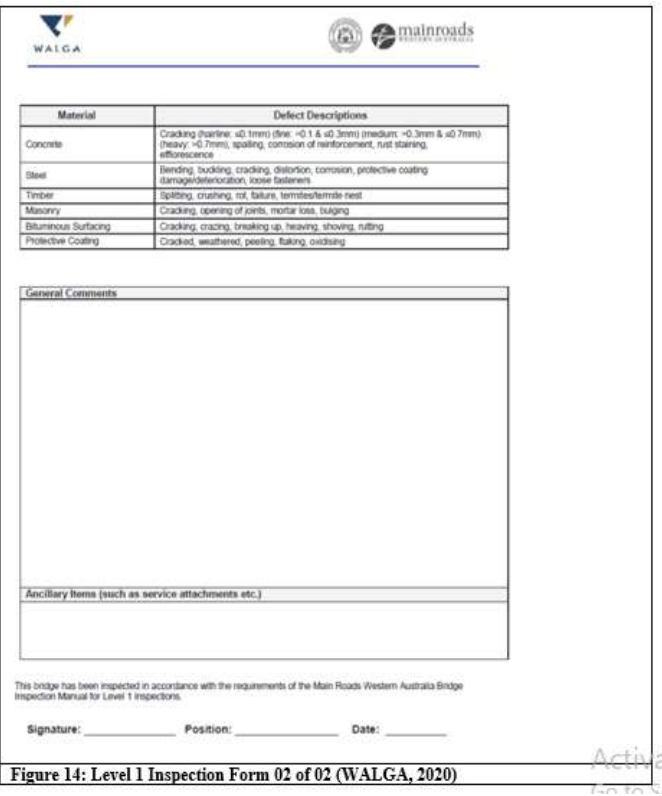
Bridge Number:		Crossing Name:	
Road Name:		Road Number:	
SLK:		Local Authority:	
Responsibility Area:		Latitude:	
Inspected By:		Longitude:	
Inspection Date:			

Have structural issues been found that require further investigation? (Y/N) ☐

Inspection Item	Defect Yes	Defect No	Comments (including location and extent)	Maint. Required
1. Road Surface Signs and Delineators, missing, damaged, obscured Road Surface and Footpaths: material defects, surfacing defects, settlement, depressions, joint transitions, kerbing, shoulders	☐	☐		☐
2. Guardrails/Barriers Accident damage, connections, alignment, material defects	☐	☐		☐
3. Road Drainage Scuppers, drains, gully traps, erosion	☐	☐		☐
4. Waterways, Vegetation and Debris Vegetation and debris in waterways and clearance envelope Embankment erosion, scour, damaged guide-banks	☐	☐		☐
5. Footpaths Drainage, even surface, surface condition, railing	☐	☐		☐
6. Expansion Joints and Deck Joints Loose/damaged fixings, damaged/missing seals, damage to deck/nosings, obstructions in gap, gaps closed, decks in contact/damaged	☐	☐		☐
7. Bearings Bearings displaced or damaged, seating, corrosion, seized	☐	☐		☐
8. Superstructure Material defects or damage to beams/stringers, fasteners, soffit, cross bracing or coatings Debris/dirt build-up, impact damage, excessive movement/vibration, dampness through deck, condition of air release holes	☐	☐		☐
9. Substructure Material defects to piles, footings, walls or capbeams. Movement of abutment or wing walls. Substructure protection (bridges over road/rail).	☐	☐		☐

Defect Descriptions

Figure 13: Level 1 Inspection Form 01 of 02 (WALGA, 2020)



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Material	Defect Descriptions
Concrete	Cracking (hairline: ≤0.1mm) (fine: >0.1 & ≤0.3mm) (medium: >0.3mm & ≤0.7mm) (heavy: >0.7mm), spalling, corrosion of reinforcement, rust staining, efflorescence
Steel	Bending, buckling, cracking, distortion, corrosion, protective coating damage/deterioration, loose fasteners
Timber	Splitting, crushing, rot, failure, termites/termite nest
Masonry	Cracking, opening of joints, mortar loss, bulging
Bituminous Surfacing	Cracking, crazing, breaking up, heaving, shoving, rutting
Protective Coating	Cracked, weathered, peeling, flaking, oxidising

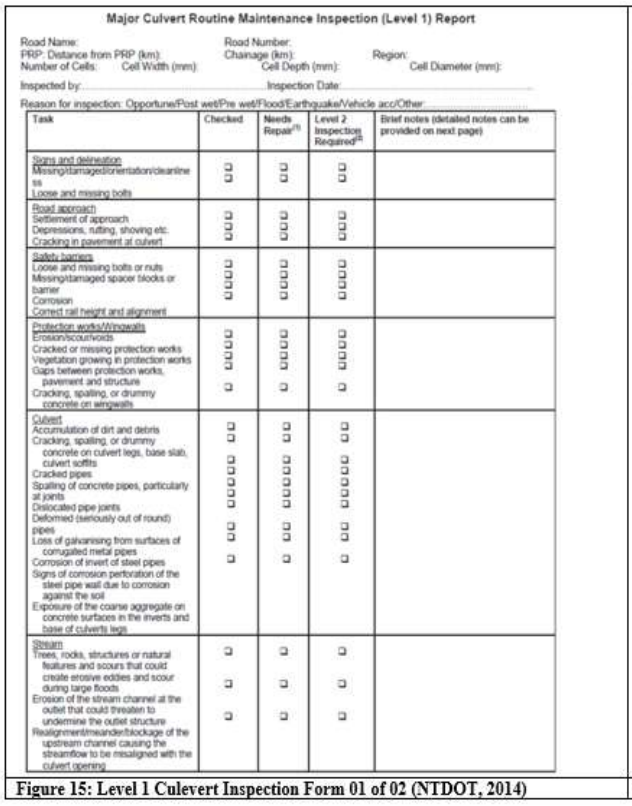
General Comments

Ancillary Items (such as service attachments etc.)

This bridge has been inspected in accordance with the requirements of the Main Roads Western Australia Bridge Inspection Manual for Level 1 Inspections.

Signature: _____ **Position:** _____ **Date:** _____

Figure 14: Level 1 Inspection Form 02 of 02 (WALGA, 2020)

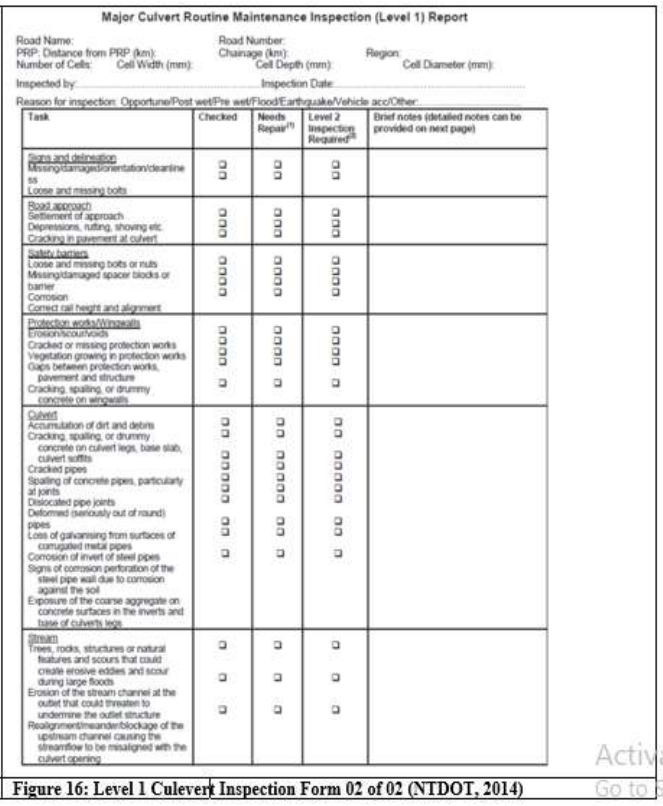


Major Culvert Routine Maintenance Inspection (Level 1) Report

Road Name: Road Number:
PRP: Distance from PRP (km): Chainage (km): Region:
Number of Cells: Cell Width (mm): Cell Depth (mm): Cell Diameter (mm):
Inspected by: Inspection Date:
Reason for inspection: Opportune/Post wet/Pre wet/Flood/Earthquake/Vehicle acc/Other:

Task	Checked	Needs Repair[1]	Level 2 Inspection Required[2]	Brief notes (detailed notes can be provided on next page)
Signs and delineation Missing/damaged/orientation/cleanliness Loose and missing bolts	☐ ☐	☐ ☐	☐ ☐	
Road approach Settlement of approach Depressions, rutting, shoving etc. Cracking in pavement at culvert	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	
Safety barriers Loose and missing bolts or nuts Missing/damaged spacer blocks or barrier Corrosion Correct rail height and alignment	☐ ☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	
Protection works/Wingwalls Erosion/scour/voids Cracked or missing protection works Vegetation growing in protection works Gaps between protection works, pavement and structure Cracking, spalling, or drummy concrete on wingwalls	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	
Culvert Accumulation of dirt and debris Cracking, spalling, or drummy concrete on culvert legs, base slab, culvert soffits Cracked pipes Spalling of concrete pipes, particularly at joints Dislocated pipe joints Deformed (seriously out of round) pipes Loss of galvanising from surfaces of corrugated metal pipes Corrosion of invert of steel pipes Signs of corrosion perforation of the steel pipe wall due to corrosion against the soil Exposure of the coarse aggregate on concrete surfaces in the inverts and base of culverts legs	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
Stream Trees, rocks, structures or natural features and scours that could create erosive eddies and scour during large floods Erosion of the stream channel at the outlet that could threaten to undermine the outlet structure Realignment/meander/blockage of the upstream channel causing the streamflow to be misaligned with the culvert opening	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	

Figure 15: Level 1 Culevert Inspection Form 01 of 02 (NTDOT, 2014)

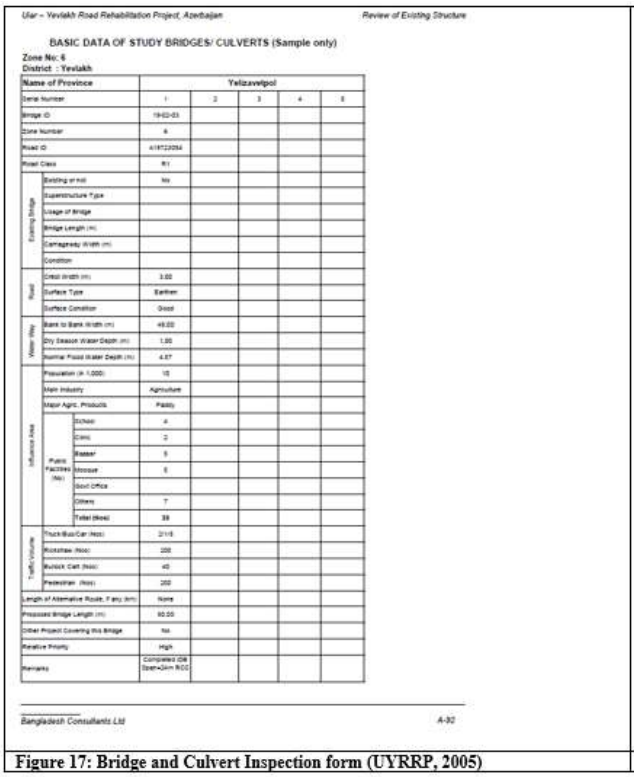


Major Culvert Routine Maintenance Inspection (Level 1) Report

Road Name: Road Number:
PRP: Distance from PRP (km): Chainage (km): Region:
Number of Cells: Cell Width (mm): Cell Depth (mm): Cell Diameter (mm):
Inspected by: Inspection Date:
Reason for inspection: Opportune/Post wet/Pre wet/Flood/Earthquake/Vehicle acc/Other:

Task	Checked	Needs Repair[1]	Level 2 Inspection Required[2]	Brief notes (detailed notes can be provided on next page)
Signs and delineation Missing/damaged/orientation/cleanliness Loose and missing bolts	☐ ☐	☐ ☐	☐ ☐	
Road approach Settlement of approach Depressions, rutting, shoving etc. Cracking in pavement at culvert	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	
Safety barriers Loose and missing bolts or nuts Missing/damaged spacer blocks or barrier Corrosion Correct rail height and alignment	☐ ☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	
Protection works/Wingwalls Erosion/scour/voids Cracked or missing protection works Vegetation growing in protection works Gaps between protection works, pavement and structure Cracking, spalling, or drummy concrete on wingwalls	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	
Culvert Accumulation of dirt and debris Cracking, spalling, or drummy concrete on culvert legs, base slab, culvert soffits Cracked pipes Spalling of concrete pipes, particularly at joints Dislocated pipe joints Deformed (seriously out of round) pipes Loss of galvanising from surfaces of corrugated metal pipes Corrosion of invert of steel pipes Signs of corrosion perforation of the steel pipe wall due to corrosion against the soil Exposure of the coarse aggregate on concrete surfaces in the inverts and base of culverts legs	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
Stream Trees, rocks, structures or natural features and scours that could create erosive eddies and scour during large floods Erosion of the stream channel at the outlet that could threaten to undermine the outlet structure Realignment/meander/blockage of the upstream channel causing the streamflow to be misaligned with the culvert opening	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	

Figure 16: Level 1 Culevert Inspection Form 02 of 02 (NTDOT, 2014)



Uar – Yevlakh Road Rehabilitation Project, Azerbaijan — Review of Existing Structure

BASIC DATA OF STUDY BRIDGES/ CULVERTS (Sample only)

Zone No: 6
District : Yevlakh

Name of Province		Yelizavetpol				
Serial Number		1	2	3	4	5
Bridge ID		19-02-03				
Zone Number		6				
Road ID		41972/2054				
Road Class		R1				
Existing Bridge	Existing or not	No				
	Superstructure Type					
	Usage of Bridge					
	Bridge Length (m)					
	Carriageway Width (m)					
	Condition					
Road	Crest Width (m)	3.00				
	Surface Type	Earthen				
	Surface Condition	Good				
Water Way	Bank to Bank Width (m)	49.00				
	Dry Season Water Depth (m)	1.00				
	Normal Flood Water Depth (m)	4.67				
Influence Area	Population (in '1,000)	15				
	Main Industry	Agriculture				
	Major Agric. Products	Paddy				
	Public Facilities (No) School	4				
	Clinic	2				
	Market	5				
	Mosque	5				
	Post Office					
	Others	7				
	Total (Nos)	39				
Traffic Volume	Truck/Bus/Car (Nos)	2110				
	Rickshaw (Nos)	200				
	Bullock Cart (Nos)	40				
	Pedestrian (Nos)	250				
Length of Alternative Route, if any (km)		None				
Proposed Bridge Length (m)		50.00				
Other Project Covering this Bridge		No				
Relative Priority		High				
Remarks		Completed Old Span+2km RCC				

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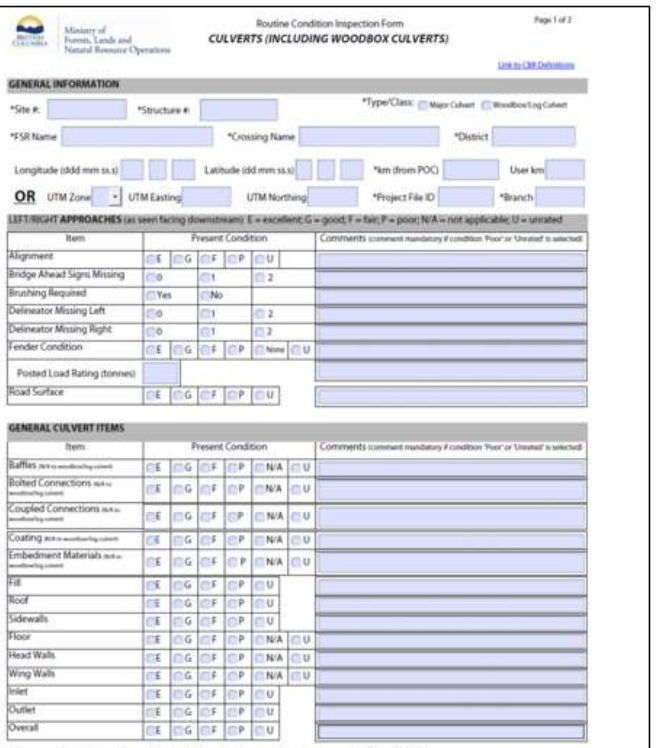
Figure 17: Bridge and Culvert Inspection form (UYRRP, 2005)



Ministry of Forests, Lands and Natural Resource Operations

Routine Condition Inspection Form — Page 1 of 3

CULVERTS (INCLUDING WOODBOX CULVERTS)

Link to Cliff Definitions

GENERAL INFORMATION

*Site #: *Structure #: *Type/Class: Major Culvert Woodbox/Log Culvert

*FSR Name *Crossing Name *District

Longitude (ddd mm ss.s) Latitude (dd mm ss.s) *km (from POC) User km

OR UTM Zone UTM Easting UTM Northing *Project File ID *Branch

LEFT/RIGHT APPROACHES (as seen facing downstream) E = excellent; G = good; F = fair; P = poor; N/A = not applicable; U = unrated

Item	Present Condition	Comments (comment mandatory if condition 'Poor' or 'Unrated' is selected)
Alignment	E G F P U	
Bridge Ahead Signs Missing	0 1 2	
Brushing Required	Yes No	
Delineator Missing Left	0 1 2	
Delineator Missing Right	0 1 2	
Fender Condition	E G F P None U	
Posted Load Rating (tonnes)		
Road Surface	E G F P U	

GENERAL CULVERT ITEMS

Item	Present Condition	Comments (comment mandatory if condition 'Poor' or 'Unrated' is selected)
Baffles	E G F P N/A U	
Bolted Connections	E G F P N/A U	
Coupled Connections	E G F P N/A U	
Coating	E G F P N/A U	
Embedment Materials	E G F P N/A U	
Fill	E G F P U	
Roof	E G F P U	
Sidewalls	E G F P U	
Floor	E G F P N/A U	
Head Walls	E G F P N/A U	
Wing Walls	E G F P N/A U	
Inlet	E G F P U	
Outlet	E G F P U	
Overall	E G F P U	

Figure 18: Routine Condition Inspection Form (BC, 2013)

IV. DISCUSSION

Culverts and Structures' inventory was determined by combining the culverts and bridges available information, drawings, and project-specific requirements. Different projects may have different types of bridges and culverts with historical importance, which may vary. The study tried to explain how efficient inspection outcomes and rich data can be explained while the team will have in-depth knowledge about the project scopes and requirements with clients' preferences and directions. The loss of capacity or inexperience also significantly influence the priority and nature of inspection works. This is to highlight that the whole design team and project management team heavily rely on input data. The quality and credibility of system outputs are susceptible to the quality of input data. Besides, inaccurate data produce inaccurate information results in significant time delay and variations during execution. Therefore, The essential quality of data will always reflect the care taken when it was collected.

Relevant issues in data quality include (Dowling and Rummey, 2014):

- Is the data sufficiently well defined (eg bridge width may mean overall structure width, width between kerbs, or aggregated width of traffic lanes)?
- Are tolerances specified consistent with end-user requirements? For example, tolerances may vary for different end-users of the data (eg, etwork/corporate level vs analysis of individual structures).
- Are automated measurement techniques available, used, checked for calibration?
- Are observers or inspectors suitably experienced, trained and accredited?
- Has there been a verification investigation that the design and construction reports are accurate?
- Is data checked for validity after being entered?
- Are the security arrangements for the storage of data adequate?
- Is there a review or audit process for data collection?
- Is data received approval from the service unit manager before finalising?
- Is data and relevant additional field information, including video, photos are catalogued and recorded in Enterprise content Management or similar asset register?

V. CONCLUSION

The project works were financed by Islamic Development Bank (IDB), and Procurement of the works would be done through International Competitive Bidding as per procurement guidelines of IDB. The procurement guidelines that used were:

- Prequalification of suitable bidders through open tendering among the member countries of IDB,
- Standard Tender Document and tendering procedure of international financing institutions like WB or ADB and FIDIC condition of contracts.

RTSD had engaged Bangladesh Consultants Ltd for providing consultancy services to:

- assist PIU in the process of preparation of documents of prequalification of bidders, preparation of tender documents, evaluation of prequalification applications, issue of tender documents, pre-tender meeting, clarifications and amendments, evaluation of tenders and recommendation for the award of contract, and
- supervise construction works.

It was planned that prequalification of bidders, tendering and contract to award would be completed by may 2006, the contract works completed in 2 years time, and after that contractor could have a defect liability period of one year. The engineer and his staff were responsible for the supervision of construction works while PIU and his staff will monitor the progress and be responsible for the RTSD. The supervising staff's organogram with the line of communication among Consultants, RTSD and IDB. It was envisaged that an international contractor providing modern technologies would use locally available resources through international competitive with encouraging local participation in Joint Ventures or Associations. The unit costs for equipment, material and labour were based on information and data from the international competitive tendering for similar other ongoing or proposed projects in the country. The cost estimates had been prepared based on current prices of locally available material and labour, on plant and equipment purchase from the international market or local market as applicable. Recent price rise in the international market for fuel and reinforcing steel had also been considered.

Cost estimates of the project work had been prepared using the bill of quantities in conjunction with the Bid Documents:

- Engineering Drawings
- General and Technical Specifications
- General and Special Conditions of Contracts (FIDIC)
- Any other information contained in the bidding document

The Bills of Quantities comprised the followings:

a) General and Preliminary
b) Site Clearance and earthworks
c) Pavement Works
d) Drainage
e) Bridgeworks
f) Day works
g) Contingency Provision
h) Grand Summary

For better data management and presentation in a Project Management Information System (PMIS), the inventory team required to understand that throughout the life cycle of a project; "*a significant amount of data is collected, analysed, and transformed. Project data are collected as a result of various processes and are shared within the project team. The collected data are analysed in context, aggregated, and transformed to become project information during various processes"* (PMBOK, 2017 p. 27).
The following three processes are used in project data and information:

- **Work performance data.** It includes reported per cent of work physically completed, quality and technical performance measures, start and finish dates of schedule activities, number of change requests, number of defects, actual costs, actual durations, etc. Project data are usually recorded in a Project Management Information System (PMIS) and project documents.
- **Work performance information.** The performance information includes deliverables, implementation status for change requests, and forecast estimates to complete.
- **Work performance reports.** The information is compiled in project documents intended to generate decisions or raise issues, actions, or awareness such as; status reports, memos, justifications, information notes, electronic dashboards, recommendations, and updates.

This study's main goal was to represent a context-sensitive and site-specific Structural Inventory from a single project outcome. This study also brought a few sample examples from various countries as a data collection process. The audience should understand that the site-specific project relevant approach should be adopted and approval should be made from clients or relevant authorities before site inspection and final submission.

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Conflicts of Interest: There is no conflict of interest.

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