

Task 1 Report

Project Title: Evaluation of a New Arch Bridge Technology for Short Spans

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Introduction

The Montana Department of Transportation (MDT) desires cost-effective solutions for constructing short-span crossing structures. Each crossing must satisfy a unique set of design criteria based on the roadway geometry, geotechnical conditions, hydraulic flow, environmental and ecological situation, construction and maintenance constraints, etc. Several bridge and culvert designs are available for such crossings, each having multiple alternatives (e.g., for bridges, precast concrete, steel or wood stringers; for culverts, precast concrete, steel or aluminum pipe, etc.), with each option or style offering advantages and disadvantages at any given location based on the specific site conditions. The purpose of this project is to conduct a design review of selected types of bridge and culvert structures with respect to the various criteria listed above. Task 1 of the project is to refine the evaluation criteria and identify the crossing systems to be considered, as detailed below. Task 2 of this project then consists of evaluating these crossing systems using the established design criteria.

The general configuration of each structure will be described in terms of its geometry and major design components. Geometric features such as shape, span¹ and height of opening will be described. Only single-span structures 10 to 75 feet in length will be considered. The height and shape of the opening will also be reported because it relates to the structure's functionality in terms of wildlife passage, among other criteria. Lastly, design features such as whether it utilizes wing walls, side walls, and end walls and whether it requires a bridge deck or has a continuous road surface, will be summarized. Because the choice between a bridge and a culvert is not always obvious, some of their advantages and disadvantages are presented in Table 1. Furthermore, there is not always a clear distinction between a culvert and bridge—not all

¹ For this project, the span is defined as the shortest distance between two supports in the direction of traffic.

culverts have a bottom and not all bridges have decks. Nevertheless, federal regulations for inspection and classification of structures are applicable to crossings with spans greater than 20 ft.

Table 1: Advantages and Disadvantages of Culverts and Bridges (Maine State Highway Administration, 2006)

<i>Culverts</i>		<i>Bridges</i>	
Advantages	Disadvantages	Advantages	Disadvantages
<ul style="list-style-type: none"> • Usually little to no structural maintenance • Scour is usually localized and more predictable • Road above structure is typically less frost- or ice-susceptible 	<ul style="list-style-type: none"> • May require debris or ice removal, usually associated with multi-celled units • Exit water velocity can be higher than in a natural stream—may degrade stream • Possible barrier to fish/wildlife passage 	<ul style="list-style-type: none"> • Less susceptible to clogging • More natural stream channel width/depth • Waterway area increases with rising stage up to structure 	<ul style="list-style-type: none"> • Usually requires more structural maintenance • Elements susceptible to scour and stream meander • Deck is susceptible to ice and frost formation

Evaluation Criteria

The following criteria were developed to systematically evaluate various bridge and culvert designs based on structural, hydraulic, foundation, environmental, construction, durability, maintenance and cost considerations.

Structural

Designs that have been widely implemented are generally considered proven with respect to structural performance. For the sake of this evaluation, proven technologies will be arbitrarily defined as those that have been successfully used in over 25 installations. The basic structural design of each crossing type will be described, as appropriate (e.g., arch, girder, and truss). The performance of newer technologies, however, will be evaluated using available literature that discusses laboratory and field testing, vehicle load ratings, and seismic performance. The methodology used to evaluate structural capacity (e.g., Load and Resistance Factor Design (LRFD), Allowable Stress Design, load testing, etc.), and the loading scenarios used in the design method (e.g., HL-93, HS-20 or HS-25 truck loadings) will also be reported.

Hydraulics

The majority of culverts and bridges are constructed to provide crossings over waterway features. The size and shape of the crossing structure is therefore dependent upon the stream geometry and the expected flows (e.g., 10-, 25-, 50-, 100- or 500-year events, depending on site

characteristics). Certain shapes may provide more efficient water passage under various situations; however, no existing evaluation methodology to quantify shape-based efficiency was found in literature. Therefore, to allow for expedient comparison of this characteristic between different types of crossing structures, consideration is being given to calculating an “apparent opening ratio (AOR)”. This ratio will be calculated as the area of the actual cross section divided by the area of a rectangle whose sides touch the horizontal and vertical edges of the actual opening (as illustrated in Figure 1). Values of AOR will range between about 0.75 and 1.0, where an arch has perhaps the greatest area reduction based on its shape ($AOR \approx 0.75$) and a rectangular structure has little to no area reduction ($AOR = 1.0$). Debris and ice passage can also be an issue with crossing structures and can be influenced by their shape. The ability to pass debris and ice will be commented on for each system, as possible and appropriate. Lastly, the Manning’s roughness coefficient, n , will be reported for structures with a bottom.

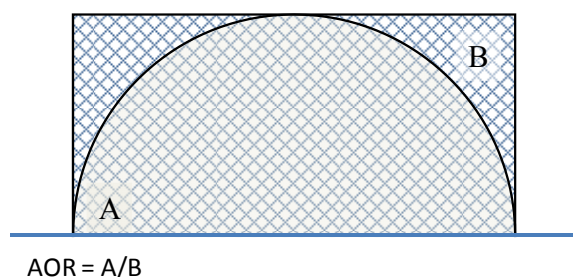


Figure 1: Illustration of apparent opening ratio calculation.

Foundation

Structural foundations are designed to support the structure and control vertical movement. This critical component of the design must provide these functions during high flow events, making it necessary to design the foundation to resist or limit scour based on the site-specific hydraulic conditions. The sensitivity of each crossing type to differential and/or absolute settlement will be assigned a value using a scale from 1 to 3 (e.g., 1 – low sensitivity to differential settlement to 5 – high sensitivity to differential settlement). The evaluation will also comment on the compatibility of each foundation type with each crossing structure. Finally, any unique foundation design or construction requirements associated with each crossing structure will be identified.

Environmental

In areas where passage of fish and aquatic organisms as well as wildlife are taken into consideration, “the evaluation of potential environmental impacts can have a significant impact on structure-type selection and configuration, especially for highway bridges over streams” (MDT, 2002). Fish passage through culverts is usually dependent on the depth of flow and velocity regime within the structure during certain times of the year, and is now frequently accounted for during culvert design. In general, bridges are assumed to not be barriers to fish passage. Wildlife passage is a growing concern and may be incorporated during the design

phase of new structures. The Task 2 evaluations will address this criterion by indicating the increase in opening size needed to provide a path 6.5 ft wide and 10 ft high, the minimum path size appropriate for wildlife underpasses with water flow (Clevenger and Huijser, 2009). Two values will be determined for each structure. One is the ratio of the increase in area divided by the area for wildlife (A/B in Figure 2, which shows an example for an arch structure). This ratio will be greater than or equal to 1.0 (1.0 for rectangular structures), with larger values corresponding to systems that require proportionately larger structures (based on their shape) to accommodate wildlife passage. Similarly, the increase in span needed to accommodate wildlife (X in Figure 2) will also be determined; for rectangular structures X will be 6.5 ft, which is the width of the proposed wildlife crossing path. Again, greater values of X indicate a less efficient means of providing wildlife passage.

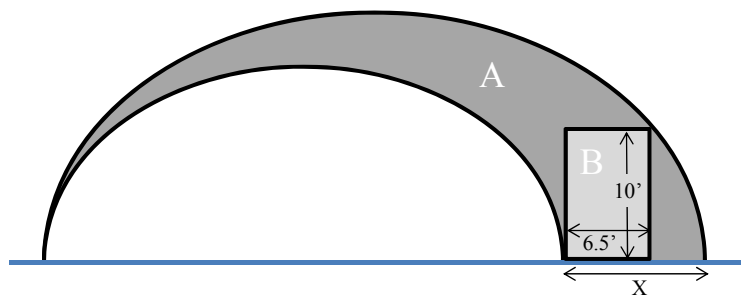


Figure 2: Example schematic of increased structure size to provide wildlife crossing.

In general, environmental issues are minimized when all construction activities occur beyond the limits of the ordinary high water mark for a stream. Thus, environmental issues are usually considered early in the design phase of the project when selecting the structure type, configuration and size (MDT, 2002). Therefore, the Task 2 evaluations will also indicate whether a system requires construction activities in the streambed (i.e., below the ordinary high water mark).

Construction

Crossing structures need to accommodate the basic roadway geometry in both elevation and cross-section; therefore, as part of their construction, embankments and/or fills may be required to raise the road surface, which may or may not incorporate the use of retaining walls (e.g., abutments, wingwalls or headwalls). Buried structures (such as culverts and buried arch bridges, as opposed to structures that incorporate a bridge deck) require fill material. The Task 2 evaluations for buried structures will identify the range in fill depths compatible with the structure and the total volume of fill required (with and without any retaining structures, as appropriate). Total volume computations will be made for buried structures based on a 40 ft roadway width and a single reference span length (e.g., 25 ft), and a height/roadway elevation compatible with all structure types. Any constraints on the type of fill will also be noted during the evaluation.

The method of constructing each crossing structure type will also be qualitatively evaluated to assess its complexity. Based on the criteria listed below, a value of 0 or 1 will be assigned, 0 if the criterion does not pose any particular difficulty or specialization, and 1 if it does. These values will be added together to provide a single number that represents the overall complexity of a particular technology (0 to 1 – easy, 2 to 3 – moderate, 4 to 5 – difficult).

- Equipment (e.g., concrete pump truck, crane, pile driver)
- Special procedures or limitations on construction conditions (e.g., cold-weather concreting, assembly of components, compaction restrictions)
- Expertise (e.g., specialized training, necessary past experience)
- Sensitivity to design tolerances
- Availability and use of special materials

Other construction evaluation criteria include the time required to complete pre-construction and construction activities, and the adaptability to a phased construction approach. Estimates of the time (in months) necessary to design, permit, bid and award a project, as well as the time to construct the structure in the field, will be estimated for each technology. Finally, a qualitative assessment of the ability of each structure to accommodate a phased construction approach will be made. Each structure will be rated on a scale of 1 to 3 based on how well a particular technology accommodates traffic flow during construction (1 – accommodates traffic well to 3 – does not accommodate traffic well).

Durability and Maintenance

The durability of each crossing structure will be assessed based on its ability to withstand damage and fatigue from items such as traffic, corrosion, vandalism, fire, etc. A 1 to 3 scale will be used for this evaluation (1 – low durability to 3 – high durability). The maintenance needs of each crossing structure will be evaluated based on the frequency and complexity of the associated activities. Each structure will be rated on a scale between 1 and 3 (1 – little to no maintenance required to 3 – requires frequent or substantial maintenance). These considerations will also factor into the cost of the structure.

Cost

The expected cost to construct and maintain 15 crossing configurations will be estimated based on five span lengths (10, 20, 35, 55 and 75 ft), three heights (4, 10 and 20 ft) and a single width (40 ft). Anticipated maintenance costs will be based on the design life of each structure. Using the design life and cost information, a life-cycle cost analysis of various structure types and configurations will also be performed, depending on the availability of cost information.

Summary of Evaluation Criteria

Specific evaluation details for all of the criteria are summarized in Table 2.

Table 2: Summary of Evaluation Criteria

General	Name, brief description																											
	Support type: <input type="checkbox"/> beam <input type="checkbox"/> arch <input type="checkbox"/> slab <input type="checkbox"/> truss <input type="checkbox"/> culvert																											
	Design method: <input type="checkbox"/> LRFD <input type="checkbox"/> Allowable Stress Design <input type="checkbox"/> other _____																											
Structural	Live load: <input type="checkbox"/> HL-93 <input type="checkbox"/> HS-20 <input type="checkbox"/> HS-25 <input type="checkbox"/> MS 22.5 <input type="checkbox"/> other _____																											
	<input type="checkbox"/> Proven technology? (> 25 installations in U.S.) If not: evaluate any laboratory or field testing performed																											
Hydraulics	Apparent Opening Ratio (A/B) _____ Unique debris/ice passage issues _____ Manning's <i>n</i> _____ (N/A for bottomless structures)																											
Foundation	Compatible with: <input type="checkbox"/> earthen <input type="checkbox"/> spread footing <input type="checkbox"/> piles <input type="checkbox"/> other _____ Unique design or construction requirements _____ Unique susceptibility to scour _____ Sensitivity to total settlement: 1 (low) _____ 5 (high) Sensitivity to differential settlement: 1 (low) _____ 5 (high)																											
Environmental	Increased Opening Ratio for wildlife path (A/B) _____ Increase in span for wildlife path, X _____ <input type="checkbox"/> Construction activities within the ordinary high water mark																											
Construction	Buried structures: acceptable range in fill height (ft) _____ total fill volume for standard length and depth, 40 ft width (yd ³) _____ Overall complexity score: <input type="checkbox"/> easy (0–1) <input type="checkbox"/> moderate (2–3) <input type="checkbox"/> difficult (4–5) Preconstruction duration (months) _____ Construction duration (months) _____ Phased construction/accommodates traffic well: 1 (does) _____ 3 (does not)																											
Durability & Maintenance	Durability: 1 (low) _____ 3 (high) Maintenance: 1 (little to no) _____ 3 (frequent)																											
Cost and Design Life	<table border="1"> <thead> <tr> <th rowspan="2"><i>Span (ft)</i></th> <th colspan="3"><i>Height (ft)</i></th> </tr> <tr> <th>4</th> <th>10</th> <th>20</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>\$</td> <td>\$</td> <td>\$</td> </tr> <tr> <td>20</td> <td>\$</td> <td>\$</td> <td>\$</td> </tr> <tr> <td>35</td> <td>\$</td> <td>\$</td> <td>\$</td> </tr> <tr> <td>55</td> <td>\$</td> <td>\$</td> <td>\$</td> </tr> <tr> <td>75</td> <td>\$</td> <td>\$</td> <td>\$</td> </tr> </tbody> </table>	<i>Span (ft)</i>	<i>Height (ft)</i>			4	10	20	10	\$	\$	\$	20	\$	\$	\$	35	\$	\$	\$	55	\$	\$	\$	75	\$	\$	\$
<i>Span (ft)</i>	<i>Height (ft)</i>																											
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	Estimated design life (years) _____																											

Systems to be Evaluated



The specific short span crossing structures that will be considered in this effort are identified and described in Table 3 below. The table begins with bridge structures and transitions to culvert structures, although as mentioned previously, this distinction has become progressively more obscure, especially as traditional culvert materials are increasingly promoted for use in longer span structures and formed with cross-section geometries that would be considered more traditional of bridges (e.g., long span arches and open bottom structures, respectively). In the bridge category, concrete, steel and wood superstructure systems are considered, variously in beam, arch, slab, and truss configurations. In the culvert category, the focus is on concrete box, corrugated steel and corrugated aluminum structures, in a variety of shapes with both closed and open bottom geometries. Non-proprietary and proprietary systems are considered, including a number of bridge systems developed by various states generally for short-span and/or low volume road applications. These systems are in varying stages of development, from field demonstration to commercial licensing.


The crossing structures to be evaluated in Task 2 have been assigned to the following general categories:

- concrete beam structures,
- concrete slab structures,
- concrete arch structures,
- concrete box structures,
- steel beam structures,
- steel truss structures,
- timber structures,
- corrugated aluminum structures, and
- corrugated steel structures.


Detailed evaluations will be performed on each structure listed in each row in Table 3. Two crossing systems described in the literature that will not be evaluated as part of this project are listed in Table 4 (railroad flat car bridges and tube girder bridges). Railroad flatcar bridges were judged inappropriate due to the variable geometry, materials, and past load histories of the flat cars themselves. The tube girder bridge systems appeared to be too early in its development (only limited laboratory testing has been done) for immediate consideration in this study.

Table 3: Systems That Will Be Evaluated In Task 2

Name	Brief Description	Span (ft, max or range)	More Information
<i>Concrete Beam Structures</i>			
Concrete I-Girder Bridge	<ul style="list-style-type: none"> • Bridge constructed with prestressed precast concrete I-shaped girders and a cast-in-place concrete deck, typical designs include Types 1, MT-28, A, IV, or M-72 • Most common type selected by MDT for new bridges 	148	<ul style="list-style-type: none"> • MDT, 2002 • http://www.mdt.mt.gov/other/bridge/external/structures-manual/part_II/Chp-13-FINAL.pdf
Ultra-High Performance Concrete Pi-Girder Bridge	<ul style="list-style-type: none"> • Developed by Iowa State University • Prestressed precast girders resemble Greek letter π cast with ultra-high performance concrete and an integral deck for accelerated construction • Demonstration bridge constructed in 2008 and field tested in 2008 and 2009 	65	<ul style="list-style-type: none"> • Rouse et al., 2011 • http://www.iowadot.gov/operationsresearch/reports/reports_pdf/hr_and_tr/reports/TR-574%20Final.pdf

Name	Brief Description	Span (ft, max or range)	More Information
Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)	<ul style="list-style-type: none"> Developed by FHWA Three geosynthetic reinforced soil components: foundation, abutment, and integrated approach Concrete beams and asphalt driving surface 28 existing implementations 	140	<ul style="list-style-type: none"> Adams et al., 2011(a) and (b) http://www.fhwa.dot.gov/everydaycounts/technology/grs_ibs/intro.cfm http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/index.cfm
Concrete Arch Structures			
Cretex Arch Bridge	<ul style="list-style-type: none"> Precast concrete arches with vertical sides Vendor: Cretex Concrete Products West (Montana) 	12–48	<ul style="list-style-type: none"> http://www.cretexwest.com/Catalog.aspx?id=14&pid=2
Bridge in a Backpack	<ul style="list-style-type: none"> Developed by University of Maine, licensed by Advanced Infrastructure Technologies Polymer encased concrete arches covered with decking, fill, and road surface Vendor: Advanced Infrastructure Technologies (Maine) 	25–70	<ul style="list-style-type: none"> http://www.aitbridges.com/ http://www2.umaine.edu/aewc/content/view/185/71/
CON/SPAN Bridge System	<ul style="list-style-type: none"> Modular component system of precast concrete arches, headwalls, and wingwalls Vendor: CONTECH Construction Products (Montana) 	12–60	<ul style="list-style-type: none"> http://www.contech-cpi.com/Products/Bridges-and-Structures/Precast/CONSPAN-Bridge.aspx
BEBO Arch System	<ul style="list-style-type: none"> Modular component system of precast concrete arches, headwalls, and wingwalls Vendor: CONTECH Construction Products (Montana) 	12–102	<ul style="list-style-type: none"> http://www.beboarch.com/ http://www.contech-cpi.com/Products/Bridges-and-Structures/Precast/BEBO-Bridge.aspx

Name	Brief Description	Span (ft, max or range)	More Information
<i>Concrete Slab Structures</i>			
Concrete Slab Bridge	<ul style="list-style-type: none"> Reinforced concrete slab bridge, cast-in-place or precast 	34	<ul style="list-style-type: none"> MDT, 2002 http://www.mdt.mt.gov/other/bridge/external/structures-manual/part_II/Chp-13-FINAL.pdf
Cretex 3 Sided Box Culvert	<ul style="list-style-type: none"> Precast concrete, open bottom box, similar to concrete slab bridge or box culvert, the top can be the driving surface or be buried Precast wingwalls also available Vendor: Cretex Concrete Products West (Montana) 	12–30	<ul style="list-style-type: none"> http://www.cretexwest.com/Catalog.aspx?id=14&pid=2
HY-SPAN: The Instant Bridge	<ul style="list-style-type: none"> Precast concrete, open bottom box, similar to concrete slab bridge or box culvert, the top can be the driving surface or be buried Footings and wingwalls can be precast or cast-in-place Vendors: The Fort Miller Company (New York), Independent Concrete Pipe Corporation (Utah), etc. (none located in Montana) 	6–40	<ul style="list-style-type: none"> http://www.hyspanbridge.com/index.html http://www.fortmiller.com/hyspan.html
<i>Concrete Box Structures</i>			
Concrete Box Culvert	<ul style="list-style-type: none"> Reinforced precast concrete box, wall thickness usually depends on size of opening Vendors: Glacier Precast Concrete (Montana), Cretex Concrete Products West (Montana) 	~14	<ul style="list-style-type: none"> ASTM C1433 http://www.glacierprecast.com/

Name	Brief Description	Span (ft, max or range)	More Information
<i>Steel Beam Structures</i>			
Steel Girders	<ul style="list-style-type: none"> Steel I-girders with concrete deck 	30–130	<ul style="list-style-type: none"> MDT, 2002 http://www.mdt.mt.gov/other/bridge/external/structures-manual/part_II/Chp-13-FINAL.pdf
Modified Beam-in-Slab Low-Volume Road Bridge System	<ul style="list-style-type: none"> Developed by Iowa State University Longitudinal steel W sections embedded in concrete deck 2 existing implementations 	80	<ul style="list-style-type: none"> Wipf et al., 2004 (a), (b), and (c) http://www.iowadot.gov/operationsresearch/reports/reports_pdf/hr_and_tr/reports/tr467voll1.pdf
U.S. BRIDGE Vehicular Beam	<ul style="list-style-type: none"> Galvanized or painted steel beam bridge Vendor: U.S. BRIDGE (Ohio) 	10–60	<ul style="list-style-type: none"> http://www.usbridge.com/index.php/usb/bridges/C4/
Pre-fabricated Beam Bridge	<ul style="list-style-type: none"> Pre-assembled modular bridge components of steel, (galvanized or painted); concrete or asphalt road surface paved after installation Vendor: LONG SPAN Bridge & Culvert (Pennsylvania) 	16–150	<ul style="list-style-type: none"> http://www.longspanbridge.com/bridge_systems_prefab.php



Name	Brief Description	Span (ft, max or range)	More Information
<i>Steel Truss Structures</i>			
U.S. BRIDGE Vehicular Truss	<ul style="list-style-type: none"> • Prefabricated steel vehicular through-truss bridge, available in several styles; precast abutment system also available • Vendors: CONTECH Construction Products (Montana), U.S. BRIDGE (Ohio) 	10–300	<ul style="list-style-type: none"> • http://www.usbridge.com/index.php/usb/bridges/C62/ • http://www.contech-cpi.com/Products/Bridges-and-Structures/Truss/US-Bridge-Vehicular-Truss.aspx
<i>Timber Structures</i>			
Timber Girder Bridges	<ul style="list-style-type: none"> • Timber girders with timber decking • Vendor: York Bridge Concepts (Florida) 	15–30	<ul style="list-style-type: none"> • http://www.dot.state.mn.us/bridge/documents/formslinks/inspection/USFS-TimberBridgeManual/em7700_8_chapter02.pdf
Glue-Laminated Timber Girder Bridges	<ul style="list-style-type: none"> • Glulam girders with transversely oriented glulam deck panels • Vendors: York Bridge Concepts (Florida), Bridge Builders USA (North Carolina), Signature Bridge (Ohio) 	24–80	<ul style="list-style-type: none"> • http://www.fhwa.dot.gov/publications/publicroads/97winter/p97wi32.cfm
Stress-Laminated Slab Bridges	<ul style="list-style-type: none"> • Slab bridge composed of multiple laminations placed side-by-side to achieve desired width, with or without glulam girders 	60	<ul style="list-style-type: none"> • http://www.fhwa.dot.gov/publications/publicroads/97winter/p97wi32.cfm
Glue-Laminated Arch	<ul style="list-style-type: none"> • Glulam arch support structure 	200	<ul style="list-style-type: none"> • http://www.fhwa.dot.gov/publications/publicroads/97winter/p97wi32.cfm

Name	Brief Description	Span (ft, max or range)	More Information
<i>Corrugated Aluminum Structures</i>			
Aluminum Box Culvert	<ul style="list-style-type: none"> • Corrugated Aluminum, can be assembled near field site and lifted into place; headwalls and wingwalls available • Vendor: CONTECH Construction Products (Montana) 	9–25	<ul style="list-style-type: none"> • http://www.contech-cpi.com/Products/Bridges-and-Structures/Plate/Aluminum-Box-Culvert.aspx
Aluminum Structural Plate	<ul style="list-style-type: none"> • Corrugated Aluminum, can be assembled near field site and lifted into place, available in shapes: <ul style="list-style-type: none"> • round, • single-radius arch, • horizontal & vertical ellipse, • pipe-arch, and • underpass • Vendor: CONTECH Construction Products (Montana) 	5–23	<ul style="list-style-type: none"> • http://www.contech-cpi.com/Products/Bridges-and-Structures/Plate/Aluminum-Structural-Plate.aspx
SUPER-PLATE	<ul style="list-style-type: none"> • Corrugated Aluminum with thrust beams and reinforcing ribs, available in shapes: <ul style="list-style-type: none"> • low & high profile arch, and • horizontal ellipse • Vendor: CONTECH Construction Products (Montana) 	19–39	<ul style="list-style-type: none"> • http://www.contech-cpi.com/Products/Bridges-and-Structures/Plate/SUPER-SPAN-and-SUPER-PLATE.aspx
Dur-A-Span	<ul style="list-style-type: none"> • Corrugated Aluminum structural plate available in shapes: <ul style="list-style-type: none"> • pipe, • pipe-arch, • arch, • box culvert, • underpass, and • vertical ellipse • Vendor: Big R Manufacturing (Colorado) 	8–25	<ul style="list-style-type: none"> • http://www.bigrmfg.com/products/structuralplate/dur-a-span.php

Name	Brief Description	Span (ft, max or range)	More Information
Aluminum Structural Plate Bridges	<ul style="list-style-type: none"> • Aluminum structural plate available in shapes: <ul style="list-style-type: none"> • low & high profile arch, • low & high profile bottomless box culverts, • single radius arch, • horizontal & vertical ellipse, • round, • pipe-arch, and • pear • Vendor: LONG SPAN Bridge & Culvert (Pennsylvania) 	5-83	<ul style="list-style-type: none"> • http://www.longspanbridge.com/bridge_systems.php
<i>Corrugated Steel Structures</i>			
MULTI-PLATE	<ul style="list-style-type: none"> • Galvanized corrugated steel, available in shapes: <ul style="list-style-type: none"> • pipe, • pipe-arch, • horizontal & vertical ellipse, • arch, and • underpass • Vendor: CONTECH Construction Products (Montana) 	5-26	<ul style="list-style-type: none"> • http://www.contech-cpi.com/Products/Bridges-and-Structures/Plate/MULTI-PLATE.aspx
SUPER-SPAN	<ul style="list-style-type: none"> • Galvanized corrugated steel with thrust beams, available in shapes: <ul style="list-style-type: none"> • low & high profile arch, • horizontal ellipse, • pear, and • pear-arch • Vendor: CONTECH Construction Products (Montana) 	19-45	<ul style="list-style-type: none"> • http://www.contech-cpi.com/Products/Bridges-and-Structures/Plate/SUPER-SPAN-and-SUPER-PLATE.aspx

Name	Brief Description	Span (ft, max or range)	More Information
Super-Cor	<ul style="list-style-type: none"> • Galvanized corrugated steel, available in shapes: <ul style="list-style-type: none"> • box, • arch, and • round • Vendor: Big R Manufacturing (Colorado) 	10–82	<ul style="list-style-type: none"> • http://www.bigrmfg.com/products/structuralplate/supercor/
Bolt-A-Plate	<ul style="list-style-type: none"> • Galvanized corrugated steel plates available in shapes: <ul style="list-style-type: none"> • standard arch, • low & high profile arch, • pipe-arch, • horizontal & vertical ellipse, • underpass, • pear-shaped underpass, and • round • Vendor: Big R Manufacturing (Colorado) 	5–38	<ul style="list-style-type: none"> • http://www.bigrmfg.com/products/structuralplate/bolt-a-plate/index.php
Steel Structural Plate Bridges	<ul style="list-style-type: none"> • Galvanized corrugated steel plate available in shapes: <ul style="list-style-type: none"> • low & high profile arch, • low & high profile bottomless box culverts, • single radius arch, • horizontal & vertical ellipse, • round, • pipe-arch, and • pear • Vendor: LONG SPAN Bridge & Culvert (Pennsylvania) 	5–83	<ul style="list-style-type: none"> • http://www.longspanbridge.com/bridge_systems.php

Table 4: Systems That Will Not Be Evaluated In Task 2

Type	Brief Description	Max. Span (ft)	More Information
Railroad Flatcar Bridges	<ul style="list-style-type: none"> Developed by Iowa State University Five single-span demonstration projects 	~66	<ul style="list-style-type: none"> Wipf et al., 2007 http://www.intrans.iastate.edu/reports/tr498_voll.pdf
Tube Girder	<ul style="list-style-type: none"> Developed by University of Nebraska Concrete-filled steel tube (with reinforcing bar added) girder bridge with concrete deck Picture of load tested 1/4-scale specimen: 	100	<ul style="list-style-type: none"> Yakel et al., 2007 http://www.ne-ltap.unl.edu/ndor/Innovative_Designs_Short_Bridges.pdf

Next Steps

Pending MDT review of this task report (and subsequent discussion and revision of its content as necessary), work will begin on Task 2 of this project, which consists of applying the proposed evaluation criteria to the selected crossing structures. This work primarily will be accomplished using information obtained from available literature, but will be augmented, as necessary, by interviews with individuals familiar with the systems (particularly the proprietary systems). When this work is complete, it will be summarized in a second task report.

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