FHWA FLH CULVERT ASSESSMENT AND DECISION-MAKING PROCEDURES MANUAL

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FLH Culvert Assessment Policy (Oct. 2010)

- Project vs. Program Level
- Assess culverts with spans < 20 feet on 3R or broader scope projects:
  - Structures with known condition or performance problems
  - All cross-road structures when access is “unimpeded”
  - All cross-road structures => 48” rise when access is “impeded”
    - Minimum of 2 Structures per mile

Assessment and Decision-Making Procedures

- Needed to implement policy
- Contracted with Ayres Associates, Fort Collins, CO for assistance
- Surveyed Existing State DOT Procedures/Criteria:
  - Ohio
  - CALTRANS
  - Minnesota
  - Oregon

Assessment and Decision-Making Procedures

- Two Distinct, *Qualitative* Procedures
  - Assessment
    - Levels 1 and 2
    - Conducted in the Field (2 people; 15 min.)
    - Facilitates project scope definition
  - Decision Making
    - Based on assessment results
    - Typically conducted in the Office

Assessment and Decision-Making Procedures

- 5 Barrel Material Types
  - Corrugated Metal
  - Concrete
  - Plastic
  - Masonry
  - Timber
- Appurtenances/End Treatments

Level 1 Assessment

- Rate Condition and Performance
- Categories for each
- Narrative Descriptions
- Photographic Guides
- *Judgment*

Level 1 Assessment

- Condition Ratings
  - Good, Fair, Poor, Critical
  - Poor or Critical rating triggers Level 1 Action
- Performance Ratings
  - Problem exists or not (Y/N)
  - Yes triggers Level 1 Action
- Level 1 Action
  - Routine fix defined in Decision Making

FHWA FLH CULVERT ASSESSMENT GUIDE

CONDITION ASSESSMENT RATING CODES

Good	Like new, with little or no deterioration, structurally sound and functionally adequate.
Fair	Some deterioration, but structurally sound and functionally adequate.
Poor	Significant deterioration and/or functional inadequacy, requiring repair action that should, if possible, be incorporated into the planned roadway project.
Critical	Very poor conditions that indicate possible imminent failure that could threaten public safety, requiring immediate repair action.
Unknown	All or part of the culvert is inaccessible for assessment or a rating cannot be assigned.

Notes:

- In general, the lowest elemental rating for the culvert determines the overall rating.
- Culvert conditions are assigned the above ratings, while failing culvert performance parameters are indicated by a check box if present.
- This guide is used for the rating of culverts with spans less than 20 feet as measured along the centerline of the roadway, as defined by NBIS.
- Due to the varied background and experience of the assessors, and variety of structures and deterioration modes, there is some inherent subjectivity to assigning the ratings in this guide.

Condition Categories Examined

Category	Rating					
Invert deterioration	Good	Fair	Poor	Crit	Unk	N/A
Joints & Seams	Good	Fair	Poor	Crit	Unk	N/A
Corrosion / Chemical	Good	Fair	Poor	Crit	Unk	N/A
Cross-Section Deform	Good	Fair	Poor	Crit	Unk	N/A
Cracking	Good	Fair	Poor	Crit	Unk	N/A
Liner / Wall	Good	Fair	Poor	Crit	Unk	N/A
Mortar and Masonry	Good	Fair	Poor	Crit	Unk	N/A
Rot and Marine Borers	Good	Fair	Poor	Crit	Unk	N/A
Headwall/Wingwall	Good	Fair	Poor	Crit	Unk	N/A
Apron	Good	Fair	Poor	Crit	Unk	N/A
Flared End Section	Good	Fair	Poor	Crit	Unk	N/A
Pipe End	Good	Fair	Poor	Crit	Unk	N/A
Scour Protection	Good	Fair	Poor	Crit	Unk	N/A

Example CMP Condition Criteria: Corrosion Above Invert

CORRUGATED METAL PIPE CONDITIONS *Refer to Photographic Guide for further assistance with rating assignments.*				
	Good	Fair	Poor	Critical
Corrosion (Above Invert)	Little or no surface rust above the invert Little or no coating loss if coated above the invert	Minor surface rust and limited pitting above the invert Connection hardware corroded but intact	Perforations visible or easily made by hammer test strike above the invert Connection hardware failing	Significant section loss resulting in extensive infiltration of backfill soil, voids and embankment and/or roadway damage

Decision Making

- Follows field assessment
- Identifies actions/fixes for:
  - Access problems
  - Condition problems
  - Performance problems
  - Combination of both

Decision Making

- Matrices provide options and selection criteria for:
  - Barrel liners
  - Localized repairs
  - Replacement techniques
  - Performance repairs
  - Discipline assistance

Decision Making

- Possible Condition Fixes (barrel focus)
  - Repair
    - Local/spot (man entry)
    - Full-Circumference Liner
  - Replace
    - Open Trench
    - Trenchless

Decision Making (Condition)

- Local Repair Methods (man-entry)
  - Spot Grouting
  - Epoxy Injection
  - Short Cast-in-Place Sleeves
  - Expansion Seal Rings
  - Invert Paving
  - Re-point Masonry

Decision Making (Condition)

- Liner Repair Methods
  - Segmental Slip
  - Continuous Slip
  - Fold & Form
  - Spiral Wound
  - Cured-in-Place Pipe
  - Spray-on Grout/Epoxy

Decision Making (Condition)

- Replacement Techniques
  - Open Trench
    - Traditional
    - Plug and Abandon
  - Trenchless
    - Jack & Bore
    - Horizontal Drilling
    - Pipe Bursting

Decision Making

- Possible Performance Fixes
  - Level 1: Routine fix
  - Level 2: Fix based on Level 2 investigation/assessment results

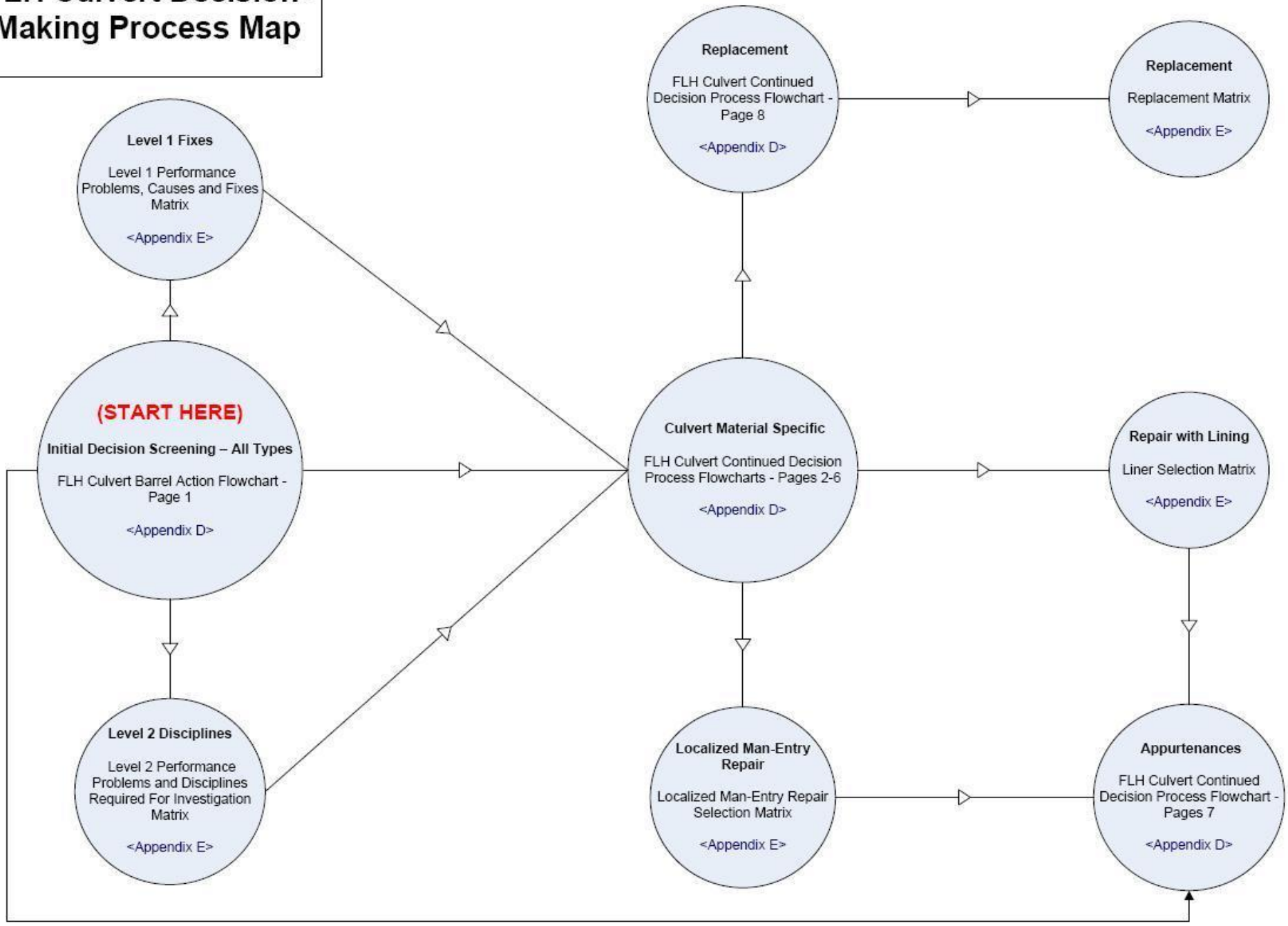
Decision Making (Performance)

- Level 1: Routine fixes
  - Maintenance required (blockage)
  - Overtopping/Embankment damage
  - Inlet/Outlet Failure
  - Scour Problem
  - Alignment Problem

Decision Making (Performance)

- Level 2: Fix based on Level 2 investigation results
  - Embankment piping or instability
  - Channel instability
  - Aggressive environment
  - Open-bottom/AOP culvert
  - Historical feature (programmatic issue)
  - Structural failure

FLH Culvert Decision-Making Process Map



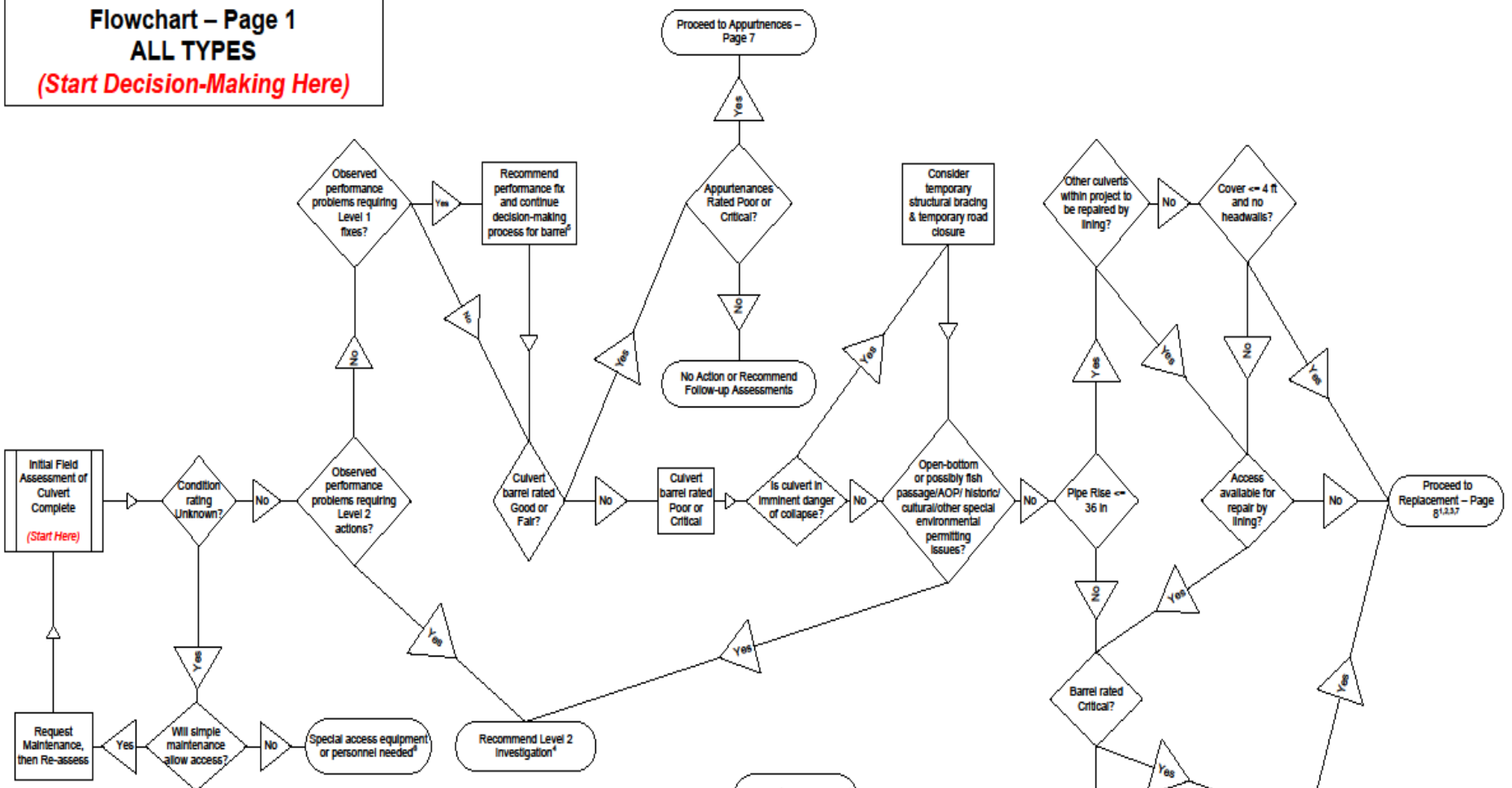
Liner Selection Matrix

This matrix summarizes properties, advantages and disadvantages of some of the liners commonly used in full-length, full-circumference repairs. Note that culverts with a slope greater than 1.5% can usually accommodate significant diameter reduction, as long as the diameter is not reduced within four feet of the inlet end. If the slope is greater than 1.5% and a liner will significantly reduce the pipe diameter, it is recommended the liner be terminated short of the pipe end and a new tapered or beveled inlet section be installed. See the sources noted below the table for more detailed discussion. More options and considerations for liner selection are also presented in the FLH Culvert Pipe Liner Guide and Specification, 2005.

Rehabilitation Type	Diameter Limits	Space Requirements for Installation	Shape, Deformation & Joint Discontinuity Tolerance	Structural Restoration	Diameter Reduction	Flow Bypass Required When Flow is Present?	Abrasion and Corrosion Resistance	Rough Comparative Cost	Other Factors and Limitations
Slip Liner - Segmental	Up to 158in. diameter for segmental; up to 72in. common	Small to moderate	Deformations and discontinuities in pipe can block insertion and limit diameter of the liner; host pipe must be round or semi-round	Depends on liner and annulus composition	Significant	Sometimes	Good	Low to Moderate; $50/lin.ft. for 18in. Diameter; $120/lin.ft. for 30in. Diameter; $400 to $500 per lin.ft. for 60in. diameter	Low safety concern for installers; Low environmental concern with installation process, in particular with low-density grout
Slip Liner - Continuous	Up to 72in. diameter common for continuous	Moderate to large							Moderate safety concern for installers; Low environmental concern with installation process, in particular with low-density grout; jointing can be labor intensive for fusion-welded
Fold-and-Form PVC or HDPE Liner (close-fit)	Up to 24in. diameter for PVC and 36in. for HDPE; Less than 15in. to 18in. most common; 4in. min.	Small	Deformations, discontinuities and pipe size changes will likely cause problems; host pipe must be round/circular shape	Does not restore structural integrity	Minimal	Usually	Very Good	Moderate to High; $100 to $300 per lin.ft.	Moderate safety concern for installers; Moderate environmental concern with installation process; specialized equipment and trained personnel needed.
Spiral-wound Liner	8in. to 120in. diameter, depending on type	Small	Host pipe must be round or semi-round; can tolerate minor discontinuities, deformations and pipe size changes	Depends on liner and annulus composition	Can be significant	Sometimes	Very Good	Moderate to High; $100/lin.ft. for 18in. Diameter; $570/lin.ft. for 78in. diameter; up to $750 per lin.ft. for larger diameters	Moderate safety concern for installers; Low environmental concern with installation process; larger manual systems require manned-entry; liners may become brittle in freezing temps; specialized equipmer and trained personnel needed.
Cured-in-Place Pipe (CIPP)	12in. to 108in. diameter; 48in. or less most common	Small to moderate	Non-circular shapes, discontinuities and pipe size changes can be accommodated	May restore structural integrity, depending on liner wall thickness	Minimal for non-structural; Moderate for structural	Always	Very Good	High; $100/lin.ft. for 18in. diameter; up to $800 per lin.ft. for larger diameters	Moderate safety concern for installers; High environmental concern with installation process, in particular with contaminated water disposal and contro of ground water infiltration; some resins may be toxic. Specialized equipment and trained personnel needed.
Spray-On Cement Mortar Lining	12in. to 24in. diameter most common; larger diameter possible	Small	Host pipe must be round or semi-round; can accommodate minor bends, discontinuities and imperfections in host pipe	Restores structural integrity if reinforced	Minimal for non-structural; Moderate for structural	Always	Poor	Low to Moderate; $100 to $150/lin.ft. for 24in. diameter; $250 to $350 per lin.ft. for 60in. Diameter	Low safety concern for installers; High environmental concern with installation process; specialized equipme and trained personnel needed; cement subject to breakdown if runoff is acidic or contains sulfates; infiltration control required; bends and long lengths car be problematic for pulling sled through pipe at necessary steady rate and verifying application thickness.
	12in. to 24in. diameter most								Low safety concern for installers; High environmental concern with installation process; specialized equipme

FLH Culvert Barrel Action Flowchart – Page 1 ALL TYPES

(Start Decision-Making Here)



Notes:

1: Culverts rated Critical with extensive roadway and embankment damage should generally be excavated and replaced.

2. Culverts with Poor or Critical barrel condition rating, rise less than or equal to 36 inches, cover less than or equal to 4 feet and no headwalls present will likely be replaced if lane or road closure is allowed by the client.

3. If a repair or replacement terminator is reached for culvert barrels in Poor or Critical condition, and there is a Poor or Critical appurtenance condition, proceed to Page 7 – Appurtenances after barrel actions have been determined.

4. Refer to Level 2 Disciplines matrix for further guidance on disciplines required for Level 2 investigation recommendations.

5. Refer to Level 1 Performance Fixes matrix for guidance on performance fix recommendations.

6. Based on the limited access conditions encountered, recommend the appropriate special access equipment and/or personnel required to complete the assessment, i.e. divers, pipe crawler, ROV or rope access/climing techniques.

7. The recommendation to replace culverts less than 36 inches in rise, under 4 feet of less of cover, with no headwall and favorable traffic conditions is based on limited cost analysis and trench safety guidelines. Specific project conditions, such as the use of trenchless techniques on nearby culverts or availability of cost-effective lining technology, may counter this recommendation.

Hydraulic Toolbox Demo

- Questions?
- CADM Manual posted on-line:
  - http://www.cflhd.gov/programs/techdevelopment/hydraulics/culvert-assessment/index.cfm
- Toolbox Software posted on-line:
  - http://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox40.cfm