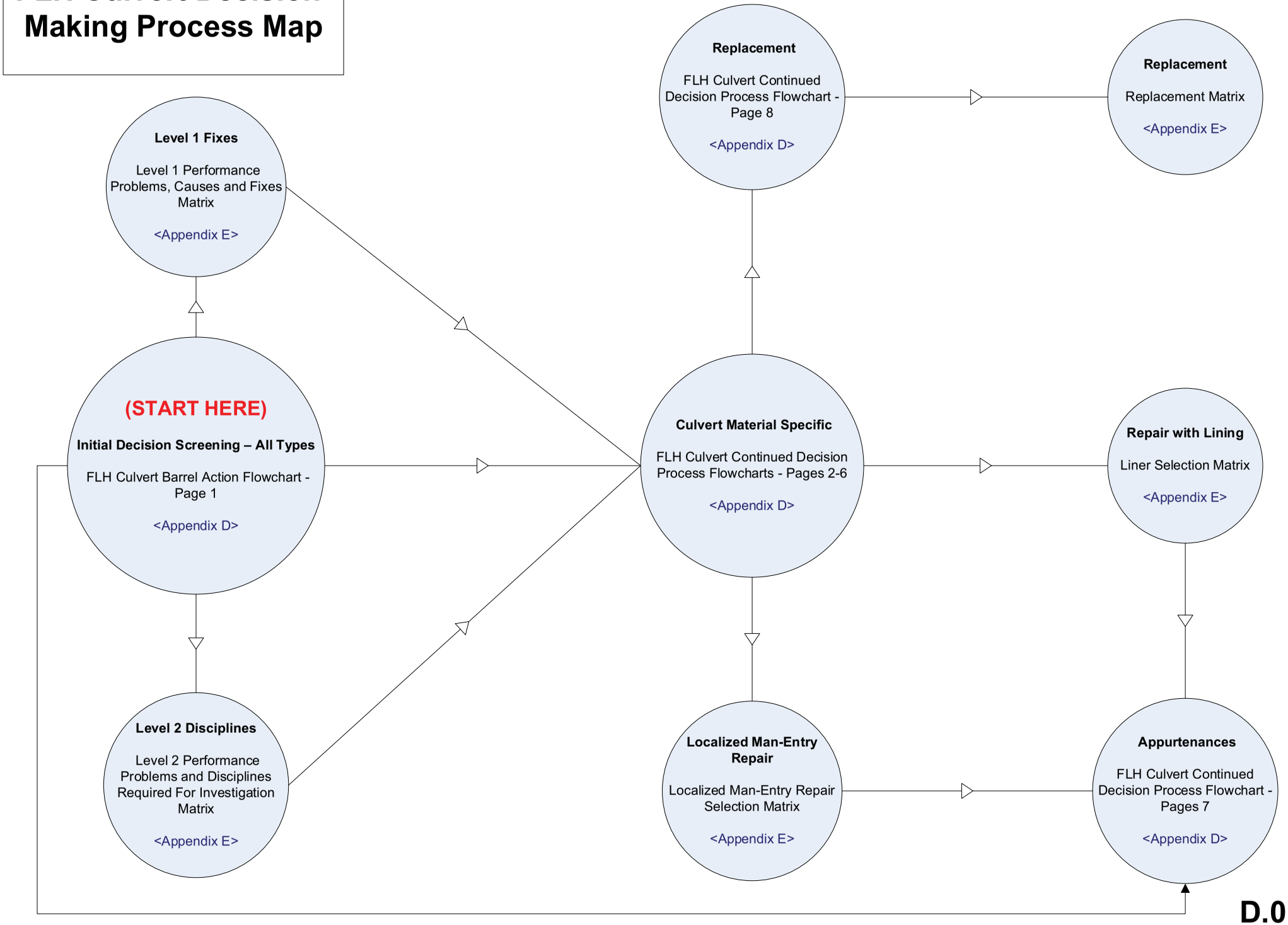
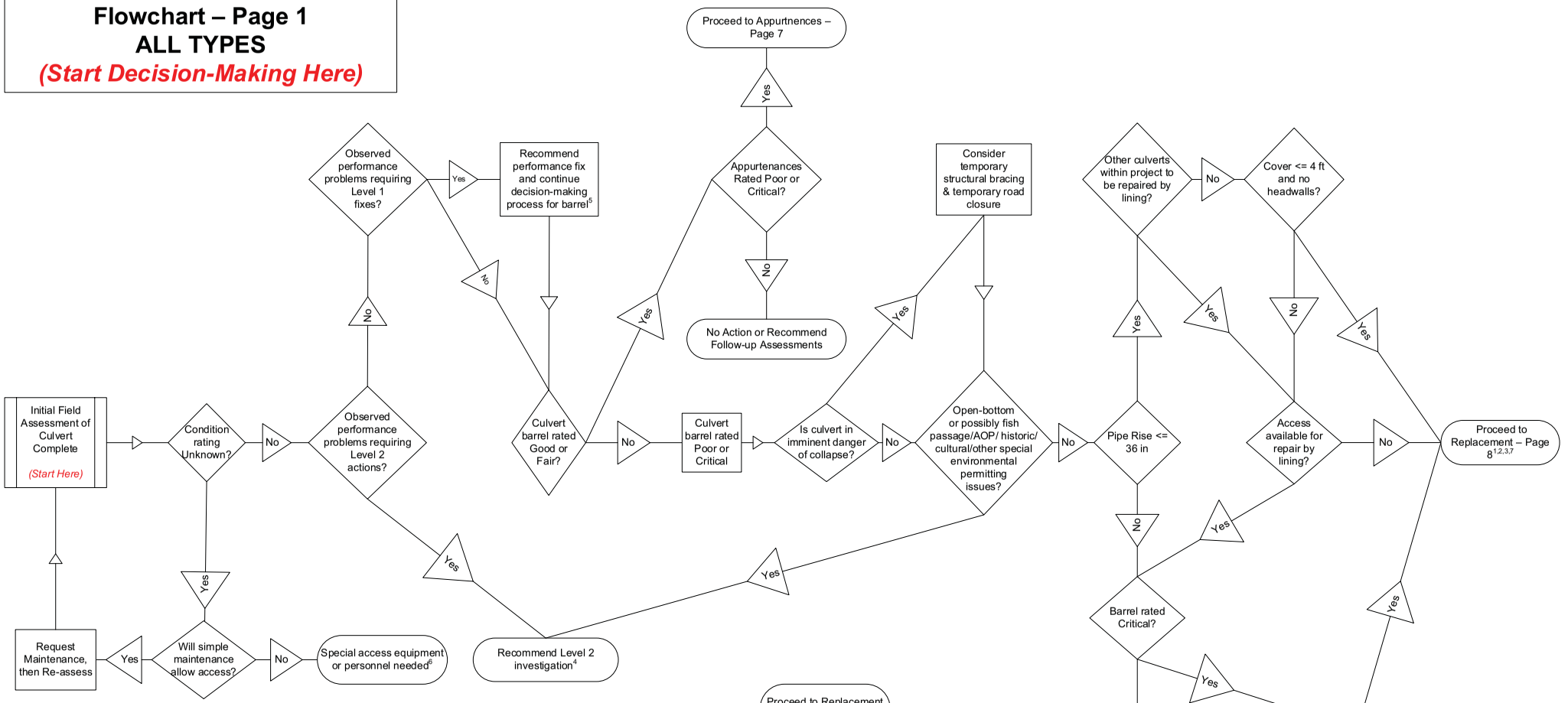
APPENDIX D – CULVERT DECISION-MAKING PROCESS MAP AND FLOWCHARTS

FLH Culvert Decision-Making Process Map



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.

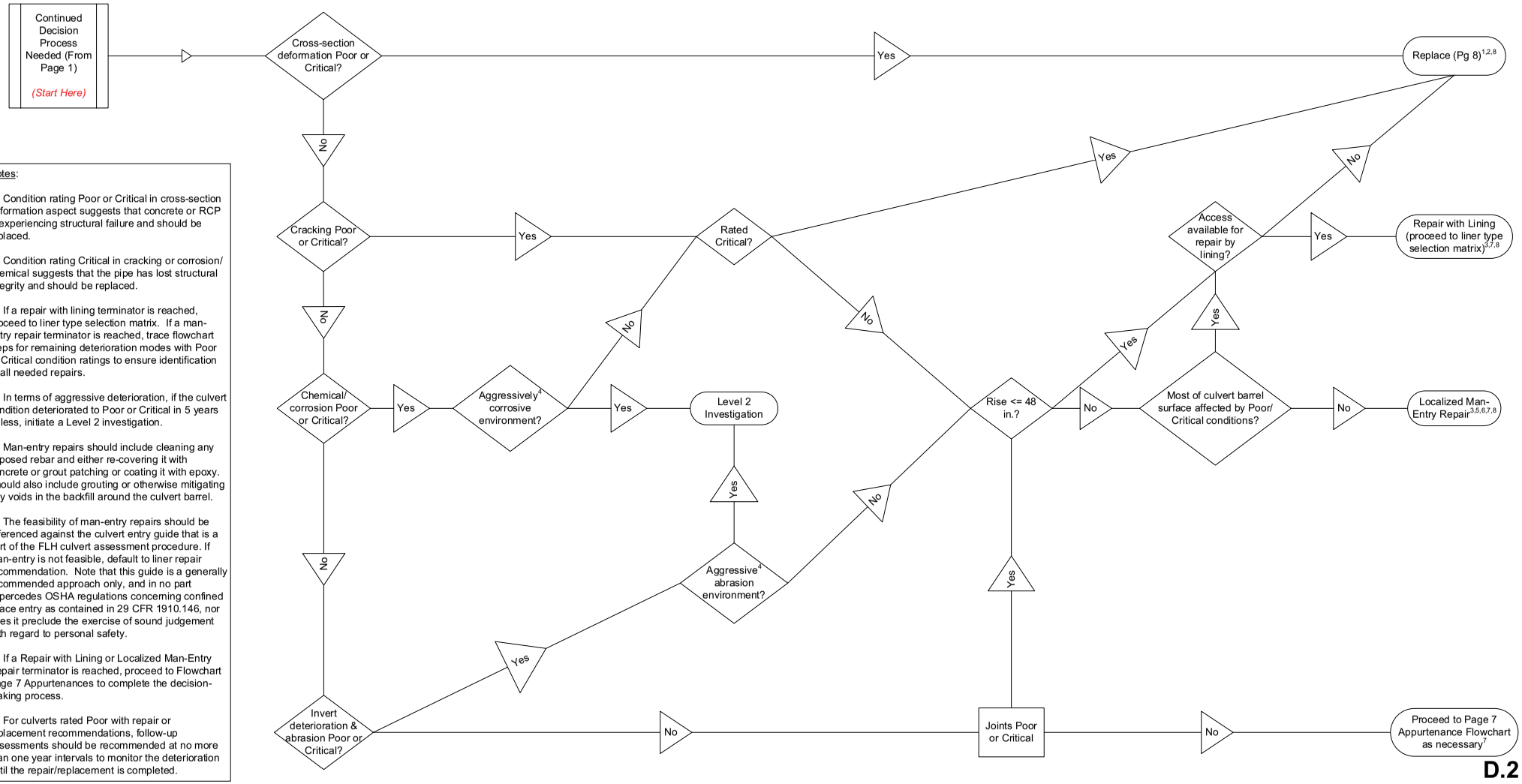
4. Refer to Level 2 Disciplines matrix for further guidance on disciplines required for Level 2 investigation recommendations.

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

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.

FLH Culvert Continued Decision Process Flowchart – Page 2 Concrete & RCP



Notes:

1. Condition rating Poor or Critical in cross-section deformation aspect suggests that concrete or RCP is experiencing structural failure and should be replaced.

2. Condition rating Critical in cracking or corrosion/ chemical suggests that the pipe has lost structural integrity and should be replaced.

3: If a repair with lining terminator is reached, proceed to liner type selection matrix. If a man-entry repair terminator is reached, trace flowchart steps for remaining deterioration modes with Poor or Critical condition ratings to ensure identification of all needed repairs.

4: In terms of aggressive deterioration, if the culvert condition deteriorated to Poor or Critical in 5 years or less, initiate a Level 2 investigation.

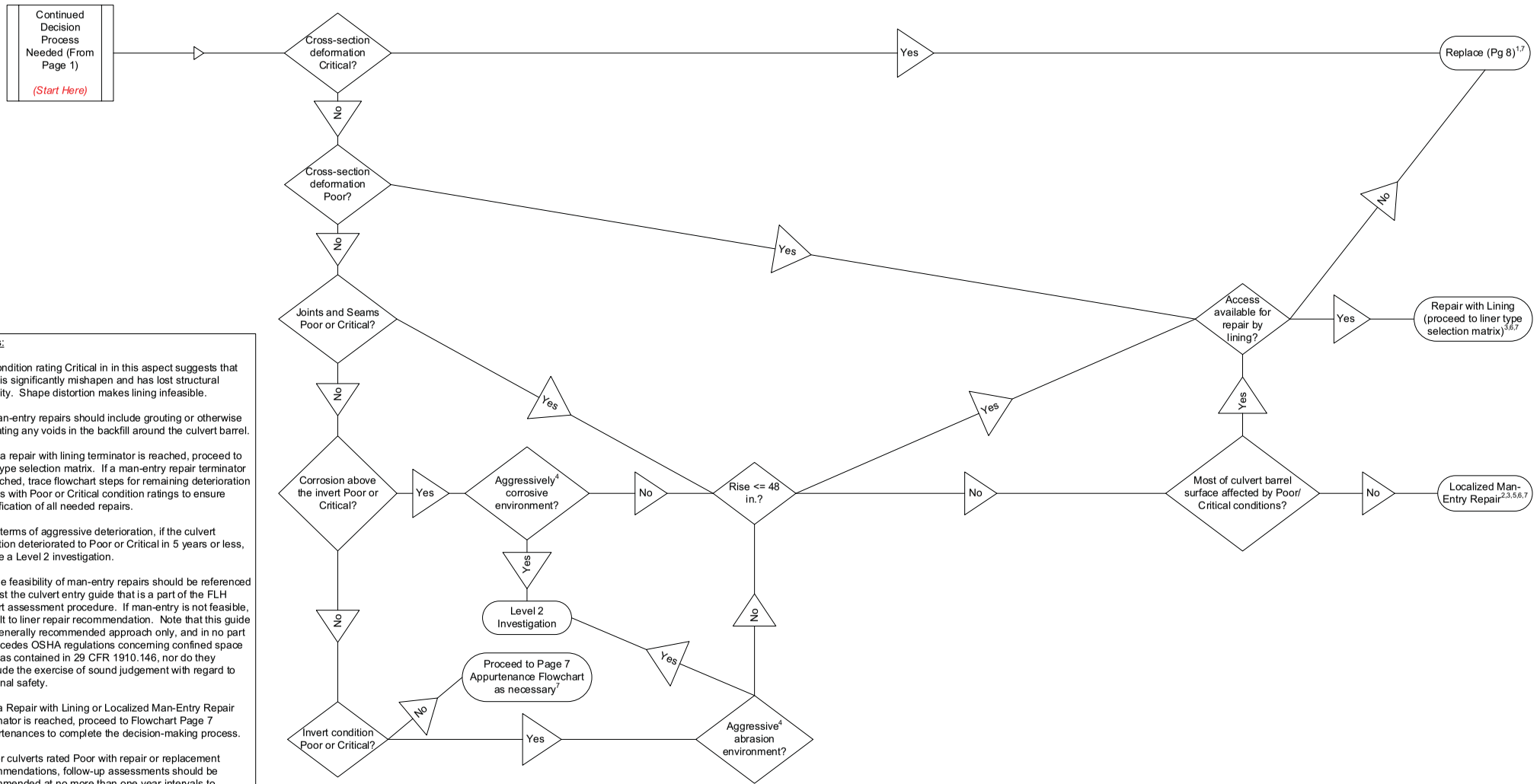
5. Man-entry repairs should include cleaning any exposed rebar and either re-covering it with concrete or grout patching or coating it with epoxy. Should also include grouting or otherwise mitigating any voids in the backfill around the culvert barrel.

6. The feasibility of man-entry repairs should be referenced against the culvert entry guide that is a part of the FLH culvert assessment procedure. If man-entry is not feasible, default to liner repair recommendation. Note that this guide is a generally recommended approach only, and in no part supercedes OSHA regulations concerning confined space entry as contained in 29 CFR 1910.146, nor does it preclude the exercise of sound judgement with regard to personal safety.

7. If a Repair with Lining or Localized Man-Entry Repair terminator is reached, proceed to Flowchart Page 7 Appurtenances to complete the decision-making process.

8. For culverts rated Poor with repair or replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration until the repair/replacement is completed.

FLH Culvert Continued Decision Process Flowchart – Page 3 CMP



Notes:

1: Condition rating Critical in in this aspect suggests that CMP is significantly mishapen and has lost structural integrity. Shape distortion makes lining infeasible.

2: Man-entry repairs should include grouting or otherwise mitigating any voids in the backfill around the culvert barrel.

3: If a repair with lining terminator is reached, proceed to liner type selection matrix. If a man-entry repair terminator is reached, trace flowchart steps for remaining deterioration modes with Poor or Critical condition ratings to ensure identification of all needed repairs.

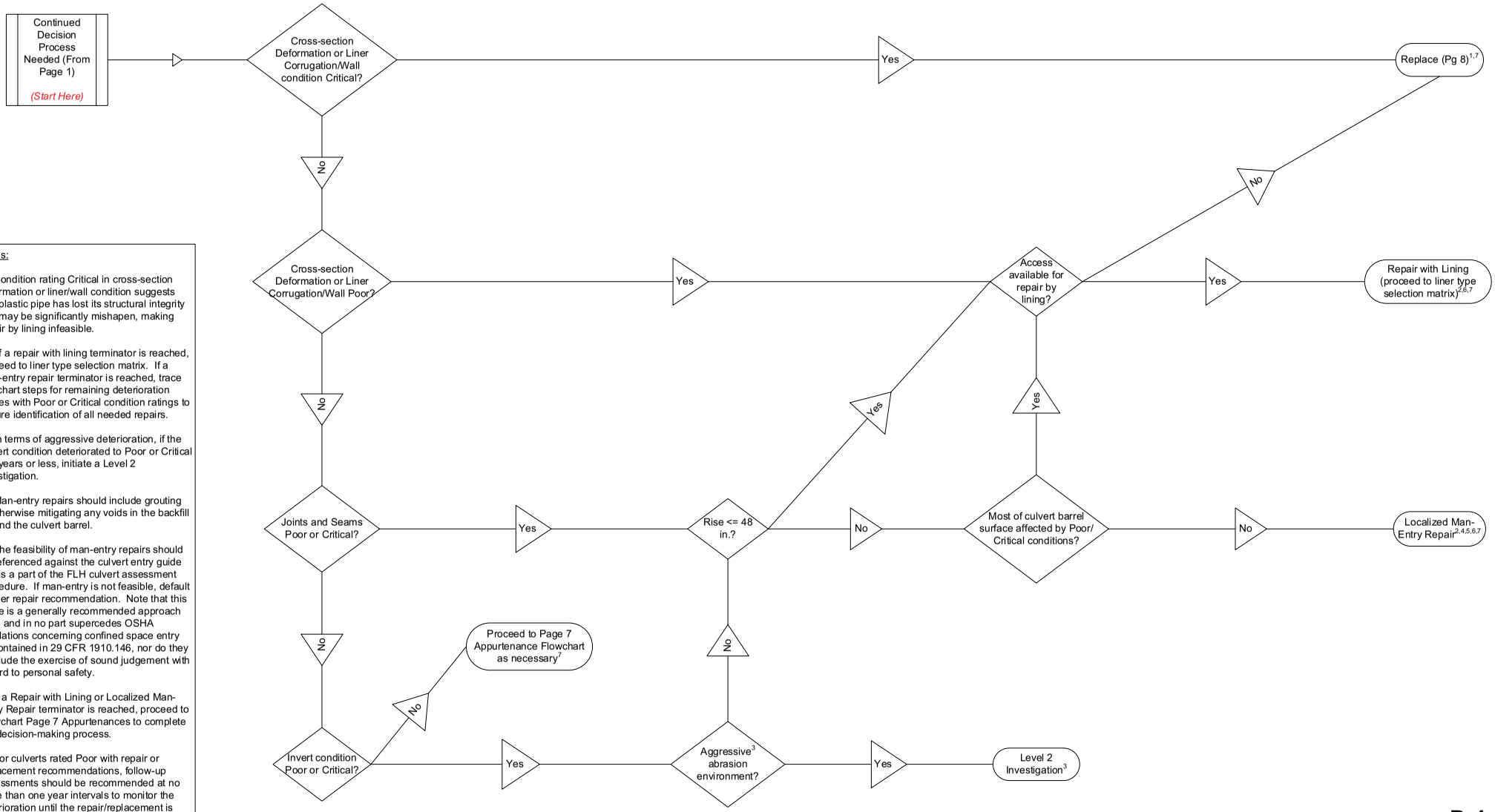
4: In terms of aggressive deterioration, if the culvert condition deteriorated to Poor or Critical in 5 years or less, initiate a Level 2 investigation.

5. The feasibility of man-entry repairs should be referenced against the culvert entry guide that is a part of the FLH culvert assessment procedure. If man-entry is not feasible, default to liner repair recommendation. Note that this guide is a generally recommended approach only, and in no part supercedes OSHA regulations concerning confined space entry as contained in 29 CFR 1910.146, nor do they preclude the exercise of sound judgement with regard to personal safety.

6. If a Repair with Lining or Localized Man-Entry Repair terminator is reached, proceed to Flowchart Page 7 Appurtenances to complete the decision-making process.

7. For culverts rated Poor with repair or replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration until the repair/replacement is completed.

FLH Culvert Continued Decision Process Flowchart – Page 4 Plastic



Notes:

1: Condition rating Critical in cross-section deformation or liner/wall condition suggests that plastic pipe has lost its structural integrity and may be significantly mishapen, making repair by lining infeasible.

2: If a repair with lining terminator is reached, proceed to liner type selection matrix. If a man-entry repair terminator is reached, trace flowchart steps for remaining deterioration modes with Poor or Critical condition ratings to ensure identification of all needed repairs.

3: In terms of aggressive deterioration, if the culvert condition deteriorated to Poor or Critical in 5 years or less, initiate a Level 2 investigation.

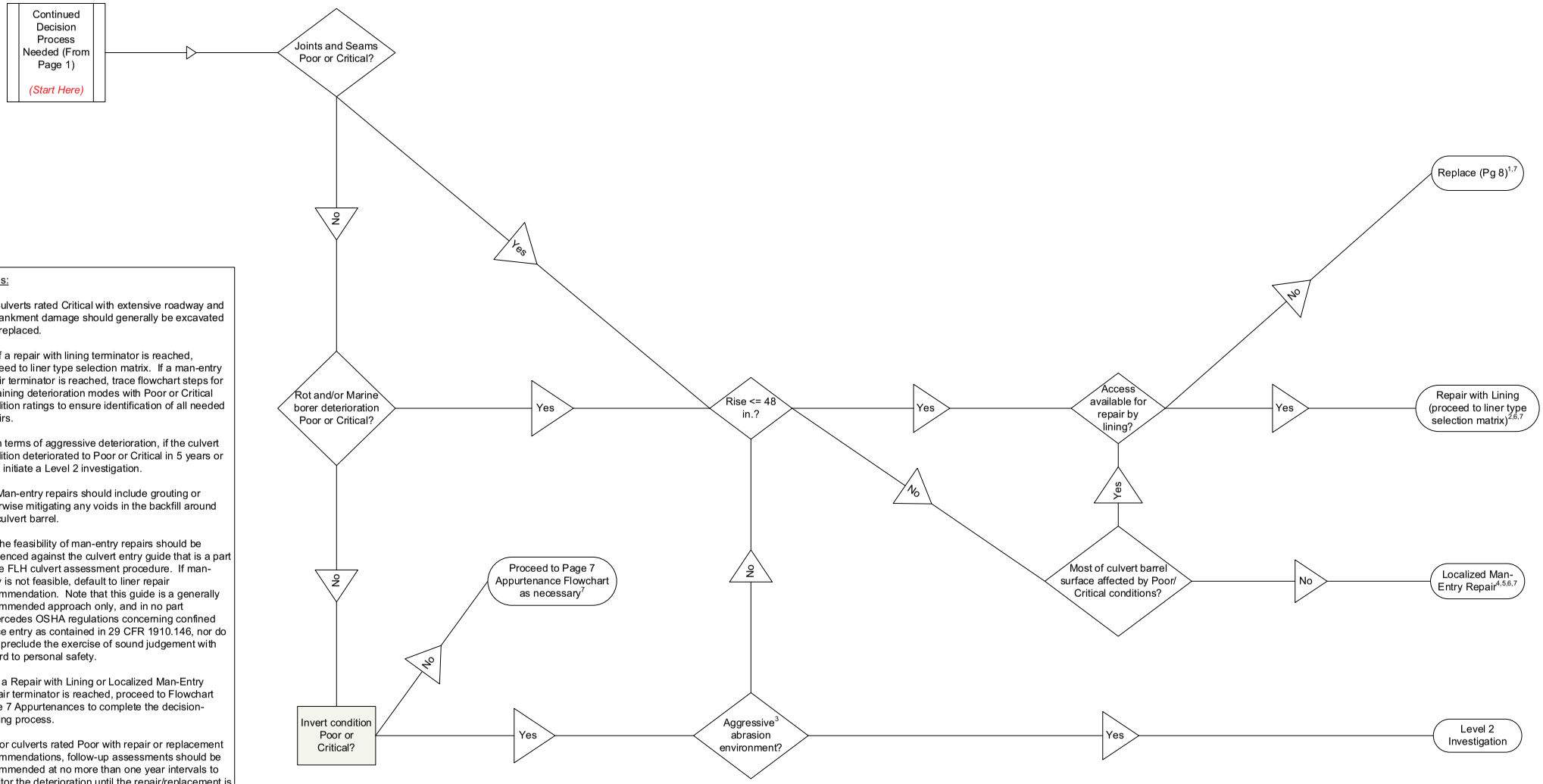
4. Man-entry repairs should include grouting or otherwise mitigating any voids in the backfill around the culvert barrel.

5. The feasibility of man-entry repairs should be referenced against the culvert entry guide that is a part of the FLH culvert assessment procedure. If man-entry is not feasible, default to liner repair recommendation. Note that this guide is a generally recommended approach only, and in no part supercedes OSHA regulations concerning confined space entry as contained in 29 CFR 1910.146, nor do they preclude the exercise of sound judgement with regard to personal safety.

6. If a Repair with Lining or Localized Man-Entry Repair terminator is reached, proceed to Flowchart Page 7 Appurtenances to complete the decision-making process.

7. For culverts rated Poor with repair or replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration until the repair/replacement is completed.

FLH Culvert Continued Decision Process Flowchart – Page 5 Timber



Notes:

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

2: If a repair with lining terminator is reached, proceed to liner type selection matrix. If a man-entry repair terminator is reached, trace flowchart steps for remaining deterioration modes with Poor or Critical condition ratings to ensure identification of all needed repairs.

3: In terms of aggressive deterioration, if the culvert condition deteriorated to Poor or Critical in 5 years or less, initiate a Level 2 investigation.

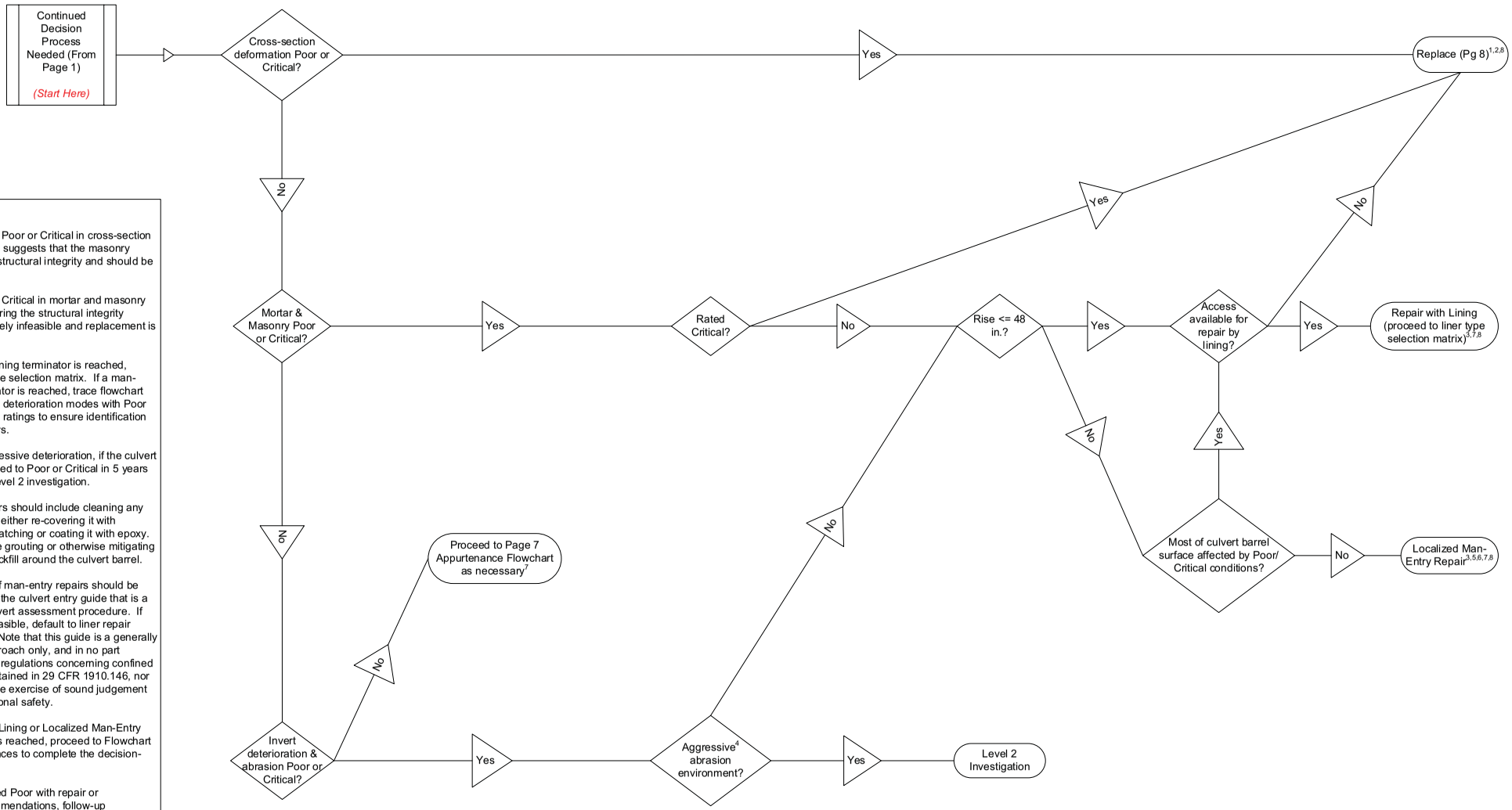
4: Man-entry repairs should include grouting or otherwise mitigating any voids in the backfill around the culvert barrel.

5. The feasibility of man-entry repairs should be referenced against the culvert entry guide that is a part of the FLH culvert assessment procedure. If man-entry is not feasible, default to liner repair recommendation. Note that this guide is a generally recommended approach only, and in no part supercedes OSHA regulations concerning confined space entry as contained in 29 CFR 1910.146, nor do they preclude the exercise of sound judgement with regard to personal safety.

6. If a Repair with Lining or Localized Man-Entry Repair terminator is reached, proceed to Flowchart Page 7 Appurtenances to complete the decision-making process.

7. For culverts rated Poor with repair or replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration until the repair/replacement is completed.

FLH Culvert Continued Decision Process Flowchart – Page 6 Masonry



Notes:

1. Condition rating Poor or Critical in cross-section deformation aspect suggests that the masonry culvert has lost its structural integrity and should be replaced.

2. Condition rating Critical in mortar and masonry suggests that restoring the structural integrity through repair is likely infeasible and replacement is appropriate.

3: If a repair with lining terminator is reached, proceed to liner type selection matrix. If a man-entry repair terminator is reached, trace flowchart steps for remaining deterioration modes with Poor or Critical condition ratings to ensure identification of all needed repairs.

4: In terms of aggressive deterioration, if the culvert condition deteriorated to Poor or Critical in 5 years or less, initiate a Level 2 investigation.

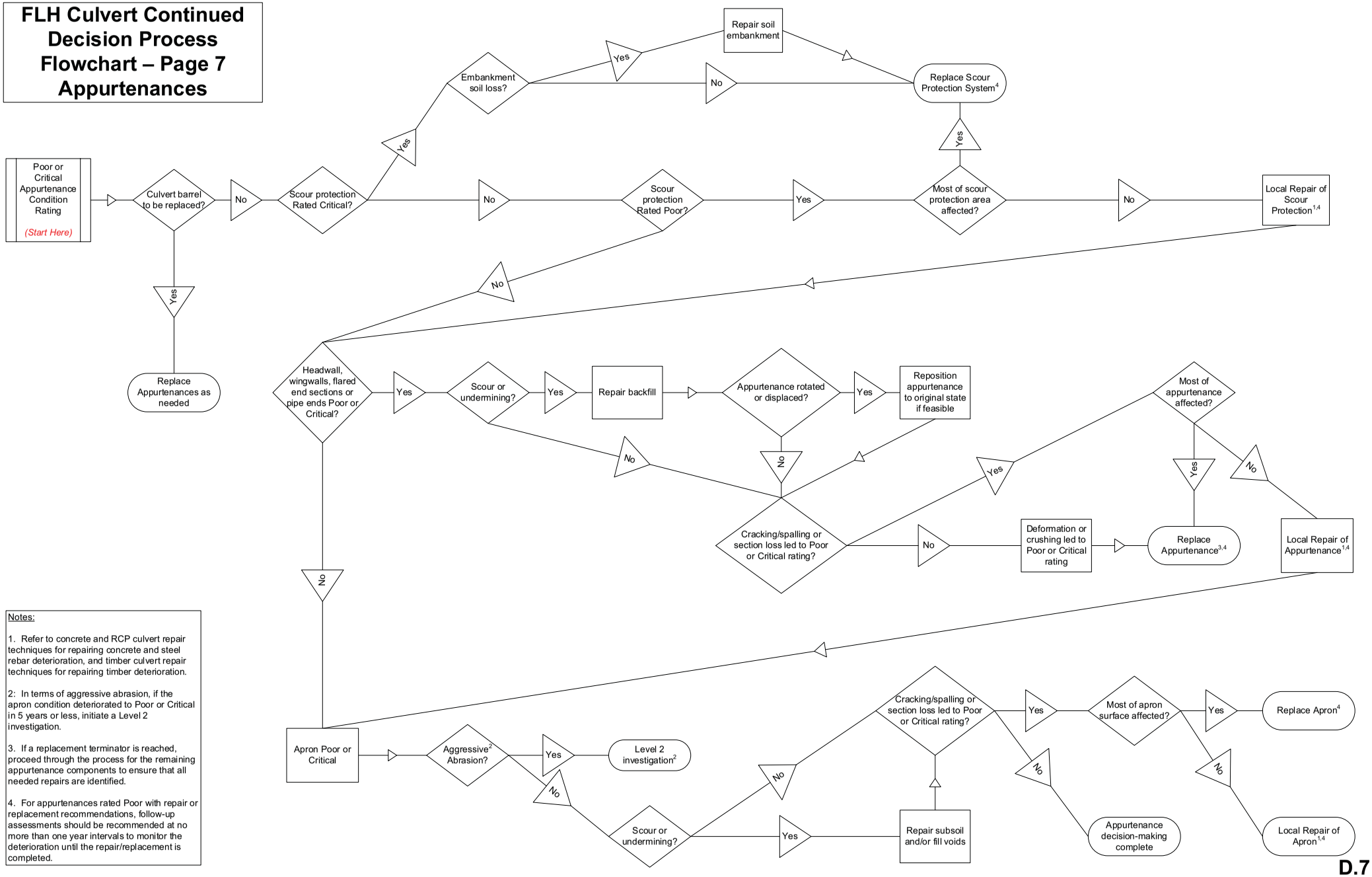
5. Man-entry repairs should include cleaning any exposed rebar and either re-covering it with concrete or grout patching or coating it with epoxy. Should also include grouting or otherwise mitigating any voids in the backfill around the culvert barrel.

6. The feasibility of man-entry repairs should be referenced against the culvert entry guide that is a part of the FLH culvert assessment procedure. If man-entry is not feasible, default to liner repair recommendation. Note that this guide is a generally recommended approach only, and in no part supercedes OSHA regulations concerning confined space entry as contained in 29 CFR 1910.146, nor do they preclude the exercise of sound judgement with regard to personal safety.

7. If a Repair with Lining or Localized Man-Entry Repair terminator is reached, proceed to Flowchart Page 7 Appurtenances to complete the decision-making process.

8. For culverts rated Poor with repair or replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration until the repair/replacement is completed.

FLH Culvert Continued Decision Process Flowchart – Page 7 Appurtenances



Notes:

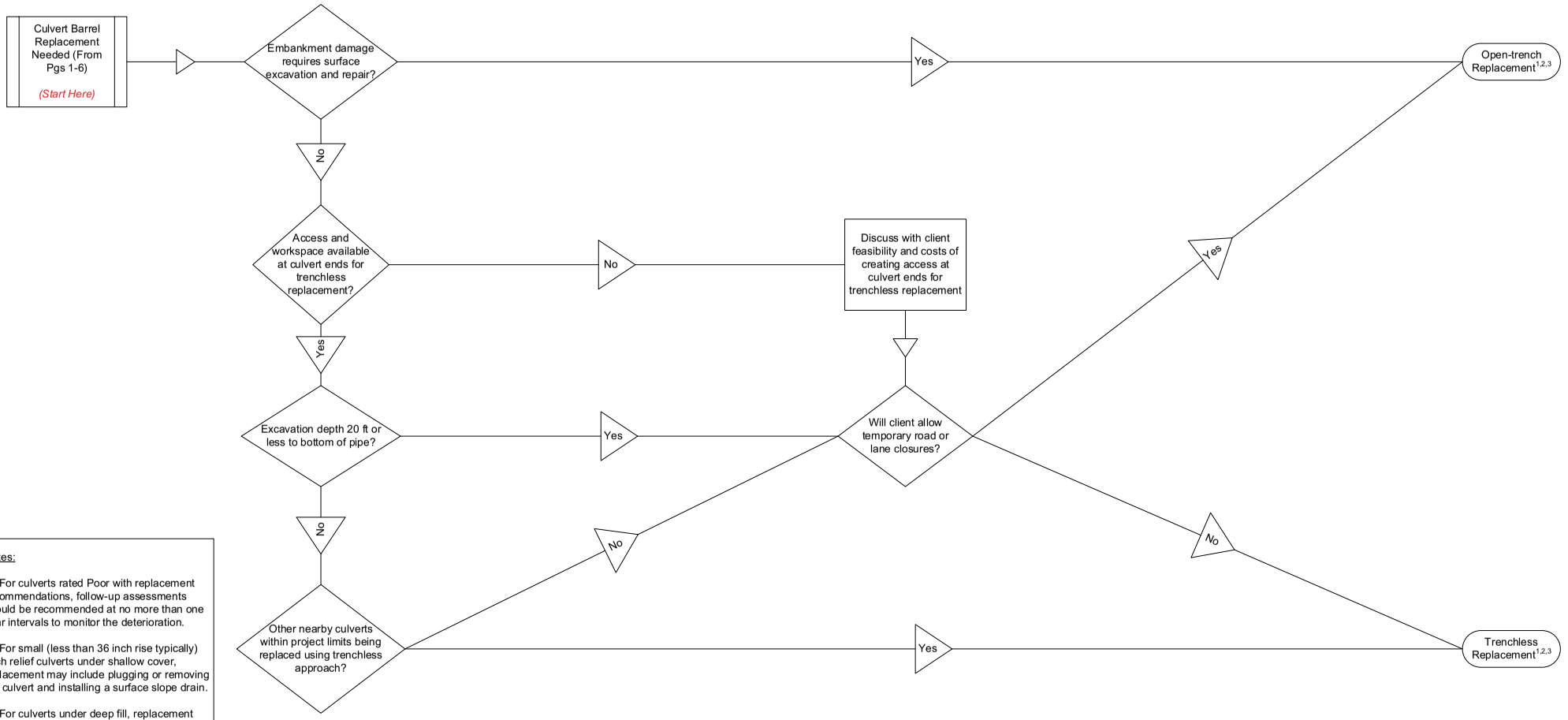
1. Refer to concrete and RCP culvert repair techniques for repairing concrete and steel rebar deterioration, and timber culvert repair techniques for repairing timber deterioration.

2: In terms of aggressive abrasion, if the apron condition deteriorated to Poor or Critical in 5 years or less, initiate a Level 2 investigation.

3. If a replacement terminator is reached, proceed through the process for the remaining appurtenance components to ensure that all needed repairs are identified.

4. For appurtenances rated Poor with repair or replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration until the repair/replacement is completed.

FLH Culvert Continued Decision Process Flowchart – Page 8 REPLACEMENT - ALL TYPES



Notes:

1. For culverts rated Poor with replacement recommendations, follow-up assessments should be recommended at no more than one year intervals to monitor the deterioration.

2. For small (less than 36 inch rise typically) ditch relief culverts under shallow cover, replacement may include plugging or removing the culvert and installing a surface slope drain.

3. For culverts under deep fill, replacement may include plugging the deep culvert and installing and shallower culvert.