INDIANA DEPARTMENT OF TRANSPORTATION

INTER-DEPARTMENT COMMUNICATION
Standards Section -- Room N642

June 15, 1998

DESIGN MEMORANDUM No. 98-01
TECHNICAL ADVISORY

TO: **All Design, Operations, and District Personnel, and Consultants**

FROM: ***/s/ Richard VanCleave***
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Design Policy Engineer
Technical Services Division

SUBJECT: **New Pipe Specifications, Standard Drawings, and Procedures**

REFERENCE: **Design Memorandum No. 98-01 Policy Change**

EFFECTIVE: **All Lettings after September 1, 1998**

SUPERSEDES: **Design Memorandum No. 42 and All Addenda**

INTRODUCTION

Approximately one year ago, Design Memo #42 was published to inform designers of the design procedures related to the pipe specifications that became effective with the January 1998 edition of the Supplemental Specifications. Since then, two addenda have been distributed to clarify issues that some designers found confusing. Because the September 1998 version of the Supplemental Specifications includes additional pipe-related changes, it would normally be necessary to publish a third addendum to discuss the required design procedure revisions.

However, instead of writing a third addendum to Design Memo #42, it has been decided to consolidate the information contained in the original memo, the two previously published addenda, and the new design procedures associated with the changes included in the September 1998 edition of the Supplemental Specifications. This consolidated document has been designated as Design Policy Memorandum #98-01.

This memo serves as a technical advisory and has been prepared to provide additional instructions regarding the implementation of the policy outlined by Design Policy Memorandum #98-01.

The changes included in the September 1998 version of the Supplemental Specifications pertain to pipe end sections, concrete anchors, safety metal end sections, and grated box end sections. More information regarding the revised design procedures for these items appears later in this technical advisory.

RESPONSIBILITIES OF DESIGNERS

The following checklist contains tasks that are common to projects that include pipe and related items. More detailed information related to each checklist item is provided later in this memo. If an individual project presents issues not included in the checklist, the Standards Section or Hydraulics Unit must be contacted for additional instructions.

- Determine Proposed Structure Layout.
- Determine Individual Structure Drainage Areas.
- Perform Required Hydrological Calculations.
- Determine Required Size & Type for Each Structure.
- Perform Sanitary Sewer and Water Utility Coordination.
- Plan Preparation.
  - Preliminary Field Check Plans.
  - Final Check Prints.
- Identification of Pay Items/Quantity Calculations.
- Standard Drawing Selection.
- Special Provision Requirements.

In addition, this memo also details an alternate procedure for contract document preparation that is appropriate for projects that began plan development prior to June 1, 1997.

TECHNICAL ADVISORY #98-01 SCOPE

This technical advisory applies to all projects that are let by INDOT. This includes projects for Local Public Agencies, the Department of Natural Resources, INDOT Toll Road Division, or any other party that uses the INDOT contract letting process.

For the purposes of this memo, it is assumed that all projects are designed by one of the following:

- INDOT Central Office Design Personnel.
- INDOT District Design Personnel.
- INDOT Toll Road Division Personnel.
- Consultant Design Personnel.
- Local Public Agency Design Personnel.

For projects designed by INDOT central office designers, the Hydraulics Unit will perform some tasks that designers from other organizations perform for their projects. The tasks performed by the Hydraulics Unit are specifically identified in this memo. If no reference to the Hydraulics Unit is made, the INDOT central office designer is responsible for the performance of the task.

If a project designer does not feel that he fits into one of these categories, the Standards Section must be contacted for additional instructions.

DETERMINE PROPOSED STRUCTURE LAYOUT

Usually, the designer's first step in the hydraulic design process is the development of the proposed drainage structure layout for the project. This layout can be as simple as a single culvert for a rural small structure replacement project or as complex as multiple storm drain systems for an urban street project. Regardless of the complexity of the layout, it is the designer's responsibility to ensure that all runoff routed to the project area is perpetuated in a manner that does not impact the performance of the constructed roadway or damage adjacent property.

In conjunction with establishing the proposed drainage structure layout, the designer must identify the application for each structure. Virtually every structure will be in accordance with one of the following applications:

- **Mainline Culvert**-A culvert is defined to be a new structure (pipe, cast-in-place or precast reinforced concrete structure, structural plate arch structure, etc.) that extends through an embankment on both ends. The mainline designation indicates that the culvert is installed under mainline pavement.
- **Public Road Approach Culvert**-A new culvert structure under a public road approach.
- **Driveway Culvert**-A new culvert structure under a driveway or field entrance.

- **Storm Drain**-A newly installed structure that conveys runoff and has at least one end connected to a manhole, inlet, catch basin, or similar structure. Pipes connected to inlets located in paved medians, grassed medians, or lawn areas are considered storm drain structures.
- **Drain Tile**-An existing subsurface drainage structure, usually installed by an adjacent property owner, that must be perpetuated through the project area. Rules regarding the perpetuation of these structures are discussed later in this technical advisory.
- **Pipe Extension**-Pipe extensions involve the installation of new pipe at one or both ends of an existing pipe structure.
- **Concrete Culvert Extension**-A concrete culvert extension is defined as new construction that extends an existing reinforced concrete slab-top, box, or arch culvert structure. Acceptable methods for constructing the extension include cast-in-place reinforced concrete or installation of precast reinforced concrete box sections.
- **Slotted Drain Pipe**-Slotted drain pipe is used to intercept sheet flow at pavement edges. It can also be installed in concrete gutters in conjunction with curb inlets at sag locations.
- **Slotted Vane Drain Pipe**-Slotted vane drain pipe is used to intercept sheet flow in urban driveway areas.

In the case of urban storm drain design, it is not intended that exact curb inlet locations be determined at this time. The purpose of the layout is to establish the routing for mains and to identify outlet locations for each proposed system.

DETERMINE INDIVIDUAL STRUCTURE DRAINAGE AREAS

Next, the designer must determine the area that contributes runoff to each structure in the drainage system. For urban storm drain systems, it is acceptable to divide the overall system drainage area into convenient subareas.

The Hydraulics Unit will determine structure drainage areas for projects designed by INDOT central office personnel.

PERFORM REQUIRED HYDROLOGICAL CALCULATIONS

The next step in the design process is to determine the design storm requirements and calculate the associated runoff magnitudes for each structure in the proposed drainage system. The Hydraulics Unit will perform this task for projects designed by INDOT central office personnel, but all other designers are responsible for these calculations on their projects. The following methods are acceptable for determining design storm runoff magnitudes:

- **Rural Areas**
  - Rational Method (for areas #80 Hectares).
  - NRCS (Formerly SCS) Curve Number Method (TR-20).
  - Coordinated Discharges of Selected Streams in Indiana, IDNR, 1987.

- **Urban Areas**
  - Rational Method (for areas #40 Hectares).
  - NRCS (Formerly SCS) Curve Number Method (TR-20).
  - Coordinated Discharges of Selected Streams in Indiana, IDNR, 1987.

If an IDNR Construction in a Floodway Permit is required, the Letter of Discharge from IDNR shall be used to document the design storm magnitudes.

If the NRCS (formerly SCS) Curve Number Method is used, the Huff 2nd quartile distribution as presented in the Purdue University Report "Statistical Characteristics of Short Time Incremental Rainfall" (Purdue Report No. CE-EHE-92-09) must be used in place of the NRCS (SCS) Type II rainfall distribution.

Before the runoff magnitudes can be calculated in accordance with one of the approved methods, the design storm frequency requirements must be determined. These requirements depend on the application of the proposed structure and the functional classification of the road over the proposed structure.

The appropriate design storm frequencies are listed below:

- **Culverts**

	DESIGN CRITERIA		
FUNCTIONAL CLASSIFICATION	**ALLOWABLE HEADWATER**	**ROADWAY SERVICEABILITY**	**MAXIMUM VELOCITY**
INTERSTATE	Q_{100}	Q_{100}	Q_{50}
OTHER MULTI-LANE	Q_{100}	Q_{100}	Q_{50}
TWO-LANE			
ADT∃3000	Q_{100}	Q_{100}	Q_{50}
3000>ADT∃1000	Q_{100}	Q_{25}	Q_{25}
ADT<1000	Q_{100}	Q_{10}	Q_{10}
DRIVEWAYS	Q_{100}	Q_{10}	Q_{10}

More information regarding the definition of each design criteria will appear in the structure sizing portion of this technical advisory.

- **Storm Drains**

  Storm drain hydraulic design requires that the magnitudes of runoff generated by contributing areas during the Q_{10} and Q_{50} storm events be determined.

- **Slotted Drain Pipe/Slotted Vane Drain Pipe**

  Generally, slotted drain pipe and slotted vane drain pipe are used as components of a storm drain system. If this is the case, the structure is to be treated as a storm drain and the Q_{10} and Q_{50} storm magnitudes must be determined. In the rare cases that these structures are used as a culvert that also intercepts sheet flow, the magnitudes of the design storm frequencies listed in the culvert table must be determined in addition to Q_{10} and Q_{50}.

- **Pipe Extensions**

  The design storm frequency requirements for pipe extension structures are identical to the requirements for new structures of the same application.

- **Culvert Extensions**

  The design storm requirements for culvert extension structures are identical to those for new culverts.

- **Underdrains & Drain Tile Structures**

  The design storm concept does not apply to these structures.

If a designer has any questions regarding hydrological calculation requirements, he must contact the Standards Section or the Hydraulics Unit.

DETERMINE REQUIRED STRUCTURE SIZE & TYPE

Once the required design storm runoff magnitudes for each structure have been determined, the structure sizing process can begin. Again, the Hydraulics Unit is responsible for performing this function for projects designed by INDOT central office personnel. Designers of all other projects are responsible for structure sizing.

The following methods are acceptable for performing the structure sizing process:

- **Culverts (New and Extended Structures)**
  - HY-8 Computer Software.
  - FHWA Manual “Hydraulic Design of Highway Culverts” (HDS No. 5).

- **Storm Drains (New and Extended Structures)**
  - HYDRA Module of HYDRAIN Software Package.
  - Any Commercially Available Design Software Capable of Sizing Pipes Based on Gravity Flow and Performing Hydraulic Grade Line Calculations.
  - Hand Calculations Satisfying Gravity Flow and Hydraulic Grade Line Requirements Noted Above.

- **Slotted Drain Pipe & Slotted Vane Drain Pipe**
  - Manufacturer’s Publications with Capture Rate Information for Sag and On-grade Installations.

If a designer has any doubt whether his intended structure sizing method is acceptable, he must contact the Hydraulics Unit.

CULVERT STRUCTURE SIZING PROCESS

The hydraulic design criteria for culverts appeared in the table located in the hydrology section of this memo. These criteria are listed and defined below:

- **Allowable Headwater**-For the appropriate design storm frequency, the headwater elevation for the proposed structure cannot exceed the existing condition. There may also be additional site constraints that restrict the allowable headwater elevation to below existing levels. One such limitation is that the headwater elevation at a culvert may not exceed the natural channel flood profile by more than 0.3 m. Other sample constraints include the following:

  - Grade of upstream driveways.
  - Finished floor elevation of adjacent buildings or other improvements.
  - Elevation of existing crop land or other property.

- **Roadway Serviceability**-For the appropriate design storm, headwater caused by the proposed pipe cannot exceed the following:

  - If Q_{100} is the appropriate design storm, the headwater elevation must be at least 0.6 m below the edge of pavement elevation.

- If the appropriate design storm frequency is less than Q_{100}, the headwater elevation must not exceed the edge of pavement elevation.

- **Maximum Velocity**-All culverts require energy dissipators to prevent erosion. The dissipator design must be in accordance with the April 1988 edition of the INDOT "Channel Design" manual or another method approved by the Hydraulics Unit. The riprap used in the dissipators is to be in accordance with the following:

  - Revetment riprap is required at all structures with an outlet velocity of 2.0 m/s or less.
  - Class 1 riprap is required at all structures with an outlet velocity between 2.0 m/s and 3.0 m/s.
  - Class 2 riprap is required at all structures with an outlet velocity greater than or equal to 3.0 m/s.

If clear zone or other issues prohibit the use of the required riprap gradation, the designer must contact the Hydraulics Unit for additional instructions.

The culvert sizing process is performed in accordance with a priority system. This system consists of six trials where specific installations are considered prior to evaluating other structure types. The design priority system is listed below:

- **Trial 1**-Single Circular Pipe Installation.
- **Trial 2**-Single Deformed Pipe Installation.
- **Trial 3**-Single Specialty Structure Installation.
- **Trial 4**-Multiple Circular Pipe Installation.
- **Trial 5**-Multiple Deformed Pipe Installation.
- **Trial 6**-Multiple Specialty Structure Installation.

The principles of the priority system are summarized below:

- Pipe structures are preferred to specialty structures (precast reinforced concrete box sections, precast reinforced concrete three sided culverts, or structural plate arches).
- Circular pipes are preferred to deformed pipes.
- Single cell installations are preferred to multiple cell installations.

During the performance of Trials 1, 2, 4, or 5 of the culvert sizing process, specific pipe materials are not to be considered. Instead, two generic designs are required. One design will size pipes with smooth interiors and the second will size pipes that have corrugated interiors. The smooth interior hydraulic design will be

based on a Manning's n value of 0.012 and can use nomographs or computer software normally used for sizing reinforced concrete pipe. The corrugated hydraulic design is based on a Manning's n value of 0.024 and can utilize nomographs or computer software traditionally used to size corrugated metal pipe. If the corrugated pipe design indicates that structural plate pipe is required, the Manning's n value must be in accordance with accepted engineering practice. Nomographs or computer software used to size structural plate pipe may be used to determine the required size for these larger structures.

The two hydraulic designs for an individual structure will be based on identical pipe lengths and invert elevations.

When separate hydraulic designs are performed for smooth and corrugated interior pipe, the following scenarios are possible:

- **Case 1**-The required smooth interior and corrugated interior pipe sizes are identical. In this case, the structure callout in the plans includes the required pipe size and no reference to an interior designation is made.
- **Case 2**-The required smooth interior and corrugated interior pipe sizes are different. In this case, the structure callout in the plans indicates the structure requires a smooth pipe of one size or a corrugated pipe of another.
- **Case 3**-An acceptable pipe size can be determined for one interior designation, but not the other. When this situation occurs, the structure callout will indicate the required pipe size and interior designation.
- **Case 4**-No acceptable pipe size can be found for either interior designation. The designer must proceed to the next trial of the culvert sizing process.

If it is determined that a pipe is acceptable for a culvert structure, the proposed pipe size must be greater than or equal to the minimum sizes tabulated below:

Structure Application	Minimum Circular Paper Size	Minimum Deformed Pipe Size
Driveway Culvert	375 mm	0.10 m^2
Mainline/Public Road Approach Culvert (2 lanes)	375 mm	0.10 m^2
Mainline/Public Road Approach Culvert (3+ lanes)	900 mm	0.60 m^2

In addition to the minimum pipe size requirements listed above, cover is another factor that the designer needs to consider during

the structure sizing process. For circular pipe structures, a minimum of 0.30 m of cover (measured from the top of the pipe to the bottom of the asphalt or concrete pavement) must be provided. If the structure requires a deformed corrugated interior pipe material, at least 0.45 m of cover must be provided. The cover over a circular pipe structure should never exceed 30.5 m and the cover for deformed corrugated interior pipe structures should never exceed 4.0 m. If the pavement grade or structure invert elevations cannot be adjusted to conform to the cover criteria discussed above, the Standards Section must be contacted for additional instructions.

The culvert sizing process is illustrated by Figures A-1 through A-6 located in Appendix A of this technical advisory.

STORM DRAIN STRUCTURE SIZING PROCESS

Roadway Type/No. Of Travel Lanes	Allowable Encroachment	Storm Frequency
Interstate	Edge of Travel Lane	Q_{50}
More Than Two Travel Lanes	Across One Half of a Travel Lane	Q_{10}
Two Travel Lanes	1.2 m onto Travel Lane	Q_{10}
One Lane Ramps	2.4 m of Ramp Must Remain Clear	Q_{10}

The number of travel lanes represents the number of lanes designated for through traffic.

Median inlet spacing for interstate and other divided highways is also based on an allowable encroachment width. Runoff collected by inlets in grass or paved median areas must not encroach beyond the inside pavement edge for the storm frequency listed above.

Curb inlet spacing calculations must be in accordance with accepted engineering practice. The designer must contact the Hydraulics Unit if there is any question whether the intended calculation method is acceptable. Gutter flow that bypasses curb inlets installed on grade must be accounted for at downstream structures. In addition, flanking inlet(s) should be provided at sag locations to mitigate ponding problems resulting from grate clogging.

After calculating the required curb inlet spacing, actual inlet locations must be determined. All curb inlets and associated laterals must be included in all system modeling required for the design and check storm evaluation discussed below:

- **Design Storm**-All storm drain structures are to be designed so that Q_{10} passes through each structure via gravity.

- **Check Storm-**The storm drain network must accommodate the Q_{50} storm event. The system may operate under pressure, but the Hydraulic Grade Line (HGL) must remain below the rim elevation at all system manholes, inlets, catch basins, and other similar structures.

The design process for storm drain structures does not require two sets of hydraulic calculations, because all pipe materials acceptable for use as storm drains have a smooth interior designation. Therefore, computer modeling or hand calculations for storm drain pipe sizing can be based on a Manning's n value of 0.012.

The minimum pipe size utilized for storm drain structures is 300 mm or 0.10 m^2. The cover provided over a storm drain structure must be at least 0.30 m and no greater than 30.5 m. The minimum full flow velocity for storm drain structures is 0.8 m/s and the recommended maximum velocity is 2.0 m/s. Storm drain outlet structures also require energy dissipators to mitigate potential erosion. The dissipator riprap gradation requirements are identical to those outlined for culvert structures. The Hydraulics Unit must be contacted for additional instructions if the required riprap gradation is prohibited due to clear zone or other issues.

If a satisfactory pipe cannot be found for a storm drain structure, the only acceptable specialty structure type is the precast reinforced concrete box section. If a suitable precast reinforced concrete box section size cannot be determined, the Hydraulics Unit must be contacted for additional instructions.

SLOTTED DRAIN/SLOTTED VANE DRAIN PIPE STRUCTURE SIZING PROCESS

The design requirements for these structure types depend on the application for the structure. Commonly used applications and the associated design requirements are listed below:

- **Superelevated Pavement Edge Installations (Slotted Drain Pipe)**-When installed adjacent to the edge of superelevated pavement sections, the slotted drain sizing is to be based on a 50 year storm frequency for interstate facilities and a 10 year storm frequency for all other roadways. The pipe sizing must be in accordance with accepted practices contained in recognized engineering publications.
- **Gutter Installations at Sag Curb Inlets (Slotted Drain Pipe)**-The design storm requirements for these installations are identical to those for storm drains. The length and size of pipe required must be determined in accordance with accepted practices contained in recognized engineering publications.
- **Storm Drain Structure-**Slotted drain pipe or slotted vane drain pipe installed as a component of a storm drain system must

adequately intercept sheet flow and also accommodate all upstream runoff collected by the storm drain system. Therefore, the sizing process involves two steps for these structures. The structure is first sized in accordance with the storm drain sizing procedure outlined previously in this memo (one exception is that Manning's n=0.024 for slotted drain pipe). The pipe size obtained from the above process must be checked for adequacy for interception of sheet flow. The sheet flow interception design storm frequency is to be Q_{50} for interstate facilities and Q_{10} for all other roadways.

- **Culvert Structure**-The sizing of a slotted drain pipe (corrugated interior designation) or a slotted vane drain pipe (smooth interior designation) for a culvert application is also a two step process. The structure is first sized as a culvert in accordance with all requirements for culvert sizing outlined previously. After the appropriate culvert size is determined, it is necessary to verify whether the structure is adequate for intercepting sheet flow at the site.

If the required slotted drain pipe or slotted vane drain pipe size exceeds the maximum size listed on the appropriate standard drawing, the Hydraulics Unit must be contacted for additional instructions.

PIPE EXTENSION STRUCTURE SIZING PROCESS

The sizing of pipe extension structures is to be in accordance with the following:

- **Match Existing Pipe Size and Interior Designation**-If possible, the pipe extension should be the same size and material as the existing pipe. However, at this stage, it is only necessary to identify the required interior designation for the extension.
- **Perform Appropriate Hydraulic Analysis**-If the extended structure is a culvert, the appropriate hydraulic calculations must be performed to verify whether the extended structure meets all design criteria. Because the structure interior designation is known, it is only necessary to perform hydraulic calculations appropriate for that interior designation. If the structure is a storm drain, the hydraulic analysis must verify that all storm drain design criteria outlined previously are met.

If the extended structure meets all required design criteria, then the structure sizing process is complete. If the extended structure does not meet the required design criteria, the designer must reevaluate whether the existing structure can be replaced with a new structure. If it is not possible to replace the existing pipe

because of construction method, traffic maintenance, or other concerns, the Hydraulics Unit must be contacted for further instructions.

CONCRETE CULVERT EXTENSION SIZING PROCESS

If an existing cast-in-place reinforced concrete slab-top culvert, box culvert, or arch culvert requires extending, the designer must decide whether the extension will be constructed using cast-in-place reinforced concrete or precast reinforced concrete box sections. Once the extension method has been determined, the appropriate culvert design criteria must be checked to verify that the extended structure meets all hydraulic requirements. If the analysis indicates that the extended structure does not meet the hydraulic requirements, the designer must reevaluate whether the existing structure can be removed and replaced with a new structure. If it is not possible to replace the existing culvert because of construction method, traffic maintenance, or other concerns, the Hydraulics Unit must be contacted for further instructions.

DRAIN TILE STRUCTURE SIZING PROCESS

There is no formal structure sizing process for structures required to perpetuate existing drain tile. These structures are to match the size of the existing tile, if possible. If it is not possible to match the existing tile size, the Hydraulics Unit must be contacted for additional instructions.

PERFORM SANITARY SEWER & WATER UTILITY COORDINATION

Coordination with utilities should begin as soon as possible once it is determined that the proposed construction will impact existing utility facilities. On INDOT projects, the coordination will be handled through the Utilities Unit. For projects not on INDOT routes, the designer should contact all affected utilities as soon as possible.

If it is determined that utility relocation elements are going to be included in the contract, the designer must verify that all elements of the utility construction are included in the contract documents. For example, the Standard Specifications contain no material or testing requirements for sanitary sewer or water main pipe. Therefore, if construction of these facilities is required, the designer is responsible for including all applicable requirements in the contract via special provision(s). If the utility has specific casting, manhole, or other facility requirements that differ from those contained in the Standard Specifications or standard drawings, these requirements must be included in the contract via plan details or special provisions.

PRELIMINARY FIELD CHECK PLAN PREPARATION REQUIREMENTS

There are two plan submittals during the design process that are important with respect to hydraulic design. The landmark submittals in the plan development schedules normally followed by road and bridge replacement projects are the Preliminary Field Check Plans and Final Check Prints. For traffic projects, bridge rehabilitation projects, or other projects that do not follow the typical road or bridge replacement submittal schedule, the incorporation of pipe-related elements into plan submittals is to be determined on a project-by-project basis. Consultant designers are responsible for coordinating with the INDOT reviewer to determine when the pipe related elements are to be incorporated into plan submittals for these projects.

As a minimum, the Preliminary Field Check Plans must include hydraulic related information on the following sheets:

- Plan & Profile Sheet(s).
- Construction Detail Sheet(s) (if included in plans).
- Structure Data Sheet(s).

Structure related information to be included on the Plan & Profile Sheet includes the following:

- Plan Portion of Sheet.
  - Structure Callout.
    - Structure Number & Location.
    - Type of Manhole, Inlet, or Catch Basin, if required.
    - Structure Length.
    - Structure Size & Type.
      - Pipe.
      - Smooth Pipe.
      - Corrugated Pipe
      - Smooth Pipe or Corrugated Pipe.
      - Precast Reinforced Concrete Box Section (Include Structure Skew).
      - Precast Reinforced Concrete Three Sided Culvert (Include Structure Skew).
      - Structural Plate Arch (Include Structure Skew).
      - Pipe Extension.
      - Culvert Extension.
      - Slotted Drain Pipe.
      - Slotted Vane Drain Pipe.

    - Pipe End Treatments, if Required.
        - Pipe End Section.
        - Concrete Anchor.
        - Safety Metal End Section.
        - Grated Box End Section.
- Profile Portion of Sheet.
    - Structure Number.
    - Structure Invert Elevation Information.
    - Length, Size, & Slope of Storm Drain Main Structures.

Sample Plan & Profile Sheet structure callouts are listed below:

- Structure No. 11 @ +123.2-Manhole Type C-4, 84.1 m 450 mm Pipe, & 1 Pipe End Section Required.
- Structure No. 12 @ +123.2-15.5 m 375 mm Pipe and 2 Pipe End Sections Required.
- Structure No. 13 @ +123.2-24.0 m 900 mm Smooth Pipe and 2 Pipe End Sections or 1050 mm Corrugated Pipe and 2 Concrete Anchors Required.
- Structure No. 14 @ +123.2-19.5 m Min. Area 0.10 m^2 Corrugated Pipe and 2 Grated Box End Sections Required.
- Structure No. 15 @ +123.3-28.0 m Min. Area 0.17 m^2 Smooth Pipe and 2 Safety Metal End Sections Required.
- Structure No. 16 @ +123.2-24.5 m 1800 mm x 1200 mm Precast Reinforced Concrete Box Sections Required, Skew 30E Right.

Structure sizes in plan callouts are to be in accordance with tables included in Appendix B of this memo. In general, structure sizes are expressed as follows:

- Circular pipe sizes are expressed by the diameter in mm.
- Deformed pipe sizes are expressed in terms of minimum area in m^2.
- Precast reinforced and cast-in-place concrete structure sizes and structural plate arch structure sizes are expressed by the span and rise in mm.

Structure lengths are to be determined in the following manner:

- **Culvert Structures (Including Pipe & Culvert Extensions)**-The structure length is to be rounded up to the next 0.5 m.
- **Storm Drain Structures (Including Pipe Extensions)**-The structure length is to be rounded up to the next 0.1 m. The measurement is to be made along the pipe centerline from the outside edge of the wall of the manhole, inlet, or catch basin structure.

If a culvert structure requires different smooth interior and corrugated interior pipe sizes, the required pipe length and invert elevations are identical for the two structure alternates.

When it is known that existing drain tile will be impacted by the proposed construction, the plans must illustrate how the tile is to be perpetuated. Perpetuation of field tile will be in accordance with the following:

- **Tile Outlets at Ditch Prior to Crossing Mainline Pavement**-The existing tile is to be removed within the right-of-way and replaced with Type 4 Pipe (an explanation of pipe types occurs later in this memo). A 3.0 m long section of drain tile terminal section equipped with a rodent screen is required to be placed on the outlet end of the Type 4 Pipe.
- **Tile Will Outlet in Storm Drain System**-If the tile is to be perpetuated by tying into a storm drain, the existing tile must be removed within the right-of-way. The tile will be replaced with Type 2 pipe and will connect to the storm drain system at a manhole, inlet, catch basin, or similar structure.
- **Tile is Intercepted by Side Ditch After Crossing Mainline Pavement**-The existing tile will require removal within the existing right-of-way. New Type 1 pipe will be installed between the right-of-way line and the proposed outlet location. A rodent screen is required at the pipe outlet.
- **Tile is to be Perpetuated Across the Right-of-Way**-All existing tile within the right-of-way is to be removed. Type 1 pipe will be required from right-of-way line to right-of-way line to replace the existing tile.

Concrete collars are required to connect existing tile to Type 1, 2, or 4 pipe. The plans must contain a detail that illustrates the dimensional requirements of all collars.

At locations where a reconstructed drain tile outlets into a side ditch, riprap is required between the pipe outlet and the ditch flow line to prevent erosion. Revetment riprap is to be used unless clear zone or other considerations require that a different gradation be utilized.

The structure related information to be included on detail sheets depends on the project and the type of details provided in the plans. If construction details are included, structure callouts must be included for identification purposes, but the callouts may refer to the appropriate Plan & Profile Sheet.

The Structure Data Sheet requires the following structure related information:

- Structure Number & Location.
- Structure Size.
- Pipe Type, if Applicable.
- Structure Description, as Appropriate.
  - Required Manhole, Catch Basin, or Inlet.
  - Pipe.
  - Smooth Pipe.
  - Corrugated Pipe.
  - Precast Reinforced Concrete Box Section.
  - Precast Reinforced Concrete Three Sided Culvert.
  - Structural Plate Arch.
  - Pipe Extension.
  - Culvert Extension.
  - Slotted Drain Pipe.
  - Slotted Vane Drain Pipe.
- Structure Length.
- Structure Skew (Precast Reinforced Concrete & Structural Plate Structures Only).
- Cover (Not Required for Precast Reinforced Concrete Three Sided Culverts).
- Invert Elevations.
- Service Life Criteria (Type 1, 2, 3, & 5 Pipe, Specific Pipe Material, and Pipe Extension Structures Only).
  - Required Service Life Duration.
  - Structure Site Designation (Abrasive or Non-abrasive).
  - Structure pH.
- B Borrow for Structure Backfill.
- Revetment Riprap.
- Pipe End Treatments.
  - Concrete Anchor.
  - Pipe End Section.
  - Grated Box End Section.
  - Safety Metal End Section.

For new structures that require pipe (excluding slotted drain pipe or slotted vane drain pipe), it is generally intended that the contractor be allowed to select a pipe material from a list of materials that are acceptable for installation at the structure site. At this time, it is not necessary to determine the acceptable materials for individual structures, but the designer does need to determine the appropriate pipe type from the classification system included in the Supplemental Specifications. The appropriate pipe type for various structure applications is to be selected from the list below:

- **Type 1 Pipe**-Mainline and Public Road Approach Culverts.
- **Type 2 Pipe**-Storm Drain Structures.
- **Type 3 Pipe**-Driveway Culverts.
- **Type 4 Pipe**-Longitudinal Underdrains and Drain Tile.
- **Type 5 Pipe**-Broken-back and Other Structures that Require Coupled Pipe.

Pipe type structures requiring different smooth interior and corrugated interior pipe sizes require two complete sets of entries on the Structure Data Sheet. The top row reflects the data for the smooth interior structure alternate and the second row contains the data related to the installation of the corrugated interior pipe alternate.

If there is sufficient justification, it is permissible to require a specific pipe material for a structure instead of designating a pipe type. The justification must be documented in the design calculations. Structure Data Sheet entries for these structures are not to include a pipe type designation, as the word “Pipe” is to be the structure description.

Pipe service life criteria must be determined for all structures requiring Type 1, 2, 3, and 5 Pipe, as well as specific pipe material, and pipe extension structures. These criteria are determined in the following manner.

- **Required Service Life Duration**-The required service life depends on the functional classification for the contract’s mainline roadway. If the mainline has an interstate or arterial functional classification, the required service life duration for all structures in the contract is 75 years. If the mainline functional classification is collector or local, the required service life duration for all structures on the project is 50 years.
- **Structure Site Designation**-Structure sites are defined as being either “abrasive” or “non-abrasive”. All mainline culvert sites must be given an abrasive designation. In a similar vein, driveway and public road approach culverts installed in natural channels also have sites classified as abrasive. Driveway and public road approach culverts installed on constructed ditch lines and storm drain structures are generally given non-abrasive site designations. However, if the designer determines that runoff at an individual structure site is likely to contain materials that could damage the pipe interior, the designer is permitted to assign an abrasive site designation to the structure. A non-abrasive site designation is to be given for Type 1 pipe or Type 2 pipe used for perpetuating drain tile.

- **Structure pH**-Each culvert and storm drain structure that requires pipe (except slotted drain pipe and slotted vane drain pipe) must be assigned a structure pH value. During the design process, two to three pH values are obtained for each structure. The lowest (most acidic) value is the pH assigned to the structure.

  Prior to the Preliminary Field Check plan submittal, a preliminary structure pH value must be determined and recorded on the Structure Data Sheet. The preliminary pH value is obtained from one of the following sources:

  - **Scope Report**-Some scope reports will include pH data for existing structure locations. This pH data can be used to establish preliminary structure pH values for proposed structures as described below:
    - **Existing Mainline Culvert Structures**-The scope report pH value at an existing culvert site is considered to be the preliminary pH for the corresponding proposed structure(s).
    - **Existing Storm Drain Structures**-The scope report pH value for an existing storm drain structure is considered to be the preliminary pH value for all structures in the corresponding proposed storm drain system. If the scope report contains pH values for more than one structure in an existing storm drain system, the lowest value will be considered the preliminary pH for all proposed structures in the corresponding storm drain system.
    - **Existing Side Ditch Culverts**-The scope report pH value for an existing side ditch culvert is considered to be the preliminary pH value for all proposed structures on the corresponding segment of side ditch. If the scope report contains pH data for more than one culvert on the same ditch line segment, the lowest value will be considered the preliminary pH for all culverts on the equivalent proposed ditch line segment.
  - **Testing**-Proposed structures that have not been assigned a preliminary pH value after review of the scope report may require testing of runoff samples to obtain the value. Consultant designers need to refer to the project Design Agreement to verify whether provisions for pH testing are included. If no such provisions are included in the Design Agreement, pH testing will not be performed. If the Design Agreement includes pH testing provisions, such testing will be utilized to determine the preliminary pH value for all remaining pipe structures. The scope of the testing required will be in accordance with Appendix C of this memo. INDOT designers will begin performing pH testing in accordance with Appendix C requirements in January 1999.

When a sample is required for an existing storm drain system, the sample is to be taken at the system outlet. It is not necessary to remove structure castings to obtain samples.

If pH testing is warranted for the project, but no water is available for sampling at a required structure, the following rules apply:

- **Mainline Culverts**- If a sample can be taken at an adjacent mainline culvert, the pH of that sample will also be assigned to both corresponding proposed structures. If no sample can be taken at an adjacent structure, the preliminary pH value required for the proposed structure will not be determined by testing.
- **Storm Drain Structure**-If a sample is available at the outlet of an adjacent existing storm drain system, the sample pH will apply for all structures in both corresponding systems. If samples are not available at outlets of adjacent systems, the preliminary pH for the structures in the storm drain system under consideration will not be determined by testing.
- **Side Ditch Culverts**-If a sample is available at any existing pipe in the same segment of side ditch, the pH of that sample will apply to all corresponding proposed culverts in the ditch line segment. If samples are not available at any existing culvert in the ditch line segment, the preliminary pH value for all corresponding proposed structures will not be determined by testing.

- **Map**-If proposed pipe structures have not been assigned preliminary pH values based on scoping report data or from field testing, the pH map contained in Appendix C of this memo can be used to determine the required values. The map illustrates the pH value that is to be assigned to all structures within each county.

Structure pH values are not to be greater than 7.0 and are expressed to the nearest 0.5. If pH testing is performed and the equipment provides more precise readings, the pH value is to be rounded down to the next (more acidic) 0.5.

The structure pH for Type 1 Pipe used for perpetuation of existing drain tile will be equal to the pH map value for the project location. The structure pH value for Type 2 Pipe used for existing drain tile perpetuation will be equal to the structure pH for the storm drain system that serves as the tile outlet.

If a designer has any questions regarding the procedures related to the determination of the structure pH value for the Preliminary Field Check Plans, please contact the Standards Section.

The Preliminary Field Check version of the Structure Data Sheet does not require that individual structure quantities be recorded for backfill or riprap items. It is satisfactory to place an "X" in those columns of the table to indicate that these items are required for individual structures.

Beginning with the September 1998 letting, concrete anchors will be measured and paid for by the unit. Therefore, if a designer has downloaded the original version of the revised Structure Data Sheet, it will be necessary to revise the "Concrete, A, Structures" and "m^3" column headers to "Concrete Anchor" and "EA" respectively.

For plan submittals after the Preliminary Field Check Plans and before the Final Check Prints, the designer is simply required to maintain the same requirements for structure design and plan preparation that have been described for the Preliminary Field Check Plan submittal.

FINAL CHECK PRINTS SUBMITTAL REQUIREMENTS

The Final Check Prints Submittal requires the following additional plan preparation elements:

- **Incorporate Comments from Previous Submittal.**
- **Finalize Structure Data Sheet.**
- **Prepare Pipe Material Sheet.**
- **Prepare Underdrain Table.**

In order to perform the above tasks, it is necessary to complete the following work elements:

- **Finalize Structure pH Values**-The Preliminary Field Check Plans Structure Data Sheet contains a preliminary pH value for all proposed culvert and storm drain structures that require pipe. It is necessary to obtain additional data prior to determining a final pH value for these structures. This data may be obtained from the following source:
  - **Geotechnical Report**-If a geotechnical report is available for the project, it may contain pH data for existing structures. This data can be used to assign a second pH value to corresponding proposed structures in accordance with procedures stated earlier in this memo for converting existing structure pH data contained in scoping reports.

- **Testing**-If a proposed structure second pH value is not available from a geotechnical report, it may be obtained via pH testing. Testing by consultant designers will be required if provisions for testing are included in the Design Agreement for the project. INDOT designers are required to perform testing after January 1, 1999. The testing will be performed in accordance with the procedures shown in Appendix C and discussed in the Preliminary Field Check Plans portion of this memo.
- **Map**-If a geotechnical report or pH testing does not provide the second pH value for a pipe structure, the pH map in Appendix C can be used to determine the required value.

Again, pH values are to be recorded to the next 0.5 and the maximum structure pH is 7.0.

After the second pH value has been obtained for each structure, it is to be compared to the structure's preliminary pH. If the two values are within 0.5 of each other, the final structure pH is the lower value. If the two values vary by more than 0.5, a third structure pH is required. The third value is obtained by testing, if the conditions for pH testing discussed previously in this memo are met. If testing is not appropriate, the third pH value is obtained by referring to the Appendix C pH map. The three structure pH values are then compared and the lowest value is considered the final structure pH. The final structure pH is then recorded on the Structure Data Sheet.

- **Perform Pipe Material Selection Process**-After structure pH values are finalized, it is the appropriate time to determine the acceptable materials for all structures that require pipe (except slotted drain pipe and slotted vane drain pipe).

  There are two formal methods for determining the acceptable materials for Type 1, 2, 3, and 5 pipe structures. The first method requires a review of the 715-PIPE, 715-PSLC, AND 717-PHCL standard drawings to determine which materials are appropriate for the proposed cover depth and service life criteria at the site. The alternative to performing a manual review of the standard drawings is to allow the Pipe Material Selection Software to perform an electronic one.

  When performing the pipe material selection process, each corrugated metal pipe protective coating or invert treatment is considered to be a distinct material. For example, the following list includes three materials:

- Zinc Coated Corrugated Steel Pipe.
- Zinc Coated Corrugated Steel Pipe with Bituminous Paved Invert.
- Polymer Precoated Galvanized Corrugated Steel Pipe.

Although all three are varieties of corrugated steel pipe, they are considered unique in terms of this design procedure.

If the pipe material selection process is performed and the result is that no materials are found to be acceptable, the designer must contact the Standards Section for additional instructions.

If it is determined that only one pipe material is acceptable for a structure, no pipe type is designated for the structure. A pipe type designation for a structure indicates that there are at least two materials acceptable for installation. The Final Check Print version of the Structure Data Sheet has a dash (--) entered in the “Pipe Type” column and the word “Pipe” is entered in the column to the right. The Pipe Material Sheet is used to identify the required material for the structure.

When two or more materials are found to be acceptable for a structure, the required pipe type designation remains in effect. The required Structure Data Sheet entries include the required pipe type in the appropriate column and the word “Pipe” in the column to the right. If the structure is a culvert and all of the acceptable materials have the same interior designation, the “Pipe” entry is modified to include the appropriate interior designation. All acceptable materials are listed on the Pipe Material Sheet.

The pipe material selection process does not apply to Type 4 Pipe structures. In addition, Type 4 pipe structures do not appear on the Pipe Material Sheet. The materials listed in 715.02(d) of the Standard Specifications are appropriate for all such structures.

The material selection process for pipe extension structures differs somewhat from the process for structures utilizing new pipe. The rules for material selection for pipe extension structures are as follows:

- **A Specific Material is Required**-A specific material must be determined for each pipe extension structure. No pipe type is to be assigned to a pipe extension structure.

- **Match Existing Pipe Material**-Whenever possible, the extension material is to match the existing pipe. If the existing pipe is corrugated metal, but it is not known whether it is steel or aluminum alloy, the extension should be a corrugated steel pipe material.
- **Material Must Meet Cover and Service Life Criteria**-The thickness of corrugated metal pipe extensions or $D_{0.3}$ rating for reinforced concrete pipe extensions must meet all cover and service life requirements that apply to new pipe structures.
- **Match Existing Corrugated Metal Pipe Coating**-If the existing pipe is corrugated metal, the extension coating should match that of the existing pipe, if possible. If the existing pipe is fully bituminous coated, the extension should be fiber bonded bituminous coated. If it is impossible to match the existing pipe coating or the existing pipe coating is unknown, any coating/thickness combination that satisfies cover and service life requirements may be used.

The material selection process for extensions of existing reinforced concrete slab-top, box, or arch culverts consists of determining whether the extension will be constructed of cast-in-place reinforced concrete or precast reinforced concrete box sections. A dash (--) is to be entered in the "Pipe Type" column and the words "Cast-in-Place Culvert Extension" or "Precast Concrete Box Section Culvert Extension" are entered in the column to the right. In addition, all cast-in-place extensions must be detailed in the plans. The details can be prepared in the same manner as those typically required for widening of an existing bridge structure. Plan details may be required for precast reinforced concrete box section extensions. It is up to the designer to review the available standard drawings and determine if additional plan details are required. No entries for concrete culvert extension structures are required on the Pipe Material Sheet.

There is no material selection process performed for the following new structures as they are either specifically designed or they have a specific application:

- Precast Reinforced Concrete Box Sections.
- Precast Reinforced Concrete Three Sided Culvert.
- Structural Plate Arch.
- End Bent Drain Pipe.
- Slotted Drain Pipe.
- Slotted Vane Drain Pipe.

Structure Data Sheet entries for these structures include a dash (--) in the “Pipe Type” column and the specific structure name is listed in the column to the right. No Pipe Material Sheet entries are required for these structures.

- **Determine Underdrain Layout**-The following rules apply to the design of underdrain systems:
  - **Underdrain System Warrant**-Underdrains are warranted if the pavement design indicates that they are required. If no pavement design is performed for a project, underdrains are only used if approval is obtained from the Materials Engineering Section. If underdrains are warranted, installation requirements must be shown on the Typical Cross Section Sheet.
  - **Geotextiles for Underdrain Warrant**-Geotextiles for underdrains are warranted only if required by the Geotechnical Report. If no Geotechnical Report is available, geotextiles for underdrains are only used when approved by the Geotechnical Section.
  - **Underdrain Outlet Pipe**-PVC pipe is used for underdrain outlets. The pay item for this pipe is “Pipe, Underdrain Outlet”.
  - **Connection of Longitudinal Underdrain to Outlet Pipe**-Elbows used to connect longitudinal underdrains to outlet pipe at on-grade outlets are included in the Type 4 Pipe quantity. Wyes used to connect longitudinal underdrains to outlet pipe at a sag location are included in the quantity for the underdrain outlet pipe. Allowances for elbows and wyes are 0.6 m and 1.5 m, respectively.
  - **Transverse Pipes**-Transverse pipes connecting longitudinal underdrains are not to be used. If the only available outlet for a longitudinal underdrain is located on the opposite side of the installation, an outlet pipe must be installed across the pavement and under the opposing longitudinal underdrain. If no suitable outlet is available on either side of the pavement, the designer must contact the Materials Engineering Section for further instructions.
  - **Maximum Outlet Spacing**-The maximum outlet spacing for longitudinal underdrains should be limited to 100 m, where practical.
  - **Minimum Underdrain Grade**-The minimum underdrain grade is 0.20%. At locations where the profile grade is flatter than 0.20% (including within vertical curve limits), special underdrain grades must be determined and shown on the plans. The method of illustrating the special grades is up to the designer. However, the special grade limits and required depths must be clearly defined.

- **Underdrain Backfill**-Longitudinal underdrains are backfilled with aggregate for underdrains. This aggregate is measured and paid for by the cubic meter. The backfill used for underdrain outlet pipe to 0.3 m outside the shoulder is B borrow for structure backfill. Suitable excavated material is utilized as backfill for the remainder of the outlet pipe. Outlet pipe backfill is not measured for payment as its cost is included in the cost of the pipe.
- **Outlet Protectors**-Outlet protectors are required at the end of underdrain outlet pipes. Type A protectors are required at outlets located on the outside of interstate and other divided highway facilities. Type B outlet protectors are required at all other locations. Sod and delineator posts used in conjunction with outlet protectors are not measured for payment as the costs associated with these items are included in the cost of the outlet protector.

- **Perform Quantity Calculations**-The first step in the quantity calculation process is identification of the appropriate pay items. The following rules apply to pipe related pay items:
  - All drainage structures, except slotted drain pipe and slotted vane drain pipe, that require method 1 or method 2 backfill as shown on the 715-BKFL series of standard drawings will have their backfill quantities calculated assuming B borrow for structure backfill will be utilized.
  - Pipe type pay items never include information related to specific materials, such as thickness, strength classification, $D_{0.3}$ rating, etc.
  - The following rules apply to including interior designations in pipe type pay items:
    - Type 2 Pipe pay items never include an interior designation.
    - If all of the acceptable materials for a culvert structure have the same interior designation, the pipe type pay item must include a reference to the required interior designation (i.e. Pipe, Type 3, Circular, 375 mm Corrugated).
    - If a culvert structure pipe type pay item includes an interior designation, the designation does not appear in pay items for related work. For example, if the pay item for a structure is Pipe, Type 1, Circular, 900 mm Smooth, the pay item for pipe end sections placed on the pipe ends is “Pipe End Section, 900 mm”.
    - If a culvert structure requires different smooth interior and corrugated interior pipe sizes, the pay item for the required structure end treatments reflects both required sizes. For example, if a mainline culvert structure requires 900 mm smooth pipe with two pipe end sections or

1050 mm corrugated pipe with two concrete anchors, the pay items for the structure are as below:

- Pipe, Type 1, Circular, 900 mm Smooth or 1050 mm Corrugated.
- Pipe End Section 900 mm or Concrete Anchor, 1050 mm.
- If a driveway culvert requires 375 mm smooth pipe or 450 mm corrugated pipe and two pipe end sections, the pay items related to the structure are as below:
  - Pipe, Type 3, Circular, 375 mm Smooth or 450 mm Corrugated.
  - Pipe End Section, 375 mm or 450 mm.
  - For structures requiring different smooth interior and corrugated interior pipe sizes, it is necessary to calculate separate backfill quantities for each structure alternate. However, the backfill quantity for the smooth interior alternate is used to calculate the total contract quantity that appears on the Schedule of Pay Items.

- Pay items for specific pipe material structures and pipe extension structures require the following information:
  - Reinforced Concrete Pipe-Strength Classification and $D_{0.3}$ rating.
  - Corrugated Steel Pipe-Required Protective Coating, Invert Treatment, and Material Thickness.
- Specialty structure pay items include the specific required structure type. Sample specialty structures are listed below:
  - Precast Reinforced Concrete Box Sections.
  - Precast Reinforced Concrete Three Sided Culvert.
  - Structural Plate Arch.
  - Slotted Drain Pipe.
  - Slotted Vane Drain Pipe.
  - Underdrain Outlet Pipe.
  - End Bent Drain Pipe.

If a designer has any questions regarding pay item format requirements, he must contact the Standards Section. If there are questions regarding the relationship between pay items and the HighEst estimating software, he must contact the Contracts Section.

- **Standard Drawing Selection**-The following rules apply to the selection of pipe related standard drawings:

  - **715-BKFL Series**-These drawings pertain to pipe structures only. If there are specialty structures (i.e. precast reinforced concrete box sections) required for the project,

plan details must be prepared to illustrate trench and backfill requirements for these structures. The designer must evaluate the backfill requirements (method 1 vs. method 2 backfill, trench vs. embankment installations, median installations, etc.) for structures on the project and select the appropriate drawings. The flowable mortar version of the required drawings must also be selected, because the contractor always has the option to substitute flowable mortar backfill for the B borrow for structure backfill included in the contract. Also, if any sheet from the series is required for the contract, sheet 715-BKFL-09 is also required because the general notes for the series are on this sheet.

- **715-PIPE Series**-If the contract includes pipe type pay items, standard drawing 715-PIPE-01 must also be included.
- **715-PHCL Series**-The height of cover tables associated with the materials shown on the Pipe Material Sheet to be acceptable for various structures on the project must be included in the contract.
- **715-PSLC Series**-All three sheets in the series must be included in all contracts that contain pipe type pay items.
- **All Other 715 Standard Drawing Series**-Individual standard drawings are required if details or other information contained on the sheet apply to the contract. The designer must make sure that every series of standard drawings included in the contract has its general note sheet included as well, if such a sheet exists.

- **Special Provision Preparation**-The following rules apply to special provision preparation:
  - **Sanitary Sewer/Water Utility Special Provision**-Recurring special provision 107-R-169 is still required for all contracts that have utility facilities within the project area right-of-way. If sanitary sewer or potable water facility construction is included in the contract, another special provision is also required. This unique special provision must include material requirements for all sanitary sewer and water main pipe. The special provision must also include all testing requirements of the utility. If the utility desires to utilize a casting, manhole, or other facility that differs from requirements contained in the Standard Specifications or shown on the standard drawings, the utility requirements must also be included in the special provision.
  - **Pipe Material Abbreviation Recurring Special Provision 715-R-361**-A recurring special provision containing commonly used pipe related abbreviations has been developed. This recurring special provision allows the designer to utilize the abbreviations on plan sheets, in pay items for structures requiring specific materials, and other contract

documents. This recurring special provision is included in Appendix D of this memo and will be included in the Recurring Special Provisions with the January 1, 1999 edition.

TRACING SUBMITTAL REQUIREMENTS

There are no additional pipe related requirements associated with the Tracings submittal. Any errors contained in the Final Check Print submittal or changes required due to changing conditions at the project site can be corrected prior to the Tracings submittal.

REQUIREMENTS FOR CONTRACT DOCUMENTS REFERRING TO PIPE GROUPS

Projects that have a design notice-to-proceed or begin design development date of June 1, 1997 or later must meet all design and contract document preparation requirements discussed previously in this memo. Projects with a design notice-to-proceed or begin design development date prior to June 1, 1997 had the project hydraulic design and plan preparation work performed in accordance with the procedures in effect at the time. If the designer of such a project wishes, he can incorporate the current hydraulic design and plan preparation requirements into the project. No amendments to Design Agreements will be processed to incorporate the current requirements, however.

In lieu of incorporating the current hydraulic design and plan preparation requirements into these pre-June 1, 1997 projects, the designer can follow alternate procedures discussed below to incorporate the current pipe related specifications. No amendments to Design Agreements will be processed to incorporate these revised requirements.

These alternate procedures do not need to be incorporated into the plans until the Tracings submittal. However, incorporation at the earliest possible date is appreciated. It is much easier to correct errors during the design phase compared to the bidding phase.

ALTERNATE PROCEDURES FOR PROJECTS WITH NOTICE-TO-PROCEED/START DESIGN DEVELOPMENT DATE PRIOR TO JUNE 1, 1997

HYDRAULIC DESIGN REQUIREMENTS

It is not necessary to perform the dual hydraulic design required of pipe culvert structures by the current procedure. This eliminates the potential for pipe pay items that require different smooth interior and corrugated interior pipe sizes. Also eliminated is the potential for pay items of the following formats:

- Pipe End Section, 375 mm or 450 mm.
- Pipe End Section, 900 mm or Concrete Anchor, 1050 mm.

PIPE PAY ITEM REQUIREMENTS

Under this alternate procedure, pipe group pay items may be used to pay for pipe installed on the contract. This allows the designer to utilize all previously prepared plan sheets without making changes to incorporate the pipe types included in the current procedure.

However, there are some differences in how pipe groups are handled compared to the previous procedure. These differences are discussed below:

- **Pipe Groups Are Structure Specific**-The acceptable materials for a pipe group structure will no longer be found in a generic list on a standard drawing.
- **Pipe Group Pay Item Indicates At Least Two Materials Are Acceptable**-If only one material is acceptable for installation at a structure, a pipe group pay item must not be used.
- **Pipe Group Pay Item Does Not Include Material Specific Information**-Information that pertains to specific pipe materials, such as thickness or strength classification, is not included in a pipe group pay item.
- **Pipe Group Pay Item Only Applies to New Structures**-If a structure involves attaching new pipe to an existing one, a pipe group designation is not to be made. A pipe extension pay item that identifies the required material is required for such a structure.

PIPE MATERIAL SELECTION PROCESS

As is the case with the current regular design procedure, it is necessary to perform a material selection process for each structure with a designated pipe group. The following discussion includes the steps required to perform the pipe material selection process using the Pipe Material Selection Software. If the designer uses the metric standard drawings to perform the material selection process, similar principles apply:

- **Convert Pipe Group to Equivalent Pipe Type**-The software requires input based on the regular design procedure. Therefore, a pipe group designation is meaningless to the program and the equivalent pipe type must be determined.
- **Determine Which Pipe Material Interior Designation(s) Are Acceptable for Culvert Structures**-Unless the hydraulic design results state otherwise, program input for culvert structures must indicate that both smooth interior and corrugated

interior pipe materials are acceptable. If the hydraulic design for a structure indicates that only materials of a specific interior designation are to be considered, the program input must reflect the required interior designation. However, it is not necessary to indicate on the plans or include in pipe group pay item that a specific pipe interior designation is required.

- **Determine Structure Service Life Criteria**-The structure pH, required service life duration, and abrasive/non-abrasive site designation are all required input for the software. These parameters are to be determined in accordance with current design procedures. Again, it is not required to record these service life criteria on the plans.
- **Convert Proposed Pipe Size and Cover to Metric Units (if English Contract)**-The software requires metric input and provides output in metric units. Therefore, if the contract is prepared in English units, it is necessary to convert the pipe size and cover depth for each structure to the appropriate metric dimensions. Likewise, after the pipe material selection process is complete, it is necessary to convert the software output (corrugation profile, material thickness, D-load rating, etc.) to English units. The software instruction manual contains information related to English/metric unit conversions.

The pipe material selection process for specialty structures, structures that require a specific pipe material, and pipe extension structures is performed in accordance with current requirements described earlier in this memo.

Perpetuation of existing drain tile impacted by construction activities is handled in the following manner for pre-June 1, 1997 projects:

- If the tile is to be intercepted by a ditch prior to crossing mainline pavement, the existing tile must be removed within the right-of-way and replaced with the appropriate class of drain tile (standard class drain tile is no longer included in the Standard Specifications). A 3.0 m long drain tile terminal section equipped with a rodent screen is required at the outlet end of the structure.
- If the tile is to be intercepted by a ditch after crossing mainline pavement, the existing tile is removed within the right-of-way and replaced with Group A Pipe equipped with a rodent screen. Contact the Standards Section for instructions regarding material selection for these structures.
- If the tile is to be perpetuated by connecting to a storm drain system, the existing tile is removed within the right-of-way and replaced with Group L Pipe. Contact the Standards

Section for instructions regarding the selection of appropriate materials for these structures.

- If the tile is perpetuated by reconnecting to the existing tile at the downstream right-of-way line, the existing tile is removed within the right-of-way and replaced with Group A Pipe. Contact the Standards Section for instructions regarding material selection for these structures.

Revetment riprap is required at drain tile outlets as discussed earlier in this memo for the regular design procedure.

ANALYSIS OF PIPE MATERIAL SELECTION PROCESS RESULTS

If the software indicates that there are no materials acceptable for installation at a structure site, the designer must contact the Standards Section for additional instructions.

If the software indicates that there is only one material acceptable for a structure, no pipe group designation is to be assigned. The Structure Data Sheet entry in the “Pipe Group” column is a dash (--) and the word “Pipe” is entered in the column to the right. The required material is identified on the appropriate version of the Pipe Material Sheet (two versions of the Pipe Material Sheet have been prepared for contracts using pipe group pay items-a metric version and an English version). The pay item for the structure is of the following format-“Pipe, Specific Material Identification, 900 mm”. The specific material identification includes the parameters discussed earlier in this memo for the regular design procedure.

If the software indicates that two or more materials are acceptable for installation at a structure site, the pipe group designation remains in effect. The pipe group is indicated in the appropriate column on the Structure Data Sheet and the word “Pipe” is entered into the column to the right. The acceptable materials are noted on the appropriate version of the Pipe Material Sheet.

Pipe Material Sheet entries for pipe structures requiring a specific material and pipe extension structures are identical to those discussed earlier in this memo for the regular design procedure.

No Pipe Material Sheet entries are required for specialty structures and structures requiring a specific class of drain tile.

UNDERDRAIN REQUIREMENTS

If the contract contains pipe group pay items, longitudinal underdrains must be paid for as Group K Pipe. All other underdrain

related features are to be in accordance with the current requirements discussed earlier in this memo.

STANDARD DRAWING REQUIREMENTS

This alternate procedure requires the following rules related to standard drawing selection:

- Standard drawing 715-PIPE-01 is not included in metric contracts that include pipe group pay items.
- Standard drawings MP and MPA are not included in English contracts that include pipe group pay items. If such a contract includes a structural plate pipe structure that requires concrete field paving, the designer must reproduce the appropriate details from MPA and include them on a plan detail sheet.
- English contracts must use the E 715-BKFL series of recurring plan details instead of Standard Drawings MN and MN-1 to illustrate backfill requirements.
- It is necessary to include all required underdrain details on the Typical Cross Section Sheet for all English contracts. Standard Drawing MN is not to be used on English contracts.

SPECIAL PROVISIONS REQUIREMENTS

The alternate procedure requires the following rules related to special provision preparation:

- **Recurring Special Provision 715-R-341, Pipe Material Selection**-This special provision is required for all contracts with pipe group pay items.
- **Recurring Special Provision 715-R-342, Pipe Backfill Methods**-This special provision is required for all contracts with a Structure Data Sheet that refers to method A or method B backfill.
- **Recurring Special Provision 715-R-361, Pipe Material Abbreviations**-This special provision is available for designers who wish to use abbreviations for specific pipe materials in contract documents.
- **Recurring Special Provision 718-R-326, Underdrains**-This special provision is required for all contracts that pay for longitudinal underdrains as Group K Pipe.

If there are any questions regarding contract document requirements for projects with a design notice-to-proceed or start development date prior to June 1, 1997, the Standards Section must be contacted immediately.

This memorandum was prepared by Jeffrey G. James, Standards Staff Engineer, Technical Services Division.

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APPENDIX A

APPENDIX B

TABLE B-1
CONVERSION FROM ENGLISH DESIGN PIPE SIZE
TO METRIC PAY ITEM PIPE SIZE
CIRCULAR SMOOTH PIPE

DESIGN DIAMETER (in.)	PAY ITEM DIAMETER (mm)
12	300
15	375
18	450
21	525
24	600
27	675
30	750
33	825
36	900
42	1050
48	1200
54	1350
60	1500
66	1650
72	1800
78	1950
84	2100
90	2250
96	2400
102	2550
108	2700
114	2850
120	3000
126	3150
132	3300
138	3450
144	3600

TABLE B-2
CONVERSION FROM ENGLISH DESIGN PIPE SIZE
TO METRIC PAY ITEM PIPE SIZW
CIRCULAR CORRUGATED PIPE

DESIGN DIAMETER (in.)	PAY ITEM DIAMETER (mm)
12	300
15	375
18	450
21	525
24	600
27	675
30	750
33	825
36	900
42	1050
48	1200
54	1350
60	1500
66	1650
72	1800
78	1950
84	2100
90	2250
96	2400
102	2550
108	2700
114	2850
120	3000
126	3150
132	3300
138	3450
144	3600

TABLE B-3
CONVERSION FROM ENGLISH DESIGN PIPE SIZE
TO METRIC PAY ITEM PIPE SIZE
CIRCULAR CORRUGATED PIPE (STRUCTURAL PLATE)

DESIGN DIAMETER (ft-in.)	PAY ITEM DIAMETER (mm)
5-0	1500
5-6	1655
6-0	1810
6-6	1965
7-0	2120
7-6	2275
8-0	2430
8-6	2585
9-0	2740
9-6	2895
10-0	3050
10-6	3205
11-0	3360
11-6	3515
12-0	3670
12-6	3825
13-0	3980
13-6	4135
14-0	4290
14-6	4445
15-0	4600
15-6	4755
16-0	4910
16-6	5065
17-0	5220
17-6	5375
18-0	5530
18-6	5685
19-0	5840
19-6	5995
20-0	6150
20-6	6305
21-0	6460

TABLE B-4
CONVERSION FROM ENGLISH DESIGN PIPE SIZE
TO METRIC PAY ITEM PIPE SIZE
DEFORMED CORRUGATED PIPE

DESIGN PIPE SIZE (in. x in.)	DESIGN AREA (sft)	METRIC PIPE SIZE (mm x mm)	PAY ITEM AREA (m^2)
17 x 13	1.1	430 x 330	0.10
21 x 15	1.6	530 x 380	0.15
24 x 18	2.2	610 x 460	0.20
28 x 20	2.9	710 x 510	0.27
35 x 24	4.5	885 x 610	0.42
42 x 29	6.5	1060 x 740	0.60
49 x 33	8.9	1240 x 840	0.83
57 x 38	11.6	1440 x 970	1.08
64 x 43	14.7	1620 x 1100	1.37
71 x 47	18.1	1800 x 1200	1.68
77 x 52	21.9	1950 x 1320	2.03
83 x 57	26.0	2100 x 1450	2.42
60 x 46	15.6	1520 x 1170	1.45
66 x 51	19.3	1670 x 1300	1.79
73 x 55	23.2	1850 x 1400	2.16
81 x 59	27.4	2050 x 1500	2.55
87 x 63	32.1	2200 x 1620	2.98
95 x 67	37.0	2400 x 1720	3.44
103 x 71	42.4	2600 x 1820	3.94
112 x 75	48.0	2840 x 1920	4.46
117 x 79	54.2	2970 x 2020	5.04
128 x 83	60.5	3240 x 2120	5.62
137 x 87	67.4	3470 x 2220	6.26
142 x 91	74.5	3600 x 2320	6.92

TABLE B-5
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
DEFORMED CORRUGATED PIPE (STRUCTURAL PLATE)

DESIGN PIPE SIZE (ft-in. x ft-in.)	DESIGN AREA (sft)	METRIC PIPE SIZE (mm x mm)	PAY ITEM AREA (m^2)
STRUCTURAL PLATE STEEL PIPE-ARCH			
6-1 x 4-7	22	1850 x 1400	2.0
6-4 x 4-9	24	1930 x 1450	2.2
6-9 x 4-11	26	2060 x 1500	2.4
7-0 x 5-1	28	2130 x 1550	2.6
7-3 x 5-3	31	2210 x 1600	2.9
7-8 x 5-5	33	2340 x 1650	3.1
7-11 x 5-7	35	2410 x 1700	3.3
8-2 x 5-9	38	2490 x 1750	3.5
8-7 x 5-11	40	2620 x 1800	3.7
8-10 x 6-1	43	2690 x 1850	4.0
9-4 x 6-3	46	2840 x 1910	4.3
9-6 x 6-5	49	2900 x 1960	4.6
9-9 x 6-7	52	2970 x 2010	4.8
10-3 x 6-9	55	3120 x 2060	5.1
10-8 x 6-11	58	3250 x 2110	5.4
10-11 x 7-1	61	3330 x 2160	5.7
11-5 x 7-3	64	3480 x 2210	5.9
11-7 x 7-5	67	3530 x 2260	6.2
11-10 x 7-7	71	3610 X 2310	6.6
12-4 x 7-9	74	3760 x 2360	6.9
12-6 x 7-11	78	3810 x 2410	7.2
12-8 x 8-1	81	3860 x 2460	7.5
12-10 x 8-4	85	3910 x 2540	7.9
13-3 x 9-4	97	4040 x 2840	9.0
13-6 x 9-6	102	4110 x 2900	9.5
14-0 x 9-8	105	4270 x 2950	9.8
14-2 x 9-10	109	4320 x 3000	10.1
14-5 x 10-0	114	4390 x 3050	10.6
14-11 x 10-2	118	4550 x 3100	11.0
15-4 x 10-4	123	4670 x 3150	11.4
15-7 x 10-6	127	4750 x 3200	11.8
15-10 x 10-8	132	4830 x 3250	12.3
16-3 x 10-10	137	4950 x 3300	12.7
16-6 x 11-0	142	5030 x 3350	13.2
17-0 x 11-2	146	5180 x 3400	13.6
17-2 x 11-4	151	5230 x 3450	14.0
17-5 x 11-6	157	5310 x 3510	14.6
17-6 x 11-8	161	5460 x 3560	15.0

TABLE B-5 (CONTINUED)
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
DEFORMED CORRUGATED PIPE (STRUCTURAL PLATE)

DESIGN PIPE SIZE (ft-in. x ft-in.)	DESIGN AREA (sft)	METRIC PIPE SIZE (mm x mm)	PAY ITEM AREA (m^2)
STRUCTURAL PLATE STEEL PIPE-ARCH (CONTINUED)			
18-1 x 11-10	167	5570 x 3610	15.5
18-7 x 12-0	172	5660 x 3660	16.0
18-9 x 12-2	177	5720 x 3710	16.4
19-3 x 12-4	182	5870 x 3760	16.9
19-6 x 12-6	188	5940 x 3810	17.5
19-8 x 12-8	194	5990 x 3860	18.0
19-11 x 12-10	200	6070 x 3910	18.6
20-5 x 13-0	205	6220 x 3960	19.0
20-7 x 13-2	211	6270 x 4010	19.6
STRUCTURAL PLATE ALUMINUM ALLOY PIPE-ARCH			
6-7 x 5-8	29	2010 x 1730	2.7
6-11 x 5-9	31	2110 x 1750	2.9
7-3 x 5-11	34	2210 x 1800	3.2
7-9 x 6-0	36	2360 x 1830	3.3
8-1 x 6-1	39	2460 x 1850	3.6
8-5 x 6-3	41	2570 x 1910	3.8
8-10 x 6-4	44	2690 x 1930	4.1
9-3 x 6-5	47	2820 x 1960	4.4
9-7 x 6-6	49	2920 x 1980	4.6
9-11 x 6-8	52	3020 x 2030	4.8
10-3 x 6-9	55	3120 x 2060	5.1
10-90 x 6-10	58	3280 x 2080	5.4
11-1 x 7-0	61	3380 x 2130	5.7
11-5 x 7-1	64	3480 x 2160	5.9
11-9 x 7-2	67	3580 x 2180	6.2
12-3 x 7-3	70	3730 x 2210	6.5
12-7 x 7-5	73	3840 x 2260	6.8
12-11 x 7-6	77	3940 x 2290	7.2
13-1 x 8-2	83	3990 x 2490	7.7
13-1 x 8-4	86	3990 x 2540	8.0
13-11 x 8-5	90	4240 x 2570	8.4
14-0 x 8-7	94	4270 x 2620	8.7
13-11 x 9-5	101	4240 x 2870	9.4
14-3 x 9-7	105	4340 x 2920	9.8
14-8 x 9-8	109	4470 x 2950	10.1
14-11 x 9-10	114	4550 x 3000	10.6
15-4 x 10-0	118	4670 x 3050	11.0
15-7 x 10-2	123	4750 x 3100	11.4

TABLE B-5 (CONTINUED)
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
DEFORMED CORRUGATED PIPE (STRUCTURAL PLATE)

DESIGN PIPE SIZE (ft-in. x ft-in.)	DESIGN AREA (sft)	METRIC PIPE SIZE (mm x mm)	PAY ITEM AREA (m^2)
STRUCTURAL PLATE ALUMINUM ALLOY PIPE-ARCH (CONTINUED)			
16-1 x 10-4	127	4900 x 3150	11.8
16-4 x 10-6	132	4980 x 3200	12.3
16-9 x 10-8	136	5110 x 3250	12.6
17-0 x 10-10	141	5180 x 3000	13.1
17-3 x 11-0	146	5260 x 3350	13.6
17-9 x 11-2	151	5410 x 3400	14.0
18-0 x 11-4	156	5490 x 3450	14.5
18-5 x 11-6	161	5610 x 3510	15.0
18-8 x 11-8	167	5690 x 3560	15.5
19-2 x 11-9	172	5840 x 3580	16.0
19-5 x 11-11	177	5920 x 3630	16.4
19-10 x 12-1	182	6050 x 3680	16.9
20-1 x 12-3	188	6120 x 3730	17.5
20-1 x 12-6	194	6120 x 3810	18.0
2010 x 12-7	199	6350 x 3840	18.5
21-1 x 12-9	205	6430 x 3890	19.0
21-1 x 12-11	211	6430 x 3940	19.6
20-1 x 13-11	216	6120 x 4240	20.1
20-7 x 14-3	224	6270 x 4340	20.8
21-5 x 14-7	241	6530 x 4450	22.4
21-11 x 14-11	254	6680 x 4550	23.6
22-8 x 15-3	267	6910 x 4650	24.8

TABLE B-6
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
DEFORMED SMOOTH PIPE

DESIGN PIPE SIZE (in. x in.)	DESIGN AREA (sft)	METRIC PIPE SIZE (mm x mm)	PAY ITEM AREA (m^2)
23 x 14	1.8	575 x 365	0.17
30 x 19	3.3	770 x 490	0.31
34 x 22	4.1	865 x 550	0.38
38 x 24	5.1	960 x 610	0.47
42 x 27	6.3	1055 x 670	0.59
45 x 29	7.4	1150 x 730	0.68
49 x 32	8.8	1250 x 795	0.82
53 x 34	10.2	1345 x 855	0.95
60 x 38	12.9	1535 x 975	1.20
68 x 43	16.6	1730 x 1095	1.55
76 x 48	20.5	1920 x 1220	1.90
83 x 53	24.8	2110 x 1340	2.30
91 x 58	29.5	2305 x 1465	2.73
98 x 63	34.6	2495 x 1585	3.21
106 x 68	40.1	2690 x 1705	3.73
113 x 72	46.1	2880 x 1830	4.28
121 x 77	52.4	3070 x 1950	4.87
128 x 82	59.2	3265 x 2075	5.49
136 x 87	66.4	3455 x 2195	6.17
143 x 92	74.0	3648 x 2315	6.87
151 x 97	82.0	3840 x 2440	7.63
166 x 106	99.2	4225 x 2680	9.22
180 x 116	118.6	4610 x 2925	11.02

TABLE B-7
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
PRECAST REINFORCED CONCRETE BOX SECTIONS

DESIGN BOX SIZE (ft x ft)	PAY ITEM SIZE (mm x mm)	DESIGN BOX SIZE (ft x ft)	PAY ITEM SIZE (mm x mm)
3 x 2	900 x 600	10 x 5	3000 x 1500
3 x 3	900 x 900	10 x 6	3000 x 1800
4 x 2	1200 x 600	10 x 7	3000 x 2100
4 x 3	1200 x 900	10 x 8	3000 x 2400
4 x 4	1200 x 1200	10 x 9	3000 x 2700
5 x 3	1500 x 900	10 x 10	3000 x 3000
5 x 4	1500 x 1200	11 x 4	3300 x 1200
5 x 5	1500 x 1500	11 x 6	3300 x 1800
6 x 3	1800 x 900	11 x 8	3300 x 2400
6 x 4	1800 x 1200	11 x 10	3300 x 3000
6 x 5	1800 x 1500	11 x 11	3300 x 3300
6 x 6	1800 x 1800	12 x 4	3600 x 1200
7 x 4	2100 x 1200	12 x 6	3600 x 1800
7 x 5	2100 x 1500	12 x 8	3600 x 2400
7 x 6	2100 x 1800	12 x 10	3600 x 3000
7 x 7	2100 x 2100	12 x 12	3600 x 3600
8 x 4	2400 x 1200		
8 x 5	2400 x 1500		
8 x 6	2400 x 1800		
8 x 7	2400 x 2100		
8 x 8	2400 x 2400		
9 x 5	2700 x 1500		
9 x 6	2700 x 1800		
9 x 7	2700 x 2100		
9 x 8	2700 x 2400		
9 x 9	2700 x 2700		

TABLE B-8
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
PRECAST REINFORCED CONCRETE THREE SIDED CULVERT

DESIGN CULVERT SIZE (ft x ft)	PAY ITEM SIZE (mm x mm	DESIGN CULVERT SIZE (ft x ft)	PAY ITEM SIZE (mm x mm)
12 x 3	3600 x 900	16 x 3	4800 x 900
12 x 4	3600 x 1200	16 x 4	4800 x 1200
12 x 5	3600 x 1500	16 x 5	4800 x 1500
12 x 6	3600 x 1800	16 x 6	4800 x 1800
12 x 7	3600 x 2100	16 x 7	4800 x 2100
12 x 8	3600 x 2400	16 x 8	4800 x 2400
12 x 9	3600 x 2700	16 x 9	4800 x 2700
12 x 10	3600 x 3000	16 x 10	4800 x 3000
13 x 3	3900 x 900	17 x 3	5100 x 900
13 x 4	3900 x 1200	17 x 4	5100 x 1200
13 x 5	3900 x 1500	17 x 5	5100 x 1500
13 x 6	3900 x 1800	17 x 6	5100 x 1800
13 x 7	3900 x 2100	17 x 7	5100 x 2100
13 x 8	3900 x 2400	17 x 8	5100 x 2400
13 x 9	3900 x 2700	17 x 9	5100 x 2700
13 x 10	3900 x 3000	17 x 10	5100 x 3000
14 x 3	4200 x 900	18 x 3	5400 x 900
14 x 4	4200 x 1200	18 x 4	5400 x 1200
14 x 5	4200 x 1500	18 x 5	5400 x 1500
14 x 6	4200 x 1800	18 x 6	5400 x 1800
14 x 7	4200 x 2100	18 x 7	5400 x 2100
14 x 8	4200 x 2400	18 x 8	5400 x 2400
14 x 9	4200 x 2700	18 x 9	5400 x 2700
14 x 10	4200 x 3000	18 x 10	5400 x 3000
15 x 3	4500 x 900	19 x 3	5700 x 900
15 x 4	4500 x 1200	19 x 4	5700 x 1200
15 x 5	4500 x 1500	19 x 5	5700 x 1500
15 x 6	4500 x 1800	19 x 6	5700 x 1800
15 x 7	4500 x 2100	19 x 7	5700 x 2100
15 x 8	4500 x 2400	19 x 8	5700 x 2400
15 x 9	4500 x 2700	19 x 9	5700 x 2700
15 x 10	4500 x 3000	19 x 10	5700 x 3000

TABLE B-8 (CONTINUED)
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
PRECAST REINFORCED CONCRETE THREE SIDED CULVERT

DESIGN CULVERT SIZE (ft x ft)	PAY ITEM SIZE (mm x mm	DESIGN CULVERT SIZE (ft x ft)	PAY ITEM SIZE (mm x mm)
20 x 3	6000 x 900	24 x 3	7200 x 900
20 x 4	6000 x 1200	24 x 4	7200 x 1200
20 x 5	6000 x 1500	24 x 5	7200 x 1500
20 x 6	6000 x 1800	24 x 6	7200 x 1800
20 x 7	6000 x 2100	24 x 7	7200 x 2100
20 x 8	6000 x 2400	24 x 8	7200 x 2400
20 x 9	6000 x 2700	24 x 9	7200 x 2700
20 x 10	6000 x 3000	24 x 10	7200 x 3000
21 x 3	6300 x 900	25 x 3	7500 x 900
21 x 4	6300 x 1200	25 x 4	7500 x 1200
21 x 5	6300 x 1500	25 x 5	7500 x 1500
21 x 6	6300 x 1800	25 x 6	7500 x 1800
21 x 7	6300 x 2100	25 x 7	7500 x 2100
21 x 8	6300 x 2400	25 x 8	7500 x 2400
21 x 9	6300 x 2700	25 x 9	7500 x 2700
22 x 3	6600 x 900	26 x 3	7800 x 900
22 x 4	6600 x 1200	26 x 4	7800 x 1200
22 x 5	6600 x 1500	26 x 5	7800 x 1500
22 x 6	6600 x 1800	26 x 6	7800 x 1800
22 x 7	6600 x 2100	26 x 7	7800 x 2100
22 x 8	6600 x 2400	26 x 8	7800 x 2400
22 x 9	6600 x 2700	26 x 9	7800 x 2700
22 x 10	6600 x 3000	26 x 10	7800 x 3000
23 x 3	6900 x 900	27 x 3	8100 x 900
23 x 4	6900 x 1200	27 x 4	8100 x 1200
23 x 5	6900 x 1500	27 x 5	8100 x 1500
23 x 6	6900 x 1800	27 x 6	8100 x 1800
23 x 7	6900 x 2100	27 x 7	8100 x 2100
23 x 8	6900 x 2400	27 x 8	8100 x 2400
23 x 9	6900 x 2700	27 x 9	8100 x 2700
23 x 10	6900 x 3000	27 x 10	8100 x 3000

TABLE B-8 (CONTINUED)
CONVERSION FROM ENGLISH DESIGN TO METRIC PAY ITEM PIPE SIZE
PRECAST REINFORCED CONCRETE THREE SIDED CULVERT

DESIGN CULVERT SIZE (ft x ft)	PAY ITEM SIXE (mm x mm)
28 x 3	8400 x 900
28 x 4	8400 x 1200
28 x 5	8400 x 1500
28 x 6	8400 x 1800
28 x 7	8400 x 2100
28 x 8	8400 x 2400
28 x 9	8400 x 2700
28 x 10	8400 x 3000
29 x 3	8700 x 900
29 x 4	8700 x 1200
29 x 5	8700 x 1500
29 x 6	8700 x 1800
29 x 7	8700 x 2100
29 x 8	8700 x 2400
29 x 9	8700 x 2700
29 x 10	8700 x 3000
30 x 3	9000 x 900
30 x 4	9000 x 1200
30 x 5	9000 x 1500
30 x 6	9000 x 1800
30 x 7	9000 x 2100
30 x 8	9000 x 2400
30 x 9	9000 x 2700
30 x 10	9000 x 3000

TABLE B-9
NON-REINFORCED CONCRETE PIPE, CLASS 3 WALL THICKNESS

PIPE SIZE (mm)	WALL THICKNESS (mm)
300	44
375	47
450	57
525	69
600	85
675	94
750	107
825	113
900	119

TABLE B-10
REINFORCED CONCRETE PIPE WALL THICKNESS

PIPE SIZE (mm)	WALL THICKNESS (mm)
300	69
375	75
450	82
525	88
600	94
675	100
750	106
825	113
900	119
1050	132
1200	144
1350	157
1500	169
1650	182
1800	194
1950	207
2100	219
2250	232
2400	244
2550	257
2700	269
2850	282
3000	294
3150	307
3300	319
3450	332
3600	344

TABLE B-11
PRECAST REINFORCED CONCRETE BOX SECTION WALL THICKNESS

SPAN x RISE (mm x mm)	WALL THICKNESS (mm)	
	COVER < 0.6 m	COVER ∃ 0.6 m
900 x 600	175	100
900 x 900	175	100
1200 x 600	190	125
1200 x 900	190	125
1200 x 1200	190	125
1500 x 900	200	150
1500 x 1200	200	150
1500 x 1500	200	150
1800 x 900	200	175
1800 x 1200	200	175
1800 x 1500	200	175
1800 x 1800	200	175
2100 x 1200	200	200
2100 x 1500	200	200
2100 x 1800	200	200
2100 x 2100	200	200
2400 x 1200	200	200
2400 x 1500	200	200
2400 x 1800	200	200
2400 x 2100	200	200
2400 x 2400	200	200
2700 x 1500	225	225
2700 x 1800	225	225
2700 x 2100	225	225
2700 x 2400	225	225
2700 x 2700	225	225
3000 x 1500	250	250
3000 x 1800	250	250
3000 x 2100	250	250
3000 x 2400	250	250
3000 x 2700	250	250
3000 x 3000	250	250
3300 x 1200	275	275
3300 x 1800	275	275
3300 x 2400	275	275
3300 x 3000	275	275
3300 x 3300	275	275

TABLE B-11 (CONTINUED)
PRECAST REINFORCED CONCRETE BOX SECTION WALL THICKNESS

SPAN x RISE (mm x mm)	WALL THICKNESS (mm)	
	COVER < 0.6 m	COVER ∃ 0.6 m
3600 x 1200	300	300
3600 x 1800	300	300
3600 x 2400	300	300
3600 x 3000	300	300
3600 x 3600	300	300

TABLE B-12
REINFORCED CONCRETE HORIZONTAL ELLIPTICAL PIPE WALL THICKNESS

SPAN X RISE (mm x mm)	WALL THICKNESS (mm)
575 x 365	69
770 x 490	82
865 x 550	88
960 x 610	94
1055 x 670	94
1150 x 730	113
1250 x 795	119
1345 x 855	125
1535 x 975	138
1730 x 1095	150
1920 x 1220	163
2110 x 1340	175
2305 x 1465	188
2495 x 1585	200
2690 x 1705	213
2880 x 1830	225
3070 x 1950	238
3265 x 2075	244
3455 x 2195	250
3648 x 2315	263
3840 x 2440	275
4225 x 2680	300
4610 x 2995	325

APPENDIX C

APPENDIX D

PIPE MATERIAL ABBREVIATIONS

The following pipe material abbreviations have been used:

ABBREVIATION	PIPE MATERIAL
CSP	Corrugated Steel Pipe
CSPA	Corrugated Steel Pipe-Arch
FBC&L	Fully Bituminous Coated & Lined
ZC	Zinc Coated
ACT2	Aluminum Coated Type 2
PPG	Polymer Precoated Galvanized
FBBC	Fiber Bonded Bituminous Coated
CAAP	Corrugated Aluminum Alloy Pipe
CAAPA	Corrugated Aluminum Alloy Pipe-Arch
SPSP	Structural Plate Steel Pipe
SPSPA	Structural Plate Steel Pipe-Arch
SPAAP	Structural Plate Aluminum Alloy Pipe
SPAAPA	Structural Plate Aluminum Alloy Pipe-Arch