

14.0 LOW LEVEL OUTLET WORKS

14.1 General

In general, a low level outlet structure can be used to provide one or more of the following functions:

- Supply adequate water to meet downstream needs.
- Facilitate the drawdown of the reservoir during an emergency or to allow for inspection and maintenance work to be carried out.
- Serve as a diversion structure during construction.
- Accommodate hydropower generation.

The low level outlet structure typically consists of a reinforced concrete intake structure, conduit, gatewell, and terminal structure. A typical arrangement is shown on Figure 14-1.

14.2 Structure Location and Layout

The structure should normally be sited on the most competent portion of the dam foundation, preferably close to an abutment, so that vertical and horizontal movements (settlement and spreading) that may occur over the length of the structure are minimized. In addition, it is preferred that the low level outlet be located well away from the spillway structure.

The gatewell is normally located just upstream from the crest of the dam in order to minimize the pressurized (water) length of conduit that is located within the impervious core of the dam, and to facilitate access.

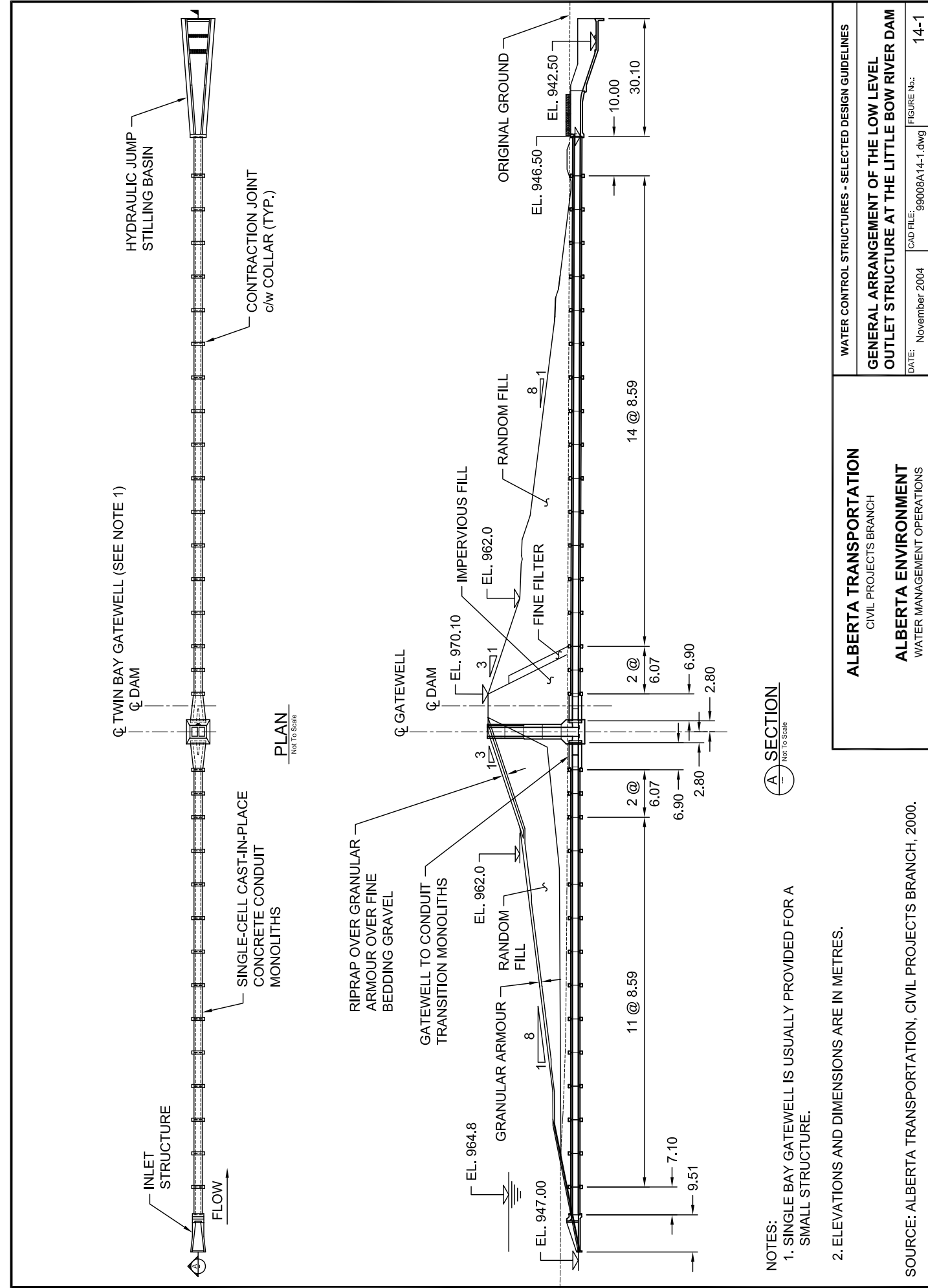
14.3 Seepage and Drainage Measures

Seepage control is ordinarily provided by the impervious backfill placed around the structure as part of the impervious core of the dam embankment. Seepage collars cast directly around the conduits should not be used since they can cause stress concentrations as discussed in Section 13.4.

To prevent piping along the outside wall of the conduit, a zone of filter material, possibly in conjunction with drainage gravel, is normally provided around the downstream end of the conduit, and properly tied in with the drainage measures provided at the terminal structure.

14.4 Intake Structure

An intake structure is usually used to provide good entrance conditions into the conduit, and to permit auxiliary appurtenances such as a bulkhead or stop log closure device, trash rack, or fish screen if required, to be installed. The intake structure and conduit are designed to resist the uplift



forces that would occur when the bulkhead or stop log device is in place and the conduit is dewatered, or the trashrack or fish screen becomes plugged.

In some instances such as where sediment deposition or water quality is a concern, consideration can be given to providing a high level intake, or an overflow crest with vertical shaft with some features similar to that described in Section 13.5.

14.5 Conduit

The design of the conduit is discussed in Section 13.6. For precast concrete pipe, connection details between the pipe and the gateway structure, where founded on a competent foundation, are as illustrated on Figures 14-2 and 14-3.

An air vent must be provided within the section of each conduit located immediately downstream of the control gate in order to prevent the development of negative pressures and pressure surges. Information for sizing the air vent can be found in Smith (1995).

Ideally, the invert at the downstream end of the conduit should be set well above the bed of the outlet channel so that it is free draining and free of ice during the winter in order to facilitate access for inspection and maintenance when the structure is not being operated.

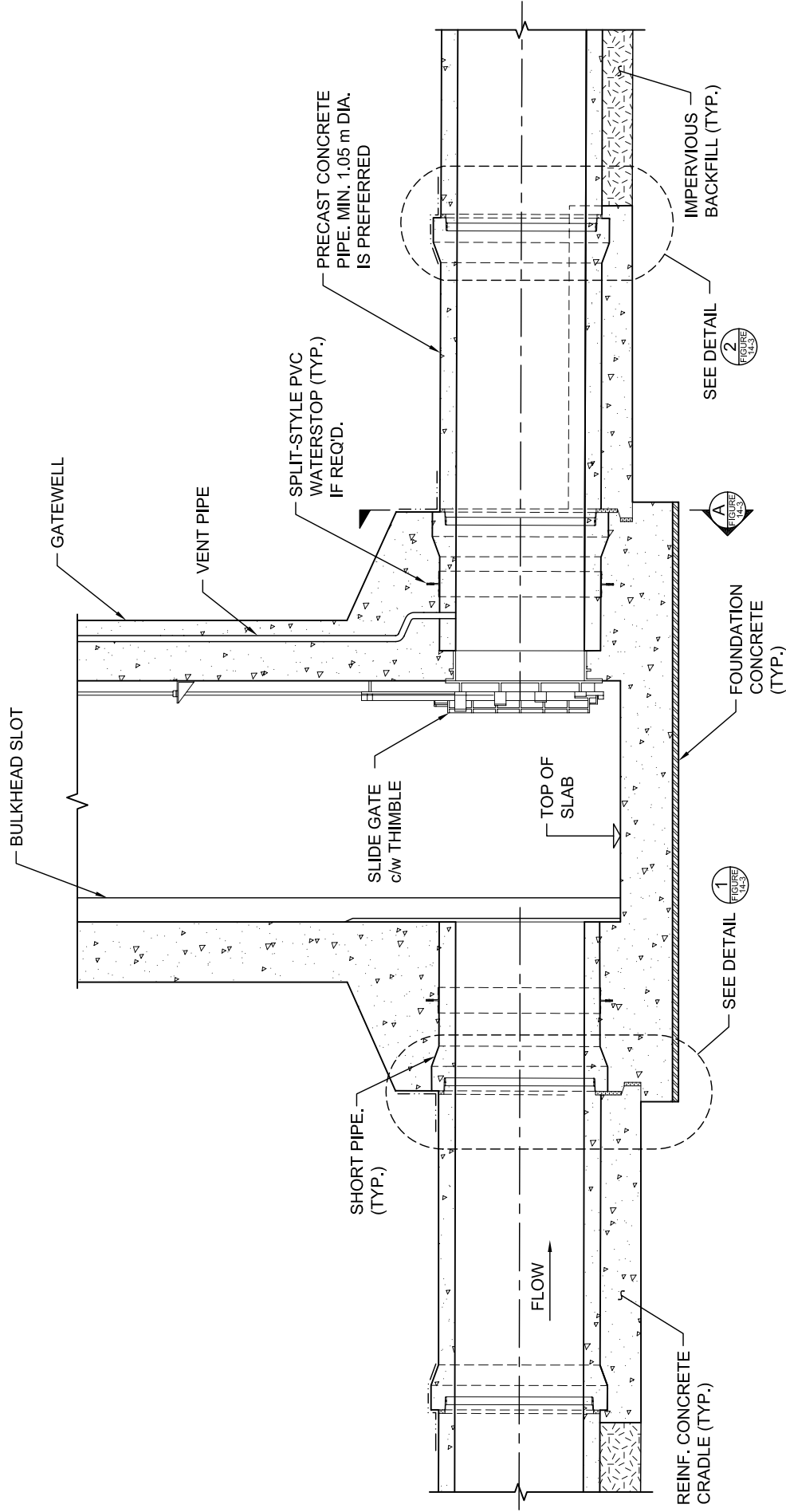
14.6 Gateway

A gateway is ordinarily provided to house and permit access to the flow control gate. Depending on the type of gate used, the gateway would operate either as a wet well (slide gate) or a dry well (bonnet gate). The provision of either an upstream emergency bulkhead or guard gate is required to permit inspection and maintenance. Consideration should also be given to providing a smaller diameter bypass pipe system to facilitate the release of small flows without having to operate the primary control gate at partial openings.

In some cases, such as where water must be continuously released in order to meet downstream riparian requirements, a gateway with twin gate bays may be required so that releases can be maintained while the gate in one bay is being serviced.

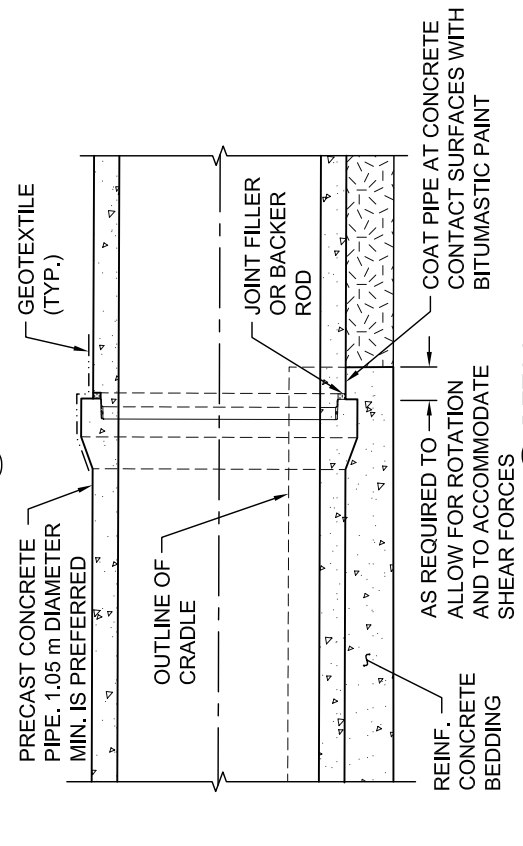
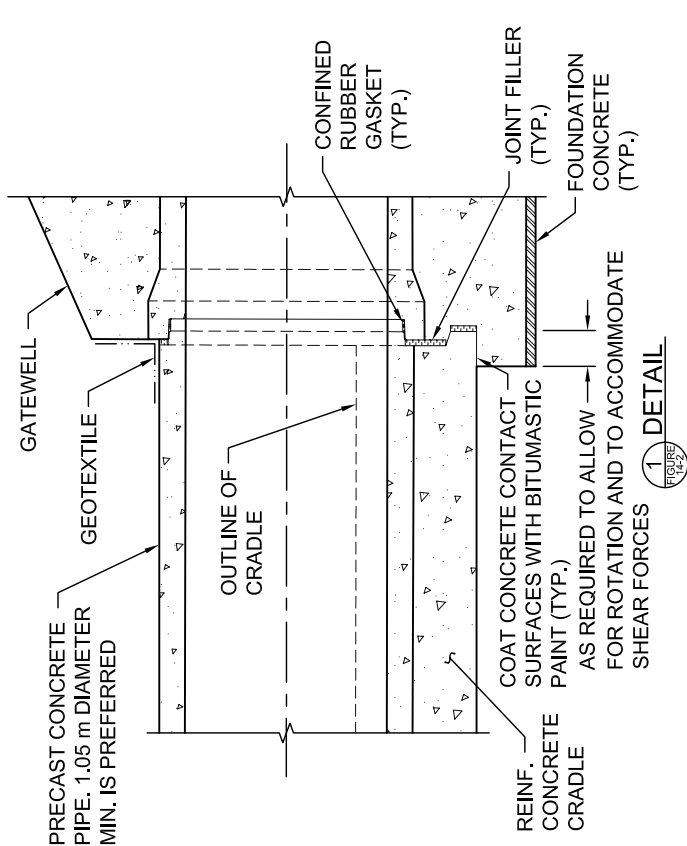
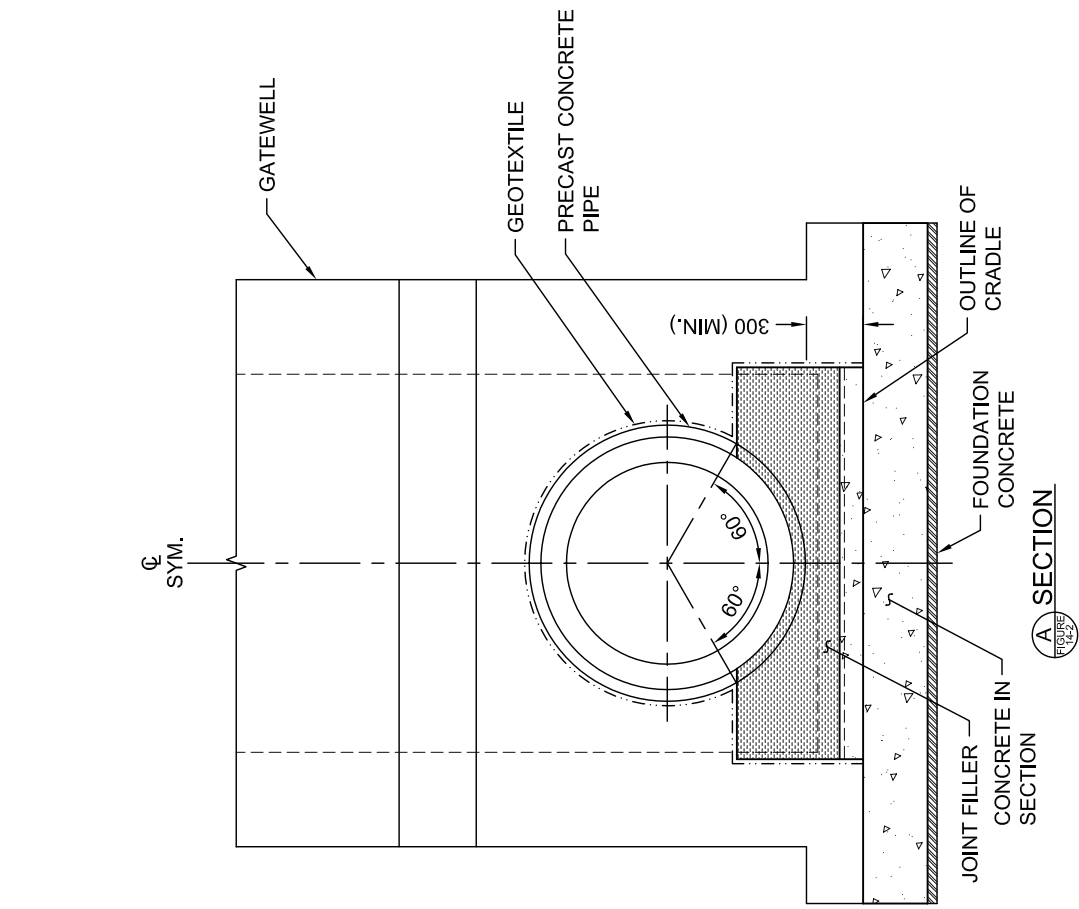
As part of the stability analyses, the wet well should be checked for the case when it is dewatered for inspection or maintenance purposes with the reservoir at FSL, whereas the dry well should be checked for the reservoir at FSL and the peak IDF level.

For a specific installation, special care is required in identifying all of the conditions and loading combinations that can occur. Some examples of conditions and loading combinations that may apply for a typical wet well installation are provided below. The load symbols are defined in Section 4.0, and load factors are discussed in Section 9.0.



NOTES:

1. WRAP PIPE JOINTS WITH GEOTEXTILE FABRIC FOR ADDED PROTECTION AGAINST PIPING (INFILTRATION).
2. GATEWELL SLAB AND CRADLE MUST BE CAST AGAINST A COMPETENT FOUNDATION. WHERE SOFT FOUNDATIONS ARE ENCOUNTERED, SPECIAL MEASURES WILL BE REQUIRED.



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WATER MANAGEMENT OPERATIONS

WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES		
PRECAST CONCRETE PIPE/STRUCTURE CONNECTION DETAILS		
DATE: November 2004	CAD FILE: 99008A14-3.dwg	FIGURE No.: 14-3

1 DETAIL
2 DETAIL

Construction Condition:

- $D+E+V$ (surcharge)

Usual Condition

- $D+E+H_{FSL}$ (external and internal)+ U_{FSL}
- $D+E+H_{SDF}$ (external and internal)+ U_{SDF}

Unusual Condition

- $D+ E+ H_{FSL}$ (external and internal)+ Q

Extreme Condition

- $D+E+H_{IDF}$ (external and internal)+ U_{IDF}
- $D+E+ H_{FSL}$ (external and internal)+ Q_{MDE}

The wet well should be designed to prevent leakage from the interior of the wet well into the surrounding embankment. Consequently, the resulting crack widths, particularly under Usual Loading Conditions, should be reviewed as discussed in Section 9.1.1.

Similarly, some examples of conditions and loading combinations that may apply for a typical dry well installation are provided below. The load symbols are defined in Section 4.0, and load factors are discussed in Section 9.0.

Construction Condition:

- $D+E+V$ (surcharge)

Usual Condition

- $D+ E+H_{FSL}$ (external)+ U_{FSL}
- $D+ E+H_{SDF}$ (external)+ U_{SDF}

Unusual Condition

- $D+ E+H_{FSL}$ (external)+ $U_{FSL}+Q$

Extreme Condition

- $D+E+H_{IDF}$ (external)+ U_{IDF}
- $D+ E+H_{FSL}$ (external)+ $U_{FSL}+Q_{MDE}$

14.7 Terminal Structure

The terminal structure for a low level outlet structure should preferably consist of a hydraulic jump stilling basin, subject to appropriate tailwater conditions. Where the properties of the outlet channel are too variable or complex to allow for determining reliable tailwater conditions, an impact basin or a baffle chute drop may be used subject to the qualifications outlined in Sections 13.7.3 and 13.7.4.

Erosion protection requirements downstream of the terminal structure are discussed in Sections 12.7.1, 13.7.3, and 13.7.4.

14.8 Cavitation

For a low level outlet structure, conditions that can lead to cavitation may exist immediately downstream of the control gate. As a result, the potential for cavitation should be examined and appropriate measures provided as outlined in Section 12.8. For heads above 45 m, EM 1110-2-1602 (1980) suggests that a metal liner should be provided within the conduit immediately downstream of the gate; however for heads below 45 m, a liner should not be required.