DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
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LOS ANGELES, CALIFORNIA 90017-3489

CESPL-EDH 05-March-2020

MEMORANDUM FOR RECORD

SUBJECT: Hydrology & Hydraulics (H&H) Branch Policy Memorandum #1
"Side Drain Connections into Flood Risk Management Projects"

1. **Purpose**: The purpose of this memorandum for record (MFR) is to establish policy based on the authorized project's purpose and level of protection for the hydraulic design and criteria for side drain inlets into flood control channels within the Army Corps of Engineers, Los Angeles District (Corps) and supplement criteria found in EM 1110-2-1601, *Hydraulic Design of Flood Control Channels.*

2. **References**:

   a. CESPL-EDH MFR, Subject: "H&H Policy Memorandum #1, Side Drain Connections into Flood Control Channels," dated 29 December 1998.

3. **Discussion**: The goal of this design memorandum is to lay out a design methodology for side drains pertaining to Corps projects. This method is to be applied to all future Corps projects, in addition to evaluating an applicant's 408 design permit, including "After the Fact" permits to existing Corps projects. The design philosophy behind the side drain policy is as follows:

   a. Provides a design which does not cause an adverse effect to the main channel's hydraulic function.

   b. Ensures that the side drain connection to the main channel does not promote interior flooding.

   c. Adheres to the Authorized Project's Level of Protection as defined in Design Reports.

4. **Criteria**:

   a. Hydrologic Considerations;

      (1) Drainage Area. The drainage area contributing flows to the side drains or lateral (lateral) inflows leading to the main channel must be within the authorized project's drainage area defined in the project's hydrologic study.

In other words, no additional drainage area will be allowed from outside the project's defined drainage area.

(2) Discharge: In general, the Corps builds the main channel that considers tributary areas as the project moves to the downstream terminus point. Depending on the project's level or protection, the project could have been authorized based on a discharge such as the Standard Project Flood or in recent times, based on probability in the form of flood-frequency, such as the 100-yr flood event or 1 percent annual chance exceedance (ACE). Whatever level of protection the main channel offers, the cumulative effects of the lateral inflows must NOT bring in more flows that would exceed the main channel's level of protection. The Non-Federal (local) project sponsor will review how the main channel hydrologic conditions were developed and determine the appropriate lateral coincidental flows. Consideration for storm centering and coincident flows could allow for higher lateral inflows if it is determine the main line is not in the peak flow region.

b. Adverse Effects in the Main Channel: Adverse effects in the main channel are those which limit the channel from functioning as intended. Lateral flows can cause, but are not limited to the following issues:

(1) Flows that exceed their design discharge may increase the risk to flooding.

(2) Significant lateral flow may cause a standing wave condition near the location of the inlet, resulting in overbank local flooding.

(3) Flow placed without properly adhering to submergence guidelines can cause local inflows to form surface waves that could cause the main channel to overflow.

(4) Flow exiting a lateral structure may cause an erosion condition at the main channel bottom.

(5) Lateral inlets placed too low may clog with debris due to a lack of significant positive drainage.

c. To mitigate the impact of potential adverse conditions, channel designs must adhere to the following criteria:

(1) If the side drain proposal increases the in-channel flow above the authorized discharge capacity, then the design engineer will need to consider on-site detention in order to reduce the lateral coincident flow with respect to the peak of the channel. The design requirements vary slightly from the common

stormwater management practice of on-site detention to reduce peak flow of a proposed project to an existing condition, as the Corps channel was designed to receive a specific coincident flow that is generally lower than the lateral peak.

(2) All side drain connections (i.e., pipes, culverts, etc.) must be designed with a certain angle of entry to minimize the flow disturbances within a channel that are caused by a sudden increase in side inflow. For supercritical flow conditions (high velocity), the maximum permissible angles of entry are listed below:

Pipe Size*	Angle of Entry
Up to 24"	90°
24-33"	60°
36-57"	45°
60" and over	30°

For subcritical flow conditions (low velocity), the maximum permissible angles of entry are listed below:

Pipe Size*	Angle of Entry
Up to 36"	90°
36-57"	45°
60" and over	30°

* For box or rectangular culvert entries, use the equivalent cross sectional area.

(3) In addition, a minimum of 4 feet of submergence from the top of the pipe to design water surface should be used in the side drain inlet design to help minimize surface flow disturbances caused by both a sudden increase in channel discharge and a notch in the channel side wall. The invert of the inlet should be a minimum of 6 inches above the channel invert. See Attachment 1. If the 4 feet of submergence is not possible due to a shallow channel depth in relation to the size of the side drain, parapet walls along the channel may be considered to achieve this criteria. The parapet walls should extend downstream from the side drain inlet a distance of 4 times the base width of the channel. Another design option is to split the flow and have two smaller side drain inlets that meet the 4 feet of submergence. See Attachment 2.

(4) As a general guideline, the side drain design discharge should be less than 3% of the channel design discharge. This percentage minimizes the flow disturbance that the side drain introduces into the channel. Side drain

discharge in excess of 3% of the channel discharge should be conveyed with a confluence structure. However, in a stable subcritical channel, side drain flows as high as 10% of the main channel may be designed as a side drain inlet, if factors such as freeboard, channel configuration, and channel lining are addressed in the design and approved by the Corps. The criteria in designing a confluence structure is found in EM 1110-2-1601, *Hydraulic Design of Flood Control Channels*. Hydraulic modeling using the Corps models such as HEC-RAS may be applied to determine the hydraulic impacts. Advanced numerical modeling techniques such as using 2-dimensional (AdH) or Computational Fluid Dynamics may be required for more complex side drain designs. In such cases, outside independent engineering consultants may be required to review and certify the adequacy of the modeling.

(5) Connections are to be located preferably within a straight reach of a channel. If possible inlets should not be located upstream of piers, or transitions. They should not be located immediately downstream of confluence structures, or transitions. The above mentioned locations my cause unforeseen hydraulic complications and/or disruptions to the water surface, causing the water surface to abruptly rise above a stable water surface (i.e., encroaches into the freeboard of the channel.) Inlets should be located approximately two channel widths from non-prismatic sections. Even if there is no discharge from the lateral, the wall discontinuity at the lateral may generate an oblique standing wave.

d. Flap gate requirement: Each storm drain connection should be analyzed for the potential flows in the main channel:

(1) The conveyance of the lateral to drain during an in channel design event.

(2) The possible conveyance of backflow introduced into the interior due to high in channel flow depth.

(3) The capacity for the lateral to drain during a side drain design event.

(4) Each of the above three conditions (d1 – d3) can be determined by calculating the hydraulic grade line (HGL) of the side drain system with respect to the analysis of its coincident flood frequency. In other words, the design engineer must check the hydraulic grade line for the design flood in the channel as well as the design flood for the side drain to ensure that no interior flooding may occur. It is necessary to check both floods because they are usually independent events. Typically, the side drain is designed for a local storm with the coincident tail water in the channel. The local agency

responsible for the interior flood control normally requires that the design HGL for the side drain be below the invert elevation of all of the drain inlets at the street level to prevent local flooding. However, the design HGL must be checked to make sure that it is below the ground level above the side drain for its entire length. If it is not, water will flow from the channel back into the side drain and out the drain inlets during a channel design flood. If the channel HGL is in fact high enough to cause backflow and interior flooding, a flap gate (also known as an automatic drainage gate.) must be installed to temporarily close off the drain outlet when submerged by high tail water.

e. This policy memorandum does not address the structural aspects of junction structures. However, the appropriate junction structure must be used when connecting to any Corps flood control channel. Coordinate with the Section 408 project leader to obtain structural requirements and/or Junction Structure details. For trapezoidal channels, the side drain junction structure must include a cantilevered head wall. See Attachment 3.

5. **Deviations:** Any deviation from criteria in this MFR shall require written approval by the H&H Branch of the Corps through the Section 408 Program Manager.

RENE VERMEEREN, P.E., D.WRE
Chief, Hydrology & Hydraulics Branch
Corps of Engineers, Los Angeles District

Attachments

1. Standard for Angle of Entry for Storm Drains
2. Submergence Criteria (Including a Parapet Wall)
3. Side Drain Details for Trapezoidal Channel (with Flap Gate)

CESPL-ED-H Org: 29 December 1998

MEMORANDUM FOR RECORD

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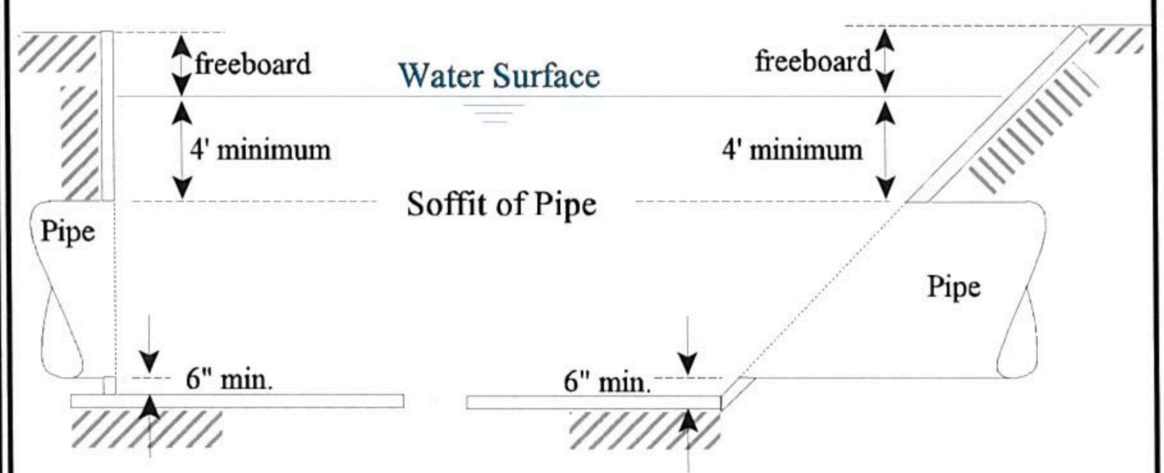
Side Drain Connections into Flood Control Channels

SUBMERGENCE



SUPERCRITICAL FLOW
(high velocity)

Pipe Size	Angle of Entry
up to 24"	90^{0}
24"-33"	60^{0}
36"-57"	45^{0}
60" and over	30^{0}

SUBCRITICAL FLOW
(low velocity)

Pipe Size	Angle of Entry
up to 36"	90^{0}
36"-57"	45^{0}
60" and over	30^{0}

NOTE:
Project details must be verified by the Corps of Engineers.

Standards for Angle of Entry of Storm Drains

US Army Corps of Engineers
Los Angeles District

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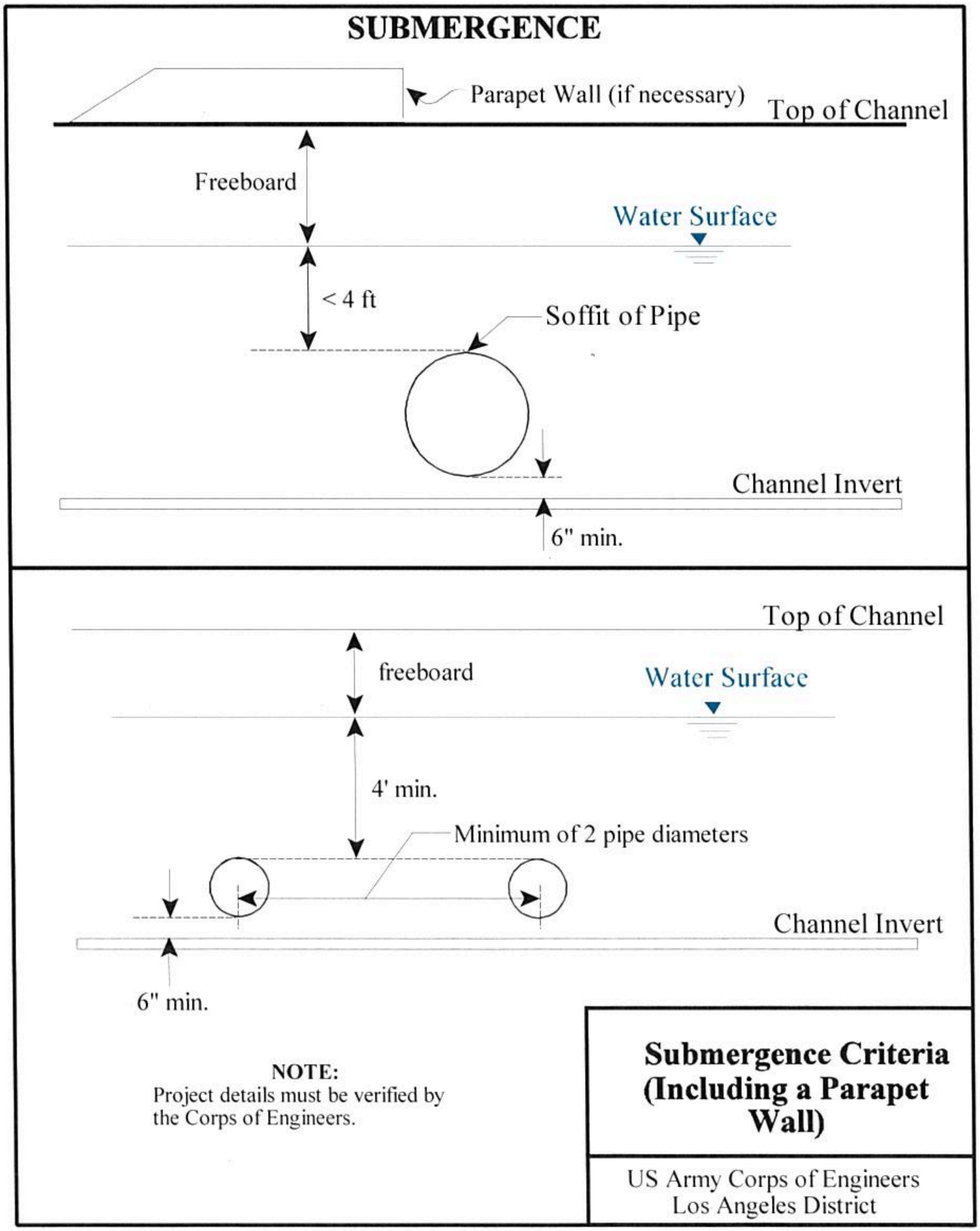

ATTACHMENT 2

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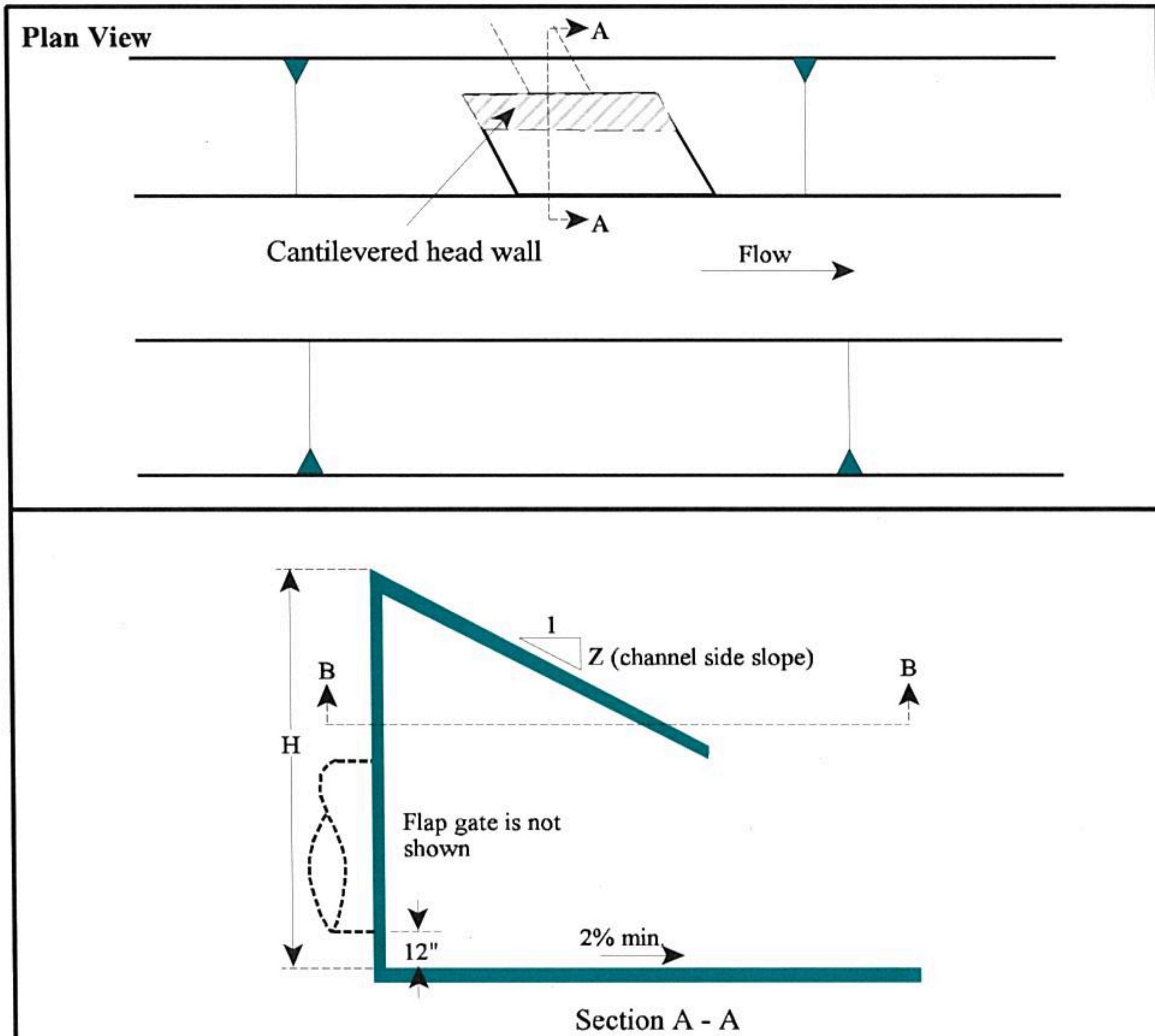

NOTES:
1. See sheet 2 for Section B-B and dimensions.
2. See Permit Manual for structural dimensions.
3. Project details must be verified by the Corps of Engineers.

Side Drain Details for Trapezoidal Channel (with Flap Gate)
Sheet 1 of 2

US Army Corps of Engineers
Los Angeles District

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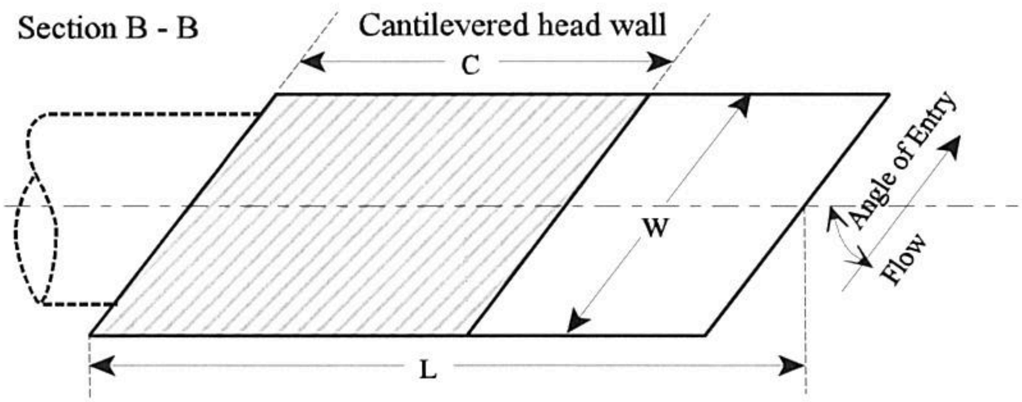
Side Drain Connections into Flood Control Channels



Pipe Dia (in)	Angle of Entry	W (Ft-in)	DIMENSIONS (ft-in)								
			Z=2.0			Z=2.5			Z=3.0		
			C	H	LL	C	H	LL	C	H	LL
12	90	2 - 0	2 - 4	4 - 7	9 - 7	2 - 4	4 - 4	11 - 4	2 - 4	4 - 2	13 - 4
15	90	2 - 3	2 - 3	4 - 10	10 - 2	2 - 3	4 - 7	12 - 2	2 - 3	4 - 5	14 - 4
18	90	3 - 0	3 - 0	5 - 7	11 - 8	3-0	5 - 3	13 - 10	3 - 0	5 - 0	18 - 2
21	90	3 - 3	3 - 4	6 - 0	12 - 7	3 - 4	5 - 8	14 - 11	3 - 4	5 - 5	17 - 8
24	90	3 - 6	3 - 7	6 - 6	13 - 6	3 - 7	6 - 1	16 - 1	3 - 7	5 - 10	18 - 9
24*	60*	3 - 8	3 - 9	6 - 5	15 - 3	3 - 9	5 - 11	18 - 2	3 - 9	5 - 8	21 - 4
30	90	4 - 0	4 - 3	7 - 5	15 - 5	4 - 3	6 - 11	18 - 3	4 - 3	6 - 7	21 - 4
30*	60*	4 - 0	4 - 5	7 - 2	17 - 4	4 - 5	6 - 9	20 - 8	4 - 5	6 - 6	24 - 3
36	45	5 - 0	5 - 9	7 - 10	23 - 4	5 - 9	7 - 5	28 - 1	5 - 9	7 - 2	32 - 11
42	45	5 - 8	6 - 6	8 - 9	26 - 2	6 - 6	8 - 4	31 - 5	6 - 6	8 - 0	36 - 10
48	45	6 - 0	7 - 2	9 - 7	28 - 8	7 - 2	9 - 1	34 - 4	7 - 2	8 - 9	40 - 4
54	45	6 - 6	7 - 10	10 - 6	31 - 4	7 - 10	9 - 11	37 - 7	7 - 10	9 - 7	44 - 1
60	30	8 - 0	10 - 5	11 - 1	47 - 8	10 - 5	10 - 7	58 - 0	10 - 5	10 - 2	68 - 10
66	30	8 - 6	11 - 4	11 - 11	51 - 2	11 - 4	11 - 4	62 - 2	11 - 4	10 - 11	73 - 10
72	30	9 - 0	12 - 2	12 - 9	54 - 8	12 - 2	12 - 1	66 - 5	12 - 2	11 - 8	78 - 9
78	30	9 - 6	13 - 0	13 - 6	58 - 2	13 - 0	12 - 10	78 - 8	13 - 0	12 - 5	83 - 9
84	30	10 - 0	13 - 0	13 - 9	59 - 3	13 - 0	13 - 1	72 - 0	13 - 0	12 - 8	85 - 5

* indicates supercritical flow regime

Note:

1. Dimensions were taken from the LAD Permit Manual
2. "C" is the length along the slope
3. "L" is the horizontal length

Side Drain Details for Trapezoidal Channel (with Flap Gate)

Sheet 2 of 2

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