

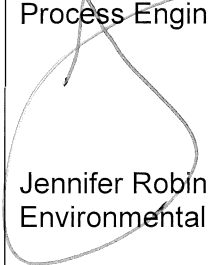


METRO WATER RECOVERY

INDUSTRIAL PRETREATMENT PROGRAM MONITORING FACILITY DESIGN CRITERIA AND ENGINEERING REPORT REQUIREMENTS POLICY

PURPOSE/SCOPE:

This document defines the Industrial Pretreatment Program's requirements for Industrial User's monitoring facility engineering reports and monitoring facility design criteria.

Version Number	Approved By	Effective Date
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PURPOSE AND APPLICABILITY

This policy outlines applicant requirements to enable Metro Water Recovery's Industrial Pretreatment Program to comply with the sampling and monitoring requirements of the National Pretreatment Regulations, 40 CFR 403 and Metro's Rules and Regulations Governing the Operation, Use and Services of the System (Rules & Regulations). Because of the complexity of the regulatory requirements, Metro developed this policy to interpret, clarify, and provide information and direction to applicants, consulting engineers, and Metro staff with regard to monitoring facility design applications, review processes, and requirements. Additionally, this policy will guide applicants in the design, construction, or updates of sampling and monitoring facilities that meet the accessibility, safety, accuracy, and equipment requirements needed to comply with the requirements. The information in this policy will help to ensure that applicants submit complete and accurate applications and that Metro's review efforts are as consistent as possible.

REGULATORY BASIS

The National Pretreatment Regulations have sampling and monitoring requirements for Categorical Industrial Users, Significant Industrial Users, and Authority Monitoring. The following excerpts from the National Pretreatment Regulations highlight the foundational requirements that this policy clarifies. Please note that in the citations below, Metro is the Control Authority, the Authority is the US Environmental Protection Agency, and the User is the Significant Industrial User or Categorical Industrial User.

- Categorical Industrial Users –
 - Item 403.12 (b)(4) of 40 CFR Part 403 requires that “the user shall submit information showing the measured average daily and maximum daily flow, in gallons per day, to the POTW from each of the following:
 - (i) Regulated process streams; and
 - (ii) Other streams as necessary to allow use of the combined wastestream formula of § 403.6(e). (See paragraph (b)(5)(iv) of this section.)
 - Item 403.12 (g)(1) of 40 CFR Part 403 requires that industrial users routinely monitor, analyze, and report analytical results of effluent streams to demonstrate continuous compliance with the industrial discharge permit “including the flow and the nature and concentration, or production and mass where requested by the Control Authority.”
 - Item 403.12 (g)(3) of 40 CFR Part 403 requires that reports “must be based upon data obtained through appropriate sampling and analysis performed during the period covered by the report, which data are representative of conditions occurring during the reporting period.”
 - Item 403.12 (g)(5) of 40 CFR Part 403 requires that “[a]ll analyses shall be performed in accordance with procedures established by the Administrator pursuant to section 304(h) of the Act and contained in 40 CFR part 136 and amendments thereto or with any other test procedures approved by the Administrator.” Where “administrator” refers to Environmental Protection Agency (EPA).
- Significant Industrial Users –
 - Item 403.12 (h) of 40 CFR Part 403 requires that significant non-categorical industrial users routinely submit “a description of the nature, concentration, and flow of the pollutants required to be reported by the Control Authority.” This item further clarifies that the data and reports “must be based on sampling and analysis performed in the period covered by the report, and in accordance with the techniques described in 40 CFR part 136 of this chapter and amendments thereto.”
- Authority Monitoring –
 - Item 403.8 (f)(2)(v) requires the Authority (Metro) to “[r]andomly sample and analyze the effluent from Industrial Users and conduct surveillance activities in order to identify, independent of information supplied by Industrial Users, occasional and continuing noncompliance with Pretreatment Standards.” This item further requires the Control Authority to “[i]nspect and sample the effluent from each Significant Industrial User at least once a year,”

Metro implements these federal requirements through issuance of industrial discharger permits to Significant and Categorical Industrial users with flow and pollutant monitoring requirements and annual authority monitoring at each permitted industrial user facility. To support these efforts, Metro's Rules and Regulations include the following key requirements:

- Item 6.22.2. Permit Application In support of the application, the Industrial User shall submit, in units and terms appropriate for evaluation, the information identified below. 13. Any other information deemed necessary by Metro Water Recovery to characterize and evaluate the potential and/or actual discharge from the facility and to support associated permitting decisions.
- 6.24. MONITORING FACILITIES/REQUIREMENTS
 - 1) Metro Water Recovery may require to be installed and operated at the Industrial User's own expense, monitoring facilities to allow inspection, sampling, and flow measurement of any discharges as necessary to determine compliance with the provisions of these Rules and Regulations.
 - 2) There shall be ample room in or near such sampling manhole or facility to allow accurate sampling representative of the discharge and preparation of samples for analysis. The facility, sampling, and measuring equipment shall be maintained at all times in a safe and proper operating condition at the expense of the Industrial User. All devices shall be calibrated in accordance with manufacturers' specifications to ensure their accuracy, unless a waiver is obtained from, or an alternative method specified by, Metro Water Recovery.
 - 3) The sampling and monitoring facilities shall be provided in accordance with Metro Water Recovery's requirements and all applicable local construction standards and specifications. Construction shall be completed within such a time frame as Metro shall specify by written notification.
 - 4) Unless specifically stated otherwise, all samples must be preserved, handled, and analyzed according to 40 Part 136 of the Code of Federal Regulations (40 CFR 136), Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act, and amendments thereto. Where 40 CFR 136 does not contain sampling or analytical techniques for the Pollutant(s) in question, or where the Administrator of the EPA determines the Part 136 sampling and analytical techniques are inappropriate for the Pollutant(s) in question, sampling and analysis shall be performed by using validated analytical methods or any other applicable sampling and analytical procedures, including procedures specified by Metro Water Recovery.
 - 5) The analytical method(s) selected by the Industrial User must be "sufficiently sensitive" for all monitoring conducted to meet requirements of these Rules and Regulations or other Metro Water Recovery requirements. A method is sufficiently sensitive when the method detects and accurately and precisely quantifies the amount of the analyte, i.e. there is a valid and positive result. Or, the analytical method is sufficiently sensitive when the method limit is less than or equal to Metro Water Recovery specific discharge limitations, permit limitations, or applicable pretreatment standard.
- 6.25. INFORMATION SUBMITTAL, INSPECTION AND SAMPLING, RECORD KEEPING REQUIREMENTS

Metro Water Recovery may require any Industrial User to submit information as necessary to determine compliance with the Requirements of these Rules and Regulations. All information required by these Rules and Regulations, or a permit or order issued hereunder, must be signed and certified for accuracy by an Authorized Representative of the Industrial User.

Metro Water Recovery shall have the right to enter and inspect the facilities of any Industrial User to ascertain compliance with the Requirements of these Rules and Regulations and any permit or order issued hereunder. Persons or occupants of premises where Wastewater is created or discharged shall allow Metro or its representatives ready access at all reasonable

times to all parts of the premises for the purposes of inspection, sampling, records examination and copying, or in the performance of any of their duties.

Metro Water Recovery, CDPHE, and the EPA shall have the right to set up on the Industrial User's property such devices as are necessary to conduct sampling, inspection, compliance monitoring and/or metering operations. Where an Industrial User has security measures in force which would require proper identification and clearance before entry into the Industrial User's premises, the Industrial User shall make necessary arrangements with security guards so that upon presentation of suitable identification, Staff from Metro, the CDPHE, and the EPA will be permitted to enter, without delay, for the purposes of performing their specific responsibilities. Unreasonable delays in allowing Metro access to the Industrial User's premises shall be a violation of these Rules and Regulations.

APPLICATION PROCESS

Prior to construction and operation, all new or discovered industrial users must submit a monitoring facility design application to Metro that demonstrates how the proposed monitoring facility(ies) meet the requirements of these monitoring facility design criteria. In addition, industries with Metro approved monitoring facility(ies) must submit a monitoring facility design submittal to Metro that demonstrates how the proposed monitoring facility(ies) meet the requirements of these monitoring facility design criteria prior to commencement of construction. This engineering report and application must be prepared by an engineer licensed in the State of Colorado. The monitoring facility design must be submitted by the industrial user's authorized representative and provided in duplicate including one hardcopy and one electronic copy. Currently, Metro is not authorized to accept electronic copies for determining regulatory compliance, therefore the hard copy is the official submittal for determining compliance with all applicable rules, regulations, or other requirements including compliance deadlines.

The monitoring facility application process consists of a written application, review, written decision, and construction certification. The applicant must obtain approval of the monitoring point design from the Metro Water Recovery (Metro) Industrial Pretreatment Program Permit and Engineering Section (P&E) prior to commencement of construction. Purchasing equipment or constructing monitoring facilities without having first obtained design approval is performed at the applicant's own risk. If the (P&E) does not approve the monitoring facility design application that is based on prepurchase equipment or a constructed installation, Metro may require the applicant to replace the equipment or modify the installation.

Once received, the P&E will add the application to the project queue and prioritize the assignment of the project and review based on date received, critical deadlines, resource availability, and project priorities, like an emergency. Once initiated, an engineer from the P&E will review the application for conformance with the monitoring facility design criteria and engineering report requirements. The P&E staff may require modifications to address design criteria or additional clarifications or information to complete the review. Upon issuance of a Request for Information (RFI), Metro P&E will place the review on hold until the applicant provides the information necessary to complete the review. The RFI may include an enforceable response deadline. The RFI process may take multiple iterations with the applicant depending on the complexity and clarity of the response(s). Once the review is complete, the P&E may approve, conditionally approve, or deny the monitoring facility design through a written decision document. Please note that the P&E does not provide verbal decisions. The P&E issues all decisions in writing.

Definitions

1. Submergence ratio – submergence limit defined by the ratio of the downstream head to the upstream head.
2. Monitoring Facility – the location that houses the equipment, sampling taps and instrumentation required to measure the wastewater flow and character. The monitoring facility is the location where all measuring and monitoring is performed to report discharge permit compliance.

Section 1: Monitoring Facility Design Criteria Engineering Report Requirements

1. General requirements
 - a. An engineering report shall accompany all monitoring facility design applications. The report shall provide the basis for the proposed monitoring facility design, including calculations and construction drawings.
 - b. The engineering report and design documents shall be prepared by a professional engineer licensed in a field with applicable experience. The professional engineer must be licensed in the State of Colorado by the Colorado Department of Regulatory Agencies (DORA).
 - c. The report shall include copies of all manufacturer product specific equipment and pertinent information to verify compliance with these design criteria. Examples include, but are not limited to dimensional drawings, manufacturer's specifications, equipment options selections/recommendations, pump curves, etc.
 - d. Metro recognizes that some conditions may exist that prohibit the monitoring facility design from meeting all of the design criteria included in this policy. In limited cases and when sufficient justification is provided, the applicant may request a site-specific deviation as part of the application. When a site-specific deviation is requested, the industrial user must provide equivalent methods. The Metro Industrial Pretreatment Program P&E may approve, conditionally approve, or deny individual site-specific deviations as part of the decision document.
2. Description and purpose of project
 - a. If applicable, a copy of historical written Metro approval and application package and a summary of the proposed modifications to the monitoring facility(ies).
3. Site Location
 - a. Facility address and area map.
4. IU Facility/Facilities Area Definition
 - a. Activities performed within the IU facilities and location(s) where those activities are performed (e.g., material receiving, material storage, production areas, office areas, etc). Clearly identify where any industrial and categorical processes are performed. Any facilities with categorical processes shall install monitoring facilities at the "end-of-process" before introduction of other diluting wastestreams.
 - b. Operating hours, number of personnel for how long and in what areas.
 - c. Facility site plan demonstrating a&b above.
 - d. Plumbing plan and site piping plan
 - i. Facility plumbing and site piping plan shall include 1) sources of domestic wastewater from toilets, bathroom and kitchen sinks and showers, 2) industrial and process wastewater sources, 3) drains, plumbing/piping demonstrating the domestic and process wastewater sources and flow of each through the building(s) and the facility's site to the monitoring facility(ies) and through the outfall location to the municipal sewer connection.
 - e. Qualitative description of the wastewater generated from each area.
5. Flow evaluation

- a. Description of water use and wastewater produced (quality & quantity) by the IU. Identify water use and wastewater generated (quality and quantity) in each use area within the IU facility(ies).
 - i. Describe discharge pattern (i.e., continuous, batch, variable). When variable and batch discharges are utilized, describe discharge frequency and duration and any seasonal or monthly variability.
 - ii. All facilities that discharge process wastewater in batches shall design batching equipment to discharge for a minimum of 30-minute duration to allow adequate time for samplers to collect all required grab samples.
 - b. Flow analysis for each source of wastewater in (a) that includes maximum instantaneous flow rate, average daily flow rate, minimum flow rate. Provide estimated duration of maximum instantaneous flow. For gravity flow, include discussion and calculations justifying selected pipe diameters and pipe slopes. For pumped discharges provide discussion of pump and piping size selection.
6. Selected monitoring facility or facilities
 - a. Description of selected monitoring facilities. Justify selected facilities based on flow pattern, flow quantity (compatibility with flow min/max), flow quality (compatibility with any chemicals, presences of solids, oils, or foams), and anticipated parameters to be measured and monitored (selected device must be compatible with regulatory monitoring requirements for the parameter).
 - b. Provide drawings demonstrating locations for all compliance monitoring facilities location of facility outfall to receiving sewer. Provide hydraulic gradelines, sewer inverts, manhole locations, etc.
 - c. Provide engineering calculations demonstrating the selected flow monitoring device is sized appropriately for the range of flow.
 - d. Identify location for all compliance monitoring facilities on drawings.
 - e. Describe how the facility design accommodates Metro staff's 24-hour access including security clearance, locks, and security codes.
 - f. The engineering report must provide all equipment cutsheets and/or equipment specifications.
7. The engineering report must include a discussion of the operation and maintenance activities required to maintain proper operation and accuracy (i.e. calibration procedures) of the monitoring facility devices and instruments.
 - a. For example: flow measuring devices must be kept clean of fibers, stringy material and particles.

Section 2: Monitoring Facility Design Criteria Requirements

1. General
 - a. Site plumbing shall be configured such that domestic wastewater from toilets, bathroom and kitchen sinks and showers do not flow through the monitoring facility.
 - b. All equipment must be properly operated, maintained, and calibrated to manufacturer's requirements and recommendations.
 - c. All monitoring facilities must be made fully accessible to Metro employees at all times and must not require specialized equipment to access.
 - d. Must include heating and air conditioning as required to meet sampling and monitoring requirements of the discharge permit.
 - e. Meet requirements of the discharge permit (as applicable)
 - f. Provide a local flow measurement readout in the same room as the monitoring facility.
 - g. Metro may require installation of a sampling fridge at the monitoring facility to improve sample storage conditions at proper temperature. Monitoring facility design shall include

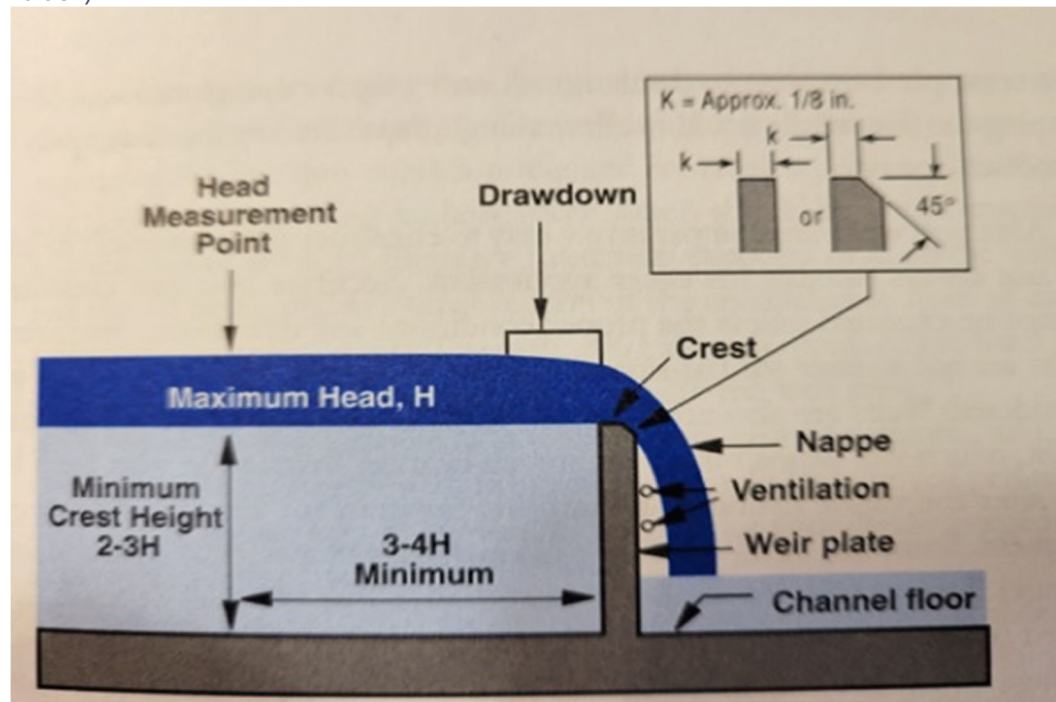
space adequate for a sampling fridge. Where provided, the sampling fridge shall be maintained at a temperature such that samples are preserved at $\leq 6^{\circ}\text{C}$ and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity. Fridge temperature shall be verified by a Traceable Digital-Bottle Refrigerator thermometer, or equal.

2. Monitoring Facility Accessibility and Safety Considerations
 - a. All monitoring facilities and ancillary equipment must be independently accessible for sampling staff and Metro staff at all times.
 - b. At least 3-foot wide corridors (ingress/egress paths) must be provided for sampling personnel carrying sampling equipment (e.g. coolers, bottles, autosampler)
 - i. Ingress/egress corridors shall provide safe access, free of tripping hazards, protrusions overhead and from the sides and other hazards. For outdoor facilities, consider cars, shrubs, etc.
 - c. Sampling facilities shall be ergonomically friendly and shall provide safe and reasonable/reachable access to sampling ports, waste stream to be sampled and to all sampling equipment and readout screens without the use of accessory equipment such as, but not limited to, ladders, rigging, hoists, safety climbs, etc.
 - d. The area surrounding the monitoring facility shall be open and unobstructed providing adequate space for safe access of at least two sampling personnel and sampling equipment.
 - e. When designing the monitoring facilities, consider the autosampler suction tubing length can never exceed 20 feet.
 - f. When the monitoring facility is located in a manhole or vault, the depth from bottom of vault/manhole to ground surface must not be more than ten (10) feet.
 - g. All monitoring facilities shall include adequate lighting, heating and ventilation.
 - h. IUs must not install monitoring facilities that require confined space entry for Metro personnel.
3. Flow Metering Design Criteria
 - a. General
 - i. To develop these flow metering design criteria, Metro has referenced the ISCO Open Channel Flow Measurement Handbook. Although referenced for these design criteria, Metro does not require or promote ISCO or Fluidyne brands. Other peer reviewed engineering reference manuals recognized and accepted as good engineering practice are also acceptable. Where manufacturer' specific design standards are used, the application and engineering report shall include these references for Metro's review.
 - ii. All piping and open channels shall be designed to contain the entire range of flows expected, including max instantaneous.
 - iii. The selected flow meter shall be compatible with the wastestream character (e.g. consider chemical and solids makeup).
 - iv. All flow meters shall be accessible and shall be maintained and calibrated to the manufacturer's requirements and recommendations. Calibrations must be conducted no less than once per year.
 - v. All flow meters must be located with adequate upstream and downstream hydraulic conditions at each metering device (e.g., avoiding turbulence, eddy currents, air entrainment) to ensure flow measurement accuracies within +/- 10% of actual flows over the full range of anticipated flow variations.
 - vi. Must include a non-resettable totalizer.
 - vii. Must provide continuous measuring and reporting.
 - viii. Must provide a dedicated 4-20 output signal or equal (e.g. ISCO TIENet 306 Sampler Interface) for connection of Metro's autosampler. Must provide the programmed maximum flow setting at 20 mA.

- b. Closed Pipe flow meters
 - i. Magnetic flow meters
 - 1. Magnetic flow meter installations must be designed for full pipe flow conditions to measure and meter the flow accurately.
 - 2. Minimum straight, consistent diameter of pipeline length upstream and downstream of the metering device: 5 pipe diameters upstream and 2 pipe diameters downstream.
 - ii. Other closed pipe flow meters shall be installed in accordance with manufacturer requirements and recommendations.
- c. Open Channel Flow Meters
 - i. General
 - 1. All open channels and open channel flow metering devices must be designed to provide free flow through the flow meter throughout the full range of flow. The downstream conveyance and design water surface elevation must avoid submergence or backflow conditions at the flume or weir.
 - 2. Must provide both primary and secondary measuring devices.
 - 3. Provide a location for Metro to install a Metro flow meter (i.e., bubbler)
 - ii. Weirs

Weir Design must meet the minimum design requirements within these criteria or from ISCO Open Channel Flow Measurement Handbook (ISCO). Please refer to Figure 1, from ISCO, Sixth Edition for design criteria variable references.

Figure 1 Sharp Crested Weir (Source ISCO Open Channel Flow Measurement Handbook, Sixth Edition)



- 1. Must be designed to provide free/critical flow conditions across the entire operating range of flow.

2. Conform to requirements within ISCO including:
 - a. Sharp crested weirs, the weir plate thickness must be 1/8 to 1/4 inch thick or if thicker, provide a downstream chamfered edge.
 - b. The upstream edge must be sharp with right angle corners, perpendicular to the axis of the flow channel.
 - c. Connection of the weir plate to the channel must be waterproof to avoid leaks around the weir opening.
 - d. The length of the weir crest or notch angle must be accurately determined and identified in the engineering report and drawings.
 - e. The weir must be designed to provide adequate ventilation (Figure 1).
 - f. The minimum weir crest height must be 2-3H or at least 12-inches, whichever is greater.
 - g. The approach to the weir plate must be straight for at least 20 times the design maximum head (H) of fluid and must have little to no slope.
 - h. The weir crest must be set higher than the maximum downstream water surface elevation to allow freefall over the weir at the maximum instantaneous flow rate.
 - i. The head measuring location must be at least 3-4 times the maximum head expected over the weir. The measuring location must be located in a quiet section of the channel away from disturbances. The zero point of the head measuring device must be set exactly level to with the weir crest.
 - j. The cross-sectional area of the approach channel shall be at least 8 times that of the nappe at the crest for a distance of 20 times the head on the crest. The approach channel must be designed to minimize turbulence and provide a uniform velocity profile.
3. V-Notch Weirs
 - a. The V-notch weir shall be designed in accordance with Table 1

*Table 1: V-Notch Weir Minimum and Maximum Head and Flow Rates**

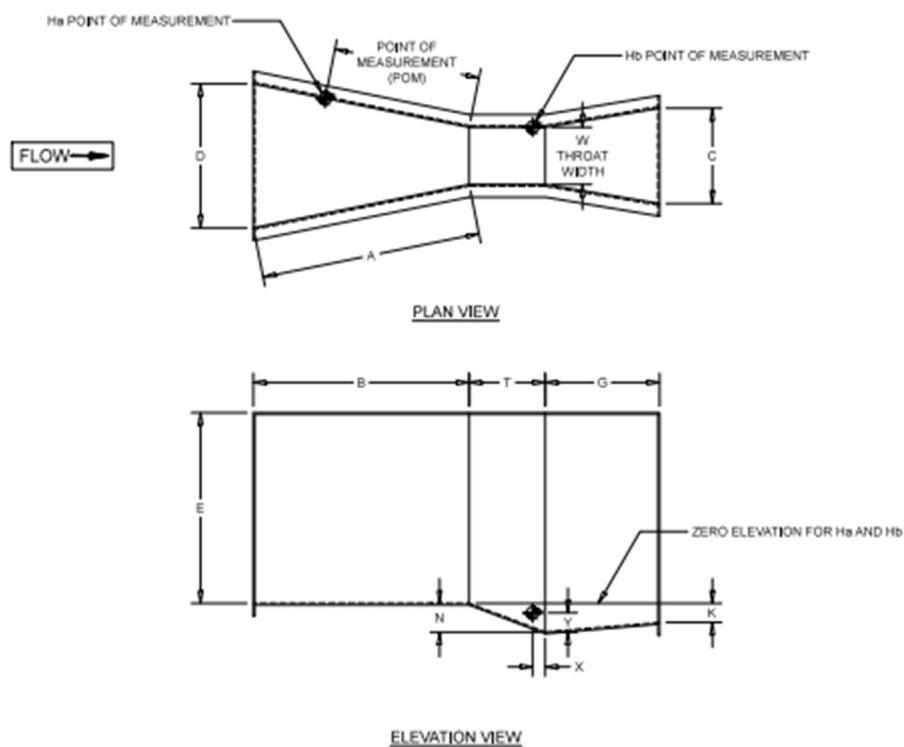
V Notch Angle	Minimum Head (ft)	Minimum Flow, (gpm)	Maximum Head (ft)	Maximum Flow (gpm)
22.5	0.2	3.99	2.0	1,260
30	0.2	5.43	2.0	1,720
45	0.2	8.31	2.0	2,630
60	0.2	11.6	2.0	3,660
90	0.2	20.1	2.0	6,350

*Source: Table 3-1 of ISCO Open Channel Flow Measurement Handbook, 6th Edition

- iii. Minimum Design Requirements for Flumes
 1. Flumes shall be set in a solid foundation (e.g. concrete) and maintained level within the foundation. The foundation shall not allow the flume to flex or twist that would result in inaccurate flow measurement readings.
 2. Approaching flow must be well distributed across the entrance width to the flume (i.e. parallel flow lines to the flume centerline). Approaching

- flow shall be free of surges, waves, and surface boils. Straightening vanes may be used to improve the approaching flow profile.
3. Approaching channel shall be straight (e.g. free of bends, reductions, valves) for at least 5 channel widths upstream of the head measuring location (staff gauge location)
 4. Flumes shall be designed to avoid submerging the flume and to maintain a submergence ratio appropriate to the specific flume. The submergence ratio is defined as the ratio of the downstream depth to the upstream depth and is expressed as a percentage.
 5. Parshall Flume
 - a. Must be constructed according to ASTM 1941 (See Figure 2).

Figure 2. Parshall Flume Dimension Drawing D 1941(source: OpenChannelFlow)



W (SIZE)	A	POM	B	C	D	E	T	G	K	N	X	Y
1"	1'-2 9/32"	9 17/32"	1'-2"	3 21/32"	6 19/32"	9"	3"	8"	3/4"	1 1/8"	5/16"	1/2"
[2.54 CM]	[36.27 CM]	[24.21 CM]	[35.56 CM]	[9.29 CM]	[16.75 CM]	[22.86 CM]	[7.62 CM]	[20.32 CM]	[1.91 CM]	[2.86 CM]	[0.79 CM]	[1.27 CM]
2"	1'-4 5/16"	10 7/8"	1'-4"	5 5/16"	8 13/32"	10"	4 1/2"	10"	7/8"	1 11/16"	5/8"	1"
[5.08 CM]	[41.43 CM]	[27.62 CM]	[40.64 CM]	[13.49 CM]	[21.35 CM]	[25.4 CM]	[11.43 CM]	[25.4 CM]	[2.22 CM]	[4.29 CM]	[1.59 CM]	[2.54 CM]
3"	1'-6 3/8"	1'-0 1/4"	1'-6"	7"	10 3/16"	12"	6"	12"	1"	2 1/4"	1"	1 1/2"
[7.62 CM]	[48.67 CM]	[31.12 CM]	[45.72 CM]	[17.78 CM]	[47.23 CM]	[60.96 CM]	[15.24 CM]	[30.48 CM]	[2.54 CM]	[5.72 CM]	[2.54 CM]	[3.81 CM]
6"	2'-0 7/16"	1'-4 5/16"	2"	1'-3 1/2"	1'-3 5/8"	2'	1'	2'	3"	4 1/2"	2"	3"
[15.24 CM]	[62.07 CM]	[41.44 CM]	[60.96 CM]	[38.74 CM]	[39.69 CM]	[60.96 CM]	[30.48 CM]	[60.96 CM]	[7.62 CM]	[11.43 CM]	[5.08 CM]	[7.62 CM]
9"	2'-10 5/8"	1'-11 1/8"	2'-10"	1'-3"	1'-10 5/8"	2'-6"	1'	1'-6"	3"	4 1/2"	2"	3"
[22.86 CM]	[87.95 CM]	[58.74 CM]	[86.36 CM]	[38.1 CM]	[57.47 CM]	[76.2 CM]	[30.48 CM]	[45.72 CM]	[7.62 CM]	[11.43 CM]	[5.08 CM]	[7.62 CM]
12"	4'-6"	3"	4'-4 7/8"	2'	2'-9 1/4"	3'	2'	3'	3"	9"	2"	3"
[30.48 CM]	[137.2 CM]	[91.44 CM]	[134.3 CM]	[60.96 CM]	[84.46 CM]	[91.44 CM]	[60.96 CM]	[91.44 CM]	[7.62 CM]	[22.86 CM]	[5.08 CM]	[7.62 CM]
18"	4'-9"	3'-2"	4'-7 7/8"	2'-6"	3'-4 3/8"	3'	2'	3'	3"	9"	2"	3"
[45.72 CM]	[144.8 CM]	[96.52 CM]	[141.9 CM]	[76.2 CM]	[102.6 CM]	[91.44 CM]	[60.96 CM]	[91.44 CM]	[7.62 CM]	[22.86 CM]	[5.08 CM]	[7.62 CM]
24"	5'	3'-4"	4'-10 7/8"	3'	3'-11 1/2"	3'	2'	3'	3"	9"	2"	3"
[60.96 CM]	[152.4 CM]	[101.6 CM]	[149.5 CM]	[91.44 CM]	[120.7 CM]	[91.44 CM]	[60.96 CM]	[91.44 CM]	[7.62 CM]	[22.86 CM]	[5.08 CM]	[7.62 CM]
36"	5'-6"	3'-8"	5'-4 3/4"	4'	5'-1 7/8"	3'	2'	3'	3"	9"	2"	3"
[91.44 CM]	[167.6 CM]	[111.8 CM]	[164.5 CM]	[121.9 CM]	[157.2 CM]	[91.44 CM]	[60.96 CM]	[91.44 CM]	[7.62 CM]	[22.86 CM]	[5.08 CM]	[7.62 CM]

- a. Submergence ratio (H_b/H_a) must not exceed 50% for 1-, 2-, and 3-inch flumes and 60% for 6- and 9-inch flumes. For Parshall flumes, H_b is measurement location in the throat and H_a is the primary measurement point located upstream of the throat.
- b. Flow shall be maintained within the minimum and maximum flow rates specified in Figure 3.

Figure 3. Minimum and Maximum Flow through Parshall Flumes (Source ISCO Open Channel Flow Measurement Handbook, Sixth Edition)

Throat width, W in./ft.	Min. head, feet	Minimum flow rate			Max. head, feet	Maximum flow rate		
		CFS	GPM	MGD		CFS	GPM	MGD
1 in.	0.10	0.010	4.28	0.006	0.70	0.194	87.3	0.126
2 in.	0.10	0.019	8.55	0.012	0.80	0.478	215	0.309
3 in.	0.10	0.028	12.6	0.018	1.10	1.15	516	0.743
6 in.	0.10	0.054	24.3	0.035	1.50	3.91	1750	2.53
9 in.	0.10	0.091	40.7	0.059	2.00	8.87	3980	5.73
1 ft.	0.10	0.120	54.0	0.078	2.50	16.1	7240	10.4
1.5 ft.	0.10	0.174	78.0	0.112	2.50	24.6	11,000	15.9
2 ft.	0.15	0.423	190	0.273	2.50	33.1	14,900	21.4
3 ft.	0.15	0.615	276	0.398	2.50	50.4	22,600	32.6
4 ft.	0.20	1.26	567	0.816	2.50	67.9	30,500	43.9
5 ft.	0.20	1.56	698	1.01	2.50	85.6	38,400	55.4
6 ft.	0.25	2.63	1180	1.70	2.50	103	46,400	66.9
8 ft.	0.25	3.45	1550	2.23	2.50	140	62,600	90.2
10 ft.	0.30	5.74	2570	3.71	2.75	199	89,200	128
12 ft.	0.33	7.93	3560	5.13	3.50	347	156,000	224

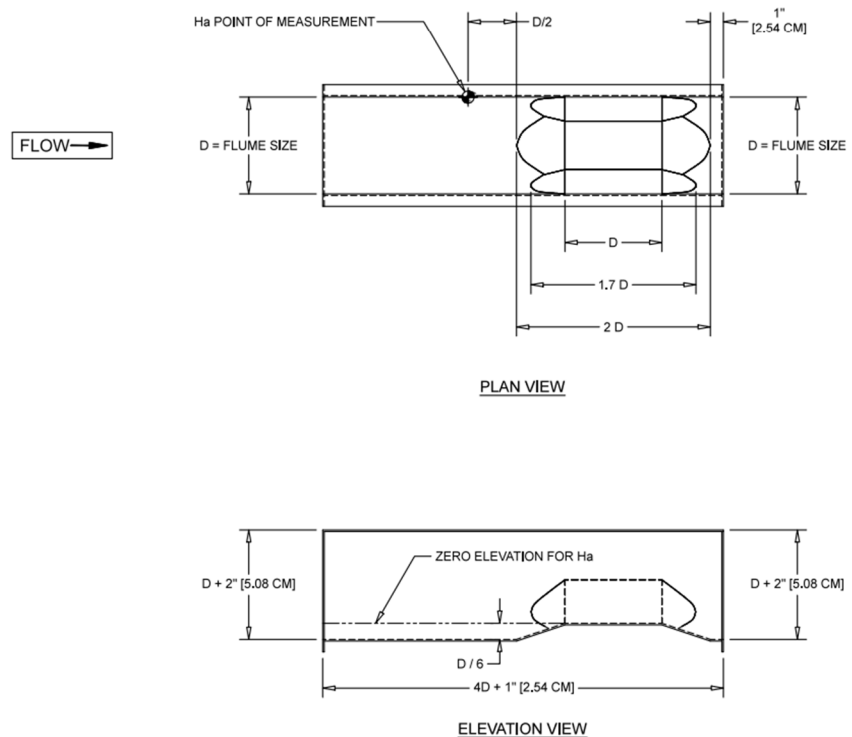
- c. Flow shall be calculated using equations in Figure 4 – Source: ISCO

Figure 4. Discharge Equations for Parshall Flumes (Source ISCO Open Channel Flow Measurement Handbook, Sixth Edition)

Throat width, W	CFS	GPM	MGD
1 in.	$Q = 0.3380 H^{1.550}$	$Q = 151.7 H^{1.550}$	$Q = 0.2184 H^{1.550}$
2 in.	$Q = 0.6760 H^{1.550}$	$Q = 303.4 H^{1.550}$	$Q = 0.4369 H^{1.550}$
3 in.	$Q = 0.9920 H^{1.547}$	$Q = 445.2 H^{1.547}$	$Q = 0.6411 H^{1.547}$
6 in.	$Q = 2.060 H^{1.580}$	$Q = 924.5 H^{1.580}$	$Q = 1.331 H^{1.580}$
9 in.	$Q = 3.070 H^{1.530}$	$Q = 1378 H^{1.530}$	$Q = 1.984 H^{1.530}$
1 ft.	$Q = 4.000 H^{1.522}$	$Q = 1795 H^{1.522}$	$Q = 2.585 H^{1.522}$
1.5 ft.	$Q = 6.000 H^{1.538}$	$Q = 2693 H^{1.538}$	$Q = 3.878 H^{1.538}$
2 ft.	$Q = 8.000 H^{1.550}$	$Q = 3590 H^{1.550}$	$Q = 5.170 H^{1.550}$
3 ft.	$Q = 12.00 H^{1.566}$	$Q = 5386 H^{1.566}$	$Q = 7.756 H^{1.566}$
4 ft.	$Q = 16.00 H^{1.578}$	$Q = 7181 H^{1.578}$	$Q = 10.34 H^{1.578}$
5 ft.	$Q = 20.00 H^{1.587}$	$Q = 8976 H^{1.587}$	$Q = 12.93 H^{1.587}$
6 ft.	$Q = 24.00 H^{1.595}$	$Q = 10770 H^{1.595}$	$Q = 15.51 H^{1.595}$
8 ft.	$Q = 32.00 H^{1.607}$	$Q = 14360 H^{1.607}$	$Q = 20.68 H^{1.607}$
10 to 50 ft.	$Q = (3.688 W + 2.5) H^{1.6}$	$Q = (1655 W + 1122) H^{1.6}$	$Q = (2.384 W + 1.616) H^{1.6}$

6. Palmer-Bowlus Flume
Figure 5 provides a reference drawing of a Palmer Bowlus Flume.

Figure 5: Palmer Bowlus Flume (Source: Openchannelflow)



- a. Palmer-Bowlus flumes designs are not standardized, therefore Palmer-Bowlus flume design must be based on appropriate sizing and data tables from the specified flume manufacturer and must be included in the design submittal.
- b. Upstream pipe slope must be considered to maintain critical flow through the throat. The selected slope shall be justified in the engineering report.
- c. There must be a straight approach (i.e., no bends, reducers, valves, etc.) to the flume for at least 25 flume widths (D) upstream of the flume.
- d. Downstream pipe capacity must be larger than the upstream pipe capacity (e.g. slope and or pipe diameter must be larger than the upstream pipe slope).
- e. Submergence ratio (H_b/H_a) must not exceed 85% for Palmer Bowlus flumes. Where H_a is located at $D/2$ upstream of the beginning of the throat ramp and H_b is located in the channel downstream of the flume with the zero elevation at the same height as the top of the throat ramp. The application must identify both H_a and H_b measuring locations from the flume manufacturer.

7. Trapezoidal

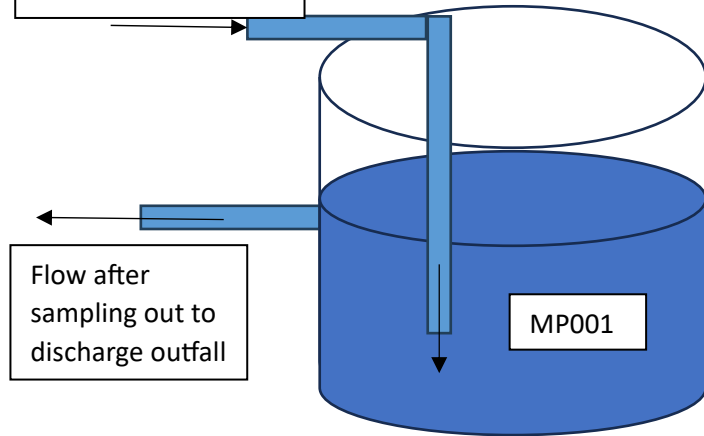
- a. Trapezoidal flumes are not standardized, therefore trapezoidal flume design must be based on appropriate sizing and data

- tables from the specified flume manufacturer and must be included in the design submittal.
- b. There must be a straight approach (i.e., no bends, reducers, valves, etc.) to the flume for at least 20 throat widths (D) upstream of the flume.
 - c. Submergence ratio must not exceed 80%. The application shall identify proper measurement locations for determining submergence ratio.
4. Water Quality Characterization: In-Line Instrumentation and Sampling Tap Design Criteria
- a. All instruments used for water quality characterization shall be calibrated, operated, and maintained according to manufacturer requirements and recommendations.
 - b. All water quality characterization instruments, equipment, and sampling taps shall be located downstream of the flow measuring device location.
 - c. All monitoring facilities shall provide a minimum of two 120V/60 Hz GFI power outlets.
 - d. Close pipe facilities:
 - i. The pressure at the closed pipe sampling location shall not exceed 15 psi.
 - ii. Inline pH instrumentation: Where the permittee is required or chooses to include continuous inline pH monitoring, the pH meter must be:
 1. Installed at a location that provides a representative sample.
 2. Installed such that the pH probe remains wetted at all times.
 - iii. When discharged wastewater pH is determined by grab samples the sample tap or port must be located downstream of the flow measuring device. Pursuant to 40 CFR 136, pH analysis must be performed within 15 minutes of taking the grab sample.
 - iv. Provide one (1) access port with a shut off valve and 3/4-inch NPT thread to accept Metro's pH probe instrument during Authority Monitoring activities.
 - v. Provide three (3) sampling taps (ports) with shut off valves. All sampling ports shall be configured with 3/8-inch barbed nipples.
 1. Sample taps shall not be located on the bottom of the pipe and should be located near 90 degrees (or 180 degrees).
 2. Taps must be located in an area that provides clear space of no less than 1 foot to any obstruction such that a sampling technician can easily fit large bottles under and around the sample taps.
 - e. Open channel sampling
 - i. pH monitoring: Where permittee is required or chooses to include continuous inline pH monitoring, pH meter shall be:
 1. Installed at a location that provides a representative sample.
 2. Installed at a location the is wetted at all times.
 - ii. Facilities with open channels must provide a design that enables samplers to take grab samples. Grab sample bottles may be as large as nine inches tall and 4 inches wide and samples must be attained directly from the waste stream without use of a transfer dipper. See Figures below for examples.



Flow downstream of
flow metering and in
for grab sampling

Flow after
sampling out to
discharge outfall



Large diameter pipe (12-
inch or greater) with
access "hatch" or
"window" to provide grab
access (must have
adequate depth of flow
to fill a large sample
bottle). Pipeline must not
be located greater than
3-4 feet from ground
surface or access
platform must be
provided.



Box with a plate to create
a back up of water for
grab sampling