ENVIRONMENTAL MANAGEMENT BUREAU
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

WATER QUALITY MONITORING MANUAL

VOLUME II

MANUAL ON EFFLUENT QUALITY MONITORING

February 2008

PREFACE

This manual on Effluent Quality Monitoring (EQM) constitutes Volume II of a two-volume manual on Water Quality Monitoring, Volume I being the manual on Ambient Water Quality Monitoring (AWQM).

Volume II is a guide to monitor the quality of effluent from industries and other regulated wastewater dischargers. The objective is to standardize effluent quality monitoring procedures to ensure that the water quality monitoring programs follow certain Quality Assurance/Quality Control (QA/QC) protocols and acceptable field methods.

The primary users of the EQM manual are the technical staff of the EMB, both the Central and Regional Offices. Other users may include the technical staff of LLDA and other agencies or individuals under the DENR.

Users may also include other government regulators and implementers, consultancy firms, industries, monitoring groups such as Multi-partite Monitoring Teams (MMTs), students and researchers.

The manual is intended to be a dynamic document that will be periodically reviewed and updated as deemed necessary.

ACKNOWLEDGMENTS

The EMB-DENR acknowledges with gratitude the technical assistance provided by the Japan International Cooperation Agency (JICA) for the Capacity Development Project on Water Quality Management (CDPWQM) through which the revision of this Water Quality Monitoring Manual was undertaken along with other guidelines of the Philippine Clean Water Act of 2004.

The EMB-DENR is also grateful to the following organizations for their support and invaluable assistance in the preparation of this manual, for diligently reviewing the drafts, and giving suggestions for improvement.

The Technical Working Group:

- Industrial Technology Development Institute, Department of Science and Technology*, (ITDI-DOST)*
- Laguna Lake Development Authority (*LLDA*)
- League of Provinces of the Philippines (*LPP*)
- Local Water Utilities Administration (*LWUA*)
- Mines and Geosciences Bureau (*MGB*)
- Manila Water Company, Inc. (*MWCI*)
- Maynilad Water Services, Inc. (*MWSI*)
- Metropolitan Waterworks and Sewerage System (*MWSS*)
- Pollution Control Association of the Philippines, Inc. *(PCAPI)*
- Philippine Coast Guard (PCG)

The Environmental Management Bureau Central Office

The Environmental Management Bureau Regional Offices

The JICA Philippine Office

The JICA Project Technical Assistance Team

Woodfields Consultants, Inc.

ACRONYMS, ABBREVIATIONS, SYMBOLS AND UNITS

Agencies, Organizations, Offices

CALABARZON	-	Cavite Laguna Batangas Rizal Quezon
DA	-	Department of Agriculture
DENR	-	Department of Environment and Natural Resources
EMB	-	Environmental Management Bureau
JICA	-	Japan International Cooperation Agency
LLDA	-	Laguna Lake Development Authority
LGU	-	Local Government Unit
NGO	-	Non-Government Organization
NWRB	-	National Water Resources Board
WCI	-	Woodfields Consultant Inc.
WHO	-	World Health Organization

Technical, Chemical and Scientific Terms

AWQM	-	Ambient Water Quality Monitoring
AVFO	-	Animal-Vegetable Fats and Oil
AVS	-	Acid Volatile Substance
BS	-	Blind Sample
BTEX	-	Benzene Toluene Xylene
CAS	-	Chemical Abstract Service
CB	-	Cartridge Blank (Filter Blank)
CDO	-	Cease and Desist Order
COC	-	Chain of Custody
CWA	-	Clean Water Act
DAO	-	Department Administrative Order
EB	-	Equipment Blank
ECC	-	Environmental Compliance Certificate
EQM	-	Effluent Quality Monitoring
FB	-	Field Blank
FD	-	Field Duplicate
FDF	-	Field Data Form
FQC	-	Field Quality Control
GC	-	Gas Chromatography
GES	-	General Effluent Standards
GIS	-	Geographic Information System
GPS	-	Global Positioning System
MDL	-	Method Detection Limit
MPN	-	Most Probable Number
NOV	-	Notice of Violation
PD	-	Presidential Decree

PNSDW - Philippine National Standards for Drinking Water
QA/QC - Quality Assurance/Quality Control
RA - Republic Act
RPD - Relative Percentage Difference
RS - Replicate Sample
RPSD - Relative Percent Standard Deviation
SI - Systems International d'Unites
SS - Split Sample
TB - Trip Blank
WQG - Water Quality Guidelines
WQM - Water Quality Monitoring

Symbols

As - Arsenic
B - Boron
Ba - Barium
BOD - Biochemical Oxygen Demand
Ca - Calcium
Cd - Cadmium
CdS - Cadmium Sulfide
Cl - Chloride
CN - Cyanide
Cr - Chromium
Cr^{+6} - Hexavalent Chromium
Cu - Copper
$CuSO_4$ - Copper Sulfate
DDT - Dichloro Difluoro Trichloroethane
DO - Dissolved Oxygen
F - Fluoride
Fe - Ferrous or Iron
HCl - Hydrochloric Acid
Hg - Mercury
MBAS - Methylene Blue Alkyl Substances
Mn - Manganese
NaCl - Sodium Chloride (common table salt)
NH_3 - Ammonia
NH_3-N - Ammonia Nitrogen
Ni - Nickel
N-NO_3 - Nitrogen-Nitrate
PAH - Polyaromatic Hydrocarbon
Pb - Lead (Plumbum)
PCB - Polychlorinated Biphenyl
pH - Potential of Hydrogen
PO_4 - Phosphate

SO_4	-	Sulfate
TCE	-	Trichloroethylene
TDS	-	Total Dissolved Solids
TSS	-	Total Suspended Solids
Zn	-	Zinc

Units

cm, cm^2, cm^3	-	centimeter, square centimeter, cubic centimeter
°C	-	degree Centigrade
°F	-	degree Fahrenheit
ft, ft^2, ft^3	-	foot, square foot, cubic foot
g	-	gram
g/L	-	gram per liter
gal	-	gallon
ha	-	hectare
hm^2	-	square hectometer
in, in^2, in^3	-	inch, square inch, cubic inch
kg	-	kilogram
km, km^2	-	kilometer
L	-	liter
lb	-	pound
m, m^2, m^3	-	meter, square meter, cubic meter
µg	-	microgram
µg/L	-	microgram per liter
µL	-	microliter
µm	-	micrometer
mi	-	mile
mg	-	milligram
mg/L	-	milligram per liter
mL	-	milliliter
mm	-	millimeter
n mile	-	nautical mile
oz	-	ounce
ppb	-	parts per billion
ppm	-	parts per million
ppt, ‰	-	parts per thousand
qt	-	quart
t	-	ton
yd, yd^2	-	yard, square yard

CONVERSION TABLE

LENGTH		
SI/Metric	**Conversion**	**English**
1 km	1,000 m	0.621 mi 0.54 n mile
1 m	100 cm	39.4 in 3.28 ft 1.09 yd
1 cm	100 mm	0.394 in
1 mm	1,000 µm	0.0394 in 39.4 mils
1 µm	0.001 mm	0.0000394 in 0.0394 mil

AREA		
SI	**Metric**	**English**
1 ha	10,000 m^2 1 hm^2	2.47 acres
	1 m^2	1.196 yd^2 10.764 ft^2
	1 cm^2	0.155 in^2

VOLUME		
SI	**Metric**	**English**
1,000 L	1 m^3	31.315 ft^3
1 L	0.001 m^3 1,000 cm^3	0.264 gal 1.06 qt
1 mL	1 cm^3	0.06 in^3

WEIGHT			
SI/Metric	**Conversion**	**Comparable Water Volume**	**English**
1 t	1,000 kg	1 m^3	2,205 lb
1 kg	1,000 g	1 L	2.205 lb
1 g	1,000 mg	1 mL	0.035 oz
1 mg	1,000 µg	1 µL	--

CONCENTRATION	
1 g/L	1 ppt, ‰
1 mg/L	1 ppm
1 µg/L	1 ppb

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CHAPTER I
INTRODUCTION

This Manual on Effluent Quality Monitoring (EQM) addresses the requirements of the Philippine Clean Water Act (CWA) of 2004 or RA 9275 and its Implementing Rules and Regulations (IRR), DAO 2005-10 on compliance monitoring and self-monitoring by the industries. This Manual was developed primarily to guide the EMB-DENR/LLDA inspectors in monitoring the quality of effluent from industries and other establishments whose wastewater discharges are regulated by the government. It may also serve as reference for other users, such as the industries undertaking self-monitoring to ensure that their discharges meet the effluent quality standards.

The EQM manual is divided into eight chapters as follows:

Chapter I – INTRODUCTION

This Chapter details the purpose, scope, exclusions and limitations of the manual.

Chapter II – OBJECTVES OF EFFLUENT QUALITY MONITORING

This Chapter explains why effluent quality monitoring is undertaken.

Chapter III – EFFLUENT QUALITY MONITORING PLAN

This Chapter contains basic information about planning the effluent quality monitoring. It describes the necessary preparations for sampling and briefly discusses the elements of a sampling plan: the objectives of sampling, selection of sampling stations, sampling criteria, sampling techniques, and proper handling of samples until analyzed.

Chapter IV –SAMPLING AND FIELD TEST METHODS AND TOOLS

This chapter provides an overview of alternative methods and tools that may be used in effluent sampling, flow measurements and field analysis. It describes the suitability and limitations of each method and tool.

Chapter V – QUALITY ASSURANCE & QUALITY CONTROL

This Chapter explains the importance of quality assurance and quality control in effluent quality monitoring and describes the various QA/QC options and their applicability. This chapter also emphasizes the need for the EMB-DENR personnel to undergo the necessary training and develop the required competency to ensure that samples are collected following the prescribed protocols.

Chapter VI – EFFLUENT SAMPLING ACTIVITIES

This Chapter describes the effluent sampling activities which include planning the effluent sampling, coordination with the laboratory, preparation of sampling containers, effluent sampling and on-site measurements, safety precautions, and preservation, storage and transport of samples to the laboratory.

Chapter VII – FLOW MEASUREMENT

This Chapter is a guide to selection of appropriate effluent flow measurement method. It describes the suitability and limitations of each measurement device.

Chapter VIII – DATA PRESENTATION AND REPORTING

This Chapter discusses how to evaluate the results of effluent monitoring and prepare the monitoring report. It includes a sample report form to be used when reporting results of effluent sampling activities.

CHAPTER II
OBJECTIVES OF EFFLUENT QUALITY MONITORING

2.1 Introduction

In line with the goal of the Philippine CWA to protect, preserve and revive the quality of Philippine waters, the EMB-DENR developed the General Effluent Standards (GES) to serve as basis for taking positive actions in preventing, controlling and abating water pollution.

The Philippine CWA of 2004 defines *effluent* as "discharges from known source which are passed into a body of water or land or wastewater flowing out of a manufacturing plant, or industrial plant including domestic, industrial or recreational facilities."

As mandated in the CWA, facilities discharging effluent to land resources must ensure that the effluent quality will not affect the usability of land nor impair the quality of the groundwater resources. Discharges to water bodies should meet the GES while discharges to land for irrigation and other agricultural purposes should meet the guidelines of the Department of Agriculture (DA).

Effluent Quality Monitoring is the process of checking, evaluating or investigating the quality of the effluent or wastewater discharges from an industry, establishment or facility.

2.2 Objectives of Effluent Quality Monitoring

Effluent quality monitoring is undertaken by the EMB-DENR primarily to ensure compliance by the industries and commercial establishments with the GES. The EMB-DENR monitors the quality of effluent through the discharge permitting system even as the industries are encouraged to undertake self-monitoring of the quality of discharges.

The effluent or wastewater discharge is monitored for specific effluent quality parameters to ensure that the concentrations are within allowable limits. The monitoring results are used as basis for regulatory and control actions, e.g., issuance of discharge permits, issuance of notice of violation (NOV), conduct of technical conference, cease and desist order (CDO), or imposition of fines and penalties or computation of wastewater charges.

Effluent monitoring is also used to:

- Evaluate the effectiveness of effluent treatment and control;

- Identify potential environmental problems and evaluate the need for remedial actions or mitigating measures;
- Support permit revision and/or renewal based on new data;
- Detect, characterize and report unplanned releases by the facility or establishment;
- Determine the impact to the receiving media (water body, groundwater and land); and
- Determine the effectiveness of the waste minimization/cleaner technologies adopted by the facility.

CHAPTER III
EFFLUENT QUALITY MONITORING PLAN

3.1 Introduction

A monitoring plan is a report that describes how the effluent will be monitored and how the effluent quality will be measured. A well-designed monitoring plan will help ensure that the procedures for effluent sampling and other activities will conform to the objectives of monitoring.

Plans are designed according to the objectives of monitoring and take into account such factors as time, budget, equipment, human power, and implementation constraints. As effluent quality monitoring entails time and resources, the activities should be properly planned to optimize the use of resources.

This chapter guides through the preparation of monitoring plan. A sample is provided in **Attachment 3.1** for reference.

3.2 Components of a Monitoring Plan

A monitoring plan typically includes the following components:

- Objectives of Monitoring
- Background Information
- Monitoring Stations
- Effluent Quality Parameters for Measurement
- Frequency of Monitoring
- Water Quality Sampling and Test Methods
- Quality Assurance and Quality Control Procedures

3.3 Preparation of Effluent Monitoring Plan

The efficacy of effluent monitoring is only as good as its preparation. Careful planning and coordination is critical to a successful monitoring program. At a minimum, the sampling team must know the location of the establishment, the distance from the laboratory, sampling location, the number of discharge outlets, number and types of samples to collect, the frequency of collection, source of supplies and equipment, and where the samples will be submitted.

Table 3.1 lists some basic considerations in preparing the effluent monitoring plan.

Table 3.1
Considerations in Preparing an Effluent Monitoring Plan

- Determine the objectives of the monitoring
- Determine the location of the establishment, type of industry, and the type of WTP
- Determine the number and location of the discharge outlet and permit condition
- Determine the number of samples to be collected and the parameters to be analyzed
- Determine the sampling containers and field tests to be performed
- Determine the time it will take for the samples to reach the laboratory.

(1) Determine the objectives of the monitoring plan

An effluent quality monitoring program should have clear objectives. The objectives would be the basis for deciding the parameters to measure, the number of samples, the frequency of sampling, the type of container, preservation method, sampling techniques and analytical methods to be used. The primary objectives of effluent monitoring are described in Section 2.2.

(2) Determine the location of the establishment, type of industry and the type of Wastewater Treatment Facility

If the effluent from the industry or establishment is to be monitored for the first time, it is advisable to conduct preliminary survey of the company and the treatment facility in particular.

A preliminary survey will facilitate identification of appropriate sampling sites and sampling methods. It will help the monitoring team gain an understanding of the type of treatment the facility uses, the industry type, including chemicals and other hazardous substances used in the facility that may alter the effluent quality.

Items to be considered in the preliminary survey include:

- Background information on the facility, including the following:
    1) vicinity map,
    2) plant layout,
    3) manufacturing process flow diagram,
    4) source of water supply,
    5) wastewater generated from the different processes,
    6) treatment methodology,
    7) discharge points,
    8) sampling points,
    9) production levels,
    10) number of discharging days,
    11) volumetric flow rate of wastewater generated per outlet (if available), and
    12) name of water body where the wastewater is discharged into,
    13) Waste minimization/pollution prevention strategy.

Coordination with the LGUs and the concerned agencies will facilitate access to this information. The EMB Regional Offices have the list of all industrial establishments and their locations within their jurisdictions.

(3) Determine the number and location of the discharge outlet and permit condition

After gaining access to the facility and based on the preliminary survey results, the number and location of discharge outlets can be verified. From the discharge permit application filed by the Pollution Control Officer (PCO), it can be determined whether the facility discharges effluent by "batch".

Sampling may be conducted based on the probable days the facility discharges effluent. (The number of discharging days is also considered by EMB-DENR in the computation of pollution load for the determination of the wastewater charge fees and calculation of fines and penalties). The facility representative, particularly the PCO can give this information during the preliminary survey. If the company has been issued a Discharge Permit from EMB-DENR/LLDA, such information is part of discharge permitting requirements and thus is available and can be verified from the said Office.

(4) Determine the number of samples to be collected and parameters to be analyzed

The type of industry and the treatment process will give an idea as to how many samples will be collected and the parameters to be analyzed.

If the facility will be monitored for the first time, it is necessary to assess the nature of the facility to determine the parameters to be analyzed and the pollution load. (Pollution load refers to the amount or quantity of the pollutant parameter, e.g. kg BOD being discharged by the facility). The Revised WQG and GES may be used as guide in identifying the significant effluent quality parameters per sector.

The laboratory should also be consulted prior to sampling.

(5) Determine the sampling containers and field tests to be performed

Field test parameters normally include pH, temperature, residual chlorine and conductivity. Confirm the field tests to be conducted based on the objective of monitoring and type of wastewater treatment employed by the facility. The sampling containers to be used will depend on the test parameters to be analyzed.

The latest EMB-approved analytical methods may be referred to in determining the necessary volume of sample and the appropriate type of container, preservation and holding time for each effluent quality parameter.

(6) Determine the time it will take for the samples to reach the laboratory.

The monitoring team shall identify in advance which laboratory will handle the analysis of the water samples. Consideration should be given to the distance of the facility or the establishment to the laboratory, the method of transport and the holding time for the parameters to be analyzed.

Safety issues related to sampling should also be addressed. This shall include identification of hazards during sampling and handling of chemicals used in sample preservation. This is discussed in more detail in Section 6.3.3 Safety Considerations.

Once the overall sampling requirements have been addressed, critical details relevant to sampling equipment, field analytical equipment, standard operating procedures and quality assurance must be carefully addressed.

3.4 Selection of Sampling Stations

Selection of sampling stations depends on the purpose of effluent quality monitoring.

- If the discharger intends to meet the DENR requirement on Self-Monitoring program, then sampling from the effluent streams of the wastewater treatment plant (WTP) will be sufficient.
- However, if the discharger intends to evaluate the performance efficiency of the treatment units, samples should be collected from the influent stream of the WTP and from the effluent streams of each treatment unit.

3.4.1 Strong Waste Discharges

For strong wastewater whose initial BOD value before treatment is equal to or greater than 3,000 mg/L[1], sample should be collected from the influent and effluent streams of the wastewater treatment plant (WTP) to determine the efficiency or % removal of the treatment facility. Compare the result with the effluent standard to determine which is lower or more stringent.

Strong wastewater discharges are industrial wastes with high BOD and TSS compared with domestic wastewater. This may also include discharges with high levels of toxic substances which are difficult to treat. Such wastes will normally require a combination of biological or chemical treatment in order to meet the effluent standards.

It takes an experienced individual or inspector to judge that an industry will generate strong wastewater.

The manufacturing or process flow diagram can give an indication if a process will generate strong wastewater.

A manufacturing process may generate strong wastewater if:

- It uses excessive water in the process resulting in high volumetric flow
- It uses highly organic raw material
- It uses toxic chemicals
- It uses complex or complicated processes

[1] Revised Water Quality Guidelines and General Effluent Standards.

It is possible to verify if an industry generates strong wastes based on the following:

- Characterization of wastewater
- Overall material balance in the process flow
- Level or degree of treatment required to reduce the strength of the influent (primary, secondary, advanced and specific treatment processes required namely activated sludge, filtration, disinfection, nutrient removal, etc.)
- Knowledge of or information on the chemical constituents present in influent
- Cost of the treatment facility
- Effect on the receiving water body in terms of dissolved oxygen depletion

3.4.2 Temperature Measurement for Facilities Discharging Hot Effluents

When establishing sampling points from the pollution source to the receiving body of water for facilities discharging hot effluents, items to be considered shall include, but not be limited to the following conditions:

(a) For Rivers

- The volume of effluent discharge from the facility and the size of the water body (e.g. river, creek).
- The maximum temperature tolerable to the most sensitive species that thrive in the receiving water body. (check with BFAR on the list of species and the maximum tolerable temperature).
- The background temperature of the water body per season.
- Sample should be collected from upstream of the source, few meters (2-5 meters wherever practicable and accessible) before outfall.
- Sample should be collected from downstream of the outfall, before mixing with discharges of other sources (if there are other sources within the vicinity). If there are no other dischargers other than the facility, collect sample before discharging to the water body.

(b) For Lakes and Marine Waters

For lakes and marine waters, the following shall be considered:

- If there is no hydrological model available for the receiving water body, require the facility to conduct thermal plume modeling to determine the appropriate sampling location within the water body.
- Consider the seasonal hydrological condition of the water body (e.g. current direction, temperature).
- The maximum temperature tolerable to the most sensitive species that thrive in the receiving water body.
- Collect sample at the identified station, at least 1 foot or 30.48 centimeters from the surface of the water body.

3.5 Basic Considerations in Sampling

The basic considerations should be taken into account in the selection of the sampling location or station:

- The location must provide a sample that is representative of the final effluent discharged to receiving waters.
- It must be downstream of all treatment processes, including disinfection (chlorination/de-chlorination, ultraviolet light, etc.).
- The station should be such that the flow rate of the effluent can be measured or estimated.
- The station must be accessible. Safety of the person conducting effluent sampling must be considered in selecting the site.

Sampling stations or discharge outlets established by the facility must be clearly shown or reflected in the Plant and Drainage Lay-out that may be required by EMB-DENR in the processing of discharge permit applications. This will facilitate sampling from common stations by the dischargers and EMB-DENR.

If the facility has multiple discharge outlets, the facility has to declare and identify them, as part of the permitting requirements. Each discharge outlet shall be sampled to identify and characterize the type of effluent being discharged. A typical map showing sampling location is presented in **Figure 3.1**.

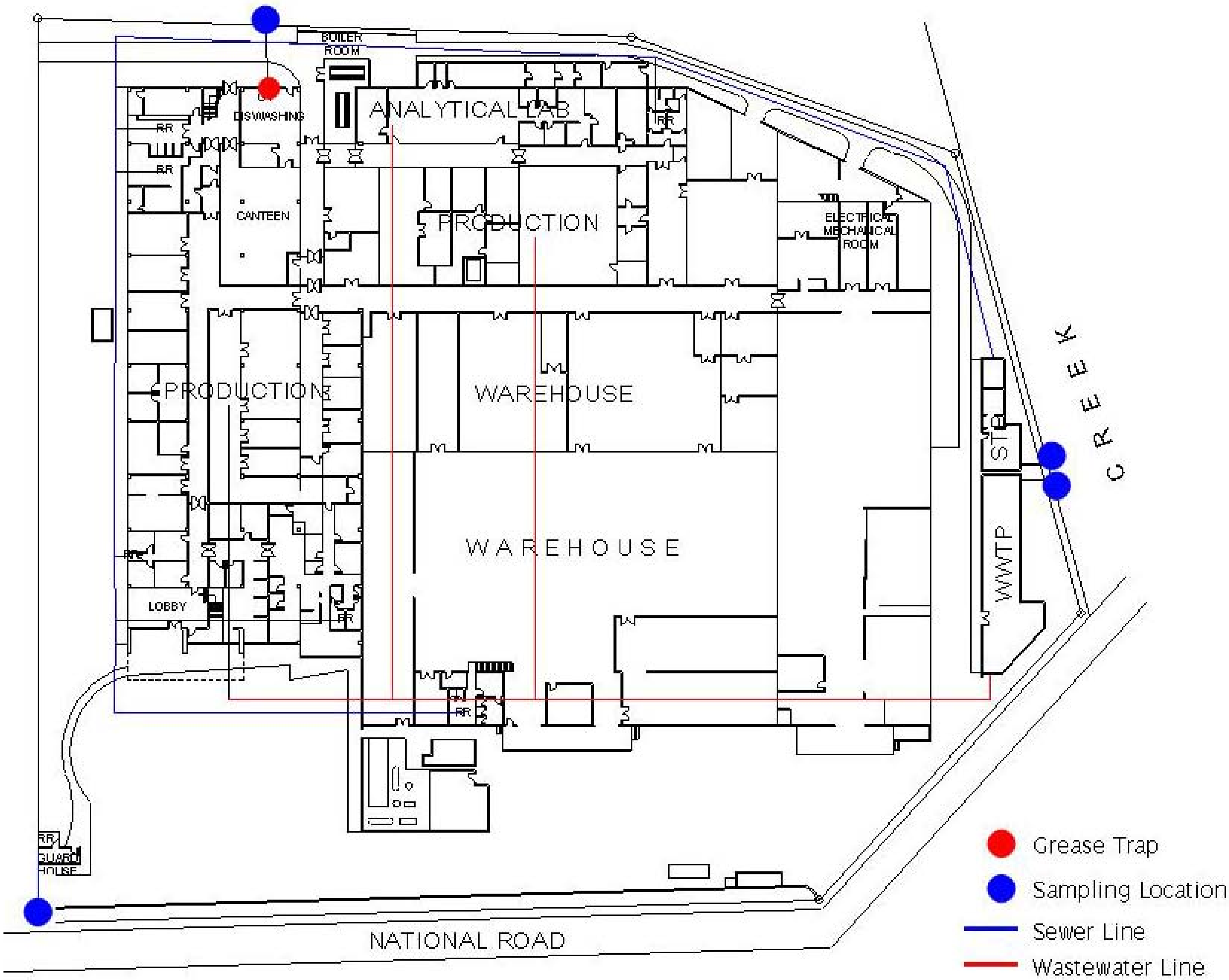


FIGURE 3.1
Plant Layout Showing Sampling Location

3.6 Frequency of Sampling

The frequency of sampling depends on the variability of effluent flow rate and on the wastewater characteristics. Samples may be taken at longer intervals when variability is low and at shorter intervals when variability is high.

The EMB-DENR inspectors must conduct effluent quality monitoring in accordance with their compliance monitoring program for the industry. This is also in line with the Discharge Permitting requirements/permit conditions which require effluent sampling before first time issuance or renewal of Discharge Permit.

Sampling for significant parameters may be conducted on a monthly basis or as necessary or as indicated in the permit conditions. This periodic effluent analysis is included in the PCO's SMR submitted to EMB.

However, effluent samples may be collected by the discharger as often as necessary based on the sampling schedule specified in its own effluent quality monitoring program to monitor the efficiency of its wastewater treatment plant.

3.7 Effluent Quality Sampling and Test Methods

The intended method of analysis should be indicated in the plan, including the methods for measurement of effluent discharge and should always be related to the objectives of monitoring.

Selection of test method should be coordinated with the laboratory as it will depend primarily on available equipment, reagents and apparatus. On the other hand, sampling procedures, containers and preservation techniques should conform to the selected laboratory method.

If the selected method is recognized by the EMB, it would be acceptable.

3.8 Effluent Quality Parameters for Analysis

The effluent quality parameters for analysis will depend on the type of industry being monitored. A food manufacturing industry, for example, will monitor different parameters compared to a chemical industry where heavy metals are present. The revised GES can be referred to for the significant effluent parameters per industry sector.

The largest current use of water for agriculture, landscape and irrigation, offers significant opportunities for water reuse. The quality of effluent for land applications is of particular importance to crop/fish productivity, human and animal health and the environment. Refer to the Department of Agriculture's Guidelines on the Procedure and Technical Standards for the issuance of a Certification Allowing for the Safe Re-use of Wastewater for the Purposes of Irrigation and other Agricultural Uses.

3.9 Coordination with the Laboratory

Close coordination with the laboratory is extremely important in EQM. Coordination with the laboratory should be undertaken during the preparation of the monitoring plan.

The laboratory should be informed of the following:

- The parameters proposed for analysis and the number of samples to be collected so that the laboratory could prepare appropriate containers, reagents, equipment and apparatus to be used in sampling.
- If there is intention to conduct on-site measurements or field testing so that the necessary field equipment can be prepared.
- The estimated time the samples will be received at the laboratory.

A sample submittal form/chain of custody is to be provided by the laboratory during the conduct of effluent sampling.

3.10 Quality Assurance and Quality Control Procedures

The QA/QC procedures that will be observed during sampling, transport, handling, preservation and laboratory analysis should be specified in the plan. Details of QA/QC procedures are discussed in Chapter V.

3.11 Field Personnel

The Effluent Quality Monitoring Manual is designed in such a way that procedures are simplified so that the User can easily follow. Plant personnel, specifically the WTP Operators and Technicians should have knowledge of the basics of effluent monitoring, particularly the sampling protocols. It will be to the user's benefit, especially the beginners to undergo training on this aspect to better appreciate and comprehend effluent monitoring activities.

All personnel involved in effluent sampling and data collection activities must have the experience and skills to perform these activities.

CHAPTER IV
SAMPLING AND FIELD TEST METHODS AND TOOLS

4.1 Introduction

This Chapter provides an overview of the different methods and tools available for field sampling and field tests.

4.2 Types of Effluent Samples

There are two types of effluent samples: grab sample and composite sample.

4.2.1 Grab Sample

A grab sample is a single water sample collected at one time from a single point[1]. A grab sample can represent only the composition of the source at the time and place of sampling.

Grab sampling is suitable when:

- analyzing situations at specific sites (e.g. BOD content in the final sump pit before discharge to a water body)
- analyzing for unstable parameters that have to be measured right away or on site (e.g., DO, temperature, pH, TDS, salinity)
- a snapshot of water quality at a particular instant is desired
- the characteristics of the waters are known to be relatively constant over time
- collecting samples to be analyzed for parameters that could be adversely affected by compositing process.

4.2.2 Composite Sample

The PNSDW of 2007 defines composite sample as a series of individual grab samples taken at different times from the same sampling point and mixed together. A composite sample may also be a number of grab samples of equal or weighted volumes mixed in one container.

Composite samples are preferred when the concentration of the parameter under consideration is expected to vary with time (or location).

[1] Philippine National Standards for Drinking Water 2007; DOH-AO No. 2007-0012. The 2007 PNSDW is available in the DOH website: www.doh.gov.ph

There are four types of composite sample:

(1) Fixed Volume Composite Sample

In a fixed volume composite, both the time and the size of the sample remain constant. This is used when the flow rate of the wastewater does not vary more than 15% of the average flow.

(2) Time Composite Sample

This is collected by mixing samples of equal volume collected at regular time interval.

(3) Flow-proportioned Composite Sample.

When variability in effluent flow rates exists, flow proportioned composite sampling is a technique that must be used.

A flow-proportioned sample could be collected by keeping the time interval constant and varying the sample volume with the changing wastewater flow, or the volume remains the same and the time interval between sampling varies.

Flow proportional composite sampling is necessary when effluent flow rates vary significantly (variations exceeding +15% of the daily mean more than 10% of the time).

The following is a hypothetical example of calculations for quantity collected:

If 1% of the effluent discharge (expressed per second) has to be collected and the discharge is 10 L/sec then 100mL must be collected. If the discharge doubles, in order to collect the required 1%, a 200mL sample should be collected.

(4) Depth-Integrated Composite Sample.

Collected in pre-determined depths of the water column in equal water volumes and mixed in one container.

4.3 Sampling Methods

4.3.1 Manual Grab Sampling

Manual sampling is a technique used for collecting grab samples for immediate on-site field analysis. Manual sampling is preferred over the use of automatic equipment over extended periods of time, especially when it is necessary to observe and/or note unusual conditions.

The more commonly used grab sampling methods are described below.

4.3.1.1 Direct Sampling with the Sample Container

Sampling may be done using the sample container which maybe a wide-mouthed glass container, plastic container, BOD bottle, or vial with cover.

The appropriate laboratory sample container is submerged in the effluent stream on a chain or pole until it is full. It is then retrieved, preserved as necessary and capped.

The sampling procedures are as follows.

(1) Put on protective gloves.

(2) Obtain a pre-labeled sample bottle and remove the lid without touching the inner surface of either the bottle or the lid.

(3) Rinse the container at least three times with the effluent, except for container with preservative and for sample intended to be analyzed for Petroleum oil, Animal and Vegetable Fats & Oil (AVFO), total coliform or fecal coliform.

(4) Hold the bottle below the neck and lower it into the effluent. Ensure that the hands do not touch the bottle opening. For samples to be analyzed for petroleum oil or AVFO, take samples only from the surface of the water. Do not submerge the sample bottle below the water surface.

(5) Slowly lift the container towards the flow. Fill it to about 4/5 full. Enough space should be left to allow for addition of preservative, if necessary, and to allow for mixing the sample.

(6) Cap or cover the container and place the sample in a cooler containing sufficient quantity of ice.

(Please take note of the recommended QA/QC procedures in Chapter 5 and safety measures in Chapter 6.3.3.)

Grab sample can also be collected at the outfall or sampling station identified by the facility using the appropriate container. **Figure 4.1** and **4.2** shows the collection of effluent samples from different locations through direct sampling using sample container.

Figure 4.1

Grab sampling using direct container (plastic container) at outfall/discharge.

Figure 4.2

Sampling using direct container at improvised sampling port.

4.3.1.2 Sampling with Intermediate Container

Wastewater/effluent is collected in a bucket or other container and immediately transferred to the appropriate laboratory container(s), preserved as necessary and capped.

It is advisable to use an intermediate container (e.g. bucket, beaker, wide-mouth bottles) to collect a grab sample if any one of the following conditions exists:

- If sample cannot be obtained by direct sampling (e.g. deep tanks, wastewater pond);
- If volume of effluent discharge is high.

The intermediate container may be an unpreserved sample container, beaker, bucket, pond sampler or dipper.

Intermediate devices also prevent unnecessary contamination of the outer surface of the sample bottle, which would otherwise result from direct immersion in the source.

The more common intermediate sampling devices are described below.

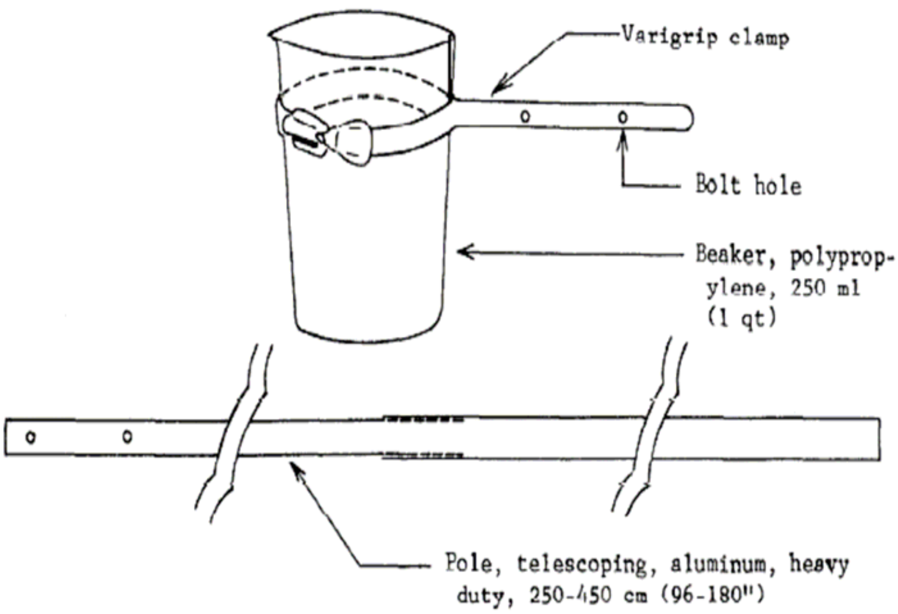
(1) Dip/Pond Sampler

With an intermediate device such as the dip/pond sampler, (**Figure 4.3**) samples can be obtained at distances as far as 3 m (10 ft) from the edge of the source, preventing the sampler from having to contact the source physically.

The assembly of this container and any additional equipment required to access the sample location (e.g., extension arms, poles) must be appropriate for the parameter to be analyzed. The decontamination of this equipment must also be appropriate for the parameter to be analyzed and for the design of the equipment. Dippers and pond samplers can be either reused or discarded.

The pond sampler consists of an adjustable clamp attached to the end of a two- or three-piece telescoping aluminum or fiberglass pole that serves as the handle. The clamp is used to secure the container.

Figure 4.3
Pond Sampler



(2) Bucket Container

The effluent is collected in a bucket and appropriately clean (outside as well) laboratory container (e.g. volatiles vial) is held at an angle and submerged into the liquid until it is full and air bubbles have been expelled at which time it is carefully retrieved, preserved as necessary and capped. Take care to avoid sample contamination from the outer part of the laboratory container, label adhesives or the retrieval device. See **Figure 4.4** and **4.5**.

Figure 4.4

Sample collected from intermediate container (pail). Sample is collected in a sample container (glass vial).

Figure 4.5

Samples in glass vials. Samples with air bubbles (such as the sample on the right) should be discarded.

4.3.2 Composite Sampling

Composite samples can be collected either by automated or manual methods.

A manual composite sample consists of grab samples typically taken at equally spaced time intervals and combined or mixed when all sub-samples have been collected.

Automated composite samples can be taken either proportional to the wastewater stream flow (in which case there must be a flow sensing device connected to the sampler) or on an equal volume/equal time method.

Some composite samples are collected by the following techniques:

Flow Proportional:

AUTO 1 Automatic equipment collecting samples proportional to the wastewater stream flow at time intervals of 30 minutes or less over the sampling period, under typical flow conditions.

MANUAL 1 A minimum of 8 grab samples taken at equally spaced time intervals over the sampling period (e.g. every 3 hours in a 24 hour period) combined in proportion to the wastewater stream flow.

Equal time/Equal volume:

AUTO 2 Automatic equipment collecting samples of equal volume at equally spaced time intervals of 15 minutes or less over the sampling period.

MANUAL 2 A minimum of 8 grab samples taken at equally spaced time intervals over the sampling period (e.g. every 3 hours in a 24 hour period) combined in equal volumes.

MANUAL 3 A minimum of 3 grab samples taken at time intervals of at least 6 hours over the sampling period and combined prior to analysis, or analyzed individually and the mean reported.

MANUAL 4 Three grab samples taken at time intervals of at least 2 hours over an 8-hour sampling period.

For regulatory purposes, grab sampling is preferred. It has the advantage of having the test results available at once from the laboratory.

Composite sampling normally requires an automatic sampler where samples can be collected at different time intervals. Manual composite sampling will require additional personnel to collect samples at different time intervals.

Composite sampling has the advantage of getting the samples during low and peak loads entering the treatment plant. When designing a new treatment facility, composite sampling will give a better waste characterization of the influent.

4.4 On-Site Measurements

On-site measurement of samples is necessary to obtain actual concentration of effluent quality parameters that might change during transport to the laboratory, or these parameters might change due to some value adjustments required in subsequent laboratory analyses.

Usually, water quality checkers are used for on-site measurements (pH, DO, temperature, salinity, conductivity and total dissolved solids). Follow the on-site measurement procedures as discussed in Section 6.6.

4.5 Recording Field Observations

The person conducting sampling should have a field notebook wherein all relevant details are recorded at the time of sampling (See **Figure 4.6** and **4.7**). The field book should be:

- Be hard-bound; not a loose-leaf.
- Not be discarded but stored for future reference when full because it contains data in original form which are invaluable for reference purposes.
- Be provided with page numbers.
- Have all entries written in ballpen or permanent ink only. Errors entered in the field book should be crossed out once by a straight line.

Figure 4.6
Sample showing, hardbound field book and permanent ink pen used in recording field observations.

Figure 4.7
Loose sheet of paper, pencil and sign pen should <u>not</u> be used in recording field notes

Details recorded should include:

- Those noted on the sample bottle.
- Type of samples collected.
- Kind of measurements done and how those were taken.

- The results obtained (including blanks, standards, etc., and the units employed).
- Preservatives used.
- All supporting information (any unusual local features at the site and time of sampling) should also be noted. If there has been any variation from the agreed sampling station, this should be noted indicating the reasons. Any need for a permanent change in sampling station should be brought to the attention of the EMB-DENR and the inventory should be changed if necessary.
- If a standard field record layout is used in place of a plain notebook, adequate space should be available for comments and observations. The layout and content of the pages should reflect the sequence in which the various procedures will be carried out.

4.6 Field Data Forms and Labels

Maintaining accurate records of field sample collections is an essential part of any effluent monitoring program.

4.6.1 Field Data Forms

Field data forms must include:

- the date and time of sample collection for each parameter tested,
- names of collectors,
- sample site names or codes,
- influent/effluent flows,
- color and odor of the water sample, etc.

Figure 4.8, is an odor descriptor wheel developed by St. Croix Sensory for use with environmental odor samples. The eight main odor categories are based on the original International Association on Water Pollution Research and Control (IAWPRC) odor wheel for water samples. This list of terms was condensed down from a master list of 800 terms. The ASTM International E18 Sensory Evaluation Committee originally compiled odor descriptor master list of 800 terms from published literature and industrial organizations.

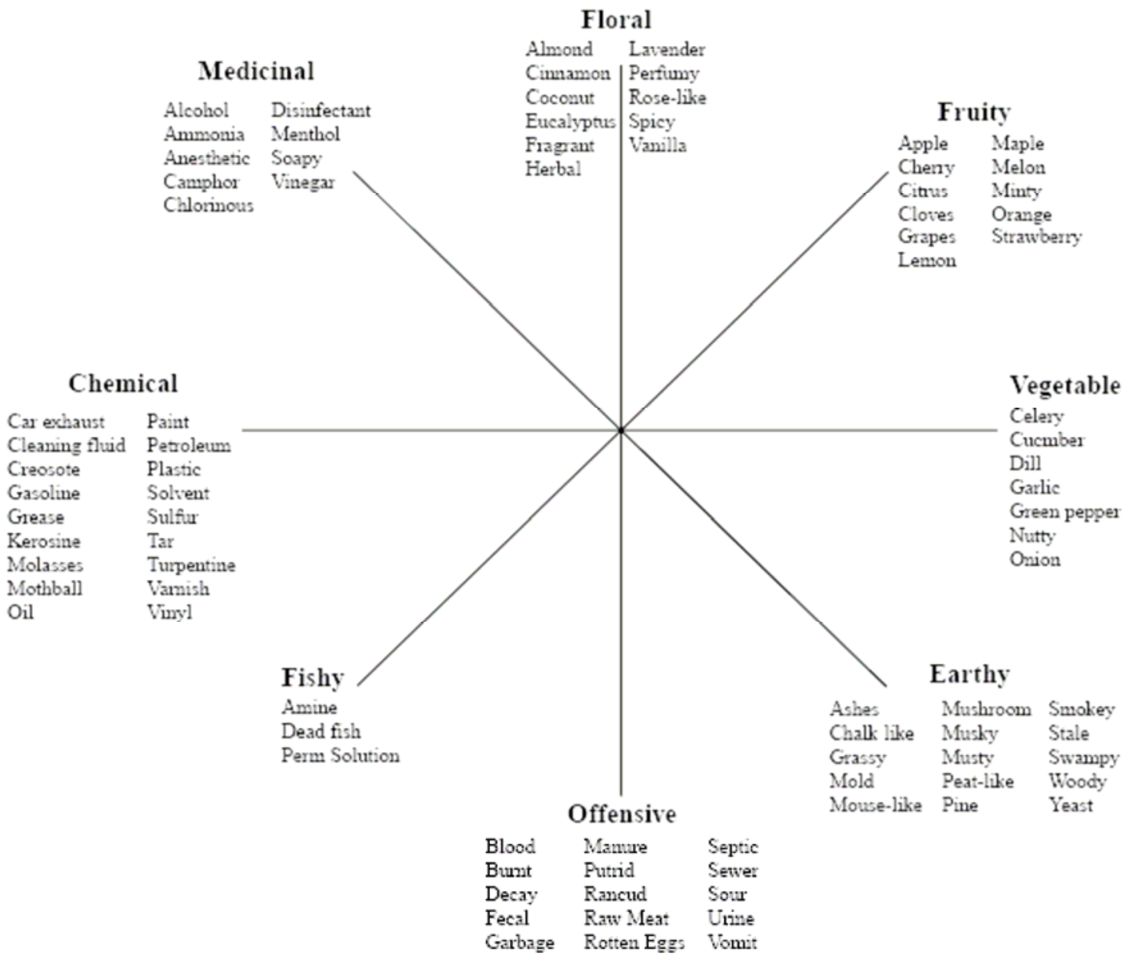


Figure 4.8
Odor Descriptor Wheel

Field data forms (FDF) should be signed by the field personnel when all entries are completed and all samples are collected. See Attachment 4.1 for example of an FDF.

Remember:

Good-quality data collection is an essential component of a sampling program.

4.6.2 Sample Label

Correct documentation of samples is important as it ensures sample identification.

Labels should be:

1) clean
2) secured
3) waterproof and non-smearing
4) large enough for the facility name and date.

Ensure that sample labels do not become detached during storage and transport.

Pre-printing standard information on the label can save time in the field. **Figure 4.9** shows sample bottles with pre-printed label. The marking pen must be xylene and toluene-free, non-smearing and can maintain a permanent legible mark. It is important to include the date, sample code/identification and name of the collector on the label to avoid confusion upon receipt by the laboratory personnel.

Figure 4.9
Sample container with pre-printed label

4.7 Documents or Records of Field Activities

In a matter involving potential litigation, all of the records generated during field activities may become evidentiary documents and the needs of the project should be considered when these records are being validated. **Table 4-1** contains a list of sample records that may be generated during field sampling activities and the purpose of each document.

Table 4.1 Examples of Records and Documents Generated During Field Activities

Type of Document or Record	Purpose of Document or Record
Instrument Calibration Records	Maintains accurate record of instrument calibration
Field Notebook	Maintains accurate record of field activities by providing written notes of all activities
Effluent Sampling Form	Maintains accurate record of samples collected
Chain-of -Custody	Maintains proof that samples were not tampered with and that samples were under the appropriate possession at all times

CHAPTER V
QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Introduction

This chapter explains the various QA/QC indicators and how they are used in effluent monitoring. It describes quality control procedures that are necessary to develop information which can be used to evaluate the quality of analytical data. QC/QA terms are defined and explanations on why, when and how QC/QA samples are taken or analyzed are provided.

QA/QC procedures should be incorporated into any monitoring activity. If deviation from the procedures becomes necessary as a result of unforeseen field events, then justification for the deviations must be documented in the field book. Alternative or new procedures not covered in this manual or in the EMB-approved laboratory method must be submitted to the EMB and approved before implementation.

The need to observe QA/QC procedures during any sampling activity is emphasized to ensure that samples are neither contaminated nor altered due to improper handling.

5.2 Sources of Error

Effluent quality monitoring involves a lot of steps and there is a potential for error at each of these steps. The major sources of error are measurement error, and sample handling error.

Measurement error occurs because none of the methods (field kits, field instruments, or laboratory analysis) provides perfect effluent measurements. Measurement error cannot be eliminated but can be reduced by instrument calibration, proper training, and equipment maintenance.

Another source of measurement error is the method's detection limit. As chemical concentration approaches zero, accurate measurements are more difficult to obtain. If the concentration cannot be detected by the method, it does not mean that the chemical is not present in the water. Most likely, the concentration is less than the detection limit. The result should be reported as the detection limit with a less-than symbol (for example, lead concentration is <0.01 mg/L).

Sample handling error could be caused by contamination of the sample during the sampling or due to contaminated equipment or container, or because air is trapped in the sample bottle when it was closed after sampling. Improper storage and transportation of the sample are other sources of handling error. This kind of error can be minimized by closely following proper handling procedures.

5.3 Quality Control Methods

5.3.1 Equipment Calibration and Maintenance

All equipment used in the field must be maintained according to the manufacturer's recommendations. Each of the field instruments must be checked and examined before sampling to ensure that the equipment works properly. For some equipment (e.g., DO meters, temperature meters, pH meters) specific preventive maintenance schedule and calibration procedure are required.

Spare parts such as batteries, probes, standard solutions, glassware, etc. should be kept on hand. Spare parts for instruments used each day in the field should be taken along in the vehicle.

Dirty or soiled sampling equipment can contaminate a sample and adversely affect its representatives. *Equipment must be cleaned thoroughly after each sampling day* by washing with a strong, phosphate-free detergent and thoroughly rinsing with tap water followed by rinsing with deionized water and allowed to air dry thoroughly. After drying, the equipment should be placed into sealed plastic bags until needed. (Note: latex gloves should be worn during all phases of equipment cleanup.) Plastic beakers used to collect the samples should be washed daily.

If multiple samples at multiple sites are to be collected with the same piece of sampling equipment during a particular sampling trip, the equipment should be rinsed at each site immediately prior to the collection of the first sample. This is accomplished by first rinsing with water from the same source as the water being collected for the sample. However, care must be taken so as not to disturb the water to be sampled.

5.3.2 Field Data Form and Chain of Custody of Samples

Whenever project personnel collect water sample for analysis, all associated field data and descriptive information must be recorded on the Field Data Form (Refer to **Attachment 5.1**). This form must be completely filled out.

All field and laboratory generated samples and data must be handled in an orderly and consistent manner so as not to compromise their integrity. This procedure is termed sample and/or data chain of custody. Chain of custody (COC) is defined as the unbroken trail of accountability that ensures the physical security of samples, data and records. A COC form is shown in **Attachment 5.2**.

For each set of samples, including duplicate and blank samples submitted to the laboratory for analysis the sample collector must fill out and submit a COC form from the laboratory. The COC must contain information on the project, the station, the date and time when the sample was collected and the parameters for analysis.

Each sample submitted for analysis must have the appropriate label.

Upon receipt of the sample(s) submitted, the laboratory personnel should check the sample labels against the information written on the form. If there are any discrepancies the laboratory should inform the sample collector or the organization's quality assurance representative. The laboratory then assigns a log number to the set of samples and returns a copy of the form to the sample collector or authorized personnel of the monitoring agency. The original copy is kept by the laboratory for their records.

5.3.3 Quality Control Checks

5.3.3.1 Field Quality Control Samples

The test results of quality control samples taken in the field reflect the precision and accuracy of the entire process, from sample collection to analyses. Below is a brief description of field quality control (FQC) samples that should be collected when appropriate.

(1) Equipment Blank (EB)

An Equipment Blank is a type of field blank used to determine if contamination has been introduced through contact with sampling equipment or to verify effectiveness of equipment cleaning procedures.

Laboratory water free of analyte is transported to the site and processed through the sample collection device, preserved if necessary and returned to the laboratory for analysis. Laboratory water should not be stored for future use, a hold time of one week is recommended.

EB should be processed whenever contamination is suspected, with each analytical batch or every 20 samples. Corrective action for contamination detected in equipment blanks is addressed by laboratory users evaluating data.

(2) Field Blank (FB)

A Field Blank is used to determine if interferences are present in the field environment. This would include contamination from sample bottles, storage, transport and sample preparation.

A FB is usually laboratory de-ionized water that is transported to the sampling site, opened to the contaminated environment, and processed as a sample (filtration, preservation, etc.). One FB should be submitted with each analytical batch or every 20 samples or whenever contamination is suspected. Contamination detected in field blanks would need to be evaluated by both field and laboratory personnel.

(3) Filter Blank or Cartridge Blank (CB)

A Cartridge Blank is used to determine if interferences are introduced during the filtration or sampling process. Laboratory water is used to rinse the filter and filtration apparatus. At least one CB should be processed with each sample batch or whenever contamination is suspected.

(4) Trip Blank (TB)

A Trip Blank is routinely used when sampling for volatile organic compounds. Volatile organic compounds are most susceptible to this type of contamination. The laboratory supplies samplers with a VOC vial containing acidified analyte-free water. The vial is transported to the sampling site and returned to the laboratory without being opened. Sample contamination from penetration of the Teflon cap by halogenated solvents during transport or at the site can be detected with a TB. TBs are logged into the data management system and are assigned a sample ID number.

(5) Field Duplicates (FD)

Field Duplicates (duplicate sample, replicate sample) are two separate samples collected at the same time and placed under identical circumstances and treated exactly the same throughout field and laboratory procedures. Results give a measure of the precision associated with sample collection, preservation and storage as well as with laboratory procedures. Field duplicate data provide the best measurement of precision from sample collection through analyses.

FD should be taken on 5% of the sample volume. Duplicates are logged in as individual samples and can arrive at the laboratory as “blind” duplicates if the laboratory user desires.

A field duplicate should not be confused with a split sample.

(6) Split Samples (SS)

Split samples are aliquots of samples taken from the same sample container after thoroughly mixing or compositing the sample. They are analyzed independently and are used to document intra- or inter-laboratory precision. SS may also be used by program personnel to request matrix spike analysis for tests requiring two separate samples.

(7) Blind Sample (BS)

A Blind Sample is a sample submitted to the lab for analysis, the composition or origin of the sample is known to the submitter but unknown to the analyst. A BS can be a duplicate sample, blank sample, proficiency sample, or an interlab comparison sample.

Table 5.1 summarizes the application of the different field quality control methods.

Table 5.1 Different Field Quality Control Measures and their Interpretation

Method	Requirement	Acceptance Limit[1]	Corrective Action
Pre-cleaned Equipment Blank (EB)	If contamination is suspected: 1 per sampling trip if equipment is not cleaned in the field, and 1 per quarter per project (For Autosampler, collect 1 EB each time intake tubing is replaced) or 1 every 20 samples	>MDL	Qualify associated samples up to 5 times the contamination level. Investigate equipment cleaning, analyte-free water and container, sample bottles, environmental conditions, preservatives, shipping, etc.

[1] If the result of laboratory analysis of the sample for the specified Q C method is greater than the MDL, it indicates that contaminant is not present and the test results are acceptable.

Method	Requirement	Acceptance Limit[1]	Corrective Action
Field Blank (FB); Filter or Cartridge Blank (CB); Trip Blank (TB)	When contamination is suspected. 1 per sampling trip if no EB is collected or 1 every 20 samples	>MDL	Qualify associated samples up to 5 times the contamination level. Investigate environmental conditions, sample bottles, analyte-free water and container, preservatives, shipping, etc.
Field Duplicate (FD) or Replicate Samples (RS)	Varies per project: at least one per quarter or 1 every 20 samples	< 20 % RPD or RSD*	Qualify affected samples. Investigate collection procedure, sample bottles, equipment cleaning, etc.
Split Samples (SS)	Varies per project: as needed	<20 % RPD or RSD*	Qualify affected samples. Investigate laboratory analyses. Then, evaluate splitting techniques.
*Relative Percent Difference (RPD) is used when comparing two results and Relative Percent Standard Deviation (RSD) is used when comparing three or more results.			

Note: Adapted from *www.qasr_sec_03_2005. Water Quality Field Sampling, Quality Assurance Requirement,* December 2005.

5.3.4 Prevention of Sample Contamination

The quality of data generated in a laboratory depends primarily on the integrity of the samples that arrive at the laboratory. Consequently, the field personnel must take the necessary precautions to protect samples from contamination and deterioration.

There are many sources of sample contamination. The following are some basic precautions to be observed:

(1) Field measurements should always be made on site or on a separate sub-sample which is then discarded. They should never be done on the water sample to be submitted to the analytical laboratory.

(2) Sample container, new or used, must be cleaned according to the recommended methods.

(3) Only the recommended type of sample container for each parameter should be used.

(4) Water sample containers should be employed for water samples only. Containers that have been used in the laboratory to store concentrated reagents should never be used as sample containers.

(5) Preservatives should be freshly prepared and dispensed with using clean glassware.

(6) Recommended preservation methods must be followed. When preserving samples, the possibility of adding the wrong preservative to a sample or cross-contamination of the preservative stocks should be minimized by preserving, in one operation, all the samples for a particular parameter.

(7) The inner part of sample containers and caps should not be touched with bare hands, gloves, mitts, etc. Do not put anything in the sample bottle except the water sample and recommended preservatives.

(8) Sample containers must be kept in a clean location, away from dust, dirt, fumes and grime. Vehicle cleanliness is important to minimize contamination.

(9) Sample containers which have been sterilized for microbiological sampling must remain sterile until the sample is collected. If the sterile heavy-duty paper or aluminum foil has been lost or if the top seal has been broken, do not use the bottle.

(10) All foreign objects, especially metal objects must be kept out of contact with preservatives and water samples.

(11) Specific conductance should never be measured in sample water that had earlier been used for pH measurements. Potassium chloride diffusing from the pH probe alters the conductivity of the sample.

(12) Samples must never be left to stand in the sun; they should be stored in a cool, dark place; ice chests are recommended. Keep the empty bottles in the coolers for additional cleanliness.

(13) Samples must be submitted to the laboratory as promptly as possible. The sample must reach the laboratory early enough such that the recommended holding time for the parameter to be analyzed is not exceeded, taking into account the necessary preparatory activities prior to laboratory analysis.

(14) All sampling instrument, equipment, containers, supplies and materials to be used in sampling should be packed properly in clean containers before leaving for the site.

5.4 Personnel Qualification and Training

Effluent monitoring activities should always be undertaken under the direction and supervision of persons in authority who have the right educational background, experience and qualification in effluent monitoring.

All personnel involved in data collection and water sampling activities must have the necessary skills to perform their duties and must have demonstrated understanding of the use and calibration of field equipment, sampling procedures, monitoring forms and the various quality assurance and quality control methods. Otherwise, they can undertake sampling and related activities only in the company, direction and supervision of a qualified officer or supervisor.

Thus, field personnel must be trained on every aspect of effluent quality monitoring before assigning them to effluent sampling and related activities.

The training must include expectations on ethical behavior and data integrity. An effective training program should include actual field sampling exercises with an experienced sampler. During this training period, under the guidance of the trainer, the trainee should perform all aspects of field activities, including preparations for travel, maintenance of equipment, calibration, sampling, collecting QC samples, and completing the necessary effluent field sampling documentation, under the direction and supervision of experienced staff. Training procedures, training records, and demonstration of capabilities must be documented indicating the specific field task, date of training, and proper signatures. Qualification should be backed up by certification that the personnel had passed the required training.

CHAPTER VI
EFFLUENT SAMPLING

6.1 Introduction

An understanding of proper sampling and analytical techniques is essential in collecting effluent samples to ensure reliable results.

Effluent sampling is taken for a variety of reasons such as to obtain (1) routine operating data and overall plant performance (2) data that can be used to implement proposed new programs, and (3) data needed for reporting regulatory compliance, which is the main purpose of this manual. To meet the goals of effluent sampling, the data collected must be:

- *Representative*. The data must represent the wastewater or environment being sampled.
- *Reproducible*. The data obtained must be reproducible by others following the same sampling and analytical protocols.
- *Defensible*. Documentation must be available to validate the sampling procedures. The data must have known degree of accuracy and precision.
- *Useful*. The data can be used to meet the objectives of the sampling plan.

Alternative or new procedures not covered in this manual or in the EMB-approved laboratory method must be submitted to the EMB-DENR and approved before implementation.

6.2 Preparatory Activities

Part of the personnel training on effluent sampling is to know the sampling activities involved in the process. An overview of the entire process will give the water sampler appreciation, commitment and the responsibilities to ensure the integrity of the test results. **Figure 6.1** below summarizes the said activities. Each activity will be discussed further in the preceding sections.

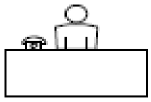
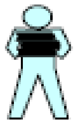
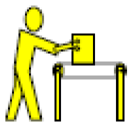
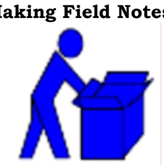
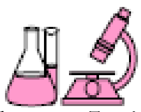
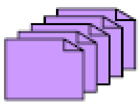
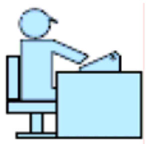
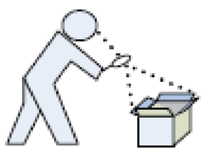
Step	Effluent Sampling Activity		Responsibility
1	 **EMB Office**	Preparation of Sampling Plan to ensure all requirements for sampling are met	Head, WQMS
2	 **Sampling**	Collecting water samples. Effluent samples can be taken from discharges of different types of treatment plant, biological and chemical, and shall also include effluents from storm drains, wetlands and those discharges for land application	EMB WQMS
3	 **Field Testing**	Conduct field tests, e.g. pH, temperature, chlorine residual, based on the treatment type and the objective of monitoring field tests	EMB WQMS
4	 **Making Field Notes**	Field notebooks, to record observations, information or data gathered during sampling	EMB WQMS
5	 **Preservation, Storage and Transport**	Preservation, storage and transport of samples should follow standard protocols to ensure the integrity of samples to be analyzed	EMB Laboratory Staff
6	 **Laboratory Testing**	Laboratory analysis of samples shall include all parameters required for specific type of industry and type of treatment used	EMB WQMS
7	 **Documentation**  **Reporting**	Documentation of all activities and preparation of report by the Head of the Sampling Team	EMB WQMS
8	 **Review**	Audi reports, checking field documentation laboratory test results, etc.	EMB PCD

Figure 6.1
Layout of Different Activities in Effluent Sampling

6.3 Planning the Effluent Sampling

An effective effluent monitoring is only as good as its preparation. Careful planning and coordination is critical to a successful sampling program. Based on the monitoring plan, at a minimum, the sampling team must know the location of the establishment, the distance from the laboratory, sampling location, the number of discharge outlets, number and types of samples to collect, the frequency of collection, source of supplies and equipment, and where the samples will be submitted.

6.3.1 Travel Orders and Travel Plans

Whether the monitoring team or personnel belongs to a government or a private institution, the members are advised to secure a travel order and prepare a travel itinerary before embarking on field work.

The travel order would ensure that the activity is recognized by an approving official and each team member is authorized to travel. A travel order will protect the team members in the event an untoward incident happens during the travel period or during the actual sampling activity.

A travel itinerary will give the office an idea of the location of the monitoring team at all times. This will facilitate contacting, communicating with or locating the team in times of need.

6.3.2 Preparation of Sample Containers

6.3.2.1 Sample Containers

(1) Type of sample container

Normally, appropriately cleaned sample containers for specific parameters to be analyzed can be requested from the testing laboratory. However, if laboratory-prepared containers cannot be obtained, make sure that the right sample containers, properly cleaned are ready before leaving for sampling. **Figure 6.2** below shows the different types of sample container.


(a) amber & clear glass bottles


(b) amber glass jugs


(c) wide-mouth jars


(d) vials


(e) plastic bottles


(f) BOD bottles

Figure 6.2
Sample Containers

If laboratory-prepared containers could not be obtained, make sure that the right type, sufficient number and properly cleaned sample containers are ready before leaving for sampling.

- Ensure that there are enough containers to hold all the samples to be collected for the specific parameters to be analyzed and for the required number of analysis per parameter.
- Inspect all containers and covers for cracks and chips and for cleanliness. Do not use containers with visible defects or discoloration.
- Do not use containers that have been used for storage of chemicals or other liquids. All containers must be decontaminated according to recommended procedure.
- The analyses to be performed on the sample dictate the type of sample containers. Plastic containers offer the advantage of being less likely to break than glass but are not appropriate for certain parameters.

- For microbiological analysis, strong, thick-walled glass sample bottles with a minimum capacity of 120 ml are recommended. The bottles should have screw caps of a type that will maintain an effective seal even after having been autoclaved many times.

(2) Cleaning of sample containers

Inadequately or inappropriately cleaned sample container may contaminate the sample, thus great care must be taken in cleaning. Clean the containers (whether glass or plastic) and new ones according to the step-by-step procedures described in **Table 6.1**.

Table 6.1 Sample Containers for Specific Water Quality Parameters and Recommended Cleaning Procedures

Parameter to be Analyzed	Recommended Container[1]	Cleaning Procedures
1. Organochlorine pesticides, PCBs and organo-phosphates	1,000 ml amber glass with Teflon-lined cap	Rinse three times with tap water, once with chromic acid[2], three times with organic-free water, twice with washing acetone, once with special grade[3] acetone, twice with pesticide grade hexane and dry (uncapped) in a hot air oven at 360^{O}C.
2. Phenols and Phenolic substances	1,000 ml amber glass with teflon-lined cap	Rinse three times with tap water, once with chromic acid[2], three times with organic-free water, twice with washing acetone, once with special grade[3] acetone, twice with pesticide grade hexane and dry (uncapped) in a hot air oven at 360^{O}C for at least 1 hour
3. Arsenic, Barium, Cadmium, Hexavalent Chromium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, Zinc	500-1,000 ml Polyethylene (depending upon number of metals to be determined)	Rinse three times with tap water, once with chromic acid[4], three times with tap water, once with 1:1 nitric acid and then three times with distilled water in that order

Parameter to be Analyzed	Recommended Container[1]	Cleaning Procedures
4. Mercury	100 ml glass	Rinse three times with tap water, once with chromic acid[2], three times with tap water, once with 1:1 nitric acid and then three times with distilled water in that order
5. Acidity, Alkalinity, Calcium, Chloride, Color, Fluoride, pH, Potassium, Sodium, Specific conductance, Sulfate, Turbidity	1,000 ml Polyethylene	Rinse three times with tap water, once with chromic acid[2], three times with tap water, once with 1:1 nitric acid and then three times with distilled water in that order
6. Ammonia Nitrogen, nitrate, nitrite Total Nitrogen	250 ml Polyethylene	Rinse three times with tap water, once with chromic acid[2], three times with tap water, and three times with distilled water, in that order
7. Phosphorus, total	50 ml glass (Sovirel)	Rinse three times with tap water, once with chromic acid[2], three times with tap water, and three times with distilled water, in that order

Notes: (1) Teflon containers can also be used to replace either the recommended polyethylene or glass containers
(2) Chromic acid - 35 ml saturated $Na_2Cr_2O_7$ per liter reagent grade conc. H_2SO_4
(3) Special grade acetone - pesticide grade when GC analysis to be performed, UV grade for LC analysis
(4) Chromic acid should not be used if the sample will be analyzed for chromium

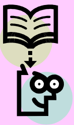
6.3.2.2 Maintenance of Equipment and Supplies

All equipment used in the field must be maintained according to the manufacturer's recommendations. Each field instrument must be checked and examined before sampling to ensure that it works properly. Observe preventive maintenance and calibration schedules recommended by the manufacturer.

Supplies such as batteries, probes, standard solutions, laboratory wares, etc. should be kept on hand. Spare parts for instruments used each day in the field should be taken along in the vehicle.

6.3.2.3 Checklist of Requirements

The checklist in **Table 6.2** may be used to verify if all necessary preparatory works have been undertaken and all materials, equipment and supplies for sampling are available.



Remember to double check if all necessary equipment, materials, supplies and reagents are in the transport vehicle before leaving for field work.

Table 6.2
Checklist for Preparatory Activities, Materials, Equipment and Supplies

1. Paperwork

___ Travel order and itinerary
___ Inventory/survey of sampling stations
___ Plant or drainage lay-out and vicinity map
___ Road map (if monitoring for the first time)
___ List of samples required at each sampling station

2. Coordination

___ Institutional coordination for travel arrangements, sampling arrangements (e.g. boat hire) and transport of samples (if requiring transport by air or sea)
___ Notification to the laboratory on the expected date and time of sample arrival
___ Laboratory staff have been provided with the list of parameters to be analyzed on site including the list of QA/QC methods based on sampling plan
___ Verification of local weather conditions and feasibility of travel

3. For documentation

___ Pens (not pencil, not sign pen), clip board
___ Sample labels
___ Field notebook
___ FDF, COC, Other forms (e.g. Garber index, survey forms)
___ Camera with film, digital camera or recorder for photo documentation
___ GPS

4. For sampling

___ Sample bottles and covers, preservatives, labels and marker pens trash bags, wash bottles, field laboratory wares (pipette, beakers, Erlenmeyer flask, etc.)
___ Sample containers/transit containers and ice packs
___ Effluent Monitoring Manual
___ Filtering apparatus, filter paper (if required)

___ Samplers/sampling equipment including extension poles, if needed

5. For flow measurements
___ Meter stick (for depth measurements)
___ Current meter/float
___ Flow-measuring bobber/20 meter nylon line or rope
___ Measuring tape
___ Calculator
___ Stop watch
___ Flow record form

6. For Safety
___ First-aid kit
___ Rubber gloves, or disposable vinyl gloves, boots, etc.
___ Material safety data sheets (MSDS)
___ Waterless hand wash or hand wipes

7. Transportation
___ Vehicle with sufficient capacity for personnel, supplies and equipment
___ Road-worthiness of vehicle. Check battery, lubrication, coolant, windshield washer
___ Sufficient fuel for the trip (either in the tank, in fuel container or availability of gasoline stations along the route
___ Availability of spare tire, jack, wheel wrench, early warning device, tool kit and flashlight.

8. Double-check
___ Equipment calibration
___ Itinerary against travel details on inventory
___ Accessories for equipment and meters (including cables, chargers and spare batteries) and consumables

6.3.3 Safety Considerations

Knowledge of the hazards that may be encountered and the means by which they can be minimized are necessary considerations in any effluent sampling program.

Field staff will encounter a wide range of hazards in the course of their work. To give just a few examples, wastewater-courses may be highly contaminated with sewage or chemicals, access to sampling stations may involve crossing dangerous terrain, which inevitably carries the possibility of slipping and personal injury. Field staff should be trained to recognize and deal with many possible hazards they are likely to encounter.

When conducting sampling, samplers need to be aware of health and safety hazards and take the proper precautions. Safety requirements can be gathered from:

- Information on file
- personnel that have previously sampled the facility, or by contacting the facility.

6.3.3.1 Personal Protective Equipment (PPE)

Samplers need to be properly attired and have adequate safety PPE available. PPEs for of effluent sampling include:

- EYE AND FACE PROTECTION: Goggles and face protection must be used when workers are at risk from flying particles, liquid chemicals, acids or caustic liquids, chemical gases or vapors.
- HEAD PROTECTION: hard hat. Hard hats must be worn where there is a danger of falling objects.
- FOOT PROTECTION: Safety shoes. Safety shoes with impact protection are required in work areas where heavy objects or tools could accidentally drop on the feet.
- HAND PROTECTION: Safety gloves. Gloves are required to protect workers from cuts, scrapes, punctures, burns, chemical absorption, or temperature extremes. It is crucial that the type of glove being used is the right one for the job since incorrect gloves may provide no protection. This is a particular problem with chemical absorption where incorrect gloves may allow certain chemicals to reach your skin – and you may be unaware that it is happening. Charts that can assist in determining the right gloves for the job are available from glove manufacturers.
- HEARING PROTECTION: Earplugs. Appropriate earmuffs or earplugs must be made available as a last resort if it is not possible to make the workplace less noisy.
- RESPIRATORS: Appropriate respirators must be worn as a last resort, if it is not possible to ventilate the work area properly.

Field personnel are responsible for maintaining their PPEs in good condition.

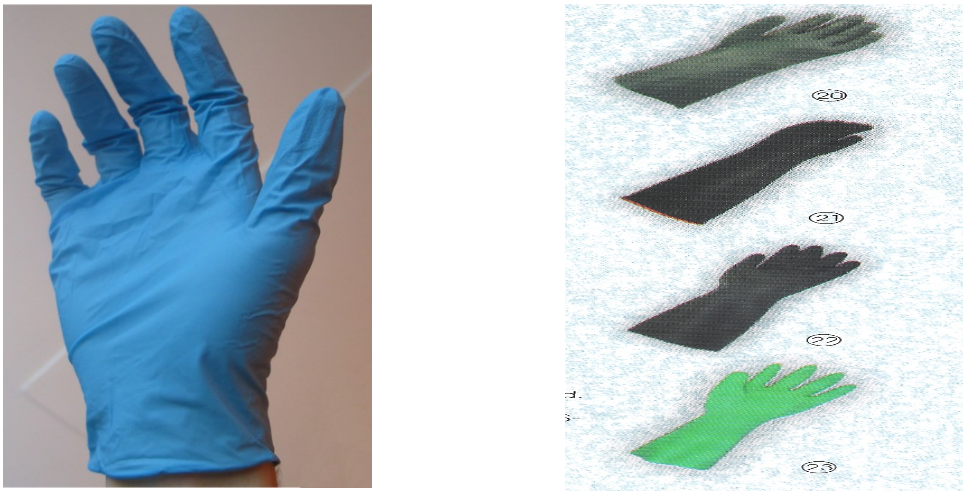


Figure 6.3
Hand Protection

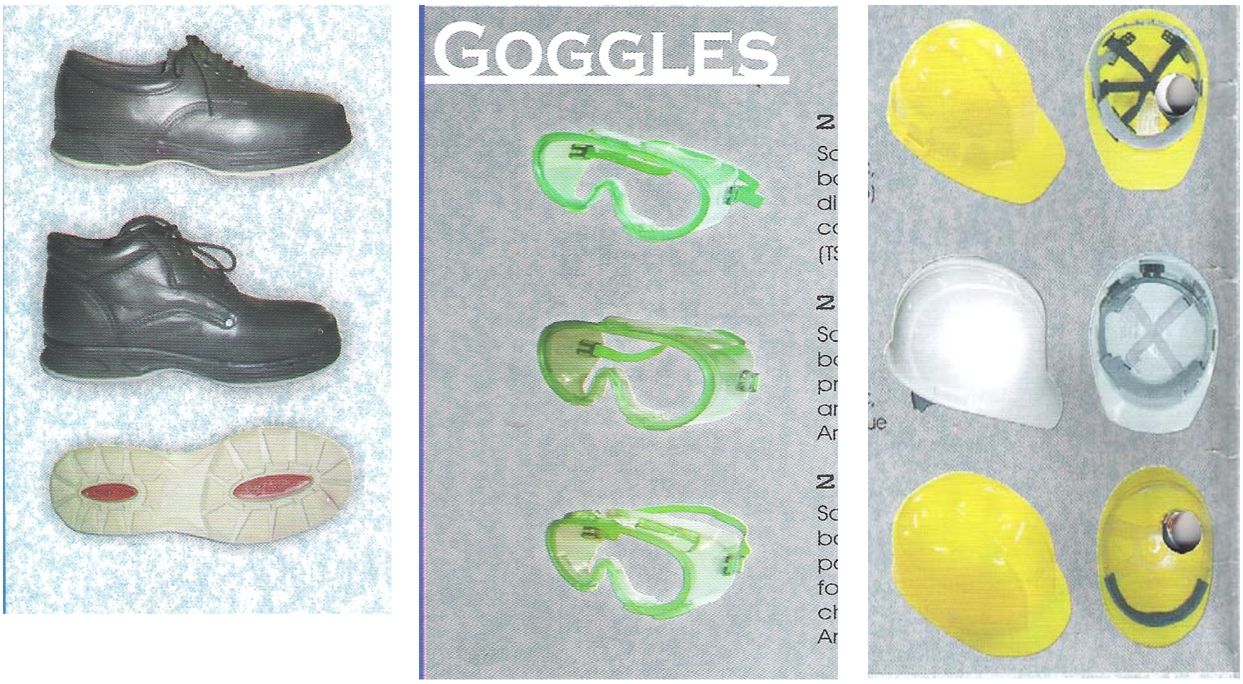


Figure 6.4
Safety Shoes, Eye Goggles and Hard Hat

6.3.3.2 Confined Spaces

Samplers should not enter confined spaces unless they are properly trained and have the proper equipment such as rescue equipment and respirators. Never enter confined spaces (such as septic tanks and process tanks) unless first tested for sufficient oxygen and found free of toxic and explosive gases. Two persons should be present, one to enter the confined space and one to stay outside of the confined space. The person entering the confined space should wear a safety harness that is attached to a retrieval system. Use of this type of system will allow the rescue of the person in the confined space without requiring anyone else to enter. Safety issues when working with septic tanks are provided below.

Safety Issues when Sampling in Septic Tanks

- Septage is infectious material. It can cause disease if ingested or if it comes in contact with broken skin. Always wash hands immediately with soap after contacting septage or tools and equipment that may have contacted septage, and always before eating or drinking.
- Never smoke while operating septage equipment. Septic tanks may generate methane, an explosive gas. Smoking also promotes the hand to mouth route of infection.
- Use caution around the septic tank. Never enter a septic tank. Every year people are killed because they enter tanks, which are confined spaces that may contain toxic gas or too little oxygen. Use caution when walking around septic tanks. Septic tanks may cave in or break when excessive weight is placed on the lid or manhole cover.
- Always secure septic tank lids with screws or locks.
- Always use PPEs such as gloves, boots, hard hat and face mask

6.3.3.3 Handling of Chemicals

Corrosive compounds, including acids and bases are sometimes used for the preservation of effluent samples for special analysis. The following must be observed:

- Exercise proper care to avoid inhalation of vapors, powders and direct contact with skin, eyes and clothing.
- Never pipette chemicals by mouth.

- Clean up spills immediately by either diluting with enough water, neutralization or mopping up of the chemical followed by disposal of the contaminated material.

The Material Safety Data Sheet (MSDS) of chemicals used, especially in the on-site testing shall be consulted in case of doubts or for additional information.

6.3.3.4 First Aid Kit

A basic first-aid kit should be carried at all times and should not be left in the transport vehicle if staff is obliged to move any significant distance from it. Staff should also be trained on the conduct of basic first aid at a minimum.

Figure 6.5
First Aid Kit

6.4 Kinds of Samples

While the purpose of this Manual is to address effluent samples, there are instances when other samples may be collected:

- *Effluent samples* are routinely collected by EMB personnel and the facility owner for monitoring and permitting purposes

- *Influent samples* are collected by EMB for facilities discharging strong wastes.

- *Abstracted water* may be collected from the facility to confirm the quality of the abstracted water as declared by the facility during the computation of the Net Waste Load. *Abstracted water can be* *sampled in groundwater, surface water or in existing water utilities operated within the vicinity.*

6.5 Effluent Sampling

The components that make up the wastewater effluent from a facility depend on the type of collection system used and may include:

- *Domestic (also called sanitary) wastewater.* Wastewater discharges generated from households (single residential structures) dwelling units specifically from toilets, kitchens, washing areas and other similar sanitary conveniences.
- *Commercial Wastewater.* All wastewater generated from trading or business establishments and/or any other related firms or companies, which include but not limited to restaurants, shopping malls, commercial laboratories, hospitals, markets, commercial condominiums, hotels, gasoline stations, and other establishments.
- *Industrial wastewater.* All wastewaters from any producing, manufacturing, processing, trade or business or any other operations/activities from industrial establishments.[1]
- *Infiltration/Inflow.* Water that enters the collection system through indirect and direct means.
- *Stormwater.* Runoff resulting from rainfall.

Collection of effluent samples may be a relatively simple task to others. However, the issue in collecting effluent samples is how to get a sample which represents the quality and condition of the system being sampled. Often times, the sampling activity is where most errors are committed resulting in questionable laboratory test results.

Remember:

An effluent sample is as good as its collection.

The following should be considered when collecting effluent samples:

- Samples should be collected from a location that is representative of the facility's discharge.

- If the facility has more than one discharge point it may be necessary to collect samples from several locations in order to adequately characterize the facility's entire discharge.

[1] DAO 2005-10, Implementing Rules and Regulations of Clean Water Act of 2004 (R.A. 9275)

Convenience, accessibility, and safety should also be considered when selecting a sampling site.

- Sample should be collected from the center of flow with the container facing upstream to avoid contamination.

- Samples should be collected in areas that are turbulent and well mixed and where the chance of solids settling is minimal. When sampling, the surface of the wastewater should not be skimmed nor should the channel bottom be dragged.

- Samples should not be collected from stagnant areas containing immiscible liquids or suspended solids.

- All wastewater samples obtained for analysis must be from a point in the effluent stream that is representative of the whole stream composition.

- The volume of sample taken must be sufficient to allow for analysis of all required parameters plus associated quality control samples (e.g. field duplicate, laboratory replicate and spiked sample).

It is recommended that all automated and manual sampling devices and equipment, their containers and all tubing, valves and contact components be dedicated to a particular sampling site in order to minimize the possibility of contamination.

As an alternate to this dedicated application, it is the User's responsibility to demonstrate that the sampling equipment is clean, free from contamination and suited to the sampling and analysis needs at the next location.

Generally, the cleaning and preparation of equipment should include:

- warm water,
- phosphate free washing detergent,
- hot and cold water rinsing,
- distilled water rinsing,
- multiple rinses with the actual wastewater being sampled. This is especially important where trace levels of contaminants are being analyzed.

6.5.1 Effluent Sampling Procedure

Procedure in collecting effluent sample shall be as follows:

1) Based on preliminary survey, locate the facility's outfall.
2) Prepare sample containers.
3) Label the containers accordingly. If no pre-printed label is available, label the samples, at a minimum indicating the sample ID, Date & Time of collection and the name of the Facility.
4) Put on proper personal protective equipment (PPE) such as gloves (for hand protection), hardhat (for head protection) and safety shoes or rubber boots.
5) Collect effluent sample following sample collection procedures mentioned in Chapter VI, Section 6.5, Sample Collection.
6) Rinse the outside surface of the sample container with tap water before placing inside the cooler or ice chest to prevent contamination.
7) Conduct on-site measurement as necessary.

Remember:

Always wear the proper personal protective equipment (gloves, goggles, safety shoes or boots, long sleeves shirt) before collecting sample.

Figures 6.6 to **6.11** are illustrations on the different methods of collecting effluent sample from different outfalls or facilities. Note the check mark (✓) when proper PPEs are worn and a cross mark (⊘) when proper PPEs are not worn.

Figure 6.6
Sample Collection from a Mining Effluent

Sample is collected from the final outfall. Follow procedure in effluent sampling as discussed in Section 6.5.1.1.

Figure 6.7
Sample Collection from a Sump Pit

Sample is collected at the pit using alternative equipment such as another bottle, and then transferred to the sample bottle.

Figure 6.8
Sample Collection from a V-Weir

Figure 6.9
Effluent sample collection from a triangular weir of a restaurant by direct sampling with the sample container

Figure 6.9 shows effluent sample collection from a restaurant. Left photo shows sample collection for AVFO analysis. Right photo shows collection of effluent sample for analysis of other parameters such as BOD, TSS. (Note: always use gloves when collecting effluent samples).

Figure 6.10
Direct Sampling using sample container, at specified sampling station

Figure 6.10 shows collection of effluent sample from a pharmaceutical manufacturing plant, provided with a flow meter. Two discharges along the pipe were provided for split sampling.

Figure 6.11
Sampling using the Sample Container

Figure 6.11 shows sample collection of leachate from a dumpsite. Sample is taken before mixing with the receiving body of water (e.g river).

Figure 6.12
Sampling from a Small Scale Industry Food Manufacturing Facility (Nata de Coco Processing) Outfall.

Figure 6.12 shows sample collection from a small scale industry (Nata de Coco processing facility). Sample is collected at the facility's outfall (effluent discharging from the facility's perimeter fence).

6.5.2 Effluent Sampling in Typical Treatment Facilities

In the collection of effluent samples, another consideration relates to the type of treatment facility employed by the establishment. Depending on the nature of the wastes to be treated, treatment type may be generally classified as chemical and biological treatment.

(1) Biological Treatment (Aerobic System-Activated Sludge, Trickling Filters and Anaerobic Systems)

The effluent is normally taken from the discharge of the last treatment unit. For aerobic systems employing activated sludge process and trickling filter, the sample is collected from the outflow of the secondary sedimentation tank or final clarifier.

(2) Ponds/lagoons

The ponds or lagoons are normally provided with weirs where the flow rates can also be measured. Effluent samples can be taken from the outfall right after the weir or from its discharge outfall.

(3) Chemical treatment

The sample is collected from the discharge of the last sedimentation tank.

(4) Septic Tank

Effluent from the septic tanks is difficult to collect. Sampling station can either be from the outfall or from the ditches (before discharge to drainage).

If septic tank effluent has no accessible sampling point or has no outfall (such as pipe is located underground), sample is collected at the effluent filter of the last chamber.

If the septic tank has submersible pump, sample is collected during discharge.

Always observe safety precautions, when collecting effluent samples from septic tanks. See Section 6.3.3, Safety Considerations.

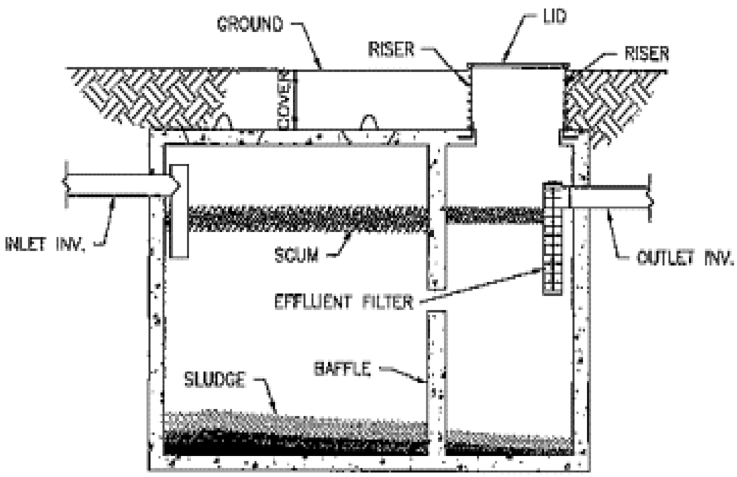


Figure 6.13
Septic Tank Design.
Collect sample in the last chamber (at the effluent filter pipe)

A bailer may be used in collecting sample with small outlet as shown in Figure 6.11 (Sample collection from groundwater monitoring well). The sample will then be transferred to the appropriate containers.

Figure 6.14
Sample collection using alternative container (bailer)

(5) Chlorinated Effluents

Effluent sample is collected from the unit following the chlorine mixing tank. The chlorine residual should be immediately measured before any sample is lifted for bacterial examination. The sterile sampling bottle should already contain the required volume of de-chlorinating agent (sodium thiosulfate).

(6) Special Cases of Monitoring

(a) Waste Minimization/Clean Technologies

If the facility is practicing waste minimization or uses clean technology, based on preliminary survey conducted and interview with plant personnel, indicate such in the report. Thus, a good conclusion on the result of effluent monitoring can be made.

The following guidelines on effluent sampling may be followed by the EMB staff in-charge of sampling:

1. Check waste minimization implementation program
2. Check records of implementation with emphasis on the following data:
   - Volume of wastewater before waste minimization
   - Volume of wastewater after waste minimization
   - Waste minimization option
     - source reduction
     - reuse of effluent
     - land application

3. Collect sample from the last stage of waste minimization program i.e., before re-use, before land application, etc.
4. Analyze test parameters typical to an effluent (pH, BOD, etc.)

   Note: For irrigation and other agricultural purposes, the effluent should meet the Guidelines on the Procedures and Technical Standards for the issuance of a certification allowing for the Safe Re-use of Wastewater for the purposes of irrigation and other agricultural uses, pursuant to Section 22.C of R.A. 9275 or the Philippine CWA of 2004**.**

(b) Discharges to land

Effluent Use as Irrigation Water

Sample effluent can be taken right after the last treatment unit. The effluent to be used for irrigation is normally hauled by trucks. A sample of this water can be taken for confirmation purposes (to ensure that same quality of water is used for irrigation).

Effluent Re-use for Watering Plants/Gardening

Sample effluent at the discharge of the holding/storage tank (where effluent is collected) before use for gardening.

(c) Small Scale Industries

Small scale industries such as backyard food processing, sometimes do not have a WTP and discharge waste directly to the drainage system. Take effluent sample from the outfall of the establishment or facility as shown on **Figure 6.12** above.

(d) Industries Practicing Zero Discharge or Closed Loop Treatment System

If industries are applying for zero discharge, the following documents should be checked:

- Drainage lay out

- Check the wastewater flow direction. No wastewater should flow outside the boundary fence into stream, river, lake, pond, ditch or drainage tile.

➢ Water Balance

- Check the process flow and account for all water entering the system, and all water use and reuse operations with respect to water flow.

- For closed-loop cooling tower systems, check for the lay out of water distribution and frequency of blowdown.

➢ Treatment employed for the re-use of wastewater

- Check for the connection of the effluent discharge and the storage tank for re-use water.
- Check where the water is being re-use in the facility, e.g for watering plants, aesthetic purposes or for other uses.

➢ Groundwater quality monitoring for impounding lagoons

- Check for the presence of groundwater monitoring wells down gradient to the impounding lagoons.

- Check for the results and analysis of groundwater monitoring report. Presence of contaminants shows possible seepage from impounding lagoons.

6.6 On-site Measurement

Field analyses of samples are necessary to obtain actual values of effluent quality parameters that might change during transport to the laboratory or these parameters might change due to some value adjustments required in subsequent laboratory analyses. Usually, water quality checkers are used for on-site measurements (pH, temperature, salinity and conductivity).

6.6.1 Materials, Equipment and Apparatus

- Field Data Form. See Attachment 5.1.
- Instruments, reagents, maintenance kits for all instruments used
  - Water Quality Checker. **Figure 6.15**.
  - pH meter with temperature meter;
  - Specific conductance/total dissolved solids meter;

- o If using a multiprobe instrument, it should have the specific parameter measurement capability.

- ➢ Ice cooler with sufficient ice to maintain the temperature to 4˚C until arrival in the laboratory
- ➢ Meter stick or calibrated poles; pegs
- ➢ Ballpoint pen (never use sign pen)
- ➢ Drainage layout showing discharge points.
- ➢ Plastic/glass beaker or wide-mouthed container
- ➢ Rubber gloves for taking a dip sample

6.6.2 Measurement of pH, temperature, D.O., salinity and specific conductivity (using water quality checker)

Fig. 6.15
Multi-Probe Water Quality Checker

6.6.3 Measurement of pH

Figure 6.16
Portable pH meter

(1) Materials, Reagents and Apparatus

- Portable pH meter with analog or digital display calibrated with buffer solution in the laboratory.
- Buffer solution (if not calibrated in the laboratory)
- 250 ml capacity beaker or clean plastic container
- Extra supplies needed for maintenance of probe
- Extension pole (optional)
- Field data sheet to record results

(2) Procedure

(Note: If the pH meter comes with instructions for use, it is better to follow the manufacturer's instructions).

(i) Calibrate the meter following the manufacturer's recommended procedures for field calibration.

(ii) Collect effluent sample in accordance with the recommended procedures.

(iii) With the pH meter/probe turned on, remove the storage cap from the probe. Dip the meter/probe in the sample.

(iv) Wait for the meter reading to stabilize then read the measurement.

(v) Record and then turn the meter off. Rinse the probe/electrode with distilled water and replace the storage cap.

(vi) Repeat steps (ii) to (v) two more times to get three (3) pH readings, replacing the water with a new effluent sample from the container every time.

(vii) Calculate the average of the 3 readings. The result represents the pH of the effluent sample.

6.6.4 Measurement of Temperature

(1) Materials, Reagents and Apparatus

- Thermometer or probe or good grade of mercury or alcohol-filled or dial type centigrade thermometer
- 2 liter plastic beaker or clean plastic container
- Extra supplies needed for maintenance of probe
- Integrated Water Sampler (optional)
- Extension pole (optional)
- Data sheet to record results

(2) Procedure

If the pH probe is capable of reading temperature, simply record the temperature displayed in the pH probe while getting the pH measurement.

If another thermometer is used, the bulb of the thermometer is immersed on the sample and the reading is taken. Five readings should be taken on each sample and the mean is reported.

Figure 6.17
Thermometer

6.6.5 Measurement of Dissolved Oxygen (DO)[2] (Modified Winkler Method)

(1) Materials and Apparatus

- 300mL capacity BOD incubation bottles with tapered ground glass pointed stoppers and flared mouths
- Pipettes with elongated tips capable of transferring 2.0mL of reagent.

(2) Reagents

- Manganous sulfate solution
- Alkaline iodine-azide solution
- Concentrated sulfuric acid
- 0.025 N sodium thiosulfate standard titrant

[2] For BOD monitoring of effluent, the samples will be analyzed for DO in the field.

Reagents except for the concentrated sulfuric acid must be prepared in the laboratory in accordance to the procedures prescribed by the EMB-DENR.

(3) Procedure

(i) Collect sample in a 300mL BOD incubation bottle. Entrainment or dissolution of atmospheric oxygen or loss of dissolved oxygen must be avoided by preventing turbulence and formation of bubbles when filling bottles.

(ii) Using separate pipettes, add 2.0mL manganous sulfate solution followed by 2.0mL of the alkaline iodide-azide solution well below the surface of the liquid, stopper with care to exclude air bubbles, and mix well by inverting the bottle several times. If white precipitate is formed, there is no need to continue analysis, as this means that DO is zero.

When the precipitate settles, leaving a clear supernatant above the settled precipitate, shake again. When settling has produced at least 200mL of clear supernatant, carefully remove the stopper and immediately add 2.0mL of concentrated sulfuric acid using another pipette and allowing the acid to run down the neck of the bottle, re-stopper and mix by gentle inversion until the content attains a deep yellow color. Complete the analysis within 45 minutes.

(iii) Titrate with thiosulfate solution to a pale straw color using another pipette. Add 1.0 – 2.0mL of starch solution and continue to titrate to the first disappearance of the blue color.

Each mL of thiosulfate titrant used is equivalent to 1.0 mg DO when the entire bottle contents are titrated.

6.6.6 Measurement of Salinity (for Re-use in Irrigation)

(1) Materials, Reagents and Apparatus

- Conductivity meter/probe with platinum graphite electrode type cell
- With temperature sensor or salinimeter;
- Field data sheet

(2) Procedure

(i) Calibrate the instrument according to the manufacturer's instructions using one calibration standard, a potassium chloride (KCl) solution, as applicable. The acceptance criterion for initial calibration or a calibration check is that the instrument reading must be within ± 5% of the standard value. Use standard seawater (S = 35 ppt) when measuring salinity in the open ocean or estuaries with a predominance of seawater. Potassium chloride may be used in estuarine waters with low salinity (S = 0 – 40 ppt).

(ii) Rinse the probe with de-ionized water after calibration.

(iii) Simply dip the instrument into the effluent to be tested, following the same procedures as that for temperature measurement. Read and record the meter reading in the field data form. Rinse the probe with de-ionized water after each sample measurement, and then replace the storage cap.

6.6.7 Measurement of Specific Conductivity

(1) Materials, Reagents and Apparatus

- Conductivity meter/probe with platinum graphite electrode type cell with temperature sensor;
- KCl standard solution for calibration
- Field data form

Reminder:

Specific conductance should never be measured in sample water that has earlier been used for pH measurements.

(2) Procedure:

To ensure accuracy of method, follow the manufacturer's instructions for the particular brand of specific conductivity meter to be used.

For most brands, the procedures are as follows:

(i) Make sure the instrument is set up to measure *Specific Conductivity*, not Conductivity. Perform zero calibration if required by the instrument.

(ii) Simply immerse the conductivity probe or sensor at the effluent sample.

(iii) Allow the conductivity instrument to stabilize;

Measure the water temperature (if necessary for manual temperature compensation) and record the temperature;

If the meter is equipped with manual temperature compensation, adjust the conductivity meter to the water temperature per manufacturer's instructions;

If the conductivity meter has a set of positions that multiply the reading by powers of ten in order to measure the full range of potential conductivities, set this dial to the correct range in order to take a reading;

(iv) Record the sample conductivity measurement reading in the field data sheet. Rinse off the probe with de-ionized water.

(v) Follow the manufacturer's instructions for probe storage between each use.

Figure 6.18
Conductivity Meter

6.6.8 Measurement of Total Dissolved Solids

(1) Materials, Reagents and Apparatus

- Conductivity meter/TDS probe
- Beaker or wide mouthed jar
- Field data sheet

(2) Procedure

Using conductivity/TDS meter

(i) Calibrate the instrument according to the manufacturer's instructions. It is better to follow the manufacturer's instructions for using the instrument, otherwise, use the following procedures:

(ii) Rinse the probe with de-ionized water after calibration.

(iii) Set the meter to the TDS mode.

(iv) Collect effluent sample using any of the grab sampling methods. Transfer the sample to a beaker or wide-mouthed jar. Dip the probe into the sample, wait until the reading stabilizes. Read and record the measurement in the field data sheet.

Figure 6.19
TDS Meter

6.7 Field Notes

A sampling field data form or field notebook must be properly filled out for all analyses done in the field.

The following information must be recorded:

- The name of the Facility
- The sample ID
- The type of sample being collected e.g. effluent sample, duplicate sample, field blank, etc.
- The time and date the sample was collected or the analysis was undertaken;
- The name/s of sample collector

- If samples were collected for laboratory analysis, indicate the following:
  - The sampling method used
  - The preservative(s) (premeasured or added amount) and preservation checks performed.
  - The sample container used
- If blanks are collected, record the following:
  - Type of analyte-free water used;
  - Source of analyte-free water
  - List of the sampling equipment used to prepare the blank.

Figure 6.20
Recording Field Observations

Field Quality Check (FQC) must be documented following the same procedure used for routine samples. FQC bottles must be labeled and sampling information entered in the field notebook and chain-of-custody form.

6.8 Preservation, Storage and Transport of Samples

Once samples are taken, they should be delivered immediately to the laboratory for analysis. Delay in sample transport to the laboratory could cause great errors in monitoring results. Thus, the route from each sampling station should be worked out beforehand to ensure that the transport of sample takes the shortest practicable time.

If the samples cannot be delivered and analyzed soon after sampling, samples should be preserved.

The storage of the samples at a temperature of about 4°C, preferably in the dark, will retard biological activity substantially and reduce the change in physical and chemical properties of water samples. If refrigeration is not possible, the collected samples can be packed with ice in an insulated container.

6.8.1 Preparing Samples for Transport

When preparing samples for transport, verify that the number and types of sample bottles match the field logbook and the chain-of-custody form. Each sample bottle should be labeled and filled out with permanent marker. Each label must include:

- Site ID or field number;
- Date and time of collection; and
- Sample type/preservation.

All comments and notes pertinent to the samples should be placed on the chain-of-custody form and not on the sample labels.

Figure 6.21
Labeled and Sealed Effluent Samples
(Source: LLDA)

The following do's and don't's are recommended when preparing samples for transport:

DO's	DON'T's
✓ Check that each bottle is securely capped to prevent leaking and contamination.	• Do not use tape or paraffin on lids or jars containing organic samples.
✓ Pack samples in fresh ice for shipping with a volume of ice equal to at least the volume occupied by samples, but preferably twice the volume of ice to samples. The amount of ice necessary will vary depending on the length of time in transit from the field or base to the laboratory and the time of year. During the summer, in particular, the cooler and the samples should be pre-chilled.	• Do not send samples chilled with "blue ice" or other types of commercial, refreezable containers.
✓ Keep ice/water and packing materials totally separated.	• Do not chill sample container with dry ice or with other substances that have a freezing point below 0°C; this may cause sample containers to freeze and can result in ruined samples and/or broken sample containers.
✓ Coolers should be double lined (a bag within a bag) with unused and untreated heavy weight trash bags. After samples and ice are placed in a doubled bag, seal each bag with a knot or by gathering the top of the bag, folding it over, and securing with filament tape.	• Do not mix ice/water with packing materials.
	• Do not mix foam peanuts with ice for shipping.
	• Do not ship nutrient samples in coolers with samples that have been treated with nitric acid preservative. Contamination from the acids used in sample preservation may create false readings for some nutrient species.

Figure 6.22
Samples Packed with ice in cooler

6.8.2 Chain-of-Custody

Chain of Custody (COC) form should be filled up (at least duplicate), which will accompany the samples, during transport to the laboratory. The person handling the samples to the laboratory should sign the COC. Once the samples are received by the laboratory, the laboratory personnel who receive the samples should also sign the COC and provide the duplicate copy to the one releasing the samples for documentation.

A sample of the Chain of Custody is attached as **Attachment 5.2.**

CHAPTER VII
FLOW MEASUREMENT

The measurement of flow in conjunction with effluent quality sample collection is essential. Laboratory analysis of a sample will give only the concentrations, usually in milligrams per liter (mg/L), of various effluent constituents. With flow measurement, the concentrations can be translated into pollution loadings which provide the mass in terms of kilogram per unit time such as kg BOD_5/day.

Flow data should be collected with the same care and precision which is required for representative sample collection. Whenever possible, the location of the flow measurement should be at the same site where the sample is taken.

A number of devices are available that can be used to measure flow rates in open channels and close conduits. The flow-metering devices used for the measurement of different flow streams are identified in **Table 7.1.**

Table 7.1
Application of flow-metering devices[1]

Metering Device	Application Primary Effluent	 Secondary Effluent
For Open Channels		
Head/area		
Flume	✓	✓
Weir	✓	✓
For Closed Conduits		
Head/pressure		
Flow tube	✓*	✓
Venturi	✓*	✓*
Moving fluid effects		
Magnetic (tube type)	✓	✓
Ultrasonic (transmission)	✓	✓
Vortex shedding	✓	✓
Positive displacement		
Turbine		✓

*flushing or diaphragm sealed connections recommended

[1] Wastewater Engineering Treatment Disposal Reuse, 3rd edition by Metcalf & Eddy 1991.

Pipes are closed conduits through which water flows. Conduits may flow full or partially full. Pipes are referred to as conduits (usually circular) which flow full. Conduits flowing partially full are called open channels. An open channel is one in which the stream is not completely enclosed by solid boundaries and therefore has a free surface subjected to atmospheric pressure. The flow in such channel is caused not by some external head, but rather by the gravity component along the slope of the channel.

In open channels, or partially filled conduits, the head generated by an obstruction, and the corresponding velocity are used to determine the flow rate. In closed conduits, three techniques are commonly used for measuring flow rates in closed conduits: (1) insertion of obstruction to create a predictable headloss or pressure difference, (2) measurement of the effect of the moving fluid, and (3) measurement of incremental units of fluid volume.

The most common methods and devices of flow measurement discussed in this section are direct container method, sump pump, weirs, parshall flumes, open channel measurement, california pipe method, venturi meter, and electronic measurements.

7.1 Direct Container Methods

Direct container methods have the advantage of being easy. These are simply measurements of the amount of time it takes to fill a container. Different types of containers can be used depending on their availability.

Some of the direct container methods are listed in **Table 7.2** with their corresponding volumetric formula.

For this method to approach accuracy, the minimum filling time should be about 10 seconds, and the flow should be less than 30 gallons per minute (gpm).

7.1.1 Flow Measurement Using Container

Materials:

- Personal Protective Equipment (PPE) such as goggles, gloves, safety shoes/boots.
- Container with known volume (e.g. 20 liter capacity plastic pail, etc.)
- Stop watch
- Field Notebook/Field Data Form/Ballpen

Procedure:

1) Wear proper personal protective equipment (gloves, safety shoes/safety boots, eye goggles as necessary).

2) Get the container with known volume and a stop watch

3) Place the container below the pipe or outfall.

4) Fill the container with the effluent.

5) Using a stop watch record the time it takes to fill the container.

6) Discard the content of the container and repeat Steps 3-5, three times.

7) Get the average of the three readings (time to fill the container).

8) Compute the volume using the formula for the type of container used (see Table 7.2).

9) Compute the flowrate by using the formula

$$Q = V/t,$$

where V – Volume of the container

t – average time to fill the container in seconds

Below is an example of the computation:

It takes 15.2, 15 and 15.8 seconds to fill a bucket with dimensions, D_1 = 20.0 cm, D_2 = 25.0 cm, H = 28.0 cm. What is the flow?

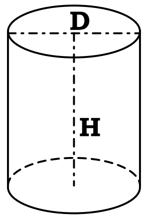
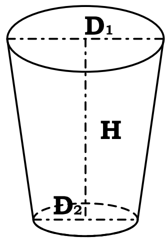
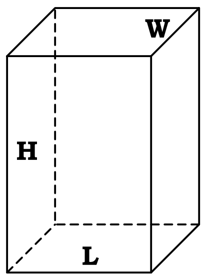
$$V = \pi/12\ H\ (D_1^2 + D_1D_2 + D_2^2)$$
$$= 3.1416/12\ (28.0)\ [\ (20.0)^2 + (20.0)\ (25.0) + (25.0)^2\ ]$$

$$V = 11{,}178.83\ cm^3$$

$$t = \frac{15.2 + 15 + 15.8}{3} = 15.33\ sec.$$
$$Q = 11{,}178.83\ cm^3\ /\ 15.33\ sec$$
$$Q = 729.21\ cm^3/sec$$

In this example and in the rest of this manual, Q is the quantity of the effluent discharge.

Table 7.2
Container Types and Formula

Container Type	Figure	Formula
Right Cylinder		$V = \frac{1}{4} \pi D^2 H$
Frustrum of a Cone		$V = (^1/12) \pi H (D_1^2 + D_1 D_2 + D_2^2)$
Rectangular Parallelepiped		V = HLW

7.2 Sump Pump

Many pumping stations still discharge raw or disinfected sewage directly to watercourses, so a method to calculate flow by using the sump pump is very useful. Because many pumping station discharges have either underwater (submerged) or inaccessible outfalls, the best method calculated flow is direct proportion to the kilowatt hours used by the station.

A summary of the pump method follows.

If the flow, *Q* kwh is used, then the volume pumped per pump cycle is:

$$V_p = V_s + Q_1 \, tp$$

Where:

V_p = volume pumped/cycle, m^3

V_s = storage volume of wet well, m^3

Q_1 = flow of the influent water, m^3

tp = time pump runs/cycle, sec

The error introduced is the flow into the sump during the pump cycle. To correct this error, a station constant must be calculated, based on the station's electrical meter.

$$C = \frac{1{,}000 \, V_s \left(1 + \frac{t_p}{t_f}\right)}{nK_h}$$

where:

C = station constant, m^3/kwh
t_f = time required for wet well to fill, sec
n = number of revolutions made by the meter disch per one pump cycle
K_h = meter constant, watt-hours/revolution

Thus the flow can be calculated:

$$Q_{avg} = \frac{C \, (E_{t1} - E_{t0})}{t}$$

where:

Q_{avg} = average flow for the period, m^3
C = station constant, m^3/kwh
E_{t0} = kwh reading at the beginning of the period
E_{t1} = kwh reading at the end of the period, and
t = elapsed time between observations E_{t0} and E_{t1}, min.

The meter should be read at an interval greater than one hour.

If the instantaneous flow is desired, it is equal to the flow of the influent sewer. To calculate the Q_i:

$$Q_i = \frac{V_s}{t_f}$$

where:

Q_i = flow of influent sewer, m^3
Vs = storage volume, m^3
t_f = time required to fill the sump, sec

However, three notes of cautions should be remembered:

(1) When both pumps are operating together instead of alternately in stations with more than one ejector pump, the force main will choke, decreasing the head loss (h_L) and thus decreasing the efficiency.
(2) Pay attention to meter multipliers (e.g., one notch = 4 kwh).
(3) In pneumatic ejector stations versus pumping stations, the "batch" volume of discharge will be constant because the pressure vessel discharges under forced air pressure when full.

7.3 Weirs

A weir is a low dam or overflow structure built across an open channel. It has a specific size and shape with a unique free-flow, head-discharge relationship. The edge or surface over which the water flows is called the crest. Discharge rates are determined by measuring the vertical distance from the crest to the water surface in the pool upstream from the crest.

Weirs can be used for both high flows with the discharge measured by the water stage in the pool behind the weir or for volumetric flows in extremely low flow conditions that are too small to measure by current meter. One disadvantage of using weirs is that in sediment laden streams the weir will allow sediment depositions in the pool above the weir.

Many formula and shapes and sizes of weirs are used to compute the discharge rate. Some commonly used weirs will be described here. The basic principle is that the discharge is directly related to the water depth above the notch in which the water flows; this distance is called the head (h).

7.3.1 Flow Measurement in Weirs

Materials:

- Personal Protective Equipment
- Weir Stick or Ruler
- Field Notebook/Field Data Form/Ballpen

Procedure:

1) Wear the appropriate PPEs. (gloves, safety boots, etc.)
2) Using a weir stick or ruler measure the height of the water above the notch where the water flows. This is H_{max} the maximum head over the weir.

   Observe the following conditions when measuring the height of the water. Proper measurement conditions occur when the nappe flows 'free' over the weir crest. The stream of water leaving the weir crest is called the nappe. Free flow, or critical flow, occurs when the nappe is thrown clear of the weir face and air flows freely under the nappe, and between the nappe and the weir face. Weirs provide accurate discharge measurements only within flow ranges specified by the size and geometry of the weir notch or crest. When the downstream water level rises to a point where air no longer flows freely beneath the nappe, the nappe is not ventilated and accuracy of the discharge measurement suffers because of low pressure beneath the nappe. Weir measurements are not usable when the downstream water level submerges the weir crest.

   The actual measuring point is located upstream of the weir plate, in the weir basin. A staff gage is commonly used to measure the head (height of water above the crest) at a point in the weir basin upstream from the point where drawdown begins. Drawdown, or surface contraction, is the slight lowering of the water surface as the water approaches the weir. Drawdown typically begins at a distance of about four times the elevation head on the crest upstream of the weir. The gage should be situated a distance upstream of the weir equal to four times the maximum head expected over the weir.

   Measurement accuracy can be enhanced by using a recording gage situated in a stilling well, instead of a staff gage in the weir basin.

3) Measure for the head, H by locating the sampling/measuring point upstream of the weir plate, 4 times H_{max}.

4) Record the measurement on the field notebook or field data form.
5) Compute the flow using the formula for weirs.

7.3.2 Rectangular Weirs

The rectangular weir, **Figure 7.1** is the most commonly used thin plate weir. Rectangular weirs can be "suppressed," or "contracted." Suppressed means there are no contractions. A suppressed weir's notch width is equal to the channel width; thus, there really isn't a notch - the weir is flat all the way along the top. When approach conditions allow complete contractions at the ends and at the bottom, (the free-fall at the weir head is completely within the notch area), the weir is called a contracted weir. Weir contractions cause the water flow lines to converge through the notch.

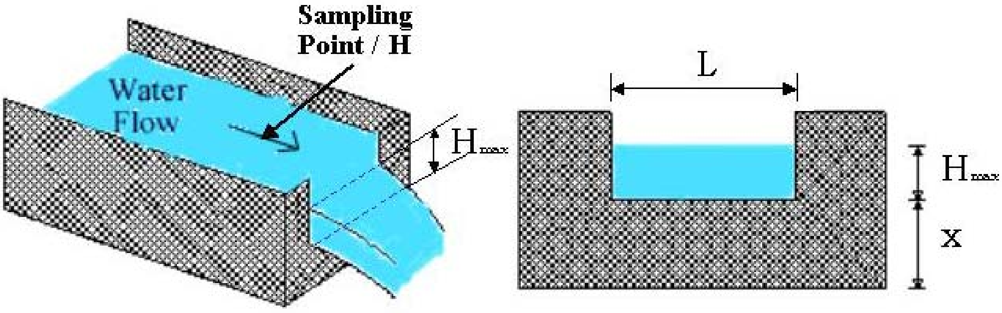


Figure 7.1
Rectangular Weir

Francis[2] provides the following formula:

For suppressed rectangular weir,

$$Q = 1.84 L H^{1.5}$$

Where, Q = discharge flow rate in m^3/sec
L = length of the weir crest, m
H = weir head, m
= height at sampling point minus X

H - should be measured at a point about 4 times H_{max}.

[2] Gillesana, D. I. T., "Fluid Mechanics and Hydraulics" revised edition. 2003.

For contracted rectangular weir,

$$Q = 1.84\,(L - 0.2H)\,H^{1.5}$$

Where,
- Q = discharge flow rate in m^3/sec
- L = length of the level crest head, m
- H = weir head, m;
- 0.2H = correction for end contractions

- H_{max} = maximum head

H - should be measured at a point about 4 times H_{max}.

Example:

Determine the flow over a suppressed weir 3 m long, 1.2 m high under a head of 900 mm.

Given:

Type of weir: Suppressed weir
L = 3 m
x = 1.2 m
H = 0.9 m

Required: discharge rate, Q

Solution:

$$Q = 1.84\,L\,H^{1.5}$$

$$Q = 1.84\,(3)\,(0.9)^{1.5}$$

Answer: Q = 4.7131 m^3/sec.

7.3.3 V-Notch Weirs

Triangular or V-notch weirs measure low discharges more accurately than horizontal weirs. The V-notch is most commonly a 90° opening with the sides of the notch inclined 45° with the vertical. Since the V-notch weir has no crest length, much smaller flows are represented by a given head than for a rectangular weir. V-notch weirs should always be used when frequent low flows are included in the overall range to be measured.

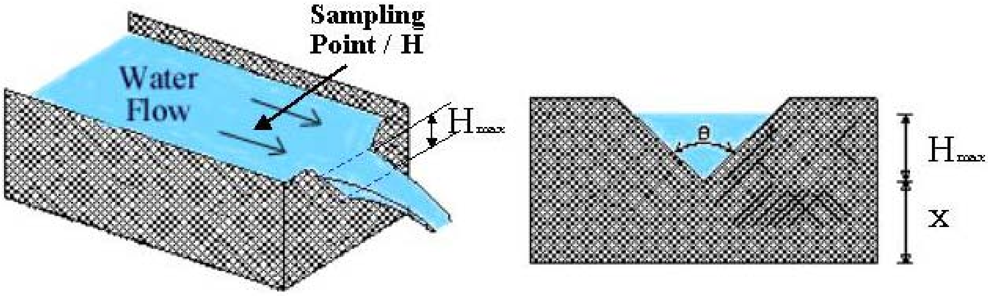


Figure 7.2
V-notch Weir

Procedure in Measuring Flow:

(1) Measure the V-notch angle, θ or find it from plant records,
(2) Measure the maximum head over the weir, H_{max}, usually with a measuring stick,
(3) Measure head, H at a distance 4 times H_{max} upstream of the weir basin.
(4) Then, find the instantaneous flow with the formula below for V-notch weirs

$$Q = 1.4 \left(\tan\frac{\theta}{2} \right) H^{2.5}$$

Where, Q = discharge flow rate in m^3/sec
θ = V-notch angle in degrees (°)
H = height/head at measuring point minus X
= head of the weir should be measured at a point about 4 times H_{max}
H_{max} = maximum head or the distance from the apex of the triangular notch to the surface of the water in meters

.

Example:

What is the flow rate of an effluent discharging from a 60° triangular weir of 17 ft high, under a 1750 mm head?

Given:

Type of weir: 60° v-notch triangular weir
x = 17 ft
H = 1.75 m

Required: discharge rate,Q

Solution:

$$Q = 1.4 \left(\tan\frac{\theta}{2} \right) H^{2.5}$$

$Q = 1.4 [\tan (60/2)] (1.75)^{2.5}$

Answer : Q = 3.2746 m^3/sec

7.3.4 Cipoletti (or Trapezoidal) Weir

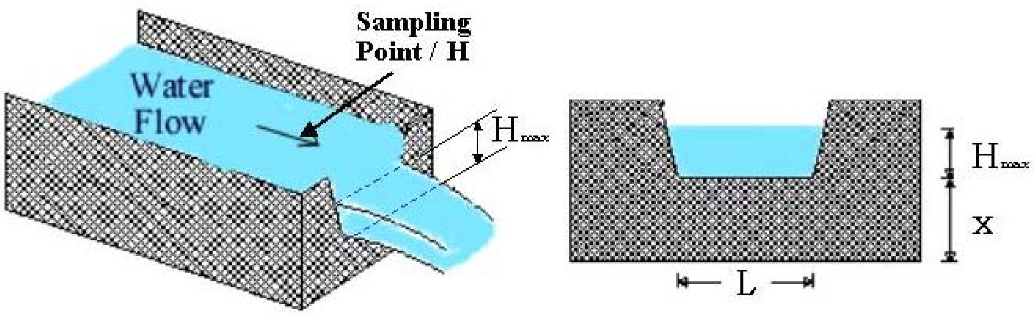


Figure 7.3
Cipoletti (or Trapezoidal) Weir

The Cipoletti or Trapezoidal Weir, as shown in **Figure 7.3** is similar to a rectangular weir with end contractions except that the sides incline outwardly at a slope of 1 horizontal to 4 vertical. This slope causes the discharge to occur essentially as though it were without end contraction.

$$Q = 1.859\, L\, H^{1.5}$$

Where,	Q	=	discharge flow rate in m^3/sec
	L	=	length of the weir crest, m
	H	=	weir head, m

H - should be measured at a point about 4 times H_{max}.

Note that L is measured along the bottom of the weir (called the crest), not along the water surface.

Follow measurement procedure as in rectangular weir.

Example:

A trapezoidal weir of crest length 4 meters, crest height of 2.75 meters is used to discharge wastewater without exceeding a head of 1.15 meters. What is the discharge rate?

Given:

Type of weir: Cipoletti weir
L = 4 m
x = 1.75 m
H = 1.15 m

Required: discharge rate, Q

Solution:

$$Q = 1.859\, L\, H^{1.5}$$

$$Q = 1.859\,(4)\,(1.15)^{1.5}$$

Answer: $Q = 9.1704\ m^3/sec$

7.4 Flumes

Flumes are shaped, open-channel flow sections that force flow to accelerate. Acceleration is produced by converging the sidewalls, raising the bottom, or a combination of both. Flumes range in size from very small-1 inch (in) wide-to large structures over 50 feet (ft) wide that are installed in ditches, laterals, and large canals to measure flow. Commonly, irrigation channels are designed to operate at near bank full to extend delivery coverage and, when the landscape is flat, to minimize earthwork involved in bank height construction. Flumes, compared to weirs, have the advantage of less head loss through the device, yet are more complicated to construct and more difficult to analyze.

7.4.1 Parshall Flume

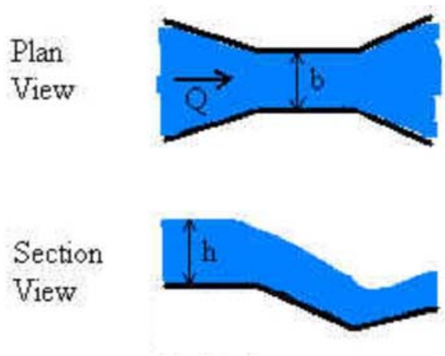


Figure 7.4
Parshall Flume

Parshall flumes are the most common. The discharge equation for the standard Parshall flume sizes are of the form,

$$Q = C h^n$$

Where, Q = discharge flow rate in ft^3/sec
h = measured head, ft
C and n for each size are given in **Table 7.3**

Table 7.3
Coefficients (*C*) and exponents (*n*) for Parshall flumes equation

Throat width *(b)*	Coefficient (*C*)	Exponent (*n*)
1 in	0.338	1.55
2 in	0.676	1.55
3 in	0.992	1.55
6 in	2.06	1.58
9 in	3.07	1.53
1 ft	3.95	1.55
2 ft	8.00	1.55
3 ft	12.00	1.57
4 ft	16.00	1.58
5 ft	20.00	1.59
6 ft	24.00	1.59
7 ft	28.00	1.60
8 ft	32.00	1.61
10 ft	39.38	1.60

12 ft	46.75	1.60
15 ft	57.81	1.60
20 ft	76.25	1.60
25 ft	94.69	1.60
30 ft	113.13	1.60
40 ft	150.00	1.60
50 ft	186.88	1.60

Table 7.4 shows the advantages and disadvantages of Parshall Flumes

Table 7.4
Advantages and Disadvantages of Parshall Flumes

ADVANTAGES	DISADVANTAGES
1. Can operate with small head losses. 2. Insensitive to velocity of approach. 3. Good measurements with considerable downstream submergence. 4. The discharge velocity is high to eliminate sediment deposition.	1. Cannot be used in closed-coupled, combination structures. 2. More expensive than weirs and offices. 3. Requires a solid, watertight foundation. 4. Requires accurate and careful workmanship for satisfactory construction, installation, performance.

7.4.2 Parshall Flume Flow Measurement

1) Wear the appropriate PPEs (gloves, safety boots, etc.)
2) The actual measuring point is located upstream from the throat a distance of 2/3 of the length of the approach channel.
3) Parshall flumes typically contain two water-level recorders to measure discharge under submerged conditions, one located in the sidewall of the contracting inlet and one located slightly upstream from the lowest point of flow in the throat. Both water-level recorders are used to determine the difference in vertical head between the two measuring points. This difference is then applied when calculating discharge under

submerged conditions. Only the upper measuring point is used when calculating discharge under non-submerged conditions.

Example:

Determine the flow over a parshall flume with an 8 feet throat width under a head of 1.3 ft.

Given:

Parshall flume
b = 8 ft
h = 1.3 ft

Required: discharge rate, Q

Solution:

$Q = C h^n$

From Table 7-3, @ b = 8 ft,

C = 32.00; n = 1.61

$Q = 32.00 (1.3)^{1.61}$

$Q = 48.8201 ft^3/sec /(35.3147 ft^3/m^3)$

Answer : Q = 1.3824 m^3/sec

7.5 Velocity-Area Method

When the wet cross-sectional area and average velocity are known, flow may be obtained by applying a formula

$$Q = A V$$

Where,	Q	=	the discharge flow rate
	A	=	the wet cross-sectional area
	V	=	is a mean velocity of water flowing inside the pipe

7.5.1 Float Method

Materials:

- Meter Stick
- Stop watch
- Field Notebook/Field Data Form/Ballpen
- Float materials (e.g ping pong ball)

Procedure:

(1) Wear proper PPEs.

(2) Measure the wet cross-sectional area, A, of the channel by measuring the depth of the water inside the channel and the width of the channel.

(3) Estimate the mean velocity, Vmean, of the waste stream by measuring the surface velocity using the float method. By using a meter stick, measure two points along the length of the channel. Record the length in the field notebook/Field Data Form.

(4) Using the stop watch, record the time it takes a float to travel between two points in a straight length of the channel.

(5) Make at least five trials. The time it takes a float to travel between two points in a straight length gives the surface velocity of the water. The mean velocity can be computed by multiplying the average velocity by a factor of 0.85. Hence,

$$V_{mean} = \frac{0.85\,(V_1 + V_2 + V_3 + V_4 + V_5)}{5}$$

(6) When the wet cross-sectional area and the average velocity are known, flow in the channel can be obtained by applying the formula,

$$Q = A\,V_{mean}$$

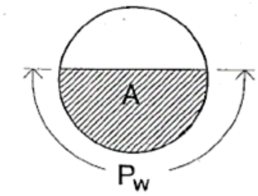
Where,
Q = the discharge rate, m^3/sec
A = the wet cross-sectional area of the sewer, m^2
V_{mean} = the mean velocity of water flowing, m/sec

7.5.2 Manning Equation

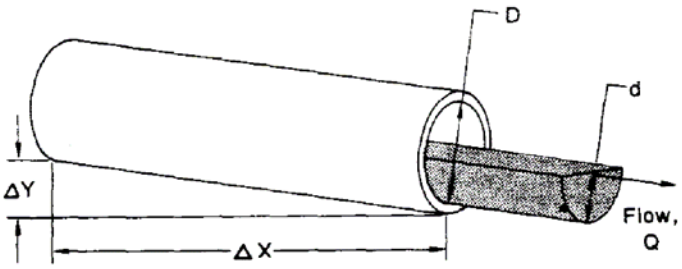
The Manning equation relates velocity to total bed resistance or friction to calculate flow velocity, V. The equation balances the gravitational acceleration of water in an inclined, open channel against surface area and bed roughness. The Manning equation is intuitively appealing because of its simple form:

$$V = \frac{R^{2/3}\, S^{1/2}}{n}$$

Where,	V	=	flow velocity, m^3/sec
	n	=	Manning roughness coefficient, shown in **Table 7.4**
	R	=	hydraulic radius, m
	S	=	longitudinal slope



$$R = \frac{\text{Area, A}}{\text{Wetted Perimeter, Pw}}$$



$$S = \frac{\Delta Y}{\Delta X}$$

The term, R, is very difficult to solve mathematically, but its solution is easy and fast graphically. A nomograph solution is shown in **Figure 7.5, Figure 7.6** and **Figure 7.7**.

Manning's *n* is a dimensionless number that defines the flow resistance of a unit of bed surface. Resistance is a function of particle size, bed shape and constructional bed forms.

Table 7.5
Values of Manning Roughness Coefficient

SURFACE	BEST	GOOD	FAIR	BAD
Uncoated cast-iron pipe	0.012	0.013	0.014	0.0156
Coated cast-iron pipe	0.011	0.012*	0.013*	
Commercial Wrought-iron pipe, black	0.012	0.013	0.014	0.015
Commercial wrought-iron pipe, galvanized	0.013	0.014	0.015	0.017
Smooth brass and glass pipe	0.009	0.010	0.011	0.013
Smooth lockbar and welded "OD" pipe	0.010	0.011*	0.013*	
Riveted and spiral steel pipe	0.013	0.015*	0.017*	
Vitrified sewer pipe				
	0.010	0.013*	0.015	0.017
	0.011			
Common clay drainage tile	0.011	0.012*	0.014*	0.017
Glazed brickwork	0.011	0.012	0.013	0.015
Brick in cement mortar ; black sewers	0.012	0.013	0.015*	0.017
Neat cement surfaces	0.010	0.011	0.012	0.013
Cement mortar surfaces	0.011	0.012	0.013*	0.015
Concrete pipe	0.012	0.013	0.015*	0.016
Wood slave pipe	0.010	0.011	0.012	0.013
Flank flumes:				
Planned	0.010	0.012*	0.013	0.014
Unplanned	0.011	0.013*	0.014	0.015
With battens	0.012	0.015*	0.016	
Concrete-line channels	0.012	0.014*	0.016*	0.018
Cement-rubble surface	0.017	0.020	0.025	0.030
Dry-rubble surface	0.025	0.30	0.033	0.035
Dressed-ash air surface	0.013	0.014	0.015	0.018
Semicircular metal flumes, smooth	0.011	0.012	0.013	0.015
Semicircular metal flumes, corrugated	0.0225	0.025	0.0275	0.030
Canals and ditches:				
Earth, straight and uniform	0.017	0.020	0.0225 *	0.025
Rock cuts, smooth and uniform	0.025	0.030	0.033*	0.035
Rock cuts, jagged and irregular	0.035	0.040	0.045	
Winding sluggish canals	0.0225	0.025*	0.0275	0.030
Dredged earth channels	0.025	0.0275 *	0.030	0.033
Canals with rough stony beds,	0.025	0.030	0.035	0.040

weeds on earth banks				
Earth bottom, rubble sides	0.028	0.030	0.033	0.035
Natural stream channels:				
(1) Clean, straight bank, full stage, no rifts or deep pools	0.025	0.275	0.030	0.033
(2) Same as (1), but some weeds and stones	0.030	0.033	0.035	0.040
(3) Winding, some pocis and shoals, clean	0.033	0.035	0.040	0.045
(4) Same as (3), lower stages, more ineffective slope and sections	0.040	0.045	0.050	0.055
(5) Same as (3), some weeds and stones	0.035	0.040	0.045	0.050
(6) Same as (4), stony sections	0.045	0.050	0.055	0.060
(7) Sluggish river reaches, rather weedy or with very deep pools	0.050	0.060	0.070	0.080
	0.075	0.100	0.125	0.150
(8) Very weedy reaches				

*Values commonly used in designing.

Figure 7.5
Manning Formula Pipe Flow Chart, n = 0.010

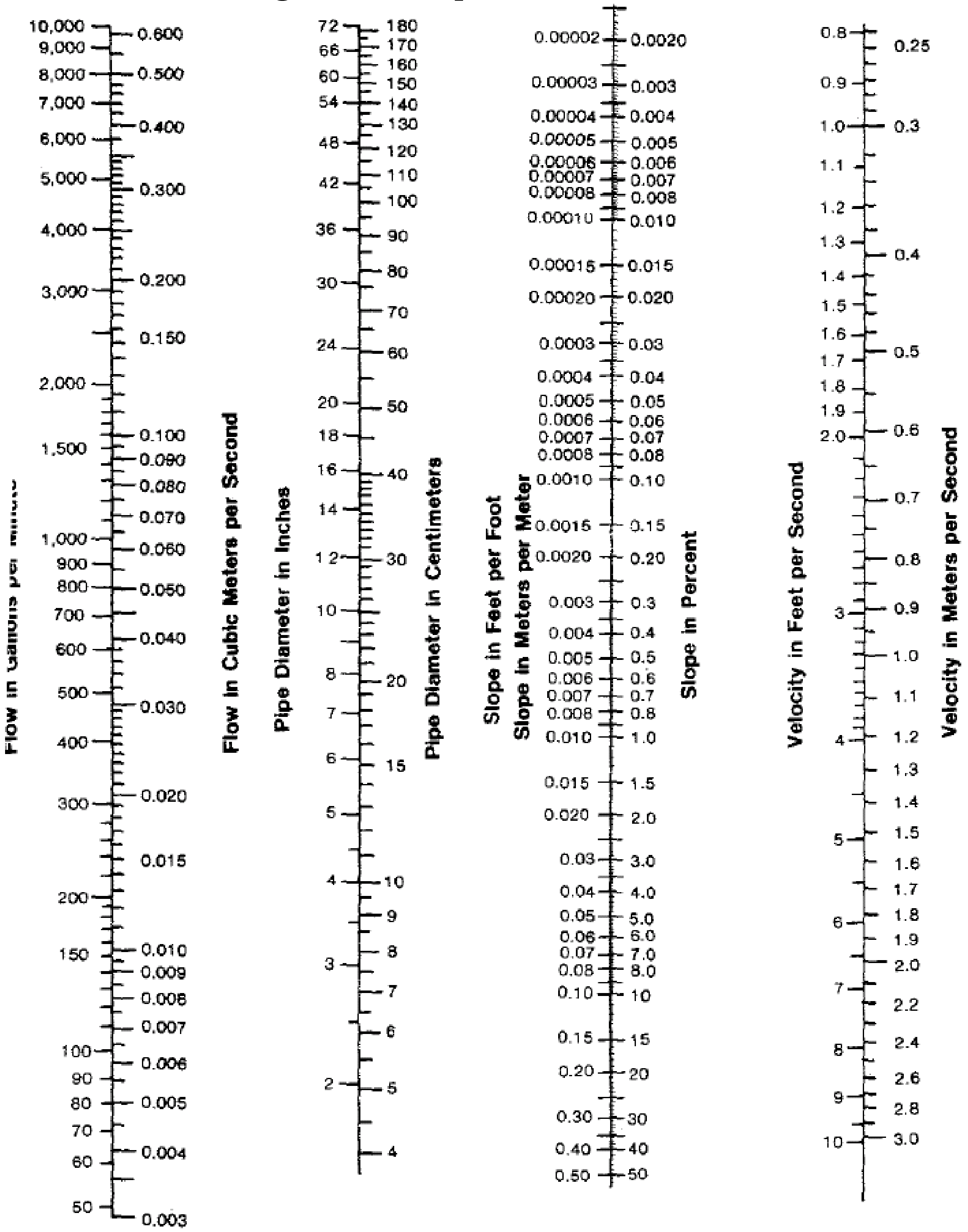


Chart based on the formula $Q=\frac{1.486}{n} \times AR^{\frac{2}{3}} \times S^{\frac{1}{2}}$ for pipe flowing full.

Manning formula pipe flow chart (English/metric units). $n =$ 0.010. *[Courtesy: Water & Sewer Works, Sept. 1977 (Now — Water Engineering & Management).]*

Figure 7.6
Manning Formula Pipe Flow Chart, n = 0.011

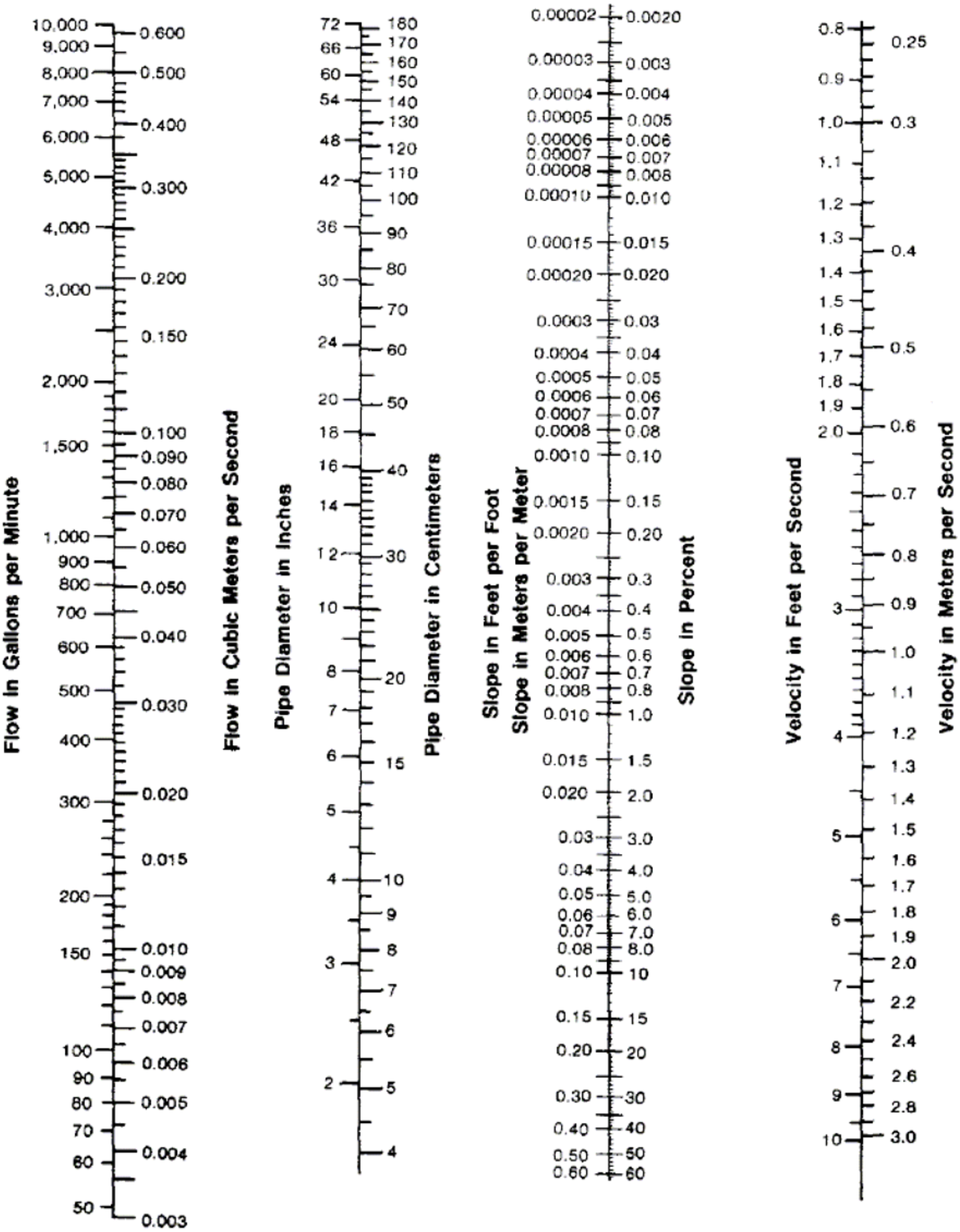


Chart based on the formula $Q=\frac{1.486}{n} \times AR^{\frac{2}{3}} \times S^{\frac{1}{2}}$ for pipe flowing full.

Manning formula pipe flow chart (English/metric units). $n =$ 0.011. *[Courtesy: Water & Sewer Works, Sept. 1977 (Now — Water Engineering & Management).]*

Figure 7.7
Manning Formula Pipe Flow Chart, n = 0.012

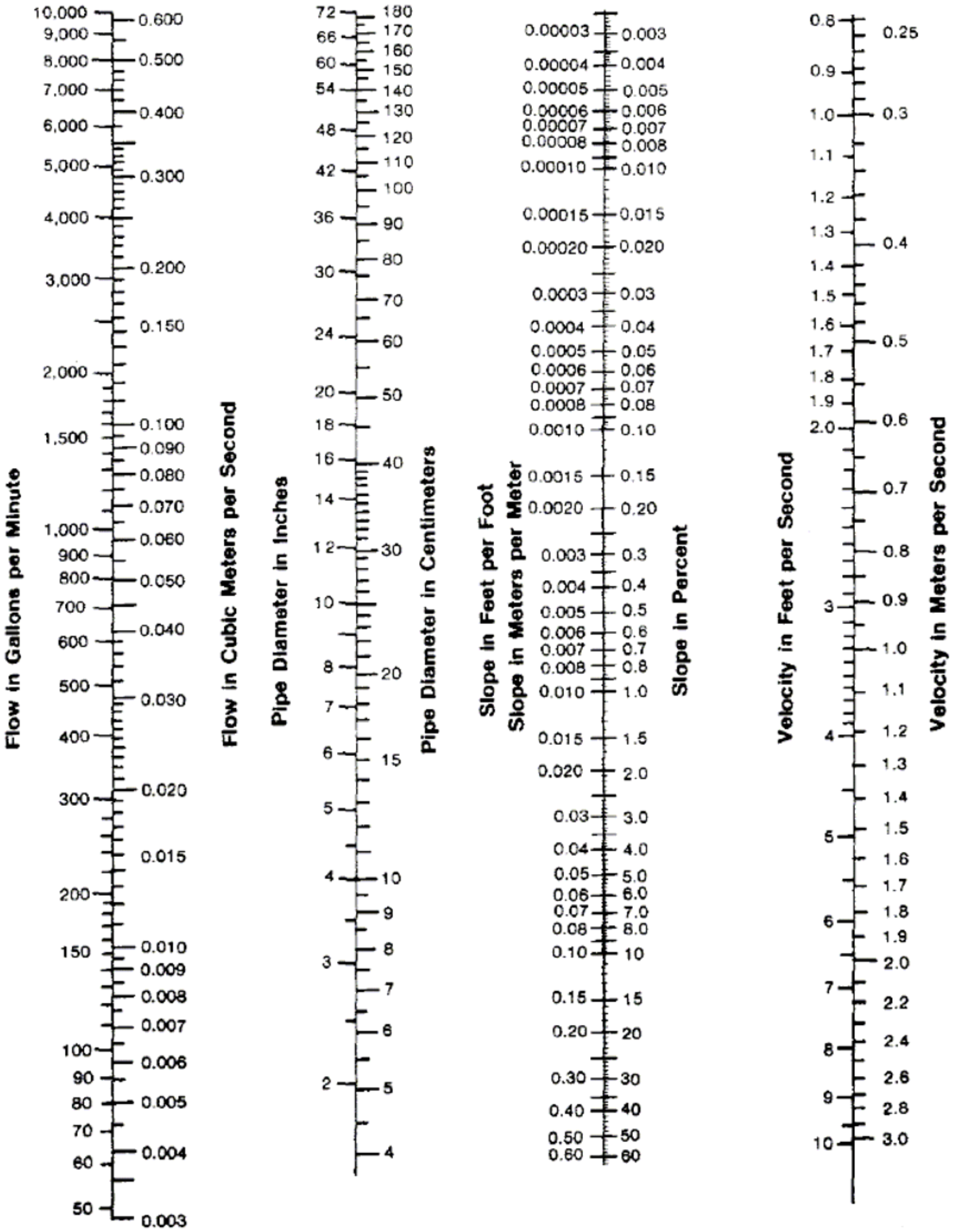


Chart based on the formula $Q = \frac{1.486}{n} \times AR^{\frac{2}{3}} \times S^{\frac{1}{2}}$ for pipe flowing full.

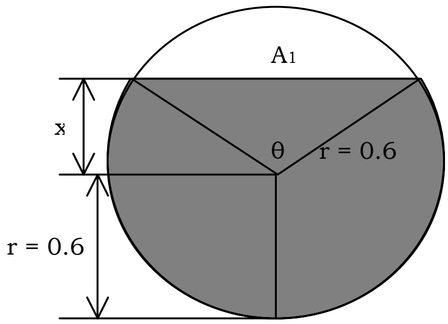
Manning formula pipe flow chart (English/metric units). *n* = 0.012. *[Courtesy: Water & Sewer Works, Sept. 1977 (Now — Water Engineering & Management).]*

Example:

A 600-mm radius concrete sewer pipe is laid on a slope of 0.001, was found to be 7/8 full. Determine the discharge through the pipe.

Given:

Type of open channel: circular concrete sewer pipe
S = 0.001
7/8 full
r = 600 mm = 0.6 m



Required: discharge rate, Q

Solution:

Q = A V

$$Q = \frac{A \; R^{2/3} \; S^{1/2}}{n}$$

A = 7/8 Atotal
= 7/8 π $(0.6)^2$
A = 0.9896 m^2

A1 = 1/8 π $(0.6)^2$
A1 = A_{sector} – $A_{triangle}$
1/8 $\pi r^2 = \frac{1}{2} r^2 \theta_{radians} - \frac{1}{2} r^2 \sin\theta$
$\theta_{radians} - \sin\theta = 0.785$

Solve by trial and error:
θ = 101.185°

Then,

$$P = \frac{\Pi\,(0.6)\,(360° - 101.185°)}{180}$$

P = 2.71 m

R = A/P = 0.9896/2.71
R = 0.365

$$Q = \frac{(0.9896)\,(0.365)^{2/3}\;0.0062^{1/2}}{0.012}$$

Answer: Q = 1.332 m^3/sec

7.6 Open Pipe Method

If there is no flow measurement system and the outfall discharges is unsubmerged above receiving water, an open-pipe method can be used to determine flow such as the California Pipe Method.

California Pipe Method

This method measures the discharge from the open end of partially filled horizontal pipes discharging freely into the air. This method is sometimes considered a trajectory method. However, the measurement is really based on the brink depth at the end of the pipe. This method can be adapted to the measurement of discharge in small open channels where the discharge can be diverted through a horizontal pipe flowing partially full and discharging freely into the air.

Figure 7.8 illustrates one pipe fitting arrangement to accommodate the California pipe discharge measurement. Other arrangements may be possible. With such an arrangement, the only measurements necessary are the inside diameter of the pipe and the vertical distance from the upper inside surface of the pipe to the surface of the flowing water at the outlet end of the pipe. With this information, the discharge may be computed by:

$$Q = 8.69 \left(1 - \frac{a}{d}\right)^{1.88} d^{2.48}$$

Where,

Where,	Q	=	discharge (ft^3/s)
	a	=	distance measured in the plane of the end of the pipe from the top of the inside surface of the pipe to the water surface (ft)
	d	=	internal diameter of the pipe (ft)

Many applications of this method undoubtedly have been for coastal discharges. Four basic criteria must be satisfied for the method to be valid:

(1) The pipe must be level.
(2) The pipe must be discharged partially full, with *a/d* greater than 0.45
(3) The pipe must be discharged freely into the air.
(4) The velocity of approach must be practically zero.

This equation, developed from experimental data for pipes 3 to 10 in in diameter, gives reasonably accurate values of discharge for that range of sizes under certain flow conditions. It cannot be used with corrugated metal pipes.

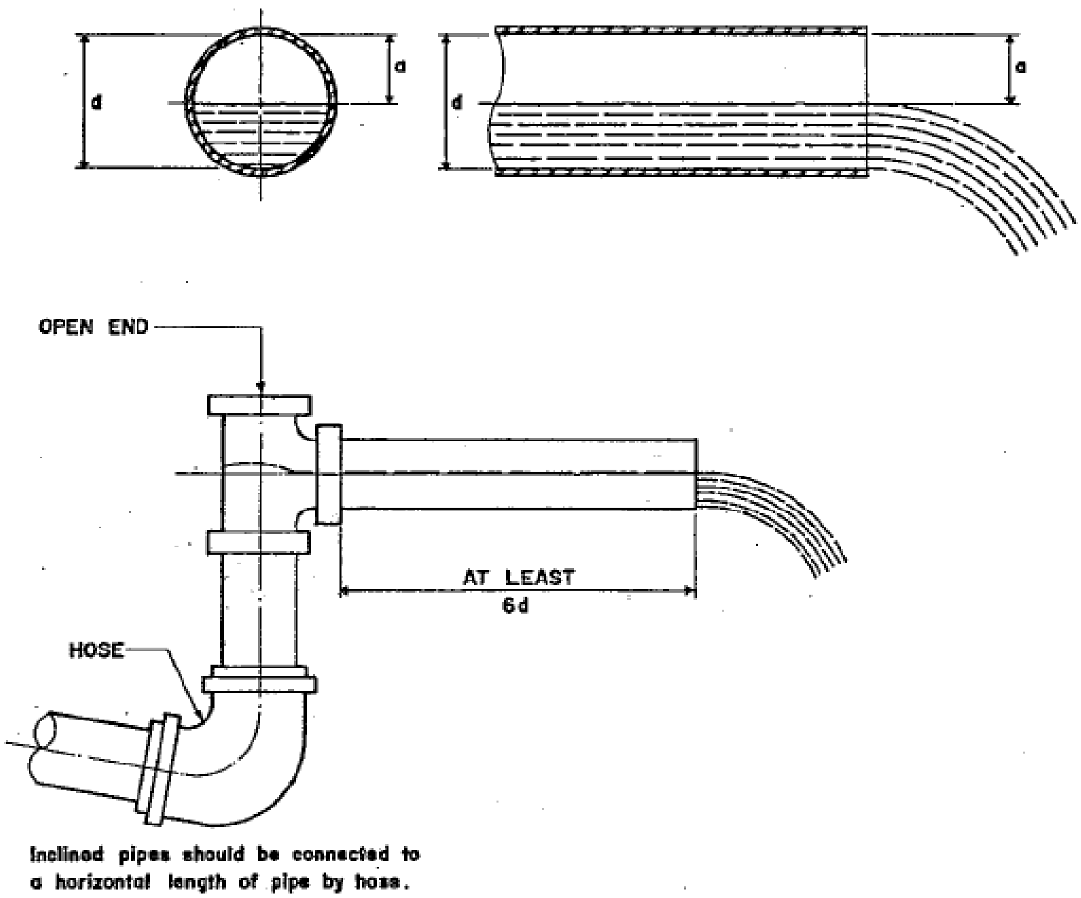


Figure 7.8
California Pipe Flow Method

7.7 Flow Measurement in Pressure Conduits

Using pipelines instead of open channels has many advantages. Pipelines prevent loss of water by evaporation and seepage. Pipeline flow can be measured in many ways.

7.7.1 Venturi Meter

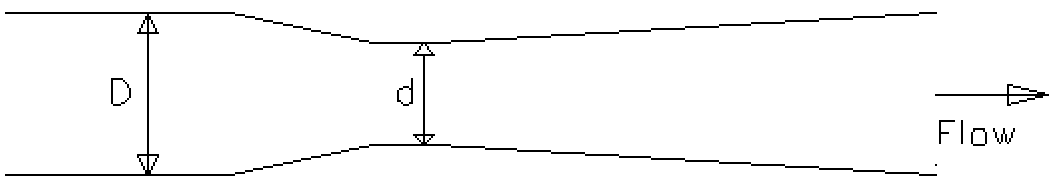


Figure 7.9
Venturi Meter

The classical Venturi tube (also known as the Herschel Venturi tube) is used to determine flow rate through a pipe. Differential pressure is the pressure difference between the pressure measured at D and at d. The angle of divergence is kept small to reduce the head lost caused by turbulence as the velocity is reduced.

The calculations are for a Classical Venturi Tube carrying a liquid adopts the energy equation.

$$\frac{8Q_1^2}{\pi^2 g D^4} + \frac{p_D}{\gamma} + z_D - HL = \frac{8Q_2^2}{\pi^2 g d^4} + \frac{p_d}{\gamma} + z_d$$

Example:

A horizontal 150 mm diameter pipe gradually reduces its section to 50 mm diameter, subsequently enlarging into 150 mm section. The pressure in the 150-mmpipe at a point just before entering the reducing section is 140 kPA and in the 50-mm section at the end of the reducer, the pressure is 70 kPa. If the 600 mm of head is lost between the points where the pressure are known, compute the rate of flow of water through the pipe.

Given:

Venturi
D = 0.15 m
d = 0.05 m
p_D = 140 kPa
p_d = 70 kPa
HL = 0.60 m

Required: discharge rate

Solution:

$Q_1 = Q_2 = Q$

Energy equation between 1 and 2:
E1 – HL = E2

$$\frac{8Q^2}{\pi^2(9.81)(0.15)^4} + \frac{140}{9.81} + 0 - 0.060 = \frac{8Q^2}{\pi^2(9.81)(0.05)^4} + \frac{70}{9.81} + 0$$

$13{,}057\ Q^2 = 6.5356$

$Q = 0.0224\ m^3/sec = 22.4\ L/sec$

7.8 Electronic Measurement

Modern innovations in the measurement of flow rate incorporate electronic devices that can correct for varying pressure and temperature (i.e. density) conditions, non-linearities, and for the characteristics of the fluid.

Measuring flow using electronic equipment is the most convenient method. Record the reading as shown on the meter on field notebook or field data form.

7.8.1 Magnetic Flow Meter

Magnetic flow meters are most directly electrical in nature, deriving their first principles of operation from Faraday's law. A magnetic field is applied to the metering tube, which results in a potential difference proportional to the flow velocity perpendicular to the flux lines. The magnetic flow meter requires a conducting fluid, e.g. water, and an electrical insulating pipe surface, e.g. a rubber lined non magnetic steel tube.

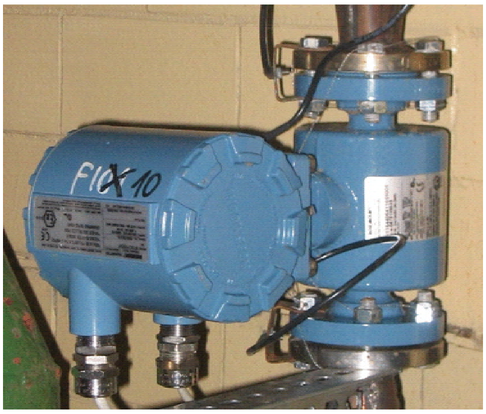


Figure 7.10
Industrial Magnetic Flow Meter

7.8.2 Vortex Flow Meter

Vortex meters depend on piezoelectric sensors to detect vortices shed from a stationary shedder bar. A vortex flow meter is typically made of 316 stainless steel or Hastelloy and includes a bluff body, a vortex sensor assembly and the transmitter electronics, although the latter can also be mounted remotely (**Figure 7.11**). The majority of vortex meters use piezoelectric or capacitance-type sensors to detect the pressure oscillation around the bluff body. These detectors respond to the pressure oscillation with a low voltage output signal which has the same frequency as the oscillation. Such sensors are modular, inexpensive, easily replaced, and can operate over a wide range of temperature ranges. Sensors can be located inside the meter body or outside. Wetted sensors are stressed directly by the vortex pressure fluctuations and are enclosed in hardened cases to withstand corrosion and erosion effects.

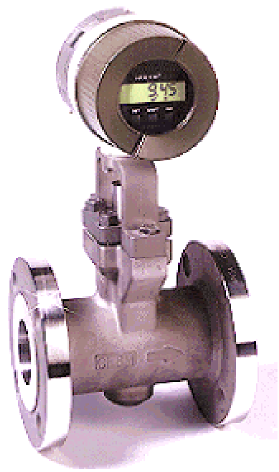


Figure 7.11
Vortex Flow Meter

7.8.3 Ultrasonic Flow Meter

Ultrasonic Flow Meters measure the difference of the transit time of ultrasonic pulses propagating in and against flow direction. The speed at which sound propagates in a fluid is dependent on the fluid's density. If the density is constant, however, one can use the time of ultrasonic passage (or reflection) to determine the velocity of a flowing fluid.

Some manufacturers produce transducer systems that operate in the shear-mode, sending a single pulse and receiving a single pulse in return. Narrow-beam systems are commonly subject to walk-away (the signal completely missing the downstream transducer). Wide-beam systems overcome beam refraction and work better in changing liquid density and temperature. With the advent of digital signal processing, it has become possible to apply digital signal coding to the transmitted signal. This can eliminate many of the problems associated with noise and variations in liquid chemistry.

CHAPTER VIII
DATA PRESENTATION AND REPORTING

EMB inspectors involved in the conduct of effluent sampling shall prepare a report including the evaluation of test results. A report format is used for this purpose.

The industries are required by EMB to submit its periodic report using the PCO Self-monitoring Report Format.

The raw data must be transferred to a usable format and must be presented in a way that can be easily reviewed. The two most common approaches are the table form and graphical form.

The recommended outline for reporting Effluent Sampling is shown on Table 8-1, Effluent Sampling Report Form, where basic and general information regarding the facility are included.

The results of effluent sampling will be tabulated against the GES to determine if a standard has been exceeded at any point in time.

Table 8.1 EFFLUENT SAMPLING REPORT FORM

Republic of the Philippines
Environmental Management Bureau- Region __
Address:

EFFLUENT SAMPLING REPORT

A. Basic Information

1. Name of Establishment:
2. Office Address:
3. Plant Address:
4. Contact Person/Position Title:
5. Purpose of Effluent Sampling:
   ( ) To assess water pollution source installation and check compliance with the requirements of RA 9275 and its IRR DAO 2005-10
   ( ) To conduct sampling in connection with its application for Discharge Permit ( ) New ( ) Renewal
   ( ) To investigate pollution complaint
   ( ) To check status of commitment to___________

B. General Information

.

1. Nature of Business
2. Type of Industry/Code:
3. Year Established:
4. Name of CEO:
   Phone No:_________ E-mail: _________
5. Name of PCO: _________ Accreditation No: ____
   Phone No:_________ E-. mail: ___________

6. With Discharge Permit:
   ( ) Yes Permit No.______ Date Issued: ____Expiry:______
   ( ) No

C. Plant Manufacturing Information

1. Raw Materials/Finished Products list

Raw Materials	**Quantity**	**Finished products**	**Quantity**
1.		1.	
2.		2.	
3.		3.	

2. Type of operation
   ( ) Batch
   ( ) Continuous

3. Status of operation during sampling
   ( ) Not operating
   Why?___________________________________
   ( ) Below rated capacity Production output_____________________
   ( ) Normal Rated Capacity____________________________

D. Water Supply/Wastewater Generation

1. Source of water
   ( ) Deep well
   ( ) MWSS
   ( ) Water District
   ( ) Surface water (lake, river, ..)

2. Water Inventory

	Vol. Water used	Vol. Wastewater generated
Process	_____	______
Washing/Cleaning	_____	______
Cooling	_____	______
Domestic	_____	______
Others	_____	______

Total water consumption: ______
Total volume of wastewater Generated: ______
Water reused or recycled for irrigation and other agricultural purposes ______

3. Quality of Abstracted Water:
   Date of Analysis: _____
   pH _____
   TSS _____
   Petroleum Oil/AVFO _____
   BOD _____
   Heavy metal _____

E. Information on Water Pollution

1. With WTP ( ) Yes ( ) No
2. If there is WTP:

   Type of WTP ( ) Chemical
   ( ) Biological

   Date Installed: _________
   Design capacity: _________
   Cost of WTP: _________
   Maintenance Cost: _______
   Discharge point: _________ No. of discharge points: ____
   Receiving water body: _________ Water Classification: _____
   Latest Analysis of water body (Date): _________________

	Upstream	Downstream
PH	______	___________
TSS	______	___________
BOD	______	___________

   Flow metering device used: ( ) V-weir ( ) Flow meter
   Influent: _______
   Effluent _______

3. Components of WTP:
   3-1 Primary treatment
   ( ) Screening
   ( ) Primary sedimentation tank
   ( ) Grit Removal
   ( ) Oil/water separator
   ( ) Equalization tank

   3-2: Biological Treatment
   ( ) Activated Sludge
   ( ) Anaerobic Digestion
   ( ) Trickling Filter
   ( ) Oxidation/Stabilization pond
   ( ) Sequencing Batch Reactor
   ( ) Others

3-3: Chemical Treatment
- ( ) pH adjustment
- ( ) Disinfection
- ( ) Oxidation/reduction
- ( ) Flocculation/coagulation
- ( ) Others

3-4 Condition of the WTP
- ( ) properly maintained
- ( ) inadequately maintained
- ( ) poor maintenance

4. If WTP is under construction or undergoing rehabilitation

4-1 system or units under construction or being modified
____

4-2 estimated completion
____

4-3 treatment units utilized to treat wastewater
____

F. Field Data:

a. Date and Time of Sampling:_____________________
b. Sampling Station Identification: __________________
c. Type of Sample: ______________________________
d. Flow rate: ____________________________________

G. Evaluation of Results:

Analytes	**Results**	**Effluent Standard**	**Remarks (Passed/Failed)**
pH			
Temperature			
TSS			
BOD			
COD			
Chlorine			
Total Coliform			

H. Findings and Observations:

____
____
____

I. Remarks and Recommendation:

____
____
____
____

Date: ______________________________

Prepared By: ______________________________
(Position)

Reviewed By:

____
Chief, Water Quality Management Section

Noted By:

____
Chief, Pollution Control Division

Attachments:

( ) Field Data Form
( ) Chain of Custody Form
( ) Laboratory Analysis Results

ABC TECHNOLOGY CORPORATION

EFFLUENT SAMPLING PLAN

ANNUAL WASTEWATER SAMPLING FOR EFFLUENT QUALITY PARAMETERS

DATE PREPARED:
April 29, 2005

DATE OF SAMPLING:
May 03, 2005

PROJECT COORDINATOR:
EMB-DENR Region 4A, Pollution Control Department

SAMPLING TEAM:
Maria Reyes
Mark Santos
Allan Dela Cruz
Joseph De Leon

LABORATORY:
EMB-DENR Region 4A
QWS Laboratory

I. OBJECTIVE FOR SAMPLING EVENT

The primary objective of this sampling event is to collect representative grab samples of the effluent discharges to assure ABC's (ABC Technology Corporation) compliance with the Revised DENR Administrative Order-35 standards.

A split sampling will also be done to check the quality and reliability of the results. Samples will be sent to EMB-DENR Region 4A Laboratory and to QWS Laboratory.

II. INFORMATION OF THE ESTABLISHMENT/FACILITY

Name of Facility:
Address:
Industry Type:
Type of Treatment/WTP:

III. DISCHARGE LOCATION

The compliance monitoring points/locations are listed in Table 1 (refer to Figure 1, the ABC Site Plan with sampling locations):

Table 1
WTP Discharge Location

Outlet Number	Location of the Outlet	Name of Receiving Water Body
1	***STP*** discharge	Ilagan Creek
2	***WTP*** discharge	Ilagan Creek
3	Canteen wastewater at ABC storm culvert	Storm water culvert connected to…> 2 km to Agar River
4	Guardhouse domestic waste discharging at ABC storm culvert	Storm water culvert connected to…> 2 km to Agar River

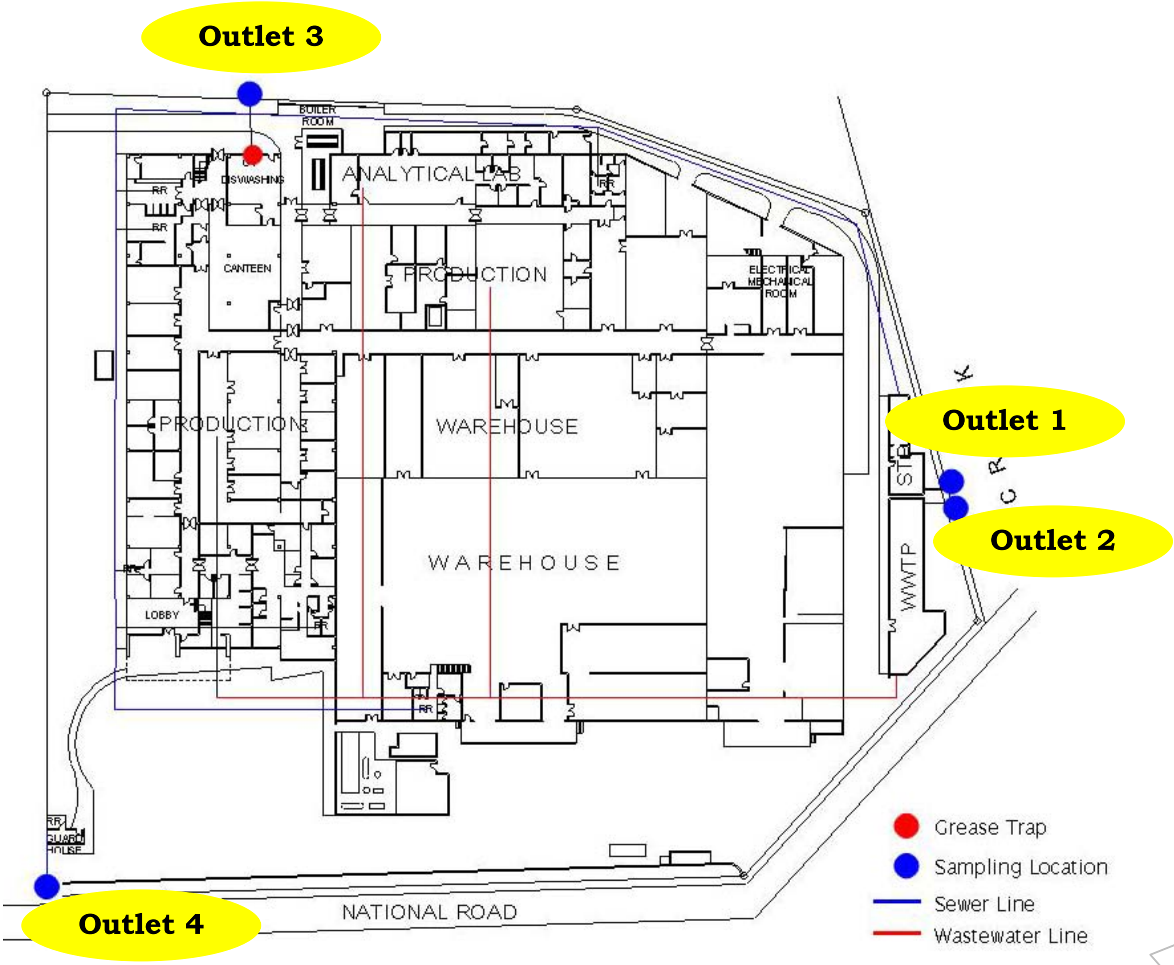


Figure 1
ABC Site Plan

IV. SAMPLING CRITERIA AND ANALYSIS

1. Parameters and Analytical Methods

   Grab samples shall be collected at the above-mentioned compliance points for wastewater analysis.

   Table 2 below lists the parameters for water quality analysis per type of discharge. To assess compliance, analytical results of samples taken must conform to the Revised DAO 35 Effluent Standards.

Table 2
Samples Parameters and Sample Location

Outlet Number	Location of the Outlet	Sample Parameters
1	***STP*** discharge	pH, TSS, BOD, Fecal Coliform, AVFO
2	***WTP*** discharge	BOD, TSS, AVFO, Surfactants, Nitrate, Ammonia-Nitrogen, Phosphate
3	Canteen wastewater at ABC storm culvert	Color, Temp, pH, COD, TSS, AVFO, Surfactants
4	Guardhouse domestic waste discharging at ABC storm culvert	pH, TSS, BOD, Fecal Coliform, AVFO

Specific Analytical Method, Sample Volume, Container Type, Preservation and Holding Time required for this compliance monitoring are listed in Table 3

Table 3
Analytical Method, EMB-DENR Limits, Sample Volume, Container Type, Preservation and Holding Time

Parameter	Analytical Method	EMB-DENR Limits	Volume Requirement (ml)	Container	Preservation	Ratio of Preservative to Water Sample	Holding Time
Ammonia-Nitrogen	Colorimetric, Titrimetric, Potentiometric Distillation Procedure, Potentiometric, Ion Sensitive Electrode		400	P, G	Cool, 4°C H_2SO_4 to pH < 2	2 ml of conc. H_2SO_4 per liter of sample and store at 4°C	24 hours
AVFO	Gravimetric, Separatory Funnel Extraction, Spectrophotometric (Infrared)		1,000	G only	Cool, 4°C HCl to pH < 2	5 ml HCL per liter and cool to 4°C (preserve on site)	> 48 hours if refrigerated
BOD	5-day BOD Test (bio-assay)		1,000	P, G	Cool, 4°C	-	48 hours
Color (True)	Colorimetric-Platinum-Cobalt		50	G	Cool, 4°C	-	24 hours
COD	Titrimetric or Spectrophotometric		50	P, G	H_2SO_4 to pH 2		7 days
Fecal Coliform	Multiple Tube Fermentation		100	G, sterile	Cool, 4°C		6 hours
Surfactants (MBAS)	Methylene Blue Active Substances (MBAS)		250	G, P	-	Filter	24 hours
Nitrate	Colorimetric,		100	P, G	Cool, 4°C		24 hours

Parameter	Analytical Method	EMB-DENR Limits	Volume Requirement (ml)	Container	Preservation	Ratio of Preservative to Water Sample	Holding Time
	Brucine				H_2SO_4 to pH < 2	2 ml conc. H_2SO_4 per liter of water sample	> 24 hours
pH	Meter and probe		25	P, G	Determine on site	-	6 hours
Phosphate			25	P, G	Filter on site Cool, 4°C	-	48 hours
Temperature	Meter and Probe, Thermometer		1,000	P, G	Determine on site	-	No holding time
TSS	Gravimetric		1,000	P, G	Icing at 4°C	None Required	24 hours

2. Quality Control Requirements

At a minimum, the quality control plan should contain the following elements:

- Linearity of calibration
- Verification of calibration
- Method detection limits
- Analysis of blanks (at least 10% of the total number of samples per batch)
- Purity and traceability of reference standards
- Laboratory proficiency testing program

All samples will be split in the field and sent to two laboratories – QWS Laboratory and EMB Region IV Laboratory.

3. Sample Retention

The laboratory shall retain all samples collected for re-analysis, if necessary, for a period not exceeding the maximum holding times referenced in the analytical method.

4. Data Reporting

The laboratory shall report results for samples analyzed not later than 7-working days after receipt. The final analytical report is to be submitted to the EMB Sampling Team of the EMB Region IV hard copy and should include the following:

- o Certificate of analysis showing minimum detection limits for each analytical method.
- o Chain of Custody (COC), signed by each sampler, courier and laboratory staff receiving the samples noting the date, time, condition of samples, temperature and were applicable pH as received.
- o QA/QC reports for field sampling and all laboratory analysis reports shall include all equipment calibration records and quality control checks.

The EMB Sampling Team will prepare the report following Standard Report Form for Effluent Monitoring.

V. SAMPLING PROGRAM AND FIELD QA/QC

1. Bottle Labeling Standards

   a. Prepared prior to entering the field
   b. Indelible ink
   c. Sample Information:
      i. Sampling Point Name

ii. Date of Sampling
iii. Time of Sampling
iv. Outlet Number

For this sampling activity, sample identification is listed in Table 4, where the date is in DD-MMM-YY format:

Table 4
Sample Identification

SAMPLE IDENTIFICATION	SAMPLE LOCATION	SAMPLE BOTTLES
ABC_Outlet#1_date_time	***STP*** discharge	1 – 100 ml G(E) 3 – 1,000 ml G
ABC_Outlet#2_date_time	***WTP*** discharge	1 – 25 ml P 1 – 250 ml P 1 – 100 ml P 1 – 400 ml P 3 – 1,000 ml G
ABC_Outlet#3_date_time	Canteen wastewater at ABC storm culvert	1 – 50 ml G 1 – 250 ml P 1 – 50 ml P 2 – 1,000 ml G
ABC_Outlet#4_date_time	Guardhouse domestic waste discharging at ABC storm culvert	1 – 100 ml G(E) 3 – 1,000 ml G

2. <u>Chain of Custody</u>

The chain of custody (COC) form can be filled out prior to sampling. The specific sample ID, type of sample (i.e. effluent or influent, etc.) turnaround time of laboratory results (i.e. 24 hours TOT), date and time that the sample was collected, sample location, sample preservative & analytical tests required, must be written on the sample bottle and the COC. Every time the samples change hands, the COC must be signed. An original COC accompanies the samples to the laboratory, while a copy of the COC is retained for the EMB Sampling Team.

3. <u>Field QA/QC</u>

a. For onsite measurements, the equipment must be decontaminated prior to use.
b. A trip blank, preserved and filled by the laboratory before sampling, shall accompany every compliance monitoring activity.

Total QC sample volumes, which are in addition to the sample parameters indicated in Table 4, are indicated in Table 5.

Table 5
QC Sample Type and Required Volume

QC SAMPLE TYPE	REQUIRED QC VOLUME
Duplicate	One (1) additional set of samples for all parameters, at a single location
Trip Blank (as named by lab, or TB-01)	(At least 10% of the total number of samples per batch), 40-ml vials preserved and filled with de-ionized water by the laboratory, to accompany bottle ware from and return back to the laboratory.

4. Field Data Collection

Record the following information on the Field Data Form.

a. For onsite measurements, the equipment must be calibrated and decontaminated prior to use. Calibration report shall be included in the QA/QC report.
b. pH on-site analysis:
   i. Perform pH meter calibration before testing any samples. Record calibration data on completed field data form.
   ii. Perform and record pH data using the pH meter and pH paper.
   iii. Attach all field pH data and pH calibration records to the field data form.
c. For automated samplers, a record of calibration and maintenance shall also accompany the analytical report.
d. Select a sampling point for duplicate sample and record location in field notes.
e. A trip blank shall also accompany every regular compliance sampling activity.

5. Sampling

a. Prior to the day of sampling, the laboratory shall be notified of the project requirements. The laboratory will provide the necessary sample containers and coolers for transportation of samples from ABC to the laboratory.

b. Each sample container shall be labeled prior to sample collection. The sampling location, date and time of collection, outlet number, and testing parameter shall be identified on the label. Each bottle shall have a unique sample identification number.

c. On the day of sampling, the sample containers, the filled out COC, and all necessary personal protective equipment (PPE) shall be transported to the sampling locations.

d. Grab sampling will be done to collect the sample for effluent quality analysis. Record the pH and temperature of the sample collected. Seal all the bottles properly.

e. Once sample containers are filled, the containers shall be placed in the coolers and chilled to 4°C. The coolers are then delivered to the laboratories.

VI. LABORATORY MANAGEMENT DATA EVALUATION AND REPORTING

1. Sample Management by Laboratories

   a. Maintaining chain of custody of the samples from delivery to disposal.
   b. Temperature of the samples upon receipt written on COC (Cold Storage).
   c. Samples are to be logged into the laboratories' information management system.
   d. A signed copy of the COC showing laboratory ID number received by the EMB Sampling Team from the laboratory.
   e. Final Certified Analytical Results sent to EMB Sampling Team.

2. Data Reporting

   a. All preliminary and final reports shall include the Facility Name and sample event date.
   b. The final analytical report is to be submitted to EMB Sampling Team and should include the following:
      i Certificate of analysis showing minimum detection limits for each analytical method.
      ii Chain of Custody (COC), signed by each sampler, courier and laboratory staff receiving the samples noting the date, time, condition of samples, temperature, and pH where applicable.

VII. SAMPLING TEAM/WORKING GROUP

The undersigned, as representatives of EMB-DENR Region 4A and ABC Technology Corporation approved the conditions of this sampling plan.

Project Manager | Date
EMB-DENR Region 4A

Pollution Control Officer | Date
ABC Technology Corporation

Laboratory Manager | Date
EMB-DENR Region 4A

Control No.: ____________

FIELD DATA FORM
(Effluent Monitoring)

Sample ID: ______________________ **Station No.:** ______________________

Name of Establishment: ____

Type of Industry: ____

Location: ____

(Sitio, Barangay, Municipality, Province)

Coordinates (GPS): East: ________________ North: ____________________

Date of Sampling: ________________________ **Time:** ____________________

Name/Classification of Receiving Body of Water: ____________________

Weather Condition: ____

Visual Color of Sample: ________________ **Odor of Sample:** ________________

Estimated Flow Rate: ____

Observation of Surroundings: ____

____

On-Site Tests:

Parameter	Unit	Test 1	Test 2	Test 3	Average	Test Method
pH						
Temperature						
DO						
Conductivity						

Sample for Laboratory Analysis:

Type of Sample: ☐ Grab ☐ Composite

☐ Single Sample ☐ Duplicate ☐ Split ☐Others:

Parameter for Analysis	Sample Volume (ml)	Container Type	Sampling Method	Preservation

Sampled by: ______________________ Signature: ________________

Analyzed on-site by: ______________________ Signature: ________________

Conforme: (Company Representative): ______________________ Signature: ________________

SS/COC Control #

Attachment 5.2

SAMPLE SUBMITTAL/CHAIN OF CUSTODY FORM

Client/Facility/Source: Industrial Water Supply,	Tel: 02-988 88 88 Fax: 02-988 88 87
Project Name:	
Sampled by:	
Sampling Source:	
Submitted by:	Date mm/dd/yy — Time: ____ a.m. ____ p.m.
Special Instructions/Comments:	

Department of Environment and Natural Resources
ENVIRONMENTAL MANAGEMENT BUREAU
Research and Development Division
DENR Compound, Visayas Avenue, Diliman, Quezon City
Tel. Nos. (0632)-4264338/4339; Fax. No. (0632) 426-4335/4340

FOR LABORATORY USE ONLY

Mode of Delivery	Condition Received	Category of Sample	Payment
☐ Walk - In EMB ☐ PENRO/CENRO ☐ Courier ☐ Others ______	☐ Frozen ☐ Y ☐ N Sealed ☐ Cold ☐ Y ☐ N Container Intact ☐ Ambient ☐ Y ☐ N # of sples match COC ☐ Preserved ☐ Others, ______	☐ Private ☐ Regional ☐ Project EMB ☐ Other	OP NO: Amount:

Received by: (Signature & Printed Name) — Date: mm/dd/yy — Time: ___AM ___PM

Total # of Samples Received: ____________ — Samples Relinquished To

Lab. Sample No.	Station No./Pt.	Sample identification	Sample Type	Date/ Time Sampled mm/dd/yy	am	pm	Analyses Requested	Field Preservation	Container #	Container Type	Quantity Received
		IWSI 01	EF	**10/8/2007**	**8:30**		BOD	Ice		G (B)	
		IWSI 02	EF	**10/8/2007**	**9:00**					G (B)	
		IWSI 03	EF	**10/8/2007**	**9:30**					G (B)	
		IWSI 04	EF	**10/8/2007**	**10:00**					G (B)	

Lab Unit Concerned:

Date: mm/dd/yr — Time: ______ a.m. ______ p.m.

Name/Initial of Lab Personnel:

Remarks:

Sample Type

A (A)-ambient air A (S)- Source emission
B- Brook Creek- Creek Falls - Falls F- fishpond L-lake RW-river water SW-sea water S-spring water
C - Crustacean Fish - Fish SG- sea grass Sed - Sedimer SF - Shellfish
DW- deep well TW- treated water
IN- influent EF - effluent MW - mining waste OF- outfall WW - wastewater
QC-QC/PT sample LF- landfill SE- sewage Rain-rainwater Sludge- sludge oil- oil others ______

Container Type

Al-aluminum foil G-glass P-plastic G(B) glass borosilicate Al(S)-aluminum foil, solvent, rinsed G(E)-Glass Sterile
G(S) glass solvent rinsed G (A)or (PA)- glass or plastic, acid washed O- others, specify ______

Sample Source

- ☐ Air
- ■ Surface water
- ☐ Ground/ drinking water
- ☐ Biota/sediments
- ☐ Industries
- ☐ Other

Sample Disposal

☐ Laboratory Procedure
☐ Other procedure, specify ______
Total Quantity Disposed:
☐ ______ milliliters ☐ ______ grams

Disposed by: Date:
(Signature and Printed Name)

Other Comments:

GLOSSARY OF TERMS

Abstracted Water

Water taken from any source (groundwater or surface water) either temporarily or permanently.

Auto Sampler

A device to collect samples automatically either in proportion to the wastewater flow or as equal volumes at equal time intervals.

Biochemical Oxygen Demand (BOD)

Sometimes referred to as *Biological Oxygen Demand (BOD)*. A measure of the amount of oxygen removed (respired) from aquatic environments by aerobic microorganisms either in the water column or in the sediments. The parameter BOD uses the maximum rate of O_2 consumption over a 5 day period in the dark at 20^0 to estimate the total amount of "biodegradable" organic matter in the system. Typically too insensitive to be useful for pristine lakes and so is used primarily for wastewater "streams" or systems impacted by organic pollution.

Blank Sample

An uncontaminated sample of reagent water which is free of the target parameters and of any substance which may interfere with that analysis.

Buffer

Any of certain combinations of chemicals used to stabilize the pH values or alkalinities of solutions.

Calibration

The determination, checking, or rectifying of the graduation of any instrument giving quantitative measurements.

Chain of Custody (COC)

is defined as the unbroken trail of accountability that ensures the physical security of samples, data and records

Chamber

An enclosed space, cavity or compartment of a septic tank.

Chemical Oxygen Demand (COD)

A measure of the oxygen-consuming capacity of inorganic mater present in water or wastewater. It is expressed as an amount of oxygen consumed from a chemical oxidant in a specific test. It does not differentiate between stable and unstable organic matter and thus does not necessarily correlate with biochemical oxygen demand.

Cipoletti Weir

A contracted weir of trapezoidal shape, in which the sides of the notch are given a slope of one horizontal to four vertical to compensate as much as possible for the effect of end contractions.

Cleaner Production

The application of an integrated, preventive environmental strategy to processes, products, services to increase efficiency and reduce risks to humans and the environment.

Composite Sample

A combination of individual samples of water or wastewater taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability to the individual sample. Individual samples may have equal volume or may be roughly proportioned to the flow at the time of sampling.

Conductivity (electrical conductivity and specific conductance)

Measures water's ability to conduct an electric current and is directly related to the total dissolved salts (ions) in the water. Called EC for electrical conductivity and is reported in micromhos per centimeter (umhos/cm) which has been recently renamed as uS/cm (microSiemans per centimeter). EC is temperature sensitive and increases with increasing temperature. Most modern probes automatically correct for temperature and standardize all readings to 25°C and then refer to the data as *specific* EC.

Contamination

A general term referring to the introduction of materials not normally found in water that make the water less desirable or unfit for its intended or beneficial uses.

Contracted Weir

A rectangular notched weir with a crest width narrower than the channel across which it is installed and with vertical sides, extending above the upstream of waters as t leaves the notch.

Contraction

(1) The extent to which the cross-sectional area of a jet, nappe, or stream is decreased after passing and orifice, weir or notch.

(2) The reduction in cross-sectional area of a conduit along its longitudinal axis.

Control Section

The cross section in a waterway which is the bottleneck for a given flow and which determines the energy head required to produce the flow.

Crest

The top of a dam, dike, spillway, or weir, to which the water must rise before passing over the structure.

Critical Depth

The depth of water flowing in an open channel or partially filled conduit corresponding to one of the recognized critical velocities.

Data

Records of observations and measurements of physical facts, occurrences, and conditions, reduced to written, graphical, or tabular form.

Discharge

This includes, but not limited to the act of spilling, leaking, pumping, pouring, emitting, emptying, releasing or dumping of any liquid materials into water body or onto land form which it might flow or drain into said water body.

Dischargers

It refers to any person or persons, natural or juridical, discharging liquid wastes, and/or other wastes into the environment.

Dissolved Oxygen (DO or O_2)

The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms and the prevention of offensive odors. DO levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. Levels above 5 milligrams per liter (mg O_2/L) are considered optimal and most fish cannot survive for prolonged periods at levels below 3 mg O_2/L. Levels below 1 mg O_2/L are often referred to as *hypoxic* and when O_2 is totally absent *anoxic* (often called anaerobic which technically means *without air*). Secondary and advanced wastewater treatment systems are generally designed to degrade organic matter to ensure adequate dissolved oxygen in waste-receiving waters (from North American Lake Management Society).

Dissolved Solids

Theoretically, the anhydrous residues of the dissolved constituents in water. Actually, the term is defined by the method used in determination. In water and wastewater treatment the Standard Methods tests are used.

Effluent

These are discharges from known source which are passed into a body of water or land, or wastewater flowing out of a manufacturing plant, industrial plant including domestic, commercial and recreational facilities.

Flow Rate

The rate at which water moves by a given point; It is usually measured in cubic meters per second (m^3/sec) or cubic feet per second (cfs).

Grab Sample

A single sample of wastewater taken at neither set time nor flow.

Geographic Information System (GIS)

A computer system, which allows for input and manipulation of geographic data to allow researchers to manipulate, analyze and display the information in a map format.

Holding Time

The period of time between sample collection (e.g. end of twenty four hour time sample collection period) and initiation of sample analysis.

Hydrology

The study of water's properties, distribution and circulation on Earth.

Industrial Wastewater

This refers to any liquid waste resulting from any activity, process of industry, manufacturer or from the development, processing or recovery of any natural resources.

Industrial Waste

The liquid wastes from industrial process, as distinct from domestic or sanitary wastes.

Infiltration

Extraneous water that enters the sewer system through leaking joints, cracks and breaks, or porous walls.

Inflow

Storm water that enters the sewer system from the storm drain connections (catch basins), roof leaders, foundation and basement drains, or through manhole covers.

Inorganic Matter

Chemical Substances of mineral origin, or more correctly, not of basically carbon structure.

Mean Velocity

The average velocity of a stream flowing in a channel or conduit at a given cross section or in a given reach. It is equal to the discharge divided by the cross-sectional area of the reach. Also called the average velocity.

Open-Channel Flow

Flow of fluid with its surface exposed to the atmosphere. The open channel refers to any conduit in which liquid flows with a free surface. Included are tunnels, non-pressurized sewers, partially filled pipes, and canals.

Organic Matter

Chemical Substances of animal or vegetable origin, or more correctly, of basically carbon structure, comprising compounds consisting of hydrocarbons and their derivatives.

Orthophosphate

An acid or salt containing phosphorous as PO_4.

Parameter

A particular physical, chemical, or biological property that is being measured.

Parshall Flume

A calibrated device developed by Parshall for measuring the flow of fluid in an open conduit. It consists essentially of a contracting length, a throat, and an expanding length. At the throat is a sill over which the flow passes at critical depth. The upper and lower heads are each measured at definite distance from the sill. The lower head need not be measured unless the sill is submerged more than about 67 percent.

pH

The reciprocal of logarithm of the hydrogen ion concentration. The concentration is the weight of hydrogen ions, in grams per liter of solution. Neutral water, for example, has a pH value of 7 and hydrogen ion concentration of 10^{-7}.

Pollution Load

This refers to the amount or quantity of a pollutant parameter being discharged by the facility.

Recorder

A device that makes a graph or other automatic record of the stage, pressure, depth, velocity, or the movement or position of water controlling devices, usually as a function of time.

Rectangular Weir

A weir having a notch that is rectangular in shape.

Replicate Sample

It is an additional or second aliquot of a randomly selected sample in the analytical run.

Recording

It refers to record-keeping and documentation of information and data pertaining to sampling, analysis, QA/QC procedures, equipment maintenance and any other relevant information.

Sampler

A device used with or without flow measurement to obtain an aliquot portion of water or waste for analytical purposes. It may be designed for taking a single sample (grab), composite sample, continuous sample or periodic sample.

Significant Parameters

These are the specific parameters assigned to different types of industries for monitoring purposes.

Spiked Sample

It is a randomly selected sample in the analytical run to which known (and recorded) quantities of each target parameters have been added.

Septic Tank

A watertight receptacle which receives the discharge of the plumbing system or part thereof, and is designed to accomplish the sedimentation and digestion of the organic matter in the sewage within the period of detention/retention.

Static Head

(1) The total head without reduction for velocity head or losses; for example, the differences in the elevation of headwater and tail water of power plant.

(2) The vertical distance between the free level of the source of supple and the point of free discharge or the level of the free surface.

Steady Uniform Flow

A flow in which the velocity and the quantity of water flowing per unit remains constant.

Steady Flow

(1) A flow in which the rate or quantity of water passing a given point per unit of time remains constant.

(2) A flow in which the velocity vector does not change in either magnitude or direction with respect to time at any point or section.

Strong Wastewater

This refers to wastewater whose initial BOD value before treatment is equal to or greater than 3,000 mg/L.

Suppressed Weir

A weir with one or both sides flush with the channel or approach. This prevents contraction of the nappe adjacent to the flush side. The suppression may occur on one or both ends.

Suspended Solids

(1) Solids that either float on the surface of or are in suspension in water, wastewater, or other liquids, and which are largely removable by laboratory filtering.

(2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" referred to as non-filterable residue.

Suspended Matter

(1) Solids in suspension in water, wastewater, or effluent

(2) Solids in suspension that can be removed readily by standard filtering procedures in laboratory.

Target Parameter

This is a compound of interest to be analyzed individually or as part of an analytical test group.

Temperature

A measure of whether a substance is hot or cold.

Titration

The determination of the constituent in an unknown volume of solution by the measured addition of a solution of known strength to completion of the reaction as signaled by the observations of an end point.

Topography

Configuration of physical surface of land; includes relief imprints and locations of all man-made and natural features.

Total Dissolved Solids (TDS)

The amount of dissolved substances, such as salts or minerals, in water remaining after evaporating the water and weighing the residue.

Total Solids

The sum of dissolved and undissolved constituents on water or wastewater, usually stated in milligrams per liter.

Turbidity

(1) A condition on water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light rays.

(2) A measure of fine suspended matter in liquids.

(3) An analytical quantity usually reported in arbitrary turbidity units determined by measurements of light diffraction.

Turbulent Flow

(1) The flow of a liquid past an object such that the velocity at any fixed point in the fluid varies irregularly.

(2) A type of fluid flow in which there is an unsteady motion of the particles and the motion at a fixed varies in no definite manner. Sometimes called eddy flow, sinuous flow.

Velocity-Area Method

A method used to determine the discharge of a stream or any open channel by measuring the velocity of the flowing water at several points within the cross-section of the stream and summing up the products of these velocities and their respective fraction of the total area.

Velocity Approach

The mean velocity in a conduit immediately upstream from a weir, dam, venturi tube, or other structure.

Velocity Meter

A water meter that operates on the principle that the vanes of the wheel move at approximately the same velocity as the flowing water.

Waste Reduction/Minimization

Any in-plant activity that reduces, avoids or eliminates the generation of waste at its source.

Wastewater Survey

An investigation of the quantity and characteristics of each stream, as in an industrial plant or municipality.

Water body

Any significant accumulation of water, usually covering the Earth or another planet. The term *body of water* most often refers to large accumulations of water, such as oceans, seas, and lakes, but it may also include smaller pools of water such as ponds, puddles or wetlands. Rivers, streams, canals, and other geographical features where water moves from one place to another are not always considered bodies of water.

Weir

(1) A diversion dam.

(2) A device that has a crest and some side containment known geometric shape, such as V, trapezoid, or rectangle, and is used to measure flow of liquid. The liquid surface is exposed to the atmosphere. Flow is related to upstream height of water above the crest, to position of crest with respect to downstream water surface, and to geometry of the weir opening.

Water sample

A sample taken from one of the following sources drinking, surface, ground, storm runoff, industrial or domestic wastewater.

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