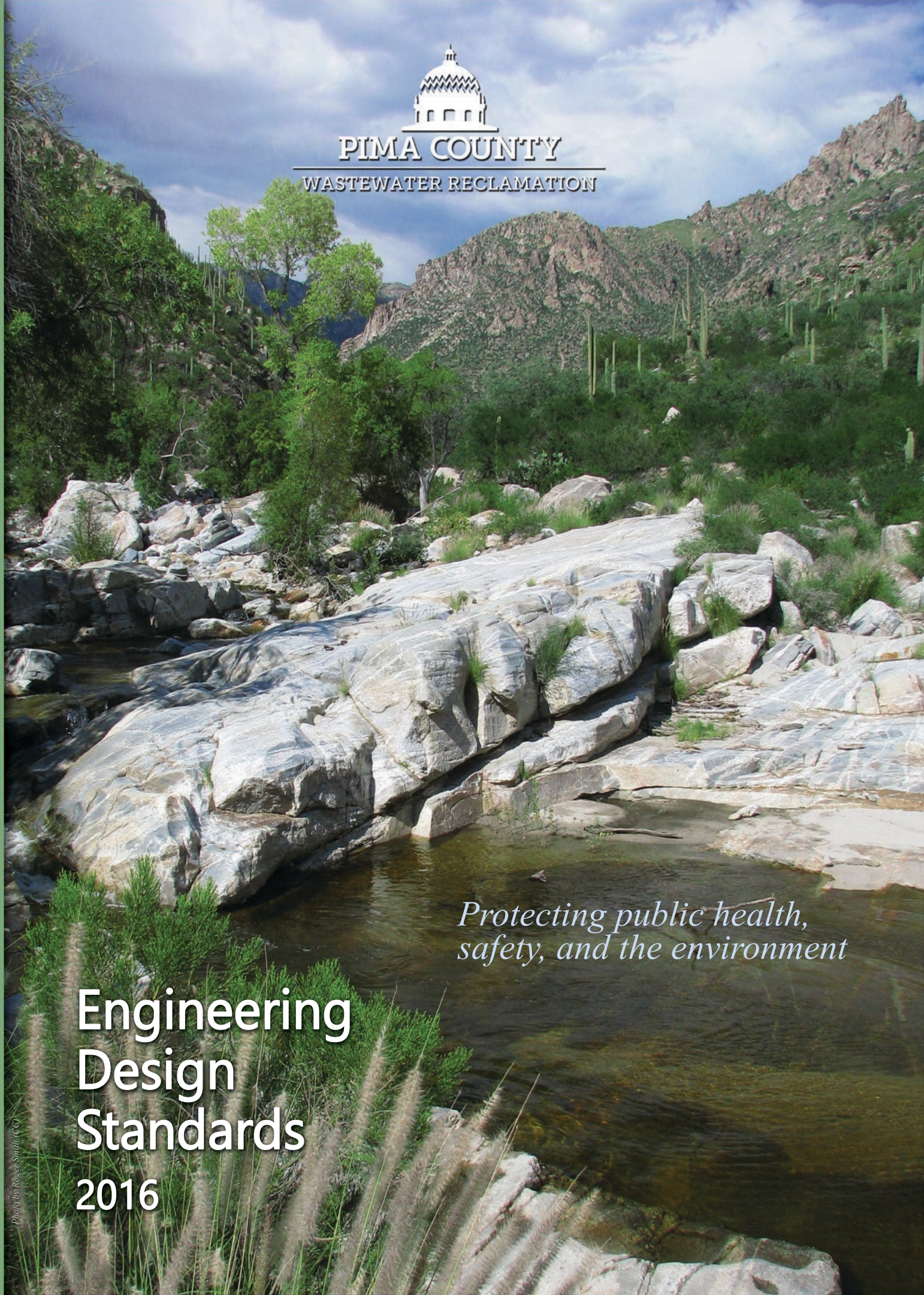


PIMA COUNTY

WASTEWATER RECLAMATION

Protecting public health, safety, and the environment

Engineering Design Standards

2016

Photo by Roger Smith (CC)

00 GENERAL CONTENTS

General Contents i
Acronyms and Abbreviations iii

01 INTRODUCTION
Table of Contents
1.1 System Overview
1.2 Pima County Wastewater Service Areas
1.3 Definitions and Terms

02 REGULATIONS, POLICIES AND PROCEDURES
Table of Contents
2.1 Regulatory Drivers
2.2 Overview of the *Design Standards*
2.3 Variances
2.4 Customer Appeals Process and the Standards Committee
2.5 Revisions
2.6 Repairs and Rehabilitation of Existing Public Sewers
2.7 Special Projects
2.8 Wastewater Reclamation Facilities
2.9 Private Sewers
2.10 Gray Water Plumbing Systems

03 PRIVATE SEWERS
Table of Contents
3.1 Overview
3.2 Classification of Public or Private Sewers
3.3 Transferring Sewers from Private to Public
3.4 Using the *Design Standards* for Private Sewers
3.5 Pre-Treatment
3.6 Private Wastewater Pumping Systems

04 UTILITY COORDINATION
Table of Contents
4.1 Process Overview
4.2 Graphical Requirements for Utility Coordination Plans

05 GRAVITY SEWER DESIGN STANDARDS
Table of Contents
5.1 Sewer Lines
5.2 Manholes and Appurtenances
5.3 Service Laterals (HCS/BCS)
5.4 Graphical Requirements for Sewer Plans

06 WASTEWATER PUMPING SYSTEMS

Table of Contents

6.1 General Classifications
6.2 Planning and Design
6.3 Capacity Phasing
6.4 Site Requirements
6.5 Pumps
6.6 Wet Wells
6.7 Manifold Piping and Appurtenances
6.8 Force Mains and Appurtenances
6.9 Odor Control Measures
6.10 Electrical and Controls
6.11 Submittals
6.12 Exceptions for Minor Wastewater Pumping Systems

07 EASEMENTS AND MAINTENANCE ACCESS

Table of Contents

7.1 Requirements for Public Sewer Easements
7.2 Conveyance of Public Sewer Easements
7.3 Temporary Construction Easements
7.4 Abandonment of Public Sewers and Easements
7.5 Maintenance Access and Encroachments within Public Sewer Easements
7.6 Maintenance Access within Right-of-Way
7.7 Landscaping and Planting Guidelines for Public Sewers

APPENDICES

A SCOUR PROCEDURES AND GUIDELINES FOR SANITARY SEWER CROSSINGS OF ALLUVIAL WATERCOURSES

B DESIGN GUIDELINES FOR SIPHONS

Acronyms and Abbreviations

Wherever the following abbreviations are used in this document, they are construed to be the same as the respective expressions represented;

Term	Description
AAC	Arizona Administrative Code
AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
ACH	Air Changes Per Hour
ACI	American Concrete Institute
ACP	Asbestos Cement Pipe
ACPA	American Concrete Pipe Association
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
ADWF	Average Dry Weather Flow
ANSI	American National Standards Institute
APP	Aquifer Protection Permit
ARS	Arizona Revised Statutes
ARV	Air Relief Valve
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AZPDES	Arizona Pollutant Discharge Elimination System
BADCT	Best Available Demonstrated Control Technology
BCS	Building Connection Sewer
BMPs	Best Management Practices
CA	Construction Authorization per R18-9-E301 – 4.01 General Permit
CCFRPM	Centrifugally Cast Fiberglass Reinforced Polymer Mortar
CCTV	Closed Circuit Television
cfs	Cubic Feet Per Second
CIP	Capital Improvement Program
CIPP	Cured in Place Pipe
CLSM	Controlled Low Strength Material
CMP	Corrugated Metal Pipe

Code	Pima County, Arizona, Code of Ordinances, specifically Title 13 – Public Services, Division II – Sewers
COT	City of Tucson
DA	Discharge Authorization per R18-9-E301 – 4.01 General Permit
dB	Decibels
Design Standards	The Pima County Regional Wastewater Reclamation Department's Engineering Design Standards 2016
dia	Diameter
DIP	Ductile Iron Pipe
DIPRA	Ductile Iron Pipe Research Association
DR	Dimension Ratio
DSD	Development Services Department
ECC	Engineer's Certificate of Completion
EPA	Environmental Protection Agency
EPDM	Ethylene Propylene Diene Monomer (rubber)
FCR	Final Compaction Report
FE	Field Engineering
Fed Spec	Federal Specifications
FEMA	Federal Emergency Management Agency
FMP	Flow Management Plan
ft	Feet
GFCI	Ground-Fault Circuit Interrupter
GIS	Geographical Information System
gpad	Gallons Per Acre Per Day
gpd	Gallons Per Day
gpm	Gallons Per Minute
HAZMAT	Hazardous Material
HCS	House Connection Sewer
HDPE	High Density Polyethylene
HMI	Human Machine Interface
HOA	Home Owners Association
Hz	Hertz
IBC	International Building Code
IMS	Infrastructure Management System (Hansen Asset Management Program)

in	Inch or Inches
IPC	International Plumbing Code
I&I	Infiltration and Inflow
LF	Linear Foot
max	Maximum
mgd	Million Gallons Per Day
MH	Manhole
min	Minimum
mil	1/1,000 of an Inch
mV	Millivolt
NASSCO	National Association of Sewer Service Companies
NCPI	National Clay Pipe Institute
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
ORP	Oxidation/Reduction Potential
OSHA	Occupational Safety and Health Administration
PAG	Pima Association of Governments
PCDSD	Pima County Development Services Department
PCRWRD	Pima County Regional Wastewater Reclamation Department
PDEQ	Pima County Department of Environmental Quality
PDWF	Peak Dry Weather Flow
P.E.	Professional Engineer
PE	Polyethylene (PE)
PF	Peaking Factor
PMOC	Point and Method of Connection
PPI	Plastics Pipe Institute
psi	Pounds Per Square Inch
PUE	Public Utilities Easement

PVC	Polyvinyl Chloride
PVCPA	The PVC Pipe Association
PWWF	Peak Wet Weather Flow
RAP	Recycled Asphalt Product
RCP	Reinforced Concrete Pipe
rpm	Revolutions Per Minute
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SDR	Standard Dimension Ratio
S.D.	Standard Detail
S.S.D.	Special Standard Detail
S.S.	Stainless Steel
sf	Square Foot
SPCS	State Plane Coordinate System
SSO	Sanitary Sewer Overflow
Standard Specifications and Details	The Pima County Regional Wastewater Reclamation Department's Standard Specifications and Details 2016
SWPPP	Storm Water Pollution Prevention Plan
TDH	Total Dynamic Head
UC	Utility Coordination
UBC	Uniform Building Code
v	Velocity
VCP	Vitrified Clay Pipe
WSS	Welded Steel Sewer

PIMA COUNTY
WASTEWATER RECLAMATION

SECTION 1
INTRODUCTION

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

1.1 System Overview 1-1

1.2 Pima County Wastewater Service Areas.....1-2

1.3 Definitions and Terms 1-3

1.3.1 Interpretation of Terms.....1-7

1.3.3 Titles and Headings 1-7

1.3.4 Capitalization of Defined Terms 1-7

Section 01

Introduction

1.1 System Overview

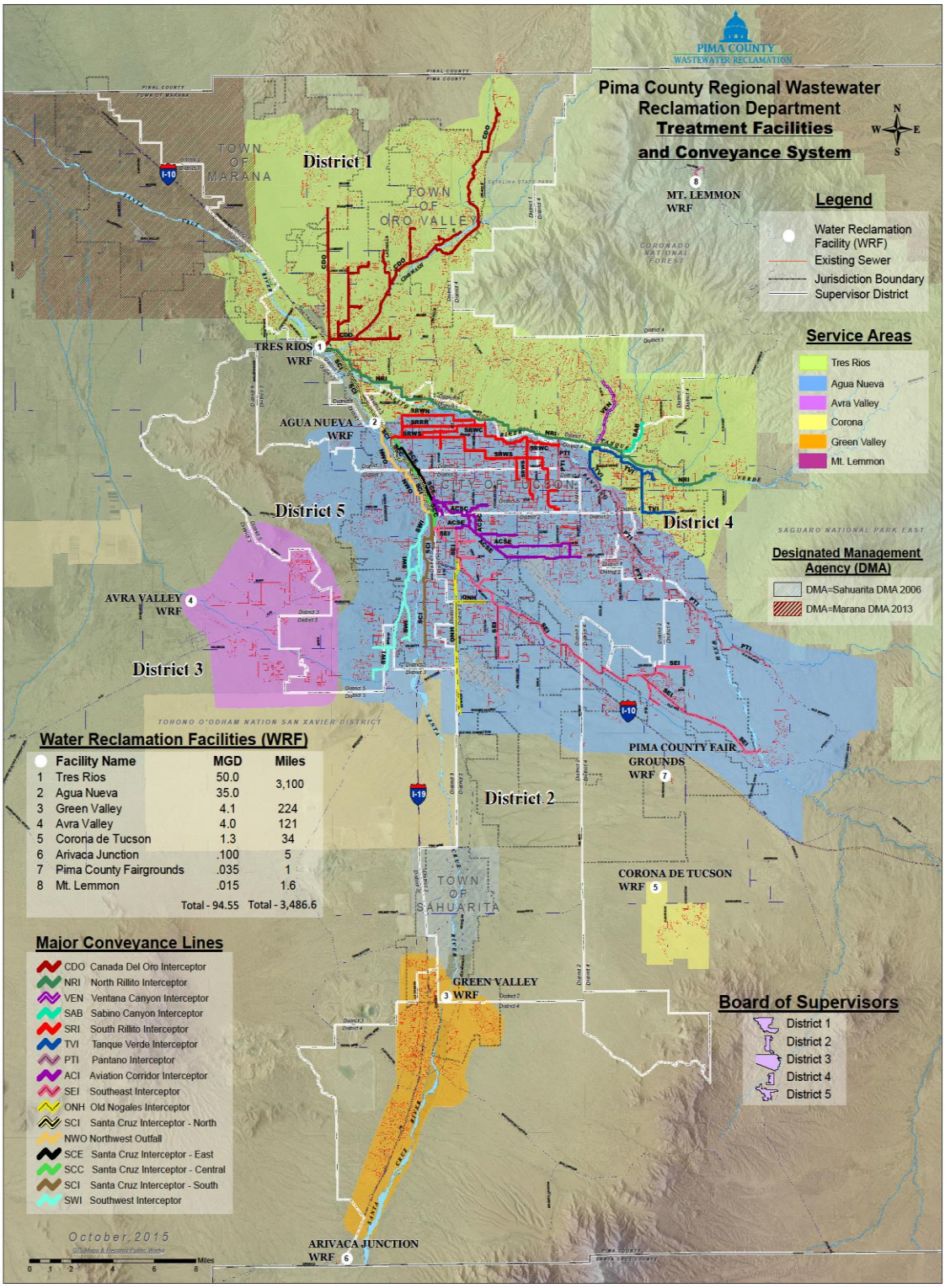
The public sanitary sewer system of Pima County presently collects more than 70 mgd throughout the County's 370 square mile service area. The service area includes the Cities of Tucson and South Tucson; neighboring towns of Marana, Oro Valley and Sahuarita; and unincorporated communities, such as Summerhaven (Mt. Lemmon), Arivaca Junction, Avra Valley, Green Valley, Corona de Tucson and Catalina. See Subsection 1.2 for a general map of Pima County's sanitary sewer service areas.

Pima County operates and maintains a conveyance system comprised of more than 3,300 miles of sanitary sewer lines, ranging in diameter from 6 to 78 inches. The existing sewer lines were built using various pipe materials, including reinforced concrete, asbestos cement, cast iron, ductile iron, glazed clay tile, vitrified clay, polyvinyl chloride, high density polyethylene and fiberglass reinforced. The conveyance system also consists of approximately 74,000 system features, including manholes, cleanouts and diversion structures. Other conveyance facilities include wastewater pumping systems, siphon facilities, metering equipment and odor control units.

Pima County also operates and maintains eight wastewater reclamation facilities, varying in capacity ranging from 0.009 mgd to 50 mgd. The major metropolitan facilities are Agua Nueva, and Tres Rios. The six outlying facilities are Green Valley, Pima County Fairgrounds, Avra Valley, Corona de Tucson, Arivaca Junction, and Mt. Lemmon. Wastewater reclamation processes include Bardenpho, oxidation ditches with and without nutrient removal, and Facultative Lagoons with and without mechanical aeration.

The public sanitary sewer system of Pima County dates from 1900, when the City of Tucson purchased the Tucson Water Company for $110,000. The city's water and sewer department was created in August 1900. The area's first wastewater treatment facility was placed into service in 1928. Pima County Sanitation District #1 was formed to address the sanitary sewer needs of Pima County residents living outside the Tucson city limits. In 1978, the Pima County Department of Sanitation was renamed the Pima County Wastewater Management Department and assumed responsibility for the operation of all the region's public sanitary sewer facilities. The Pima County Wastewater Management Department was renamed the Pima County Regional Wastewater Reclamation Department (RWRD) in 2007. In 2012 RWRD completed major upgrades to the Ina Road facility (renamed Tres Rios) and constructed the Agua Nueva facility which allowed the department to close the aging Roger Road facility.

1.2 Pima County Wastewater Service Areas



1.3 Definitions and Terms

Whenever the following terms are used in this document, the intent and meaning shall be interpreted as described in this subsection. Where there is a conflict between these definitions and those in the AAC and ARS, the AAC and ARS definitions shall apply for persons seeking a Discharge Authorization under a Type 4.01 General Permit.

100-Year Flood – A flood event that statistically has a 1 out of 100 (or one percent) chance of being equaled or exceeded on a specific watercourse in any given year.

Accept or Acceptance – Written notice from the Director or his/her authorized representative agreeing to the concept presented in the plans, studies or reports, and required as part of a review process.

Affidavit of Cost – Documentation of final construction costs.

Agency – The jurisdictional body for whom the construction is being done, either by Permit or Contract.

Aggregate – Inert material such as sand, gravel, broken stone, crushed stone, or a combination thereof.

Applicant – The owner or a representative of the owner of the property or unit requesting connection to the Public Sewer.

Approve or Approval – Written authorization from the Department for a submittal when it has been determined that it meets a County standard.

As-Built Plans or As-Builts – An annotated copy of the Sewer Plans providing the exact final location and layout of Public Sewer facilities, their positional verification and records that include deviations to the design.

Augmentation – The construction of sanitary sewer facilities adjacent to or in replacement of existing Public Sewer facilities for the purpose of increasing flow capacity.

Backfill – The material used to fill a trench from the top of shading to subgrade or finished grade.

Bedding – The material placed at the bottom of a trench and used to support the pipe prior to the placement of Shading and Backfill.

Bill of Sale – A written instrument showing the voluntary transfer of a right, interest, or title to personal property, either by way of security or absolutely, from one person to another without the actual physical possession of the property leaving the owner or being delivered to the other party.

Block-Out – An object, material or combination thereof used to fill the pipe opening and flow channel within the base of a manhole that facilitates for future removal and connection with a new pipe.

Building Connection Sewer (BCS) – The private sanitary sewer line between the commercial or industrial building and its connection to the Collection Sewer.

Calendar Day – Any day shown on the calendar, beginning at midnight, extending for a 24 hour period, and ending at midnight.

Cathodic Protection – A method for protecting metallic materials from damage caused by corrosive soils.

Code – Pima County, Arizona, Code of Ordinances; more specifically, Title 13 – Public Services, Division II – Sewers that includes ordinances governing wastewater management.

Collector or Collection Sewer – A sanitary sewer line that receives Wastewater from two or more Service Laterals.

Construction Acceptance – The Acceptance, by the Department, for the transfer of newly constructed or modified sanitary sewer assets to the Department.

Construction Permit – Written authorization from the Department to allow construction, modification or connection to Public Sewer facilities in accordance with the Sewer Plans. Also see Observation Permit.

Contractor – The individual, partnership, firm, corporation, or any acceptable combination thereof that is responsible for the construction of the Project in accordance with the Sewer Plans and Construction Permit.

Cover – The vertical distance from the top of a buried pipe to finished grade.

Crown – In a transverse cross section of pipe, the highest point of elevation on the interior surface.

d/D – Ratio of flow depth (d) to pipe diameter (D).

Day – Unless otherwise designated, day shall be understood to mean a Calendar Day.

Deficiency – Departure from, or noncompliance with, specified criteria.

Department – The Pima County Regional Wastewater Reclamation Department.

Design Drawings – The Sewer Plans prior to their Acceptance by the Department. Also see Sewer Plans.

Design Engineer – The Professional Engineer sealing the Design Drawings for a Project or design staff performing duties under his/her direct supervision.

Design Report – A document providing the supporting calculations, analysis, data, criteria and other material for a proposed special sewer facility. Also see Sewer Design Report.

Developer – One or more individuals or incorporated entities that desires to convert land from its present use to another.

Development – Any man-made improvement (change) to real property including but not limited to: buildings or structures, fencing, paving, grading, filling, excavation, trenching dredging mining, drilling, or storage of equipment or materials.

Director – The Director of the Department or his/her delegate.

Drop Manhole – A manhole having an inlet pipe connection that is located above the bench.

Engineering Directive – The process used by the Department to clarify and improve the design and construction standards and details for Public Sewer facilities.

Excavation – Any man-made cut, cavity, trench, or depression in the earth's surface formed by earth removal.

Field Engineer – The Sanitary Engineering Manager's authorized representative assigned to make detailed inspections for the construction or modification of Public Sewer facilities.

Flow Through –That part of a Public Sewer intended for receiving existing or future Wastewater originating from outside a development or municipality and not from inside a development or municipality.

Force Main – A pressurized sanitary sewer discharge line extending from a Pump Station having a horizontal length greater than 10-feet.

Full Flow – A ratio of 1.0 d/D, where d is the hydraulic grade line of Wastewater flow in the pipe and D is the inside diameter of the pipe.

Geotechnical Engineer – An Arizona-Registered Professional Engineer (Civil) responsible for project soils characterization and construction backfill compaction quality control testing and certifications.

Grey Water – Residential wastewater collected separately that originates from clothes washers, bathtubs, showers and sinks. Grey water excludes wastewater from kitchen sinks, dishwashers and toilets.

Haunch – That portion of a pipe barrel extending from the bottom to the springline.

Holiday – (1) A legal holiday pursuant to A.R.S. 1-301, as amended. (2) Microscopic holes in liners and coatings detected by a Holiday Test.

Holiday Test – Electrical testing used to determine the presence and number of discontinuities in a coating film performed on a nonconductive coating applied to an electrically conductive surface in accordance with ASTM D5162 standards.

House Connection Sewer (HCS) – The private sanitary sewer line between the residence or building connection and its connection to the Collection Sewer.

Inspector – See Field Engineer.

Interceptor Sewer – A sanitary sewer line that receives Wastewater from a number of collector and trunk sewers.

Invert – In a transverse cross section of pipe, the lowest point of elevation on the interior surface.

Jetting – A soil compaction technique that forces pressurized water into the bedding or backfill material in order to saturate it and force the air out. Also referred to as flooding.

Lift Station – A sanitary sewer facility that pumps Wastewater to a higher elevation without the need for a Force Main. Also see Pump Station.

Observation Permit – Written authorization from the Department to allow access into Public Sewer manholes. Also see Construction Permit.

Over-sizing – The increase in capacity of sanitary sewer facilities to provide capacity for future flow from within or beyond the proposed design boundaries of a Project.

Permit – See Construction Permit and Observation Permit.

Pressure Sewer – See Force Main.

Project – The specific, coordinated design, construction or similar undertaking identified by a single Project number.

Public Sewer – The sanitary sewer assets of Pima County, specifically for the conveyance of Wastewater.

Pump Station – A sanitary sewer facility that pumps Wastewater to a higher elevation and requires the use of a Force Main. Also see Lift Station.

Record Drawings – See As-Built Plans.

Right-of-Way – A general term, denoting a strip of land, property or interest therein, acquired for or dedicated to transportation and other public works purposes.

Sanitary Sewage – See Wastewater.

Scour – A computed value for the potential depth that material, from the bed and banks of a Wash, will be removed due to the flow of water during a 100-year flood event.

Service Lateral – The private sanitary sewer line between a residential, commercial, or industrial building and its connection to the Collection Sewer. Also see House Connection Sewer and Building Connection Sewer.

Sewer Basin – All portions of the sanitary sewer collection system tributary to a common point such as a connection to an interceptor sewer or pump station. By definition, the sewers within a Sewer Basin are hydraulically linked.

Sewer Design Report – Documentation of the design flows for Public Sewers and the basis for calculating the design flows, in accordance with AAC R18-9-E301(C). Also see Design Report.

Sewer Plans – The Project's official construction documents, or reproductions thereof, Accepted by the Department, that show the location, character, dimensions and details for the extension, augmentation or modification of Public Sewers. These documents may include, however not limited to, public sewer improvement plans, development plans or public sewer modification plans. Also see Design Drawings.

Shading – The material that extends from the top of the Bedding to one foot (typically) above the top of pipe.

Siphon or Inverted Siphon – A sanitary sewer conveyance facility used to convey Wastewater underneath an obstruction, such as a Wash or drainage culvert, without pumping.

Special Approval – Written authorization from the Director or his/her delegate on a case-by-case basis, to proceed with the design of a specific concept for Public Sewers that is typically not Accepted by the Department.

Special Provisions – Additions and revisions to the *Standard Specifications and Details*, specifically Section 3, covering conditions and requirements peculiar to on individual project.

Springline – In a transverse cross section of pipe, the line of maximum horizontal dimension.

Storm Drain – A conduit or system of conduits that convey stormwater runoff, street drainage, and other wash waters or drainage but excludes Wastewater.

Stub-Out – An upstream length of pipe installed at a sanitary sewer manhole that is intended for future connection.

Trench – A narrow excavation for the installation of sanitary sewer facilities or other utilities.

Trunk Sewer – A sanitary sewer line that receives Wastewater from many Collector Sewers.

Variance – A waiver, issued in writing by the Department's Sanitary Engineering Manager, granting a one-time deviation from a specific design or construction standard for unique circumstances where full compliance is not realistically feasible.

Wash – A dry creek bed or gulch that temporarily fills with water after a heavy rain; an arroyo or an alluvial watercourse.

Wastewater – The wastes from toilets, baths, sinks, lavatories, laundries, drains, and other plumbing fixtures in residences, mobile homes, institutions, public and business buildings, industrial wastewaters and other places of human habitation, employment, or recreation.

Work – All labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of Public Sewer construction and the carrying out of all the duties and obligations required by the Sewer Plans.

Working Day – Any Day, other than Saturday, Sunday or a Holiday, on which legal business can be conducted by Pima County.

1.3.1 Interpretation of Terms

When not inconsistent with the context, words used in the present tense include the future, words in the singular number include the plural, and words in the plural number include the singular.

1.3.2 Titles and Headings

The titles or headings of sections and subsections are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

1.3.3 Capitalization of Defined Terms

Defined terms within this document are capitalized. The Director reserves the right to interpret words or phrases listed in Subsection 1.3 - Definitions and Terms, where the context warrants.

PIMA COUNTY
WASTEWATER RECLAMATION

SECTION 2
REGULATIONS, POLICIES AND PROCEDURES

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

2.1 Regulatory Drivers 1
2.1.1 State Regulations 1
2.1.2 County Regulations 1
2.2 Overview of the *Design Standards* 1
2.3 Variances 2
2.3.1 Requests for Design Variances 2
2.3.2 Variance Criteria 3
2.3.3 Variance Actions 3
2.4 Customer Appeals Process and the Standards Committee 3
2.5 Revisions 4
2.6 Repairs and Rehabilitation of Existing Public Sewers 5
2.7 Special Projects 5
2.8 Wastewater Reclamation Facilities 6
2.9 Private Sewers 6
2.10 Gray Water Plumbing Systems 6

Section
02

Regulations, Policies and Procedures

2.1 Regulatory Drivers

2.1.1 State Regulations

The Pima County Department of Environmental Quality (PDEQ), through a delegation agreement with the Arizona Department of Environmental Quality (ADEQ), has the authority to review the design of new sanitary sewer facilities for subsequent issuance of a Construction Authorization (CA). When construction is complete, ADEQ receives the Engineer's Certificate of Completion (ECC) and Record Drawings for review and issuance of the Discharge Authorization (DA).

The Applicant is responsible for complying with all State regulations and requirements. Arizona Administrative Code (AAC) contains specific requirements for sanitary sewer facilities:

- AAC, Title 18 – Environmental Quality, Chapter 5 – Environmental Review and Certification;
- AAC, Title 18 – Environmental Quality, Chapter 9 – Water Pollution Control;
- AAC R18-9-101 through R18-9-403 and A.R.S. §§ 49-241 through 49-252 for statutes and rules related to the 1.11 General Aquifer Protection Permit.

When under AAC 4.01 general permit, it is the responsibility of the design engineer to process sewer submittals. The design engineer shall be responsible for making any required submittals to ADEQ or delegated authority. The design engineer and their client should never assume that RWRD is responsible for processing approvals from ADEQ.

2.1.2 County Regulations

The Applicant is also responsible for complying with the Pima County, Arizona, Code of Ordinances, Title 13 – Public Services, Divisions II – Sewers and Division III – Industrial Waste (Code). The Code establishes the general requirements and procedures for the planning, design, construction and modification of Public Sewer facilities. If a specific design requirement in the Code is more stringent than the AAC, the Code shall supersede the AAC.

2.2 Overview of the *Design Standards*

The *Design Standards* for Public Sewers in Pima County have three primary goals:

- To attain a 100-year Service Life for sanitary sewer conveyance facilities prior to rehabilitation or replacement;
- To access and maintain sanitary sewer conveyance facilities in a cost-effective manner; and

- To keep roots, grease and other obstructions out of sanitary sewer conveyance facilities.

The *Design Standards* are intended to provide specific and technical details that meet or exceed State and County regulations. These standards provide the minimum criteria for the design of Public Sewer conveyance facilities in Pima County. It is not intended that these standards be blindly applied in every application. There may be strong technical reasons why a particular standard is not appropriate for a given situation. In unique circumstances, creative engineering design, based on sound engineering principles, may meet the intent of the State and County regulations. Where necessary, either Special Approval or a design Variance, may be appropriate.

2.3 Variances

In some cases, strict compliance with the *Design Standards* may not be feasible and a Variance may be appropriate. In these cases, the Sanitary Engineering Manager of the Department may grant or deny a request for a Variance. It is the responsibility of the Sanitary Engineering Manager to administer, coordinate and execute the Variance process in coordination with the Department's plan reviewers.

A Variance may be considered either during the development of the construction documents or during the progress of construction, and limited to any of the following circumstances:

- Design slopes less than the standard minimums would eliminate the need for a pump station;
- A substitution for, or change in a standard material, results in the use of a material which can be clearly demonstrated to be of equal or superior quality;
- A strict adherence to standard specifications would be impractical or impossible because of an existing field conflict or other condition; or
- An emergency situation prohibits strict adherence to preliminary sewer layout requirements or standard specifications.

For other deviations from the *Design Standards* that do not fit any of these circumstances or for certain design concepts specified in the *Design Standards*, Special Approval shall be required and will be made by the Director or his/her delegate.

2.3.1 Requests for Design Variances

Requests for design Variances shall be submitted through the Development Liaison group for administrative processing. The Variance request shall be in a letter format and include the following elements:

- A reference to the specific standard(s) from which a Variance is being requested;

- A detailed explanation of how an extraordinary and unnecessary hardship or unusual topographic or other pre-existing physical condition of the land does not make strict adherence to the specific standard(s) feasible; and
- Any additional documentation and background information that may be helpful in assessing the request.

2.3.2 Variance Criteria

The Sanitary Engineering Manager may Approve a Variance request if all of the following criteria are met:

- The Variance does not violate State and County regulations;
- Strict application of the specific standard(s) would create an extraordinary and unnecessary hardship because of unique site conditions. The hardship shall not arise from a condition created by an action of the property owner;
- The Variance request meets the general intent and purpose of the *Design Standards*;
- The Variance will not adversely affect the rights of surrounding property owners and residents;
- The Variance will not compromise safety of the public and O&M staff;
- The Variance will not adversely impact the operation and maintenance of the system.

The Sanitary Engineering Manager shall not Approve a Variance request if any of the following conditions apply:

- Approval would solely increase economic return from the property;
- Approval would resolve the violation of a construction permit;
- Approval would resolve a misinterpretation or error in the design; or
- Approval has not been granted for comparable variances in the past.

2.3.3 Variance Actions

The Sanitary Engineering Manager will review the Variance request, and will, at his/her sole discretion, Approve or deny it. The Sanitary Engineering Manager may include conditions to an Approved Variance request if they are deemed reasonable and necessary to preserve the integrity of the Public Sewer and to ensure that the general purposes and intent of the *Design Standards* are preserved. The Sanitary Engineering Manager will notify the Applicant of the decision within 5 Working Days from the date the Variance request was received.

2.4 Customer Appeals Process and the Standards Committee

The Department has established a Standards Committee to review and address the following types of customer appeals:

- Denied Variance requests;
- Denied sewer construction permits; and

- Other issues escalated during the design-review process.

Members of the Standards Committee shall have knowledge and experience in the design and/or construction of sanitary sewers and be appointed by the Director. Each member will serve a term at the discretion of the Director. The Standards Committee will be comprised of the following members:

- The Sanitary Engineering Manager (committee chair/voting member);
- A representative from the Field Engineering group of the Department (voting member);
- A representative from the Conveyance Division (voting member);
- Two stakeholders of the construction and engineering profession (voting members); and
- One representative from the Development Liaison group of the Department (non-voting member).

A request for a review by the Standards Committee shall be submitted in writing directly to the Sanitary Engineering Manager. It is the responsibility of the Sanitary Engineering Manager to coordinate and schedule the activities of the Standards Committee. The Standards Committee will meet as necessary to conduct business, but not more frequently than twice per month. At least four voting members must be present for the Standards Committee to conduct business.

Customer appeals will be discussed and voted upon during the Standards Committee meeting. The Sanitary Engineering Manager will make a recommendation to the Director based on the results of the meeting. The Director shall be the final authority on all customer appeals and will Approve or deny the customer appeal request within 5 Working Days following the date of the meeting.

2.5 Revisions

The Sanitary Engineering Manager will be responsible for monitoring revisions to the *Design Standards* and to the *Standard Specifications and Details* to ensure that the standards:

- Are consistent with current and accepted engineering practices;
- Do not impose extraordinary burdens for typical development and improvement projects; and
- Do not conflict with Code, AAC or the public's interest.

When a specific standard requires immediate attention for clarification or improvement, the Sanitary Engineering Manager will make a request to the Standards Committee for review and Approval of an Engineering Directive. An Engineering Directive is a separate document that describes new standards, or modifications, until such revisions can be incorporated in the *Design Standards* or the *Standard Specifications and Details*. Any errors to the current standards should be brought to the attention of the Sanitary Engineering Manager, in writing.

The Department will keep users of the *Design Standards* informed of future updates through its website. Hard copy (printed) revisions will not be distributed. It is the holder's responsibility to keep the document current by periodically checking the Department's website for updates.

2.6 Repairs and Rehabilitation of Existing Public Sewers

Pursuant to AAC R18-9-E301(H), the repair and/or rehabilitation of any existing Public Sewer facility is not considered an extension, upsizing or realignment that requires a notice of intent to discharge from ADEQ. Repair and/or rehabilitation includes work performed in response to the deterioration of existing sanitary sewer facilities with the intent to maintain or restore the system to its original operational characteristics.

2.7 Special Projects

Pursuant to Code, specifically 13.24.035, projects involving the design and construction of special facilities by another governmental entity or private developer shall be considered as Special Projects. Special Projects are not to be included with the Capital Improvements Program (CIP) of the Department. Special Projects shall include, but are not limited to:

- Oversized Public Sewer facilities (sewer lines with diameters greater than 18 inches);
- Public wastewater pumping systems;
- Public wastewater reclamation facilities; and
- Expansions of existing public wastewater reclamation facilities.

The Department may impose the following additional requirements for Special Projects:

- The Department reserves the right to participate in and/or to approve (in advance) the selection of the qualified design engineer/consultant being retained by the Developer to design the facility. In certain instances, a special agreement between the developer and the Department may supersede this requirement; and
- A pre-design meeting shall be held in order to clarify the design issues/considerations, that may be unique to the Special Project.

The Department may also require the Developer, as the specific case dictates, to be responsible for completing any or all of the following tasks:

- Amending the Regional 208 Water Quality Plan;
- Developing an acceptable facility plan for the new sewer facility;
- Developing an approved method/means for disposal of the treated effluent and/or solids generated by the facility; and
- Attending any required public meetings and/or hearings and answering all questions related to the design/integrity of the proposed facility.

Where applicable, the design of Special Projects shall conform to the requirements of AAC R18-9-E301.

2.8 Wastewater Reclamation Facilities

The design of Wastewater Reclamation Facilities is unique unto its intended location, ownership and purpose. Specific requirements and criteria will be established between the Department and the Design Engineer prior to the start of any design effort.

The design of Wastewater Reclamation Facilities and selection of treatment processes and/or components will be based on:

- Compliance with all applicable regulatory standards;
- The ability to meet the projected capacity needs;
- Maximum reliability;
- Construction and operating costs; and
- Best Available Demonstrated Control Technology (BADCT).

2.9 Private Sewers

The Department encourages residential developments, in general, to be served by Public Sewers. The use of private sanitary sewers must be Approved by the Director of the Department or his/her delegate.

In accordance with Code, specifically 13.20.035, private sanitary sewers may connect to Public Sewers only at a location and in a manner approved by the Department. Private sanitary sewers shall be designed and constructed in accordance with AAC R18-5 – Environmental Reviews and Certification and AAC R18-9 – Water Pollution Control and applicable adopted plumbing code (see Section 4 for more information).

2.10 Gray Water Plumbing Systems

Effective June 1, 2010, the City of Tucson and the Town of Oro Valley require Gray Water plumbing in all new residential homes. Developments that utilize Gray Water systems may result in reduced wastewater flows, particularly in terminal sewer reaches. In order to maintain self-cleansing sewer velocities, the Department reserves the right to modify the *Design Standards* for new developments that may utilize Gray Water systems on a case-by-case basis.

PIMA COUNTY
WASTEWATER RECLAMATION

SECTION 3
PRIVATE SEWERS

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

3.1 Overview 1

3.2 Classification of Public or Private Sewers 1

3.3 Transferring Sewers from Private to Public 1

3.4 Using the *Design Standards* for Private Sewers 2

3.5 Pre-Treatment 2

3.6 Private Wastewater Pumping Systems 2

Section 03

Private Sewers

3.1 Overview

Private sewers are privately-owned sanitary sewer facilities that are operated and maintained at the expense of the property owner or homeowners' association they serve. Private sewers are located within private property and private streets without Right-of-Way or Public Sewer easements. Service Laterals (HCS/BCS) are also considered to be private sewers, even when located within Right-of-Way or a Public Sewer easement.

The connection of private sewers to the Pubic sewer system and associated fees for service are regulated under Code, specifically 13.20.40. The Department must review the plans and/or documentation that provide the location and method of connection, which are also used to determine the required connection fees.

3.2 Classification of Public or Private Sewers

The appropriate classification (public or private) for new sanitary sewer facilities will be made by the Director during the planning/subdivision review process. It is recommended that the Applicant meet with the Development Liason group of the Department to discuss the new development and project details early in the planning phase.

The Department encourages residential developments, in general, to be served by Public Sewers that conform to the Department's latest design and construction standards. The Department encourages commercial developments, in general, to be served by on-site private sewers that conform to the applicable AAC R18-9-E301 or building/plumbing codes. However, if a flow-through sewer is necessary to service adjacent parcels, the Department will require the design and construction of Public Sewers, with appropriate Public Sewer easements, for the new development.

3.3 Transferring Sewers from Private to Public

Any proposal to convert an existing private sewer to a Public Sewer shall conform to the requirements of AAC R18-9-A304(B) and requires Approval from the Director. For the Department to allow a private sewer to transfer to Public Sewer, a compelling justification must be made to accept such assets and maintenance responsibilities. For the Department to consider such a proposal, sufficient documentation shall be provided that the private sewer was designed and constructed in accordance with the *Design Standards* and that all necessary Public Sewer easements for maintenance vehicle access were dedicated.

3.4 Using the *Design Standards* for Private Sewers

The plans (construction documents) for private sewers shall be forwarded by the applicable building codes Agency to the Department for a conformance review when it is intended to transfer such facilities to public in the future. The Department will conduct a review to determine if the private sewer was designed in accordance with the *Design Standards*. This review must occur prior to issuance of the building permit by the local Agency having jurisdiction. If the review indicates conformance with the *Design Standards*, construction of the private sewer shall be inspected by the Department and As-built Plans furnished when available.

3.5 Pre-Treatment

Pursuant to Code, specifically 13.36, commercial facilities, such as metal finishers, car washes, auto repair shops, photo developers, military facilities and hospitals, that discharge regulated wastes into the sewers must have industrial discharge permits. The Pima County Development Services Department and the Industrial Wastewater Control Section will determine on a case-by-case basis if a new commercial development will require such a permit. The user shall comply with all applicable codes and regulations, whether or not contained in the permit.

3.6 Private Wastewater Pumping Systems

Private wastewater pumping systems shall be designed and operated in accordance with the latest wastewater industry standards and best management practices to prevent negative impacts to downstream Public Sewers and to the community. PDEQ is the regulating authority for private pump stations per AAC R-18-9-E301 – 4.01 General Permit.

It shall be the responsibility of the Design Engineer to recommend best management practices for odor control with the design of private wastewater pumping systems. A statement such as the following shall be included with the plans for private wastewater pumping systems:

"A Best Management Practice for Odor Control Systems may be installed at some time in the future if the installed wastewater pumping system is found to cause odor problems".

Pursuant to Code, specifically 13.20.035 and 13.20.40, the location and method of connection for private wastewater pumping systems to Public Sewers shall conform to the following requirements:

- The manhole where a private force main discharges into shall be private;
- A private gravity sewer line shall be used to connect the private discharge manhole to a Public Sewer manhole, per S.D. RWRD-300 or -301; and
- For an individual residence or a commercial establishment, with average wastewater flows less than 3,000 gpd and no manhole connection to the Public Sewer, the private force main shall connect to the service lateral (HCS/BCS) at the property line.

PIMA COUNTY
WASTEWATER RECLAMATION

SECTION 4
UTILITY COORDINATION

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

4.1 Process Overview 1

4.1.1 Submittal Requirements 1

4.1.2 Conformance Review Process 2

4.2 Graphical Requirements for Utility Coordination Plans 3

4.2.1 Landscape, Planting and Irrigation Plans 3

4.2.2 Stormwater Drainage Plans 4

4.2.3 Street Lighting and Signage Plans 4

4.2.4 Water and Reclaimed Water Plans 4

4.2.5 Sewer Modification Plans 4

Section 04

Utility Coordination

4.1 Process Overview

The plans (construction documents) for any public utility or public improvement project that is located within Right-of-Way, shall be submitted as early as possible to the Department's Utility Coordination (UC) group, where existing Public Sewers are located within the project's limits of construction. The plans, will be reviewed for conformance with the Department's standards for design and maintenance access as they relate to existing Public Sewers. Upon Acceptance of the 100%-sealed plan submittal, the Department will issue a Letter of Clearance. The Letter of Clearance is required prior to the issuance of a sewer Construction Permit by the Department if Public Sewer construction is required. The Letter of Clearance is valid for two years from the date that it is issued.

The UC group will review the plans for such projects to ensure design conformance with:

- Arizona Administrative Code Title 18, Chapter 9;
- Pima County, Arizona, Code of Ordinances Title 13 – Public Services Division II, Sewers;
- The *Design Standards*; and
- The *Standard Specifications and Details*.

4.1.1 Submittal Requirements

The typical requirements for a complete first submittal to the UC group are described in the following:

- A transmittal sheet identifying the Project Manager(s) and contact information. All submittals from City of Tucson Engineering Division must be submitted through the City of Tucson's utility coordinator. For all other jurisdictions, the Design Engineer may submit directly; however, a Letter from the jurisdiction's Project Manager must authorize their Design Engineer to submit construction documents directly to the UC group.
- 3 full sets of black line plans with a minimum scale of 1 inch = 40 feet.
- 1 set of Special Provisions. If there are no Special Provisions for the project, please identify this fact on the transmittal sheet.
- 1 itemized cost estimate. Either a cost estimate shall be provided at a 75% or greater submittal or a statement shall be provided on the transmittal sheet stating that the Department will not be financially responsible for this project.
- 1 cd-pdf containing a full set of plans as well as copies of all other documentation being provided.

The UC group may request additional information to be included with the submittal, depending on the complexity of the project. The requirements for subsequent

submittals for each project may vary. Incomplete submittals will be rejected and the owner will be notified in a timely manner.

Submittals should be processed by the project owner, typically a public agency or public utility company. Direct submittals by the Design Engineer, on behalf of the project owner, shall include written authorization for that submittal by the owner.

For projects impacting existing Public Sewers, recommendations for wastewater flow management shall also be included with the submittal. See Subsection 2.2 of the *Standard Specifications and Details* for more information.

4.1.2 Conformance Review Process

When a complete submittal is received by the UC group, the project owner will receive a notification letter confirming that the review period has begun. Within 30 working days of the notification letter date, the UC group will respond to the project owner with the results of the review.

A. Non-Conformance

When the results of the review indicate non-conformance with the Department's standards (i.e. the *Design Standards* and the *Standard Specifications and Details*), the response will typically include:

- One transmittal letter outlining all items being returned and all items required for the next submittal;
- A review comments and resolution letter from the required reviewing parties within the Department describing the details of non-conformance; and
- If necessary, any additional attachments for clarification.

B. Conformance for Unsealed Plans

If the results of the review indicate conformance with the Department's standards, but, the submittal contains unsealed plans, the UC will issue a Letter of Understanding to the project owner.

The Letter of Understanding is not an Acceptance of the project by the Department, but is rather an acknowledgement that the submittal is in conformance with Department's standards.

A final submittal of the 100%-sealed plans is required after a Letter of Understanding is issued to obtain a Letter of Clearance. The final submittal will be reviewed for new revisions and the conformance of these revisions with the Department's standards. Additional review comments will be forthcoming for any non-conformance issues on subsequent submittals.

C. Conformance for Sealed Plans

The UC group will issue a Letter of Clearance to the project owner after the 100%-sealed plan submittal is reviewed and meets the following requirements:

- The plan submittal must be sealed by the Design Engineer;
- The submittal must be complete;
- The results of the review must indicate conformance with all applicable design and construction standards; and
- When a sewer modification plan is included with the submittal, the mylar cover sheet must be included for signature by the Department.

4.2 Graphical Requirements for Utility Coordination Plans

Public utility and public improvement projects can vary in size and scope; therefore, the types of plans included in a submittal can also vary. The following requirements are provided as guidance for plans when existing Public Sewers are located within the limits of proposed construction:

- Show the Department's utility coordination tracking number (e.g. UPC-20XX-XXX) on the cover sheet of the project plans (typically assigned by the UC group after the first submittal);
- Label each existing Public Sewer manhole and cleanout with the Department's unique manhole identification number and clearly indicate if it will remain undisturbed, modified, abandoned, etc.;
- Show and label existing service laterals (HCS/BCS) that were installed after December 31, 2005;
- Label existing Public Sewer lines and force mains with the Department's plan tracking number (e.g. G-20XX-XXX), pipe diameter, material and direction of flow;
- For each existing manhole and cleanout to be adjusted, show the existing and proposed rim elevations and clearly specify the sewer modifications required;
- Clearly label horizontal and vertical clearances of existing sewer with new public utility lines and structures to the nearest hundredth of a foot; and
- For non-typical designs, the Design Engineer should contact the UC supervisor to determine what pertinent information should be shown on the plans with existing Public Sewers.

The following subsections provide more detailed requirements for specific types of plans that may be included with the submittal.

4.2.1 Landscape, Planting and Irrigation Plans

In cases where existing Public Sewer lines are located in the vicinity of new landscape and planting areas, such as in roadway medians and shoulders, the plans should provide sufficient information to show design conformance with the

requirements of Subsections 7.5, 7.6 and 7.7. The landscape, planting and irrigation plans should include the following:

- Show the location of Public Sewer lines and manholes located within the vicinity of new landscape and planting areas; and
- Provide a certification statement as required per Subsection 7.7.

4.2.2 Stormwater Drainage Plans

When new stormwater drainage facilities will be installed across or in close vicinity to existing Public Sewers, the plans for such facilities should include the following:

- In profile view or in a separate detail, label the vertical clearances of existing sewer with new stormwater drainage culverts to the nearest hundredth of a foot.

4.2.3 Street Lighting and Signage Plans

When new street light poles or street signs will be installed in close vicinity to existing Public Sewers, the plans for such infrastructure should include the following:

- In plan view, show the location of Public Sewer lines and manholes with new poles and signs; and
- If necessary, provide a separate profile detail for specific poles or sign foundations with existing sewer, showing applicable clearances will be met.

4.2.4 Water and Reclaimed Water Plans

When a water or reclaimed water plan is included with the submittal package, the plans for such infrastructure should include the following:

- Show all sewer-related modifications resulting from water or reclaimed water construction (e.g. sewer replacement per S.D. RWRD-108); and
- In plan or profile view, provide vertical clearance information for each crossing of a new water main or reclaimed main with an existing sewer line to the hundredth of a foot.

4.2.5 Sewer Modification Plans

For Projects requiring the relocation or reconfiguration of existing Public Sewers, the sewer modification plans shall be included with submittal package. The following graphical requirements shall apply to sewer modification plans:

- Show the Department's sewer project tracking number (e.g. G-20XX-XXX) on the cover sheet of the sewer plans;
- Provide the Department's Approved signature block on the cover sheet of the sewer plans;
- Clearly identify all existing utilities that are to be abandoned-in-place and those that are to be abandoned-and-removed; and
- All applicable requirements for Sewer Plans per Subsection 5.4.

The sewer modification plans may require regulatory approval from the appropriate agency (PDEQ or ADEQ) after Acceptance (Letter of Clearance) by the Department. The Project Manager is responsible for obtaining regulatory approvals of the sewer modification plan.

PIMA COUNTY
WASTEWATER RECLAMATION

SECTION 5
PUBLIC GRAVITY SEWER DESIGN STANDARDS

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

5.1 Sewer Lines 1

5.1.1 Location and Alignment 1
5.1.2 Pipe Capacity 2
5.1.3 Velocity and Slope 3
5.1.4 Standard Pipe Materials 4
5.1.5 Casings for Sewer Lines 4
5.1.6 Cathodic Protection for DIP Sewer Lines 5
5.1.7 Cover 5
5.1.8 Separation from Potable Water Mains and Facilities 6
5.1.9 Separation from Reclaimed Water Mains 6
5.1.10 Separation from Other Utilities and Structures 6
5.1.11 Washes and Stormwater Detention/Retention Basins 7
5.1.12 Abandonment of Sewer Lines 7

5.2 Manholes and Appurtenances 8

5.2.1 Placement of Manholes 8
5.2.2 Spacing of Manholes 8
5.2.3 Separation of Manholes from Pavement Items 9
5.2.4 Manholes in the Vicinity of Drainage Features 9
5.2.5 Manhole Connections 9
5.2.6 Horizontal Deflection Angles 9
5.2.7 Diameter 10
5.2.8 Change in Slope 11
5.2.9 Manhole Invert Drops 11
5.2.10 Future Connections into Manholes 12
5.2.11 Manholes in Flood-Prone Areas 12
5.2.12 Manhole Frames, Covers and Concrete Collars 13
5.2.13 Watertight Frames and Covers 13
5.2.14 New Manhole over Existing Sewer Line 14
5.2.15 Drop Manholes 14
5.2.16 Corrosion Protection for Manholes 14

5.2.17 Cleanouts 14
5.2.18 Flow Metering Stations 15
5.2.19 Abandonment of Manholes 15
5.3 Service Laterals (HCS/BCS) 15
5.3.1 Alignment of Service Laterals 15
5.3.2 Connections to Public Sewer 15
5.3.3 Internal Drop Manhole Connections 16
5.3.4 Direct Connections into 15-inch Diameter Sewer Lines or Greater 16
5.3.5 Private Cleanouts for Service Laterals 16
5.3.6 Private Backwater Valves for Service Laterals 17
5.3.7 Repair and Replacement of Service Laterals 17
5.4 Graphical Requirements for Sewer Plans 17

Section
05

Public Gravity Sewer Design Standards

5.1 Sewer Lines

5.1.1 Location and Alignment

In accordance with Code, specifically 13.20.030(A)(1), public gravity sewers shall be located:

- Beneath the paved portions of public roads, streets, avenues, alleys and Right-of-Way, to the maximum degree possible, for sewer maintenance vehicle access (see Section7); or
- Beneath the paved portions of private streets and within dedicated Public Sewer easements.

Beneath the paved portions of private streets dedicated as common area by final plat.

The following language shall be used for the common area dedication on the final plat:

1. Grantor hereby irrevocably grants and dedicates easements to Pima County for access, installation, construction, maintenance and replacement of public sewer systems in all common area "_" designated by this plat: or
2. Grantor hereby irrevocably grants and dedicates easements to the respective utility providers for access, installation, construction, maintenance and replacement of underground utilities and public sewer systems in all common area " " designated by this plat.

All new public gravity sewers shall be designed and located so as to be positioned within the paved portions of new streets to the maximum extent possible. This guideline shall be followed even in the case where adjacent lots may be required to utilize private, on-site mechanical wastewater pumping systems to achieve physical connection to the Public Sewer located beneath a street surface.

Due to environmental, operational and maintenance concerns, the location of sewers in the following areas/circumstances shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis:

- Routing across, through and between lots;
- Within or along a wash or wash environment;
- Crossing a wash outside of a road Right-of-Way;
- Within a common area except those designated as paved private streets; and

- Within areas undisturbed by development.

All sewers located outside the paved portions of public roads, streets, avenues, alleys and Right-of-Way or paved private streets shall require specific sewer easements if special approval is granted.

If Special Approval is granted for placing a sewer within an unpaved common area, the following language shall be included on the final plat for the dedication of the sewer easement:

"Applicant hereby grants to Pima County all rights of way and easements as shown hereon for the purpose of access, installation, maintenance, construction, and replacement of public sewers. Applicant agrees that all sewer rights-of-way and easements granted hereon shall conform to the PCRWRD Engineering Design Standards 2016, Section 7 and, in particular, Subsection7.5."

Sewer lines shall be designed with a uniform slope, alignment (vertically and horizontally) and a constant diameter between manholes.

Curvilinear alignments for Public Sewer lines shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis. Special Approval will not be issued unless there is absolutely no other practical solution. Cost savings shall not be the sole justification for allowing curvilinear alignments for Public Sewers.

5.1.2 Pipe Capacity

In accordance with AAC R18-9-E301(D), the capacity of new Public Sewer lines shall be designed to meet the following design flow criteria:

- AAC R18-9 Table 1 - Unit Design Flows;
- Dry weather peaking factors based on upstream population, as specified in AAC R18-9-E301(D)(b)(i);
- The ratio of the depth of flow in the pipe (d) to the diameter of the pipe (D) shall not exceed 0.75 for Peak Dry Weather Flow (PDWF) conditions ($d/D \leq 0.75$); and
- Accommodate Peak Wet Weather Flow (PWWF) when flowing full within any point in a sewer line.

For residential developments, unit design flows shall be based on 2.7 persons per single family dwelling unit and 80 gallons per person per day, unless otherwise Approved by the Department. The Department may elect to specify alternate PDWF ratios for d/D, based on development of the hydraulic model.

In accordance with AAC R18-9-E301(C), for new Public Sewers or expansions of existing Public Sewers involving new construction, the design flows and the basis for calculating these flows shall be documented in a Sewer Design Report. In addition to submitting the Sewer Design Report to PDEQ for review, a copy shall

also be submitted to the Department for determining the available capacity of existing Public Sewer conveyance and treatment facilities.

5.1.3 Velocity and Slope

A. Velocities

Gravity sewer lines shall be designed to ensure the positive flow of wastewater and provide self-cleansing velocities. Pursuant to AAC R18-9-E301(D)(2)(e), the minimum full-flow velocity shall be 2 fps when using a pipe roughness coefficient of 0.013 (Manning *n*), regardless of the material composition, age or condition of the sewer pipe. The equation for calculating the full-flow velocity in a circular pipe can be expressed as:

$$v_{FF} = \frac{1.486}{n} \times \left(\frac{D}{48}\right)^{2/3} \times S^{1/2}$$

where:

v_{FF}	=	Full-flow velocity [ft/sec]
n	=	0.013 [roughness coefficient]
D	=	Nominal pipe diameter [in]
S	=	Slope [ft/ft]

The minimum full-flow velocities required by the Department for 6 inch and 8 inch diameter sewer lines exceed the requirements of AAC and are summarized in Table 5.1.

Pursuant to AAC R18-9-E301(D)(2)(f), when velocities of 10 fps or greater are predicted to occur, the sewer line shall be either ductile iron or a pipe material of equal or better erosion resistance. Special provisions shall be considered to protect sanitary sewer manholes against shock, erosion and the increased generation of hydrogen sulfide gases.

B. Calculating Sewer Pipe Slopes

The design pipe slope shall be based on the horizontal pipe length, measured from the inside face of each connecting manhole on the sewer reach.

C. Minimum Slopes

Table 5.1 summarizes the minimum slopes required by the Department for Public Sewer lines.

Table 5.1
Minimum Slopes for Gravity Sewer Lines

Pipe Diameter (inches)	Minimum Slope (ft/ft)	*Full-Flow Velocity (ft/sec)
6 (terminal reach)	0.0110	3.0
8 (terminal reach)	0.0100	3.5
8 (non-terminal reach)	0.0044	2.3
10	0.0025	2.0
12	0.0019	2.0
15	0.0014	2.0
18	0.0011	2.0
24	0.0008	2.0
*Manning's (n) value of 0.013 used		

Increasing the diameter of a sewer line for the sole purpose of achieving a flatter slope to maintain the minimum depth of cover is not permitted.

5.1.4 Standard Pipe Materials

The following pipe materials are Approved by the Department for Public Sewer lines of less than 18-inch nominal inside diameter:

- Vitrified Clay;
- Ductile Iron; or
- Polyvinyl Chloride.

These pipe materials shall conform to the *Standard Specifications and Details*, Subsection 3.2.2.

For Public Sewer lines with a nominal inside diameter of 18 inches or greater, the Department retains the right to specify pipe materials on a case-by-case basis.

5.1.5 Casings for Sewer Lines

Where casings are required for new Public Sewer lines, the design shall conform to the requirements of either S.D. RWRD-100 or the agency having jurisdiction in the Right-of-Way, whichever is more stringent. A cathodic protection system shall also be considered in the design of casings for Public Sewer lines.

5.1.6 Cathodic Protection for DIP Sewer Lines

A corrosion report for the design of cathodic protection shall be submitted with the Design Drawings for pile-supported DIP or other buried sewer facilities with exposed metal surfaces. This requirement does not apply to direct-bury installations of DIP encased with polyethylene wrap or exposed installations of DIP with an Approved exterior coating.

The corrosion report shall evaluate the soil and any other conditions that may affect the exterior corrosion rate of the steel casings, steel piles and DIP. At a minimum, the corrosion report shall include the following for the native soils:

- Soil Classification and description;
- Earth Resistivity;
- Measure of acidity (pH);
- Oxidation Reduction Potential;
- Sulfides;
- Moisture Content (Relative);
- Potential Stray Direct Current;
- Experience with existing installations in the area;
- Cost of protective measures; and
- Life expectancy of the steel piles and DIP.

If the results of the corrosion report indicate that a cathodic protection system is necessary, a Design Report for cathodic protection shall be included with the submittal. Cathodic protection systems shall utilize magnesium anodes in lieu of impressed currents.

5.1.7 Cover

Cover shall be the vertical distance measured from the top of pipe to finished grade. The design of Public Sewers shall provide a minimum cover of 4 feet above the Public Sewer line and that portion of any Service Lateral that is located within a Right-of-Way. The depths of new Public Sewer lines from or connecting to existing shallow Public Sewer lines (less than 4 feet of cover), shall be evaluated on an “available-depth” basis.

Where the “available-depth” of existing Public Sewer lines does not allow for new Public Sewers to meet the minimum cover requirements, these requirements may be reduced with Special Approval from the Director or his/her delegate, on a case-by-case basis. Where Special Approval is obtained for new shallow Public Sewer lines, it shall be constructed of DIP or other pipe material, as Approved by the Department.

For Public Sewer lines crossing washes, see Subsection 5.1.11(A).

5.1.8 Separation from Potable Water Mains and Facilities

A. Potable Water Mains

Potable water mains and Public Sewer lines shall be separated in order to protect potable water systems from possible contamination. Separation shall be measured perpendicularly from the outside surface of the Public Sewer line to the outside surface of the potable water main. The minimum separation requirements shall conform to S.D. RWRD-108.

Where practical, the design of new Public Sewer lines and new water mains should provide for a horizontal separation of 6 feet from the outside surface of all manhole risers to the outside surface of a water main. The use of horizontal fittings in water mains to meet this design guideline (i.e. jogging around manholes), shall be avoided.

B. Wells and Other Water Facilities

The separation requirements between wells and Public Sewers shall conform to AAC R18-5-502(C)(5).

5.1.9 Separation from Reclaimed Water Mains

Separation requirements for reclaimed water mains and Public Sewer lines shall be equivalent to the separation requirements for potable water mains per Subsection 5.1.8(A).

5.1.10 Separation from Other Utilities and Structures

A. Drainage Facilities

Provide at least 2 feet of vertical clearance between stormwater drainage facilities and Public Sewer lines. If this standard cannot be met, the Public Sewer line shall be replaced with DIP or approved equal. For drainage facilities that parallel the Public Sewer line, the drainage facilities shall be located outside the normal trench areas of the sewer per S.D. RWRD-104. Drainage facilities shall not cross less than 45 degrees where possible.

B. Poles and Pole Footings

Poles and pole footings shall not be located closer than 2 feet to the outside of a Public Sewer line. If any Public Sewer lines are located in close proximity to a proposed pole location, the Sewer Plans shall include a detail for mitigating the conflict with this standard.

C. Railroad Crossings

If Public Sewer lines will be constructed across a railroad (Tucson Modern Streetcar excluded) the design shall conform to the requirements of the respective

railroad jurisdiction. In any such case, Public Sewer lines shall be protected within a steel casing that meets or exceeds the requirements per S.D. RWRD-100.

5.1.11 Washes and Stormwater Detention/Retention Basins

A. Washes

The placement of Public Sewers within or along a wash or wash environment shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis. This restriction shall also apply to crossing a wash outside of a Right-of-Way. In cases where crossing a wash cannot be avoided, the sewer alignment should be located perpendicular to the direction of flow within the wash. Diagonal crossings have a greater potential for exposure, and should be avoided.

When Special Approval is obtained for crossing a wash, the design of the Public Sewer line shall meet the following criteria:

- Provide a minimum cover 4 feet per Subsection 5.1.7;
- Place the sewer line at a depth of at least 2 feet below the Maximum Predicted Scour Depth per the *Design Standards*, Appendix A, Subsection IV; and
- The sewer line material shall be ductile iron and extend a minimum of 10 feet beyond the Lateral Migration Setback limits per the *Design Standards*, Appendix A, Subsection V.

In cases where the minimum cover and/or minimum depth of two feet below the Maximum Predicted Scour Depth cannot be met, Special Approval by the Director or his/her delegate shall also be required for the design of Scour mitigation measures such as pile-supported sewer lines per S.S.D. RWRD-101 or alternative measures per the *Design Standards*, Appendix A, Subsection VI and S.S.D. RWRD-113.

The calculations for Maximum Predicted Scour Depth per the *Design Standards,* Appendix A, Subsection IV shall be included with the Sewer Plan submittal. If mitigation measures for Scour protection are required, a Design Report for these design measures shall be included with the Sewer Plan submittal.

B. Stormwater Detention/Retention Basins

Public Sewer lines should not be located beneath stormwater basins and all reasonable design options must be exercised to avoid such locations.

5.1.12 Abandonment of Sewer Lines

Wherever possible, reaches of existing sewer pipe that are to be abandoned shall be completely removed. When the removal of sewer pipe is not feasible, it shall be abandoned-in-place per the *Standard Specifications and Details*, Subsection 3.2.3(H).

5.2 Manholes and Appurtenances

5.2.1 Placement of Manholes

Wherever possible, manholes should be located within the paved area of a Right-of-Way or within a Public Sewer easement. Manholes should be located along the centerline of paved streets or centered within a multi-use or driving lane. However, manhole location shall not interfere with street monumentation. The placement of manholes in the wheel path of vehicles shall be avoided. The placement of manholes in sidewalks, crosswalks, bike trails, wash crossings, back or side yards, behind walls, curbs or gutters shall also be avoided.

A manhole shall be provided at any of the following locations along the sewer alignment:

- A change in slope;
- A horizontal bend (horizontal deflection angles greater than zero);
- A change in pipe size;
- Where two or more incoming Public Sewer lines connect;
- A terminal end;
- The connection of an HCS/BCS that is 6 inches in diameter or larger; and
- For Public Sewer lines, 15 inches in diameter or larger, the connection of any size HCS/BCS or private sewer shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis.

5.2.2 Spacing of Manholes

Pursuant to AAC R18-9-E301(D)(3)(a), the maximum spacing between manholes is summarized in Table 5.2:

Table 5.2
Manhole Spacing Requirements

Pipe Diameter (inches)	Maximum Manhole Spacing (feet)
8 to less than 18	500
18 to less than 36	600
36 to less than 60	800
60 and greater	1,300

Extending the reach length beyond maximum manhole spacing requirements to avoid a potentially high erosion area shall also require prior approval by ADEQ/PDEQ per AAC R18-9-E301(D)(2)(c)(iv).

5.2.3 Separation of Manholes from Pavement Items

A. Curbs and Gutters

The center of any new manhole (within pavement) should be located a minimum of 5 feet away from the gutter flow line. If this standard cannot be met, provide a watertight frame and cover per Subsection 5.2.13.

B. Survey Monuments

The center of any new manhole should be located a minimum of 5 feet away from any survey monument.

C. Speed Bumps

New speed bumps and speed humps should be located a minimum of 10 feet from the frame and cover of any existing manhole or cleanout.

5.2.4 Manholes in the Vicinity of Drainage Features

Manholes shall not be located in any of the following locations unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis:

- A Wash or drainage channel;
- The overbank areas of a Wash, defined by the minimum Lateral Migration setback distances per Appendix A, Subsection V; or
- Stormwater detention/retention basins.

If Special Approval is obtained for the design of manholes in any of the preceding locations, the design shall include extra protection for hydraulic forces per the *Design Standards*, Appendix A, Subsection VI-6.5.7.2 and the use reinforced manhole joints per S.S.D. RWRD-209. A Design Report for the structural design of these manholes shall also be included with the Sewer Plan submittal.

5.2.5 Manhole Connections

The maximum number of Public Sewer line connections into a manhole is 4 (3 inlets and 1 outlet).

5.2.6 Horizontal Deflection Angles

Horizontal deflection angles are measured at a horizontal bend in a sewer line and require a manhole. The horizontal deflection angle is the change in angle between the incoming and the outgoing sewer line, as shown in Figure 5.1. Horizontal deflection angles are limited by the diameter of the outgoing sewer line, and are summarized in Table 5.3.

Figure 5.1
Horizontal Deflection Angles
(Plan View)

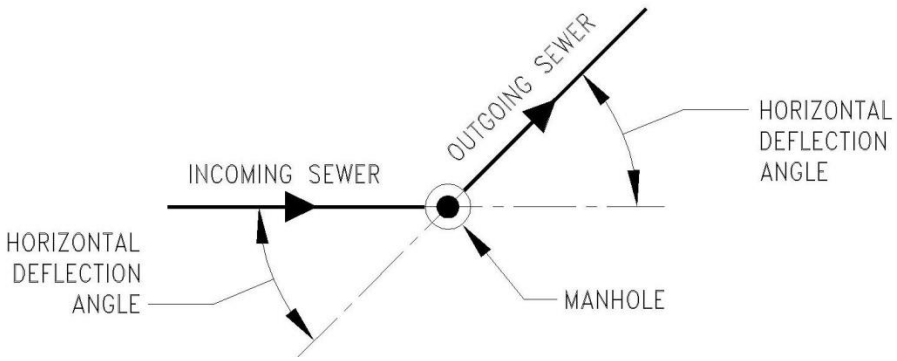


Table 5.3
Horizontal Deflection Angles

Outgoing Sewer Diameter	Maximum Horizontal Deflection Angle
Less than or equal to 10 inches	90°
Greater than 10 inches	60°

5.2.7 Diameter

The minimum diameter of a manhole (inside-diameter measured at the base) shall depend on the largest diameter of the connected pipes and the configuration of the flow channels (see S.D. RWRD-202). Where more than 3 sewer lines (excluding HCSs) connect into a new manhole, the minimum diameter shall be 60 inches. Where 3 or less sewer lines connect into a new manhole, the minimum diameter is determined as summarized in Table 5.4.

Table 5.4
Minimum Manhole Diameters for
3 or Less Sewer Line Connections

Largest Pipe Diameter or LPD (inches)	Minimum Manhole Diameter (inches)
6 to 10	48
12 to 18	60
Greater than 18	= (LPD x 5/3) + 36-in

For cast-in-place manholes or manholes with diameters greater than 60 inches, a special detail shall be provided on the Sewer Plans. At a minimum, the special detail shall provide the following information:

- Structural details for cast-in-place bases and manholes;
- Flow channel configuration;
- Bench access per S.D. RWRD-202;
- Size and stacking configuration for precast manhole sections; and
- Size and type of frame and cover.

Structural design calculations for these manholes, sealed by an Arizona registered P.E., may also be required to be included with the Sewer Plan submittal.

5.2.8 Change in Slope

When a change in slope is required within a reach of gravity sanitary sewer, a manhole shall be provided. The manhole shall be designed:

- To avoid hydraulic jumps;
- To ensure full capacity without excessive head losses; and
- To avoid turbulence and the resultant release of hydrogen sulfide gas.

5.2.9 Manhole Invert Drops

The flow channel, through the base of a manhole, shall be sloped to provide for a smooth transition of flow and minimize the deposition of solids. A minimum vertical change in elevation between the incoming pipe and the outgoing pipe, also known as the manhole invert drop, is required to provide for this slope. Manhole invert drops shall depend on the diameter of the connecting pipes and the horizontal deflection angle of the connecting pipes. For inlet and outlet pipes with the same diameter, see Table 5.5 for the required invert drops.

Table 5.5
Required Manhole Invert Drops
(Inlet and Outlet Pipes with Same Diameter)

Horizontal Deflection Angle	Invert Drop (feet)
0 to 9 degrees	Maintain Average Slope of Incoming and Outgoing Sewer Lines through Manhole; or Invert Drop = Manhole Diam. in feet x $(S_1 + S_2)/2$ Where: S_1 = Slope of incoming Reach S_2 = Slope of outgoing Reach
10 to 45 degrees	0.10
46 to 90 degrees	0.20

For inlet and outlet pipes with different diameters, invert drops shall be determined by matching the crown elevation of both pipes. In no case shall the diameter of the inlet pipe be greater than the diameter of the outgoing pipe.

The Department may allow an invert drop to be increased up to 2.5 ft to avoid the use of a Drop Manhole.

5.2.10 Future Connections into Manholes

For the design of new manholes, where a future sewer line is planned to connect into it, such as the case for development phasing, a block-out per S.D. RWRD-203 shall be required. The use of a projecting pipe at the new manhole, also known as a pipe stub-out, shall not be permitted unless the pipe stub-out is designated as private. In any such case, when construction of the future sewer line reach is completed, the existing pipe stub-out will be inspected and tested as part of the requirements for new Public Sewer construction.

For the design of a new sewer line connection into an existing manhole, the Department may require the manhole to be reconstructed or rebuilt. This requirement shall be determined after the existing manhole is assessed by the Department. The results of the assessment will depend on the condition of the manhole, flow channel configuration, steps location, and depth of flow.

5.2.11 Manholes in Flood-Prone Areas

Manholes that are located in the overbank areas of a wash or in areas prone to flooding may be subjected to Scour and lateral forces that may result in a structural failure. The design of new manholes located in such areas shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis. If Special Approval is obtained, the following requirements shall apply:

- A detail of the precast concrete manhole shall be provided in the Sewer Plans;
- The rim elevation shall be a minimum of 1-foot above the 100-year flood elevation and the requirement for a concrete collar per S.D. RWRD-212 may be waived, where warranted;
- In no case shall the maximum depth of Scour at the manhole, per Appendix A, Subsection VI-6.5.7.1, expose any of the connecting sewer lines or the base of the manhole;
- Scour calculations shall be sealed by an Arizona Registered P.E. and included with the Sewer Plan submittal;
- If the maximum depth of Scour is 12-feet or less and three or less precast concrete sections (i.e. cones and risers) will be exposed, all precast concrete sections shall have reinforced manhole joints per S.S.D. RWRD-209;
- If the maximum depth of Scour is greater than 12-feet or more than 3 precast concrete sections (i.e. cones and risers) will be exposed, a structural

analysis shall be required and include the total lateral-loading on the manhole per Appendix A, Subsection VI-6.5.7.2; and

- If required, structural calculations shall be sealed by an Arizona Registered P.E. (Structural) and included with the Sewer Plan submittal.

5.2.12 Manhole Frames, Covers and Concrete Collars

Frames and covers for manholes shall be 24 inches in diameter and conform to S.D.s RWRD-213, -214 or -215. The use of 30-inch diameter frames and covers per S.D.s RWRD-216, -217 or -218 shall be required for shallow manholes or unique manholes where entry access is hindered.

At the discretion of the Department, the use of bolted frames and covers per S.D.s RWRD-215 or -218 may be required for manholes located within a bike or multi-use path, or in cases where additional security is needed.

For manholes located in paved roads, the transportation agency having jurisdiction in the Right-of-Way may require a concrete collar to be placed around the frame and cover. In these cases, this concrete collar shall meet the minimum requirements per S.D. RWRD-211. For manholes located in unpaved areas, a concrete collar per S.D. RWRD-212 shall be required.

Where proposed construction will disturb the frame and cover of an existing manhole, it's condition must be assessed by the Department to determine if additional modifications are required. These required modifications may include:

- A new concrete collar per S.D. RWRD-211 or -212;
- A grade adjustment per S.D. RWRD-305 or 306, requiring the elevation of the frame and cover to be adjusted, however, the existing cone section or flat top slab of the manhole remains intact;
- A reconstruction of the manhole, requiring the removal and replacement of the manhole to a specified depth, excluding its base; or
- A rebuild of the manhole, requiring the replacement of the entire manhole, including the base.

5.2.13 Watertight Frames and Covers

A watertight frame and cover per S.D. RWRD-214 or -217 shall be required where:

- The manhole cover is located in a paved road and its center is less than 5 feet from the gutter flow line;
- The manhole cover is in a location that will be inundated by stormwater ponding or concentrated flows; or
- The manhole cover is located near an area where people gather and/or nuisance sewer odors are known to exist.

For a continuous series of watertight frames and covers along a sewer alignment, manhole vent assemblies per S.D. RWRD-223 or -224 may be required by the Department. The Department retains the right to determine the location and

spacing of manhole vent assemblies on a case-by-case basis. The exposed portion of the vent assembly shall be located away from drainage channels and protected with Type 'A' post barricades per COT/PC Standard Detail 106 or as Approved by the Department..

5.2.14 New Manhole over Existing Sewer Line

Where a new manhole is proposed over an existing Public Sewer line, the horizontal and vertical locations of the existing sewer line should be verified by a field survey. If, during construction, the Contractor finds the horizontal or vertical location of the sewer does not match the Sewer Plans within acceptable tolerances per the *Standard Specifications and Details*, Subsection 3.3.3(C), the Sewer Plans shall be revised and re-submitted to the Department for conformance review and Acceptance before construction of the manhole continues.

5.2.15 Drop Manholes

The use of Drop Manholes shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis. Special Approval will not be issued unless there is absolutely no other practical solution. Cost savings shall not be the sole justification for a Drop Manhole.

If Special Approval is obtained for a Drop Manhole connection, an external connection per S.S.D. RWRD-229 or -230 shall be used for Public Sewer lines. Internal Drop Manhole connections per S.S.D. RWRD-403 shall be limited to Service Laterals.

5.2.16 Corrosion Protection for Manholes

To protect the useful life of manholes, interior corrosion protection shall be required for a new manhole in any of the following cases:

- Manholes with pipe diameters of 18 inches and greater;
- Manholes located on smaller tributary lines that are within 200 feet of a manhole with pipe diameters of 18-inches and greater;
- A force main discharge manhole; or
- A manhole receiving flow from a sewer line with a slope greater than 10%.

Where interior corrosion protection is required for new manholes, it shall be specified in the Sewer Plans and conform to the requirements of the *Standard Specifications and Details*, Subsection 3.3.3(B)(viii).

5.2.17 Cleanouts

Manholes shall be provided at the terminal reach of Public Sewer lines. Cleanouts are not allowed. If an existing Public Sewer cleanout will be disturbed by proposed construction, the Department will determine on a case-by-case basis if it will be replaced with a manhole.

5.2.18 Flow Metering Stations

The requirement for new flow metering stations per S.S.D. RWRD-225 will be dictated by the Department on a project-specific basis. Special Approval by the Director or his/her delegate shall be required for proposed connections to existing flow metering stations or the relocation of existing stations.

5.2.19 Abandonment of Manholes

Wherever possible, existing manholes that are to be abandoned shall be completely removed. Where the complete removal of an existing manhole is not feasible, it shall be abandoned-in-place per the *Standard Specifications and Details*, Subsection 3.3.3(E).

5.3 Service Laterals (HCS/BCS)

5.3.1 Alignment of Service Laterals

The horizontal alignment of Service Laterals shall not violate the frontage of adjacent properties while traversing to the point-of-connection to the Public Sewer. The overall length of Service Laterals within Right-of-Way shall be minimized as required by the local agency having jurisdiction. The horizontal alignment of Service Laterals should be horizontally perpendicular to the sewer line where possible. Service Laterals located within Right-of-Way shall be horizontally straight without curves or bends.

The required slope of any Service Lateral within the Right-of-Way shall conform to local building codes. Where a conflict occurs with other utilities, the vertical rerouting of Service Laterals shall conform to S.D. RWRD-400.

5.3.2 Connections to Public Sewer

Service Laterals shall connect to the Public Sewer by method of a direct connection to the sewer line or in some cases, to a manhole. The following describes the criteria for determining the required method of connection.

HCS connections, 4 inches in diameter, shall connect to Public Sewer lines, less than or equal to 12 inches in diameter, by a direct connection per S.D. RWRD-401. HCS connections into manholes shall be avoided where possible. Non-perpendicular HCS alignments may be permitted to avoid connections into manholes. For non-perpendicular HCS alignments, the connection to the sewer line shall be located within the projected property lines of the lot it is servicing. If the connection of an HCS into a manhole cannot be avoided, it may be allowed for the following types of manholes:

- A terminal manhole with no potential for a future sewer line extension (a maximum of 3 HCS connections); or
- A manhole located within a knuckle intersection (a maximum of 2 HCS connections).

Service Laterals and private sewer systems shall connect into a Public Sewer manhole in any of the following cases:

- The internal diameter of the Service Lateral is equal to or one nominal size smaller than the diameter of the Public Sewer line (excludes a 4 inch HCS connection to an existing 6 inch diameter Public Sewer line);
- The nominal size of the Service Lateral is greater than 4 inches in diameter, regardless of the size of the Public Sewer line; or
- The Public Sewer line is 15 inches in diameter or greater, per Subsection 5.3.4.

5.3.3 Internal Drop Manhole Connections

Internal Drop Manhole connections per S.S.D. RWRD-403 shall be limited to Service Laterals. Internal Drop Manhole connections shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis. Special Approval will not be issued unless there is absolutely no other practical solution. Cost savings shall not be the sole justification for an internal Drop Manhole. Special Approval for internal Drop Manholes may be issued for the following cases:

- A new HCS/BCS connection to an existing manhole where the slope will be greater than 45 degrees; or
- The presence of an existing obstruction that will not permit rerouting of the HCS/BCS per S.D. RWRD-400.

5.3.4 Direct Connections into 15-inch Diameter Sewer Lines or Greater

A manhole shall be required where a Service Lateral must connect to a 15-inch or greater diameter Public Sewer line unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis. Special Approval will not be considered unless existing site conditions limit the ability to construct a new manhole and there is absolutely no other practical solution. Cost savings shall not be the sole justification for a direct connection. Special Approval for the direct connection of an HCS/BCS into a 15-inch or greater diameter Public Sewer line may be granted after the Public Sewer line has been assessed by the Department.

5.3.5 Private Cleanouts for Service Laterals

Pursuant to Arizona Blue Stake law (ARS 40-360.21 to 40-360.32), the Department is responsible for locating Service Laterals installed after December 31, 2005. For the purposes of accurately locating and marking an HCS/BCS within the Right-of-Way, a private cleanout per S.D. RWRD-404, shall be required for either of the following cases:

- A new HCS/BCS connection to a Public Sewer line; or
- A full replacement, realignment or repair of an existing HCS/BCS.

The placement of private cleanouts in sidewalks, driveways, and other paved or hardscape areas shall be avoided. Private cleanouts shall also be located in either of the following:

- Within private property and a Public Sewer or utility easement; or
- Within a 10-ft × 10-ft Public Sewer easement adjoining and contiguous with the Right-of-Way, Public Sewer easement, or an expressed or implied private property utility easement.

For projects that do not require a Sewer Plan to be generated (e.g. single-lot developments, etc.) documentation that clearly identifies the final installed location of the HCS/BCS and the private cleanout shall be submitted to the Department.

5.3.6 Private Backwater Valves for Service Laterals

When the finished floor elevation of a connected building is 1 foot or less above the rim elevation of the first upstream manhole or cleanout, a private backwater valve shall be installed with the Service Lateral. Where the first upstream manhole diameter is greater than 5 feet, the elevation criteria shall be increased to 18 inches. In any such case, the first upstream manhole shall not have a bolted or watertight cover. The private backwater valve shall be installed on private property and not within the Right-of-Way or the Public Sewer easement.

5.3.7 Repair and Replacement of Service Laterals

Pursuant to Code, specifically 13.20.070, the property owner shall be responsible for the repair and replacement of the Service Lateral, including the connection to the Public Sewer and the private cleanout.

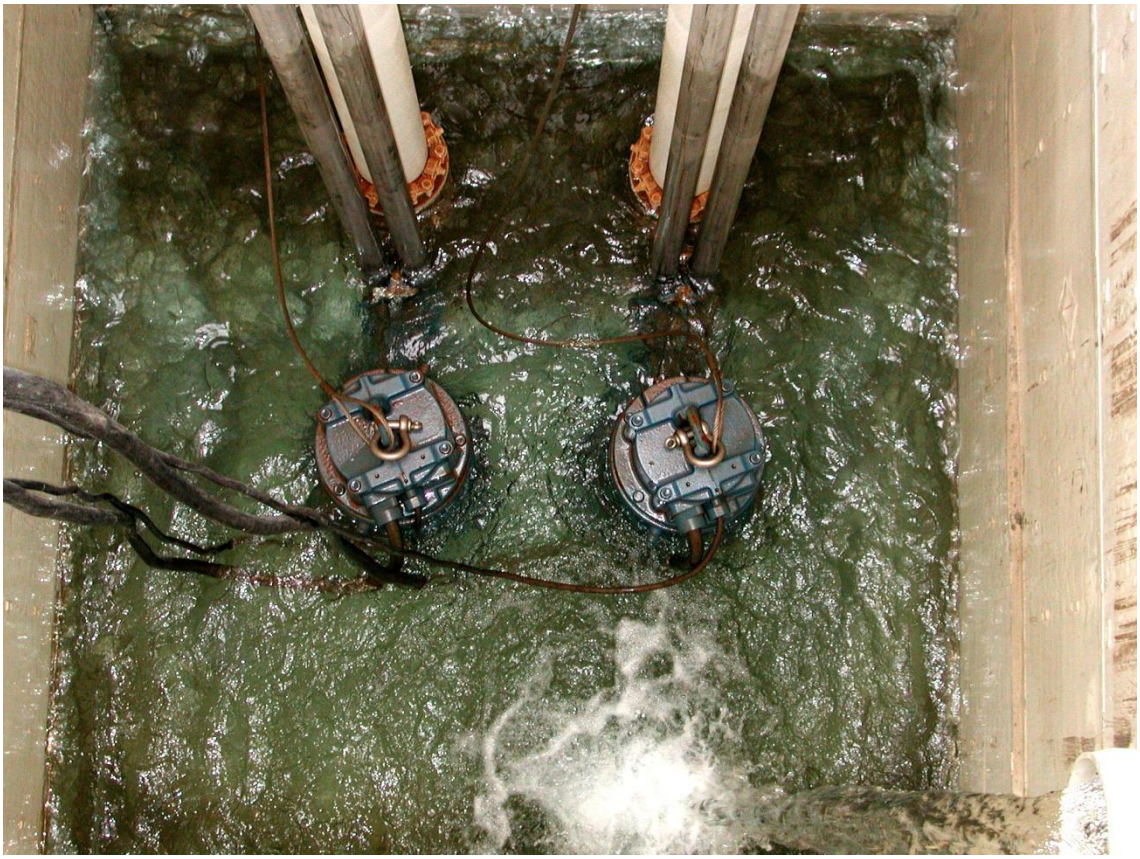
The property owner may request that the Department repair a damaged portion of the Service Lateral located within the Right-of-Way provided the damage was not caused by the property owner or his agents. The Department retains the right to approve or deny such requests on a case-by-case basis.

5.4 Graphical Requirements for Sewer Plans

The graphical requirements for Sewer Plans shall conform to the Department's current Sewer Plan checklist. A copy of the current checklist may be obtained from the Development Liaison group or downloaded from the Department's website.

Recommendations for wastewater flow management shall also be included with the submittal of the Sewer Plans. See Subsection 2.2 of the *Standard Specifications and Details* for more information.

PIMA COUNTY
WASTEWATER RECLAMATION



SECTION 6
WASTEWATER PUMPING SYSTEMS

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

6.1 General Classifications 1
6.2 Planning and Design 1
6.3 Capacity Phasing 1
6.4 Site Requirements 2
6.4.1 General 2
6.5 Pumps 4
6.5.1 General Requirements 4
6.5.2 Additional Features 4
6.6 Wet Wells 4
6.6.1 General Requirements 4
6.6.2 Additional Features 5
6.7 Manifold Piping and Appurtenances 6
6.7.1 General Requirements 6
6.7.2 Additional Features 8
6.8 Force Mains and Appurtenances 8
6.8.1 Force Mains 8
6.9 Odor Control Measures 9
6.10 Electrical and Controls 10
6.10.1 General 10
6.11 Submittals 11
6.11.1 Design Submittals 11
6.11.2 Construction Submittals 12
6.12 Exceptions for Minor Public Wastewater Pumping Systems 13

Section
06

Wastewater Pumping Systems

6.1 General Classifications

This Section provides the design standards and guidelines for wastewater pumping systems that will be operated and maintained by the Department (i.e. public wastewater pumping systems). For wastewater pumping systems that will be owned, operated and maintained by private entities (i.e. private wastewater pumping systems), see Subsection 3.6. In accordance with, Code, specifically 13.20.035 and 13.20.40, the authorization of private wastewater pumping systems and their connection to Public Sewers must be Approved by the Department.

Wastewater pumping systems with projected Average Dry Weather Flows (ADWF) greater than or equal to 10,000 gpd are classified by the Department as major wastewater pumping systems. The design standards and guidelines provided in this Section are intended for major public wastewater pumping systems. For design guidelines regarding minor public wastewater pumping systems (ADWFs less than 10,000 gpd), see Subsection 6.12.

6.2 Planning and Design

The design of public wastewater pumping systems is considered a Special Project per Subsection 2.7. The type of wastewater pumping system (e.g. private or public) will be determined by the Department.

Special Approval, by the Director or his/her delegate, shall be obtained prior to proceeding with the design of a public wastewater pumping system. At a minimum, a sewer basin study shall be submitted to the Department for consideration. The sewer basin study shall include feasibility and cost analyses for alternative design solutions.

If Special Approval is obtained for a public wastewater pumping system, the design shall adhere to all applicable design codes and standards, including, but not limited to:

- This Section (Section 6);
- AAC R18-9-E301 – 4.01 General Permit;
- State of Arizona OSHA for General Industry;
- NEMA and NEC standards; and
- All applicable fire codes, including, but not limited to, NFPA 820.

6.3 Capacity Phasing

The requirement for additional design provisions for expanding the capacity of wastewater pumping systems for future development will be evaluated on a project

specific basis. As a general guideline, where the projected timeline for the development of future phases or neighboring properties within the contributing sewer basin is greater than 20 years, the design capacity should be limited to the known development. However, where the development of future phases or neighboring properties within the contributing sewer basin is likely to occur within a 20 year period, or if the extent of development cannot be ascertained with any accuracy during the design period, additional design provisions for capacity expansion may be required.

6.4 Site Requirements

6.4.1 General

A. For general development planning purposes, the minimum lot size for a wastewater pump station site should provide for a minimum yard area of 9,000 sf that is generally flat and surrounded by a perimeter wall. The yard should be square or rectangular in shape, having a maximum length to width ratio of 2:1 (i.e. 140-ft x 70-ft). The lot size shall also meet the minimum requirements of the local zoning code.

B. The required size for a wastewater pump station site is a direct function of the Department's ability to safely and efficiently maneuver maintenance vehicles to specific components within the yard, as described in the following:

- The front of a combo-cleaner sewer truck to the wet well;
- A truck-mounted crane to the pumps and manifold piping;
- A chemical truck to the storage tanks; and
- A fuel truck to the emergency generator.

C. Wastewater pump station sites shall not be located in a Floodway. For sites located in flood-prone areas, the yard of the pump station site shall be elevated at least 1-foot above the elevation of the 100-Year Flood. Wastewater pumping systems shall also be protected from scour, in accordance with the *Scour Procedures and Guidelines* provided in the *Design Standards*, Appendix A.

D. The ingress/egress access driveways shall be unrestricted and provide year round all-weather maintenance vehicle access from the nearest paved roadway within Right-of-Way. The driveways shall also be paved or stabilized in accordance with S.D. RWRD-111. A minimum vertical clearance height of 20-ft shall be provided for the driveway and vehicle maneuvering areas within the yard.

E. Incorporate design provisions for the future possibility of gravity conversion.

F. A masonry wall, measuring 8 feet in height, shall be provided to secure the yard. This wall shall have two 20-ft wall openings, each with double-swing security gates with hinged gate wheels. A man-way gate, 3 feet in width, shall also be incorporated into gate design. All security gates shall be a tubular-steel picket design. A level concrete slab shall be provided in front of the gates to support the gate wheels and facilitate full-open position.

G. Warning signs that provide the Department's 24-hour emergency phone number shall be placed in a location that is visible from the security gate.

H. The grading design for the site shall ensure that ponding will not occur within the yard. Driveways and drivable areas for equipment access shall be stabilized per Subsection 7.7.1 at a minimum.

I. Lighting shall be provided for the yard and the control panels. Light shields for pole-mounted lights should be provided to minimize light pollution to adjacent homes. Electrical power outlets (110 Volt/20 Amp GFCI) shall be provided no greater than 50-feet away from the wet well and pipe manifold. Manual switches for yard lighting shall be provided within a secure panel at the entrance gate and at the control panel.

J. A minimum clearance of 4 feet shall be provided on all sides of standby generators.

K. A 1.5-inch potable water service shall be provided into the pump station site for the following fixtures:

- A 1.5-inch flushing hydrant, located no greater than 20-feet from the wet well and preferably within the concrete slab for the manifold piping; and
- If chemical odor control facilities are used, an emergency eyewash and shower unit.

L. A primary backflow prevention assembly shall be installed at the service line entering the site in accordance with the water purveyor's requirements. A secondary backflow prevention assembly shall also be installed for the emergency eyewash and shower unit.

M. Landscaping requirements for the areas outside of the yard shall conform to the local land-use or HOA codes and consider a low-maintenance and drought-tolerant design.

N. As a result of the U.S. Department of Homeland Security having classified pump stations as "critical infrastructure", heightened security measures shall be provided. Due to the sensitive nature of site security, specific design requirements are excluded from this document. Each project must be evaluated on a case-by-case basis and specific security requirements will be established at that time by the Department. For additional information relative to pump station security requirements, the Design Engineer should contact the Sanitary Engineering Manager.

O. Depending on the site location, offsite radio repeater towers may be required for the Department's SCADA system. The property for the repeater towers must be procured for the Department prior to final Acceptance of the pump station.

6.5 Pumps

6.5.1 General Requirements

A. Pump stations shall use duplex submersible wastewater pumps with each pump sized to handle the design flow. Refer to the Department's List of Approved Products for the recommended pump manufacturers. Pumps shall be equipped with three phase 480-volt electric motors. The pumps shall operate at a constant drive speed no greater than 1,780 rpm unless otherwise Approved. The use of Variable-Frequency Drive (VFD) pumping systems shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis.

B. The selected pumps shall be in the manufacturer's preferred operating range. This range and the system curve shall be indicated on the pump curve. The pumps shall be as close as possible to the best efficiency point of the pump curve, using the lowest horsepower motor that can be found to perform the required pumping rate.

C. As part of the project, a third (spare) pump and two original equipment manufacturer (OEM) pump rebuilt kits shall be provided and delivered to the Department's Conveyance Division.

6.5.2 Additional Features

A. The pump removal system shall use Type 316 stainless steel guide rails. Pumps shall be equipped with a sliding guide bracket that allows for installation and removal without entering the wet well. This bracket shall align the pump discharge with the discharge connection elbow for a watertight seal. The discharge connection elbow shall be attached to and supported by the floor of the wet well, and bear all static and dynamic forces from the pumps. The pumps shall not bear any direct load on the guide rails or the floor of the wet well.

B. The pump connection to the discharge connection elbow shall be accomplished by employing a simple downward motion without rotation of the pump or removal of bolts, nuts or other fasteners.

C. Each pump shall be attached to a lifting chain suspended from a hook located near the opening of the hatch. The chain shall be attached to the pump with a shackle.

6.6 Wet Wells

6.6.1 General Requirements

A. Wet wells should be rectangular in shape and constructed of pre-cast concrete sections per the *Standard Specifications and Details*, Subsection 3.3.3(B)(iii) or cast-in-place concrete per the *Standard Specifications and Details*, Subsection 3.3.3(B)(v).

B. The interior of the wet well shall have an Approved interior corrosion protection. Refer to the Department's List of Approved Products for the recommended coating and lining manufacturers.

C. Wet wells with depths greater than 25 feet shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis.

D. The floor of the wet well shall have a self-cleaning sump design that minimizes low velocity regions where sediments build up. The sump design shall use a minimum slope of 1:1 towards the pump intakes. The sump design shall allow for the flow of water into the pump intakes to be uniform, steady and free from swirl and entrained air, in accordance with the Hydraulic Institute. Grit manholes are not allowed.

E. The required storage volume of the wet well shall provide for a maximum of 6 pump cycles per hour and a minimum of 2 pump cycles per hour for ultimate design flow conditions. Pump cycle times shall not exceed the maximum frequency as recommended by the pump manufacturer. The storage volume shall also be designed to:

- Provide a minimum horizontal cross-sectional area of 20 square feet;
- Provide a minimum of 5.5 feet between the floor of the wet well and the invert of the lowest gravity influent line and a minimum pump operating range of 3.0 feet, whichever is greater;
- Keep the pump motors submerged at all times;
- Prevent surcharging of the gravity influent line(s); and
- Allow for proper pump and level controls.

6.6.2 Additional Features

A. All equipment within the wet well shall be non-sparking and explosion-proof. The wet well shall not contain any equipment requiring regular or routine inspection or maintenance that would require staff to enter the wet well.

B. All ancillary hardware in the wet well shall be Type 316 stainless steel, including but not limited to: brackets, hooks, chains, shackles, fasteners, bolts, nuts and washers. Fastenings in concrete shall use epoxy in place anchor bolts. Expansion anchors are not allowed. Refer to the Department's List of Approved Products for the recommended concrete anchor manufacturers.

C. All penetrations into the walls of the wet well shall be either cut with a core hole saw or formed. All pipe and conduit connections into the wet well shall be watertight. Electrical and chemical conduits shall be sealed to prevent the passage of hazardous gases into the junction boxes and control panels.

D. The wet well influent line shall be equipped with an influent tee or baffle made of PVC or type 316 stainless steel materials.

E. A vertical, fixed ladder shall be provided in the wet well. Refer to the Department's List of Approved Products for the recommended ladder manufacturers.

F. Hooks shall be provided near the hatch opening for hanging the pump wires, one for each pump.

G. Access hatches shall be made from aluminum or type 316 stainless steel materials. Features shall include: a locking system, a safety net or grate and an automatic hold open mechanism. Refer to the Department's List of Approved Products for the recommended hatch manufacturers. Access hatches shall provide for a clear opening area that allows for safe and efficient maintenance operations including:

- Pump removal by a hoist or crane without personnel entry;
- Vacuum-cleaning of the wet well floor with a combo-truck; and
- Personnel entries using a tripod.

H. Depending on the size and weight of each pump, the Department may require a hoist bracket to be installed on the top slab of the wet well for quick setup of a portable hoist for pump removal.

I. Wet wells shall use a passive gravity ventilation system where the air volume in the wet well is either increased or decreased as the level fluctuates. The diameter of the vent pipe shall be sized to vent at a rate equal to the maximum pumping rate of the station, however, not to exceed a maximum velocity of 600 feet per minute (fpm). The vent pipe shall not be placed in a location that will hinder access to the wet well.

J. Level monitoring within the wet well and pump on/off shall be controlled by an ultrasonic level sensor. A redundant float level control system shall also be provided. Water level control mechanisms shall be supported by brackets that are attached to the interior wall of the wet well.

6.7 Manifold Piping and Appurtenances

For the purposes of this document, manifold piping and appurtenances shall include all pipes, valves, meters, pigging access and other equipment located between the connection to the pumps and the connection to the force main.

6.7.1 General Requirements

A. All valves, manifold tees, flow meters and pigging access, shall be located above ground. The placement of manifold piping and appurtenances within a valve vault shall be avoided unless Special Approval is obtained from the Director or his/her delegate, on a case-by-case basis.

B. All manifold piping shall be flanged DIP (Class 125 flanges) with an Approved interior lining, and conform to the requirements of the *Standard Specifications and Details*, Subsection 3.2.2(D). Manifold piping located inside the wet well shall have an exterior coating that is equivalent to the Approved interior coatings for DIP pipe. Refer to the Department's List of Approved Products for recommended DIP interior linings.

C. An Approved flexible compression coupling shall be provided between each pump and the check valve to facilitate the replacement of valves and accommodate slight

alignment adjustments. Couplings shall be provided in locations that are restrained to prevent movement due to hydraulic forces in the manifold piping.

D. A flanged spool piece, with a minimum length of 8 inches, shall be provided on both sides of valves and flow meters to facilitate bolt access.

E. An Approved check valve shall be provided between each pump and the manifold connection. Refer to the Department's List of Approved Products for recommended check valves.

F. An Approved isolation plug valve shall be provided between each check valve and the manifold connection. Refer to the Department's List of Approved Products for recommended isolation plug valves.

G. An Approved air relief valve (ARV) shall be provided at each high point in the manifold piping and the force main. An Approved drain valve shall be provided at the base of air relief valves. Refer to the Department's List of Approved Products for recommended air relief valves and drain valves. The recommended locations for ARVs within the manifold piping are:

- Between each pump and the check valve; and
- Between the pigging wye and the flow meter.

H. An Approved pressure gauge shall be provided at the tee of the manifold. Refer to the Department's List of Approved Products for the recommended pressure gauge manufacturers.

I. An emergency bypass port shall be provided in a location between the manifold tee and the flow meter. The port shall be oriented where it can easily connect to a portable pumping unit that can be setup in a location that will not hinder vehicular maintenance access to the wet well. The pump-out port shall have the same diameter as the manifold piping and be comprised of a wye or tee fitting, an Approved isolation valve, and an Approved pump-out port connection. Refer to the Department's List of Approved Products for the recommended isolation valves and bypass port connections.

J. An Approved wastewater flow meter, suitable for outdoor installations and integration with the Department's SCADA system, shall be installed with the manifold piping. The length of straight pipe for the flow meter shall conform to the manufacturer's requirements. Refer to the Department's List of Approved Products for the recommended wastewater flow meters.

K. Access for pig launching shall be incorporated with the manifold piping and utilize a 45 degree wye fitting. The cap of the pig launching wye shall be secured using a Victaulic coupling or Approved equal, in lieu of a flanged-bolted cap. The cap shall be vertically located a maximum of 4 feet from the floor. A snubber rod or frame shall be attached to the cap of the pig launcher to hold the pig in place prior to launching. An Approved isolation valve shall be provided between the pig launching wye and the floor. An Approved drain valve shall be provided between the isolation valve and the pig launching wye.

L. A pig retrieval device shall also be provided with the project.

6.7.2 Additional Features

A. All exposed manifold piping, fittings and valves shall be painted with an Approved exterior paint. Refer to the Department's List of Approved Products for the recommended exterior paints. Paint thickness on the nuts and bolts shall not hinder tool access.

B. Manifold piping shall be supported by steel or concrete pipe supports, designed in accordance with DIPRA requirements. All flanges shall be a minimum of 12-inches from the floor. The axis of the horizontally supported pipes should not be at a height greater than 30-inches.

C. A continuous concrete slab shall be provided for the above-ground manifold piping and appurtenances. The concrete pad shall provide 6 inches of containment depth and be sloped to direct incidental drainage into a local drain. The local drain shall have a type 316 stainless steel drain grate cover. Piping for the local drain shall be a minimum diameter of 4 inches and connect directly into the wet well. A P-trap shall be installed with this piping to prevent sewer gases from escaping through the local drain.

6.8 Force Mains and Appurtenances

6.8.1 Force Mains

A. Force mains shall be constructed of butt-fused HDPE pipe conforming to the requirements of the *Standard Specifications and Details*, Subsection 3.2.2(E). The installation and field testing of force mains shall conform to the requirements of the *Standard Specifications and Details*, Subsection 3.2.3(D)(v).

B. The design and installation of HDPE force mains shall conform to AWWA M55 and the Handbook of PE Pipe, latest edition, available through PPI. In addition to these requirements, the design of force mains shall also meet the following criteria:

- The pressure rating of force main piping shall not be less than twice the normal operating pressure and occasional pressure surges;
- The vertical alignment of the force main shall be on a continuous grade that provides gravity drainage throughout; and
- A minimum depth of Cover of 4 feet shall be provided for the force main.

C. Pumping velocities through the force main shall be a minimum of 3 fps and a maximum of 7 fps per AAC R18-9-E301(D)(4)(a). The Department recommends a minimum pumping velocity of 4 fps.

D. Where changes in the horizontal alignment of a force main are required, long radius bends shall be used in lieu of bend fittings. Where use of bend fittings cannot be avoided, the maximum bend shall be 45 degrees. For joint installations with gravity sewer, the minimum horizontal clearance between the force main and the

gravity sewer shall not result in the horizontal jogging of the force main around manholes per S.D. RWRD-500.

E. For blue stake marking, tracer wire per S.D. RWRD-500, shall be installed with the force main. The tracer wire ends shall be protected within test stations per S.D. RWRD-501. Test stations shall be located outside of vehicular traffic lanes and adjacent to each of the following locations:

- The vertical bend where the pigging station connects to the force main;
- The manhole that the force main discharges into; and
- At every bend.

F. The location of force mains shall also be marked with visible monuments per the *Standard Specifications and Details*, Subsection 3.2.3(E) and S.D. RWRD-503. Monuments shall be provided directly above the force main, at spacing intervals no greater than 250-feet, and at every bend.

G. ARVs shall be protected in precast concrete vaults conforming to ASTM C478. Vaults shall be secured with a grated and lockable cover. Vault shall be out of vehicular and pedestrian traffic. The top of the vault shall be a minimum of 1-foot above finish grade and adjacent flood elevations.

H. The end of the force main shall connect into a Public Sewer manhole per S.D. RWRD-502.

6.9 Odor Control Measures

A. All wastewater pumping stations shall provide odor control measures. The recommended method is chemical injection. The method of aeration is not allowed.

B. A continuous concrete slab shall be provided within the yard of the pump station site for a chemical storage tank. The concrete pad shall provide 6 inches of containment depth and be sloped to direct incidental drainage into a local drain. The local drain should be located outside the footprint of the chemical storage tank and have a type 316 stainless steel drain grate cover. Piping for the local drain shall be a minimum diameter of 4 inches and connect directly into the wet well. A P-trap shall be installed with this piping to prevent sewer gases from escaping through the local drain.

C. The minimum size of the chemical storage tank shall either not require to be refilled at a frequency greater than once per month or not be less than 2,500-gallons, whichever is greater. The material of the tank and chemical lines shall be UV resistant.

D. A shade structure shall be provided for the chemical storage tank and odor control equipment.

E. Two peristaltic pumps (primary and spare) shall be provided for pumping chemicals from the storage tank into the wet well. The chemical pumps and related controls shall be secured in an Approved pad lockable panel. Chemical injection

lines shall be plumbed through conduit sleeves into the top of the wet well and shall be capable of being flushed and cleaned with water. Chemical injection lines into the wet well shall be replaceable without requiring entry into the wet well.

F. An emergency eyewash and shower unit shall be provided in a location that is accessible from the chemical injection panel.

G. The Design Engineer should contact the Department's Odor Control Unit to determine any additional or special design requirements.

6.10 Electrical and Controls

6.10.1 General

A. The minimum conduit size shall be 1-inch and shall not be more than half-full of the conductor(s). A separate electrical conduit shall be provided for:

- Each pump;
- The ultrasonic level sensor; and
- Each level control float.

B. The pump wire connections shall be intrinsically safe in an Approved electrical panel in an above-ground location that will not hinder maintenance access to the wet well.

C. The pump station shall be equipped with Approved pump control system that will be integrated with the Departments radio telemetry system. The Design Engineer shall contact the Department's Conveyance Division for details.

D. The pump station control system shall be secured in an Approved electrical control panel. Refer to the Department's List of Approved Products for the recommended electrical control panels. The pump station control panel shall be painted white and ventilated as needed to maintain temperatures within the recommended operating range for electrical equipment. The pump station control panel shall be mounted to an equipment support and shade structure per S.D. RWRD-504 with the front of the panel facing to the north. Power to the pump station control panel shall have an isolated breaker.

E. If the ADWF is project to be greater than 10,000 gpd, an Approved standby generator shall be provided. The standby generator shall meet the following criteria:

- Powered by a diesel engine;
- Equipped with a silencing muffler;
- Capable of running both pumps simultaneously (1 pump may delay start); and
- Capable of being operated for 24-hrs at full load.

F. The generator transfer switch shall be automatic and shall meet the requirements of the generator's manufacturer.

G. The electrical construction documents for wastewater pumping systems shall be prepared and sealed by an Arizona Registered P.E. (Electrical).

6.11 Submittals

6.11.1 Design Submittals

A. Design Reports for public wastewater pumping systems shall be sealed by an Arizona Registered P.E. (Mechanical or Civil) and submitted to the Department for review and Approval. At a minimum, Design Reports for public wastewater pumping systems shall provide the following information:

- Projected sewer design flows (Include a map identifying the sewer basin areas being served);
- Wet well volume and control levels (Include pump cycle times for 25%, 50%, 75% and 100% build-out levels);
- Fittings and equivalent lengths;
- Total dynamic head calculations;
- Pump selection (Include the system curve plotted on the pump performance curves for single and combined pump operation);
- Force main sizing;
- Water hammer and surge control measures (if necessary);
- Capacity of the gravity system being discharged into;
- Chemical injection system and tank sizing for odor control measures;
- Estimated operation and maintenance costs;
- Manufacturer's technical data for recommended pump station appurtenances and equipment; and
- If necessary, measures for protecting the wastewater pumping system from flooding and/or Scour (may be provided by separate document).

B. The Sewer Plans for a public wastewater pumping systems shall be prepared in accordance with the following general requirements:

<u>All Sheets:</u>

- Scaled and plotted on 24-inch x 36-inch sheets;
- Use a minimum lettering height of 1/8 inch;
- Include the Department's plan tracking number (e.g. G-20xx-xxx);

<u>Cover Sheet:</u>

- Include the words "Public Wastewater Pump Station and Force Main" in the project title;
- Include a sheet index and a general location map;
- Include separate signature blocks for Acceptance by the PCRWRD Deputy Director of the Planning and Engineering Division, and the PCRWRD Deputy Director of the Conveyance Division;
- Reference the design basis of bearing and elevation;

- Include general notes to the contractor, as Approved by the Department, and special provisions (may be continued on the second sheet);
- Sealed by an Arizona Registered P.E. (Civil);

Site Plan:

- Provide a site plan for the pump station site with a maximum scale of 1-inch = 10-feet;
- Include existing and proposed contour elevations at 1-foot intervals;
- Include design details for all site work including, however not limited to: grading, drainage, utilities, paving and landscaping;
- Include horizontal control data for property lines, easements, perimeter wall, manholes, concrete structures, driveways, etc.;
- In the case of a station malfunction, identify the location and elevation of the nearest upstream gravity manhole that an SSO would occur;
- Sealed by and Arizona Registered P.E. (Civil);

Wet Well and Manifold Piping:

- Provide a detailed plan and profile of the wet well and manifold piping, at a maximum scale of 1-inch = 2-feet;
- Include pertinent wet well elevations, including, but not limited to, pipe connections, level controls, wet well floor, top of wet well, etc.;
- Include callouts for all manifold piping and appurtenances;
- Include a pump schedule;
- Sealed by and Arizona Registered P.E. (Civil);

Force Main:

- Provide a plan and profile of the force main with a horizontal scale of 1-inch = 40-feet and a vertical scale of 1-inch = 8-feet;
- The force main plan may be submitted as a separate document if it is a joint installation with a new public gravity sewer;

Electrical:

- Provide an electrical site plan, line diagrams control diagrams and detail;
- Sealed by and Arizona Registered P.E. (Electrical);

Structural:

- Provide a structural plan for masonry walls, concrete and cast-in-place manhole structures;
- Sealed by and Arizona Registered P.E. (Structural);

6.11.2 Construction Submittals

A. The Contractor shall be responsible for preparing and submitting an Operation and Maintenance (O&M) Manual to the Department, prior to the final Acceptance of construction for the wastewater pumping system. At a minimum, the O&M submittal shall meet the following requirements:

- Include 2 hard copies (loose-leaf binder with tabbed indexes) and 1 digital PDF copy;
- Include a table of contents;
- Provide the manufacturer's technical and operation manuals for all installed pump station appurtenances and equipment; and
- Provide instructions for the safe handling of chemicals and the cleanup of spills.

B. The requirements for the As-Built Plans for wastewater pumping systems shall conform to the *Standard Specifications and Details*, Subsection 1.4.7.

6.12 Exceptions for Minor Public Wastewater Pumping Systems

The Department reserves the right to modify or waive specific standards in this Section for the design of a minor public wastewater pumping system. The use of a specific package pump station shall require Special Approval from the Director or his/her delegate, on a case-by-case basis.

PIMA COUNTY
WASTEWATER RECLAMATION

SECTION 7
EASEMENTS AND MAINTENANCE ACCESS

Engineering Design Standards

TABLE OF CONTENTS

SECTION **PAGE**

7.1 Requirements for Public Sewer Easements 1

7.1.1 Horizontal and Vertical Alignment 1

7.1.2 Short Access Easements 1

7.2 Conveyance of Public Sewer Easements.....2

7.3 Temporary Construction Easements 3

7.4 Abandonment of Public Sewers and Easements 3

7.5 Maintenance Access and Encroachments within Public Sewer Easements 3

7.6 Maintenance Access within Right-of-Way 4

7.6.1 Dead-end Streets and Cul-de-Sacs 5

7.6.2 Traffic Circles.....5

7.7 Landscaping and Planting Guidelines for Public Sewers 6

7.7.1 Stabilized Surface Treatments 6

7.7.2 Manholes in Right-of-Way.....7

Section 07

Easements and Maintenance Access

7.1 Requirements for Public Sewer Easements

The following requirements for the design of Public Sewer easements are pursuant to Pima County Code of Ordinances 13.020.030(A) and are based on the Department's goal to provide safe and efficient maintenance access to Public Sewers.

7.1.1 Horizontal and Vertical Alignment

The design of Public Sewer easements shall conform to the following requirements:

- AAC R18-9-E301(D)(2)(l);
- S.D.s RWRD-109, -110 and -111;
- Easements should be horizontally centered along the sewer line and at each manhole, to the highest degree possible;
- For sewer depths less than or equal to 10 feet, the minimum width for sewer easements shall be 20 feet;
- For sewer depths greater than 10 feet, the minimum width for sewer easements shall be twice the depth of the sewer line (invert to finish grade) and rounded up to the nearest 5 feet;
- Public Sewer easements shall be specific to Public Sewers, unless otherwise Approved by the Department on a case-by-case basis
- The driving surface shall have longitudinal slopes not greater than 9.0% unless otherwise Approved by the Department on a case-by-case basis, and cross slopes not greater than 2.0%.
- Provide a 20-foot landing area in front of each manhole with a relatively flat surface (2.0% maximum slope in any direction);
- Easements shall provide all-weather maintenance access to all manholes and
- Dead-end easements shall be avoided, except for flow-through sewers that are constructed to the subdivision/development boundary during initial sewer installation.

The Department reserves the right to modify or waive any of these requirements on a case-by-case basis (i.e. existing sewer easements).

7.1.2 Short Access Easements

The safety of the public and of the Department's maintenance staff will not be compromised; therefore, adequate visual and navigational room must be available within the Public Sewer easement and the Right-of-Way. In certain cases, Public

Sewer easements may be designed so that the Department's maintenance vehicles can navigate safely in reverse. A right-angle turn-around, per S.D. RWRD-110 may be waived when the following criteria are met:

- The Public Sewer easement is a straight line and does not exceed 150 feet in length to the last manhole within the easement;
- The safety of the maintenance vehicle will not be hindered by heavy traffic, difficult terrain and other factors; and
- No obstructions exist for the vehicle or driver to navigate within the Public Sewer easement or onto the Right-of-Way at the beginning of the easement.

7.2 Conveyance of Public Sewer Easements

Unless a prior agreement exists between the developer and the Department, the developer shall be responsible for the acquisition of all Public Sewer easements and Right-of-Way needed to construct, access and maintain new Public Sewers.

Where a new Public Sewer easement is required for a new subdivision, it must be dedicated by the final plat.

If a Public Sewer easement cannot be dedicated by final plat, it must be dedicated by separate instrument and the recording information referenced on the associated Sewer Plan. If the easement is not associated with a Sewer Plan, only the dedication and recordation will be required.

Complete detailed and accurate descriptions for all new Public Sewer easements shall be submitted to the Department for review after the initial review of the Design Drawings has been completed and prior to the next plan submittal.

A request for a Public Sewer easement should include all vital information necessary to accurately portray the location of the easement to the Pima County Real Property Services. The submittal shall include:

- A legal description of proposed sewer easement(s), sealed by an Arizona Registered Land Surveyor;
- A location map of proposed sewer easement(s) with parcel, adjacent property ownership and street identification labels (8½" × 11");
- The company's name, address and phone number;
- Copy of deed evidencing current ownership; and
- The Department's project reference number for a Subdivision Plat or Sewer Plan.

The dedication of Public Sewer easements shall grant the following rights to the Department:

- The Department or its Contractor has the right to install, anywhere within the Public Sewer easement, temporary or permanent underground or above-ground facilities that may be required to monitor, operate, maintain, repair or replace Public Sewers;

- The Department assumes no liability for damage to, or removal of, any vegetation, above-ground or underground facilities, surface treatments, materials, equipment, or structures placed within the easement or within 20 feet above the surface of the easement by anyone other than the Department or its Contractor;
- The property owner shall be liable for injury to personnel and/or damage to maintenance vehicles or construction equipment that results from contact with any prohibited encroachments anywhere within the full width of the Public Sewer easement or within 20 feet above the surface of the easement, or from any actions necessary to remove such encroachments from the easement;
- Liability for injury or damage shall include personnel and equipment of the Department and its Contractors; and
- The Department has no obligation to provide advance notice to property owners in emergency conditions, however, the Department will endeavor to provide advanced notice to property owners when it is known that a Public Sewer easement will be accessed for maintenance or construction.

Any construction, development, planting or landscaping within the Public Sewer easement shall conform to the maintenance access requirements and guidelines per Subsections 7.5, 7.6 and 7.7.

7.3 Temporary Construction Easements

Where temporary construction easements are required for construction activities that extend beyond the limits of the Public Sewer easement, they shall be specified on the Sewer Plan.

7.4 Abandonment of Public Sewers and Easements

To request the abandonment of an existing Public Sewer asset, Public Sewer easement, Right-of-Way or license agreement, an application for the release of Public Sewer easements shall be completed and submitted to the Pima County Real Property Services along with any required fees and information. If Approved, the facility, easement, Right-of-Way or license agreement shall be released by separate instrument.

The abandonment of Public Sewer assets shall conform to Subsections 5.1.12 and 5.2.19, and the *Standard Specifications and Details*, Subsections 3.2.3(H) and 3.3.3(E).

7.5 Maintenance Access and Encroachments within Public Sewer Easements

Structures, impediments or other features located within a Public Sewer easement or Right-of-Way that may hinder or prevent vehicular maintenance access to manholes, shall not be permitted without Approval from the Department. These features include:

- Walls, fences, swimming pools, gazebos, water fountains, sculptures, or any permanent or temporary structures etc.;
- Steep slopes (refer to Subsection 7.1.1) or other conditions that may subject maintenance vehicles to sliding, loss of traction or overturning;
- Abrupt changes in terrain, such as vertical curbs, retaining walls or drainage channels;
- Surface treatments that could cause maintenance equipment to become stuck or damaged, such as:
  - Sand or uncompacted soil;
  - Sharp rocks, rip-rap or boulders; and
  - Vegetative or organic ground cover.
- Trees, cacti and other vegetation that hinders maintenance vehicle access per Subsection 7.7;
- Objects that may cause injury to maintenance workers or damage to maintenance equipment; and
- The storage of vehicles (temporary or permanent), equipment or materials, by the property owner, unless Approved by the Department.

Where walls or fences are required by a property owner to limit maintenance access through a Public Sewer easement, a minimum 16-foot wide gate or a gate equivalent to the width of the existing easement, with an Approved locking system, shall be provided. No obstructions shall exist that cause the overhead clearance to be less than 20-feet. The owner of the gate shall be responsible for its full operation and for maintaining unrestricted 24-hour access for the Department. The construction of a wall, fence, gate or any other encroachment within Public Sewer easements shall require:

- Acceptance of the construction documents for the wall, fence, gate or other encroachment; or
- The recording of an encroachment agreement with the Department for the wall, fence, gate or other encroachment.

7.6 Maintenance Access within Right-of-Way

Where new sewers are not placed beneath the paved portions of roads, surface improvements sufficient to provide the Department's sewer maintenance vehicles with unrestricted year round, all-weather access to the Public Sewer manholes may be required, in accordance with Code, specifically 13.20.030(A)(1). The required surface improvements shall accommodate the weight and turning radius of the Department’s combo-cleaner trucks and conform to the requirements for turn-around areas.

For manholes that are located within Right-of-Way but outside paved areas (e.g. shoulders, sidewalks, medians, traffic circles, etc.), the design shall consider the Department’s ability to safely and efficiently maneuver a combo-cleaner truck to these manholes.

The design for providing a safe and efficient maintenance access driveway to each manhole located outside the paved areas of Right-of-Way shall consider:

- Replacing existing vertical curb with a 16 foot wide driveway;
- Providing all-weather maintenance access;
- Providing a stabilized surface treatment per S.D. RWRD-111;
- Providing a minimum 20-foot landing area for a combo-cleaner truck to park in front of each manhole with a relatively flat surface (2.0% maximum slope in any direction, unless otherwise Approved by the Department on a case-by-case basis);
- Providing post barricades, lockable gates or other types of removable barriers, Approved by the Department, to limit public access;
- Increasing the thickness of concrete to 6-inches for sidewalks, ramps, driveways, etc.;
- Avoiding the placement of irrigation and utility boxes within the maintenance access driveway;
- Constructing a concrete collar per S.D. RWRD-212;
- Adjusting the frame and cover to an elevation above finish grade to minimize wet weather inflow and inadvertent burial;
- Providing a 20-ft x 20-ft clearance zone throughout the maintenance access driveway; and
- The landscaping and planting guidelines for Public Sewers per Subsection 7.7.

The Department has the authority to take whatever action (e.g. cutting, trimming, moving, removal, etc.) is deemed necessary to gain maintenance access to Public Sewers that are restricted by vegetation, obstacles or structures. The Agency having jurisdiction over the respective Right-of-Way is ultimately responsible for maintaining, repairing or replacing these items originally placed by a Project.

7.6.1 Dead-end Streets and Cul-de-Sacs

When Public Sewers are located in a public or private cul-de-sac or other public or private permanent dead-end street, the street shall be designed with adequate turn-around area for the Department's combo-cleaner trucks. Refer to the latest version of the *Pima County Subdivision and Development Street Standards* for the minimum design criteria for dead-end streets and cul-de-sacs.

7.6.2 Traffic Circles

The design of traffic circles near or surrounding a Public Sewer manhole is strongly discouraged by the Department. If a traffic circle must be in the same location as a Public Sewer manhole, the design shall consider:

- Providing curb openings for combo-truck maintenance access if the center of the manhole cover is greater than 3 feet away from the curb;
- Placing the curb opening in a location that will minimize disturbance to the flow of vehicle traffic during sewer maintenance operations;

- Raising the frame and cover elevation so as to direct drainage away from the manhole and avoiding water harvesting; and
- Providing a sustainable landscaping and planting design that will not hinder maintenance access to manholes.

Deep-rooted trees and other aggressive root vegetation shall be avoided. Landscaping shall be limited to flowers, grasses, shrubs, and other small plants that can either be driven over or removed easily and quickly in the event that the manhole must be accessed for maintenance.

7.7 Landscaping and Planting Guidelines for Public Sewers

Planting within Public Sewer easements shall only be allowed with Special Approval. Trees with branches or roots having the potential to extend into Public Sewer easements shall be avoided. The Department assumes no liability for damage due to the removal of tree branches or roots that extend into Public Sewer easements.

In special cases where Public Sewers must be located outside paved or stabilized areas, the design of landscaping and planting shall adhere to the following guidelines:

- Limit planting to small shrubs and ground cover within 10 feet of sewer lines, provided that they can be driven over by a vehicle and do not contain spikes or thorns that can damage tires or hinder access by maintenance personnel;
- Select plants that will not develop root systems that will reach sewer facilities (contact the Department for a list of excluded plants);
- Select plants that will not interfere with visual and maintenance vehicle access to manholes;
- Do not place irrigation equipment within the maintenance vehicle access driveway to each manhole;
- Show the location of Public Sewer lines and manholes in the landscaping and planting design; and
- Provide a certification on the cover sheet, sealed by the Landscape Architect, declaring that the project was designed in accordance with the landscaping and planting guidelines for Public Sewers per Subsection 7.7.

The Department reserves the right to review the design of landscaping and planting that is proposed near Public Sewer. The Department assumes no liability for damage due to the cutting back or the removal of plants that hinders maintenance access to Public Sewer manholes.

7.7.1 Stabilized Surface Treatments

For Public Sewer easements located outside of paved areas, a stabilized surface treatment, per S.D. RWRD-111, shall be provided for clear and unrestricted vehicular maintenance access to Public Sewer manholes.

Stabilized surface treatments may not be appropriate in all cases, such as wash or channel crossings, or in environmentally sensitive areas. In such cases, the

Design Engineer should coordinate with the Department early in the planning process to find a solution for providing vehicle maintenance access to Public Sewer manholes, while conforming to all applicable Federal, State and local environmental laws, and regulations.

7.7.2 Manholes in Right-of-Way

For Public Sewer manholes located outside the paved areas within Right-of-Way, both vehicle maintenance access and visual access shall be a top priority. In these cases, the design of any improvements within the Right-of-Way shall adhere to the following guidelines:

- Provide visual access to the manhole cover from the closest travel lane;
- Provide the ability for the Department's combo-cleaner trucks to safely and efficiently pull off the road and access the manhole;
- Provide a relatively level 6-foot diameter area around the manhole cover to allow working room for setup of a tripod and related safety equipment when manhole entry is required;
- Minimize impacts to traffic flow for regular maintenance operations being performed at the manhole; and
- Preserve or improve the current maintenance vehicle access to an existing manhole.

A maintenance vehicle access lane, having a width of 16 feet, shall be provided to the manhole cover and kept free of objects that may hinder vehicle access to the manhole. These objects include, but are not limited to, shrubs, trees, boulders, riprap and drainage swales. Planting design shall locate tree trunks at least 16 feet away from a manhole and a sufficient distance so that the ultimate canopy will not overhang the maintenance vehicle access driveway. The manhole elevation shall be a minimum of 2 inches above finish grade and, under no circumstances, shall it be buried under landscaping or surface materials.

For existing manholes, if a concrete collar is not present, a concrete collar per S.D. RWRD-212 may be required.

PIMA COUNTY
WASTEWATER RECLAMATION

APPENDIX A
SCOUR PROCEDURES AND GUIDELINES FOR SANITARY SEWER CROSSINGS OF ALLUVIAL WATERCOURSES

Engineering Design Standards

SCOUR PROCEDURES AND GUIDELINES FOR SANITARY SEWER CROSSINGS OF ALLUVIAL WATERCOURSES

PREPARED FOR:

PIMA COUNTY REGIONAL WASTEWATER AND RECLAMATION DEPARTMENT

PREPARED BY:

TETRA TECH
4801 E BROADWAY BLVD.
SUITE 521
TUCSON, ARIZONA 85711

JANUARY 2009
(REVISED OCTOBER 2009)
(REVISED FEBRUARY, 2011)
(REVISED JUNE, 2011)

Registered Professional Engineer (Civil)
CERTIFICATE NO.
12481
MICHAEL E.
ZELLER
Date Signed 06/15/11
ARIZONA, U.S.A.
Expires 12/31/13

Tetra Tech, Inc.

SCOUR PROCEDURES AND GUIDELINES

I. BACKGROUND

This report presents scour procedures and guidelines for the computation of scour/erosion and lateral migration at sanitary sewer crossings of alluvial watercourses.

Over the past 20 years, advancements in the fields of hydraulic engineering, scour/erosion assessment, and sediment-transport technology have provided improved generalized methods for computing the components of scour. Historically, local design standards available for computing scour/erosion depths and lateral-migration limits of sanitary sewer and other types of pipeline crossings of alluvial watercourses have been found to provide reasonable results when all components of the scour/erosion and lateral-migration processes are considered and when they are properly applied to each individual scenario. The difficulty is that, occasionally, within the environs of central and southern Arizona in particular, hydraulic conditions which prevail in a given watercourse may fall outside of the envelope within the set of standard scour equations that were originally developed, and thus publicized procedures may not be strictly applicable under all ranges of conditions. This document is intended to provide such an approach to the computation of scour/erosion and lateral migration—one that would not only have applicability within the urban/metropolitan areas of Pima County, but would also apply in a more regional fashion to the majority of alluvial watercourses located in rural Pima County, as well as in the semi-arid and arid desert areas of Arizona, in general.

II. CONDITIONS OF USE

This simplified hydraulic design procedure contains technical concepts and guidelines to aid the engineer in the planning and design of pipelines to be placed across and/or parallel to alluvial watercourses. This procedure has been developed for use only with alluvial watercourses that are primarily composed of sands and gravels, and that are subject to erosion with a regulatory (i.e., 100-year) peak discharge of less than 10,000 cfs ($Q_{p100} < 10{,}000$ cfs).

When used in this type of conditions, the procedure presented herein should produce adequate results. However, site-specific evaluations, which encompass more detailed analyses and consider ALL local factors, are recommended whenever and wherever possible. This procedure has been developed using both sound engineering judgment and the best information currently available. Nonetheless, this procedure should only be accepted and used by the recipient individual or group entity with the express understanding that Pima County and/or the Authors of this procedure make no warranties, either express or implied, concerning the accuracy, reliability, usability, or suitability for any particular purpose of the information contained herein. As such, Pima County and/or the Authors of this procedure assume no liability, whatsoever, to any such individual or group entity by reason of any use made thereof. Furthermore, use of the procedure shall not be presumed to be the best engineering practice for any site-specific situation.

III. FOUR-STEP INITIAL EVALUATION PROCESS

Before beginning any scour/erosion assessment, the four-step initial-evaluation process which is described below should be conducted. This process is intended to assist the user in determining whether he or she can prepare his or her own scour evaluation; or, whether there needs to be a consultant retained to prepare the investigation who is an expert in the field of erosion and sediment transport. Please note that the following section is only a guideline meant to assist the user in determining the risk associated with computing his or her own scour estimates for sanitary sewer crossings of alluvial watercourses.

The Project Risk (R) can be evaluated by the equation, $R = R_1 + R_2 + R_3$, as follows:

Step 1) What is the risk/expectation of vegetal growth (R_1) in areas that are environmentally restricted, particularly with regard to maintenance concerns? (Scale from 1-10). Example:

- Low—shallow weeds/grasses within maintained channels, $R_1 = 1$,
- High—shrubs/trees growing in environmentally protected watercourses, $R_1 = 10$.

Step 2) What is the Social/Economical Risk (R_2) that is associated with failure of a sanitary sewer? (Scale from 1-10). Example:

- Low Contamination/Cost—Improvements within Small Service Area, $R_2 = 1$.
- High Contamination/Cost—Improvements within Regional Service Area, $R_2 = 10$.

Step 3) Local Risk Factors (R_3) within the proximity of the sanitary sewer are equal to the sum of the associated risks as presented in the table below, where, $R_3 = \sum R_i$:

Table 1: Factors That influence Local-Erosion Risk Evaluation, (Scale from 0-10)

Local Risk within proximity of Sanitary Sewer (R_i)	Point Value
Flow Contraction Due to Bridge Abutment Encroachments, (R_{BE})	0 or 1
Bridge Piers, (R_{BP})	0 or 1
Presence of Drop Over a Rigid Grade-Control Upstream of Crossing, (R_D)	0 or 1
Sanitary Sewer Partially or Fully Exposed to Flow, (R_P)	0 or 2
Presence of In-Stream Sand-and-Gravel Mine in Proximity of Sanitary Sewer, (R_M)	0 or 3
Curvature of Watercourse where Sanitary Sewer Crossing Is Located	0, 1 or 2
-If $(r_c/T) \geq 10$	0
-If $0.5 < (r_c/T) < 10$	1
-If $(r_c/T) \leq 0.5$	2

Step 4) Upon completion of the preceding three steps, sum R_1 thru R_3, and compare risk level with the table below:

Table 2: Scour/Erosion-Hazard Risk Evaluation

Computed Risk ($R=R_1+R_2+R_3$)	Risk Potential	Recommendation
$0 < R < 10$	Low	Proceed with Caution
$10 \leq R < 20$	Moderate	Experienced Professional Is Recommended
$20 \leq R \leq 30$	High	Experienced Professional and Detailed Investigation Are Recommended

IV. STANDARD SCOUR PROCEDURE

The following text summarizes the scour procedures and the guidelines to be used for evaluating scour/erosion and lateral-migration impacts at sanitary sewer crossings of alluvial watercourses.

4.0 Total Scour

Total scour potential (including future conditions) is loosely defined as the sum of the individual scour components described in the following subsections of this document. All recommended sanitary sewer cover depths are to be measured from the thalweg (i.e., the lowest elevation in the streambed) when the sanitary sewer is placed at the watercourse crossing. If the crossing is braided, then the burial depth is to be measured from the thalweg of the most deeply entrenched thread. As a general rule-of-thumb, the user should recognize that the upper limit of maximum scour (Z_{MAX}) computed should not exceed five times the maximum flow depth (Y_{MAX}); that is $Z_{MAX} \leq 5Y_{MAX}$.

4.1 Maximum Scour Depth

$$Z_{MAX} = Z_{TSE} + Z_{LTD} \qquad \text{Where, } Z_{MAX} \leq 5Y_{MAX} \qquad \text{(Equation 4.1.1)}$$

$$Z_{MAX} = 5Y_{MAX} \qquad \text{Where, } Z_{MAX} > 5Y_{MAX} \qquad \text{(Equation 4.1.2)}$$

Where:

Z_{TSE}	=	Total single-event (100-year) scour depth, in feet;
Z_{LTD}	=	Long-term aggradation or degradation depth, in feet;
Y_{MAX}	=	Maximum depth of flow in channel, in ft;
Z_{MAX}	=	Upper limit of maximum predicted scour depth, in feet;

A general equation for computing the single-event scour depth, Z_{TSE}, for a 100-year peak discharge along either a curved or a straight reach of an alluvial watercourse is:

$$Z_{TSE} = C_U(Z_G + Z_A + Z_T + Z_B + Z_C + Z_L) \qquad \text{(Equation 4.1.3)}$$

Where:

C_U*	=	Non-uniform scour coefficient to account for flow irregularities (per factor-of-safety from Table 3), unitless;
Z_{TSE}	=	Total single-event (100-year) scour depth, in feet;
Z_G	=	General scour depth, in feet;
Z_A	=	Anti-Dune scour depth, in feet;
Z_T	=	Low-flow thalweg depth, in feet;
Z_B	=	Bend scour, in feet;
Z_C	=	Confluence scour, in feet; and
Z_L	=	Local scour depth, in feet

*The C_U coefficient is meant to account for increased unit discharge due to flow irregularities.

Table 3: Non-Uniform Scour Coefficients[1] (C_U)		
Channel Geometry	**Value for Erodible Bed and Banks**	**Value for Erodible Bed and Protected Banks**
Natural/Irregular	1.55	1.75
Parabolic	1.50	1.70
Trapezoidal	1.33	1.55
Rectangular	1.20	1.33

[1]As derived from Blodgett (1986)

4.2.1 General Scour (Z_G):

It is reasonable to assume that general scour processes would be strongly correlated to the unit discharge of flow within the channel of an alluvial watercourse. Therefore, for purposes of this document General Scour, Z_G, has been quantified in terms of unit discharge, q, as shown below:

CLARIFICATION

$$Z_G = 0.293q^{2.3}[q^{1/15} - 1.073]$$ **Exponent is 2/3** Updated Jan. 2017 (Equation 4.2.1.1)

(If Z_G < 0.10 feet, assume Z_G = 0.10 feet)

Where:

Z_G = General scour depth, in feet; and,
q = Average peak discharge per unit width of the channel, in cfs/ft.

4.2.2 Anti-Dune Scour (Z_A):

Anti-dunes are bed forms, similarly shaped to dunes, but which move along the streambed in an upstream direction, rather than downstream as do dunes, and move in phase with the surface waves in the channel. Anti-dunes typically form when transitional flow occurs or when the flow in the channel is at near-critical or critical flow conditions—conditions which, by far, are indicative of the most common flow regimes which are found along alluvial watercourses in metropolitan Pima County during major flow events. As noted, the corresponding surface waves are in phase with the anti-dunes, and tend to break like surf when the waves reach a height approximately equal to 0.14 times the length of the wave. From this knowledge, a relationship has been established that relates the average channel flow velocity to the predicted anti-dune scour depth along the streambed. This relationship, excerpted from the *City of Tucson Standards Manual for Drainage Design* (1989, and revised in 1998) is shown below (see Figure 1, Page 5):

$$Z_A = 0.0137V^2$$ (Equation 4.2.2.1)

Where:

Z_A = Anti-Dune scour depth, in feet; and
V = Average channel flow velocity, in ft/s.

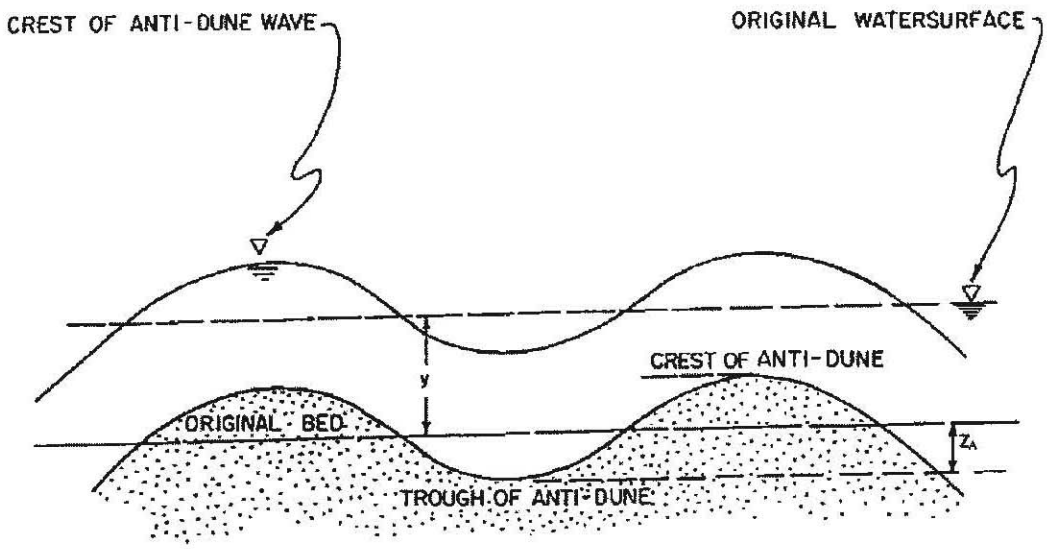


FIGURE 1

When computing Z_A, it is important for the user to keep in mind that the height of an anti-dune can never exceed one-half the maximum depth of flow ($1/2Y_{MAX}$). Accordingly, if Z_A should exceed $1/2Y_{MAX}$, then Z_A should be set equal to $1/2Y_{MAX}$ (i.e., $Z_A = 1/2Y_{MAX}$

Updated June 2013

4.2.3 Low-Flow Thalweg (Z_T):

The low-flow thalweg is a small "inner channel" which forms in the streambed of the main channel. A low-flow thalweg typically develops when the width-to-depth ratio of the main channel of an alluvial watercourse is large in comparison to the ordinary flows which occur on an annual basis. Depending upon the relationship between flow velocity, V, flow depth, Y, and flow width, W, during a 100-year event, the scour depth to account for a low-flow thalweg (Z_T) follows the relationships adopted from the *City of Tucson Standards Manual for Drainage Design* (1989, and revised in 1998), as shown below:

$Z_T = 0$	$W/Y \leq 1.15V$		(Equation 4.2.3.1)
$Z_T = 1$	$W/Y > 1.15V$	($DA < 30\ mi^2$)	(Equation 4.2.3.2)
$Z_T = 2$	$W/Y > 1.15V$	($DA \geq 30\ mi^2$)	(Equation 4.2.3.3)

Where:

Z_T	=	Low-flow thalweg scour depth, in feet;
W	=	Flow width, in feet
Y	=	Average flow depth of channel, in ft; and
V	=	Average velocity of the channel, in ft/s

Note, however, that if a low-flow thalweg is present at the site of a sanitary sewer crossing, the observed thalweg depth should be used in lieu of results generated by the preceding equations.

4.2.4 Bend Scour (Z_B):

Bend scour occurs along the outside (concave side) of a bend. It is created by spiral, transverse currents which form within the flow as the water moves through the curved alignment in the bend. The following relationships for bend scour, Z_B, are expansions of Equation 4.2.1.1, found in Section 4.2.1 of this document, upon consideration of curvature effects. These relationships are designated for use based upon different magnitudes of the ratio r_c/T, and are an additive component of the total scour, Z_{TSE}.

$$Z_B = 0.243q^{0.733}$$

If $\alpha > 60°$ [$(r_c/T) \leq 0.5$]
(use for nearly direct impingement [e.g., right-angle bends)
(Equation 4.2.4.1)

$$Z_B = 0.293q^{0.733}\left(2.1\left[\frac{\sin^2\left(\frac{\alpha}{2}\right)}{\cos\alpha}\right]^{0.2} - 1\right)$$

If $17.75° < \alpha < 60°$ [$0.5 < (r_c/T) < 10$]
(Equation 4.2.4.2)

$$Z_B = 0$$

If $\alpha \leq 17.75°$ [$(r_c/T) \geq 10$]
(Equation 4.2.4.3)

The relationship between α and r_c/T is mathematically described below (also, see Figure 2):

$$\frac{r_c}{T} = \frac{\cos\alpha}{4\sin^2\left(\frac{\alpha}{2}\right)}$$

(Equation 4.2.4.4)

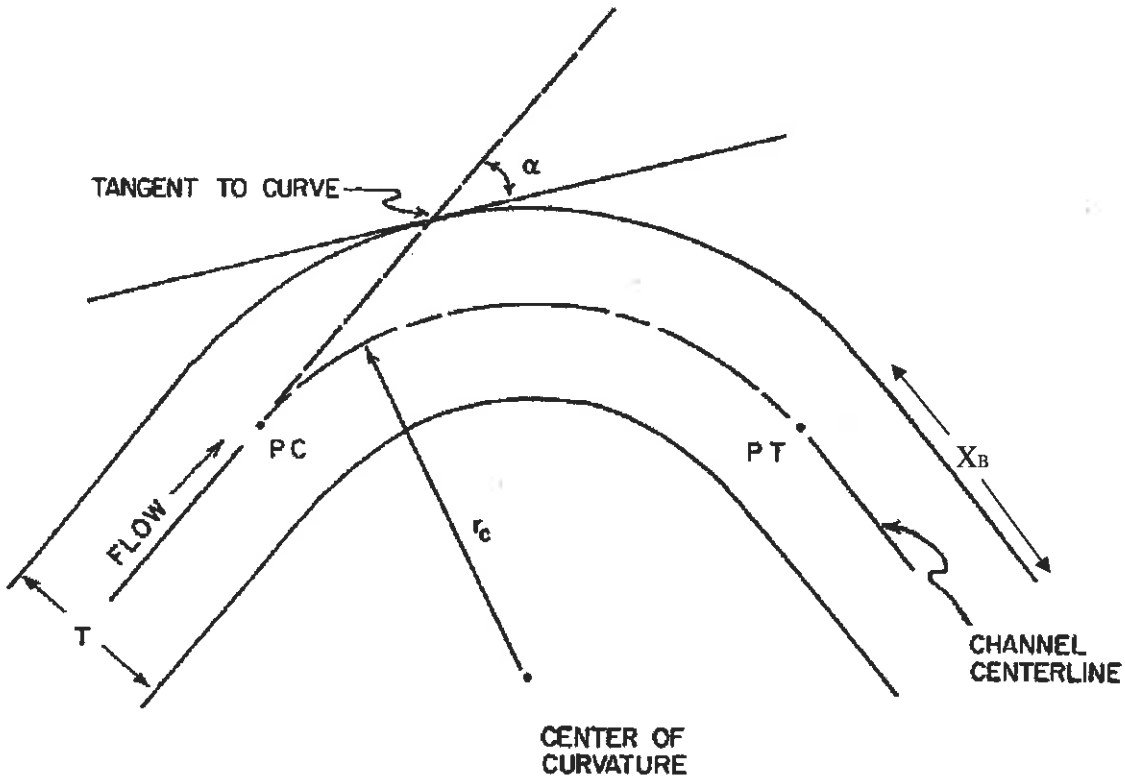
Note: Bend scour should not be applied beyond X_B, which is the downstream distance where scour is no longer influenced by flow curvature, and is mathematically defined as:

$$X_B = \left(\frac{0.6}{n}\right)Y_{max}^{1.17}$$

(Equation. 4.2.4.5)

Where:

Z_B	=	Bend scour depth, in feet;
q	=	Unit discharge of flow, Q/T, approaching bend, in cfs/ft;
r_c	=	Radius of curvature along centerline of channel, in ft;
T	=	Channel top-width immediately upstream of the bend, in ft;
α	=	Angle formed by the projection of the channel centerline from the point of curvature to a point that meets a line tangent to the outer bank of the channel, in degrees (see Figure 2);
X_B	=	Distance from bend to where scour is no longer influenced by flow curvature (see Figure 2);
n	=	Manning's "n" value; and
Y_{max}	=	Maximum depth of flow immediately upstream of the bend, in ft.



PT = Downstream point of tangency to the centerline radius of curvature
PC = Upstream point of curvature at the centerline arduous of curvature

FIGURE 2

4.2.5 Scour at Confluence of Two or More Watercourses:

Confluence scour for two or more watercourses is determined by the following relationship:

$$Z_C = Y_{MC} - Y \qquad \text{(Equation 4.2.5.1)}$$

Maximum flow depth in a confluence, Y_{MC}, can be calculated for different sediment classes using the following relationship (Ashmore and Parker 1983; Klaassen and Vermeer 1988):

$$\frac{Y_{MC}}{Y_{MS}} = 2.24 + (0.031)\alpha_c \text{ (non-cohesive sands/gravels } [30° < \alpha_c < 90°]) \qquad \text{(Equation 4.2.5.2)}$$

Where:

Z_C	=	Scour due to a confluence of two or more watercourses, in ft;
Y_{MC}	=	Maximum flow depth in the confluence scour hole, in ft;
Y_{MS}	=	Average flow depth, from water surface to mean scoured depth, in ft;
Y	=	Average flow depth, in ft.
α_c	=	Angle of confluence of two watercourses, in degrees (Note: This is not the same α depicted in Figure 2).

4.2.6 Local Scour (Z_L):

Local scour occurs whenever there is a hydraulic structure or an obstruction which causes an abrupt change in the flow direction. Causes of abrupt changes include, but are not limited to, culverts, bridge piers and bridge abutments, fill encroachments such as directional dike and levees, and grade-control structures. Local scour is caused mainly by abrupt changes in both the direction and velocity of flow, which often sets up eddy currents that create localized scour. Local scour can best be accounted by a direct summation of the contribution of scour depths as shown in the equation below:

$$Z_L = Z_{CUL} + Z_{LB} + Z_{LE} + Z_{LGC} + Z_{SS} \qquad \text{(Equation 4.2.6.1)}$$

Where:

Z_{CUL} = Local scour due to the presence of a culvert, in ft;
Z_{LB} = Local scour due to the presence of bridge piers/abutments, in ft;
Z_{LE} = Local scour due to encroachments, in ft;
Z_{LGC} = Local scour due to the presence of a grade-control structure, in ft;
Z_{SS} = Local scour due to presence of a sanitary sewer in scour zone, in ft

4.2.6.1 Local Scour due to Culvert (Z_{CUL})

If a sanitary sewer crossing is located too close to the downstream side of a culvert—which shape may be circular, box, or other variations—the sanitary sewer may be impacted by local scour created by the jet of flow issuing from the culvert outlet. Accordingly, local scour due to culverts should be determined from the following equations for cohesionless soils, which were adapted and refined from procedures presented within the *City of Tucson Standards Manual for Drainage Design* (1989, and revised in 1998).

For a circular culvert flowing full:

$$Z_{CUL} = 0.5312\left(\frac{Q_{100}^{0.50}}{D^{0.25}}\right) \qquad \text{Applies when } D_{50} < 8 \text{ mm} \quad (0.315") \qquad \text{(Equation 4.2.6.1.1)}$$

Where, D equals the diameter of the culvert, in feet.

For a non-circular or partially-full culvert:

$$Z_{CUL} = 0.3897\left(\frac{Q_{100}^{0.50}}{A^{0.125}}\right) \qquad \text{Applies when } D_{50} < 8 \text{ mm} \qquad \text{(Equation 4.2.6.1.2)}$$

Where, A equals the cross-sectional area of flow, in square feet.

Likewise, the length, $L_{Z_{CUL}}$, and width, $W_{Z_{CUL}}$, of the scour hole created at the outlet of the culvert can be computed from the following equations.

For a circular culvert flowing full:

$$L_{Z_{CUL}} = 3.3667\left(\frac{Q_{100}^{0.62}}{D^{0.55}}\right)$$ Applies when $D_{50} < 8$ mm (Equation 4.2.6.1.3)

$$W_{Z_{CUL}} = 1.2487\left(\frac{Q_{100}^{0.89}}{D^{1.225}}\right)$$ Applies when $D_{50} < 8$ mm (Equation 4.2.6.1.4)

For a non-circular or partially-full culvert:

$$L_{Z_{CUL}} = 2.2884\left(\frac{Q_{100}^{0.62}}{A^{0.275}}\right)$$ Applies when $D_{50} < 8$ mm (Equation 4.2.6.1.5)

$$W_{Z_{CUL}} = 0.6820\left(\frac{Q_{100}^{0.89}}{A^{0.6125}}\right)$$ Applies when $D_{50} < 8$ mm (Equation 4.2.6.1.6)

Where, both length and width are in feet.

Figure 4 of this document is intended to be applicable to local scour at a drop, discussed under Section 4.2.6.4 of this document. However, for purposes of local scour at a culvert it can also be assumed that the longitudinal profile of the scour hole at a culvert outlet is identical to the longitudinal profile of the scour hole depicted in Figure 4. Parameters Z_{CUL} and L_{ZCUL} are therefore substituted for parameters Z_{lss} and L_s, shown in Figure 4, to determine the point Xsce where maximum scour terminates, which is located downstream one-half the length of the calculated culvert outlet scour, L_s. In addition, for design purposes it should be assumed that maximum scour, Z_{CUL}, occurs everywhere along the streambed between the brink of the culvert outlet and the point X_{sce}.

4.2.6.2 Local Scour due to Bridge Piers (Z_{LB}):

The local scour due to bridge piers is dependent upon the shape of the bridge pier. Due to the likelihood of debris on piers during flood events the following equation, originally derived for square-nosed shaped piers, should be used for local scour due to the bridge pier:

$$Z_{LB} = \left[2.2Y\left(\frac{b_{pe}}{Y}\right)^{0.65} F^{0.43}\right]$$ (Equation. 4.2.6.2.1)

$$b_{pe} = L\sin(\phi_p) + 1.5b_p\cos(\phi_p)$$ for $1.5b_p > 5$ (Equation 4.2.6.2.2)

$$b_{pe} = L\sin(\phi_p) + 5\cos(\phi_p)$$ for $1.5b_p \leq 5$ (Equation 4.2.6.2.3)

Where:

Z_{LB}	=	Local scour contribution due to bridge piers with a pier shape reduction factor of 1.0 included, in ft;
Y	=	Depth of flow, in ft;
F	=	Upstream approach Froude number; and
b_{pe}	=	Effective pier width, from Equation 4.2.6.1.2 or 4.2.6.1.3, in ft.
b_p	=	Physical pier width, in ft;
ϕ_p	=	Angle of approach flow to pier wall ($\Phi_p = 0°$ for cylindrical piers), in ft; and
L	=	Length of pier wall, in ft;

4.2.6.3 Local Scour due to Encroachments:

Local scour due encroachments projecting into the flow of a channel (see Figure 3, Page 11), such as, but not limited to, bridge abutments and fill projections, such as overbank levees, can be computed from the following equations. Note that the equation to be utilized is dependent upon the quantity L_e/Y. For large values of L_e/Y Equation 4.2.6.3.2 should be used.

$$Z_{LE} = 2.15\sin(\theta_a)Y\left(\frac{L_e}{Y}\right)^{0.4}F^{0.33} \qquad \text{If } \frac{Z_{LE}}{YF^{0.33}} < 4.0 \qquad \text{(Equation 4.2.6.3.1)}$$

$$Z_{LE} = 4YF^{0.33} \qquad \text{If } \frac{Z_{LE}}{YF^{0.33}} \geq 4.0 \qquad \text{(Equation 4.2.6.3.2)}$$

Where:

Z_{LE}	=	Local scour contribution from encroachments, in ft;
θ_a	=	Slope angle of encroachment face (measured from horizontal), in degrees;
L_e	=	Encroachment length (use caution determining embankment length), in ft;
F	=	Upstream Froude number; and
Y	=	Upstream depth of flow, in ft.

4.2.6.4 Local Scour at Drops (Z_{LD}):

Local scour immediately below channel drops can occur under two conditions. The first condition, say at a high-head grade-control structure, is a special case where the drop is a free, unsubmerged overfall. The second condition is where the drop is submerged, as will be the circumstance for most low-head drops comprised of grade-control structures placed across alluvial watercourses. Equation 4.2.6.4.1 should be used for the first condition, while the Equation 4.2.6.4.2 should be used for the second condition. Both equations are shown below.

$$Z_{LD} = 1.32q^{0.54}H_T^{0.225} - TW \qquad \text{If } \frac{h}{Y_1} \geq 1.0 \qquad \text{(Equation 4.2.6.4.1)}$$

$$Z_{LD} = 0.581q^{0.667}\left(\frac{h}{Y_1}\right)^{0.411}\left[1-\left(\frac{h}{Y_1}\right)\right]^{-0.118} \qquad \text{If } \frac{h}{Y_1} < 1.0 \qquad \text{(Equation 4 2.6.4.2)}$$

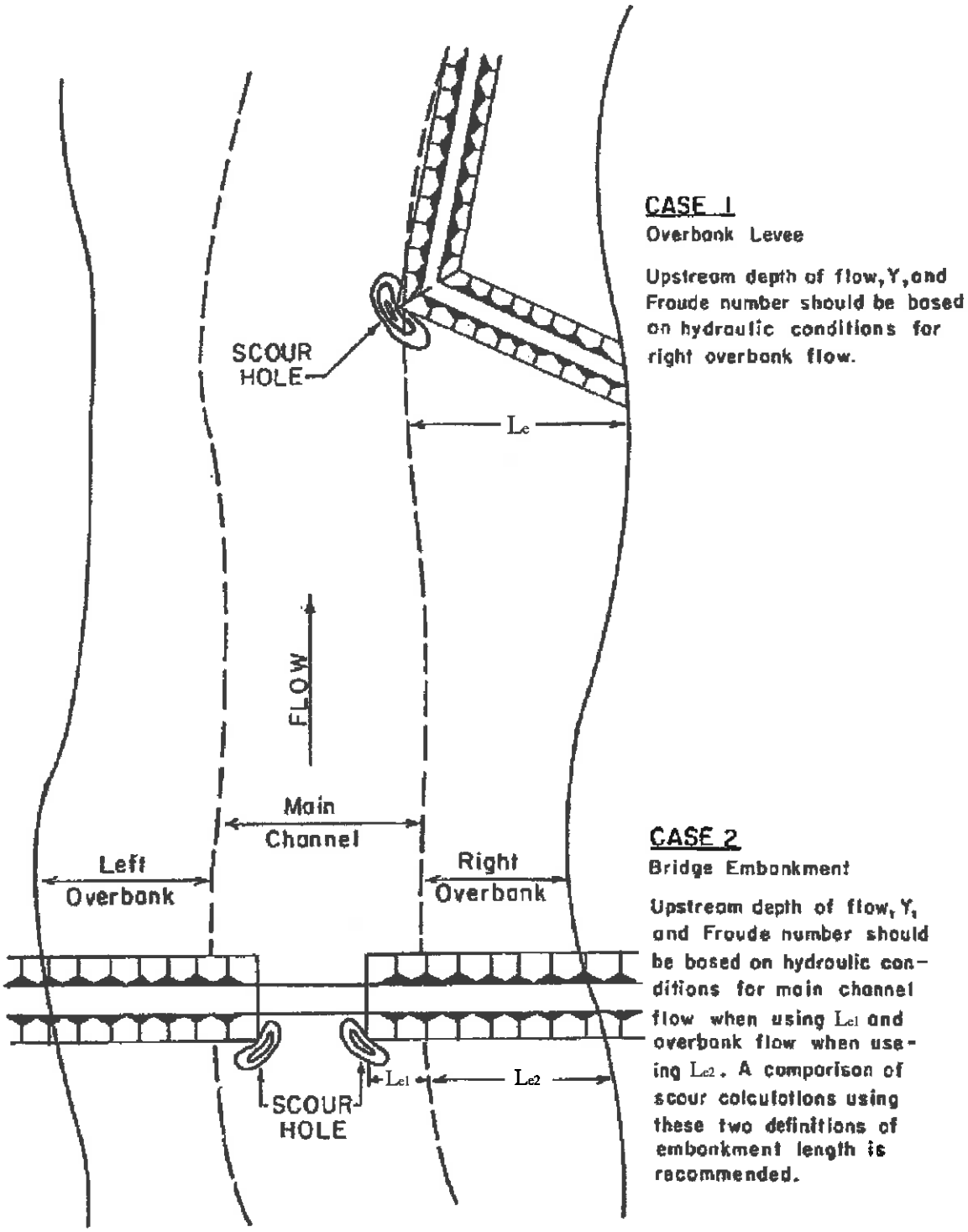

CASE 1
Overbank Levee
Upstream depth of flow, Y, and Froude number should be based on hydraulic conditions for right overbank flow.
SCOUR HOLE
Le
FLOW
Main Channel
Left Overbank
Right Overbank
CASE 2
Bridge Embankment
Upstream depth of flow, Y, and Froude number should be based on hydraulic conditions for main channel flow when using Le1 and overbank flow when using Le2. A comparison of scour calculations using these two definitions of embankment length is recommended.
Le1
Le2
SCOUR HOLE

FIGURE 3

Where:

Z_{LD}	=	Local scour contribution from drop (measured from thalweg downstream of control-point), in ft;
H_T	=	Total drop in head (measured as the difference between upstream and downstream energy grade lines), in ft (**normally, use the difference in WSELs, Y_1 - Y_2**);
Y_1	=	Upstream depth of flow, in ft;
Y_2	=	Downstream depth of flow = TW (tailwater), in ft;
F	=	Upstream Froude number;
h	=	Exposed height on downstream side of drop structure, in feet.

Figure 4, below, depicts the longitudinal profile of local scour that occurs immediately below a drop. For design purposes, it should be assumed that $L_s = 12Z_{lss}$, and that $X_{sce} = 6Z_{lss}$. In addition, for design purposes it should also be assumed that maximum scour, Z_{lss}, occurs everywhere along the streambed between the brink of the drop and the point X_{sce}.

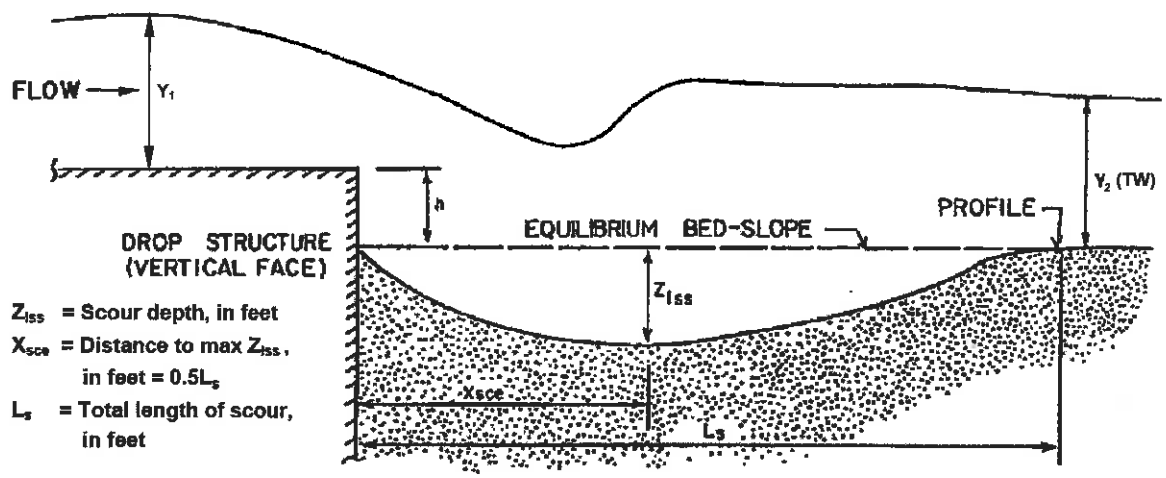


FIGURE 4

Note: If $0.85 < h/Y_1 < 1.0$, the predicted scour below a channel drop should also be computed using Equation 4.2.6.4.1. The smaller of the two values thus computed should then be used for design purposes. Figure 5, on the following page, depicts the longitudinal shape of a scour hole below an overfall.

4.2.6.5 Local Scour due to Sanitary Sewer in the Scour Zone:

The impact upon scour that the position of a sewer pipe has with respect to the streambed level; as well as the Froude number, F, of the approach flow, are two fundamental parameters that are used in the prediction of the final scour depth at a sanitary sewer crossing of an alluvial watercourse. This is because the smaller the clearance between the sewer pipe and the undisturbed streambed, the larger the influence the presence of the sewer pipe has on the scour depth. Variation of the scour depth as a function of the Froude number was presented in an

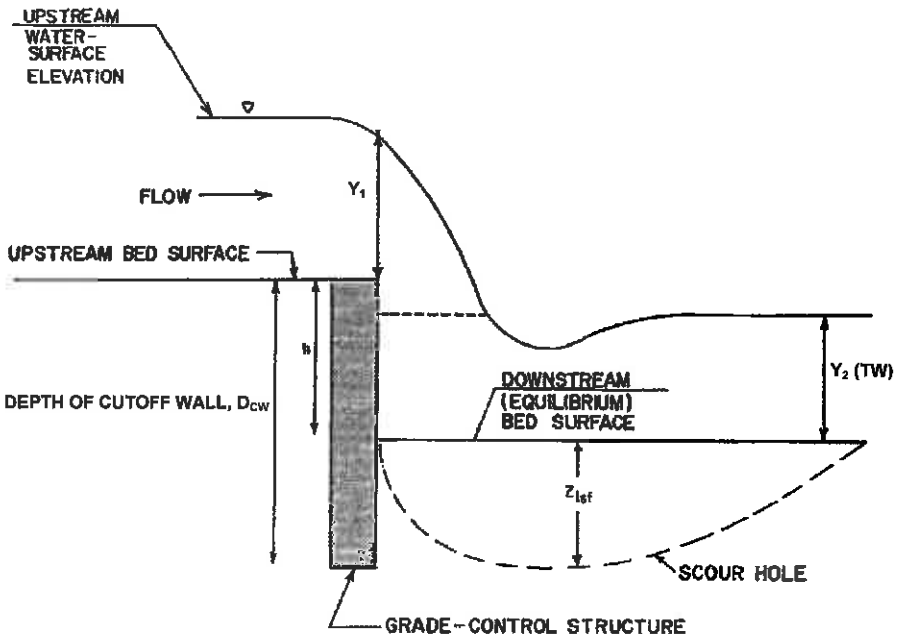


FIGURE 5

article published by Alix Moncada-M and Julian Aguirre-Pe in the *Journal of Hydraulic Engineering* in September of 1999. That published article discusses how the parameter Z_{SS}/D increases with an increase in the Froude number, F. Additionally, it was shown that an increment in the volume of removed material downstream of a sanitary sewer is produced when *e*/D increases, where "*e*" equals the initial gap between the sewer pipe bottom and the undisturbed erodible bed, in ft. Moreover, the maximum scour depth moves downstream of the sewer pipe when *e*/D increases. Equation 4.2.6.5.1 was formulated using a best-fit equation, with mean Froude numbers of 0.4, 0.6, and 0.8.

$$Z_{SS} = 2(DF)\text{sech}\left(1.7\frac{e}{D}\right) \qquad \text{(Equation 4.2.6.5.1)}$$

Where:

Z_{SS}	=	Local scour due to presence of sanitary sewer within the scour zone, in ft;
D	=	Effective diameter of sewer pipe, in ft = D_O + 4 (with debris pileup);
D_O	=	Outer diameter of sewer pipe, in ft;
F	=	Froude number; and
e	=	Initial gap between sewer pipe bottom and undisturbed erodible bed, in ft.

Note: If $e = 0$ and $F = 1.0$, $\frac{Z_{SS}}{D} = 2.0$.

4.3 Long-Term Degradation (Z_{LTD}):

Estimating long-term degradation along an alluvial watercourse can be an extremely difficult task to accomplish with reasonable accuracy. This document uses a procedure which is

a refinement to the long-term degradation methodology presented in Section 6.9 of the *City of Tucson Drainage Standards Manual*, which was published more than 20 years ago. Since that time, new techniques have been developed for determining long-term degradation—particularly with regard to the time necessary in order to achieve the amount of long-term degradation predicted. Under certain circumstances, application of a time factor can significantly reduce the amount of predicted long-term degradation. Generally, the procedure in this document assesses the long–term changes, based upon a specified dominant discharge within over specified project design life, that are predicted for riverbed slope as the alluvial watercourse approaches either an armoring or an equilibrium-slope (i.e., dynamic-equilibrium) condition.

The following three equations are recommended for computing estimates of long-term degradation along an alluvial watercourse. The first two equations, which are based upon the computed estimate of the needed time to achieve a stable slope (T_{ss}), should be used when a downstream control (such as a roadway or grade-control structure) exists, or if $D_a > D_{90}$, the particle size for which only 10 percent of the sediment sizes in the reach are larger, by weight.

$$Z_{LTD} = \frac{8}{13}(S_n - S_{eq})L_{dc} \qquad \text{for } T_{ss} < P_o \qquad \text{(Equation 4.3.1)}$$

$$Z_{LTD} = 1502.45\left[KV_{100}^{4.62}\frac{Q_{10}^{0.548}}{Q_{100}^{1.848}}W_{10}^{0.3}AC_{w,10}P_{10(n-hr)}R_sP_o(S_n - S_{eq})\right]^{1/2} \qquad \text{(Equation. 4.3.2)}$$

for $T_{ss} > P_o$

However, if D_a is less than the D_{90} particle size of the reach ($D_a < D_{90}$), then the following equation should be used to determine the limit of degradation, given the presence of armoring:

$$Z_{LTD} = \frac{(0.6562D_a)}{P_C} \qquad \text{(Equation 4.3.3)}$$

Where, in the preceding three (3) equations:

Z_{LTD}	=	Long term degradation, in feet;
A	=	Drainage Area, in square miles;
P_C	=	*Percent* of the material which is coarser that the armoring size;
Q_{10}	=	Discharge for the 10-year event, in cfs;
Q_{100}	=	Discharge for the 100-year event, in cfs;
S_n	=	Natural channel slope, in feet per foot;
S_{eq}	=	Equilibrium channel slope, in feet per foot;
L_{dc}	=	Estimated distance to downstream control; in feet
V_{100}	=	Channel velocity for the 100-year event, in feet per second;
$C_{w,10}$	=	Weighted runoff coefficient for a 10-year rainfall, dimensionless;
$P_{10(n-hr)}$	=	10-year rainfall over a n-hr storm duration, in inches;
P_o	=	Estimated time period over which streambed degradation will occur (i.e. the design life), in years;

R_s = Sediment reduction factor, in decimal format (i.e., 0.20)
T_{SS} = Estimated time to achieve a stable slope, in years;
W_{10} = Width of channel conveying the 10-year flood, in feet; and,

K = Sediment transport coefficient = $\dfrac{0.0064n^{1.77}G^{0.45}}{D_{50}^{0.61}}$

G = Gradation coefficient of sediment = $1/2\left[\dfrac{D_{50}}{D_{16}}\right]+1/2\left[\dfrac{D_{85}}{D_{50}}\right]$

In order to select the proper equation for calculating the long-term degradation for inclusion in Equation 4.3.1, the user must follow the step-by-step procedure described below to estimate the appropriate amount of long-term degradation.

Step 1: Determine the Equilibrium Slope

Compute the equilibrium slope (S_{eq}):

$$S_{eq} = \left(\left[\frac{Q_{u,10}}{Q_{n,10}}\right]^{-1.1}\left[1-R_S\right]^{0.7}\right)S_n \qquad \text{(Equation 4.3.4)}$$

Where:

S_{eq} = Equilibrium channel slope, in feet per foot;
S_n = Natural channel slope, in feet per foot;
$Q_{u,10}$ = 10-year peak discharge for *urbanized* conditions, in cfs;
$Q_{n,10}$ = 10-year peak discharge for *natural* conditions, in cfs; and
R_s = Sediment reduction factor for upstream sediment supply (i.e., the ratio of impervious area to total area [Example: urbanization, sand and gravel mining, detention/retention], varying from 0.0 to 1.0.

Where, typically, R_s = 0.15 for rural/suburban conditions and 0.5 for moderately to highly urban conditions; and,

Where, typically, $\left[\dfrac{Q_{u,10}}{Q_{n,10}}\right]^{-1.1}$ = 1.15 for rural/suburban conditions and = 1.50 for moderately to highly urban conditions.

Step 2: Determine Controlling Factor

Streambed Armoring

First, determine if long-term degradation is controlled by Streambed Armoring. To do this, calculate D_a (size of armoring material, in mm), from Equation 4.3.5:

$$D_a = 0.2659\left[\frac{V_{10}^{3.5}}{q_{10}^{0.5}}\right] \qquad \text{(Equation 4.3.5)}$$

D_a is assumed to be representative of the larger particles observed in the streambed. It should also be assumed that the D_a particle size is consistent with the D_{90} to D_{95} particle sizes in the streambed, and should be designated as the "default" streambed armoring size. In the absence of any sediment data, it should be assumed that D_{50} is 2 mm and that D_{90} is 13 mm (about 1/2 inch). However, a sediment analysis should be conducted in the event that there is evidence of possible D_a particle sizes which would better represent the potential armoring sediments that would be encountered within the study reach. If D_a is consistent with the D_{90} to D_{95} particle sizes in the study reach, then the following equation is to be used to determine the limit of degradation due to armoring:

$$Z_{LTD} = \frac{(0.6562D_a)}{P_C} \qquad \text{(Equation 4.3.3)}$$

Where:

Z_{LTD}	=	Limit of long term degradation due to armoring, in feet;
D_a	=	Size of the armoring material, in mm; and,
P_C	=	*Percent* of the material which is coarser that the armoring size.

If a downstream control exists, or if $D_a > D_{90}$ to D_{95} of the reach, then streambed armoring would not control. Under these circumstances, the following procedure should be applied:

Stable Slope

Determine long-term degradation controlled by Stable Slope using the following:

If the time to achieve the stable slope, T_{SS}, is less than the design life, P_o, of the project, that is if $T_{SS} < P_o$, use:

$$Z_{LTD} = \frac{8}{13}(S_n - S_{eq})L_{dc} \qquad \text{(Equation 4.3.1)}$$

If the time to achieve a stable slope is greater than the projected design life of the project, that is if $T_{SS} > P_o$, use the following simplified form of Equation 4.3.1 to determine Z_{LTD}, as appropriate:

$$Z_{LTD} = C_{LTD}\left[\frac{W_{10}^{0.3}}{Q_{10}^{0.376}}AP_o(S_n - S_{eq})\right]^{1/2} \qquad \text{(Equation 4.3.2A)}$$

For primarily *natural* conditions within the upstream contributing watershed (i.e., less than 10% imperviousness cover), use $C_{LTD} = 4.55$.

For primarily *rural* to *suburban* conditions within the upstream contributing watershed (i.e., from 10% to 30% imperviousness cover), use $C_{LTD} = 7.73$.

For essentially *moderately urban* to *highly urban* conditions within the upstream contributing watershed (i.e., more than 30% imperviousness cover), use $C_{LTD} = 13.99$.

The general equation to use for computing the time required to achieve a stable slope (T_{SS}) is:

$$T_{SS} = \left(\frac{1.6776 \times 10^{-7}}{R_S K}\right) \frac{(S_n - S_{eq}) L_{dc}^{\ 2} Q_{100}^{1.848}}{Q_{10}^{0.548} V_{100}^{4.62} W_{10}^{0.3} A C_{w,10} P_{10(n-hr)}} \qquad \text{(Equation 4.3.6)}$$

However, one may use the following simplified form of Equation 4.3.6 to determine T_{SS}, as appropriate:

$$T_{SS} = \frac{C_{TSS}(S_n - S_{eq}) L_{dc}^{\ 2} Q_{10}^{0.376}}{W_{10}^{0.3} A} \qquad \text{(Equation 4.3.6A)}$$

For primarily *natural* conditions within the upstream contributing watershed (i.e., less than 10% imperviousness cover), use $C_{TSS} = 0.0183$.

For primarily *rural* to *suburban* conditions within the upstream contributing watershed (i.e., from 10% to 30% imperviousness cover), use $C_{TSS} = 0.0063$.

For essentially *moderately urban* to *highly urban* conditions within the upstream contributing watershed (i.e., more than 30% imperviousness cover), use $C_{TSS} = 0.0019$.

Where:

Z_{LTD}	=	Long term degradation, in feet;
S_n	=	Natural channel slope, in feet per foot;
S_{eq}	=	Equilibrium channel slope, in feet per foot;
L_{dc}	=	Estimated distance to downstream control; in feet;
V_{100}	=	Flow velocity for the 100-year event, in feet per second;
P_o	=	Estimated time (i.e., the "design life" [typically 100 years]) over which streambed degradation will occur; in years;
T_{SS}	=	Estimated time to achieve a stable slope, in years;
Q_{10}	=	10-year peak discharge, in cfs;
Q_{100}	=	100-year peak discharge, in cfs;
K	=	Sediment property coefficient $= \dfrac{0.0064n^{1.77}G^{0.45}}{D_{50}^{0.61}}$;
A	=	Drainage Area, in square miles;
$C_{w,10}$	=	Weighted 10-year watershed runoff coefficient;
W_{10}	=	Channel top width, in feet; and
$P_{10(n\text{-}hr)}$	=	10-year, n-hr. rainfall depth, in inches;

Note that long-term degradation can be limited by downstream channel controls, as well as by streambed armoring, and can be influenced by several other factors as well—all of which can be extremely difficult to predict. Nevertheless, if applied properly the preceding relationships should provide a reasonable means of assessing long-term degradation trends which exist along watercourses which traverse less urbanized to highly urbanized watersheds in metropolitan Pima County.

V. Lateral-Migration Setback Requirements

Computation of *default* minimum setback distances along alluvial watercourses in metropolitan Pima County in order to account for lateral channel migration can be estimated from the product of an empirical coefficient times the square root of the 100-yr discharge. The procedure, below, is equivalent to applying a Level-1 analysis, as defined in the *City of Tucson Standards Manual for Drainage Design* (1989, and revised in 1998).

The following setback equations are for use with watercourses which have watershed drainage areas less than 30 square miles in size and (i.e., 100-year) peak discharge of less than 10,000 cfs (Q_{p100} < 10,000 cfs):

$$SB \geq 1.0\left(Q_{p100}\right)^{0.5} \quad \text{for } r_c / T \geq 10 \qquad \text{(Equation 5.1)}$$

$$SB \geq 1.7\left(Q_{p100}\right)^{0.5} \quad \text{for } 5 < r_c / T < 10 \qquad \text{(Equation 5.2)}$$

$$SB \geq 2.5\left(Q_{p100}\right)^{0.5} \quad \text{for } r_c / T \leq 5 \qquad \text{(Equation 5.3)}$$

Where:

SB = Minimum Setback, in feet, measured from the top edge of the highest channel bank or from the edge of the top of the 100-year water surface elevation, whichever is closer to the channel centerline;

Q_{p100} = Peak discharge of 100-year event, in cubic feet per second.

Note: The numerical value for r_c / T can be calculated by using Equation 4.2.4.4 of this Document.

For watersheds that are more than 30 square miles in size, a more specialized analysis of lateral migration and setback potential should be conducted by a qualified expert in the field of erosion and sedimentation.

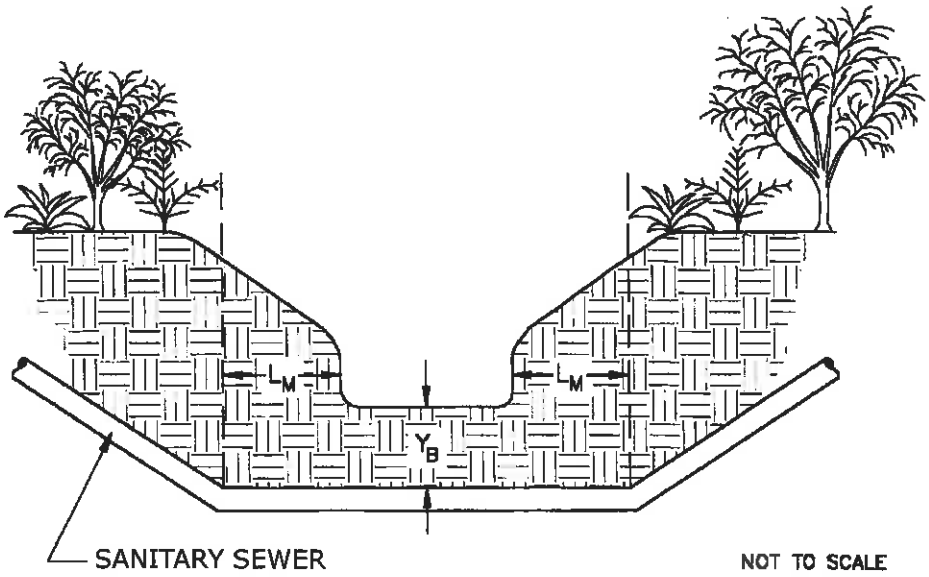
VI. ADDITIONAL DESIGN AIDS FOR SANITARY SEWER CROSSINGS OF ALLUVIAL WATERCOURSES

6.1 Determination of Sediment Particle Size

A precise determination of D_{50} should be accomplished via the collection of streambed sediments and performing a laboratory analysis to determine sediment gradation and plasticity index. However, a typical D_{50} for many washes in the metropolitan Pima County region is about 2 millimeters. It is for this reason that Tetra Tech separated applicable scour procedures into $D_{50} < 8$ mm and $D_{50} > 8$ mm—that is, to provide a simple visual means to recognize which equation was the most appropriate for use. In other words, because a D_{50} of 8 mm is about 1/3 of an inch in diameter, a diameter for which the presence of a preponderance of lesser diameter sediments in the streambed can easily be identified, such a demarcation should easily lead to the selection of the equation for use when $D_{50} < 8$ mm (which, as implied above, applies to the majority of the washes in metropolitan Pima County).

6.2 Vertical Alignment of Sanitary Sewer Crossing of Alluvial Watercourse

Once an estimate of total scour is determined using the procedures in this document, the vertical alignment of the sanitary sewer should be placed as indicated on Figure 6.



Y_B = BURIAL DEPTH, VARIES = Z_{MAX} + 2 ft
L_M = LATERAL MIGRATION LIMIT, VARIES
= SB (See Equations 5.1 - 5.3)

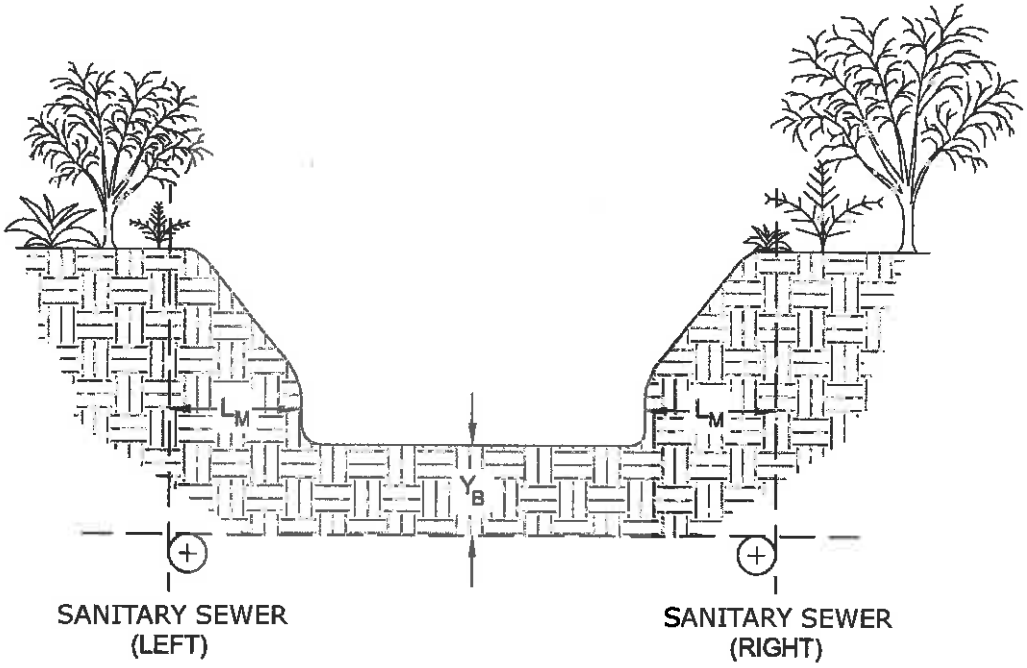
FIGURE 6

That is, the sanitary sewer should be placed at least 2 feet below the **maximum scour**, Z_{MAX}, (which includes long-term degradation); and, in the absence of permanent bank stabilization, should extend beyond each side of the stream channel a distance which equals or exceeds the predicted lateral-migration limits of the alluvial watercourse at the crossing location.

6.3 Horizontal Alignment of Sanitary Sewer Parallel to Alluvial Watercourse

Where a sanitary sewer is parallel and in close proximity to an alluvial watercourse which does not have permanent bank stabilization, the sanitary sewer should be located as shown in Figure 7.

NOT TO SCALE



Y_B = BURIAL DEPTH, VARIES = Z_{MAX} + 2 ft
L_M = LATERAL MIGRATION LIMIT, VARIES
= SB (See Equations 5.1 - 5.3)

Note: IF SANITARY SEWER IS BEYOND L_M, Figure 7 DOES NOT APPLY

FIGURE 7

That is, when a sanitary sewer is parallel and in close proximity to an alluvial watercourse, in the absence of permanent bank stabilization it should be placed at least 2 feet below the **maximum scour**, Z_{MAX}, whenever it is located within predicted lateral-migration limits.

6.4 Confluence Scour Geometry

Confluence scour geometry is characterized by steep slopes dipping downward from the upstream channels into a scour pool, which feathers out along a gently inclined bed slope which leads to a bar with a pronounced foreset slip face. Figure 8 illustrates.

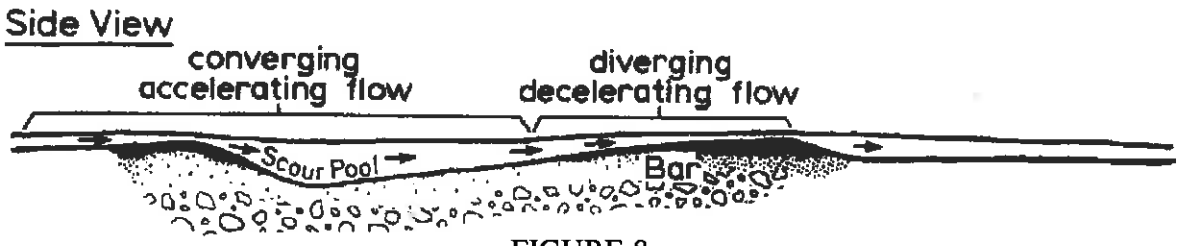


FIGURE 8

The approximate location of the scour pool can be defined as being immediately at and downstream of the confluence. See Figure 9.

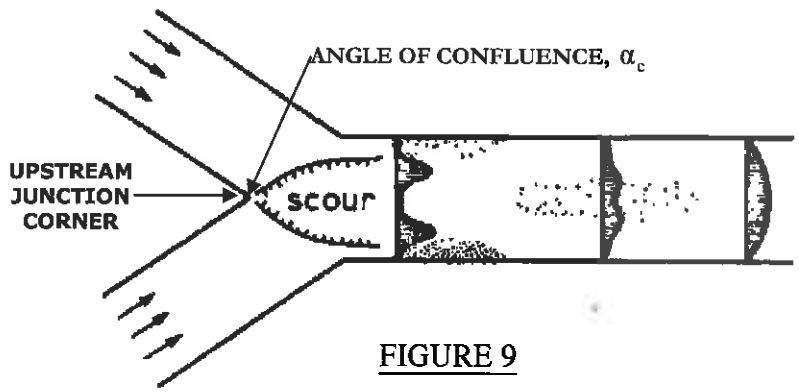


FIGURE 9

For design purposes, it should be assumed that the scour hole extends downstream from the upstream junction corner a distance equal to 2.5 times the bottom width, in feet, of the downstream channel. It is recommended that any sanitary sewer crossing of stay at lest this distance downstream of the confluence of an alluvial watercourse. If this is not possible, then for design purposes assume that the confluence scour component computed using Equation 4.2.5.1 applies everywhere within a region located 2.5 times the bottom width of the downstream channel, as measured from the upstream junction corner of the confluence.

6.5 Local Scour Geometries

Maximum local scour will occur at the locations defined for the applicable scour components presented in this document. In general, the local scour geometries for the various components can be described as follows:

6.5.1 Culvert Scour

The longitudinal profile of the scour hole will be as depicted in Figure 4, from which the contribution due to culvert scour at the point of the sanitary sewer can de determined, dependent upon the distance of the sewer pipe downstream from the brink of the culvert outlet. These criteria for culvert scour should be applied when placing a sanitary sewer across an alluvial watercourse.

6.5.2 Bridge Piers and Abutments

The shape of the scour hole created by bridge piers or by abutment scour should be assumed to be more or less consistent with that of a inverted truncated cone, with the base of the "cone" extending away from the pier or the abutment a distance equal to the depth of the computed scour component (i.e., pier scour or abutment scour). Upward from the base, it should be assumed that the sides of the scour hole everywhere slope at an angle of 3H:1V. Therefore the zone of influence of pier or abutment scour should be assumed to extend a distance of $4Z_{LB}$ from the outside diameter of the pier or from the face of the abutment. Maximum scour occurs 0.0 feet to Z_{LB} feet from the face of the pier or abutment, and then tapers off at a rate of 3H:1V until dissipating at a distance of $4Z_{LB}$ feet from the face of the pier or abutment. These criteria for bridge pier and abutment scour should be applied when placing a sanitary sewer across an alluvial watercourse.

6.5.3 Encroachments

Bridge abutments are one form of an encroachment structure for which the local scour geometry has been described in the preceding paragraph. Another type of encroachment, though, is a directional dike or levee. In general, the local scour geometry at the tip of a directional dike or levee is to be treated the same as the local scour geometry at bridge abutments. In such cases, though, Equation 4.2.6.3.2 should be applied to determine Z_{LE} if the length of the levee intercepting flow is such that $Z_{LE}/YF^{0.33} \geq 4.0$. See Figure 3. Along the riverside face of the levee, assume that the local toe scour is $2.2Y_{MAX}$, and that this scour depth extends Y_{MAX} feet from the face of the levee, tapering upward at 3H:1V and dissipating at a distance of $8.8Y_{MAX}$ feet from the face of the levee. These criteria for directional dikes and levees should be applied when placing a sanitary sewer across an alluvial watercourse.

6.5.4 Grade-Control Structure

Local scour geometry immediately downstream of a grade-control structure is generally as depicted in Figure 4 and Figure 5, from which the contribution due to grade-control-induced scour at the point of the sanitary sewer can de determined, dependent upon the distance of the sewer pipe downstream from the brink of the grade-control structure. These criteria for scour immediately downstream of a grade-control structure should be applied when placing a sanitary sewer across an alluvial watercourse.

6.5.5 Sanitary Sewer in Scour Zone

When a sanitary sewer is located within the scour zone of an alluvial watercourse (i.e., becomes exposed to the flow), the local-scour geometry is much like that formed in a bed of cohesionless material when flow issues from underneath a sluice gate. Figure 10 illustrates.

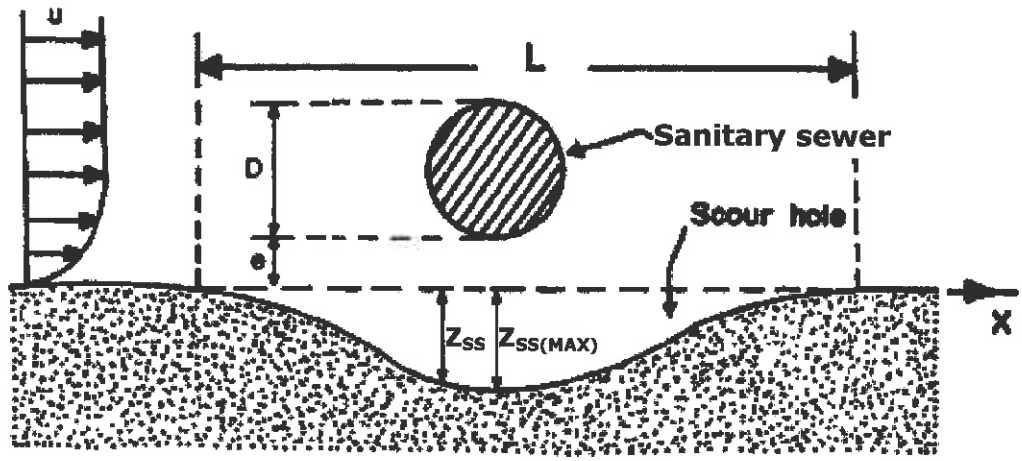


FIGURE 10

The length, L, of the scour hole illustrated in Figure 10 can be determined from the following relationship:

L= 9.2D, in feet.

Where:

L = Length of scour hole under sanitary sewer exposed to flow, in feet; and
D = Outer diameter of the Sanitary sewer, in feet.

For design purposes, it should be assumed that the maximum scour depth, $Z_{SS(MAX)}$, will occur directly under, and at the longitudinal midpoint of, the sanitary sewer. It should also be assumed that the scour-hole geometry will be symmetrically located upstream and downstream from the longitudinal midpoint of the sanitary sewer.

In addition, in the absence of a detailed HEC-RAS model, or similar backwater modeling analysis, a simple "rule-of-thumb" for selecting a Froude number to use in Equation 4.2.6.5.1 is to assume that F = 1.0 for all streambed slopes greater than 0.005 ft/ft, and that F = 0.7 for all streambed slopes less than 0.005 ft/ft. Otherwise, a backwater calculation (e.g., HEC-RAS) is required in order to determine a value for F.

6.5.6 Protection Measures

Sections 6.2 and 6.3 of this document provide guidance for both the vertical and horizontal locations of a sanitary sewer that will placed within or adjacent to the "zone of influence" of the various scour components that occur along alluvial watercourses. However, in those

circumstances where it is not possible to place the sanitary sewer below or beyond the "zone of influence" of these various scour components, mitigation measures to prevent scour can be designed. Examples of such mitigation measures are provided in Figures 11 and 12, below.

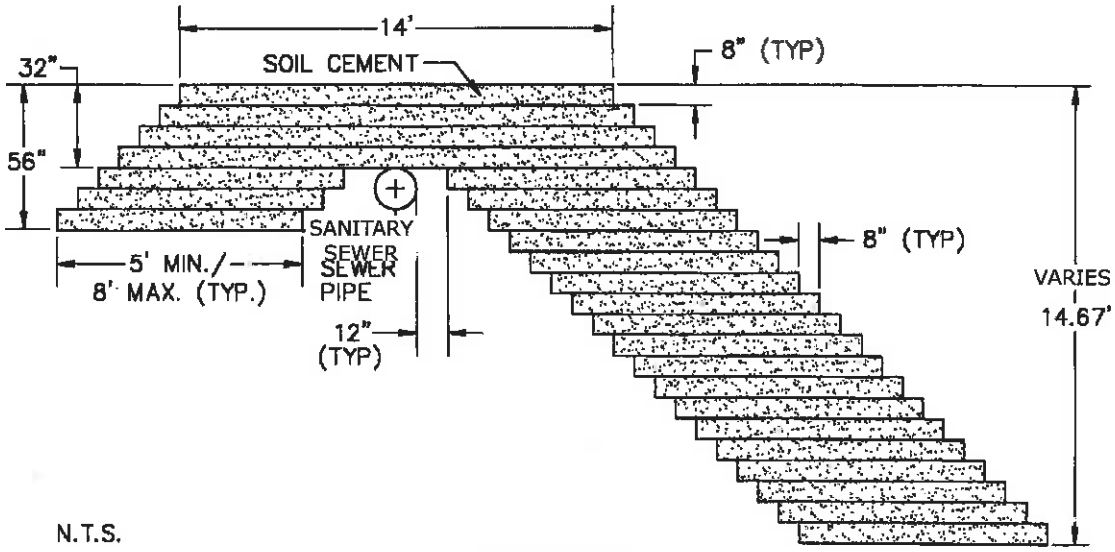


FIGURE 11

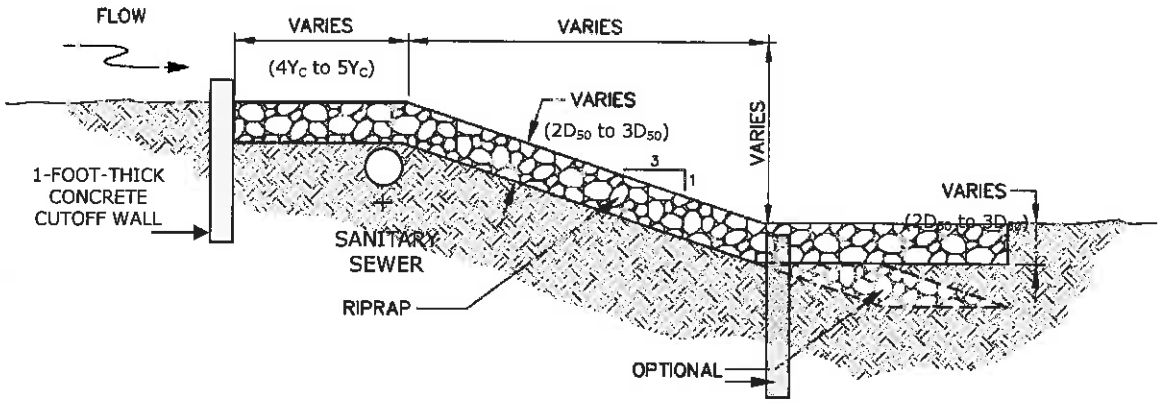


FIGURE 12

Note that Figure 11 depicts the use of a soil-cement grade-control "cap" to protect a sanitary sewer. However, this "cap" can just as easily be fabricated from roller-compacted concrete, from reinforced concrete, or from gabions. Although, based upon the durability of gabions in the metropolitan Pima County area, they should only be used if the sanitary sewer is to be "temporary" in nature (i.e., not expected to be in place more than 20 years). The thickness of materials other than soil cement should be determined when mitigation measures are designed.

Figure 12 depicts a riprap "cap" for protection of a sanitary sewer. However, the "cap" depicted in Figure 12 should only be used if the median diameter (D_{50}) of the riprap is large enough to resist scour along the alluvial watercourse. In general, the median diameter of the

riprap, in inches, can be computed using the relationship: $D_{50} = 5.543q^{0.529}S_c^{0.307}$, where q = unit discharge (including C_U, from Table 3 of this document), and S_c = channel slope.

Another method of mitigating scour at sanitary sewer crossings of alluvial watercourses would be to encase the sewer pipe in concrete and fix the line on piling. If such measures were undertaken, though, when computing scour the piles would need to be treated as if they were bridge piers, with debris pileup (see section 4.2.6.2 of this document); and the sewer pipe, also with debris pileup, would need to be considered as located within the scour zone (see Section 4.2.6.5 of this document).

6.5.7 Manholes

Manholes should be treated as if they are independent bridge piers, and the appropriate scour components should be calculated, accordingly. Debris pileup should be included when determining the width of a manhole for purposes of calculating total scour. In addition, if the manhole is located inside the lateral-migration (setback) limits of an alluvial watercourse, then when calculating scour components it should be assumed that the channel can migrate over to the manhole and expose it to the full force of the channel flow.

6.5.7.1 Maximum Scour

Manholes should be treated as if they are independent bridge piers, and the appropriate scour components should be calculated, accordingly. Debris pileup should be included when determining the width of a manhole for purposes of calculating total scour. In addition, if the manhole is located inside the lateral-migration (setback) limits of an alluvial watercourse, then when calculating scour components it should be assumed that the channel can migrate over to the manhole and expose it to the full force of the channel flow.

If manholes are not protected by either revetment along the channel banks or revetment measures within the immediate vicinity of the structure, the maximum total scour to be expected below the channel bed, at the base of the manhole, can be computed from the following relationships:

$$Z_{MAX} = Z_{TSE} + Z_{LTD} \qquad \text{Where, } Z_{MAX} \leq 5Y_{MAX} \qquad \text{(Equation 4.1.1)}$$

$$Z_{MAX} = 5Y_{MAX} \qquad \text{Where, } Z_{MAX} > 5Y_{MAX} \qquad \text{(Equation 4.1.2)}$$

Where the variables, above, are as defined in Section 4.1 of this Scour Procedures and Guidelines Document.

6.5.7.2 Forces on Manhole

The fluid forces which comprise the total lateral loading on an individual manhole during a design flood are (1) the hydrostatic force; (2) the hydrodynamic force; and (3) the impact force. These fluid forces, expressed in lbs, can be computed by use of the following equations:

$F_S = 1/2\gamma B(Y_{mh} + Z_{MAX})^2$ = hydrostatic force (Equation 6.5.7.2.1)

$F_D = 1/2\rho_s C_D[B_{mh}(Y_{mh} + Z_{MAX})](V_{mh})^2$ = hydrodynamic force (Equation 6.5.7.2.2)

$F_I = 71.532V\sqrt{W_O}$ = impact force (Equation 6.5.7.2.3)

and,

$F_{TOT} = F_S + F_D + F_I$ = maximum lateral-loading on manhole (Equation 6.5.7.2.4)

Where,

B	=	Width of manhole normal to flow, including debris, in feet (assume = a minimum of 2 feet of debris extending beyond each side of manhole)
Y	=	Depth of flow above the streambed at the manhole, in ft
Z_{MAX}	=	Maximum depth of scour below the streambed at the manhole, in ft
V	=	Velocity of flow at the manhole, in ft/sec
C_D	=	Fluid drag coefficient = 1.25
ρ_s	=	Fluid density = γ_{ws}/g = 1.94 slugs
γ	=	Unit weight of water + sediment = 68.6 lbs/ft^3 (assume = $1.1\gamma_w$) and,
γ_w	=	Unit weight of water = 62.4 lbs/ft^3
g	=	Acceleration due to gravity = 32.2 ft/sec/sec
W_O	=	Weight of floating object/debris, in lbs, (assume = 500 lbs)

Accordingly, substituting the assumed vales as indicated above, the total lateral loading on a manhole, in lbs, can be determined from:

$F_{TOT} = 31.2B(Y_{mh} + Z_{MAX})^2 + 1.2[B_{mh}(Y_{mh} + Z_{MAX})](V_{mh})^2 + 1600(V_{mh})$ Equation (6.5.7.2.5)

In Equation 6.5.7.2.5, when applicable it should be assumed that V_{mh}, the velocity of flow at the manhole, is what would be expected in the absence of bank revetment and after lateral migration of the channel exposes the manhole to the full force of the primary flow path. Note that if flow velocities are high enough, impact forces can exceed the sum of the hydrostatic and hydrodynamic forces on manholes directly exposed to primary channel flows.

The preceding equations are all based upon the assumption that the manhole top is, in all cases, elevated above the water-surface elevation of the design flood; or, in other words, always above the depth of flow (Y_{mh}). Should this not be the case, then Z_{max} should be recalculated accordingly. That is, the parameter Y (for flow depth) used in the applicable local-scour equations found in Section 4.2.6 of this document should be adjusted downward to represent the flow depth that comes into contact with the manhole above the streambed prior to any single-event scour, which should include any exposure of the manhole that is predicted to occur due to long-term channel degradation.

6.5.7.2 Nonuniform Flow Distribution

It is important to recognize that, just as is the case when computing maximum scour depth, nonuniform flow distribution is likely to occur at and in the vicinity of a manhole exposed to a primary flow path. Accordingly, when using Equation 6.5.7.2.5 to compute total lateral

loading, appropriate safety factors must be incorporated to account for nonuniform flow. When computing the depth of flow at the manhole, the maximum value should be measured from the lowest anticipated (future) thalweg, and must include superelevation, where applicable. When computing the velocity of flow at the manhole, a minimum safety factor of not less than 1.3 ($1.3V_{avg}$) should be used. A value as high as 1.6 ($1.6V_{avg}$) should be considered for use along natural channels, or areas where braided flow conditions exist.

6.5.7.3 Debris Structure or Independent Fender System

When a debris structure or independent fender system is placed upstream of a manhole that is located within a primary flow path (i.e., is located in the middle of the channel or is in an area that has become exposed due to lateral channel migration), it is unnecessary to design for debris forces and, depending upon the design of the structure or fender, may also be unnecessary to design for impact forces. However such a structure, if installed, must be designed to withstand the lateral forces and maximum scour anticipated to occur at its location during passage of the design flood. In this regard, Equation 6.5.7.2.5 is also applicable for determining the lateral loading on a protective debris structure or independent fender system installed upstream of a manhole.

The design of debris structures or independent fender systems is beyond the scope of this Scour Procedures and Guidelines Document; however, an excellent reference for the design of debris structures is:

U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 9 (HEC-9), *"Debris Control Structures, Evaluation and Countermeasures, Third Edition,"* Publication No. FHWA-IF-04-016, October 2005, and can be found online at:

http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=9&id=23

6.5.8 Recommendation

The "safest" way to prevent scour impacts at a sanitary sewer and any attendant manholes is to place the sanitary sewer below the predicted maximum total scour (including any predicted long-term degradation) and also place the alignment of the sewer and any attendant manholes beyond the predicted lateral-migration (setback) limits of the alluvial watercourse (see Sections 6.2 and 6.3 of this document).

PIMA COUNTY
WASTEWATER RECLAMATION

APPENDIX B
DESIGN GUIDELINES FOR SIPHONS

Engineering Design Standards

Appendix
B

Design Guidelines for Siphons

Special Approval, by the Director or his/her delegate, shall be obtained prior to proceeding with the design of a Public Sewer siphon. The Design Engineer should contact the Department as early as possible to review and discuss the need for a siphon. Siphons will be considered on a case-by-case basis and when no other practical method for avoiding obstacles is feasible. Cost will not be the sole consideration for allowing a siphon. If Special Approval is granted, the design of a siphon shall conform to the requirements of AAC R18-9-E301(D)(6) and the following Department guidelines:

B1. Use a minimum of 3 siphon lines, each with varying diameters (6 inches minimum), to maximize velocities and meet the capacity needs.

B2. Each siphon line shall be uniform in diameter and in horizontal alignment. Vertical bends shall be limited to 45 degrees at the bottom of the siphon lines. Siphon lines shall not be curvilinear and shall allow for the installation of a rigid vacuum hose to the bends at the bottom of the siphon line.

B3. The depth of cover for siphon lines shall conform to Subsection 5.1.11(A). The Department may allow a modification of the elevation difference between the inlet and outlet hydraulic grade lines if excessive depths will have an adverse impact on the downstream sewer.

B4. For flood-prone areas, the design of siphon manholes shall conform to Subsection 5.2.11.

B5. Maintenance vehicle access to the siphon manholes shall conform to Subsections 7.5, 7.6 and 7.7. In addition, maintenance access shall provide for a combo-cleaner truck to be positioned as necessary to reach the bends at the bottom of the siphon line with a rigid vacuum hose from both ends.

B6. Siphon manholes shall be designed to allow for maintenance personnel to enter/exit the manhole, and perform shoveling and debris-clearing activities from within the manhole during hydraulic vacuuming operations.

B7. The interior of the siphon manholes shall be coated or lined in accordance with *Standard Specifications and Details* Subsection 3.3.3(B)(viii) to protect them from corrosion. Refer to the Department's List of Approved Products for the recommended coating and lining manufacturers.

B8. Two double-leaf hatches, secured with an Approved locking system, shall be installed at each siphon manhole and positioned to allow for maintenance access as described in B4 and B5.

B9. Redwood isolation gates, per S.S.D. RWRD-228, shall be provided for each siphon line, at both ends.

B10. A vent assembly per S.D. RWRD-223 or -224 shall be provided at each siphon manhole.

B11. In cases where an air jumper pipe can be constructed in lieu of a vent assembly, the cross sectional area shall not be less than 50 percent of the combined cross section of the siphon pipes. The air jumper pipe shall be located where it will be self-draining under all operating conditions and protected from damage.

B12. Design provisions for odor control facilities will be determined on a case-by-case basis.

B13. A Design Report for the siphon facility shall be sealed by an Arizona Registered P.E. (Civil) and submitted to the Department for review and Approval. Design Report shall include an analysis that shows the siphon will provide for cleansing velocities and will not surcharge the inlet sewer.