Table of Contents

Chapter I

Introduction to Wastewater Collection

1.1	The Waste	water	Collection	System
	Operator	2		

- 1.1.1 What Is a Wastewater Collection System? 2
- **1.1.2** Why Is Operation and Maintenance of Wastewater Collection Systems Important? 2
- **1.1.3** Working as a Collection System Operator 5
 - **1.1.3.1** Who Hires Collection System Operators? 5
 - **1.1.3.2** Where Do Collection System Operators Work? 5
 - 1.1.3.3 What Pay Can a Collection System Operator Expect? 6
- **1.1.4** What Does It Take to Be a Collection System Operator? 6
- **1.1.5** Preparing Yourself for the Future 7
 - 1.1.5.1 Qualifications 7
 - 1.1.5.2 Job Outlook 7
 - 1.1.5.3 Your Personal Training Course 7
 - 1.1.5.4 Certification and Continuing Education 8

1.2 Collection System Operation and Maintenance 9

- **1.2.1** Overview of O&M Challenges 9
- **1.2.2** Why Wastewater Collection Systems Were Built 10
- **1.2.3** Need for Collection System O&M 12
- **1.2.4** Proposed SSO Rule and CMOM Program 12
- **1.2.5** Costs of a Wastewater Collection System 14
- **1.2.6** Need for Wastewater Collection System Operators 16

Chapter Review 17

Chapter 2

Wastewater Collection Systems: Purpose, Components, and Design

2.1 Introduction 22

2.2 Purpose 22

2.3 Quantity of Wastewater 23

- 2.3.1 Design Period 23
- **2.3.2** Design Flows 24
- **2.3.3** Sample Design Flow Calculation 26
- **2.3.4** Flow Measurement 27
- **2.3.5** Flow Variations 31

2.4 Components 33

- 2.4.1 Gravity Collection System 33
- **2.4.2** Low-Pressure Collection System 35
- **2.4.3** Vacuum Collection System 36
- **2.4.4** Appurtenances 40

2.5 Design 51

- **2.5.1** Layout 52
- **2.5.2** Field Surveys 52
- **2.5.3** Slope and Size 55
- **2.5.4** Velocity and Flow 56
- **2.5.5** Location and Alignment 58
- **2.5.6** Depth 59
- **2.5.7** Pipe Materials 60
 - 2.5.7.1 Rigid Pipe 61
 - 2.5.7.2 Flexible Pipe 63
- **2.5.8** Pipe Joints 67
- **2.5.9** Manhole Materials 71

2.6 Plan and Profile 72

3.3.9.2 Transition Area 106

2.7 Design Review 72	3.3.9.3 Activity Area 106
2.7.1 Office Study 72	3.3.9.4 Termination Area 107
2.7.2 Field Investigation 72	3.3.9.5 Tapers 107
	3.3.10 Pedestrian Safety 110
2.7.3 Design Items Influencing Maintenance 72	3.3.11 Worker Safety 112
2.7.4 Communication 74	3.3.11.1 Speed Limits in Work Zones 115
2.7.5 Construction, Testing, and Inspection 75	3.3.11.2 Flagger Control 116
2.8 Practical Math 75	3.3.12 Using Temporary Traffic Control Zone Devices 119
2.8.1 Population Equivalent 75	3.3.12.1 Signs 121
2.8.2 Velocity and Flow 77	3.3.12.2 Portable Changeable Message Signs 128
Chapter Review 83	3.3.12.3 Arrow Boards 129
	3.3.12.4 High-Level Warning Devices 129
Chapter 3	3.3.12.5 Channelizing Devices 130
Safe Procedures	3.3.12.6 Traffic Cones 131
Sale Procedures	3.3.12.7 Tubular Markers 131
3.1 Perform Your Duties Safely 88	3.3.12.8 Vertical Panels 131
	3.3.12.9 Drums 133
3.2 Vehicle Operation and Safety 89	3.3.12.10 Barricades 133
3.2.1 Vehicle and Equipment Inspection Procedures 89	3.3.12.11 Lighting Devices 133 3.3.12.12 Flashing Yellow Vehicle Lights 134
3.2.2 Defensive Driving 91	5.5.12.12 Plashing Tenow Vehicle Lights 154
3.2.2 Detensive Driving /1	
	3.4 Confined Space Hazards 134
	3.4 Confined Space Hazards 1343.4.1 Confined Spaces 135
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94	-
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94	3.4.1 Confined Spaces 135
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94	3.4.1 Confined Spaces 1353.4.2 Atmospheric Hazards 136
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95	3.4.1 Confined Spaces 1353.4.2 Atmospheric Hazards 1363.4.3 Mechanical and Electrical Hazards 142
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway Work 102	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for Confined Space Entry 146
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway Work 102 3.3.8.1 Time of Work 102 3.3.8.2 Specific Situations 103 3.3.8.3 Partial Street or Highway Closures 103	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for Confined Space Entry 146 3.5.1 Respiratory Protection 147
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway Work 102 3.3.8.1 Time of Work 102 3.3.8.2 Specific Situations 103 3.3.8.3 Partial Street or Highway Closures 103 3.3.8.4 Complete Street or Highway Closures	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for Confined Space Entry 146 3.5.1 Respiratory Protection 147 3.5.2 Safety Harness with Lifeline, Tripod, and Winch 151 3.5.3 Portable Atmospheric Alarm Unit 153
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway Work 102 3.3.8.1 Time of Work 102 3.3.8.2 Specific Situations 103 3.3.8.3 Partial Street or Highway Closures 103	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for Confined Space Entry 146 3.5.1 Respiratory Protection 147 3.5.2 Safety Harness with Lifeline, Tripod, and Winch 151 3.5.3 Portable Atmospheric Alarm Unit 153 3.5.3.1 Diffusion-Type Sensing Element 156
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway Work 102 3.3.8.1 Time of Work 102 3.3.8.2 Specific Situations 103 3.3.8.3 Partial Street or Highway Closures and Detours 103 3.3.8.5 Emergency Situations 103	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for Confined Space Entry 146 3.5.1 Respiratory Protection 147 3.5.2 Safety Harness with Lifeline, Tripod, and Winch 151 3.5.3 Portable Atmospheric Alarm Unit 153 3.5.3.1 Diffusion-Type Sensing Element 156 3.5.3.2 Catalytic Sensing Element 156
3.2.3 How to Charge a Battery 92 3.3 Working in Streets 94 3.3.1 Need for Temporary Traffic Control 94 3.3.2 Major Temporary Traffic Control Considerations 95 3.3.3 Fundamental Principles 96 3.3.4 Definitions 96 3.3.5 Individuals Qualified to Control Traffic 101 3.3.6 Permission to Work within the Right-of-Way of Streets or Highways 101 3.3.7 General Responsibilities 102 3.3.8 Regulations Concerning Street or Highway Work 102 3.3.8.1 Time of Work 102 3.3.8.2 Specific Situations 103 3.3.8.3 Partial Street or Highway Closures and Detours 103 3.3.8.5 Emergency Situations 103	 3.4.1 Confined Spaces 135 3.4.2 Atmospheric Hazards 136 3.4.3 Mechanical and Electrical Hazards 142 3.4.4 Engulfment Hazards 142 3.4.5 Physical Injuries 143 3.4.6 Drowning 144 3.4.7 Infections and Diseases 144 3.4.8 Insect, Bug, Rodent, and Snake Bites 145 3.4.9 Toxicants 145 3.5 Safety Equipment and Procedures for Confined Space Entry 146 3.5.1 Respiratory Protection 147 3.5.2 Safety Harness with Lifeline, Tripod, and Winch 151 3.5.3 Portable Atmospheric Alarm Unit 153 3.5.3.1 Diffusion-Type Sensing Element 156

3.5.3.5 Alarm Set Points 157	3.9.3 Explosive Atmospheres 197
3.5.3.6 Calibration 158	3.9.4 Lockout/Tagout Procedure 198
3.5.4 Ventilation Blower with Hose 159	3.9.4.1 Sequence of Lockout/Tagout System
3.5.5 Manhole Enclosure 160	Procedures 199
3.5.6 Ladders 160	3.9.4.2 Restoring Machines or Equipment to Normal Production Operations 199
3.5.7 Ropes and Buckets 161	3.10 Working near Noise 200
3.5.8 Head, Hands, Feet, and Body Protection 162	one woming noon women noon
3.5.8.1 Skin Protection 162	3.11 Firefighting 203
3.5.8.2 Head Protection 163	
3.5.8.3 Foot Protection 163	3.12 Hazard Communication Standard
3.5.8.4 Hand Protection 163	and Worker Right-To-Know Laws 204
3.5.9 Protective Clothing 164	201
3.5.10 Other Equipment and Procedures 165	3.13 Additional Resources 216
3.6 Final Precautions Before Manhole Entry 166	Charter Persieur 217
3.6.1 Health Conditions of Operators 166	Chapter Review 217
3.6.2 Required Tools, Materials, and	Chapter 4
Equipment 166	Inspecting and Testing Collection Systems
3.6.3 Briefing 166	
3.7 Procedures During Manhole Entry 167	4.1 Reasons for Inspecting and Testing 224
3.7.1 Confined Space Work Procedures 167	4.2 Inspecting Collection Systems 224
3.7.2 Operations of Manhole Entry 172	4.2.1 Types of Collection System Problems 224
3.7.3 While Operator Is in the Manhole 175	4.2.2 Infiltration and Inflow 226
3.7.4 Special Problems of Manhole Work 175	4.2.2.1 Detection and Correction of Inflow 226
3.7.5 After Leaving Manhole 176	4.2.2.2 Detection and Correction
3.7.6 Responsibility for Safety 176	of Infiltration 227
	4.2.2.3 Exfiltration 228
3.8 Excavation and Shoring 177	4.2.2.4 Repair Costs 228
3.8.1 Excavation 177	4.2.2.5 Controlling Infiltration/Inflow from Private Property 229
3.8.1.1 Safety Rules 178	
3.8.1.2 Locate Underground Utilities Before	4.3 Manhole Inspections 229
You Dig 178	4.3.1 Equipment and Staffing Requirements 230
3.8.2 Shoring 181	4.3.1.1 Equipment 230
3.8.2.1 Typical Shoring Requirements 182	4.3.1.2 Staffing 230
3.8.2.2 Responsibility at the Job Site 183	4.3.2 Frequency 231
3.8.2.3 Placing of Spoil 184	4.3.3 Procedure 233
3.8.2.4 Typical Shoring Regulations 184	
3.8.2.5 Types of Shores 185 3.8.2.6 Avoiding Trench Cave-Ins 189	4.4 Closed-Circuit Television Inspections 235
J.O.2.0 Avoluing Trench Cave-Ins 189	4.4.1 Inspection Program Basics 237
3.9 Electricity 190	4.4.2 Types of CCTV Inspection Systems
3.9.1 Hazards 193	and Equipment 239
3.9.2 Safety Precautions and Safe Procedures 195	4.4.2.1 Conventional CCTV Inspection Systems 239

4.4.2.2 Self-Propelled Transporters 240	Chapter 5
4.4.2.3 Winches 242	Pipeline Cleaning and Maintenance
4.4.2.4 Lateral-Launched Cameras 245	Methods
4.4.2.5 Portable and Small-Diameter Pipe Inspection Systems 247	5.1 Identifying Problems and Selecting Solutions 302
4.4.2.6 Digital Scanning 248	bolulions ocz
4.4.2.7 Zoom Cameras 249	5.1.1 Identifying Problems 303
4.4.2.8 Other Pipe Inspection	5.1.1.1 Types of Stoppages 303
Technologies 250 4.4.2.9 Technology Selection 254	5.1.1.2 Identifying Causes of Stoppages and Problems 304
4.4.3 Purposes of Televising Collection Systems 255	5.1.2 Methods for Cleaning and Maintaining Sewers 305
4.4.4 Using CCTV Inspection Information 256	5.1.3 Solutions to Common Problems 306
4.4.5 Equipment and Staffing Requirements 256	5.1.4 Emergency Cleaning 306
4.4.5.1 Equipment 256	5.1.5 Work Assignments 308
4.4.5.2 Staffing 257	5.1.6 Records 308
4.4.6 Procedure 259	5.1.7 Notifying the Downstream Wastewater Treatment
4.4.6.1 Logging and Recording Television Inspections 263	Plant 309
4.4.6.2 TV Log Sheet 268	5.2 Hydraulic Cleaning 309
4.4.6.3 CCTV Camera Operating Problems and Solutions 270	5.2.1 High-Velocity Cleaners 310
4.4.6.4 Shutting Down After Completing the Pipe Run 275	5.2.1.1 Personnel and Equipment 3105.2.1.2 Selecting a Nozzle 315
4.4.6.5 Final Check of Television Survey and	5.2.1.3 Equipment Setup 317
Footage Test 275	5.2.1.4 Cleaning Operation 319
4.4.6.6 Equipment Removal and Cleanup 277	5.2.1.5 Precautions and Safety 321
4.4.7 Maintenance of CCTV Equipment 278	5.2.2 Kites, Bags, and Poly Pigs 323
4.4.8 Summary 280	5.2.3 Scooters 326
4.5.00	5.2.3.1 Personnel and Equipment 327
4.5 Smoke Testing 280	5.2.3.2 Equipment Setup 328
4.5.1 Staffing and Equipment Requirements 282	5.2.3.3 Cleaning Operation 329
4.5.2 Advance Preparation 284	5.2.3.4 Precautions and Safety 331
4.5.3 Procedure 286	5.3 Mechanical Cleaning 332
4.5.4 Observing and Recording Smoke 288	5.3.1 Power Rodders 332
4.5.4.1 Smoke in Unoccupied	5.3.1.1 Classification 333
Buildings 288	5.3.1.2 Personnel and Equipment 335
4.5.5 Other Considerations 291	5.3.1.3 Sewer Rodding Tools 335
4 / Drea Tarking 200	5.3.1.4 Equipment Setup 338
4.6 Dye Testing 292	5.3.1.5 Tool Selection and Operation 339
4.6.1 Equipment and Staffing Requirements 292	5.3.1.6 Recovering Broken Rods 344
4.6.2 Procedure 292	5.3.1.7 Precautions and Safety 345
4.6.2.1 Examples of Dye Testing Operations 293	5.3.1.8 Maintenance of Rods and Equipment 346
	5.3.2 Hand Rods 347
Chapter Review 296	5 3 2 1 Personnel and Equipment 349

5.3.2.2 Equipment Setup 349 5.3.2.3 Operation 352 5.3.2.4 Precautions and Safety 353	5.6.2.4 Air Treatment and Air Flow Control 390 5.6.2.5 Sewer Construction and Repair 392
5.3.3 Power Bucket Machines 354	5.6.2.6 Monitoring 393
5.3.3.1 Personnel and Equipment 358	5.6.3 Summary 393
5.3.3.2 Equipment Setup 359 5.3.3.3 Operation 361	5.7 Corrosion Control Measures 394
5.3.3.4 Precautions and Safety 364	5.7.1 How Corrosion Relates to Hydrogen Sulfide 394
	5.7.2 Controlling Hydrogen Sulfide Through Design
5.4 Cleaning Equipment Maintenance 365	and Prevention 394
5.4.1 HVC Maintenance 366 5.4.1.1 Tools 366 5.4.1.2 Daily Maintenance 366 5.4.1.3 Cold Weather Maintenance 366 5.4.2 Rodding Machine Maintenance 367 5.4.2.1 Tools 367 5.4.2.2 Sectional Rodder 367 5.4.2.3 Continuous Rodder 368 5.4.2.4 Hydraulic Unit on Rodding Machine 368 5.4.3 Bucket Machine Maintenance 368 5.4.3.1 Tools 368 5.4.3.2 Procedures 369 5.4.4 Equipment Engine Maintenance 369	5.7.3 Chemical Control of Hydrogen Sulfide 395 5.7.3.1 Chlorine 396 5.7.3.2 Hydrogen Peroxide 397 5.7.3.3 Pure Oxygen 398 5.7.3.4 Air 399 5.7.3.5 Lime 399 5.7.3.6 Sodium Hydroxide 399 5.7.3.7 Iron Salts 400 5.7.3.8 Calcium Nitrate 401 5.7.4 Summary 401 5.8 Effects of Wastewater Degradation on Wastewater Treatment 402
	Chapter Review 404
5.5 Chemical Control Measures 370	
5.5.1 Precautions for Selecting and Using Chemicals 371	Chapter 6 Underground Repair and Construction
5.5.2 Testing for Chemical Effectiveness 372	6.1 Underground Work 412
5.5.3 Evaluating a Chemical Control Program 373	0.1 Olideigiodila Wolk 412
 5.5.4 Root Control 373 5.5.4.1 Using Chemicals 374 5.5.4.2 Applying Chemicals 375 5.5.4.3 Other Methods of Root Control 379 5.5.5 Grease Control 380 5.5.6 Rodent and Insect Control 382 	 6.1.1 Why Repairs Are Needed 412 6.1.1.1 Poor System Design 412 6.1.1.2 Poor Construction Practices 413 6.1.1.3 Damage Caused by Others 414 6.1.1.4 Aging Infrastructure 414 6.1.2 Identifying Repair Work 415
5.6 Odor Control Measures 383	6.1.2.1 Work Request 415
5.6.1 Hydrogen Sulfide Production 383 5.6.2 Controlling Odors 385 5.6.2.1 Odor Complaint Response and Investigation 385 5.6.2.2 Routine Sewer Maintenance 385 5.6.2.3 Chemical Odor Control	6.1.3 Job Planning 416 6.1.3.1 Site Visit 416 6.1.3.2 Utility Locating (Call 811) 416 6.1.3.3 Identifying Equipment, Tools, and Materials 418 6.1.3.4 Other Plan Elements 419 6.1.3.5 Environmental Considerations 419
Technologies 387	6.1.4 Preconstruction Meeting 420

6.3.8 Bedding, Backfilling, and Compaction 444

6.3.9 Other Sewer Main Line Repair Methods 445

6.1.5 Safety Considerations 420	6.4 Manhole Repairs 445
6.1.5.1 Working with AC Pipe 421	6.4.1 Assigning a Manhole Repair Job 446
6.2 Gravity Sewer Construction 422	6.4.2 Raising Manhole Frames and Covers to Grade 446
6.2.1 Reading Plans 422	6.4.2.1 Preparing the Site 446
6.2.1.1 Control Points 423	6.4.2.2 Raising the Frame and Cover 447
6.2.1.2 Surveying Instruments 426	6.4.2.3 Other Methods for Raising
6.2.1.3 Using Construction Controls 426	Manholes 449
6.2.2 Site Preparation 426	6.4.3 Repairing Manhole Bottoms and Inverts 450
6.2.3 Gravity Sewer Construction Materials 427	6.4.3.1 Correcting Manholes Without Concrete
6.2.3.1 Approved Materials 427	Bottoms 451
6.2.4 Construction Equipment 427	6.4.3.2 Correcting Manholes with Flat Bottoms 452
6.2.5 Trenches and Excavation 428	6.4.3.3 Correcting Manhole Channels 452
6.2.5.1 Safety 429	6.4.3.4 Repairing Manhole Barrels 453
6.2.5.2 OSHA Technical Manual 429	6.4.4 Installing Inside Drop Lines in Manholes 453
6.2.5.3 Excavating in Groundwater and	6.4.4.1 Materials 453
Dewatering 430	6.4.4.2 Installation Procedures 456
6.2.6 Sewer Pipe Bedding and Initial Backfill 430	6.4.5 Preventing Inflow from Entering Through
6.2.6.1 Special Pipe Foundations 431	Manhole Covers 456
6.2.7 Laying Pipe 431 6.2.7.1 Handling Pipe 431	6.5 Repairing Service Lines 457
6.2.7.2 Placing Pipe Segments 432	6.5.1 Preliminary Investigation 458
6.2.7.3 Assembling Pipe Segments 432	
6.2.7.4 Protecting the Pipe 434	6.5.2 Assigning a Service Line Repair Job 458
6.2.7.5 Completing the Pipe Bedding	6.5.3 Equipment, Materials, and Tools 458
Installation 434	6.5.4 Arriving at the Job Site 460
6.2.8 Sewer Trench Backfill and Compaction 434	6.5.5 Starting the Repair (Excavation) 460
6.2.8.1 Backfill Materials 434	6.5.6 Cutting Pipe 461
6.2.8.2 Placing Backfill 435	6.5.7 Installing a Cleanout 461
6.2.8.3 Compacting Backfill 435	6.5.8 Bedding, Backfilling, and Compaction 462
6.2.9 Surface Restoration 437	6.5.9 Completing a Service Line Location Card 462
6.2.10 Bypass Pumping 437	6.5.10 Site Visit Completion 462
6.2.10.1 Bypass Pump Setup 437	6.6 Trenchless Repairs 464
6.3 Sewer Main Line Repairs 439	
6.3.1 Preliminary Field Investigation 439	6.7 New Construction 465
6.3.2 Assigning a Main Line Repair Job 440	6.7.1 Constructing Manholes 465
6.3.3 Materials, Equipment, and Tools 440	, and the second
6.3.4 Arriving at the Job Site 441	6.8 Inspection and Testing of Sewer Construction, Repair, and Rehabilitation
6.3.5 Cutting Pavement 441	Work 468
6.3.6 Excavating the Repair Area 442	6.8.1 Duties of an Inspector 469
6.3.7 Repairing Sewer Pipe 442	6.8.2 Qualifications of an Inspector 469

6.8.3 Inspecting and Testing Construction

Materials 470

6.8.3.1 Sewer Pipe Inspection 470	Intermediate Concepts (Sections A.5–A.6) 512
6.8.3.2 Pipe Bedding and Trench Backfill	
Materials Inspection 470	A.5 Units 512
6.8.3.3 Portland Cement Concrete Inspection 471	A E I Dictance or Length 512
6.8.4 Construction Procedures Inspection 471	A.5.1 Distance or Length 512
6.8.4.1 Utilities Location and Inspection 471	A.5.2 Area 513
6.8.4.2 Trench Excavation Inspection 472	A.5.2.1 Surface Area of a Triangle 513
6.8.4.3 Pipe Laying Inspection 472 6.8.4.4 Appurtenance Inspection 472	A.5.2.2 Surface Area of a Triangle 514 A.5.2.3 Surface Area of a Trapezoid 515
6.8.4.5 Trench Backfilling and Compaction	A.5.2.4 Surface Area of a Circle 515
Inspection 473	A.5.2.5 Surface Area of a Cylinder 516
6.8.4.6 Surface Restoration and Cleanup 473	A.5.2.6 Surface Area of a Cone 517
5.8.5 Air Testing Sewers 474	A.5.2.7 Surface Area of a Sphere 518
6.8.5.1 Pressure Testing Sewers 475	A.5.3 Volume 518
5.8.6 Water Testing Sewers 484	A.5.3.1 Cube 519
5.8.7 Mandrel Testing Sewers 486	A.5.3.2 Rectangular Prism 519
5.8.8 Acceptance Testing 486	A.5.3.3 Triangular Prism 520
5.8.9 Final Inspection 488	A.5.3.4 Cylinder 520
6.8.9.1 Construction Records 488	A.5.3.5 Cone 520
6.8.9.2 Inspection of Repairs 489	A.5.3.6 Sphere 521
6.8.9.3 Inspection of Rehabilitated Sewers 491	A.5.4 Mass and Weight 521
6.9 Additional Resources 491	A.5.5 Density, Specific Weight, and Specific Gravity 522
Chapter Berriery 402	A.5.6 Concentration 522
Chapter Review 492	A.5.7 Velocity and Flow Rate 524
	A.5.8 Force and Pressure 526
Appendix A	A.5.9 Work, Head, and Power 531
Introduction to Basic Math for Operators	A.6 Metric System 534
Introduction 500	A.6.1 SI Base Units 534
	A.6.2 Measures of Length 536
Basic Concepts (Sections A.1–A.4) 501	A.6.3 Measures of Capacity or Volume 536
	- •
A.1 Numbers and Operations 501	A.6.4 Measures of Weight 536
A.I.I Addition 501	A.6.5 Temperature 537
A.I.2 Subtraction 501	Advanced Concepts (Sections A.7–A.8) 538
A.1.3 Multiplication 502	
A.1.4 Division 502	A.7 Pumps 538
A.2 Order of Operations 502	A.7.1 Pressure 538
A.2 Order of Operations 302	A.7.2 Work 539
A.2.1 More on Exponents 506	A.7.3 Power 540
A.3 Basic Algebra (Solving Equations) 506	A.7.4 Horsepower 540
	A 75 Head 5//

A.7.6 Pump Characteristics 546

A.4 Percentages 509

A.7.7	Evaluation of Pump Performance		548	
	A.7.7.1	Capacity	548	
	A.7.7.2	Efficiency	549	

- **A.7.8** Pump Speed-Performance Relationships 552
- **A.7.9** Friction or Energy Losses 553

A.8 Analysis and Presentation of Data 557

- A.8.1 Causes of Variations in Results 557
 A.8.1.1 Water or Material Being Examined 558
 A.8.1.2 Sampling 558
 A.8.1.3 Testing 558
- **A.8.2** Controlling Variation 558 **A.8.2.1 Reading Charts** 560
- **A.8.3** Describing Data or Results 560

- A.8.3.1 Graphs and Charts 561
- A.8.3.2 Numerical Representation of Data 566
- **A.8.4** Moving Averages 573
- **A.8.5** More Applications of Graphs 575
 - A.8.5.1 Volume of Sludge in a Digester 575
 - A.8.5.2 Tracking BOD Loading 578
- **A.8.6** Regression Analysis (Prediction Equations, Trends, and Correlations) 580
 - A.8.6.1 Correlations 585

Answer Key 587 Glossary 589 Index 617

A	BBP (bloodborne pathogens) program,	EPA
AADT (Annual Average Daily Traffic), 97	166 Bench-scale analysis, 400	approval number for chemicals, 371, 374
Acceptance testing, 486	Biochemical oxygen demand (BOD), 395,	registration of chemicals, 371, 382
Accessing private property, 460	396, 402	evaluation, 373
Accidents, reducing, 190	Bloodborne pathogens (BBP) program,	factors to consider, 371
Aerobic conditions, 396, 403	166	flooding as root control treatment, 378
Agency resources, 15	Blower, ventilation, 147, 159, 174	foaming as root control treatment, 375
Air, hydrogen sulfide control, 399	BOD (biochemical oxygen demand), 395,	FOG (Fats, oils, and grease), 380
Air binding, 395	396, 402	fumigant, 375
Air compressor, 149	Body resistances to electric current,	grease interceptors and traps, 380–382
Air gap, 317, 331	192–194	insect control, 382
Air jumpers, 49	Branch sewer, 33	laboratory testing of chemicals, 371
Air padding, 401	Breathing apparatus, emergency, 151	personal protective equipment (PPE), 371
Air plugs, 477	Bucket bail, 361	precautions, 371
Air shores, 187	Bucket machine, 306, 354-363, 368	public education, 381
Air testing	Bugs, biting hazard, 145	rodent control, 382
manhole-to-manhole, 477–481	Building service lateral, 33	root control, 373
sewers, 474–484	Bursting pipe, 464	safety data sheet (SDS), 371, 374
Alarm, atmospheric, 153–159	Bypass pumping, 419, 437–438, 443	selecting and using chemicals, 370–373
Alarm calibrations, 158, 172		testing program for chemical
Aluminum shoring, 185		effectiveness, 372
Anaerobic conditions, 304	C	vector control, 382
Anaerobic decomposition, 138, 140		Chemical hazards, 164
Annual Average Daily Traffic (AADT), 97	Calcium nitrate, hydrogen sulfide control,	Chemicals, sewer cleaning, 306, 370-383
Annular space, 68, 464	401	Chlorine, hydrogen sulfide control,
Appurtenance inspection, 472	Calibrations, alarm, 158, 172	396–397
Arrow boards, traffic, 129	Call Before You Dig program (811), 180	CIPP repair methods, 464
Asbestos-cement pipe issues, 61, 420	Capacity assurance, management,	Civil service exams, 7
As-built plans, 256, 325, 440	operation, and maintenance	Classifying soil, 429
Atmospheric alarm unit, 153–159	(CMOM), 12–14	Cleaning equipment maintenance, sewers,
Atmospheric hazards, 136–142	Carbon adsorption, 390	365–369
Avoiding utility conflicts, 412	Carbon filter process, 390	Cleanout installation after service line
	Carbon monoxide, hazardous levels, 141	connection repair, 461
	Cardiopulmonary resuscitation (CPR), 150,	Cleanouts, 42–46
В	165	Closed-circuit television (CCTV)
	Cast-iron pipe, 61	inspection, 235-280. See also
Backfill material	Catalytic sensing element, 156	Television inspection
moisture content, 436	Cave-ins, avoiding, 189	Clothing, protective, 164–165
native, 435	Cavitation, 395	CMMS (computer maintenance
overview, 435–436	CCTV (closed-circuit television)	management system), 236
placement, 473	inspection, 235-280. See also	CMOM (capacity assurance, management,
trench design, 431	Television inspection	operation, and maintenance), 12-14
Backflow preventers, 40, 41	Certification	Cold weather work, 321
Bacteria cultures, sewer cleaning,	first-aid, 150	Collapse, street, 3
306, 381	operator, 8	Collapsed pipe issues, 413
Bag, sewer cleaning, 323, 324	Channelizing devices, traffic, 130	Collection systems
Bail, bucket, 361	Chemical control program	components, 33
Barrel, pipe, 303	control sewer, defined, 370	confined spaces, 6
Barricades, traffic control, 132, 133	disadvantages of grease traps and	construction, 9
Basin channel correction, 452	interceptors, 380	costs, 14–16

Correcting manhole channels, 451

Collection systems (continued) Corrosion control, sewers, 394-401 Dve testing definition, 2 accessing private property, 292 aeration, 395 design, 51-71 anaerobic organisms, 396 advance preparation, 292 drawing and layout, 3 BOD effect on corrosion and odor, assumed flow velocity, 293 failures, 2 395 conducting multiple tests, 294 chemicals, 395-401 confined space entry, 293 funding, 4 contaminated flow, 294 inspection, 12, 16 design of collection system, 394 cross-connection identification, 292 low-pressure systems, 35, 37, 38 early pipe failure, 394 hydrogen sulfide, 394 discharging into a body of water, 293 odors, 12 metallic components, 394 operation and maintenance (O&M), entry and exit points, 293 preventing corrosion, 394 equipment and staffing, 292 12 - 16expected flow time of dye, 293 operator jobs, pay, and training, 6-7 routine sewer cleaning, 395 problems affecting, 9-10 flow velocity, estimating, 292 sewer-use ordinances, 395 purpose, 10 temperature effect on corrosion and illegal or defective service connection testing considerations, 75 odor, 394 detection, 294 inflow and infiltration sources, 292 Combination truck, 312 Costs, collection systems, 14-16 manhole entry, 293 Compaction, 435, 436 CPR (cardiopulmonary resuscitation), 150, Competent person 165 notification of the public, 293, 294 defined, 115 Cross-connections, 4 procedure, 292-294 job site responsibilities, 183 Cured-in-place lining pipe rehabilitation, products, 292 review of work by, 178 purpose, 292 Components, collection system, 33 Cutting pavement for main line sewer recording and reporting results, 294 safety, 292 Computer applications used in collections repair, 441 system O&M, 309 Cutting pipe for a service line connection traffic control, 293 Computerized maintenance management repair, 461 water supply needed to perform, 293 systems (CMMS), 236 Cylinder shoring, 187 windy conditions considerations, 293 Concrete and vitrified clay pipes, 431 Concrete inspection, portland cement (Type II), 471 Е D Concrete pipe, 62 Configuration, pipe, 234 Damaged pipe issues, 413 Earth movement effects on sewers, 9 Confined space entry Damage to pipes and joints caused by Easement atmospheric alarm unit, 153-159 roots, 9, 12 surface restoration, 437 blower, ventilation, 147, 159, 174 Decibel, noise exposure, 157, 201 worksite documentation, 472 calibration alarms, 158 Decision sight distance, defined, 101 worksites, 419 clothing, protective, 164 Defect codes, sewer, 264 Electrical enclosure, manhole, 160, 161 Defensive driving, 91 hazards, 142 equipment and procedures, 146-166 Deflection and offset joints, measuring, safety, 190-200 hazards, 134-146 Electrochemical sensors, 157 manhole enclosure, 160, 161 Degradation, reducing wastewater, 402 Electro scanning non-permit, 135 Design, collection systems, 51-71 advantages, 253 permit, 135, 167-170 Design drawings and specifications, 422 compared to other methods, 254 procedures, 146-166 Design flows, 24 infiltration and exfiltration sources, 254 respiratory protection, 147-151 Design period, 23 pipe defects, 254 safety, 176 Design-related issues, 413 wet-weather pipe condition assessment, safety harness, 151 Design review, 72-75 254 tripod retrieval system, 151 Dewatering excavations, 430 Emergency cleaning, sewers, 306 ventilation blower, 147, 159, 174 Discharge drop lines in force mains, Emergency escape breathing apparatus, 136 work procedures, 166-176 456 Emergency traffic control situations, 105 Confined space hazards in manhole repair Enclosure, manhole, 160, 161 Diseases Engineer role, 412, 422, 469 work, 450 associated with organisms in raw Confined space permit, 167–170 wastewater, 11, 144 Engulfment hazards, 142 Construction, collection system, 9, 75 bloodborne pathogens, 166 Equipment Contractor responsibility, 147 protection against, 11 closed-circuit television, 256 Dispersing groundwater, 430 dye testing, 292 Control devices and zones. See Traffic Ditches and trenches, sewer, 10 inspection, 89 control Drawing and layout, collection system, 3 manhole inspection, 230 Controlled density fill (CDF) in paved Drop manholes, 46, 47, 466 safety, 146-166 areas, 444 Drowning hazard, 144 sewer cleaning, 365-369 Controlling hydrogen sulfide, 395-402 Drums, traffic control, 133 sewer extension or repair, 428 Control points (hubs and reference Ductile iron pipe, 63-64 smoke testing, 282 stakes), 423-426 Dyes, tracer, 29 Exams, certification, 8

Excavation	Groundwater	1
avoiding cave-ins, 189	dispersing, 430	
finding hazardous wastes, 177	infiltration, 10	Identifying turbulence or infiltration, 234
high groundwater levels, 430	pollution, 9	IDLH (Immediately Dangerous to Life or
reducing hazards, 430	Grouting pipe rehabilitation, 464	Health), defined, 137
safety rules, 178		I/I (inflow/infiltration), 9, 24, 25, 32,
shoring, 177, 181–190		226–229
spoil bank hazard, 189	Н	Illegal taps, 413
underground utilities, locating, 178	TT 1 16 4 4 4 4 162	Immediately Dangerous to Life or Health
Exfiltration, 9	Hand and foot protection, 163	(IDLH), defined, 137
Explosive atmospheres, 197	Hand rods, 306, 308, 347–351	Infections caused by wastes, 144
	Harness, full-body, 151, 152	Infiltration identification during
_	Hazard communication, 204–216	inspection, 234
F	Hazardous waste found during excavation,	Inflow dish installation, 456
E:-14 52	177 Hazards	Inflow/infiltration (I/I), 9, 24, 25, 32,
Field surveys, 52	labeling, 209	226–229
Final inspection, 488		Inflow prevention at manhole covers, 456
Fire bydront 317, 330, 341	manhole (see Manhole, hazards)	Infrastructure-related issues, 414
Fire hydrant, 317, 330, 341	sewer construction and repair,	Inoculations as safety precaution, 11
First-aid	420, 429	Insects
certification, 150 kit, 165	Head, water, 309, 353	and bug, rodent hazards, 145
	Head protection, 163	control, 382
Flagging, traffic control, 116–119 Flag tree warning devices, traffic control,	Heavy equipment operation, 419 Hepatitis B exposure and prevention, 144,	Inside drop line connection example, 454
130	166	Inspecting collection systems. See also
Flexible pipes, 63–67	High-level flag tree warning devices, traffic	Closed-circuit television (CCTV)
and joints, 9	control, 129, 130	inspection; Television inspection
Floats, velocity, 29	High-velocity cleaner (HVC), 273, 306,	comparing pipe assessment technology,
Flooding during excavation, 430	310–323, 366	280
Flotation of sewer, 10	Holding tanks, 36	considerations, 75
Flow	Hot work, 172, 173	electro scanning, 280 inflow and infiltration (I/I), 226–229
design, 24	HVC (high-velocity cleaner), 273, 306,	manholes, 229–235
measurement, 27	310–323, 366	reasons, 224
peaking factors, 24	Hydrant, fire, 317, 330, 341	Instruments, survey, 426
regulators, 48, 50–51	Hydraulic cleaning, 309–331	Intercepting sewers, 34
sewer trench, 9	bags, 323	Interconnector sewers, 49
variations, 31	high-velocity cleaning, 310–323, 366	Intrinsically safe, defined, 157
Flusher branches, 45	kites, 323	Invert, defined, 53
Foot protection, 163	poly pigs, 235–236, 323	Inverted siphons, 49
Force mains, 36	scooters, 326–331	Iron salts, hydrogen sulfide control, 400
Foundations, pile-supported, 431	Hydraulic shoring, 185	,,,,,,,
Freezing weather work, 321	Hydrogen peroxide, handling and	
Full-body harness, 151, 152	application, 397–398	1
	Hydrogen sulfide	•
	control	Jobs for operators, 5, 6
G	air, 399	Joining pipe with resilient joints, 433
	calcium nitrate, 401	Joints
Gas service lines, working under, 472	chemicals, 395–401	pipe, 67–71
GFCI (Ground-fault circuit interrupter),	chlorine, 396–397	potential problems in sewers, 9
196	hydrogen peroxide, 397-398	Junction structures, 48
Gloves, 163	iron salts, 400	
Grademan role, 429	lime, 399	
Gradient, sewer line, 49	pure oxygen, 398–399	K
Gravity collection systems, 33–35	sodium hydroxide, 399–400	
Gravity flow, 9	corrosion, 394	Kite, sewer cleaning, 323, 324
Gravity sewer construction,	cycle, 384	
422–438	effect of pH, 384	
Grease removal, 380–382	hazardous levels, 140	L
Grinder pumps, 36	health effects and exposure time,	Labelina of have 1, 200
Ground-fault circuit interrupter (GFCI),	384–385	Labeling of hazards, 209
196	odor control, 383	Labor unions, 6
Ground surface restoration, 437	problems in sewers, 382	Lab testing for pipe, 470

forms, 231–232

Lamp holes, 45	gas detection, 233	0
Lamping during manhole inspection, 234	joints and surfaces, 234	
Large-diameter pipe issues, 431	lamping, 234	Occupational Safety and Health Act of
Lateral sewer, 33	lid defects, 234	1970 (OSH Act of 1970), 115, 182
Leaking water service lines, 414	local sewer-use ordinances, 229	Occupational Safety and Health
Leak location using air pressure testing,	locating the manhole, 233	Administration (OSHA), 6, 182
481–484	new installations, 486	Odor control
LEL (lower explosive limit), 137	oxygen deficiency/enrichment	air curtains, 392
Level surveys, 52–54	monitoring, 230	air treatment, 392
Lifeline, 151	pipe configuration, 234	air flow control, 390
Lift stations, 34	planning, 230	facilities, 391
Lighting devices, traffic control, 133	procedure, 233–235	carbon adsorption, 390
Lime, hydrogen sulfide control, 399	safety, 230, 233	caustic shock dosing, 388-389
Local ordinances, 441	traffic control, 230	chemical control, 387
Locating leaks using air pressure testings, 481–484	turbulence or infiltration identification, 234	complaint response and investigation, 385
Location cards for service line connections,	types of manholes, 233	hydraulic flow management, 392
462	ventilating the manhole, 230	hydrogen sulfide, 383
Lockout/tagout, 142, 198	Manning's formula, 56	magnesium hydroxide continuous
Lower explosive limit (LEL), 137	Manual on Uniform Traffic Control Devices	addition, 389
Low-pressure collection systems,	(MUTCD), 95	manhole sealing, 387
35, 37, 38	Masking agents, 389	masking agents, 389
	Material safety data sheet (MSDS), 209.	monitoring, 393
	See also Safety data sheet (SDS)	plan, 385–393
M	Measuring	sewer maintenance, 385
• •	distances, 426	siphon inspection, 386
Main line sewer repair, 439–445	flow, 27	survey of collection system, 387
Main sewers, 34	offset joints, 486	trap manhole inspection, 386
Maintenance, sewers	Mechanical cleaning	Odor-masking agents, 389
chemicals, 370-383	hand rods, 347–353	Offset joints
closed-circuit television (CCTV)	power bucket machines,	measuring, 486
inspection, 278–280	354–364, 368	sag issues, 414
corrosion, 394–402	power rodders, 332–347,	Olfactory fatigue, 140
equipment, 365-369	367–368	"One-call" system (Dial 811), 471
grease removal, 380	Mechanical hazards, 142	On-the-job reference tools, 489
hydrogen sulfide control, 395–396	Methane gas, atmospheric hazard,	Operation and maintenance (O&M), 2, 12–14
insect control, 382–383	136–137	Operator
methods, 305	Minimizing runoff, 420	career information, 6
objectives, 302	Mortar and grout, 449	certification, 7
odor control, 383	MSDS (material safety data sheet), 209	responsibilities, 16, 176
preventive, 9, 10	MUTCD (Manual on Uniform Traffic	Ordinances
rodent control, 382	Control Devices), 95	local, 441
root control, 373–380	control Bevices), 77	local sewer-use, 229
sulfide control (see Hydrogen sulfide,		ORP (oxidation-reduction potential), 402
control)	N	OSHA (Occupational Safety and Health
Mandrel testing sewers, 486–488	· ·	Administration), 6, 182, 429
Manhole	National Electrical Code (NEC), 195	OSH Act of 1970 (Occupational Safety and
bottoms, correcting, 452	National Fire Protection Association	Health Act of 1970), 115, 182
construction, 45, 47, 71, 466	(NFPA), 197	Outside drop manholes, 46, 47, 466
covers, preventing inflow, 456	National Institute of Occupational Safety	Overload of treatment plant, 9
hazards, 134–136, 143	and Health (NIOSH), 149	Oxidation-reduction potential (ORP), 402
preventing unauthorized removal, 468	National Pollutant Discharge Elimination	Oxygen
repair and confined space hazards,	System (NPDES) permit, 13	deficiency/enrichment, 154, 175, 176
450	Native backfill material, 434	hazardous levels, 142
Manhole inspection	NEC (National Electrical Code), 195	hydrogen sulfide control uses, 399
as part of acceptance, 231	NFPA (National Fire Protection	
buried manholes, 446	Association), 197	
condition of connected pipelines, 229	NIOSH (National Institute of Occupational	P
defects typically found, 234	Safety and Health), 149	
easement issues, 229	Noise exposure, safety, 157, 200–203	Parachutes, sewer cleaning, 323
equipment and staffing, 230	Non-permit confined space, 135	PCMS (portable changeable message sign),

Non-permit confined space, 135

NPDES permit, 13

Peaking factors, flow, 24	Polyvinyl chloride (PVC) pipe, 431	damage to pipes and joints, 9, 12
Pedestrian safety, traffic control, 94, 113,	Porcupines, 346, 354, 355, 363	intrusion, 414
114, 178	Portable atmospheric alarm unit, 153-159	issues, 9, 373
Permit, confined space, 167-172	Portable changeable message sign (PCMS),	tails and veils, 373
Personal protective equipment (PPE), 427	128–129	Rotameter, 400
Physical injury, preventing, 142	Portland cement (Type II) concrete	Route surveys, 52
Pigs, poly, 36, 323–326	inspection, 471	Routing traffic, 94–95
Pile-supported concrete pipe foundations,	Power bucket machines, 306, 354-364, 368	RTK (Right-to-Know) laws, 204
431	Power rodders, 305, 306, 332-347	Runoff, minimizing, 420
Pipe	PPE (personal protective equipment), 427	
bedding or backfill issues, 415	Precast concrete manhole, 466–467	
bursting, 464	Preconstruction meeting, 420	S
grade, 426, 430	Pressure testing sewers, 475	
handling, 431–432	Preventing	Safe procedures
inspection, 470, 472	physical injury, 143	atmospheric alarm unit, 153-159
joints, 67–71	unauthorized manhole removal, 468	atmospheric hazards, 136-142
laying, 431	Preventive sewer maintenance, 9, 10	blower, ventilation, 147, 159-160, 174
materials, 60–67	Private property, accessing, 460	bugs, biting hazards, 145
protection, 434–435	Problems, collection systems, 9–10	calibration, alarms, 158, 172
rehab or replacement, 464	Projects, storm sewer, 422	chemical hazards, 164
Pipeline cleaning	Proofing tools, 314, 322	clothing, protective, 164–165
bag, 323, 324	Protective clothing, 164–165	confined spaces, 135-136, 146-176
bucket machine, 306, 368	Public	defensive driving, 91–92
chemicals, 370–383	health, 5, 11	disease exposure, 144
corrosion, 394–401	safety, 113, 114, 178	drowning hazard, 144
emergency cleaning, 306–308	Pumps, grinder, 36	electrical
equipment, 365–369	Punch list, 488	hazards, 142
grease removal, 380–382	Pure oxygen, hydrogen sulfide control,	safety, 190–200
hand rods, 306, 308, 347-353	399	emergency traffic control situations,
high-velocity cleaner (HVC), 306,	PVC (polyvinyl chloride) pipe, 431	103–104
309–323, 366		engulfment hazards, 142-143
hydraulic cleaning, 309-331		equipment, 146–166
hydrogen sulfide control, 394–401	Q	equipment inspection, 89–91
insect control, 382		firefighting, 204
kites, 306, 323, 324	Quantity of wastewater conveyed,	first-aid kit, 165
masking agents, 389	determining, 23	hand and foot protection, 163-164
mechanical cleaning, 332, 351		harness, 151, 152
methods, 305		hazard communication, 204-216
objectives, 302	R	head protection, 163
odor control, 383	•	high-visibility clothing, 115
parachutes, 323	Raising manhole frames and covers to	hot work, 172, 173
poly pigs, 323, 324	grade, 446–450	infections caused by wastes, 144
porcupines, 346, 354, 355, 363	Raw wastewater and disease exposure, 11	insect, bug, and rodent hazards, 145
power bucket machines, 306, 354-364	Reading plans, 422–426	inspection, 89
power rodders, 305, 306, 332-347	Record drawings or plans, 256, 325, 469,	lifeline, 151
problems, 302–305, 307	488, 489	lockout/tagout, 142, 198
proofing tools, 314, 322	Recordkeeping, 10	lower explosive limit (LEL), 137
records, 308, 315, 328, 335, 349, 359,	Records, sewer cleaning, 308, 315, 328,	manhole enclosure, 160, 161
372	335, 349, 359, 372	manhole hazards, 142-144
rodding, 306, 332-347, 367-368	Reducing excavation hazards, 429	mechanical hazards, 142
rodent control, 382	Regulations, street work, 102	noise exposure, 200-203
root control, 373–382	Respiratory protection, 147	non-permit confined space, 135
scooter, 306, 326-331	Results, smoke testing, 290	physical injury, preventing, 143
scraper, 305	Right-to-Know (RTK) laws, 204	portable changeable message sign
slant jack-type roller, 357, 361, 363	Rigid pipe, 61–63	(PCMS), 128–129
solutions, 302, 305–307	Rodding, sewers, 306, 332–347, 367–368	regulations, street work, 102
stoppages, 303-304	Rodent	respiratory protection, 147–151
sulfide control (see Hydrogen sulfide,	control, 382	Right-to-Know (RTK) laws, 204
control)	hazards, 145	rodent hazards, 145
swabs, 324, 355	Root rating system, 241, 263, 265, 266	skin protection, 162–163
Plan and profile, sewers, 72, 73	Roots	speed limits in work zones, 115–116
Poly pigs, 323–326	control, 373-380	street work regulations, 102-103

Safe procedures (continued)	equipment for extension or repair	results, 290–291
toxicant hazards, 145-146	project, 427–428	safety, 282, 284
traffic control, 97, 105, 119-134	flotation, 10	sample public announcement, 285
tripod retrieval system, 151, 152	intercepting, 24	setup, 281
vehicle inspection, 89	interconnector, 49	sewer repairs and rehabilitation, 281
ventilation blower, 147, 159, 172-175	lateral, 33	staffing needs during high flow, 282
wristlets, safety, 151	main line repair, 439–445	traffic control, 282, 286
Safety	pipe handling, placement, assembly,	training crew members, 284
avoiding cave-ins, 189-190	431–432	typical results, 290, 291
Call Before You Dig program (811),	plans, 423	undetectable connections, 291
180	traffic vibrations effect, 9	windy conditions at worksite, 286
competent person role and	Shoring	Sodium hydroxide, hydrogen sulfide
responsibilities, 178, 183–184	air shores, 187	control, 399
excavations, 177–181	aluminum, 185	Software applications used in collection
ground-fault circuit interrupter (GFCI),	cave-ins, 189, 190	system O&M, 309
196	cylinder, 187–189	Soil
hazards, 4	equipment, 182, 183	classification, 429
manhole inspection, 230	excavation, 177	condition issues, 431
National Electrical Code (NEC), 195	hydraulic, 185	testing procedures, 470–471
Occupational Safety and Health	job site responsibilities, 183–184	Solid sheeting, 187, 189
Administration (OSHA), 182	purpose during excavation, 181	Solutions, sewer cleaning and
pedestrian traffic control, 113, 114, 178	regulations, 184	maintenance, 306
public, 113, 114	requirements, 182	Specific gravity, 139
reducing accidents during excavation,	safety, 178, 184, 189	Speed limits in work zones, 115
190	screw jacks, 185–187	Spoil
shoring, 178, 184, 189	shield, 189	hazards caused during excavation, 189
tailgate safety sessions, 184, 420	solid sheeting, 187, 189	placement, 184
traffic control (see Traffic control)	types, 182, 185–189	removing, 420
trenches, 189	Signs, traffic control, 100, 128, 130.	Spray-on liners pipe rehabilitation, 464
underground utilities, 178	See also Traffic control	SSO (sanitary sewer overflow), 12–14,
working in streets, 94–134	Site visit, 416	226
Safety data sheet (SDS), 163. See also	Skin protection, 162–163	Staffing
Material safety data sheet (MSDS)	Slant jack-type roller, 357, 361, 363	CCTV inspections, 258
Safety harness, 151	Slip lining pipe rehabilitation, 464	dye testing, 292
Sanitary sewer overflow (SSO), 12–14, 226	Slump test, 449, 471	manhole inspection, 230
Scooter, sewer cleaning, 306, 326–331	Smoke testing	smoke testing, 282
Scouring velocity, 55	accessing private property, 286	Steel pipe, 63
Scraper, sewer cleaning, 305	advance preparation, 284	Stoppages, 4, 303–304, 309
Screw jacks and shoring, 185–187	advantages, 281	Stopping distance, vehicle, 100
SDS (safety data sheet), 163. See also	confined space entry, 286	Storm sewer projects, 422
Material safety data sheet (MSDS)	confirming a connection, 191	Street collapse, 3
Self-contained breathing apparatus,	considerations, 291	Street work
148–151	defects causing smoke to enter	regulations, 102
Sensors, electrochemical, 157	buildings, 284	safety, 178
Septic, defined, 49	defined, 280	Structures, settling, 9 Subsidence, 225
Service interruptions, 4	during high wastewater flows, 282	Subsurface construction work, 412
Service lateral, 33–34	equipment and staffing, 282	Surcharge, 437
Service line connection	groundwater level consideration, 282	Surface restoration
location cards, 462	illegal connection identification, 282	and cleanup, 473–474
repair, 457–463	implications of smoke entering a	job site, 437
Settling	building, 284	Surveying instruments, 426
minimizing, 436	inflow and infiltration sources, 281, 291	Surveys, field, 52
sewers, 9	manhole entry, 286	Swabs, 324, 355
Sewer	notification, 284–286	5 Walst, 521, 577
cleaning and maintenance problems, 306	observing and recording, 286 operation, 284	
construction, 412, 427	pipe plugs, sandbags, and curtains, 282	Т
cut sheet, preparing, 425–426	procedure, 286–288	
defect codes, 264	public announcement sample, 285	Tailgate safety meeting, 184, 420
ditches and trenches, 9	public concerns, 284	Tanks, holding, 36
effects of earth movement, 9	recording, 288, 289	Tap defect, 413
emergency cleaning, 306-308	report sample, 289	Tapers, traffic control, 108, 111

Taps	design elements, 431	grademan role, 429
illegal, 413	excavation, 428-430, 472	grade of pipe, 426
improperly connected or defective, 413	high groundwater during excavation,	gravity sewer construction, 422-439
sewer, 42–44	430	grouting pipe rehabilitation, 464
Tee intersection corrections, 452	installing braces, 182	heavy equipment operation, 428
Television inspection. See also Closed-	pipe bedding, 430	high-velocity cleaner use, 482
circuit television (CCTV) inspection	safety, 189	inside drop line installation in manholes
camera, 239	sewer ditches, 9	453–456
equipment, 256	shoring removal, 435	inspecting repaired pipe using CCTV,
logging inspections, 263–268	width requirement, 429	444
maintenance, 278–280	Trenchless repairs, 412, 464	inspection and testing, 468-491
procedure, 259–280	Tripod retrieval system, 151, 153	job planning checklist, 417
purpose, 255	Trunk sewers, 33	large-diameter pipe issues, 431
recording inspections, 263–268, 270	TTC (temporary traffic control) zones. See	leak location using air pressure testing,
root rating system, 241, 263, 264, 266	Temporary traffic control (TTC)	474–484
TV log sheets, 268–270	Turbulence identification during	main line sewer repair excavation, 442
use, 237	inspection, 234	mandrel testing sewers, 486
Temporary traffic control (TTC) zones,	TWA (time-weighted average), 202	manhole
94-134. See also Traffic control		construction, 465–468
Testing		finding buried, 446
collection systems	U	repairs, 445–457
considerations, 75		materials and performance criteria, 422
dye testing, 292	UEL (upper explosive limit), 137	materials specifications and standards,
reasons, 224	Underground repair and construction	470
smoke testing, 280-291	acceptance testing, 486-488	measuring distances, 425, 426
mandrel, 486	accessing private property, 460	new sewer construction, 412, 426–427
new manholes after installation, 486	approved materials, 418, 427, 430, 440,	on-the-job reference tools, 489
Testing laboratories, pipe, 470	458, 469, 489	outside drop line, 453, 455
Thermoplastic pipe, 64	asbestos-cement pipe issues, 420, 421	paved areas, job site surface restoration,
Thermoset plastic pipe, 66	as-built plans or drawings, 488	437
Thrust block, 68	backfilling trenches, 430, 435, 444	permits, 420
Timber cradles for pipe foundations, 431	backfill material, 430, 434-435, 473	pipe
Time-weighted average (TWA), 202	building sewer locations form, 488, 490	assembly, 433
Tolerance zone, 418	cave-ins, avoiding, 421, 429	bedding, 430, 434, 444
Tools, on-the-job reference, 489	CCTV inspection, 473, 482, 489	bedding and trench backfill materials
Toxicant hazards, 145-146	centerline, locating, 426	inspection, 470
Tracer dyes, 29	checklists and forms, 416	cleaning before inspection and testing
Traffic control	cleanout installation after service line	487
barricades, 132	connection repair, 461	grade, 430
devices, 97, 119-134	compacting backfill, 435–437, 444, 473	planning, 416–421, 439, 471
drums, 133	compaction in narrow trenches, 435-437	preconstruction meeting, 420
flagging, 120	competent person role, 429	preventive maintenance crew,
high-level flag tree warning devices, 130	complex rehabilitation projects, 412	446, 450
pedestrian safety, 94, 113, 114, 178	confined space entry, 479	public relations management, 419
routing traffic, 130	constructing sewers above ground, 428	raising manhole frames and covers to
signs, 100, 128, 130	construction	grade, 446
stopping distances, 100	controls, 426	reading plans, 422–426
street closure, 103	inspector, 427, 468, 469, 488	rehabilitated sewer inspection, 491
tapers, 108, 111	material specifications, 427	rehabilitating or replacing entire pipe
temporary traffic control (TTC) zones,	procedures inspection, 471	section, 464
94–134	records, 488	reports, 469, 470, 488
Traffic vibrations effect on sewers, 9	related issues, 413	root intrusion, 414–415
Training	correcting manhole bottoms, 452	safety, 420–421, 427, 432, 435, 442, 450,
collection system operators, 6–7, 204	damage caused by others, 414	472
flaggers, 116	design drawings and specifications, 469	sewer
Transporter, self-propelled, 240–242	detail plans, 422	connected to settled manhole, 450
Treatment plant overload, 9	engineer role, 412, 422, 469	construction, 412, 426–428, 488
Tree removal work, 427	environmental considerations, 419–420	main line repair, 439–445
Trenches	equipment, 418, 427–428, 440, 458, 481	plans, 423
backfilling and compaction inspection,	excavation, 421, 426, 428–430, 444	shoring, 435, 442
473	field investigation for repair, 439, 458	site preparation, 426–427
defined, 177	final inspection, 488	site visit, 416, 418

Underground repair and construction (continued) special pipe foundations, 431 spray-on liners pipe rehabilitation, 464 stoppage requiring repair, 439 storm sewer projects, 422 subsurface construction work, 412 surface restoration and cleanup, 473 surveying instruments, 426 taps, illegal or improper, 413 televised pipe inspection after repair or construction, 487 terrain and conditions at worksite, 418 testing/inspecting materials, 427 tolerance zone, 418 tools, 418, 440, 458 traffic control, 419, 460 trenches (see Trenches) trenchless repair, 412, 413, 464 underground utilities, 418 underground work overview, 412-421 unimproved easement worksites, 419 water jetting compaction equipment, 436 water testing sewers, 484-486 working in special settings, 419, 426 wye and cleanout example, 462 Underground utilities Call Before You Dig program (811), 180, 416, 471 conflicts, 412, 469 locating, 178-181, 429, 442, 458 Underground voids, 414 Underground work. See Underground repair and construction Undetectable connections, 292 Unimproved easement worksites, 419 Unions, labor, 6

Upper explosive limit (UEL), 137 Utility conflicts, avoiding, 412

Vacuum collection systems, 36-39



Vandalism in collection systems, 10
Variation in flow, 31
Vehicle inspection procedures, 89
Velocity, scouring, 55
Ventilation blower, 147, 159, 174
Vent traps, 40, 42
Vertical traffic control panels, 131. See also
Traffic control
Vibrations from traffic, effect on sewers, 9
Visibility, clothing for worker safety, 115
Vitrified clay and concrete pipes, 63, 434
Voids, underground, 414



Wastewater, determining quantity conveyed, 23
Wastewater collection systems construction, testing, and inspection, 75 design, 51–71 design flows, 24 design period, 23 design review, 72, 74 gravity collection systems, 33–35 low-pressure collection systems, 35–36 manhole materials, 71 pipe excavation, 177 materials, 60–67

purpose, 22 vacuum collection systems, 36-39 Wastewater degradation dissolved sulfide, 402 distance to treatment plant, 402 effects, 402-403 oxidation-reduction potential (ORP), 402 reducing, 403 Water consolidation method of compaction, 436 Water head, 309, 353 Water jetting compaction equipment, 436 Water pressure testing, 474 Water service line, leaking, 414 Water testing sewers, 484-486 Wetted perimeter, 57 Wet-weather pipe condition assessment, Worker Right-to-Know (RTK) laws, 204 Worker visibility, clothing, 115 Working in streets, 178-181 special settings, 419 under gas service lines, 472 Work order, 446, 457 Work procedures, confined spaces, 167-172 Work request, 415-416 Worksite cleanup, 444 terrain and condition, 418 unimproved easements, 419

windy conditions, 286

Wye connection, installation, 461

Wristlets, safety, 151