FAILURE AND ROOT CAUSE ANALYSIS PROJECT REPORT

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Colorado Safe Drinking Water Program

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EXECUTIVE SUMMARY

The purpose of the Capacity Building Unit is to provide training, technical assistance, and management support services to public water systems so they can strengthen their ability to supply safe drinking water to the public. At its heart, the Failure and Root Cause Analysis project is about improving operations in the Capacity Building Unit of the Colorado Safe Drinking Water Program. The project was conducted to determine how to best direct resources toward the most critical failures of public water systems in Colorado for optimal results. Existing Acute Team data, sanitary survey results, and self-reported compliance data were analyzed using a modified Pareto analysis approach to determine the most common causes for system failure. The principle behind the Pareto analysis is that a large majority of problems are produced by a few key causes. Once identified, addressing these causes can lead to significant improvements. The Pareto analysis provides a valuable, transparent way to direct resources.

There are approximately 2000 active public water systems in Colorado. The data analyzed in this study indicate that there are significant compliance and system deficiencies in water systems within the state. Over a three-year study period, more than 9 percent of the systems evaluated through sanitary surveys had a significant deficiency, and more than 63 percent of all systems in Colorado reported a regulatory violation. While the full extent of the public health impact is unclear, more than 60,000 people were affected by boil and bottled water orders during the study period.

The following list summarizes the most frequently observed failures over the three-year study period.

- Disinfection:
  - Failure to maintain disinfection residuals
  - Inadequate disinfection equipment
  - Positive total coliform
- Cross Connection Control:
  - Presence of cross connections
  - Lack of cross connection control planning
- Distribution System Operations:
  - Failure to maintain disinfection residuals
  - Failure to maintain cross connection control
- Failure to Plan:
  - Lack of, or inadequate, bacteriological (bacti) sample-siting plan
  - Lack of, or inadequate, general monitoring plan
  - Failure to obtain design approval
- Management and Operation:
  - Operator compliance with State requirements
  - Failure to monitor and report water quality in compliance with regulations
  - Failure to obtain design approval prior to construction

The following recommendations were developed based on the Pareto analysis to focus program resources on the key failures of public water systems and to hone program efforts towards further identifying and addressing the root causes of those failures:

1. Focus training, technical assistance, and management support services on the key weaknesses and compliance failures identified in this report.
2. Develop programs to further assess the root causes of monitoring violations in order to reduce those violations.
3. Continue to improve data consistency and utilize data to develop benchmarks for improvement.
4. Utilize these and future report results to promote and enhance communication with stakeholders.

BACKGROUND

Colorado is home to more than 2,000 public water systems. Each public water system is responsible for maintaining the physical and human infrastructure needed to supply safe drinking water to the public and to comply with state and federal regulations that govern drinking water. The Safe Drinking Water Program of the Water Quality Control Division (Division) at the Colorado Department of Public Health and Environment is responsible for maintaining the state's regulatory infrastructure and monitoring and enforcing compliance with regulations. The Division conducts regulatory enforcement activities, tracks and reports on system performance, and also provides ongoing support and assistance to public water systems to ensure the delivery of safe drinking water.

The purpose of the Capacity Building Unit of the Safe Drinking Water Program is to provide training, technical assistance, and management support services to public water systems so they can strengthen their ability to supply safe drinking water to the public. This includes assisting public water systems identify and eliminate technical, managerial, and financial capacity weaknesses. The unit is funded through federal grants from the US Environmental Protection Agency.

In 2008, the Capacity Building Unit funded a study of data contained in the Division's comprehensive performance evaluation (CPE) database to identify trends in public water system deficiencies. The study involved a review of over 100 in-depth CPEs conducted between 2001 and 2008 at select public water systems in Colorado that treat surface water. The study results[1] suggested that the primary cause of system deficiencies and violations was the failure of plant staff to adequately apply water treatment concepts and process control techniques to make proper process control adjustments. The second most significant cause of deficiencies and violations was the failure of plant staff to develop and maintain plant-specific guidelines and procedures to support consistent operational decision making. While the CPE study results provided valuable information regarding system weaknesses, the study was limited in the number and type of systems evaluated.

The Capacity Building Unit conducted this project to build upon the CPE study results and further assess how to improve operations by directing services towards the most critical failures observed at public water systems in Colorado. To achieve this goal, the unit team reviewed system failure data available over a three-year period from the Division's Acute Team internal tracking database and the Colorado Safe Drinking Water Information System (SDWIS/State), and conducted a Pareto analysis to identify and illustrate the most commonly observed problems at public water systems. Based on this analysis, recommendations were developed to focus resources on key system failures and guide efforts to further identify and address the root causes of those failures.

[1] Dani, David and Summers, Scott. Evaluation of the Colorado Department of Public Health and Environment Comprehensive Performance Evaluation Database. August 25, 2008.

APPROACH

The Failure and Root Cause Analysis project was initiated in September 2008 to seek ways to improve operations in the Capacity Building Unit through focusing resources. The project team employed a Pareto analysis to evaluate three categories of data collected by the Safe Drinking Water Program: Acute Team responses, sanitary survey results, and self-reported compliance data. The Acute Team includes Division staff members who respond to water system issues that could pose an acute risk to the public and warrant an immediate response from the Division. The Acute Team becomes involved when monitoring data shows an acute health risk, certain deficiencies are identified in a sanitary survey, or when the Division learns of a potential acute risk through other means. The Acute Team internal tracking database was the primary source of acute response data.

Data from the Acute Team database were coupled with data from the Safe Drinking Water Information System (SDWIS/State), a USEPA national database that contains information about public water systems and their violations of the state and federal drinking water regulations. SDWIS/State is maintained by the Safe Drinking Water Program contains compliance data, routine and special monitoring reports, and site visit modules with sanitary survey reports from routine inspections. SDWIS was the primary source of sanitary survey and violation data.

The project approach consisted of three tasks:

Task 1. Data collection – Data were extracted from the Acute Team database and SDWIS and organized in Excel spreadsheets to facilitate analysis. Data were extracted for state fiscal years 2006 to 2008 (i.e., July 1, 2005 through June 30, 2008). This timeframe represented the latest complete years for a baseline analysis. Spreadsheets were prepared for the different data sources to reflect:

- major and minor deficiencies identified in sanitary surveys
- summary of compliance rates
- enforcement actions
- violations history
- Acute Team reporting history

Task 2. Data analysis -The second major task involved analyzing the data to identify the most frequent failures and the highest-risk failures in water systems. Data were compiled in graphs and tables using a modified Pareto analysis technique. A Pareto analysis is a statistical technique that is commonly utilized to evaluate a number of tasks that produce a significant overall effect. For this project, a modified Pareto analysis was used and the figures below were developed by presenting the data as ranked bar charts in order of significance and frequency. This information then was reviewed to identify the categories of failures that contribute most significantly to Acute Team responses, sanitary survey deficiencies, and reported violations.

Task 3. Development of Key Findings and Recommendations – The final task involved summarizing key findings and developing a set of recommendations for future program efforts. Building

recommendations based on the Pareto analysis offers a certain level of transparency in decision-making and provides internal staff and stakeholders with a clear understanding of why and how program priorities and operations are established. The approach for this project is a powerful communication and quality management technique commonly used in the manufacturing sector and was adapted for use in the government sector. The underlying premise is the same: relating data through analysis and then to the operational decisions made by the program.

The recommendations developed in Task 3 will be used to guide in-house and contract training programs, technical assistance efforts, and coaching to ensure that drinking water systems gain meaningful assistance from the Capacity Building Unit. Further, it is anticipated that the project results will provide a foundation for improved communication with stakeholders and for focused capacity building services.

Comments on Data Quality

It is important to realize that the data reported in this study represent a three-year period in time, and the data quality is consistent with that period of time. Data were compiled directly from the Acute Team and SDWIS/State databases with some quality assurance/quality control, but with minimal modifications. Changes in any of the databases made after October 2008 are not represented in this report, and should be considered in future reports. Some key observations about the data are as follows:

Violation data – Data were compiled for a three-year period, from July 1, 2005 through June 30, 2008. Official state compliance reports submitted to the USEPA are compiled annually and based on the calendar year.[2] Because of the different time periods and different methods of data analysis, it may be difficult to compare the results from this study with official state compliance reports.

Data quality – Some inconsistencies were observed in how data were categorized by the Acute Team and through sanitary surveys. For example, cross connection issues were recorded under treatment, distribution, and management categories during sanitary surveys. Total coliform positives were recorded under bacteriological /microscopic particulate analysis (bacti/MPA), distribution, and treatment categories in the acute data. Data quality improvement is a continuous effort. For the purposes of this study, these inconsistencies in data categories may have had a minor impact on how failures are compiled and reviewed in this report.

System categorization – Acute Team and sanitary survey datasets were more heavily weighted toward community systems. This was due to many small non-community groundwater sanitary surveys being conducted by outside parties and inconsistencies in how the Division input data to SDWIS/State prior to 2008. In addition, for Acute Team responses, non-community systems are

[2] Annual compliance reports for the Colorado Safe Drinking Water Program can be found on the internet at http://www.cdphe.state.co.us/wq/drinkingwater.

probably less likely to be aware of and report acute events. While the reported violation data represented systems of all types, data were not analyzed to characterize violations by system type. This is recommended as a next step for similar analysis in the future.

DATA SUMMARY

In general, Colorado has a strong history of compliance with health-based standards, as reported in annual reports prepared by the Safe Drinking Water Program. This study primarily focuses on overall compliance rates, from both health-based and non-health based violations, and on data collected about operational failures and system deficiencies. Data from the Acute Team tracking database and SDWIS were evaluated using a Pareto analysis to determine frequency and cause for systems failure. Results are reported below.

Events Reported in the Acute Team Tracking Database

The Acute Team tracking database included 156 acute events reported over the three-year study period. In the following sections, the acute events were organized according to frequency and the category of failures observed, and then compared to type of response action warranted by the failure (Figure 1), type of public water system affected (Figure 2), and the duration of the event response (Figure 3). The acute events reported in the Acute Team database were organized into the following categories[3]:

- Distribution System Deficiency
- Treatment System Deficiency, Surface Water (SW)
- Bacteriological (bacti)/MPA Results Causing Acute Situation
- Treatment Deficiency, Groundwater (GW)
- Untreated Groundwater (GW) Intended for Drinking
- Untreated Surface Water (SW) Intended for Drinking
- Tampering/Security
- Source Water Supply Disruption

In Figure 1, the number and categories of failures observed were compared to their response actions. This chart illustrates the utility of a Pareto analysis. While the Acute Team responds with various levels of required action to a variety of events, this analysis shows that the top two classifications of failures requiring a response were:

- Distribution System Deficiency (pipe breaks, leaks, power outages)
- Treatment Deficiency (turbidity spikes, chlorinator failures and positive coliform results)

As shown in Figure 1, the most frequent cause of failure was related to a distribution system deficiency and constituted 43 (28%) of all Acute Team responses. Surface water treatment deficiencies caused nearly as many required responses. Together, these two categories comprised over half of all Acute Team responses. By focusing resources on preventing distribution system and surface water treatment

[3] These categories align in general with failure classifications utilized by the Centers for Disease Control and Prevention (CDC) when reporting on the underlying causes of waterborne disease and outbreaks associated with drinking water in biennial surveillance reports.

deficiencies, the Safe Drinking Water Program has the potential to reduce internal resource demands and produce a significant and measurable overall benefit to public water systems in Colorado.

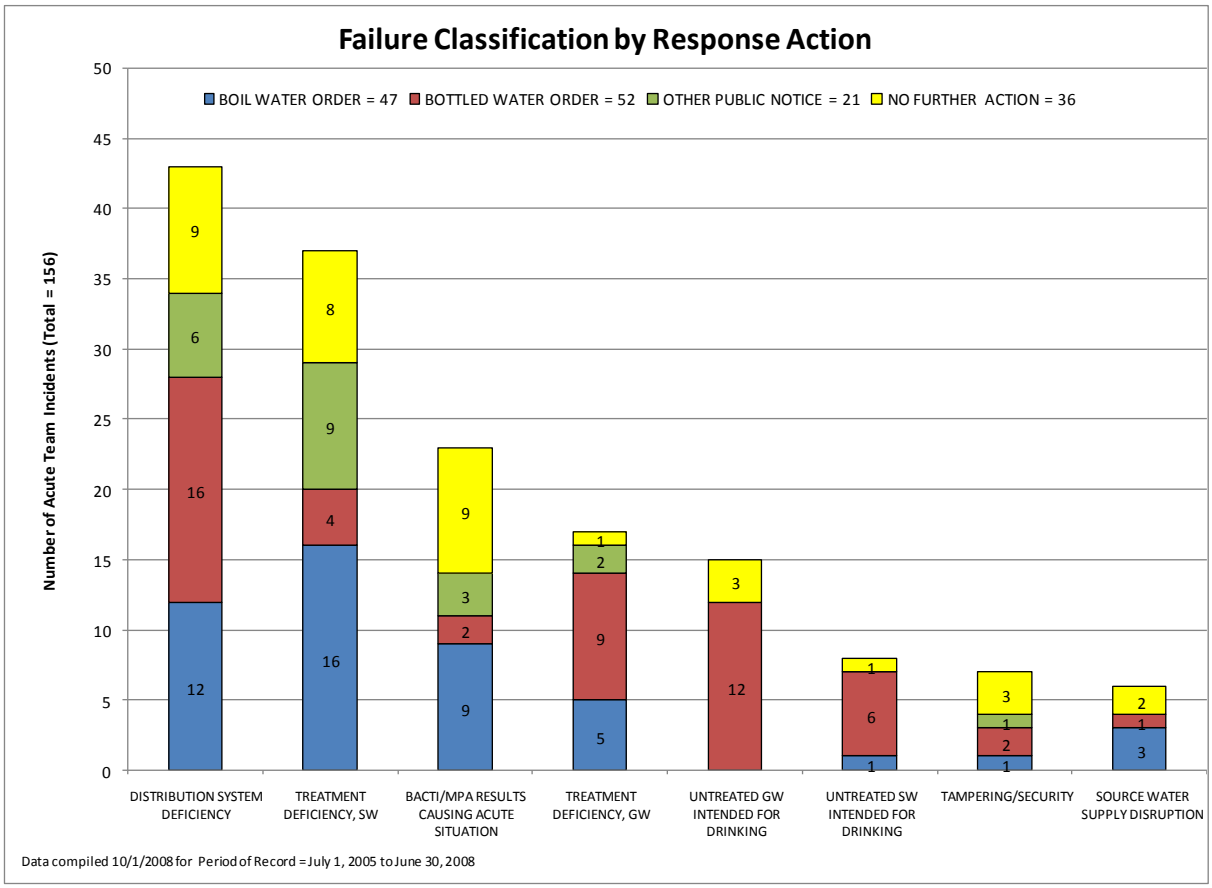

Figure 1: Failure Classification by Response Action

Figure 2 provides a comparison between the number and categories of failures observed and the type of public water systems where the failure occurred. There are three types of water systems illustrated in this figure. Community water systems serve at least 15 service connections used by year-round residents or at least 25 year-round residents. Non-transient, non-community systems regularly serve at least 25 of the same people over six months per year, but do not meet the definition of a community system. Transient non-community systems regularly serve at least 25 people daily at least 60 days out of the year, but do not meet the definition of a community or a non-transient non-community water system. An unclassified system typically does not meet the definition of a public water system. While the results suggest that the majority of acute responses occur in community water systems, the data

may be skewed towards community water systems because non-community water systems may be less likely to report their system failures to the Acute Team.

Figure 3 provides a comparison between the categories of failures observed and the duration of the response. As shown, systems with untreated groundwater or surface water intended for drinking had the longest order durations in response to acute events. The average duration of most bottled water orders was less than 20 days, whereas the average duration of bottled water orders for untreated groundwater or surface water was 300 and 362 days, respectively. This was probably because of the long lead time to design and construct infrastructure improvements to provide proper treatment where none existed. At this time the vast majority of the acute issues shown in Figure 3 have been resolved, with the exception of a few systems with untreated ground water or surface water.

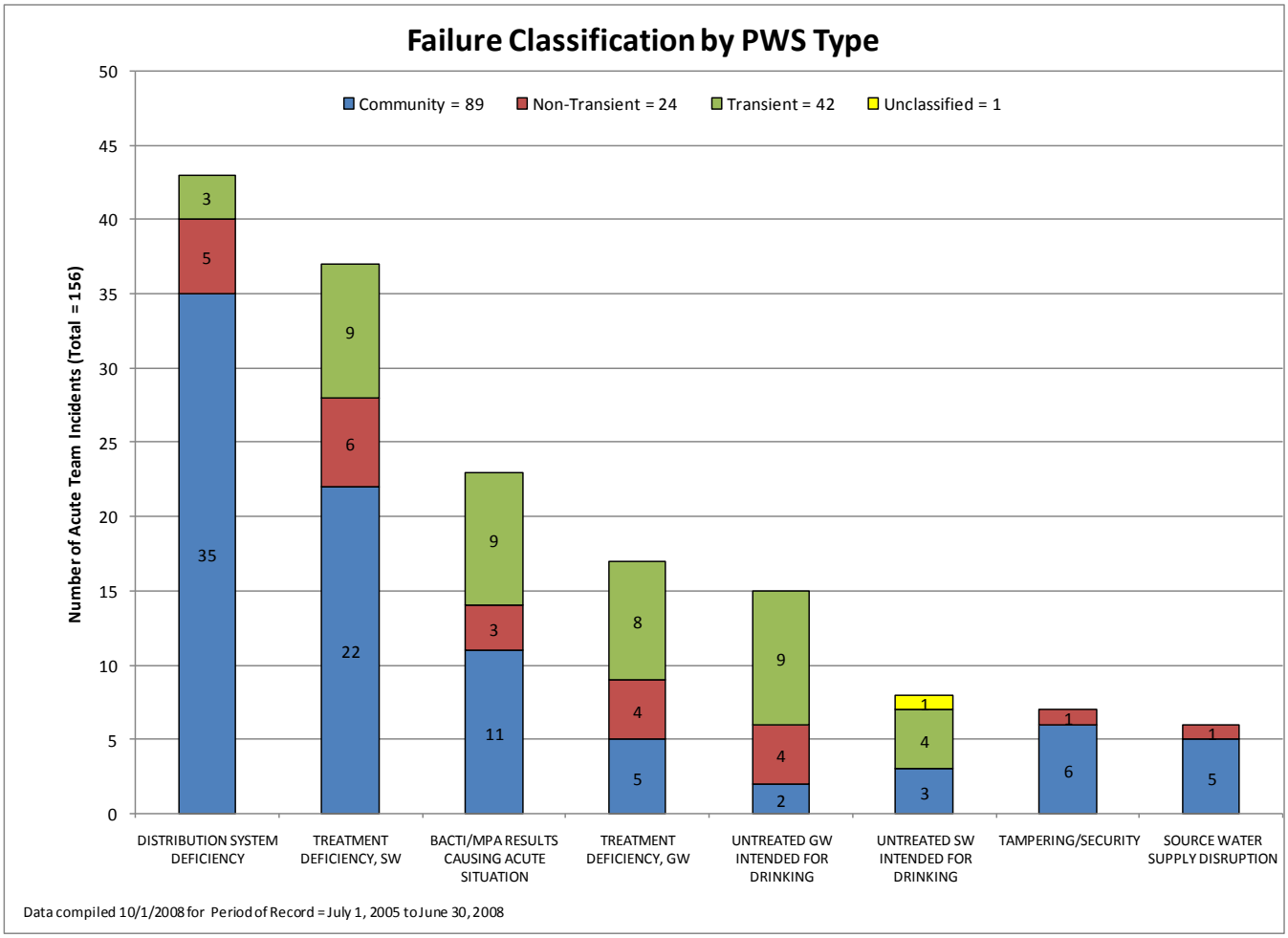

Figure 2: Failure Classification By Public Water System (PWS) Type

In addition to the data analysis provided above, several observations and insights were noted regarding the Acute Team tracking database and the nature of acute responses. The observations and insights listed below show the impact of acute response events in Colorado and the usefulness of compliance data in flagging areas of concern:

- 112 (72%) of all 156 acute responses required Tier 1 public notification, which involved notifying the public of the condition as soon as practical but no later than 24 hours after the system learns of the condition.
- 99 (63%) of all 156 acute responses required a boil or bottled water order.
- Nearly 60,000 people were affected by boil or bottle water orders. The spring 2008 *Salmonella* outbreak in Alamosa, Colorado, which had an impact on 9,200 people, was the largest boil or bottled water event during this period.
- 13 (68%) of the 19 systems that reported Bacti/MPA acute failures had at least one violation prior to the acute event (not necessarily a Total Coliform Rule [TCR] violation).
- 4 (21%) of the 19 systems that reported Bacti/MPA acute failures had TCR monitoring and reporting violations following the event (no community water systems).
- 6 (40%) of the 15 systems that had an acute response to turbidity spikes, had reported turbidity violations prior to acute violations, and 4 (26%) of these systems were using bag filters.
- 70% of all distribution system deficiencies were due to loss of system pressure due to main breaks, loss of power or other infrastructure failures.

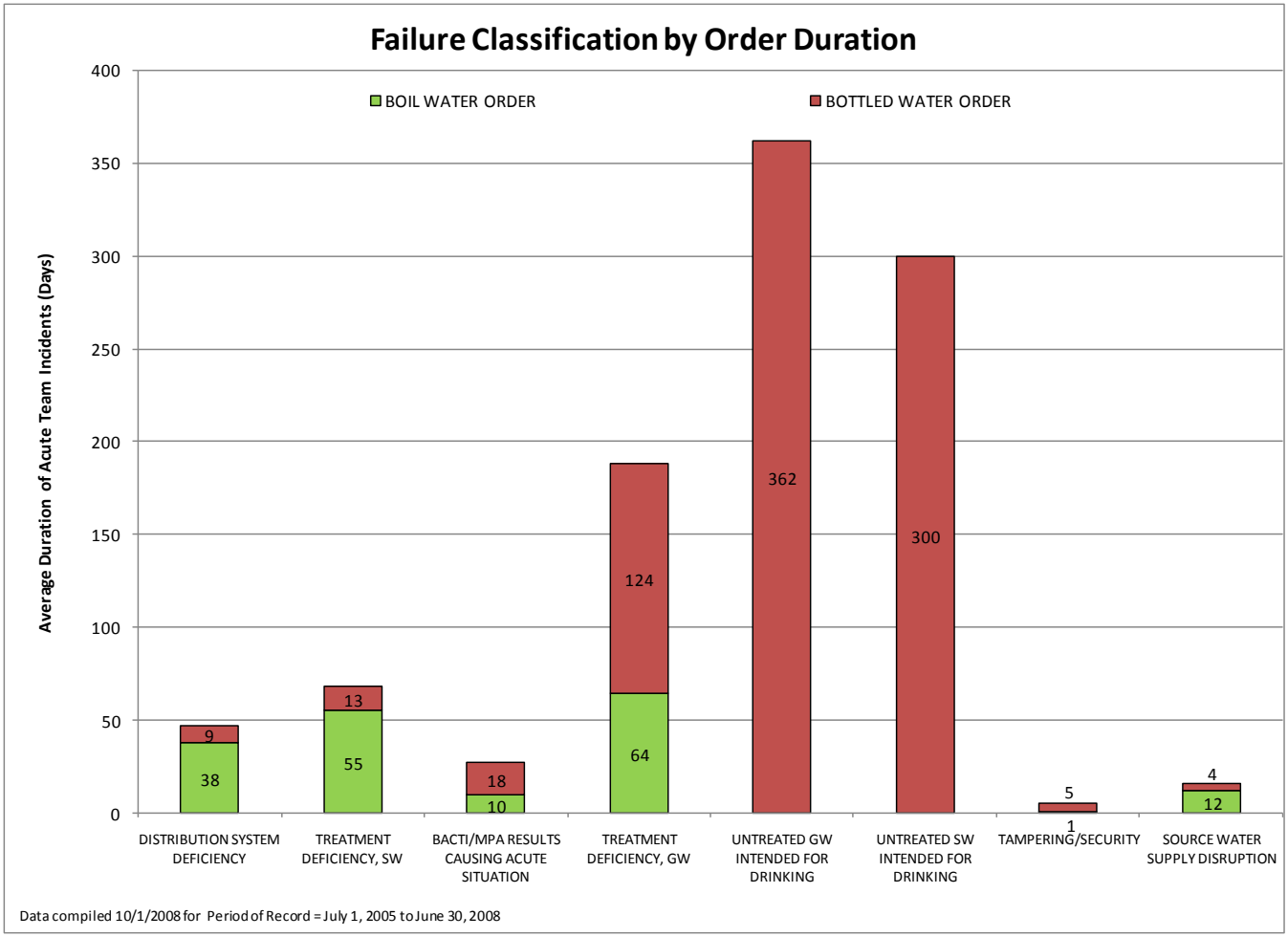

Figure 3: Failure Classification by Order Duration

Deficiencies Reported in SDWIS

The Safe Drinking Water Information System (SDWIS) /STATE included data for a total of 1,942 sanitary surveys conducted during the three-year study period. Each sanitary survey may have identified *significant* or *minor* deficiencies. In the following sections, both significant and minor deficiencies were organized into eight categories (based on the eight components of a sanitary survey provided in the Colorado Primary Drinking Water Regulations, including the requirement for operators to comply with applicable regulations) and were evaluated in detail. The eight categories of deficiencies used in this analysis were as follows:

- Treatment
- Distribution System
- Monitoring, Reporting, and Data Verification

- Source
- Finished Water Storage
- System Management and Operation
- Pump/Pumping Facility & Control
- Operator Compliance with State Regulations

Significant Deficiencies

During sanitary surveys, an inspector documents conditions that are considered to be significant deficiencies. According to the latest version of the *Colorado Primary Drinking Water Regulations*,

> *Significant deficiency means any situation, practice, or condition in a public water system with respect to design, operation, maintenance, or administration, that the state determines may result in or have the potential to result in production of finishes drinking water that poses an unacceptable risk to health and welfare of the public served by the water system. Significant deficiencies include, but are not limited to, defects in design, operation, or maintenance, or a failure or malfunction of the sources, treatment, storage, or distribution system that the Department determines to be causing, or have the potential for causing, the introduction of contamination into the water delivered to consumers.*

Article 11.4 of the *Colorado Primary Drinking Water Regulations* specifies a timeframe for reporting and addressing such deficiencies.

During the three-year study period, significant deficiencies were found during 182 (9%) of the 1,942 sanitary surveys reported in SDWIS. In these systems, there were 353 separate significant deficiency observations, or an average of nearly two significant deficiencies per deficient system. Most of the systems that had significant deficiencies also had minor deficiencies (described later in this section).

Figure 4 presents the top 281 (80%) of all significant deficiencies identified during the study period (prior to grouping by category). The most common significant deficiency codes were associated with a lack of a certified operator (O710), failure to obtain design approval (R540), deficient disinfection equipment (T112), and inadequate disinfection residual in the distribution system (D230). It is worthy to note that more recent data has indicated that compliance with operator certification requirements dramatically increased from FY05 on and is no longer as prevalent a problem.

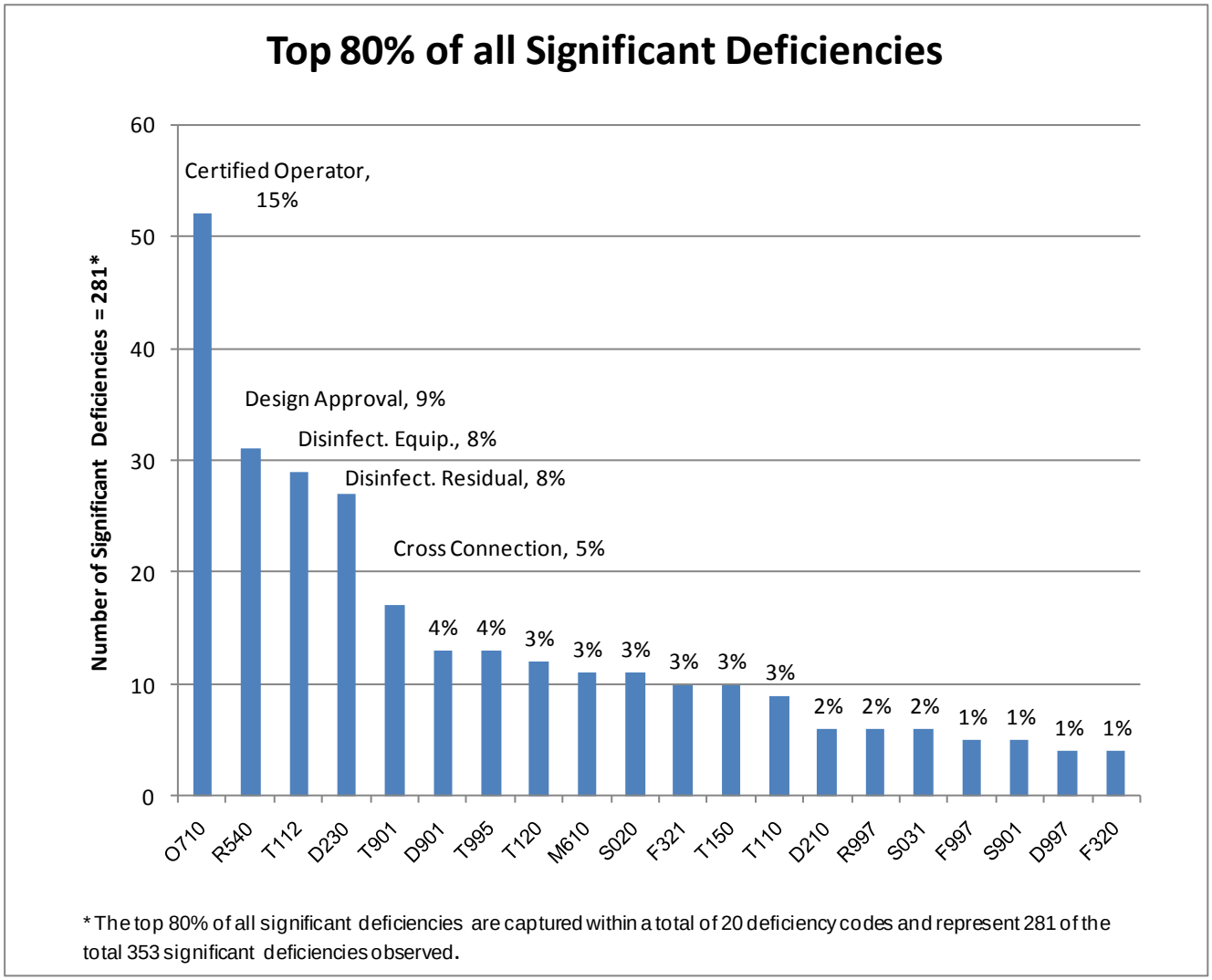

Figure 4: Top 80% of all Significant Deficiencies (See Appendix C for definitions of deficiency codes)

In Figure 5, the significant deficiencies were grouped by category, and then the number and categories of deficiencies were compared to the type of public water system where the deficiencies were observed. As shown, the most common significant deficiencies were associated with treatment processes (111 or 31%), distributions systems (54 or 15%), operator compliance with the regulations (52 or 15%), and monitoring, reporting, and data verification (48 or 14%). Detailed descriptions of significant deficiencies that fall in each category are included in Appendix C.

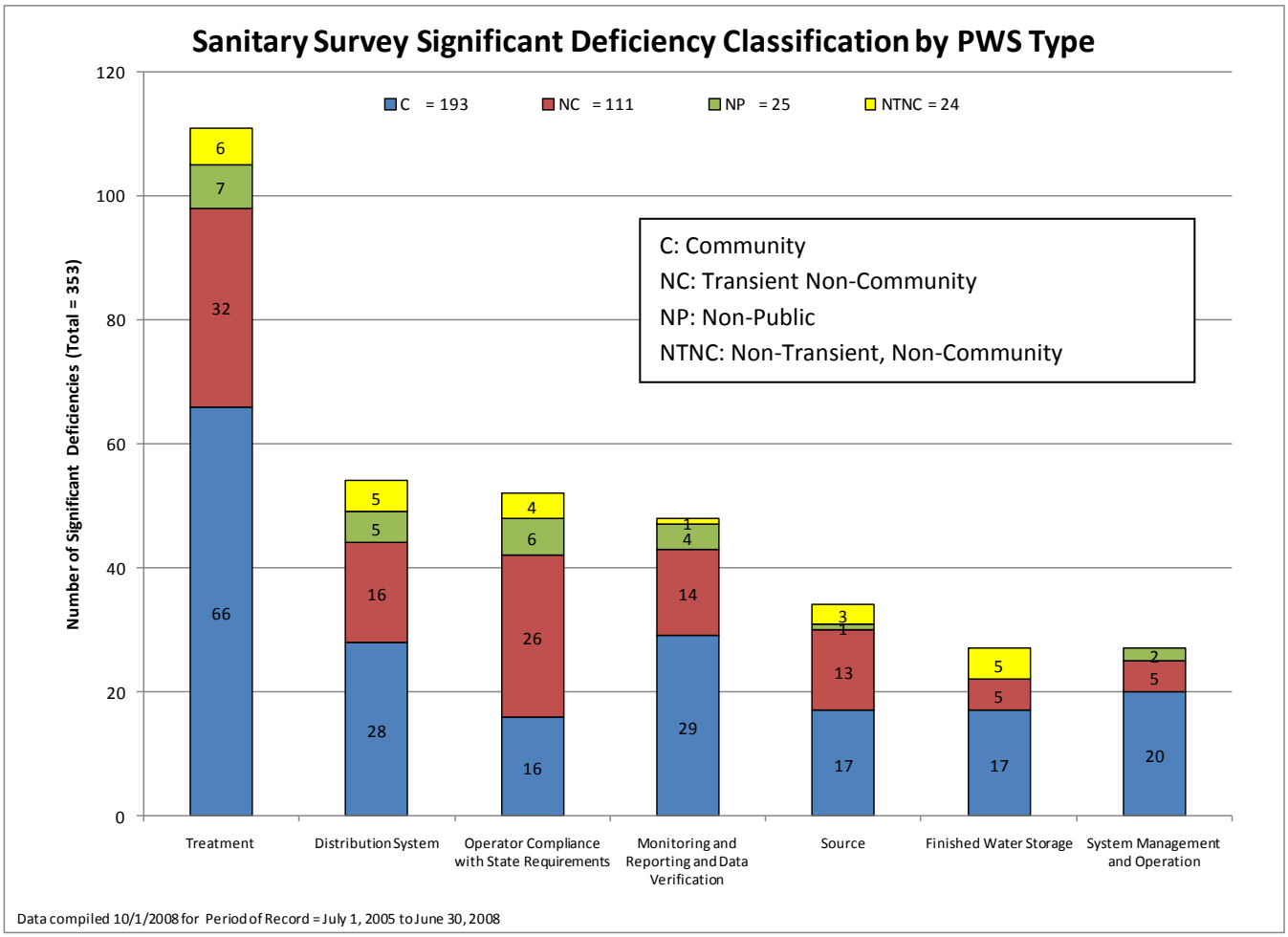

Figure 5: Sanitary Survey Significant Deficiencies by Public Water System (PWS) Type

The majority of significant deficiencies occurred in community water systems; however, this may have been in part a result of the data collection process. Sanitary surveys are conducted a minimum of every three years for community surface water systems and every five years for community groundwater

systems and non-community systems. In addition, although small non-community groundwater systems are inspected more frequently (as often as every year) by the Safe Drinking Water Program in partnership with the Consumer Protection Division and local health departments, the results of those surveys have historically not been entered into SDWIS/State. As of 2008, these data are being entered into SDWIS/State; however, a skew in the data towards community systems still exists.

Overall, approximately 74% of public water systems in Colorado are groundwater systems and the remainder serve surface water or groundwater under the influence of surface water (GWUDI). Figure 6 provides a comparison between the number and categories of significant deficiencies and the source of the drinking water for the system where the deficiency was observed. As shown, 194 (55%) of all significant deficiencies were associated with groundwater systems, 60 of which were treatment-related deficiencies. This seems to indicate that surface water and GWUDI systems contributed disproportionately more significant deficiencies to the total number observed.

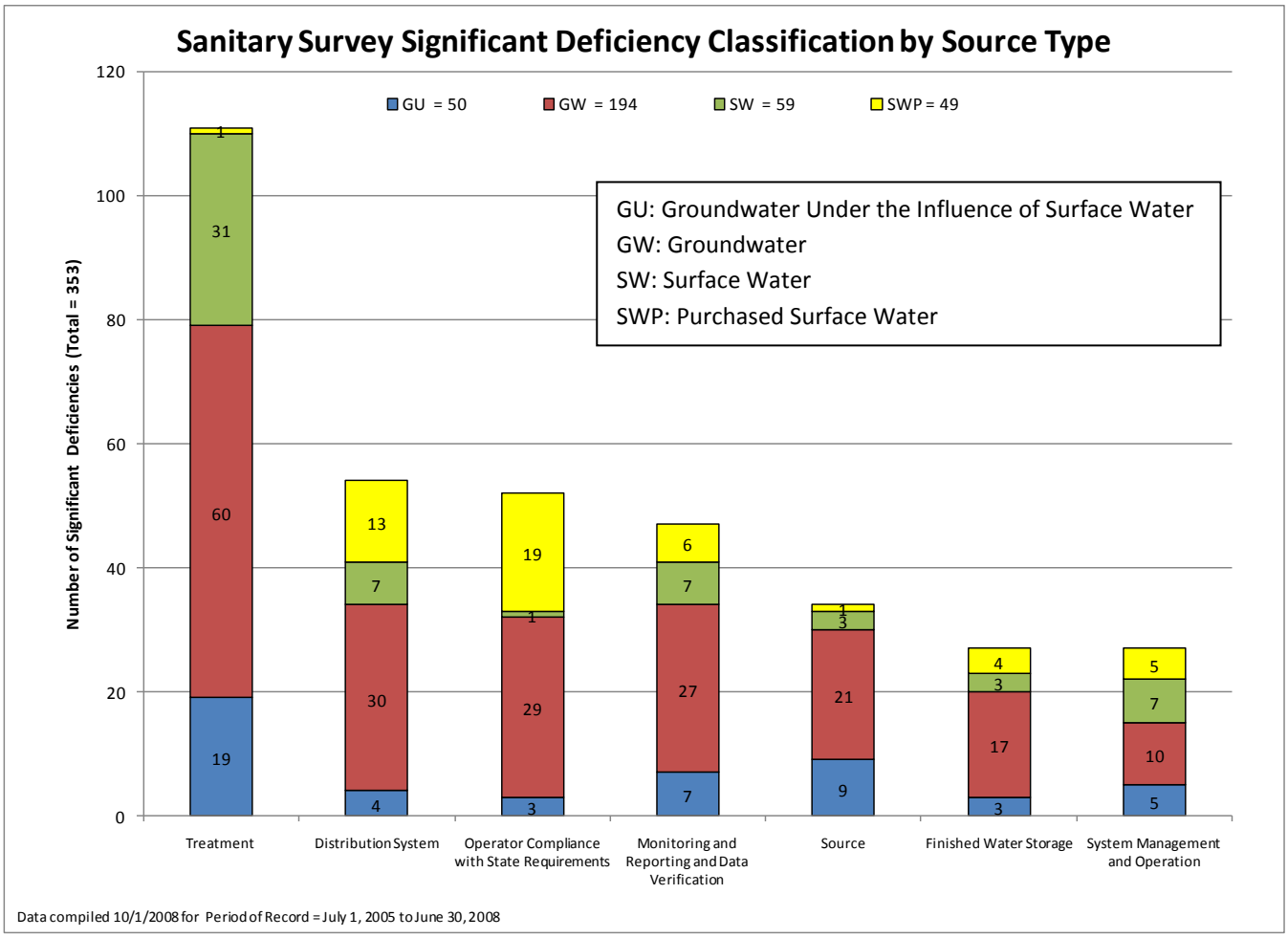

Figure 6: Sanitary Survey Significant Deficiencies by Source Type

Given that treatment deficiencies were the most common type of significant deficiency observed (see Figures 5 and 6), the nature of treatment deficiencies was further evaluated. In Figure 7, all observed *treatment* deficiencies (111 total) were evaluated based on unique treatment-related deficiency codes. As shown, the most common treatment deficiencies were a lack of, or inoperable, disinfection equipment (29 or 26%) followed by cross-connection issues (17 or 15%). Systems with these deficiencies are at a greater risk of a waterborne disease outbreak.

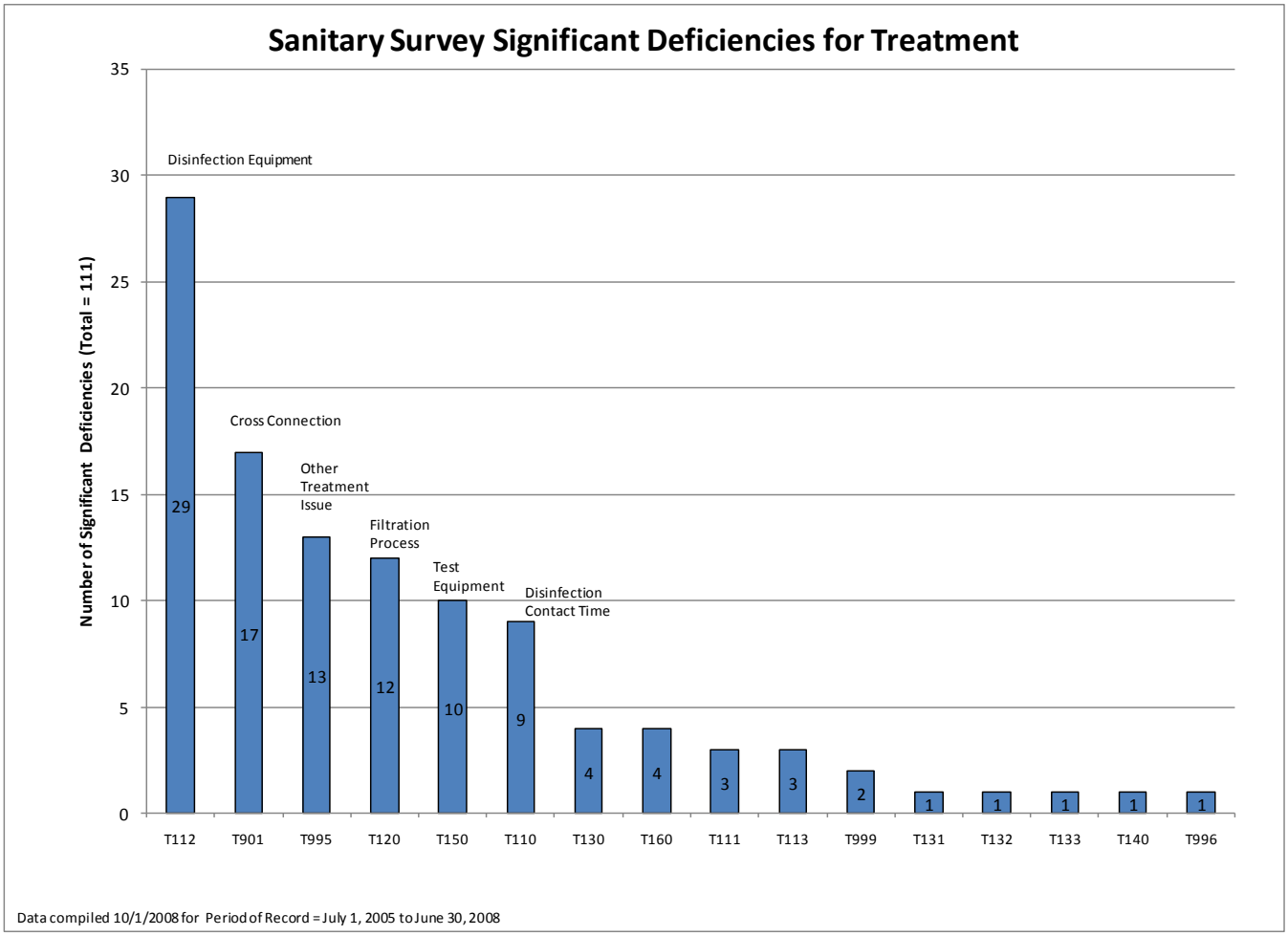

Figure 7: Sanitary Survey Significant Deficiencies for Treatment (See Appendix C for definitions of deficiency codes.)

Given that distribution system deficiencies ranked second highest in the total number of significant deficiencies observed (see Figures 5 and 6), the nature of distribution system deficiencies was also further evaluated. In Figure 8, all observed *distribution system* deficiencies (54 total) were shown based on their deficiency codes. The most common distribution system deficiencies were a failure to maintain disinfection residuals (27 or 50%), followed by cross-connection issues (13 or 12%), and raw, or untreated, water taps service customers (6 or 11%). These deficiencies have a very high potential for a significant impact on public health.

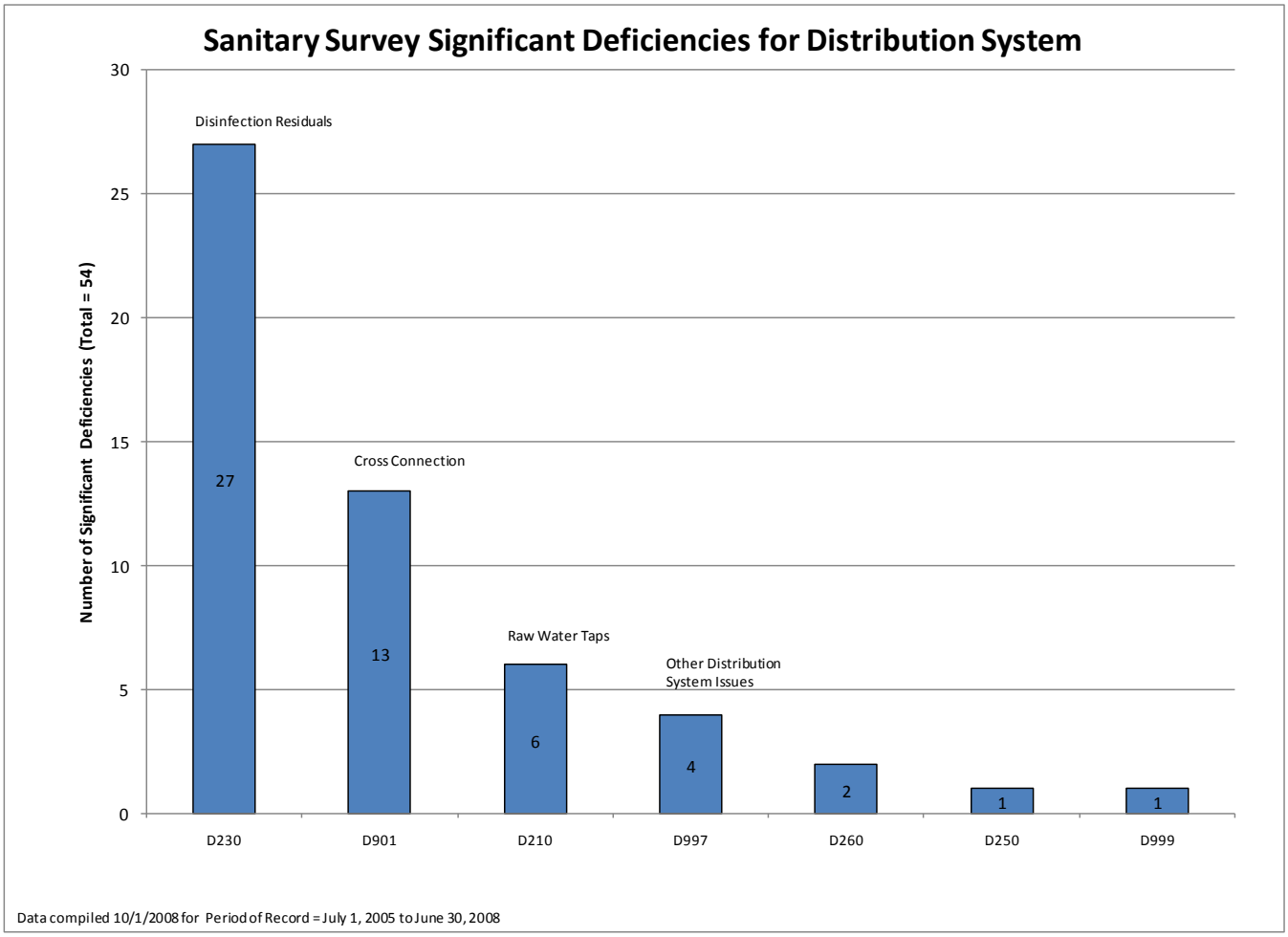

Figure 8: Sanitary Survey Significant Deficiencies for Distribution Systems (See Appendix C for definitions of deficiency codes.)

Monitoring, reporting, and data verification deficiencies ranked fourth highest in the total number of significant deficiencies observed (see Figures 5 and 6), and therefore the nature of these deficiencies was further evaluated. In Figure 9, all *monitoring, reporting, and data verification* deficiencies (48 total) are illustrated based on their deficiency codes. As shown, the most frequent monitoring, reporting, and data verification deficiency was failure to obtain plans and specifications approval for the system or renovations to the system (31 or 65%). Anecdotal information suggests that many water systems, their operators, and their design engineers do not understand the design criteria or fail to understand the significance of many of the provisions in the criteria, and that failure to obtain proper approval can lead to other failures at a later date.

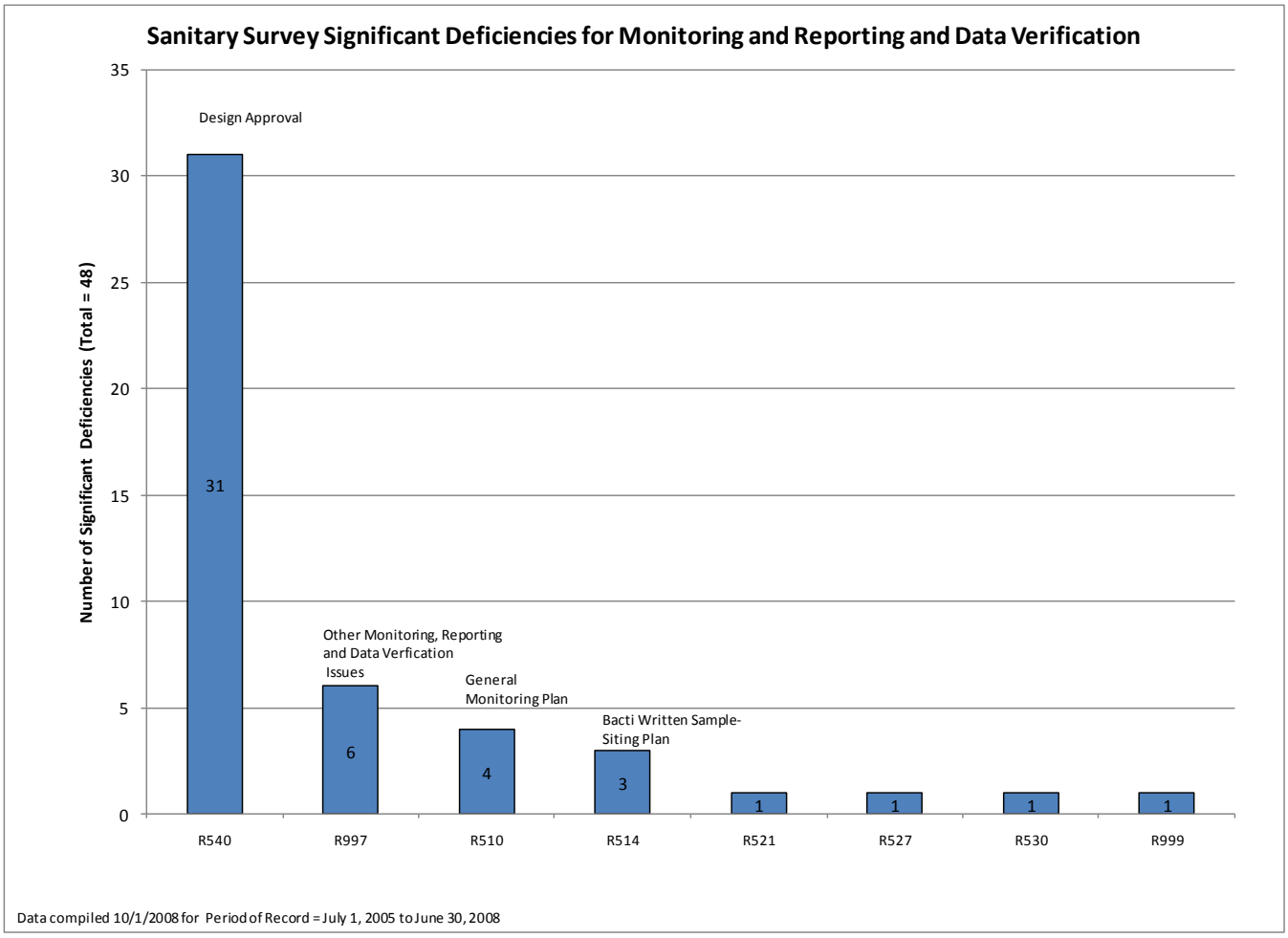

Figure 9: Sanitary Survey Significant Deficiencies for Monitoring, Reporting and Data Verification (See Appendix C for definitions of deficiency codes.)

Minor Deficiencies

Minor deficiencies were found during 477 (25%) of the 1,942 sanitary surveys reported in SDWIS/State during the three-year study period. Minor deficiencies do not contribute to increase risk as directly as the significant deficiencies illustrated on the previous few pages of this report, but they are commonly noted in sanitary survey reports. In these systems, there were 1,286 separate minor deficiency observations. Figure 10 illustrates the top 1,031 (80%) of all the minor deficiencies identified during the study period (prior to grouping by category). The most common minor deficiency codes corresponded to a lack of, or inadequate, planning for the following: cross connection control (M610), bacti sample-siting (R514), monitoring (R510), and emergency response (M820).

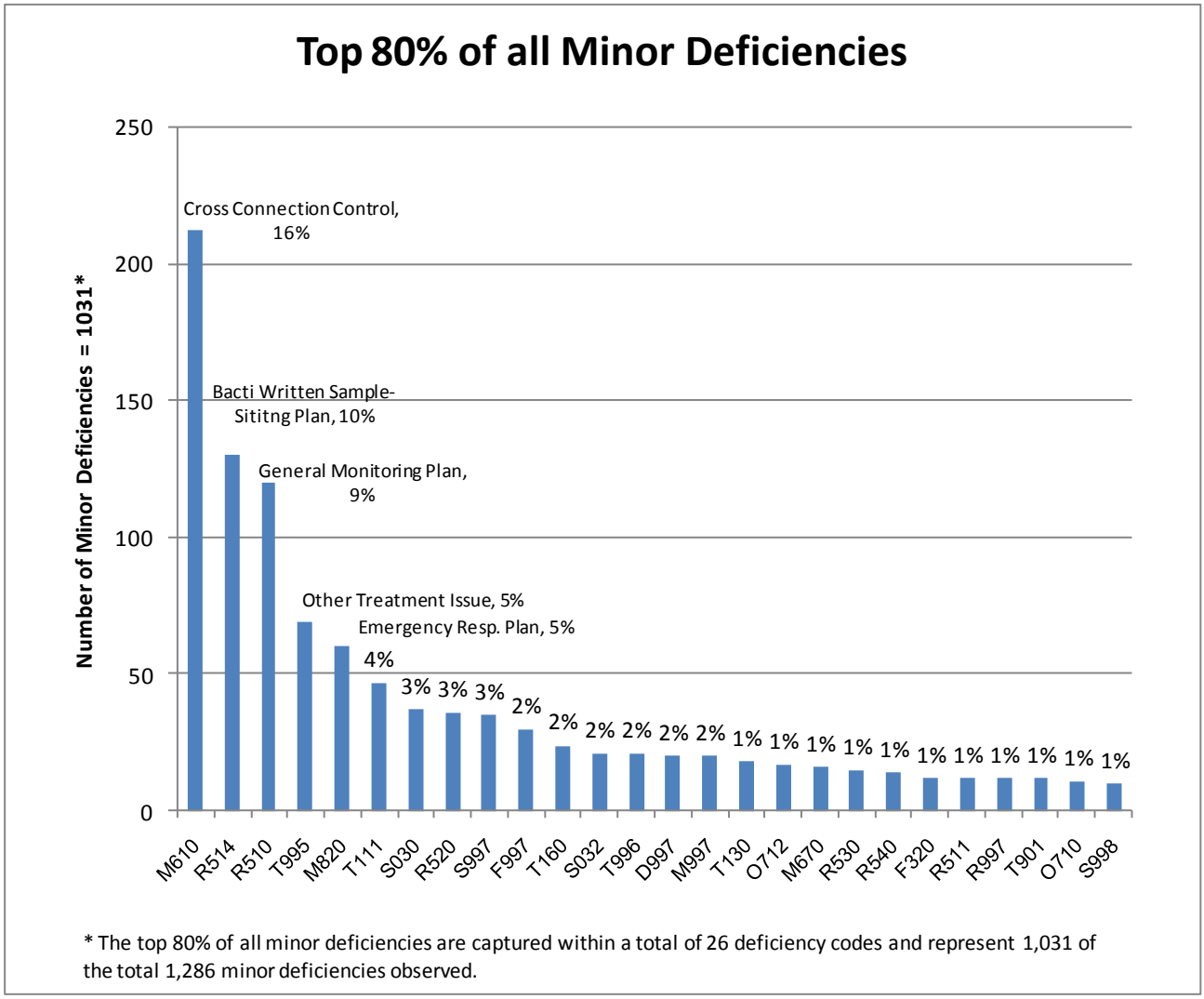

Figure 10: Top 80% of all Minor Deficiencies

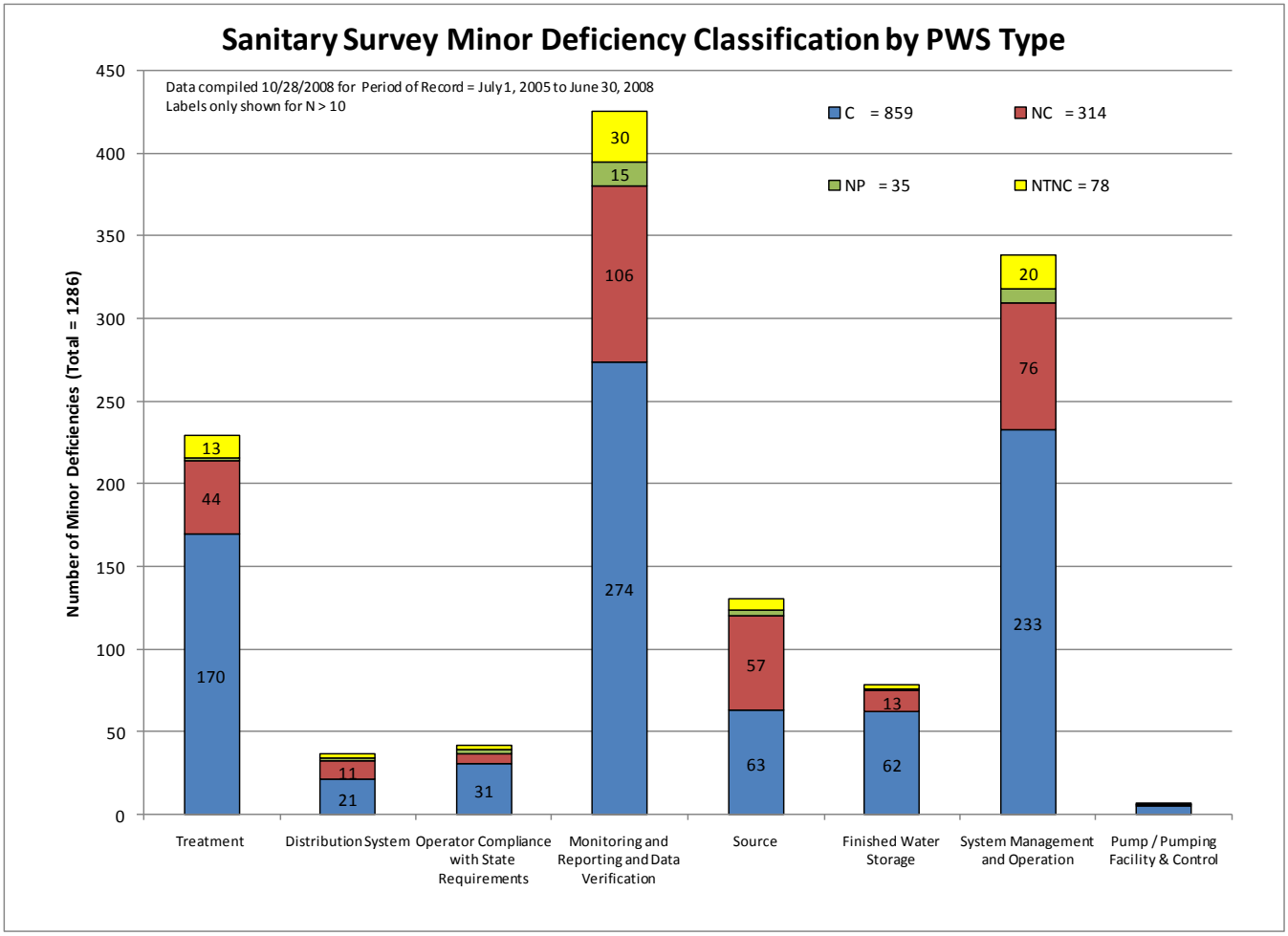

Figure 11: Minor Deficiencies by PWS Type

In Figure 11, the minor deficiencies were grouped by category, and then the number and categories of deficiencies are compared to the types of public water system where the deficiencies were observed. As shown, the most common minor deficiencies were associated with monitoring, reporting, and data verification (425 or 33%) and system management and operation (338 or 26%).

Given that monitoring, reporting, and data verification deficiencies were the most common minor deficiencies observed, the nature of these deficiencies was further evaluated. In Figure 12, all observed *monitoring, reporting, and data verification* deficiencies (425 total) are shown based on their deficiency codes. The most common monitoring, reporting, and data verification deficiency codes were a lack of or inadequate bacti sample-siting plan (130 or 31%), a lack of or inadequate, general monitoring plan (120 or 28%), and inadequate recordkeeping or document retention (36 or 8%).

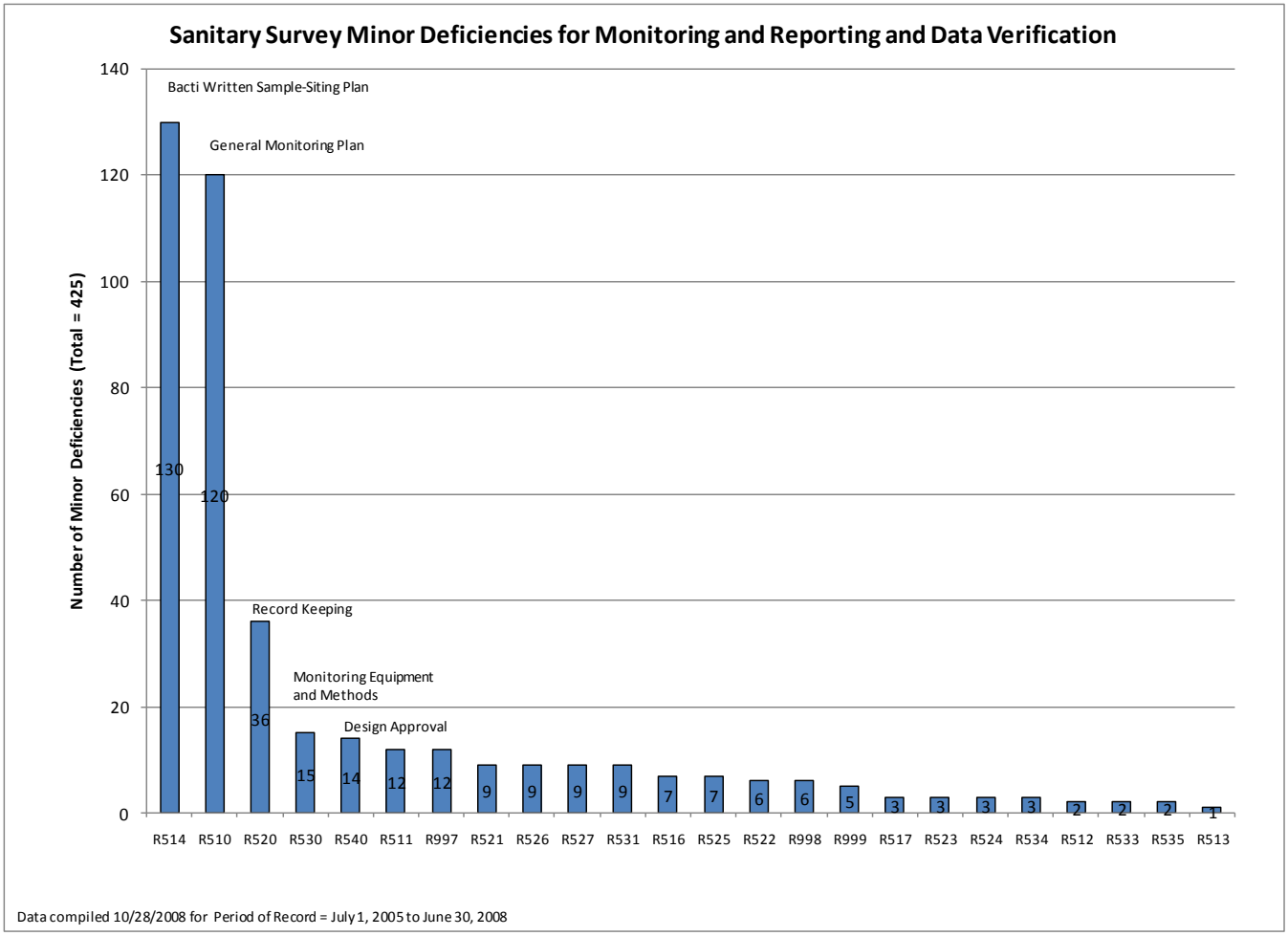

Figure 12: Minor Deficiencies for Monitoring, Reporting and Data Verification (See Appendix C for definitions of deficiency codes.)

System management and operation deficiencies were the second most common minor deficiencies observed, the nature of these deficiencies was further evaluated. In Figure 13, all observed *system management and operation* deficiencies (338 total) are illustrated based on their deficiency codes. As shown, the most common system management and operation deficiency codes were lack of cross connection control (212 or 63%), and an inadequate emergency response plan (60 or 18%).

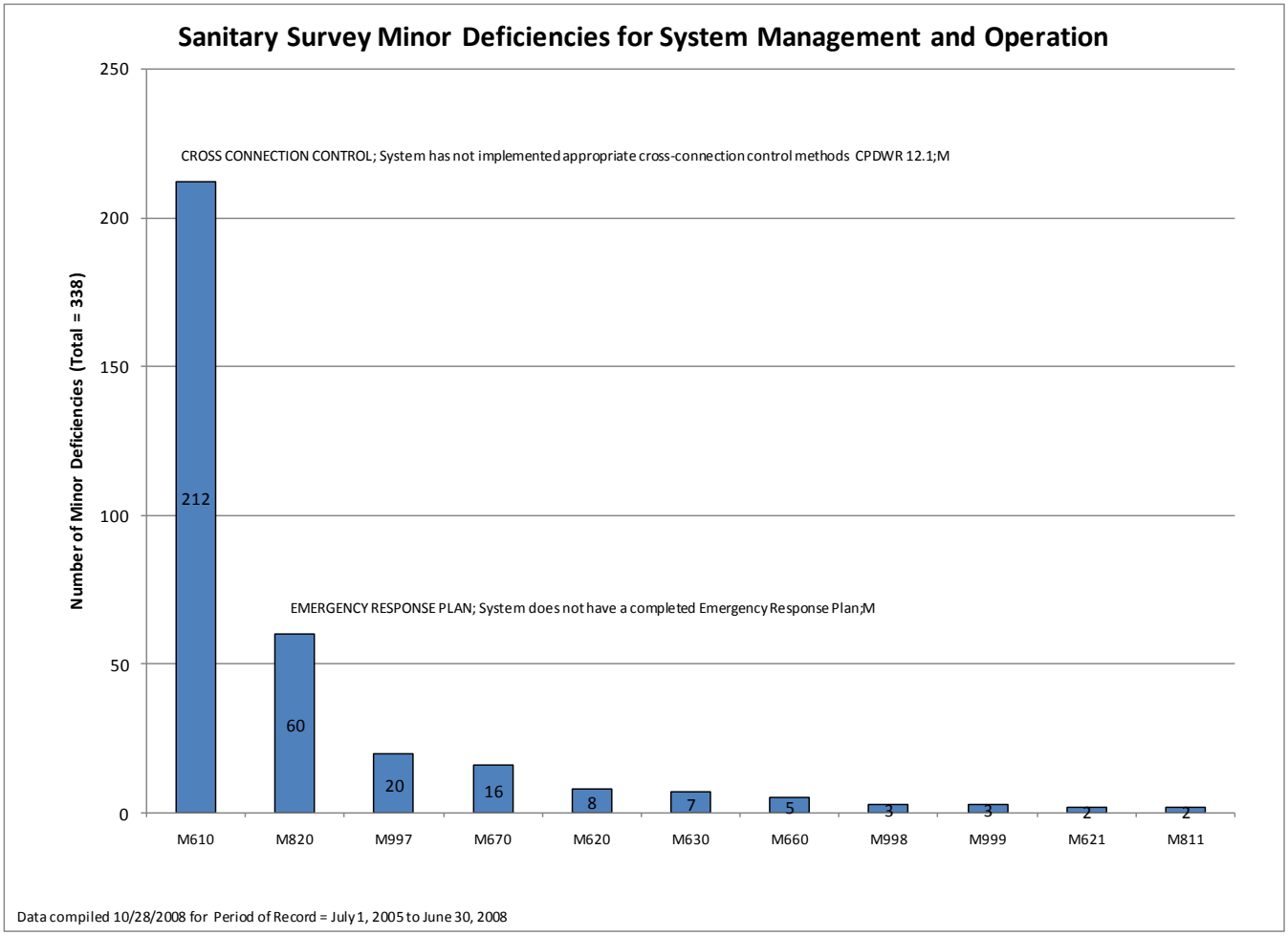

Figure 13: Sanitary Survey Minor Deficiencies for System Management and Operation (See Appendix C for definitions of deficiency codes.)

Violations Reported in SDWIS

Reports from SDWIS/State included over 16,000 violations (largely associated with monitoring and reporting) during the three-year study period. Of the 2,023 public water systems in Colorado, a total of 1,286 (approximately 63%) reported at least one violation. These water systems collectively serve 47% of the population served by all public water systems. While a total of 292 water systems (14% of all systems in Colorado) reported at least one violation in the high priority categories of maximum contaminant level (MCL) violations or treatment technique (TT) violations; these violations do indicate an increased public health risk. This information is summarized in Table 1.

TABLE 1: Summary of Violations Data, 7/1/05-6/30/08

Violation Category -	Total population affected by violations:	Percentage of population affected by violations: [a/]	Percentage of population unaffected by violations: [a/]	Total number of water systems affected by violations:	Percentage of water systems affected by violations: [b/]	Percentage of water systems unaffected by violations: [b/]
All	**2,604,165**	**47%**	**53%**	**1,286**	**64%**	**36%**
MON	2,514,412	45%	55%	1,198	59%	41%
RPT	451,828	8%	92%	249	12%	88%
MCL	263,604	5%	95%	216	11%	89%
TT	89,592	2%	98%	76	4%	96%
PN	543	0%	100%	3	0%	100%
SS	65	0%	100%	1	0%	100%

[a/] Based on a total population of 5,551,120.
[b/] Based on a total of 2,023 public water systems.

Notes: MON = monitoring, RPT = reporting, MCL = maximum contaminant level, TT = treatment technique, PN = public notice, and SS = sanitary survey. Data compiled 10/1/2008.

In Figure 14, all violations reported in SDWIS for the three-year study period were grouped according to the violation categories shown in Table 1 for ten Colorado drinking water rules. These groupings were then plotted to show the types (i.e., category and rule) of violations most commonly reported by public water systems. The drinking water rules used in this evaluation are as follows:

- Inorganic contaminants (IOC)
- Radionuclides (RAD)
- Synthetic organic chemical (SOC)
- Volatile organic chemical (VOC)
- Consumer confidence reports (CCR)
- Disinfection by-products (DBPs)
- Lead and copper rule (LCR)
- Public notification (PN)
- Surface water treatment rule (SWTR)
- Total coliform rule (TCR)

As shown in Figure 14, public water systems most frequently reported monitoring and reporting violations under the volatile organic chemical (VOC), synthetic organic chemical (SOC), and inorganic contaminants (IOC) rules. It is important to note that each of these rules contains a suite of contaminants that must be monitored at the same time and, therefore, any single failure to sample/report may result in multiple violations, one for each contaminant in the suite. No public water systems reported violations maximum contaminant level (MCL) violations under the VOC and SOC rules. 169 MCL violations were reported under the IOC rule.

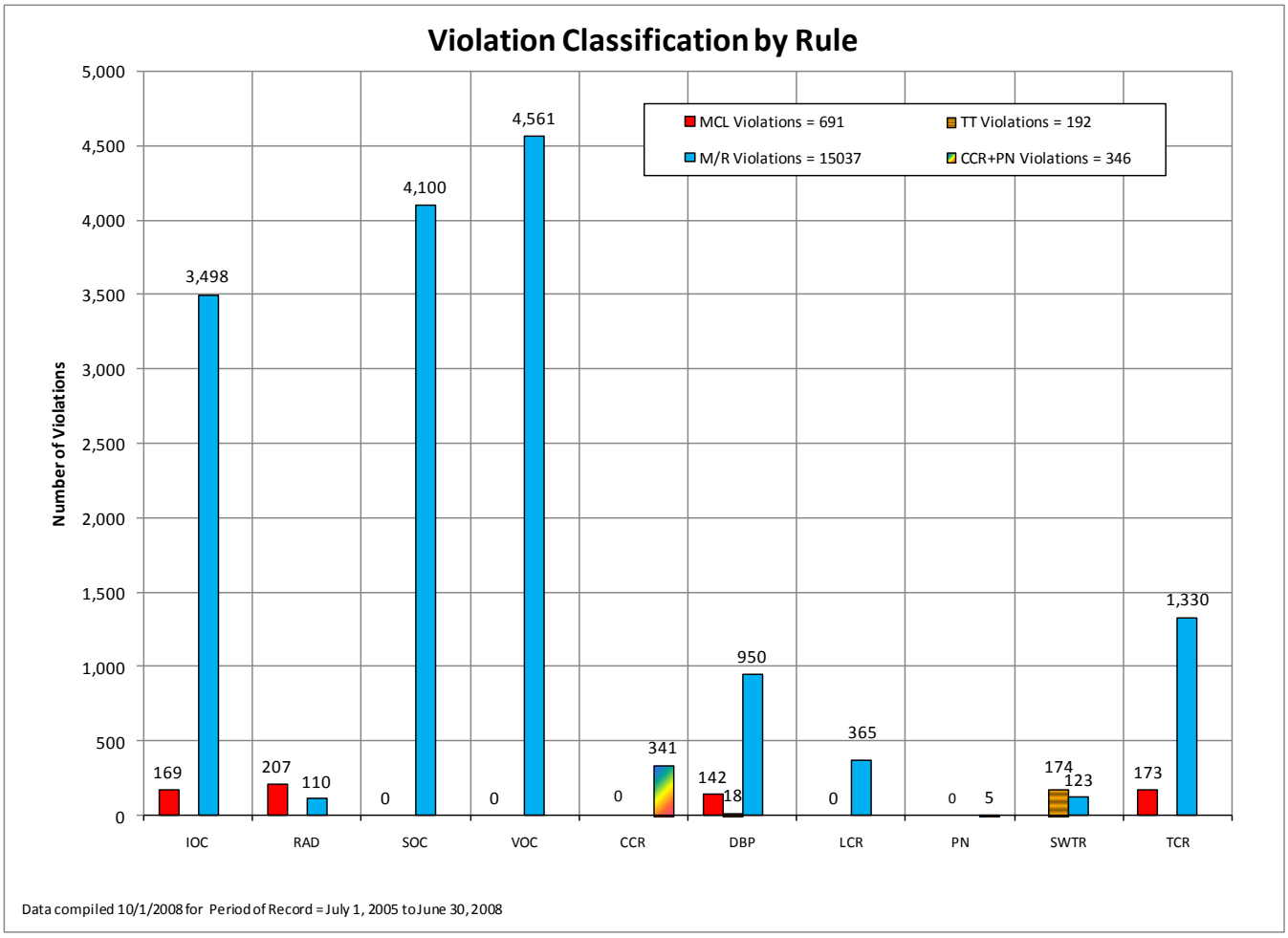

Figure 14: Violations by Type and Rule

Notes: inorganic contaminants (IOC), radionuclides (RAD), synthetic organic chemical (SOC), volatile organic chemical (VOC), consumer confidence reports (CCR), disinfection by-products (DBPs), lead and copper rule (LCR), public notification (PN), surface water treatment rule (SWTR) and total coliform rule (TCR).

Figure 15 compares the number and categories of violations to the number of public water systems in which the violations were reported. As shown, the greatest number of individual public water systems reported monitoring and reporting violations of the total coliform rule (714 or 56% of all systems with violations), followed by the inorganic contaminant rule (481 or 37% of all systems with violations), and the disinfection by-product rule (335 or 26% of all systems with violations).

Maximum contaminant level violations were most frequently associated with the Total Coliform Rule (121 or 9% of all systems with violations), followed by the Radionuclide Rule (45 or 3% of the systems with violations), and the Inorganic Contaminant Rule (40 or 3% of the systems with violations).

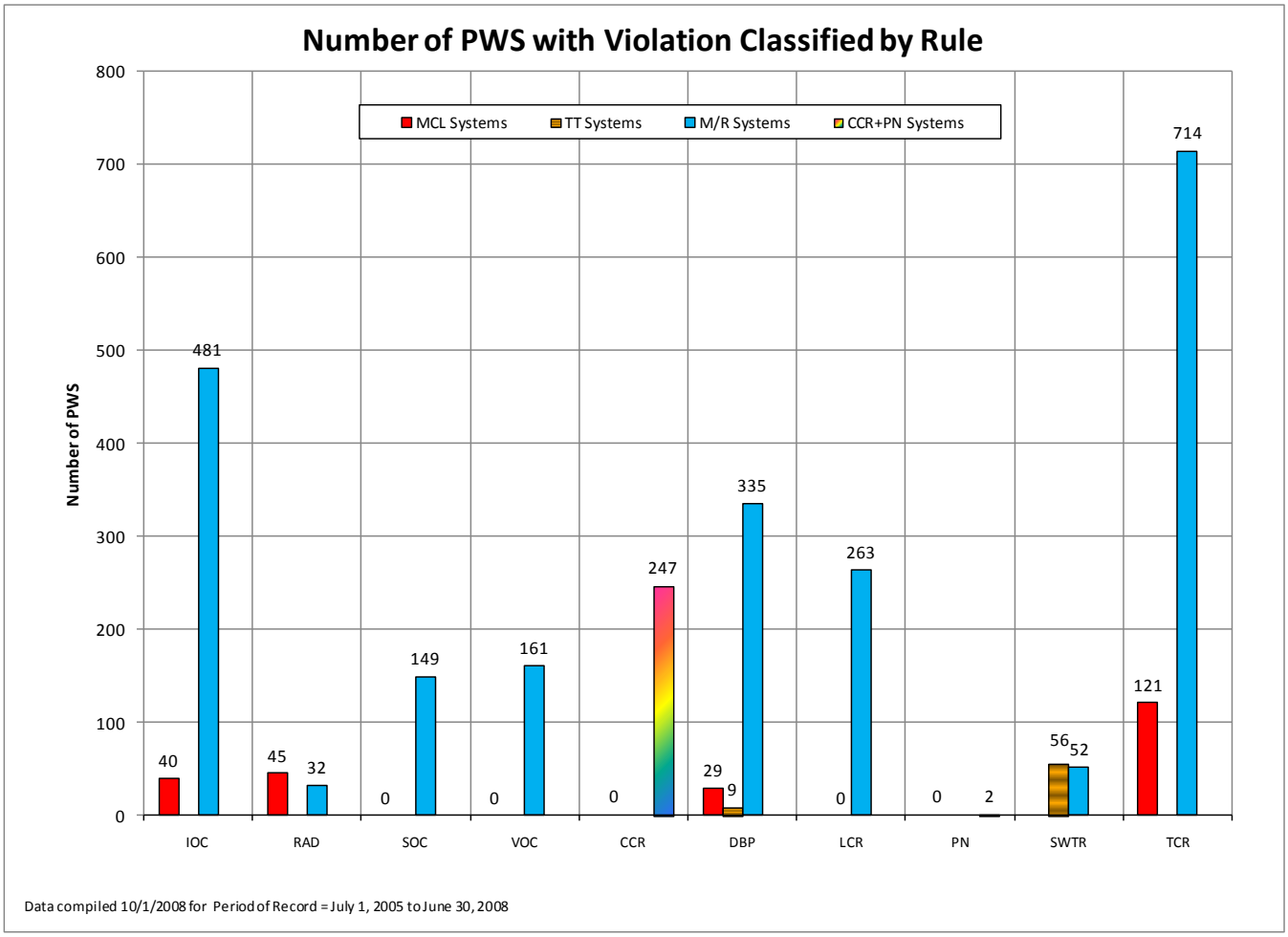

Figure 15: Number of PWS With Violations by Type and Rule

Notes: inorganic contaminants (IOC), radionuclides (RAD), synthetic organic chemical (SOC), volatile organic chemical (VOC), consumer confidence reports (CCR), disinfection by-products (DBPs), lead and copper rule (LCR), public notification (PN), surface water treatment rule (SWTR) and total coliform rule (TCR).

KEY FINDINGS

A modified Pareto analysis of the failure data for a three-year study period from the Division's Acute Team tracking database and the SDWIS/State database illustrated important trends in compliance failures at public water systems in Colorado. The following are key findings from this work.

I. Acute Team data show that over half of the system failures resulting in a response were associated with:

- distribution system deficiencies
- surface water system treatment deficiencies

The majority of acute responses occurred at community water systems, although this may be due to the failure of transient and non-transient water systems to report to the Acute Team. Systems with failures associated with untreated groundwater and surface water intended for drinking resulted in the longest duration of boil or bottled water orders. While the full extent of the public health impact is unclear, more than 60,000 people were affected by boil or bottled water orders during acute events over the three-year study period.

II. SDWIS/State data showed that individual significant deficiencies identified during a sanitary survey were most commonly associated with the lack of a certified operator, failure to obtain design approval, deficient disinfection equipment, and failure to maintain an adequate disinfection residual in the distribution system. When grouped into categories, significant deficiencies were most commonly associated with:

- treatment (primarily inadequate disinfection equipment)
- distribution systems (primarily failure to maintain disinfection residuals and cross connection control)

III. SDWIS/State data illustrated that individual minor deficiencies were most commonly associated with the lack of or inadequate cross connection control plan, bacti sample-siting plan or monitoring plan. When grouped into categories, minor deficiencies were most commonly associated with:

- monitoring, reporting, and data verification (primarily lack of or inadequate bacti sample-siting plan and general monitoring plan), and
- system management and operation (primarily failure to maintain cross connection control).

The majority of significant and minor deficiencies occurred at community water systems, although this may be in part a result of the inspection scheduling and reporting process.

IV. SDWIS/State data also showed that, while 63% of all systems in Colorado reported at least one violation during the study period, the majority of violations were monitoring and reporting violations which are not necessarily associated with an increased public health risk. About eleven percent (11%) of the systems reported at least one violation in the high-priority category of maximum contaminant level violations which do indicate an increased public health risk. Maximum contaminant level violations were most frequently associated with the total coliform rule, followed by the radionuclide rule, and the inorganic contaminant rule.

In summary, the Acute Team responses, sanitary survey results, and self-reported compliance data collected over the three-year period suggested the following primary reasons for observed failures in public water systems:

- Disinfection:
  - Failure to maintain disinfection residuals
  - Inadequate disinfection equipment
  - Positive total coliform

- Cross Connection Control:
  - Presence of cross connections
  - Lack of cross connection control planning

- Distribution System Operations:
  - Failure to maintain disinfection residuals
  - Failure to maintain cross connection control

- Failure to Plan:
  - Lack of, or inadequate, bacti sample-siting plan
  - Lack of, or inadequate, general monitoring plan
  - Failure to obtain design approval

- Management and Operation:
  - Operator compliance with State requirements
  - Failure to monitor and report water quality in compliance with regulations
  - Failure to obtain design approval prior to construction

The sanitary survey results indicated a lack of adequate planning, and compliance data in turn reflected a failure to execute planned or required activities. Minor deficiencies were most frequently related to lack of or inadequate plans for monitoring, cross-connections control. A lack of planning can create the conditions that can lead to treatment upsets, distribution failures, and contaminated water.

The observation that many systems have deficiencies and violations suggests that systems are not fully addressing sources of their compliance failures. It is believed that these systems will improve operations and reduce failures if offered appropriate and focused capacity building services.

RECOMMENDATIONS

The modified Pareto analysis described in this report provides a powerful mechanism for the Capacity Building Unit of the Safe Drinking Water Program to improve operations by identifying the most frequent key failures of public water systems so that resources can be utilized most effectively. This lays a foundation of operational improvement and will lead to future work to hone efforts that further identify and address the root causes of public water system failures. Careful data analysis and review shows that most failures observed at Colorado public water systems are associated with system operation, including fulfilling monitoring requirements, ensuring that equipment is maintained and operated properly, and maintaining existing physical infrastructure. The following recommendations are designed to aid the Safe Drinking Water Program in directing current and future resources towards the most critical failures public water systems.

- **Recommendation 1: Focus training, technical assistance, and management support services on the key weaknesses and compliance failures identified in this report.** The Capacity Building Unit of the Safe Drinking Water Program provides services to public water systems so that they can strengthen their ability to supply safe drinking water to the public. The goal of a Pareto approach is to identify a limited number of failures that, if addressed through the appropriate services, produce significant overall positive effects. Accordingly, the Capacity Building Unit and its contractors will modify operations to focus on offering services that target the following key weaknesses and compliance failures presented in this report:

  - ✓ **Disinfection**
    - ➢ Focus on troubleshooting disinfection issues, calculating required chlorine contact times, operation and maintenance requirements for chlorine pumps, the Total Coliform Rule, Disinfection Byproduct Rule, Groundwater Rule, developing and implementing bacti sample-siting plans and monitoring procedures, sampling procedures, recordkeeping requirements, and system operation and maintenance.

  - ✓ **Cross Connection Control**
    - ➢ Focus on understanding and evaluating examples of cross connection, developing cross connection control plans, troubleshooting, maintaining legal authority for cross connection control, cross connection control devices, and backflow testing requirements.

  - ✓ **Distribution Systems**
    - ➢ Focus on procedures for maintaining system integrity, including preventing and addressing pipe breaks, leaks, and loss of system power and/or pressure, valve exercising, and line flushing and maintenance requirements, including dechlorination requirements.

- ✓ **Failure to Plan**
  - ➢ Focus on developing and implementing general monitoring plans, bacti sample-siting plans, and emergency response plans; cross connection control planning; recordkeeping requirements; and design approval procedures and requirements.

- ✓ **Management and Operation**
  - ➢ Focus on certified operator requirements, proper monitoring and reporting, and meeting requirements for design approval prior to construction.

The Capacity Building Unit will work to communicate and disseminate these results of the Pareto analysis to trainers and assistance providers; work with trainers and assistance providers in further assess and understand the target areas of concern demonstrated by this analysis; and then ensure that current and future capacity building services address those target areas. The Capacity Building Unit should apply the project results to develop developing a more cohesive, organized, and strategically aligned spectrum of services for the benefit of public water systems in Colorado.

- **Recommendation 2: Develop programs to further assess the root cause of monitoring violations and to reduce those violations.** The most common failure among public water systems is failure to comply with monitoring and reporting regulations. While the health effects of inadequate monitoring are difficult to quantify, monitoring is clearly key to ensuring safe water. Operators hold primary responsibility for ensuring that monitoring data is collected and reported. The failure of an operator to conduct or report monitoring may be due to lack of accountability, lack or training or difficulty in understanding the requirements, lack of resources (e.g., time, money) to conduct the monitoring, among other reasons. The modified Pareto analysis results show that resources would be well spent on further assessing the root cause of monitoring and reporting failures and then targeting assistance to those specific problem areas.

- **Recommendation 3: Continue to improve data consistency and utilize data to develop benchmarks for improvement.** This study was made possible by the extensive database currently existing within the program. Improving data consistency and availability is an ongoing effort, and should be continued. Benchmarks should be established track and assess improvements in public water system performance and to evaluate the effectiveness of capacity building services and other programs.

- **Recommendation 4: Utilize these and future report results to promote and enhance communication with stakeholders**. The project results provide a foundation for improved communication with stakeholders and for focused development of capacity building services. The results provide a certain transparency in decision-making so that interested stakeholders as well as internal staff have a clear understanding of why and how program priorities and operations are established going forward. Appendix B provides comments and feedback

received by two selected stakeholders (i.e., Colorado Rural Water Association [CRWA] and the Rural Community Assistance Program [RCAP]) regarding the draft version of this report.

In addition to these recommendations to improve program operations in the future, it also should be noted that many existing activities are functioning well, and new services are being developed and employed to address the findings of this study. Capacity building programs and capacity coaches are available to assist communities. A wide range of training programs currently are offered by the department and its strategic partners, and new training programs are under development. Appendix A contains more detailed information on some newer efforts.

This project has illustrated that a Pareto analysis can be used as an effective tool for analyzing water system data to direct program operational resources. Because the there is an excellent resource in data from the Acute Team, sanitary surveys, compliance reporting, the program will continue to use this technique in the future to study trends in water system failures and to guide future use of resources.

APPENDIX A
NEW CAPACITY-BUILDING SERVICES

The purpose of the Capacity Building Unit is to provide training, technical assistance, and management support services to public water systems so they can strengthen their ability to supply safe drinking water to the public. This appendix provides information on select new services that are designed to target the most frequent failures experienced by Colorado's public water systems.

1. Application of concepts and testing to process control in conventional surface water treatment plants

Two advanced training courses were developed to address operational issues identified in the comprehensive performance evaluations (CPEs) and Acute Team responses at surface water treatment plants across Colorado:

Advanced Process Diagnostics for Performance Evaluation (based on CPE techniques)

- Evaluate the firm capacity of water treatment processes
- Identify and prioritize performance limiting factors
- Manage water quality data to make sound treatment decisions

Advanced Process Control and Optimization

- Optimize coagulation, flocculation, and media filtration processes
- Make and use simple, high-impact optimization tools
- Apply theory and engineering principles to everyday water treatment operations

Both courses were offered twice in 2008 and both filled up. Two additional pairs of courses will be offered in 2009 and 2010. The first pair, held in 2009, filled rapidly, with a waiting list. This indicates there is a demand among Colorado's operators to learn this kind of material.

2. Water quality and distribution system operations

A new series of courses is being developed in 2009 to address water quality and distribution system operations. This includes tank operations and line breaks and their potential impact on water quality. It also includes the utility of monitoring for coliform, chlorine residuals, heterotrophic plate count, disinfection byproducts and parameters related to nitrification in chloraminated systems (total chlorine, free ammonia, nitrite, temperature, pH, etc.). Cross-connection control as it relates to distribution system water quality also is included in this category.

3. Maintaining a disinfection barrier

Two capacity coaches have been hired to provide technical assistance to small water systems. Failure of disinfection equipment and failure to maintain a disinfectant residual are two of their top priorities for system coaching.

4. Sampling properly for total coliform rule compliance.

Four summer interns were hired for the summer of 2009 to work with systems to develop bacteriological monitoring plans. This also is a priority for coaches.

APPENDIX B
FEEDBACK FROM SELECTED STAKEHOLDERS

The following are notes from conversations with selected stakeholders (the Colorado Rural Water Association and the Rural Community Assistance Program) on the draft Failure and Root Cause Analysis Report.

Notes for conversation with Rich Hayes, Executive Director, Colorado Rural Water Association (CRWA)
prepared by Jeff Oxenford
April 17, 2009

The following notes were recorded after a conversation with Rich Hayes, executive director of the Colorado Rural Water Association (CRWA). He offered the following observations and recommendations for addressing concerns identified in the Failure and Root Cause Analysis Report. His general impression is that through improved coordination between the CDPHE and CWRA, the association could better target resources to address the issues identified in the report.

1. Board and Elected Official Training – The association has noticed a major challenge in system management due to lack of understanding of new elected officials and board members. These officials need some assistance in understanding their responsibilities as they relate to water and wastewater systems. The association has offered training but often has received only limited participation.

> Recommendation – Newly elected officials and board members need to be strongly encouraged to obtain training or possibly certification. Some states have a mandatory program, and this could be considered for Colorado.

2. Sanitary survey consistency – There seems to be some inconsistency among district engineers in what they look for and how they interpret rules. More consistency would allow for improved assistance programs.

CRWA does offer a pre-sanitary survey review when requested by systems. Circuit riders also respond to requested-for support after deficiencies are identified. Circuit riders must make 35 contacts each month, so with two circuit riders that means more than 70 systems per month can receive support. According to the agreement with the U.S. Department of Agriculture, support is only for community water systems, unless the support is to CDPHE. Support is requested by systems and covers a variety of utility issues, only a portion of which is related to regulatory matters.

> Recommendations
>
> CRWA/District Engineers Coordination – In discussions with the association, it is clear that there are CRWA resources available to assist systems. Coordination with district engineers can help

ensure that CRWA targets the most important issues and systems that need the most assistance. A few examples follow:

- Provide CRWA a list of significant noncompliance (regularly updated). CRWA could use the list to prioritize systems that receive support.
- Provide cross-training between CRWA circuit riders and district engineers. This cross-training would help ensure that CRWA assistance targets the most important issues to district engineers. Possibly have the CRWA riders observe district engineers on a few sanitary surveys.
- District engineers can refer systems with significant deficiencies to a CRWA circuit rider.
- A transient non-community (TNC) circuit rider is needed. CRWA's current circuit riders, by agreement with the USDA, can support only community water systems. There is the need for a TNC circuit rider to be funded through another mechanism, possibly the department.

3. Training coordination – CRWA agrees that there must be coordination between the different organizations offering training (i.e., CDPHE, CRWA, Rural Community Assistance Program (RCAP), the American Water Works Association (AWWA), Action Now, etc.). Coordination can ensure that key topics are adequately addressed and scheduling overlap and unnecessary duplication of effort is minimized. (Some duplication is needed.)

Recommendation: CRWA would be interested in participating in a training coordination committee or other effort.

4. Reducing monitoring and reporting violations

CRWA currently offers a class four times a year to assist systems in putting monitoring requirements on a calendar. Classes are held after systems receive the annual monitoring and reporting requirement letter. (The letter is a very good thing). CDPHE did participate in this training four years ago and its participation again would be helpful. These classes have been well-attended.

Some commercial labs are sent the monitoring and reporting schedules, allowing them to better assist systems. CRWA could also be a source of the reminders if it had access to these letters, prior to other contacts with these systems.

Recommendations

- Provide the CRWA with access to the monitoring and reporting requirements for systems.
- Have CDPHE participate in the association's monitoring classes.
- Consider a master database and reminder systems for monitoring and reporting.

Notes from discussion with Joy Barrett and Bill Hogrewe, Rural Community Assistance Partnership (RCAP) on the Failure and Root Cause Analysis Project – prepared by Jeff Oxenford
April 20, 2009

Planning

- Provide examples of good planning: What would a good plan look like? The state could provide examples of a good plan or contacts at utilities that have done a good plan.
- Provide training that helps systems develop an outline of a good plan.
- Provide training focused on the engineering community or organizations that provide assistance to utilities on what plan elements must be addressed. A good example is USDA's training to the engineering community on what it expects to see in the preliminary engineering reports.

Monitoring and reporting

- While operators are responsible for monitoring and reporting, boards/managers must be made aware of requirements to be sure that operators have the necessary resources and support to accomplish monitoring and reporting requirements. This is not a major emphasis in the current board training materials. Another class or effort would probably be needed.
- Texas and New Mexico have fee-based programs to cover monitoring and analysis of infrequently measured analytes (i.e., volatile organic contaminants and synthetic organic contaminants).

Coordination

- Training coordination —CDPHE is the logical group to coordinate training among the many groups offering training to the water supply community. Coordination is needed on what (what content needs to be delivered), where (is there adequate coverage of the state?) and how (what is the best format for delivering the content?).
- Coordination of assistance — There must be a prioritized list of systems that need support. Coaches could combine their efforts with RCAP and CRWA to target systems and determine what systems need one-on-one assistance or where group support would be valuable. This prioritized list also could be used to facilitate support among funding agencies.

Data gaps

- It would be good to have a breakdown of violations by system size.

APPENDIX C
SANITARY SURVEY DEFICIENCY CODES

Significant Deficiency Category	Description
Distribution System	**DS**
D210	RAW WATER TAPS; System has customer service connections that serve untreated drinking water CPDWR 7.1.2(c) & 7.6.1(b);S
D230	DISINFECTION RESIDUALS; System is not maintaining the required disinfection residuals in the distribution system CPDWR 7.1.2(c)(3)(i) & 7.6.1(c);S
D250	HIGH LEAKAGE RATES; System usage data indicates that high leakage rates pose a risk of backsiphonage CPDWR 1.11.1 DCPWS Appendix I, 2.1.1;R
D260	DISTRIBUTION SYSTEM MAPS; System does not maintain updated distribution system maps CPDWR 1.12.1(d);C
D901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk CPDWR 12.1 (a);S
D997	OTHER DISTRIBUTION SYSTEM ISSUES 1; Inspector identified distribution system issue;R
D999	OTHER DISTRIBUTION SYSTEM ISSUES 3; Inspector identified distribution system issue;R
Finished Water Storage	**FW**
F310	STORAGE CONDITION; The storage structure(s) is in bad condition and is not properly protected from potential sources of contamination CPDWR 5.8(a)(3) DCPWS Appendix I, 1.0.3;R
F320	STORAGE DESIGN; The storage structure(s) has not been properly designed (i.e., valved improperly, improper liner, improper ventilation, within 50 feet of sewer lines, etc.) DCPWS Appendix 1;R
F321	STORAGE COVER; The finished water storage structure(s) is not properly covered CPDWR 7.2.1© & 7.3.1©;S
F330	STORAGE MAINTENANCE; The system lacks a maintenance program for the storage structure(s);R
F901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk CPDWR 12.1 (a);S
F997	OTHER STORAGE ISSUES 1; Inspector identified storage issue;R
System Management and Operation	**SM**
M610	CROSS CONNECTION CONTROL PROGRAM; System does not have a written Cross-Connection Control Program CPDWR 12.1(b) & 1.6.3(g);M
M620	OPERATION & MAINTENANCE PLAN; System does not have a documented Operations and Maintenance Plan;R
M660	INSTRUMENTATION; System lacks necessary instrumentation for measuring flows, pressure, etc. for use in management and operation of facilities;R
M820	EMERGENCY RESPONSE PLAN; System does not have a completed Emergency Response Plan;M
M997	OTHER MANAGEMENT ISSUE 1; Inspector identified system management and operation issue;R
M998	OTHER MANAGEMENT ISSUE 2; Inspector identified system management and operation issue;R
M999	OTHER MANAGEMENT ISSUE 3; Inspector identified system management and operation issue;R
Operator Compliance with State Requirements	**OC**
O710	CERTIFIED OPERATOR; The system does not have a certified operator Regulation 100;S

Significant Deficiency Category	Description
Monitoring and Reporting and Data Verification	**MR**
R510	GENERAL MONITORING PLAN; System lacks a monitoring plan detailing the system's background information, sources, treatment and distribution system or Plan has not been properly maintained CPDWR 1.12;M
R514	BACTI WRITTEN SAMPLE-SITING PLAN; System lacks a properly designed bacteriological sampling plan; Plan is inadequate for the system CPDWR 5.1.1(a) & 1.12.1(e);M
R521	MONITORING BACTERIOLOGICAL; System is not current with all bacteriological (TCR) monitoring requirements CPDWR 5.1.1;M
R527	MONITORING LEAD AND COPPER; System is not current with all lead and copper monitoring requirements CPDWR 8.6;M
R530	MONITORING EQUIPMENT; System lacks the proper equipment necessary for day to day analyses CPDWR 1.6.1;M
R540	DESIGN APPROVAL; System has not received plans & specs approval for the system or for renovations to the system, including the addition of new sources, changes in treatment or changes in the distribution system CPDWR 1.11.2;S
R997	OTHER MR&D ISSUES 1; Inspector identified MR&D issue;R
R999	OTHER MR&D ISSUES 3; Inspector identified MR&D issue;R
Source	**SO**
S010	SRC SP SPRING CATCHMENT; System has spring source that does not provide adequate protection of sourcewater to the system CPDWR 1.11.1 DCPWS - Part 2.2;S
S011	SRC SP LOCATION; System has located a spring in a location that causes it to be impacted by surface contamination CPDWR 1.11.1 DCPWS - Part 2.2.2;S
S020	SRC GE PLAN APPROVAL; System has constructed a new source since last inspection that does not adequately provide safe drinking water to consumers CPDWR 1.11.2 (b);S
S030	SRC WL CONSTRUCTION; System has well source that does not provide adequate protection of sourcewater to the system CPDWR 1.11.1 DCPWS - Part 2.1;M
S031	SRC WL LOCATION; System has located a well in a location that causes it to be impacted by surface contamination CPDWR 1.11.1 DCPWS - Part 2.1.2, 2.1.4, 2.2.2;S
S032	SRC WL WELL SEAL; System has a well source that sanitary seal is not properly installed and maintained DCPWS - Part 2.2;R
S040	SRC GE DESIGN CRITERIA; Physical condition of the source does not meet State of Colorado design criteria specified for potable water systems DCPWS - Part 2;R
S901	SRC GE CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk CPDWR 12.1 (a);S
S997	SRC GE OTHER SOURCE ISSUES 1; Inspector identified source issue;R
S999	SRC GE OTHER SOURCE ISSUES 3; Inspector identified source issue;R
Treatment	**TR**
T110	CONTACT TIME SW GWUDI; System does not have adequate disinfection contact time between the point of disinfection and the first customer CPDWR 1.11.1 DCPWS - Part 6.1.10;S
T111	CONTACT TIME GW; System does not have adequate disinfection contact time between the point of disinfection and the first customer CPDWR 1.11.2 DCPWS - Part 6.1.10;M
T112	DISINFECTION EQUIPMENT; No disinfection equipment present or equipment not operating CPDWR 7.1.2 (a),(b) & 7.6.1(b);S
T113	EP DISINFECTION; Surface water system is not maintaining disinfectant residual of 0.2 mg/L at entry point to the distribution system or not maintaining CT properly CPDWR 7.1.2©(2) & 7.6.1(b);S
T120	FILTRATION PROCESS; Surface water or GWUDI sources without proper filtration processes CPDWR 7.1.3(a),(b);S
T130	DESIGN CRITERIA; Physical condition of the treatment plant does not meet State of Colorado design criteria specified for potable water systems;R
T131	ALARM EQUIPMENT; No provisions to warn operators of treatment failures/malfunctions DCPWS Part 3.8;R
T132	PLANT HYRAULICS; Hydraulic conditions within treatment plant are not adequate to handle anticipated flows DCPWS Part 9.4;R
T133	REDUNDANT UNITS; Redundant treatment units or spare parts not available for breakdown/outages DCPWS - Part 4.1, 5.0.7, 7.4.2, 9.4;R
T140	WATER QUALITY; Existing treatment is inadequate to handle current or anticipated water quality conditions to continue to achieve adequate water quality DCPWS Part 4.0;R
T150	TEST EQUIPMENT; System does not have adequate test equipment to perform required process control testing CPDWR 1.6.1;S
T160	CHEMICAL SAFETY; Gas chlorine facility safety features and other chemical safety issues;R
T901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk CPDWR 12.1 (a);S
T995	OTHER TREATMENT ISSUE 1; Inspector identified treatment issue;R
T996	OTHER TREATMENT ISSUE 2; Inspector identified treatment issue;R
T999	OTHER TREATMENT ISSUE 5; Inspector identified treatment issue;R

Minor Deficiency Category	Description
Distribution System	**DS**
D210	RAW WATER TAPS; System has customer service connections that serve untreated drinking water. This is an alleged violation of the CPDWR 7.1.1, 13.2;S
D230	DISINFECTION RESIDUALS; At the time of inspection, no disinfection residual was detected in the distribution system CPDWR 7.1.2(c)3, 13.2(c)1;S
D240	INADEQUATE PRESSURE; System does not maintain a minimum distribution pressure of 35 psi or has pressures below 20 psi during peak flows. CPDWR 1.11.1, 12.1 DCPWS Appx I, 2.1;S
D260	DISTRIBUTION SYSTEM MAPS; System does not maintain updated distribution system maps CPDWR 1.12.1(d);R
D901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk. This is an alleged violation of the CPDWR 12.1 (a);S
D997	OTHER DISTRIBUTION SYSTEM ISSUE 1; Inspector identified distribution system issue;R
D998	OTHER DISTRIBUTION SYSTEM ISSUE 2; Inspector identified distribution system issue;R
D999	OTHER DISTRIBUTION SYSTEM ISSUE 3; Inspector identified distribution system issue;R
Finished Water Storage	**FW**
F310	STORAGE CONDITION; The storage structure is in bad condition and is not properly protected from potential sources of contamination CPDWR 7.2.1(c) 7.3.1(c) DCPWS Appx I, 1.0.3;S
F311	STORAGE ACCESS; The storage structure(s) lacks proper measures to prevent unauthorized access. Access hatches should be locked and the site should be protected from vandalism. DCPWS Appx I 1.0.4;M
F312	STORAGE FLOODING; The storage structure(s) is not properly protected against flooding DCPWS Appx I 1.0.2;M
F320	STORAGE DESIGN; The storage structure(s) has not been properly designed (i.e., valved improperly, improper liner, improper ventilation, within 50 feet of sewer lines, etc.)DCPWS Appx 1;R
F321	STORAGE COVERED; The finished water storage structure(s) is not properly covered or the cover is compromised CPDWR 7.2.1(c) 7.3.1(c);S
F330	STORAGE MAINTENANCE; The system lacks a maintenance program for the storage structure(s);M
F901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk. This is an alleged violation of the CPDWR 12.1 (a);S
F997	OTHER STORAGE ISSUE 1; Inspector identified storage issue;R
F998	OTHER STORAGE ISSUE 2; Inspector identified storage issue;R
F999	OTHER STORAGE ISSUE 3; Inspector identified storage issue;R
System Management and	**SM**
M610	CROSS CONNECTION CONTROL; System has not implemented appropriate cross-connection control methods CPDWR 12.1;M
M620	OPERATION AND MAINTENANCE PLAN; System does not have a documented Operations and Maintenance Plan;R
M621	ORGANIZATIONAL OPERATING PLAN; The system lacks an Operational Plan or delegation hierarchy for when ORC is gone;M
M630	RECORD KEEPING; The system lacks a record keeping system for compliance (including monitoring), operating, maintenance, personnel, and other records, and has a plan for filing,records retention archiving and disposal;R
M660	INSTRUMENTATION; System lacks necessary instrumentation for measuring flows, pressure, etc. for use in management and operation of facilities;R
M670	MATERIALS STORAGE; Building used to store potential contaminants or materials that pose safety risks to operators or contamination risk;M
M811	SECURITY IMPLEMENTATION; System has not implemented security enhancements based on vulnerability assessment or other security analysis;R
M820	EMERGENCY RESPONSE PLAN; System does not have a completed Emergency Response Plan;M
M997	OTHER MANAGEMENT ISSUE 1; Inspector identified system management and operation issue;R
M998	OTHER MANAGEMENT ISSUE 2; Inspector identified system management and operation issue;R
M999	OTHER MANAGEMENT ISSUE 3; Inspector identified system management and operation issue;R

Minor Deficiency Category	Description
Operator Compliance with State Requirements	**OC**
O710	CERTIFIED OPERATOR; The system does not have a certified operator Regulation 100;S
O711	OPERATOR AT PROPER LEVEL TREATMENT; The ORC is not certified at the proper level for treatment facilities Regulation 100;M
O712	OPERATOR AT PROPER LEVEL DISTRIBUTION; The ORC is not certified at the proper level for the distribution system Regulation 100;M
O997	OTHER OPERATOR COMPLIANCE ISSUE 1; Inspector identified operator compliance issue;R
O999	OTHER OPERATOR COMPLIANCE ISSUE 3; Inspector identified operator compliance issue;R
Monitoring and Reporting and	**MR**
R510	GENERAL MONITORING PLAN; System lacks a monitoring plan detailing the system's background information, sources, treatment and distribution system or Plan has not been properly maintained CPDWR 1.12;M
R511	GENERAL MONITORING PLAN SUBMISSION; Plan has not been submitted to the Division in accordance with the regulations. This is an alleged violation of the CPDWR 1.12.2;M
R512	GENERAL MONITORING PLAN MAINTENANCE; Monitoring plan has not been properly maintained CPDWR 1.12;R
R513	GENERAL MONITORING PLAN CHANGES; Changes to plan have not been submitted to the Division within 30 days CPDWR 1.12.3;M
R514	BACTI WRITTEN SAMPLE-SITING PLAN; System lacks a properly designed bacteriological sampling plan; Plan is inadequate for the system. Not having a Bacteriological Sampling Plan is an alleged violation of the CPDWR 1.12.1(e), 5.1.1(a), ;M
R516	DISINFECTION BYPRODUCTS MONITORING PLAN; System lacks a DBP monitoring plan, System does not follow their DBP monitoring plan CPDWR 7.5.3(f) & 1.12.1(e);M
R517	LEAD AND COPPER MONITORING PLAN; System lacks a lead and copper sample siting plan CPDWR 8.7(a)(1) & 1.12.1(e);M
R520	RECORD KEEPING; System does not maintain records according to the minimum requirements: 5 Years bacteriological analysis, including turbidity, 10 years chemical analysis, 10 Years sanitary surveys, etc. CPDWR 1.6.3;M
R521	MONITORING BACTERIOLOGICAL; System is not current with all bacteriological (TCR) monitoring requirements CPDWR 5.1.1;M
R522	MONITORING INORGANICS; System is not current with all inorganics monitoring requirements CPDWR 6.1.1;M
R523	MONITORING ORGANICS; System is not current with all organics monitoring requirements CPDWR 6.2.1;M
R524	MONITORING RADIONUCLIDES; System is not current with all radionuclide monitoring requirements CPDWR 6.3.1;M
R525	MONITORING TURBIDITY AND RESIDUAL DISINFECTANT; System is not current with all turbidity and residual disinfectant monitoring requirements or the sampling location is not appropriate.CPDWR 7.1.4;M
R526	MONINTORING DISINFECTION BYPRODUCTS; System is not current with all DBP monitoring requirements CPDWR 7.5.3(b);M
R527	MONITORING LEAD AND COPPER; System is not current with all lead and copper monitoring requirements CPDWR 8.6;M
R530	MONITORING EQUIPMENT AND METHODS; System lacks the proper equipment necessary for day to day analyses CPDWR 1.6.1, 10.5.1;M
R531	Monitoring Equipment Calibration; System does not maintain calibration logs. System is not calibrating their analytical equipment in accordance with the manufacturer's recommendations;R
R533	MONITORING SURFACE WATER DISINFECTION; Surface water system serving population greater than 3,300 does not have continuous chlorine residual monitoring capability CPDWR 7.1.4(a)(2);M
R534	MONITORING POINT OF ENTRY; System is not monitoring disinfectant residuals at entry point to the distribution system or is not located appropriately.CPDWR 7.1.4(a), 13.4;M
R535	DISINFECTION PROFILE; System did not begin development of disinfection profile when required or has not updated the profile to account for treatment changes.CPDWR 7.2.2, 7.3.2, 7.4.7, 7.4.8;M
R540	DESIGN APPROVAL; System has not received plans & specs approval for the system or for renovations to the system, including the addition of new sources, changes in treatment or changes in the distribution system CPDWR 1.11.2;S
R997	OTHER MR&D ISSUES 1; Inspector identified MR&D issue;R
R998	OTHER MR&D ISSUES 2; Inspector identified MR&D issue;R
R999	OTHER MR&D ISSUES 3; Inspector identified MR&D issue;R

Minor Deficiency Category	Description
Source	**SO**
S020	SRC GE PLAN APPROVAL; System has constructed a new source since last inspection that does not adequately provide safe drinking water to consumers CPDWR 1.11.2 (b);S
S030	SRC WL CONSTRUCTION; System has well source that does not provide adequate protection of sourcewater to the system CPDWR 1.11.1 DCPWS - Part 2.1;M
S031	SRC WL LOCATION; System has located a well in a location that causes it to be impacted by surface contamination CPDWR 1.11.1 DCPWS - Part 2.1.2, 2.1.4, 2.2.2;S
S032	SRC WL WELL SEAL; System has a well source that sanitary seal is not properly installed and maintained DCPWS - Part 2.2;R
S040	SRC GE DESIGN CRITERIA; Physical condition of the source does not meet State of Colorado design criteria specified for potable water systems DCPWS - Part 2;R
S901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk. This is an alleged violation of the CPDWR 12.1 (a);S
S997	SRC GE OTHER SOURCE ISSUES 1; Inspector identified source issue;R
S998	SRC GE OTHER SOURCE ISSUES 2; Inspector identified source issue;R
S999	SRC GE OTHER SOURCE ISSUES 3; Inspector identified source issue;R
Treatment	**TR**
T110	CONTACT TIME (SW AND GWUDI); System does not have adequate disinfection contact time between the point of disinfection and the first customer CPDWR 7.1 DCPWS - Part 6.1.10;S
T111	CONTACT TIME GROUND WATER; System does not have adequate disinfection contact time between the point of disinfection and the first customer CPDWR 13.2 DCPWS - Part 6.1.10;M
T112	DISINFECTION EQUIPMENT; No disinfection equipment present or equipment not operating CPDWR 7.1.2, 13.2 ;S
T120	FILTRATION PROCESS; Surface water or GWUDI sources without proper filtration processes CPDWR 7.1.3(a),(b);S
T122	FILTRATION BACKWASH RECYCLE; Filter backwash recycling improperly CPDWR 7.5;M
T123	MEMBRANE FILTRATION; Membrane filtration issues CPDWR 7.4.17(b);M
T130	DESIGN CRITERIA; Physical condition of the treatment plant does not meet State of Colorado design criteria specified for potable water systems;R
T131	ALARM EQUIPMENT; No provisions to warn operators of treatment failures/malfunctions DCPWS Part 3.8;R
T133	REDUNDANT UNITS; Redundant treatment units or spare parts not available for breakdown/outages DCPWS - Part 4.1, 5.0.7, 7.4.2, 9.4;R
T150	TEST EQUIPMENT; System does not have adequate test equipment to perform required process control testing CPDWR 1.6.1;S
T160	CHEMICAL SAFETY; Gas chlorine facility safety features and other chemical safety issues;R
T901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk. This is an alleged violation of the CPDWR 12.1 (a);S
T995	OTHER TREATMENT ISSUE 1; Inspector identified treatment issue;R
T996	OTHER TREATMENT ISSUE 2; Inspector identified treatment issue;R
T997	OTHER TREATMENT ISSUE 3; Inspector identified treatment issue;R
T998	OTHER TREATMENT ISSUE 4; Inspector identified treatment issue;R
T999	OTHER TREATMENT ISSUE 5; Inspector identified treatment issue;R
Pump / Pumping Facility &	**PU**
P901	CROSS CONNECTION; System has an uncontrolled cross-connection that allows contamination to enter drinking water that will cause an immediate sanitary risk. This is an alleged violation of the CPDWR 12.1 (a);S
P997	OTHER PUMP FACILITIES ISSUE 1; Inspector identified pump facilities issue;R
P999	OTHER PUMP FACILITIES ISSUE 3; Inspector identified pump facilities issue;R