Continuous Quality Improvement in WaSH Manual and Implementation Guide

January 2017
This document was prepared by The Water Institute at UNC as part of the WaSH MEL project, funded by The Conrad N. Hilton Foundation.

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Acknowledgements: The Water Institute is grateful to the Conrad N. Hilton Foundation for financial support of this work. The Water Institute is also grateful to Oriel STAT A MATRIX (Edison, NJ) for providing Dr. Ramaswamy with access to a 2011 version of selected Lean Six Sigma training materials [1] that informed the development of this manual. Several concepts and images from these materials have also been adapted to the WaSH context, with permission, for use in this manual.

Disclaimer:
The findings, suggestions and conclusions presented in this manual are entirely those of the authors and should not be attributed in any manner to The University of North Carolina at Chapel Hill or The Conrad N. Hilton Foundation.
Acronyms and Abbreviations

CQI 
Continuous Quality Improvement

E. coli  
Escherichia coli

L  
Liters

MEL 
Monitoring, Evaluation and Learning

M&E  
Monitoring and Evaluation

NGO 
Non-governmental Organization

ODF  
Open Defecation Free

SDG  
Sustainable Development Goal

SMS 
Short Message Service

UNC 
The University of North Carolina – Chapel Hill

VLC 
Virtual Learning Center

WaSH  
Water and Sanitation, Hygiene

WaSH MEL  
Water and Sanitation, Hygiene Monitoring, Evaluation and Learning

WHO  
World Health Organization

WI  
Water Institute

WQ  
Water Quality
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1. Introduction to this manual

This Manual is intended to provide the steps and exercises needed to understand and implement Continuous Quality Improvement activities for Water, Sanitation, and Hygiene programs. The manual is intended to complement in-person and on-line training modules, and to be used by implementers under the guidance of a CQI facilitator with prior experience implementing and supporting CQI projects, and with the capacity to provide both statistical and strategic support if needed. While the manual itself provides a good introduction to the principles of WaSH CQI, it is not recommended that the manual be used standalone resource without these additional forms of training, support, and guidance. If you have any questions about the content of this manual, or about WaSH CQI, please visit the WaSH MEL website: www.washmel.org

2. Overview of CQI

This section provides an overview and description of the continuous quality improvement (CQI) method. It is intended to help familiarize readers new to CQI with the general principles and purpose of the method, and provide a brief description of its background and history. For a more detailed review and history, readers may consult some of the sources referenced in this section.

2.1. Introduction to CQI

Continuous quality improvement is a systematic method of using data to improve processes.

Sometimes WaSH and other organizations face obvious problems with clear solutions, however often there is a deeper cause to many of our problems. In some cases, problems may not even be detected at all. Therefore, instead of constantly trying to detect and fix problems as they occur, it is important to take a systematic approach to dig deeper to identify and address the root cause of problems, in order to improve the performance of WaSH organizations.

When an organization faces complex problems with their performance or outcomes, the common approach is for organizations to encourage staff to work harder, provide more training, or allocate additional staff and/or resources rather than addressing underlying issues in existing processes. In contrast to conventional methods, CQI focuses on processes and seeks to identify how steps within a process can be improved to affect the outcome. CQI differs from other methods in that it does not judge the data as good or bad, but as a tool to help an organization constantly improve.

What do we mean by quality? Quality is always defined in terms of the experience and outcomes received by the customer. In this case, the customer is the end user or recipient of WaSH services, regardless of whether they pay directly for those services. Quality, then, is an attribute of any output from a process that meets a customer’s needs. Improvement is any action that increases the quality of the services or product received by the customer or increase the efficiency of service delivery.

What do we mean by continuous? Continuous improvement is the regular and active engagement of the organization in efforts to increase the quality and efficiency of its processes. As one improved process stabilizes, the organization will then look to identify the next improvement opportunity. Often one CQI project can lead to another CQI project. As the organization begins working to improve one aspect of a process, it can reveal additional opportunities to improve. Initial CQI cycles may be small and exploratory, leading to later cycles that are more sophisticated.
CQI allows organizations to rapidly identify and prioritize improvement opportunities; collect high-quality monitoring data that are fit-for-purpose; launch rapid improvement projects; and quantify their impact. CQI systematically harnesses the creativity of existing teams to define clear improvement goals, leverage appropriate monitoring data to identify opportunities, then implement and sustain rapid improvements in areas with the greatest impact. This process becomes an ongoing cycle, with teams identifying and tackling new improvement opportunities every 3-12 months.

2.2. Placing CQI within the M&E Context

CQI is a tool that can be "dropped in" to existing WaSH programs to improve outcomes. The priorities for CQI projects should be determined based on the needs and priorities of the WaSH program to be improved. If an organization has an existing monitoring and evaluation platform, CQI can leverage that platform to use existing data and collect any new data needed for understanding improvement opportunities. If no such platform exists, independent monitoring activities can be conducted. The resulting data can be analyzed and used to generate improvements, which can then be implemented on a pilot basis. Successful improvements generated by the CQI program can then feed back into broader WaSH programming.

![Figure 1. Placing CQI within the operational context](image)

2.3. CQI Training Program

In order to implement CQI successfully, organizations must form and train CQI teams and stakeholders, and access experienced CQI facilitators. In addition, organizations should work to create a "culture of improvement," in which using data to identify improvement opportunities is seen a productive form of contribution, and all team members are encouraged to help identify solutions. A culture of improvement and widespread organizational involvement builds internal support for CQI and increases the chances of success for CQI projects.
This manual can serve as a guide for training and implementation, but is no substitute for in-person training and interaction, with the support of an experienced facilitator. A typical training program can be organized like a pyramid, in which all members of the organization receive some training and exposure to CQI, with increased levels of training for those with more involved CQI roles (Figure x).

- Typically, all members of the organization would participate in a 2-4 hour training session on the “improvement mindset” and an introduction to WaSH CQI in general.
- Those who would be participating in CQI projects would receive additional training, consisting of an (approximately) 5-day workshop. The workshop would cover much of the content in this manual.
- Those who would ultimately be leading CQI teams would receive an additional 5-day training covering the same tools and methods in greater detail.
- Finally, technical experts providing support in the analysis and interpretation of CQI data would receive in-depth technical training lasting at least 4 weeks.
- High-level champions such as program and regional directors would not necessarily receive additional training, but would participate in a 1-day session to identify organizational priorities and select problems on which initial CQI projects would focus.

![Figure 2. Example CQI training program](image)

### 2.4. Types of CQI projects
Continuous Quality improvement is a versatile approach, and multiple types of CQI projects are possible.

#### 2.4.1 Adaptation projects (“Just do it”)
In some cases, a problem closely resembles one that has been solved previously in a similar context, and an existing improvement package appears suitable. In such cases, the project becomes an “adaptation” project, in which the CQI method is used to determine whether the existing solution works in the new context and, if so, to customize the solution to the new context as needed. Adaptation projects often proceed quite rapidly.
2.4.2 Rapid cycle improvements
In other cases, existing improvement packages that address the current problem are not available, but the problem in question is one in which data collection is rapid and easy, and the identified solutions are also relatively rapid and easy to implement. An example of this would be a change in a reporting form that is used on a daily basis by a WaSH organization. In such cases, the CQI method is used to make “rapid cycle improvements,” in which data are collected, analyzed, and used to identify improvements all within a few days to weeks; then the improvements are rapidly piloted at a small scale and, if successful, scaled up.

2.4.3 Quality improvement projects
In full quality improvement projects, existing improvement packages likely to address the current problem may not yet be available, and the problem in question may require substantive data collection and/or involved implementation of identified solutions. In these cases, the full CQI method is applied over a period adequate to collect and analyze sufficient data, and to implement solutions at a large enough pilot scale to determine their effectiveness. In some cases, it is also necessary to collect data over a period of time before the effectiveness of the improvement package can be determined. Successful solutions can be scaled-up. Full-scale CQI projects can take more time per cycle than adaptation projects and rapid cycle improvements.

2.5. Background

2.5.1 Brief history
While the introduction of CQI methods is new to the WaSH sector, these methods have been used successfully for decades in other sectors. Implementation science methods such as CQI have proven
highly effective for addressing complex challenges in manufacturing [2], service industries [3], healthcare [4], and financial services [5]. The impact of these methods has been transformational in many cases. CQI methods are largely credited with the incredible growth of the Japanese automobile manufacturing industry in the half-century following World War II. In 1949, Toyota implemented statistical quality control (SQC), an early version of CQI, under the guidance of W. Edwards Deming, one of the original “fathers” of modern industrial quality improvement. Since that time, Toyota proceeded to grow exponentially, from a production level of fewer than 10,000 vehicles in 1950, to more than 1 million vehicles per year by 1969. Much of this meteoric growth was attributed to the application of quality improvement methods to the manufacturing process, resulting in a set of CQI-like methods known as “The Toyota Way” (Liker, 2004.). Today, Toyota remains one of the world’s leading auto manufacturers, with a strong reputation for quality and affordability.

Figure 3. Growth of Toyota Sales 1950-1970

Implementation science methods have similarly transformed healthcare since the 1990s. One example of this is the profound impact of a simple surgical checklist on outcomes after surgery. A global study found that the use of such a checklist to prevent the most common surgical errors significantly reduced
infections, complications, and deaths after surgery [6]. Application of continuous quality improvement methods in healthcare settings is now commonplace, and has been credited with countless improvements in clinical outcomes.

![Mortality rate during surgery](image)

Figure 4. Effect of a surgical safety checklist on post-surgery mortality across 8 countries [6].

CQI has also been successfully applied in the service sector, the financial sector, and many other industries. However, implementation science methods have not yet found widespread application in the international development sector.

One major challenge within this sector is providing sustainable access to high-quality water, sanitation, and hygiene (WaSH) services for global populations. Among the Sustainable Development Goals (SDGs) adopted by the United Nations General Assembly in 2015 is the goal of ensuring “availability and sustainable management of water and sanitation for all.” Achieving this goal will require not only increasing the proportion of the world’s population with access to WaSH infrastructure, but also increasing the quality and sustainability of WaSH services. While quality improvement methods may be well suited to supporting progress towards these goals, CQI has not been previously applied to WaSH.

2.6. Overview of WaSH CQI – DMAIIS

The WaSH CQI project cycle consists of six steps:

1. DEFINE
2. MEASURE
3. ANALYZE
4. IDENTIFY
5. IMPLEMENT
6. SUSTAIN

Together, these steps comprise a systematic approach to using data for improvement. The steps are described briefly below and in more detail throughout the manual:

2.6.1 DEFINE
In DEFINE, the CQI team defines the focus of the improvement project. This is the most critical step of CQI, because it determines the outcome that will be achieved if the project is successful. In the DEFINE step, a CQI team is formed. The team then defines the organizational process on which the current CQI project will focus. This includes identifying the inputs, outputs, and process steps that comprise each process, as well as defining the problem to be solved, and what success will look like once it has been resolved. The CQI team then defines team roles and project goals, and creates a written project plan called a Project Charter.

2.6.2 MEASURE
In MEASURE, the CQI team determines which data are needed for the improvement project, develops a data collection plan, and collects data, either from existing sources, from new data collection activities, or both. The team ensures that the right data are collected in a robust and reproducible way, so that the team will be able to identify important patterns and root causes in the ANALYZE step.

2.6.3 ANALYZE
In ANALYZE, the CQI team analyzes the data collected in the MEASURE step to find patterns in the data that could provide clues about the root causes of problems. They will use a variety of tools, including graphs and histograms, scatterplots, Pareto charts, regression analysis, and others.

2.6.4 IDENTIFY
In IDENTIFY, CQI teams review the results of the ANALYZE step and use them to brainstorm ideas for solutions. They will use structured decision-making tools to identify the best solution ideas and develop them into an improvement package that can be piloted and implemented in the next step.

2.6.5 IMPLEMENT
In IMPLEMENT, the CQI team iteratively pilot, refine, and then implement the improvement package identified in the previous step. Implementation is a dynamic process, in which data collected during piloting and implementation feeds back into the process to ensure that the final improvement package produces the best outcome. They will also collect post-implementation to determine the impact of the improvement on the original problem or opportunity.

2.6.6 SUSTAIN
In SUSTAIN, successfully implemented improvement packages are standardized so that they can be implemented easily and reproducibly by the organization. Manuals and standard operating procedures (SOPs) are developed, and measures are put in place to sustain and scale improvements across the organization and over time.
3. Six Sigma and Lean Methods

CQI builds upon many different implementation science tools and methods. Two of these are the LEAN and Six Sigma approaches. LEAN focuses on improving the efficiency of processes by eliminating waste. Six Sigma focuses on improving the quality of processes by eliminating defects. Both are important to the WaSH CQI method.

3.1. Improving Quality and Eliminating Waste

3.1.1 Outputs, defects, process variables

For each process, there is a defined output that a customer will receive (that customer may be either external or internal to the organization that owns the process). As mentioned earlier, we want to ensure that outputs are of sufficient quality to meet customer’s needs and specifications.

- Variability is a measure of how different an actual output is from the specified/required process output.
- A defect is any problem with a process, product, or service that results in an output that does not meet the needs of the customer. A defect can be a shortcoming in what is delivered to a customer, in the time at which it is delivered, or in the method by which it is delivered to the customer.

In some cases, variation above or below the specification is defined as a defect (e.g. actual borehole depth be between 95% and 105% of the specified depth); in other cases, a defect may be defined by variation in only one direction (e.g., arsenic concentration must not exceed 10 parts per billion [PPB], but there is no lower limit for arsenic).

Examples of defects in WaSH include:

- An organization specifies that boreholes must be drilled to 20-40 meters. Therefore a borehole that is 15 meters or one that is 45 meters would be considered a defect.
- An organization specifies that households within communities should be within 1 kilometer of a waterpoint. If a community’s nearest waterpoint is located 3 kilometers away from the community, this would be a defect.
- An organization specifies that broken down school latrines should be repaired within seven days; any broken school latrine that is not repaired within seven days would be a defect.
- Aby drinking water delivered to households that does not meet national water quality standards for microbial quality is a defect.

CQI uses simple, statistical methods to track defects and variability in order to reduce both of them within our processes. This method was developed by Motorola and has been credited with saving the company 17 billion USD as of 2005 [Reference].

Increasing efficiency by reducing waste

The goal of CQI is also to increase the efficiency of processes by doing more with less. This can be accomplished by identifying and reducing waste within processes. Waste is also defined by the experience of the customer. It is anything that does not add value to the process output (either product or service) and includes activities or purchases that stakeholders would not want to pay for if they knew these things were happening. Waste can occur at all levels and in every department of an organization.
It is important to make the distinction between waste and steps that are necessary even though they do not directly add value. Within any process, some activities do not directly add value, but are necessary in order to perform the value-adding steps; however, steps that serve no purpose are considered waste.

3.2. Two types of projects

3.2.1 Reducing variability – consistent performance (Six sigma)
The six sigma approach is to ensure consistent performance of a process that leads to reduced variability.

3.2.2 Reducing waste (Lean)
In a lean project, the purpose is to reduce waste within a process.

3.3. Defects
As noted above, a defect is defined as any problem with a process, product, or service that results in an output that does not meet the needs of a customer. In WaSH CQI, teams work during the DEFINE step to develop definitions of defects for the specific process and improvement project of interest. These defects are then counted during MEASURE, along with related process variables. In ANALYZE, the CQI team determines which factors predict the occurrence of defects, and in IDENTIFY, solutions are identified to reduce the occurrence of defects. Implementing and sustaining these solutions increases the quality of WaSH programs.

3.4. Improving efficiency
Likewise, CQI teams work to define Waste in the context of the chosen process and CQI project during the DEFINE step, and to identify potential forms and sources of waste. These forms of waste are tracked in MEASURE, along with associated process variables. In ANALYZE, the team determines which factors predict the occurrence of waste, and in IDENTIFY, solutions are developed to reduce and eliminate waste. Implementing and sustaining these solutions increases the efficiency of WaSH programs.

3.4.1 LEAN principles
By applying the lean principles of identifying and reducing all types of waste, and always prioritizing those processes and outputs that add value for the customer, WaSH organizations can dramatically improve their efficiency over time, thereby providing better service to more customers with their finite resources.

3.5. Quality Goals
In order to maintain service quality, WaSH organizations should seek to provide WaSH services that are:

- Effective
- Equitable
- Customer-centered
- Sustainable
- Efficient

Prioritizing these quality goals will ensure that benefits for customers are fairly, efficiently, and sustainably maximized. WaSH organizations should seek not only to provide “access” to customers, but to deliver on these quality goals at all times, and to delight customers.
3.6. Creating a CQI Program within an organization
In order to create an effective CQI program within a WaSH organization, it is important to have awareness, buy-in, and participation at all levels. For this reason, a broad-based training program, such as the training pyramid described above, is essential. While CQI team leaders and facilitators may run many of the day-to-day aspects of improvement projects, good ideas for improvement may come from or be implemented by any member of an organization. For this reason, it is important that everyone in an organization understand and contribute to WaSH CQI in some way.

3.7. Golden Principles of CQI
There are several “golden principles” of quality improvement that are useful to keep in mind when implementing a CQI program.

1. All improvement is change, but not all change is improvement
2. When considering an improvement, ask “Is this the best thing we can do for the customer?”
3. All work is process: improvement involves changing the process
4. Data are king: improvement efforts should be driven by data, not by the opinions of leaders
5. Root causes are deep; ask “why” again and again when looking for the reasons behind problems
6. Think of sustainability—put measures in place to sustain improvements

It is important for the CQI to go to the “Gemba” or the workplace. During the CQI project, the entire team should go to where the process is happening to observe and learn more about the process. By seeing the process firsthand, the team may identify steps in the process, potential problems, and the actual conditions under which the process is occurring.

3.8. Keys to success
CQI projects are most likely to be successful when the following factors are in place:

- Committed project sponsors, who will push the project forward
- Effective monitoring of performance
- Ambitious but achievable goals
- Clear plan for improvement
- Team members who set aside sufficient time on a regular basis for CQI
- Buy-in from team members at all levels
- Focus on the customer’s needs

If these measures are in place, a broad training program is implemented, and the golden rules of CQI are observed, then WaSH CQI programs will have a high probability of achieving meaningful and sustainable improvements.
4. Define

4.1. Introduction
You are now ready to begin your Continuous Quality Improvement project. DEFINE is the first step in the CQI process. Before improvement can occur, it is necessary to clearly define the problem or opportunity you are addressing, the specific process you hope to improve, and what a successful outcome will look like for this project. These elements will be captured in a written document called a project charter, along with details of the CQI team’s members, available resources, and plans for communicating with stakeholders.

Some of the questions that can help the CQI team to clearly defined and describe the improvement focus of the CQI project include:

i. What is the problem to be solved?
ii. When does the problem occur?
iii. Where does the problem occur?
iv. Why does the problem occur?
v. Who does the problem affect or is involved in the problem?
vi. How is this a problem

Answering these questions helps your CQI team focus on problems and processes of particular importance to your organization, and on which your team can productively focus its energy.

4.2. Steps
The following are steps to follow when undertaking the DEFINE step of the CQI process:

4.2.1. Assemble the CQI team
Assemble a CQI team before beginning the WaSH CQI process. Make an effort to include members with diverse organizational roles to ensure varying perspectives on your team. Ensure that your team has enough members to address the issues, but is not so large that progress is hindered. Typically, 5-10 members is a good size for a core CQI team. Members of your CQI team should expect to spend 1-10% of their time on improvement projects. The team should include the following roles:

- Project sponsor: a high-level individual within the unit conducting the CQI project, with the authority to allow the project to go forward, allocate staff time to it, and explain/support the project to high-level personnel within the organization. The project sponsor should expect to spend 1-2% of his/her time on CQI.
- CQI team members: Members of the organization at any level with experience relevant to the problem or opportunity to be solved. Team members should expect to spend about 5% of their time on CQI.
- CQI team leader: A CQI team member with good leadership skills and with sufficient interest and availability to lead the CQI team. The team leader will be responsible for assembling the CQI
team to work on the project, and ensuring that the team stays on track. The team leader should expect to spend about 10% of his/her time on CQI.

4.2.2 Write opportunity statement
Once the WaSH CQI team has been assembled, you will need to work together to define the area(s) for program improvement. It is important for the WaSH CQI team to clearly and specifically define the area(s) or issue(s) of concern.
Key Terms for CQI Project Charters

Customer: A customer is anyone who uses the output of a process. This could be an external customer, such as a household that constructs a latrine after a CLTS triggering, or an internal customer, such as a drilling team, that uses the information from an improved borehole siting protocol. The customer does not necessarily pay for the output he/she receives.

Defect: A defect is anything that does not meet the customer’s needs or specifications. A defect could be the failure to meet specifications in terms of what output the customer receives, when he/she receives it, the quality of the output, its sustainability, or the customer’s level of satisfaction with the output. Examples of potential defects include a cracked latrine slab, a late delivery, a contamination event in a water system, or a borehole site that produces a dry well.

WaSH CQI projects will likely have greater success if:

a. The problem is related to a key organizational issue
b. The problem is linked to a clearly defined process (you can identify the starting and ending points)
c. The team can identify the customers who use or receive the output from this process
d. The team can clearly identify what a defect is and count its occurrence
e. The team can demonstrate how improvements could enhance performance
f. There is appropriate organizational support

Keeping these criteria in mind, your WaSH CQI team will develop a targeted opportunity statement for the CQI project that is in line with the goals of your organization.

Here is an example of an opportunity statement for a hypothetical CQI team interested in increasing water point functionality:

We have an opportunity to enhance our customer’s experience of sustainable access to safe water by efficiently improving the functionality of the customer’s water points with a target of 90% functionality.

4.2.3 Project Charter

Next, the CQI team will create a project charter. The project charter is a short document describing how the WaSH CQI process will work. The project charter helps to clarify roles and goals, reduce mission drift, and transfer ownership of the project from the sponsor(s) to the CQI team. A CQI project charter should include the following elements:

a. Description of Project
   a. Purpose
   b. Importance
Overview of Charter Elements

1. Purpose

This section describes the problem or opportunity that the CQI team wishes to improve. The team should consider the following questions:

- What is wrong, or where can we improve?
- What are the goals for the team?

NOTE: The purpose should NOT include assumptions about causes of the problem or possible solutions: Just the specific change the team wants to create.

Example: Reduce the proportion of household water quality samples containing detectable *E. coli* by at least 20%.

Teams may struggle with this- it can be tempting to draft statements that specify: Improve X by changing Y—however, if the data ultimately show that changing Y does not improve X, then the purpose is invalid. CQI teams must exercise discipline and omit presumed causes and solutions at this stage, no matter how confident they may be in their assumptions about these.

2. Importance

In this section, the CQI team should describe the relevance of this project to the organization’s overall mission. This can be done by addressing the following questions:

- Why is it important to customers?
  
  Example: Safe and reliable water supply is important to households because it reduces disease burden among their families.

- Why is it important to the mission?
Example: The mission of our organization is to improve the livelihood and well-being of people living in Country X. Clean, reliable water is a human right and central to achieving this mission.

c. Why is it important to employees?

Example: Employees of our organization sign a pledge that they believe in our organizational mission. Therefore, ensuring that our organizational goals are met is in line with their personal goals.

d. Why should it be worked on now?

Example: Recent evidence shows that water quality in County X is poor and that people prioritize improved access to water. Every day that we do not work on this problem, we leave millions of customers at risk of preventable diseases.

e. What will be the impact of this project, if successful?

Example: To increase the proportion of people in County X who consume water free from detectable microbial contamination by 50%. To reduce visits to health care facilities for acute gastrointestinal illnesses by 5% in country X.

For the last question, the CQI team should estimate the project’s potential impact on your mission, or the potential magnitude of the improvement opportunity. Rough figures are OK. Choose targets that are ambitious but achievable.

3. Scope (focus)

This section of the project charter identifies the boundaries of the team’s work, including:

a. The start and end points of the process the team is improving

b. The extent of the team’s decision-making authority

c. Budgetary limits the team must respect

Defining the CQI project’s scope helps to clarify what is within the team’s area of influence and what is outside that area. This section may also include a schedule and milestones.

Example Milestones:

I. Complete DEFINE step (January 30)
   Develop project charter (define the boundary for the CQI project)

II. Complete MEASURE step: (February 28)
   Seek approval from authority
   Train enumerators on data collection procedure
   Collect baseline data (through structured observation, survey etc.)
III. Complete ANALYZE step: (March 27)
Review and analyze baseline data collected

IV. Complete Identify step: (April 30)
Identify the cause of the problem e.g. the root cause of contamination

V. Complete Implement step: (May 29)
Use the analysis information to inform improvement
Examine additional or alternate changes that can be used to improve the process

VI. Complete Sustain step: Maintain services (Functionality, downtime) (July 26)
Monitor, improve and maintain the services (e.g. functionality, downtime)
Service utilization (safe water storage, improved source use)

4. Deliverables

Deliverables are what must be in place to accomplish desired changes.

The types of deliverables are very similar for most projects, including:

a. Process changes
b. Training programs and manuals
c. Documentation and standard operating procedures
d. Other processes and procedures for maintaining gains

The CQI team should list the deliverables that will be produced, specify the dates by which they will be completed, who will be responsible for leading on each, and who will receive each deliverable.

5. Measures (indicators)

The CQI team should also determine the data or other indicators that will be used to:

a. Establish a baseline of performance
b. Track progress
c. Judge “success”

If possible, identify the target and specifications for each measure

Example: Establish a baseline for microbial water quality in household stored water samples by conducting quantitative E. coli tests in 300 randomly-selected households in the project area (using standard sampling and testing methods) by February 10.

6. Resources accessible to the team

List all resources available to the CQI team for this project. Generally, this will primarily include the people available to do the work

a. Include team members and list how much of their time can be spent on the project
b. List other personnel not on the team, and under what circumstances they can be involved in the project

c. List vehicles, funds, and any other relevant resources available

Example:

Sponsor time 1 to 3% (Involve during project start, end of evaluation and project completion)

Country Manager time 5% (Involve in all the project steps)

Team leader time 25% (Involve in all the project steps)

Field staff/ enumerators time 50% (involve during data collection phases)

Analysis partners at local university: time 10%, (involve during project start and data analysis)

Table 1. Sample WaSH CQI Charter

<table>
<thead>
<tr>
<th>Product/Service</th>
<th>Organization</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>WaSH</td>
<td>WaSH Implementers International</td>
<td>Jane Doe, Director of WaSH</td>
</tr>
<tr>
<td>Process Leader</td>
<td>Phone No</td>
<td>John Doe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Process</td>
<td>Name of process to be improved.</td>
<td>Safe water program implementation</td>
</tr>
</tbody>
</table>
| 2. Project Description | What practical problem will be solved? What is project’s purpose? | A) Water quality: Reduce microbial contamination of stored drinking water at household level; Increase customer knowledge of causes and prevention of water contamination.  
B) Maintain Services: Increase water source functionality  
C) Service Utilization: Increase improved water source use |
<p>| 3. Objective | What metrics will be improved, what is the current performance for those metrics and how much improvement is targeted? Provide specifics on how metrics are computed. | Metrics | Current | GOAL | % Improve. | units |
| | | Proportion of households drinking water with E. coli concentrations in the high-risk category | X | X-20% | -20% | % |
| | | Proportion of improved water sources functional on day of visit | 70% | 80% | 10% | % |</p>
<table>
<thead>
<tr>
<th>4. Process Scope</th>
<th>Which process steps will be considered in this project? What is the first step and what is the last step?</th>
</tr>
</thead>
</table>
|                  | A) Water source “hardware” implementation  
|                  | B) Safe water “software” implementation  
|                  | C) Post-Implementation support activities Service Utilization  

<table>
<thead>
<tr>
<th>5. Business Case</th>
<th>Justification for this project. Why is it important? Why is it critical to business success?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To realize WaSH Implementers International’s vision of “sustainable safe water and sanitation for all,” every child in country X must consume adequate quantities of safe water every day. In country X, diarrhea diseases is the third cause of child death. Sustainable year-round access to enough safe drinking water, adequate sanitation, and hygiene is critical to these outcomes. We have an opportunity to enhance water quality and access by working to increase the safety and reliability of water sources and reduce the prevalence of microbial contamination in stored household water.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Benefit to Internal and External Customers</th>
<th>How will internal or external customers benefit from this project? How does improvement in the metrics that you have selected help them improve their performance?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beneficiaries (external customers) will enjoy improved health and livelihoods as a result of: 1) improved access to sustainable safe water, 2) improved sustainability of water services, 3) reduced medical costs. The proposed metrics will help us track water source sustainability and the microbial risk of stored water.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Team members</th>
<th>Names and roles of team members.</th>
</tr>
</thead>
</table>
| Hughes Louis Dewey: Regional Sponsor  
| Isabelle Ringing: National Sponsor  
| John Doe: Process Leader  
| Marge Innovera: Data Management Expert  
| Candace B. Rittenoff: Finance Expert  
| Dustin Dubree: Operations Expert (Hardware)  
| Jane Doe: Operations Expert (Software) Picov Andropov: Operations Expert (Transportation) |

| 8. Schedule | Project Start January 1, 2017  
|-------------|--------------------------------|
|             | Project Charter Approved January 15, 2017  
|             | Inform authorities February 1, 2017  

<table>
<thead>
<tr>
<th>Proportion of households with knowledge of safe water collection and storage practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of households practicing safe water collection and storage</td>
</tr>
<tr>
<td>X X+50% 50% %</td>
</tr>
<tr>
<td>X X+30% 30% %</td>
</tr>
</tbody>
</table>
4.2.4 Communication Plan

Once the CQI team has developed a charter, the next step will be to develop a communication plan. Regular communication with stakeholders can help you:

a. Understand what is important about your work
b. Identify better solutions to problems
c. Create more buy-in
d. Understand when and how to best involve others
e. Avoid pitfalls
f. Share lessons learned

A communication plan should list internal and external stakeholders and describe how the CQI team will remain in contact with each throughout the course of the CQI project, as in the example below:

Table 2. Sample Communication Plan

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collected</td>
<td>February 28, 2017</td>
</tr>
<tr>
<td>Data Analyzed</td>
<td>March 30, 2017</td>
</tr>
<tr>
<td>Solutions Identified</td>
<td>June 15, 2017</td>
</tr>
<tr>
<td>Solutions Implemented</td>
<td>September 30, 2017</td>
</tr>
<tr>
<td>Impact evaluation</td>
<td>November 30, 2017</td>
</tr>
<tr>
<td>Sustain Measures Completed</td>
<td>January 30, 2018</td>
</tr>
<tr>
<td>Project Completion</td>
<td>February 15, 2018</td>
</tr>
</tbody>
</table>

9. Support Required

What resources, people, departments are required?

- People and Departments
- WII-Wash Staff
- External Coach
- University partners
- Donor
- External Enumerators (contractors)
- Communities
- (Ethical oversight body)
- (National Government authorities)
- (Local Government authorities, Technical services)

- Resources
- Funds

<table>
<thead>
<tr>
<th>Data collected</th>
<th>February 28, 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Analyzed</td>
<td>March 30, 2017</td>
</tr>
<tr>
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</tr>
<tr>
<td>Sustain Measures Completed</td>
<td>January 30, 2018</td>
</tr>
<tr>
<td>Project Completion</td>
<td>February 15, 2018</td>
</tr>
<tr>
<td>Stakeholder(s)</td>
<td>Role</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
</tr>
<tr>
<td>1. WaSH Implementers International: Main HQ</td>
<td>Oversee the CQI implementation in the region</td>
</tr>
<tr>
<td>2. Donors</td>
<td>Funding the project</td>
</tr>
<tr>
<td>3. Coach</td>
<td>Technical support</td>
</tr>
<tr>
<td>4. Ministry of water resources and sanitation</td>
<td>Respect the national regulation on water quality</td>
</tr>
</tbody>
</table>

### 4.2.5 Targeting Improvement

In order to effectively improve the quality and efficiency of the process identified in the CQI charter, the CQI team must be able to track and identify the occurrence of failures in this process. We can define failures of quality and efficiency as “defects” and “waste,” respectively. If the CQI team can effectively identify the where and when defects and waste occur, and which factors are associated with their occurrence, then the team can take effective steps to reduce these occurrences.

**a. Defects**

As defined above, a defect is any problem with a process, product, or service that prevents it from meeting the customer’s specifications. Defects can be failures in what is delivered, when it is delivered, or even how products and services are used:

Examples of defects are: A broken borehole is not repaired for 120 days, or a latrine is not used by community members.

Defects are identified by comparing outputs to customer’s specifications or applicable standards.

- **I.** In some cases, variation in either direction constitutes a defect
  - (If boreholes are supposed to be 20-40 meters deep, than a borehole that is 7 meters deep or one that is 70 meters deep constitutes a defect.
- **II.** In other cases, variation in only one direction constitutes a defect
  - (if we require waterpoints to be functional on 90% of days, a borehole that is functional on 97% of days does not constitute a defect)

Prevention and correction are the two ways of addressing defects. A defect that is prevented results in improved quality and improved efficiency. A defect that is corrected results in improved quality, but the effort spent correcting that defect constitutes waste. Prevention is preferred.
b. Waste

Waste is any action that does not add value to the product or service in the eyes of the customer, or anything that the customer would not want to pay for if he/she knew it was happening. Some types of waste are easy to identify while others are more difficult to see.

There are three quick and simple techniques to help you see the waste

- Using the eight major categories of waste
- Using the major drivers of waste, overburden, and unevenness
- Using the waste assessment worksheet

Categories of Waste

![Figure 6. Major Categories of Waste](image)

1) Correction (defects and rejects)

Involves doing something over and over because it was done incorrectly the first time. It requires excess processing to fix the error and reduces capacity.

Examples:

- Water point failure and rehabilitation
- WaSH committee failure and reconstitution
- Dry wells and siting/drilling a new well
- Latrine collapses and rehabilitation
2) Over-production

Involves delivering more products or services than required to meet customer demand.

Examples:

- Drilling to 100 meters for a borehole with pump installed at 40 meters
- Hiring more people than are necessary to complete a task.
- Purchasing and powering a 5-HP submersible pump for a system that can be operated perfectly with a 1-HP pump.
- Installing 25 school latrines in a school with only 60 students.
- Overbudgeting for one part of a project, reducing the funds available for other activities

3) Over-processing

Unnecessary work that does not add value to the product or service—examples include:

- Filling out additional paperwork that does not improve a service or timely delivery
- Completing extra unneeded steps in the process (i.e., requiring drilling teams to enter the same information multiple times in the reporting process, entering data once on a paper form, then copying from the form to a spreadsheet, then pasting from the spreadsheet into a report)
- Washing sand once at the base of operations, then again at the worksite, before incorporating it into concrete latrine slabs.

4) Transport

Movement (actual or virtual) and transportation of material, equipment, lab samples, or information not absolutely necessary to meet customer requirements—Examples:

- The same staff members traveling to the same villages 2-3 times within a single week to complete different activities
- Transporting water quality samples long distances to a lab to perform a test that can be done in the field
- Storing spare equipment and parts farther than necessary from field activities,
- Traveling long distances for basic maintenance and repairs of vehicles and equipment.

5) Inventory

Maintaining extra inventory or work in process (WIP) beyond what is needed to meet normal demands—examples include:

Examples:

- Spare parts stock (10-year supply)
• Office supplies (10-year supply)
• Waiting until a certain work volume accumulates to begin working (batching),
• Hoarding, taking more supplies and stock than needed to avoid shortages

6) Motion

Any motion of people, equipment, or material (actual or virtual) that does not contribute value to the end product or service.

Examples:

• Searching for data or lost files in a disorganized office
• Gathering parts and supplies for a single job from multiple different warehouses and depots
• Face-to-face meetings are scheduled when an email or telephone call would suffice

7) Waiting

Time in which nothing is being done since materials, information, people or equipment are not available or ready

Examples include waiting for:

• Laboratory results from the capital before drilling can begin
• Evaluation data from the national office before the next year’s programming can begin
• Supplies, tools, parts, or mechanics before routine water system repairs can be made
• Paperwork, instructions, schedule, information, etc.
• A decision/approval
• Equipment and vehicles
  ▪ Funds to be released

8) Human Mind

Not involving the person doing the job, the real expert, thereby missing opportunities for improvement resulting in poor quality and higher costs—examples include:

▪ Choosing a new process or procedure without consulting those members of the organization who are most directly responsible for its day-to-day implementation
▪ Selecting locations for new water points without consulting community members about their needs and preferences
▪ Allowing the current monitoring and evaluation person to leave for a new job without training a new monitoring and evaluation expert, and without documenting their previous work
▪ Not acting on ideas from junior staff for elimination of waste
▪ Not providing training and/or cross-training on new processes
▪ Not allowing staff to put into practice what they have learned
- Not providing people with knowledge needed to do the work

4.2.1 Categories of waste
More details on the categories of waste common in WaSH processes are included in ANNEX I–categories of waste worksheet

4.2.2 Drivers of waste
While waste can arise from many causes, there are two common drivers of waste: overburden and unevenness.
- Overburden occurs when a given process step with fixed capacity receives a workload that exceeds its process capacity, slowing down the entire system.
- Unevenness occurs when the workload is extremely uneven, so that the capacity of a process is exceeded at some times, while the workload is far less than what the process can do at other times.

More details on common drivers of waste are included in ANNEX II–driver of waste worksheet

4.3. Process mapping
Process mapping is a continuous quality improvement approach that can help WaSH practitioners reduce operational waste and improve product or service quality, customer satisfaction ratings, team productivity and risk management. By effectively mapping processes, the CQI team can pinpoint where waste and defects are likely to occur, and identify potential factors that are likely to cause waste and defects. Once this information is known, the team can effectively design a data collection plan (in the MEASURE step) to collect and analyze data on the occurrence of waste and defects, as well as their determinants, so that effective improvements can be identified and implemented.

To do this, the WaSH CQI team should first identify the specific value stream by which their organization provides value to customers in the area of interest, as well as the specific process within that value stream that their problem or opportunity is part of, and describe how it fits with at least three other processes as part of a larger system. If an organization has multiple value streams, the CQI team should select the one most closely related to the focus of the current improvement project.

4.3.1 Value stream
The value stream is the entire set of activities required to bring a product or service to the customer. It provides products and services that meet customer requirements. Understanding customer requirements is critical to the value stream mapping process.
a. **Value Stream Map (VSM)**

A value stream map is a workflow visualization tool for representing how beneficiary needs are met. Showing the flow of materials and information makes waste easier to see and makes improvement opportunities easier to identify. VSM includes material and information flows:

![Value Stream Map Diagram](image)

**Figure 8. Generalized Value Stream Map**

b. **Selecting a value stream**

Select one product or service you want to improve first when selecting a value stream and creating a value stream map. This helps to maintain a clear focus for your CQI project.

c. **Timing**

Value stream mapping takes some time. The time varies depending on the specific value stream and the data available. Example: the team might require one day of planning, followed by several days to gather participants, preliminary data and arrange logistics.

d. **Benefits of Value Stream Mapping**

- Forces the team to think about improvement of the whole value stream, as well as optimizing individual processes
– Provides a common language for talking about processes
– Creates a common understanding of how value is produced
– Helps employees see how their function or process fits into the overall value stream
– Enables the team to visually identifies where waste occurs
– Helps to focus improvement efforts
– Shows linkages between product/service flow and information flow
– Shows performance data

Value Stream Mapping for WaSH

Donors
Government Headquarters

Inputs

WaSH NGO

Processes

Community
Local Government

Outputs

Water

Sanitation

Nutrition

Figure 9. Example of a WaSH Value Stream Map

The Value Stream Map helps the team visualize related processes, as well as the inputs and outputs for these processes. Once the value stream has been mapped, the CQI team can select a single process from the value stream on which to focus their improvement cycle. A high-level process map can then be created for this selected process.

A high-level process map is similar to a value stream map, except that instead of mapping an entire value stream, this map focuses on a single process within that value stream. This selected process is divided into 3-8 high-level process steps, and these are mapped out as shown below. In addition, the inputs needed to carry out the process, as well as the suppliers who provide these inputs, are shown. The processes outputs and the customers who receive these outputs are also shown (inputs, outputs, suppliers, and customers are described in greater detail below). The control/scheduling mechanism, which determines when and where the process will be carried out, is also shown.
High-Level process map

Figure 10. Generalized high-level process map
Once the high-level process map has been created, the CQI team can identify which one or two of the high-level process steps is most closely related to the problem or opportunity on which the CQI team is focusing. The identified process step(s) can be further diagrammed using a tool called SIPOC to better understand the factors that affect the quality and efficiency with which the target process step(s) are performed.

### 4.3.2 SIPOC

The team should identify the Suppliers, Inputs, Process steps, Outputs, and Customers of your Process. This is abbreviated as SIPOC (Suppliers, Input, Process steps, Output and Customer) and serves as an important tool for process mapping.

By completing the SIPOC diagram, you will be able to develop an improved data collection plan in the MEASURE step, since you will:

- Have a better idea of what data you have and what data you still need to collect
- Have an improved understanding of the relationship between the x (determinant) and y (outcome) variables in your process
– Become much more familiar with the process steps

Figure 12. Example of a generic SIPOC diagram

a. **Supplier**

A supplier is anyone who supplies the input (order, information, raw materials, or instruction) that triggers a process. They include WaSH committees, WaSH implementers, community leaders, national and local government, as well as the families who will ultimately use WaSH services.

Consider the following questions when thinking of suppliers:

- Where does the information or material required for your work come from?
- Who are your suppliers?
- What do they supply?
- Where do they affect the process flow?
- What effect do they have on the process and on the outcome?
b. **Inputs**

Consider the following questions when thinking of inputs:

- What data, supplies, requirements, and supporting systems are required for this activity?
- Who is needed to perform the action?
- Where will the action take place?

\[\text{Figure 13. Inputs}\]

\[\text{Consider the following questions when thinking of inputs:}\]

- What data, supplies, requirements, and supporting systems are required for this activity?
- Who is needed to perform the action?
- Where will the action take place?

\[\text{c. Process}\]

\[\text{Figure 14. Process steps}\]

Consider the following questions when thinking of process:

- What happens to each input?
- What conversion activities take place?
- What steps make up these activities?
d. **Outputs**

Consider the following questions when thinking of process:

- What product does this process make, or what need does it fill?
- What are the outputs of this process?
- At what point does this process end?

**e. Customer**

A customer is anyone who receives the output (action, product, service, information, intermediate product) of a process. It can be other staff within an organization, donors, local or national government, or the families ultimately receiving WaSH services.

Consider the following questions when thinking of customers:

- Who uses the products from this process?
- Who are the customers of this process?
- Are they internal or external customers?

An example of a SIPOC diagram is provided below:

**Example SIPOC diagram**
Figure 16. Example of a Blank SIPOC Diagram Template

Figure 17. Example of a Completed SIPOC Diagram
Activity: Take some time with the CQI team to practice completing a SIPOC diagram for your team’s process. This can be done on a whiteboard, blackboard, or a flipchart.

Steps for creating a SIPOC diagram include:

- Break your process into 3-8 process steps and list these
- Show the outputs from each process step
- List the customers who receive each output.
- Show the inputs (and process variables) for each process step
- List the suppliers who supply each input

When you have finished, photograph the diagram for your team’s records.

Next, use the SIPOC diagram to help you develop a data collection plan. The steps for creating a data collection plan are described below.

The improved data collection plan will provide better results throughout the rest of the project.

The SIPOC diagram can also be enhanced with additional elements to make a Detailed SIPOC Diagram. Recommended enhancements in the SIPOC include:

- Use diamonds for decision or inspection process steps
- Show the outputs from each process step
- Show the inputs (and process variables) for each process step
- Classify the inputs
- Show available data on cycle times and error rates for each process step

Example: Showing a list of inputs, outputs, cycle times, and process step capabilities for the process
4.3.3 Activity

Now that you understand process mapping and have some tools with which to perform it, try the following exercises:

- Create a Detailed SIPOC Diagram
- Identify the points at which defects and waste are most likely to occur
- Identify key determinants that may be most likely to be associated with the occurrences of defects and waste
- Identify potential “bottleneck” steps that may limit the overall rate/capacity of the process
- Photograph or document this Detailed SIPOC Diagram to support the CQI team’s further work.

Figure 18. Example of process steps for a Detailed SIPOC Diagram.
5. Measure

5.1. Overview

You will now begin working on the next step of CQI: MEASURE. In this section, you will learn how to systematically gather data on the processes and outcomes that you specified in DEFINE in order to ensure that you are answering the questions you are most interested in. The MEASURE step follows the following general outline:

**Purpose:** Gather data on current process performance

**Main questions:**
1. What is the current state of our process?
2. What data do we already have on this process?
3. What additional data do we still need to collect?
4. How can we collect these additional data?
5. How can we use all of these existing and collected data to better focus our problem statement?

**Activities:**
1. Clarify data collection goals
2. Develop operational definitions
3. Validate the measurement system
4. Begin data collection
5. Continue improving measurement consistency

**Outputs:** Data analysis plan, high-quality collected data

Collecting data about our process helps to separate what we think may be happening from what is actually happening in our processes.

High-quality data can:
1. confirm or disprove preconceived ideas or theories about a process
2. provide a baseline of performance
3. allow an organization to see the history of a problem over time
4. enable CQI teams to identify and understand relationships that might help explain variation in a process
5. measure the impact of a change on the performance of a process

When the CQI team begins to think about data, it is important that they choose to collect the right kind of information. The right kind of information describes the problem the team is trying to solve and also describes related conditions that might provide clues about causes and effects. Collecting this type of information will enable the CQI team to identify patterns in the data, associations between outcomes and related conditions, and cause-and-effect relationships in the ANALYZE step.
5.2. Types of data

A challenge that many WaSH implementers face is the selection of the right variables and indicators to monitor. In many cases, implementers who have not been trained in CQI methods will monitor only outputs (for example, number of boreholes drilled, number of hygiene promotion workshops held, number of community-led total sanitation [CLTS] triggering session participants, etc.). Monitoring only outputs is problematic because it does not provide information on whether those outputs achieved their intended objectives (improving the quantity and quality of water available to users, reducing open defecation rates, etc.), and thus impact cannot be measured. In other cases, programs measure only outcomes (water quantity per person per day, household water quality, proportion of households practicing open defecation, etc.). Robustly monitoring outcomes (Y variables) is valuable in that it enables programs to measure their impact. However, it is also important to robustly monitor related conditions (X variables) at the same time to enable CQI teams to identify determinants that affect those outcomes; identifying such linkages can provide important clues as to what actions can be taken to improve a given outcome. It is useful to think of M&E data collection as a process of collecting X and Y variables:

- **Y variables** – These are outcome variables that are most closely related to their program objectives.
- **X variables** – These are variables that are known or theorized to be potential determinants of the outcome variables

Separating variables into these two categories makes thinking about data collection easier. In many cases, the X and Y variables of interest can be measured directly. However, sometimes the team may want to collect data on something that is very difficult to measure directly; in these cases, the team may brainstorm *proxy measures*, variables that are indicative of or associated with the variable of interest, but are easier to accurately measure. An example of this would be measuring hand contact with collected water during transport from the source to the household. This is difficult to measure without a great deal of time-consuming observation; instead, the team may decide to record whether the transport container has a handle or not, as this is easier to measure, and hand-to-water contact is less likely when the container has a handle.

5.3. Clarify data collection goals

5.3.1 Introduction to the Data Collection Plan

The data collection process helps the CQI team collect the right data for its needs and ensures that the data obtained are both useful and meaningful. In order to complete this process, it is important to formulate a Data Collection Plan. A data collection plan can be created using a format similar to the example in Figure 20. The plan should contain information on what specific questions you want to answer, what type of data you will be collecting, the operational definitions for the variables that will be measured, the procedures that will be used for collecting these data, the steps that will be taken to ensure consistency in data collection, and how the data will be displayed to the appropriate audience after data collection and analysis have been completed. By the end of this section, you will be able to confidently complete a data collection plan that meets your team’s needs. The first step in filling out the data collection plan is clarifying data collection goals. To help identify your data collection goals, think about the following four questions:
Imagine that you are creating a data collection plan for a project focused on measuring and improving the functionality of boreholes with handpumps in a certain region. A question you may want the answer is: “what are the most common causes of borehole failure in this setting?” To measure this, you may want to know how often failures occur, and what are the causes of these failures. Failures would be measured as a “Y” outcome variable in this example, while causes of failure and associated process variables (such as handpump type, borehole age, implementer, etc.) would be recorded as X variables, since these are potential determinants of the outcome of interest. To measure the causes of borehole failure and other associated process variables, CQI teams could measure the occurrences of different failures across boreholes in the region, ask WaSH committees about the causes and/or the repairs made to fix each failure, and record additional process variables such as pump type, borehole age, etc. These data might be collected by surveying WaSH committee members in charge of maintaining boreholes, and asking for the necessary information, if known. Additional details could also be determined through direct observation. Once the variables and methods have been decided, the CQI team will need to develop plans for how to obtain the data in a robust and reproducible manner, to ensure that data are collected in a way that is consistent across observations and enumerators (data collectors). Finally, the CQI team will want to plan how best to present the collected data to the appropriate audience to clearly communicate the results. In a typical CQI project, the Data Collection plan will include several “Y” variables and many more “X” variables, and the above process will be repeated for each. It should be evident that the larger the scope of the data collection activities, the more complicated the data collection plan will be. Thus, in order to complete all of the requisite steps in a full Data Collection plan, the CQI team will need to effectively clarify what its data collection goals are, and choose a scope that is appropriate for the current CQI project.

**Figure 19. Overview of MEASURE step-action 1**

5.3.2 What is the “right” information?

When thinking about data collection goals, it is important to identify what the “right” information is. Strictly speaking, you will not get into root cause analysis until the ANALYZE step of CQI. However, CQI teams can often save time and effort by doing some preliminary thinking up front about what information could help the team to understand and explain:
When a problem or outcome of interest does and does not appear.

- Under what conditions it does and does not appear.

Therefore, the “right” information can be thought of as information that:

- Describes the problem to be studied
- Describes related conditions that might provide clues about causes
- Can be analyzed in ways that help the CQI team to answer the above questions

When selecting the appropriate X and Y variables to monitor, it is also useful to think about a plan for stratifying variables once the data are collected. Stratification means dividing data into groups (strata) based on key characteristics such as place and time, and is a method that enables teams to identify patterns within the data (stratification is discussed in greater detail in the ANALYZE step). These “key characteristics” are aspects of the data that you think could help explain when, where, and why a problem occurs. This helps detect patterns that localize problems or explain why the occurrence or severity of the problem varies across different times, locations, or conditions. One should try to stratify data in as many ways as possible, to help facilitate this aspect of the ANALYZE step.
Table 3. Example Data Collection Plan

Data Collection Plan

<table>
<thead>
<tr>
<th>What questions do you want to answer?</th>
<th>Project ________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Being clear about your question will help you make sure you collect the right data.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data</th>
<th>Operational Definition and Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2)</td>
<td>What to measure</td>
</tr>
<tr>
<td></td>
<td>Data type (Y or X)</td>
</tr>
<tr>
<td></td>
<td>What (variable name)</td>
</tr>
</tbody>
</table>

Recording what data you are going to collect reminds you what you want to accomplish; noting the type of data helps you decide how you should analyze the data.

An operational definition explains exactly how you will go about collecting and recording the data.

<table>
<thead>
<tr>
<th>4) How will you ensure consistency and stability?</th>
<th>5) What is your plan for starting data collection? (Attach details if necessary.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What will you do to make sure the data collected at one point in time are comparable to data collected at other times? That is, have biases been introduced in the way the data are collected?</td>
<td>How will you go about collecting the data?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thinking about how you will display the data will help you make sure you are getting the right kind of data to answer the question you have in mind.</td>
</tr>
</tbody>
</table>

| 6) How will the data be displayed? (Sketch below.) | |
|-------------------------------------------------| |
| | |

| | |
| | |
| | |
| | |
| | |
The process of data stratification will be detailed more extensively in later modules. An example is shown in Figure 2 in which water collection times are stratified by district:

**Figure 20. Time to collect water, stratified by district**

### 5.3.3 Data Audience

The audience who will receive and use collected data is an important consideration when choosing which variables to measure during data collection and what your data collection goals should be. WaSH CQI differs from traditional monitoring and evaluation in its approach, in that CQI is focused on improving the quality of WaSH services for the customer. Historically, monitoring and evaluation in WaSH has been conducted to support the creation of donor-facing reports, without a strong improvement focus. Therefore, the emphasis of traditional monitoring was often on quantifying the “Y” outcome variables. In CQI, teams are also very interested in monitoring the “X” determinant variables so that they can understand how to improve processes, and thereby affect the Y outcome variables. Thus, when planning how to eventually convey the data that you are collecting, remember that the data on these X variables will probably be shared with the CQI team and partner communities and not
necessarily with donors and other high-level stakeholders. Therefore, it is important to present these data in a way that is effective and appropriate for these more technical audiences as well.

5.3.4 Use SIPOC to identify what and where you need to measure

To identify what and where to measure, it is helpful to return back to the SIPOC diagram(s) the CQI team created in the DEFINE step. As previously mentioned, most people are accustomed to seeing results measures—data that are taken on “Y” variables, or process outputs and outcomes. Usually, if monitoring activities only collect results data, they are unlikely to effectively identify root causes of problems and fix the process. Improvement strategies are much more effective when process (“X”) variables are also measured concurrently with outcome “Y” variables. This allows teams to obtain real-time feedback about how well the process is operating, and to identify which “X” variables are associated with changes in “Y” outcomes. Doing this will help CQI teams detect problems sooner, and identify potential causes of these problems.

Figure 21. SIPOC, revisited

Activity: Using SIPOC to improve your data collection plan

- Look at your SIPOC diagram(s) and circle all the “Y” output and outcome variables that the CQI team wishes to measure
- Look at suppliers, inputs, and process steps: select “X” variables that may be associated with the “Y” variables of interest, or may affect the performance of the process to be improved
- For each of the identified variables, determine what will be measured, how it will be measured, which operational definitions will be used, and how the CQI team will ensure consistency
- Make sure the data collection plan includes each of the above variables and details.

When you are using SIPOC to identify what you are measuring, remember to use measurements that are not too difficult to obtain. To do this, think about collecting data that are either continuous or discrete, and about using proxy variables when it is too difficult to measure a variable of interest directly.

Continuous Data

- Continuous data are data that can have any value, or nearly any value, along a continuum; examples include height, weight, speed, liquid volume, population of a community, etc...
- Often obtained using a measuring system (ruler, scale, speedometer, etc.)
The usefulness of the data may be limited by the accuracy and precision of the measurement system.

Counts of non-rare occurrences can also be treated as continuous data (i.e. number of strokes needed to obtain water from a handpump).

**Discrete Data**

- Discrete data are data for variables that can be categorized or counted. Discrete variables typically have a finite number of possible values. Common examples of discrete variables include sex (M/F/other), country, profession/occupation, handpump type, number of children, season of the year, etc.

- Includes counts of relatively rare occurrences, categorical attributes, and ordinal numbers
  - Count data should be treated as discrete if the event is relatively rare (Example: failures of a water point in a given year)
  - When counting discrete occurrences, each occurrence must be independent (in other words, if a latrine is nonfunctional on Monday and remains nonfunctional on Tuesday, this should not be counted as two separate failures).

Below are some examples of common discrete and continuous variables in WaSH:

**Table 4. Examples of common continuous and discrete variables in WaSH**

<table>
<thead>
<tr>
<th>Variable type</th>
<th>Variable</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>Borehole depth (m)</td>
<td>Any positive number</td>
</tr>
<tr>
<td></td>
<td>Users per tap</td>
<td>Any positive integer</td>
</tr>
<tr>
<td></td>
<td>Flow rate (L/min)</td>
<td>Any positive number</td>
</tr>
<tr>
<td>Discrete</td>
<td>Source functional?</td>
<td>Yes; No</td>
</tr>
<tr>
<td></td>
<td>Source type</td>
<td>Household tap; public tap; well</td>
</tr>
<tr>
<td></td>
<td>Region</td>
<td>Northern Region; Central Region</td>
</tr>
</tbody>
</table>

5.4. **Develop Operational definitions and sampling procedures**

Once you have clarified the data collection goals, you should be able to complete sections 1, 2 and 6 of the Data Collection Plan. Now it is time to develop operational definitions and sampling procedures. This will allow you to complete sections 3 and 5 in your data collection plan. **The main goal of this process is to make sure that all of the data collectors measure the various characteristics in the same way.** This removes ambiguity and reduces variation in the measurements, making the data more reliable. Try to answer the following questions when developing operational definitions and sampling procedures:

- What is the variable you are trying to measure?
- What data collection process will allow you to attach a value to the variable?
How far away from target specification(s) does an outcome have to be to be counted as a defect?

What is the plan for collecting these data? What procedures will you use? Be specific and precise.

How will the data be recorded?

Does the proposed method destroy information? (e.g., listing handpumps as “passing” or “failing” the national standard for number of strokes to get water, rather than recording the actual number of strokes and calculating the pass/fail status subsequently?)

Does your customer or another entity (e.g., government or international organization) collect similar data or have applicable standards for this type of data? If so, is the proposed method comparable with other relevant methods/standards?

Figure 22. Overview of MEASURE step-action 2

5.4.1 Operational definitions

To illustrate the importance of developing operational definitions, take the following case study:

- WaSH Implementers International (a large WaSH NGO) needs to improve its safe water services
- Target: reduce the time between when a borehole failure is reported and when the borehole is repaired
- Existing data revealed typical repair times of 5 to 30 working days
- Goal: 95% of water points repaired within seven working days
- At the end of several months, the results from the regional divisions were reported:

Table 5. Example Borehole Repair Time Data, by Region
From these data, it would be easy to conclude that something is going wrong in Region 2. However, upon further investigation, the NGO discovered that regions defined “repaired within 7 days” differently. Region 2 counted the day of the breakdown as Day 1, while the other regions counted the day after the breakdown as Day 1. When region 2 calculated “repaired within 7 days” counting the day after the breakdown as Day 1 (the same way as in the other regions), the proportion of systems repaired within 7 days jumped up to 77%, right in the same range of the other observations.

This case study demonstrates how unclear operational definitions can produce inconsistent results and can cause the focus of process improvements to be misallocated.

What does a good operational definition consist of?

Hopefully, the importance of a good operational definition for data collection and analysis is clear now. But what does an operational definition consist of?

An operational definition:

- Is a precise description that tells how to get a value for the characteristic you are trying to measure
- Includes what something is and how to measure it
- Removes ambiguity so that all people involved have the same understanding of the characteristic or feature in question
- Describes the method of measuring that characteristic or feature in sufficient detail to be reproduced by others

Using these criteria, you should be able to develop robust operational definitions that will ensure the data you collect are useful and comparable.

Methods for data collection

Once an operational definition has been selected, a method for collecting the data must be decided. Several common methods can be used to collect WaSH data, each with its own strengths and weaknesses:

<table>
<thead>
<tr>
<th>Region</th>
<th>% repaired within 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73%</td>
</tr>
<tr>
<td>2</td>
<td>47%</td>
</tr>
<tr>
<td>3</td>
<td>83%</td>
</tr>
<tr>
<td>4</td>
<td>67%</td>
</tr>
<tr>
<td>5</td>
<td>76%</td>
</tr>
</tbody>
</table>
- **Direct measurement** – This approach is useful for capturing discrete values such as flow rate, arsenic concentration, or the microbial quality of drinking water. Usually some kind of tool is necessary for measurement (e.g. a suitable test for *E. coli*).
- **Direct observation** – Trained enumerators consistently evaluate technical details about infrastructure, services, and behaviors (e.g.: enumerators observe and record the type of handpump on a borehole, or observe and record a respondent’s handwashing behavior, noting whether soap was used).
- **Direct response** – A respondent answers questions about WaSH related processes. This is a cheap and easy way to collect data, but can be vulnerable to bias if questions are not worded properly, and relies upon the ability of the respondent to accurately recall details of past events.

Many times data collection will consist of a combination of all three of these measurement types. Data collection methods should be selected on the basis of their ability to collect the most accurate data within the constraints of the resources available to collect them. Typically, when more than one data collection method is feasible, the most rigorous is preferable, in the following order: direct measurement > direct observation > direct response. However, CQI teams must use their knowledge and experience of the processes to be measured in order to develop the most suitable data collection methods for each variable.

### 5.4.2 Sampling

A proper sampling approach and procedure is crucial for credible and efficient monitoring. Sampling can be defined as the collection of only some of the data of interest, with the goal of obtaining information that is representative of all the data. Statistical methods allow us to make sound conclusions about a process even from a relatively small sample, using what is called “statistical inference.”

- **Why sample?**
  When sampling for the purposes of WaSH CQI, there will be many times when collecting all of the data from a process is simply not possible. This could be because there is too much data and it would be impractical, too costly, or too time-consuming to collect and analyze all of it. It could also be because collecting the data may be destructive (e.g., testing a sample of water for *E. coli* uses up that volume of water) and it is therefore not possible to test every drop of water produced (or there would be nothing left for users to consume).

- **How to sample?**
  A representative sampling approach can provide M&E data representative of an entire program area, even if a far smaller number of communities, households and facilities are surveyed. To do this, the units (i.e., communities, facilities, and/or households) to be sampled must be selected at random from the entire population. Random sampling ensures that each unit has an equal chance to be selected. As a result, when enough units are sampled, the data obtained are representative of the entire population.

A particular type of random sampling known as cluster random sampling is especially useful when collecting WaSH data. In this approach, program areas are divided into communities or enumeration areas and several of these larger units are selected at random. Within each of the larger units, individual facilities, households, etc., may also be selected at random. In this way, a large population can be sampled without the need to visit one household in district A, then travel 50 km to district B to sample...
the next household, etc. This approach increases resource efficiency while maintaining the validity of the sampling approach.

When conducting any type of random sampling, it is important to obtain a sample size that is large enough to achieve the objectives of the monitoring activity, but not so large as to be prohibitively expensive. In order to do this, sample size calculations must be performed. These calculations enable CQI teams to obtain M&E data fit-for-purpose with an adequate degree of precision while being as efficient as possible in the use of time and resources. Examples of methods for sampling and sample-size calculation for WaSH M&E activities are provided on the WaSH MEL Virtual Learning Center’s modules on these subjects: Sampling (http://www.washmel.org/module-4-relaunch/) and Sample Size Calculation (http://www.washmel.org/module-6-relaunch/).

- Common sampling mistakes
Sampling is not difficult. However, because sampling does not collect all of the data on a process, it needs to be done correctly. If sampling is not done properly, there can be errors introduced that prevent the sample from being representative of the population that is being described, and this can lead the CQI team to miss important patterns in the data, or pursue imaginary patterns that may not really exist. The following are examples of common errors in sampling that can prevent data collection from accurately describing important WaSH processes:

1) Sampling only the locations that are most convenient—Ex: Enumerators only collect data from the communities closest to their offices, or from the households closest to where they parked their vehicles upon entering the community, potentially missing the places where problems occur most often (e.g. those at the outskirts of the community may have the lowest level of access to WaSH services).

2) Sampling only at the times that are most convenient—Ex: Enumerators only collect data when the workload is low or when the weather is good (dry season), potentially missing the times when customers experience certain types of problems (e.g. greater microbial contamination of water in the rainy season).

3) Having any other pattern of selection that matches some underlying structure in the data – Ex: all farmers go to the fields at harvest time, and all merchants go to the market on market days—if enumerators only collect data at harvest time or on market days, they will obtain a sample that has far fewer farmers or merchants than the true population.

4) Some change in the environment/process means the sample is no longer representative – Ex: an old list of communities is used for random sampling, but 100 new communities have been added in the program area since the list was created, and are excluded from the sample.

5) Disproportionate nonresponse – Ex: The communities or households you most need data from all refuse to participate in your monitoring activities at higher rates than others.

6) Measurement instrument or method error – Ex: A measurement system only records water points that are functional; your method of choosing samples tends to favor small communities over large communities.
7) Sampling plan executed improperly – Ex: Enumerators find it too hard to reach remote communities and households, and improperly exclude these, saying that the community coordinates were wrong (for remote communities they do not wish to visit) or that no one was present to be interviewed in distant households, even when this is not the case.

- Sampling Tools
Data should be collected in a way that is well-organized and easy to understand. There are two main ways in which data can be recorded: Paper survey forms and mobile survey tools (MSTs). Surveys can be extensive, with many questions and lists of potential responses, or can be as simple as checklists. They should always adhere to the principles previously outlined in this MEASURE section, and all questions on surveys should be answerable. MSTs can dramatically improve the quality and efficiency of data collection. However, adopting MSTs may have higher initial costs than using a paper survey form, since using MSTs may require purchasing smart phones or tablets. Additionally, if access to electricity or mobile networks is not reliable, MST use can be more difficult, or additional logistical measures (such as the use of power banks and regular visits to a place with network connectivity in order to transmit data) may be needed. MSTs are recommended for most full-scale monitoring activities, but paper forms may be used for smaller efforts, or where the use of MSTs is not logistically feasible. Regardless of whether the CQI team elects to use a paper survey form or an MST, the following three principles should be adhered to:

- Keep the form simple to use and understand.
- Include only the information you intend to use.
- Pilot the data collection form. Try it out before you use it full scale; make changes as needed.

5.5. Validate measurement system
By now, the Data Collection Plan should be almost complete. Now, section 4 needs to be filled out to address how to ensure consistency and stability in measurement. While parts of this problem can be addressed in the sampling plan, validation is primarily accomplished through piloting and testing the measurement system.

Figure 23. Overview of MEASURE step-action 3
The goal of this step is to minimize controllable factors that could reduce the quality of the data. Generally, this can be thought about by trying to answer the following questions:

- What factors affect the measurement?
  - What could cause your measurement system to vary over time or to give inaccurate results?

- How can you reduce the impact of these factors?
  - How can you make sure people measure the same thing in the same way day after day?
  - Be creative. Common approaches include posting visual or written examples of defects, calibrating methods and instruments using standard examples or definition, providing standardized training, and testing methods for measurement variation and errors.

5.5.1 Desired measurement characteristics
There are four main characteristics that are desired in measurement:

- Accuracy – The measured value has little deviation from the actual value. Accuracy is usually tested by comparing an average of repeated measurements with a known standard value for that unit.

![Diagram of Accuracy](Figure 25. Precision)
• Repeatability – The same person taking a measurement of the same unit gets the same result.

![Figure 26. Repeatability](image-url)
- **Reproducibility** – Other people (or other instruments or labs) get the same result when measuring the same item or characteristic.

![Figure 27. Reproducibility](image)

- **Stability** – Measurements taken by a single person in the same way vary little over time (to the extent that the characteristic being measured is also stable)

![Figure 28. Stability](image)
When validating the measurement system, these are the traits that the CQI team will be looking for.

5.5.2 Problems with measurements

There are two main types of problems that can affect measurements: problems in measurement systems themselves, and organizational problems. The broader organizational issues (6–9) are often the most troublesome, but dealing with them is beyond the scope of this section. We will focus on how to get precise and accurate measurements (issues 1–5).

Problems with the measurements themselves:

1. **Bias or inaccuracy**: The measurements have a different average value than a “standard” method (example: an inexpensive fluoride test provides results that differ dramatically from the known concentration of a fluoride calibration standard)

2. **Not repeatable**: Repeated measurements of the same attribute vary too much relative to typical process variation (example: a method for measuring the length of infants gives results that differ by 20% for two consecutive measurements of the same child)

3. **Not reproducible**: The measurement process yields different results for different operators, measuring devices, or labs; this may be a difference either in bias or in precision (example: two different enumerators record two different pump types for the same handpump)

4. **Unstable measurement system over time**: Either the bias or the precision of the measurement method changes over time, even when the underlying characteristic being measured does not (example: on two repeated visits, the GPS coordinates recorded for the same well differ by 500 meters)

5. **Lack of resolution**: The measurement process cannot measure in units precise enough to capture current process variation (example: a GPS coordinate system provides readings with an accuracy of 5 km)

Greater organizational issues

6. The wrong thing is being measured.
7. Data are not collected, distributed, or acted on in a timely manner.
8. Data are being falsified by enumerators to save time or avoid disappointing superiors with results they may not like.
9. What measurements? (No data are collected)

5.6. Begin Data Collection

Now that the data collection plan has been formulated and filled out, it is time to collect the data. The goal of this step is to ensure a smooth start-up of data collection. This will be accomplished if the following steps are taken:

- Train data collectors (enumerators).
- Pilot and error-proof data collection procedures.
If you have not done so already, pilot and test the data collection forms and procedures.

Ensure that you have adequate quality assurance/quality control (QA/QC) procedures in place so that you will be able to track and review data quality. These are described below.

Those in charge of designing the data collection methods should be there in the beginning to observe data collection firsthand, and note any problems with data collection methods, training, equipment, translations, etc.

Decide how you will display your data.

5.6.1 Data collection team

Although you may have designed an excellent set of surveys and measurement tools, it is important to ensure that the data collection team is prepared to use these tools to collect high-quality data. Many monitoring efforts fail to produce usable data or achieve their intended outcomes because of one of the following problems with the data collection team:

- Insufficient training of field staff
- Inadequate language skills of enumerators
- Inadequate translation of survey tools
- Inadequate collection and/or transport of water quality samples
- Inadequate supervision of field staff
- Lack of quality assurance and quality control procedures

To ensure that your data collection team does not run into these problems, it may be helpful to take some or all of the following precautions:

- Ensure adequate quality and duration of training – Often enumerators are taught to collect data in just one or two days—this may be adequate for simply collecting data on a few characteristics (location and type of facilities, etc.), but more involved data collection, particularly involving structured interviews with community members, typically requires between one week and one month of high-quality training before accurate and reproducible results can be obtained. An adequate training period ensures that staff are able to effectively collect high-quality data, while
adhering to protocols even after time has passed since their initial instruction. Given that the cost of training enumerators is often low relative to the total cost of monitoring, it is worthwhile to invest in adequate training so that the monitoring effort is a success. This is particularly important at the start of new monitoring campaigns, where no veteran enumerators familiar with the data collection methods are likely to be present to informally supervise and assist new team members.

- Confirm written translations and verify the language skills of field staff – This can be done quickly with an oral test by a native speaker of the required language(s). If language skills are not adequate to conduct surveys, you can have the enumerator accompanied by a translator, or replace the enumerator with a more qualified candidate.
- Ensure proper technique in sampling procedures – Practice all stages of water sampling with enumerators and have them perform each of the required tasks themselves to ensure they fully understand how to conduct water sampling correctly. In particular, ensure enumerators become familiar with proper aseptic technique, so that they can collect samples without contaminating them, and become familiar with storing samples on ice, if they must be stored or transported prior to analysis.
- Supervise field staff regularly – This will ensure accountability of enumerators and/or supervisors and will allow you to catch and fix mistakes early on, instead of after it is too late.

5.7. Continue Improving Measurement Consistency and Stability

The final step in the MEASURE process is to improve measurement consistency and stability. The goal of this step is to check that data collection procedures are being followed and that changes are made as necessary to adapt to changing conditions. The main questions you want to ask and answer are:

- Are measurements stable? How do you know?
- Are measurements consistent? How do you know?
- Do the data exhibit strange features that cannot be explained by features of the process being measured? (For example, do all households in a given region have only one occupant? If so, there may have been an error or miscommunication with the survey tools, the enumerator training, the translation of surveys, or the way data are recorded).
To continue improving measurement consistency, it is quite useful to use a Quality Assurance and Quality Control (QA/QC) plan. QA/QC can be customized according to the nature of the data to be collected. For example, for water samples, QA/QC can be readily conducted by collecting field blanks (samples of bottled or sterilized distilled water that is known to be free from the physical or microbial contaminants of concern), and field duplicate samples (a second, identical sample collected at the same time as the primary sample). Typically, field blanks and field duplicates should each make up 5-10% of all samples. Ideally, the samples should be barcoded so that the analyst does not know which samples are blanks or duplicates. A review of these samples should yield results for blanks that are close to 0 for the contaminants of concern, while duplicate samples should produce results that are within an acceptable range of variation relative to the primary water sample analyzed.

For direct observation questions, QA/QC measures can include taking photographs that can be compared back with the data. For example, a picture of a handpump can be reviewed to confirm that the recorded pump type matches what is observed in the picture. Typically, 5-10% of such pictures should be reviewed each week, at random, to assess data quality.

For all measurement methods, random validation checks can be conducted regularly by randomly selecting 5-10% of sampling units to be resurveyed a second time, shortly after the original data collection. For example, if a sample includes 100 communities, 5-10 of these at random should be selected for a second validation check. Data from the validation surveys should be compared to original surveys to note differences in variables that are expected to be relatively stable over time. For example, if two replicate surveys in a community, conducted 3 weeks apart, show large differences in the numbers of households or waterpoints present in the community, the GPS coordinates of facilities in the community, or other generally stable characteristics of the community and its facilities, it is likely that there is a problem with the data collection approach.

Another way to conduct QA/QC is to review records for results that are illogical or inconsistent (for example, a negative flow rate for a water source, an age of 300 years for a survey respondent, or GPS coordinates that would place a household in the middle of the ocean, rather than in the community in which it is known to reside. Anomalies could take the form of values that are possible, but highly improbable for the characteristic being measured (e.g. water samples with a pH of 1, a respondent with 75 children, etc). Finally, anomalies can take the form or results that are individually reasonable, but collectively improbable (e.g. out of 500 household surveys, only 3 respondents report having a child under 3 years old in the household).

Through QA/QC, you will be able to rapidly catch and address data quality problems related to issues that were not clearly explained in training, not fully understood by some or all enumerators, or not adequately handled by the current survey design. These checks also provide a safeguard against deliberate falsification of data, but allow you to target efforts to help enumerators who are struggling with accurately recordings subsets of data. Typically, an improvement mindset, rather than an accusatory approach, is most helpful in working with enumerators to address potential issues with data quality.
Alternatives to data collection

Remember that data collection can be time-consuming and resource-intensive. Therefore, before collecting new data, it is helpful to check whether any existing data are available that might meet your needs. To do this, it is useful to gather the following information:

- Assess the extent to which the available data will answer the questions you are asking (fit your goals).
- Obtain as much information as possible on how the data were collected (i.e. determine the operational definitions, data collection methods, and sampling approach used to obtain the data).
- Assess the quality of the data, with respect to the adequacy of the methods used, the adequacy of the training given to those who collected the data, and the apparent accuracy and reliability of the data, based on an inspection of the resulting dataset.

In addition to using pre-existing data, see if there are opportunities to quickly make observations of the area that you plan to collect data on that will allow you to quickly identify obvious clues about problems or solutions. For example, a quick tour of 5 or six communities may be enough to see that many water sources are broken down and abandoned in the area, and collecting additional data on water source functionality (and associated process variables) may therefore be useful. With this approach, you should be careful not to jump to conclusions based on a chance occurrence, but may select additional variables to prioritize during your subsequent data collection activities.

5.8. WaSH MEL core data collection tools

Several WaSH-specific tools, templates, and methods are available to help CQI teams monitor water, sanitation, and hygiene programs more easily and effectively. Not all WaSH CQI teams must use these tools, but the tools are available to those CQI teams who may find them useful.

5.8.1 Core indicators

The following is a list of core indicators that were developed by the Water Institute for the Conrad N. Hilton Foundation and its WaSH partners. These indicators may be useful for giving CQI teams an example of typical WaSH data that may be collected to track WaSH program performance. The set of core indicators was designed to be simple, measurable (the WI also developed operational definitions for each indicator), and relevant across multiple WaSH projects and programs. Though this list is by no means exhaustive, it may serve as a useful guide. Note that additional outcome (“Y”) variables may be monitored by each CQI team depending on the focus of their improvement project; in addition, each CQI team should identify the most important related “X” process variables to measure to identify important determinants of these “Y” outcomes of interest.

Table 6. Core WaSH Indicators Developed for the Conrad N. Hilton Foundation and its WaSH Partners

<table>
<thead>
<tr>
<th>WaSH Service Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of households using an improved primary water source year-round</td>
</tr>
<tr>
<td>% of households using an improved sanitation facility</td>
</tr>
<tr>
<td>% of households using open defecation</td>
</tr>
<tr>
<td>% of households with hygiene supplies (observed water and handwashing aid)</td>
</tr>
<tr>
<td>% of respondents that demonstrate proper handwashing (use of handwashing aid and rubbing motion)</td>
</tr>
<tr>
<td>% of Households reporting water source failures in the past two weeks</td>
</tr>
<tr>
<td>% of Households reporting water is continuously available from their main source</td>
</tr>
<tr>
<td>% of households with no detectable <em>E. coli</em> in the water used for drinking in that household (typically, stored water)</td>
</tr>
<tr>
<td>% of households with concentrations of <em>E. coli</em> corresponding to high-risk (&gt; 100 CFU/100 mL) in the water used for drinking in that household (typically, stored water)</td>
</tr>
<tr>
<td>Median distance to closest functional improved water point (m)</td>
</tr>
<tr>
<td>Median volume of water collected (L/person/day)</td>
</tr>
<tr>
<td>% of households with safely-managed water (using improved on-premises water source that is continuously available and compliant with national guidelines for <em>E. coli</em>, arsenic, and fluoride*)</td>
</tr>
<tr>
<td>% of households with safely managed sanitation (using an improved sanitation facility that is not shared with others and with safe disposal of excreta*)</td>
</tr>
<tr>
<td>% of households with basic hygiene (a handwashing facility with soap and water in the household*)</td>
</tr>
</tbody>
</table>

**WaSH Facilities Indicators (For all facilities-HH and communal)**

| % of water systems functioning on the day of the visit |
| % of water systems with reported failures in the past two weeks |
| % of water systems with reported failures in the past year |
| % of water systems functional 10 years after implementation |
| Median number of users per water point |
| Mean sanitary inspection score (0-1) for water systems |
| % of water systems meeting national standards for users per water point |
| % of water systems with no detectable *E. coli* |
| % of water systems with high-risk water (*E. coli* > 100 CFU/mL) |
| % of water systems meeting national standards for arsenic |
| % of water systems meeting national standards for fluoride |
| Mean sanitary inspection score (0-1) for latrines |
| % of sanitation facilities with basic hygiene facilities |
| % of sanitation facilities with safe disposal of excreta |

**WaSH Community Indicators**

| % of communities certified as ODF |
| % of communities with identifiable management of water systems |
5.8.2 Surveys

There are many ways to go about designing surveys. Here you can find an excerpt from a household survey that may be useful for thinking about how to conceptualize your own survey development. Note that the survey includes metadata (details about when, where, and by whom the other data were collected), as well as direct measurement, direct observation, and direct response questions. Note also that the survey includes skip logic (questions that are only asked if previous responses indicate that they are likely to be relevant). While the below excerpt is reproduced as a paper copy, it is designed to be deployed using a mobile survey tool (MST), which can automatically record GPS coordinates and photographs, and automatically implement skip logic, helping make enumerators’ data collection activities easier and more accurate.

Table 7. Example Excerpt from a WaSH Household survey

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Date</td>
<td>___________________________</td>
</tr>
<tr>
<td>2. Time: Enter hour</td>
<td>___________________________</td>
</tr>
<tr>
<td>3. Time: Enter minutes</td>
<td>___________________________</td>
</tr>
<tr>
<td>4. GPS Coordinates</td>
<td>___________________________</td>
</tr>
<tr>
<td>5. Country</td>
<td>___________________________</td>
</tr>
<tr>
<td>6. Region</td>
<td>___________________________</td>
</tr>
<tr>
<td>7. Province</td>
<td>___________________________</td>
</tr>
<tr>
<td>8. Commune</td>
<td>___________________________</td>
</tr>
<tr>
<td>10. Your name</td>
<td>___________________________</td>
</tr>
<tr>
<td>11. Name of Village</td>
<td>___________________________</td>
</tr>
<tr>
<td>12. Village ID</td>
<td>___________________________</td>
</tr>
<tr>
<td>13. Household ID. If no ID flag is present, ask the respondent’s permission to place an ID flag on the house so you can find it again later.</td>
<td>___________________________</td>
</tr>
<tr>
<td>14. Has informed consent been obtained?</td>
<td>Yes______</td>
</tr>
<tr>
<td></td>
<td>No_____</td>
</tr>
<tr>
<td>14.1 [Photo] Informed consent form</td>
<td>___________________________</td>
</tr>
<tr>
<td>15. Full name of respondent</td>
<td>___________________________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household characteristics - I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16. How many people live in your household?</td>
<td>___________________________</td>
</tr>
<tr>
<td>Household means the number of people living under this roof, including you.</td>
<td></td>
</tr>
</tbody>
</table>
17. [Direct Observation] Does the respondent live in a multi-household compound?
- Yes______
- No______
- Not applicable______
- Don’t know______

19. How many children under the age of 5 live in your household?
_________________________

**Only answer if you responded Yes to Q19**

20. Has one or more of these children under the age of 5 had diarrhea in the past two weeks? Diarrhea means having three or more loose or liquid stools within 24 hours.
- Yes______
- No______
- Not applicable______
- Don’t know______
- Decline to state______

21. Are there any children in your house who are attending primary or secondary school?
- Yes______
- No______
- Not applicable______
- Don’t know______
- Decline to state______

**Only answer if you responded Yes to Q21**

22. Has one or more of these children who attend school missed one or more days of school in the past two weeks due to illness?
- Yes______
- No______
- Not applicable______
- Don’t know______
- Decline to state______

23. What is the highest level of school you have completed?
- Never attended school______
- Some primary school (did not complete)______
- Primary (up to grade 6)______
- Secondary (up to grade 12)______
- University (above grade 12)______
- Technical Institute (above grade 12)______
- Non-formal education______
- Other (please specify)______
- Don’t know______
- Decline to state______

5.8.3 Field kits

If the MEASURE step for your CQI project involves collecting data through direct measurement, you may need specialized field equipment to accurately and reproducibly collect these data. This equipment may be as common as a reliable measuring tape, stop watch, and graduated collapsible bucket, or as
advanced as a portable colorimeter for measuring physical/chemical water quality parameters. Many options are available, depending on the CQI teams’ requirements and resources.

In many cases, however, CQI teams will need to collect similar types of direct measurement data (e.g. flow rate, GPS coordinates, and standard water quality parameters such as arsenic, fluoride, and *E. coli* concentrations). In these cases, a standardized field kit may be a cost-effective and efficient option for CQI teams. Several excellent water quality test kits are available from suppliers including DelAgua®, Wagtech®, and others. The kit that you choose to should be chosen to meet the needs of your specific evaluation. It should also meet any budget requirements of your CQI project. The Water Institute uses the WaSH MEL Field Kit. This kit may or may not meet the needs of your project, but its contents are listed below to illustrate the types of field equipment that CQI teams may commonly wish to procure in order to facilitate data collection.

**Table 8. WaSH MEL Field Kit Contents**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Part #</th>
<th>Consumable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backpack</td>
<td>Super-sturdy ballistic nylon backpack</td>
<td>Ful</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>100</td>
<td>CBT II</td>
<td>Compartment Bag with Test Bud and Sterile 100 mL Whirlpack bag with sodium thiosulfate</td>
<td>Aquagenx, LLC</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>25</td>
<td>Clip</td>
<td>Plastic clip for Compartment Bag Test</td>
<td>Aquagenx, LLC</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Plastic asset tags</td>
<td>Adhesive plastic asset tags for sample tracking (pack of 100 tags)</td>
<td>Intelliscanner®</td>
<td>ISTAGS-S100</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
<td>Arsenic Test Kit</td>
<td>Econo-Quick II Arsenic Test Kit (100 tests)</td>
<td>ITS, Inc</td>
<td>481304</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
<td>Fluoride Meter</td>
<td>Digital fluoride meter</td>
<td>Extech Instruments</td>
<td>FL700</td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Fluoride Reagents</td>
<td>TISAB tablets (tube of 100)</td>
<td>Extech Instruments</td>
<td>FL704</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
<td>pH/Conductivity meter</td>
<td>Digital pH/conductivity/TDS meter</td>
<td>Hanna Instruments</td>
<td>HI 98129</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Stopwatch</td>
<td>Digital sports stopwatch</td>
<td>Champion Sports</td>
<td>910</td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Collapsible bucket</td>
<td>20L collapsible bucket</td>
<td>Sea to Summit</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Tape measure</td>
<td>12-foot tape measure</td>
<td>Komelon</td>
<td>4912IM</td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Chlorine Meter</td>
<td>Digital Residual Chlorine Meter (optional)</td>
<td>Extech Instruments</td>
<td>CL200</td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Chlorine Reagents</td>
<td>Chlorine reagent tablets (pack of 100; optional)</td>
<td>Extech Instruments</td>
<td>CL204</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
<td>Turbidimeter</td>
<td>Portable Turbidimeter (Optional)</td>
<td>Hanna Instruments</td>
<td>HI9803</td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Nitrate test</td>
<td>Portable nitrate test (colorimeter)</td>
<td>Lamotte</td>
<td>3354</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Nitrate reagent 1</td>
<td>Nitrate reagent #1 (pack of 50)</td>
<td>Lamotte</td>
<td>2799A-H</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>Nitrate reagent 2</td>
<td>Nitrate reagent #2</td>
<td>Lamotte</td>
<td>NN-3703A-H</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
<td>Iron test</td>
<td>Portable iron test (colorimeter)</td>
<td>Lamotte</td>
<td>4447-01</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Iron reagent 1</td>
<td>Iron reagent #1 (50 tests)</td>
<td>Lamotte</td>
<td>4450-G</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>Iron reagent 2</td>
<td>Iron reagent #2 (50 tests)</td>
<td>Lamotte</td>
<td>4451-S</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
<td>Mobile phone</td>
<td>Mobile phone for data collection (Optional)</td>
<td>Various Mfrs.</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1</td>
<td>Power bank</td>
<td>Mobile power bank (&gt;10,000 mAh; optional)</td>
<td>Various Mfrs.</td>
<td></td>
<td>N</td>
</tr>
</tbody>
</table>
6. Analyze

6.1. Overview/steps

The ANALYZE step of CQI occurs once sufficient data are available to characterize the process identified in the DEFINE step. In some cases, this step occurs after data have been collected in the MEASURE step; in other cases, sufficient data may have been available from pre-existing sources. These data are analyzed using simple techniques, described below, that do not require an advanced technical background to master. In some cases, advanced techniques may be used as well. In analyzing these data, CQI teams will seek to identify and characterize patterns in the data. How do outcomes vary as a function of space and time? What are other potential explanatory variables? The understanding gained from ANALYZE can be used to refine the process map developed by the CQI team. This understanding can also be used to revisit and further focus the problem or opportunity statement initially developed in the DEFINE step. Once a focused problem statement is created, the CQI team can analyze the statement and identify potential root causes of the problem or opportunity. These potential root causes can then be verified using further data analysis techniques.

6.1.1. Goals

The goals of the ANALYZE step are to identify patterns in the data, find cause-and-effect relationships, and determine which “X” factors are most strongly associated with the “Y” outcomes of interest. This is
an important step in systematic problem solving which differentiates it from conventional problem solving: root causes are identified using statistical methods, rather than assumed based on intuition.

### 6.1.2 Main questions

There are two main questions that CQI teams should be asking during the ANALYZE step:

“**What patterns occur in the data?**”

And

“**Where are problems occurring most?**”

*Table 9. Questions to be Asked During the ANALYZE Step*

<table>
<thead>
<tr>
<th>Question</th>
<th>Hypothetical Examples</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| **What patterns occur in the data?**  | - Non-functionality of water sources is highest in communities without a WaSH committee or fee collection  
                                         - Household water contamination is strongly correlated with storage container type and water extraction method | Identifying these patterns provides clues to potential root causes of problems |
| **Where are problems occurring most?**| - 85% of all abandoned latrines are concentrated in just 19% of all communities  
                                         - 67% of seasonal borehole failures occur for systems drilled during the rainiest 3 months of the year | Identifying where problems occur tells us where we must focus our efforts to get the largest and/or most efficient improvements |

### 6.1.3 Steps

The following steps can be taken to answer the above questions:

**Step 1 - Identify patterns in the available data:**

To identify patterns in the available data, and to determine where/when problems occur most, it is useful to perform several different analyses. These can take many forms, but the most common forms include:

- A) Stratification
- B) Exploring relationships using graphs and regressions
- C) Exploring relationships using time series
- D) Inspection of maps, plots, and tables
- E) Using the Pareto principle and Pareto charts
First, however, it is helpful to briefly review the types of data we are likely to encounter, in order to help us analyze these data and look for patterns.

- **Types of data:**
  As we recall from the MEASURE step, CQI teams will likely be working both continuous and discrete data in ANALYZE. When using analysis tools such as maps, plots, tables, and parteto charts, we will select different tools depending on whether we wish to explore the relationship between continuous variables, discrete variables, or a mix of both.

- **Stratification**
  As discussed above, stratification means dividing up data on the basis of some discrete variable such as country, district, season, etc. Typically, when we refer to stratification in CQI, we mean looking at our outcome ("Y") variables across a sample that is divided up into two or more “bins” on the basis of characteristics, inputs, and/or process variables ("X" variables).

An example of using stratification to look for patterns in the data would be looking at height of individuals. The average height of adult humans is 169 cm. Let’s consider this our outcome (“Y”) variable. If we wanted to learn more about the determinants of height, we could stratify this outcome in terms of different attributes such as gender (men vs women), location (country or region), or other factors. We could then present these stratified variables as histograms, tables, or in other formats, as in the examples below.

**Average height (world): 169 cm**

*Table 10. Average height (world) stratified by gender*

<table>
<thead>
<tr>
<th>Men (cm)</th>
<th>Women (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>176</td>
<td>162</td>
</tr>
</tbody>
</table>

*Figure 32. Average height (world) stratified by gender*

*Table 11. Average height of men (cm), stratified by country*
Examples of common stratification variables for WaSH programs include:

- Country
- Region
- District
- Rural/urban
- Season of the year
- Intervention/control assignment

Other stratification variables can be included as needed.

Activity: Identify 2-3 stratification variables that are likely to be useful to your team in identifying where a problem occurs most. Stratify your data according to these variables, and present the results both in tables and in graphs. Review the results and determine whether you are able to identify any patterns in your data.

- Exploring relationships using graphs and regressions

While stratification helps us explore questions of WHERE and WHEN problems/opportunities occur most, we can also use graphs and regressions to explore questions of HOW and WHY problems/opportunities occur. In this step, we explore associations between Y outcomes and X variables that may be potential determinants of these outcomes.

An example of using associations to look for patterns in the data would be looking at the determinants of motor vehicle accidents (MVAs) in the United States. A study of 500 drivers over a 4-year period.
found that 44% of studied drivers experienced at least one MVA over the 4-year study period (Norris et al., 2000). Let’s consider this our outcome (Y) variable. If we wanted to learn more about the determinants of MVAs, we could explore the associations of this outcome with different X variables such as Driver’s Age, employment status, personality, driving habits, etc. We could then present the results as graphs, tables, or regression analysis results, as described below. A regression is a mathematical “model” that compares two variables and determines the strength of the association between them. Common types of regressions include linear regressions, logistic regressions, and others. Several common types of regressions can be performed using Microsoft Excel. Additional types of regression analysis can be performed using statistical software packages such as Minitab, Stata, and R. Many CQI teams favor R because it is free.

Simple tables and graphs can be used to explore relationships between variables.

Common types of tables include:

- Summary table: this table lists statistics about the central tendency or basic distribution of variables of interest (average or median value of a given attribute across all observations, percent of observations having a given attribute, etc.)
- Pivot table: This table shows how one variable changes as a function of another, categorical (or discrete) variable

Common types of graphs include:

- Histogram or frequency plot: this graph plots the occurrence or frequency of a discrete variable as a function of another discrete variable.
- Stratified histograms: two or more histograms plotting the frequency of a discrete variable as a function of another discrete variable; the different histograms correspond to different values of a third discrete “stratifying variable.” For example, two histograms, each representing frequency of water point failure by cause, one for failures in the dry season, the other for failures in the wet season.
- Scatterplot: a plot of a continuous Y variable as a function of a continuous X variable.

Regression analysis can also be used to explore relationships. In regression analysis, an equation (linear or otherwise) is fit to the data, and standard statistical methods are used to calculate the best-fitting equation and quantify the goodness-of-fit. Common types of regression include:

- Linear regression
- Logistic regression
- Multinomial regression

Many other types of tables, graphs, and regressions can be used to explore relationships, and the above list is meant to be illustrative, rather than exhaustive. Examples of using simple tables, graphs, and regression analysis to explore relationships between variables are presented below:

**Average rate of motor vehicle accidents for 500 drivers over a 4-year period: 44%**

*Table 12. Proportion of individuals with motor vehicle accidents during study period, by age group*

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Proportion with MVA</th>
<th>X²</th>
</tr>
</thead>
</table>
Figure 34. Motor vehicle deaths per 100,000 by age and gender
(Source: http://www.iihs.org/iihs/topics/t/older-drivers/fatalityfacts/older-people/2005)

Table 13. Proportion of individuals with motor vehicle accidents by employment status

<table>
<thead>
<tr>
<th>Employment status</th>
<th>Proportion with MVA</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not employed</td>
<td>33.3%</td>
<td>15.72***</td>
</tr>
<tr>
<td>Employed</td>
<td>51.3%</td>
<td></td>
</tr>
</tbody>
</table>
Figure 35. Proportion of individuals with MVA during study period by employment status

Table 14. Proportion of individuals with motor vehicle accidents by anxiety level

<table>
<thead>
<tr>
<th>Anxiety</th>
<th>Proportion with MVA</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>39.2%</td>
<td>4.40*</td>
</tr>
<tr>
<td>Low</td>
<td>44.0%</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>50.6%</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01  ***p<0.001

Figure 36. Proportion of individuals with MVA during the study period by anxiety level
Table 15. Proportion of individuals with motor vehicle accidents by driving behavior

<table>
<thead>
<tr>
<th>Obeys speed limits</th>
<th>Proportion with MVA</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually-Never</td>
<td>50.1%</td>
<td>15.4***</td>
</tr>
<tr>
<td>Always</td>
<td>31.3%</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01, ***p<0.001

When analyzing data for associations, the variables selected will be unique to the specific improvement focus identified in the DEFINE step. Some illustrative examples are provided below.

Examples of common “Y” outcome variables for WaSH programs related to water supply include:

- % of water systems functional on the day of the visit
- % of water systems that have experienced a breakdown in the last 2 weeks
- % of water systems in the high risk category for *E. coli* concentration (>100 CFU/100 mL)

Many other outcome variables could also be included. In many cases, “Y” variables will correspond to the outcomes or “defects” identified in the DEFINE step of CQI. However, additional “Y” variables may also be included as needed.

Examples of common “X” variables for WaSH programs related to water supply include:

- Source type
- Age of water source
- Date of visit (e.g. season)
- Implementer
CQI teams could explore associations between any “Y” outcome variable of interest and any “X” variable that might reasonably be associated with that outcome. For example, exploring the association between presence of a management committee and % of water systems functional on the day of the visit. To explore this association, the team might create a table, create a graph, or use statistical methods to study this relationship.

Table 16. Percent of water points functional on the day of the visit by management status

<table>
<thead>
<tr>
<th>Management status</th>
<th>Percent functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>No management</td>
<td>62.3%</td>
</tr>
<tr>
<td>Management</td>
<td>76.5%</td>
</tr>
</tbody>
</table>

Based on the above results, the CQI team may conclude that there is a “potential association” between management status and functionality. The team cannot infer that management CAUSES systems to be functional, because associations can often exist where there is no causal relationship, either through coincidence, as in Example A below, or through a process known as “confounding,” where two seemingly unrelated variables are both connected through a third “confounding” variable, as in Example B below (in this case, the confounding variable is age).
**Activity:** Identify 2-3 outcome ("Y") variables of interest to your team. Then identify "X" process variables that might be associated with these outcomes. Use tables, graphs, and/or regression analysis to explore the potential associations between each pair of X and Y variables. Review the results and determine whether you are able to identify any patterns in your data.

*Exploring time series data using graphs and run charts*
In some cases, we will have data collected over a period of time with relatively frequent observations. In these cases, we can refer to our data as time-series data. We can use additional types of graphs and analyses to look for patterns in time-series data. For example, if we have many observations we can use a “run chart” to study the behavior of our variable of interest over time. Below is a hypothetical run chart of weekly water point functionality data for 1000 water points over the course of a year:

![% of handpumps functional vs time](image)

**Figure 40. Example of time-series data; percent of handpumps functional vs week in which data were collected**

An inspection of this chart shows a fair degree of variability in the data: functionality rates fluctuate between statistical “control limits” of approximately 60-100%. However, during certain times of the year (weeks 20-40 or so), the process appears to undergo a shift to lower values. These findings can help give us an understanding of the behavior of the process over time, and can give us clues as to potential root causes of low functionality rates. We could break down these data further by stratifying our run charts with respect to key variables such as drilling method, geographic region, or other stratifying variables.

When looking at time series data, we want to pay special attention to two types of variation in the process we are observing:

**Common-cause variation**: the natural variability or “noisiness” of most time-series data.

**Special-cause variation**: departures from the natural variability, often due to a specific cause.

Common-cause variation often does not have a single specific cause. In the above example, the variability in functionality that we observe from week to week during the first 20 weeks is an example of common-cause variation—it appears to be essentially random. We can use CQI methods to improve our process and reduce this variation (if desirable), but there may be no single factor that “causes” the variability in our data.

Special-cause variation often DOES have a single specific cause that we can identify and, in some cases, address. In the above example, the sudden decrease in functionality rates between weeks 20-25, and
the sudden increase between weeks 40-45 are examples of special-cause variation: these changes appear to be much larger than the random variation in the data during the first 20 weeks. We can use statistical tests to check whether a sudden change is likely to be the result of random noise (common-cause variation), or whether the change is more likely to represent special cause variation. In the case of special cause variation, we can use our collected “X” variable data to identify the cause. If the cause is modifiable (easily changed), we can address it. If not, we can look for deeper root causes that may be modifiable, or use our CQI methods to identify work-arounds that enable us to solve the problem in another way. In the above example, the most likely explanation for the special-cause variation we observe is seasonality issues that reduce the functionality of water sources during the dry season. If the dry season in this country typically occurs around the period between weeks 20-40, we can be confident that this is a potential root cause. While we cannot directly control the weather, identifying this pattern may still help the CQI team to find potential root causes of problems and identify possible solutions.

- Inspection of maps, plots, and tables

In addition to the above analyses, it can be useful to visualize available data in other ways. Plotting locations on a map and color-coding them on the basis of a Y outcome of interest (for example, plotting functional water sources in green and nonfunctional sources in red) may be useful for better understanding spatial patterns in the data. Using multiple different types of plots, such as histograms, stratified histograms, scatter plots, stratified scatter plots, 3-dimensional plots, and others may also be helpful in exploring associations and trends in the data. Finally, reviewing tables of summary statistics may also be helpful for identifying patterns in available data, and obtaining an overview of the current status of the process of interest.

For situations in which both “X” and “Y” variables of interest are continuous, a scatterplot (with or without the use of a regression equation) may be helpful for identifying associations. For example, we could create a scatterplot of depth vs flow rate to test for an association between these factors. We could even stratify the scatterplot by some stratifying variable of interest, such as season or district, if we thought this might help us see the association of interest more clearly:
In this hypothetical example, the shape of the graph suggests an association between depth and flow rate. We can also fit a regression equation to continuous X and Y data to characterize the strength and direction of the association.

Figure 41. Example Scatterplot of borehole yield vs Depth

Figure 42. Example Scatterplot with regression equation

\[ y = 0.2404x + 21.007 \]

\[ R^2 = 0.9706 \]
Using the Pareto principle and Pareto charts

The “Pareto principle,” also known as the “80/20 rule,” is named after the Italian economist Vilfredo Pareto (1848-1923), who famously observed that in Italy at the time, 80% of the land was owned by just 20% of the population. He identified several other examples of power law distributions, in which a small proportion of the observations account for a large proportion of the effects. Common examples of power law distributions include the wealth of individuals, where a small proportion of the population controls a large proportion of the society’s wealth, and the popularity of websites, where a small proportion of the total number of websites account for a large proportion of internet traffic. This is distinct from a normal distribution or “bell-curve,” which tends to be associated with things that are distributed evenly in nature, such as height and weight, where large differences between individuals are unusual, and differences of 100x or 1000x are unheard of.

![Power-law distribution vs Normal distribution](https://farm4.staticflickr.com)

Figure 43. Normal Distribution VS Power-Law Distribution

Source: [https://farm4.staticflickr.com](https://farm4.staticflickr.com)

The application of the Pareto principle to CQI stems from the fact that many CQI projects are designed to create improvements in complex systems, where dozens, hundreds, or even thousands of potential causes may affect the “Y” outcome(s) of interest, and problems can occur with any number of distributions across space, time, and other stratifying variables. If problems follow a normal distribution, such that no one cause, place, or time is associated with much greater occurrences of the problem than any other, the CQI task is a challenging one. However, if the Pareto principle applies, then a small number of causes may account for a large proportion of the occurrences of our problem or outcome of interest.
To determine whether the Pareto principle applies to a given set of X and Y variables, we can use a special type of frequency plot called a “Pareto diagram” to test whether the principle applies. To do this, we will need a Y outcome that corresponds to occurrences of our outcome of interest, and a discrete X variable.

If Y is a discrete outcome, such as “functionality”, we can count occurrences, such as “# of systems that are nonfunctional”. Likewise, if X is a continuous variable, such as borehole age, we can convert it into a discrete variable by creating “bins” of ages (0-5y; 5-10y; 10-15y; 15-20y; 20-25y; 25-30y; >30y).

Once we have our variables in usable form, we calculate the percent of total occurrences due to each potential cause or X category:

Table 17. Frequency of water point failure by cause

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Power</td>
<td>2</td>
</tr>
<tr>
<td>Facility Locked</td>
<td>1</td>
</tr>
<tr>
<td>Above Ground Failure</td>
<td>10</td>
</tr>
<tr>
<td>Below Ground Failure</td>
<td>3</td>
</tr>
<tr>
<td>Source Dry</td>
<td>21</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
</tbody>
</table>

- We then order these variables from largest to smallest by their relative impact on the Y outcome, and calculate both the number and percent of occurrences of the Y outcome that each is responsible for.
- We then graph these data on a frequency plot from largest to smallest, with the “Other” category always at the end.
- On the X axis, we list the category of our X variable.
- On the Y axis, we list the frequency of our Y outcome for each X category.
- We then add a second Y axis (on the right-hand side) and plot the cumulative frequency (from 0-100%) on this axis.

Thus, the contribution of each category is shown, summing to 100%, as in the example below.
By reviewing a Pareto chart such as the example above, we can quickly determine whether one or a few causes account for most of the occurrences of the outcome of interest. In the above hypothetical example, dry water sources and above-ground breakdowns accounted for 80% of failures. In this case, we can confirm that the Pareto principle applies; a small number of causes are responsible for a large proportion of breakdowns.

- As a result, further CQI efforts should focus on these few, important causes.

In cases where the Pareto principle does not apply, CQI teams might try to analyze the data in different ways to determine whether the Pareto principle will apply when the data are analyzed differently. Examples of ways to transform the data include:

- Break the “X” variable data down in a different way (i.e. by source type or region, etc.)
- Adjust the “Y” variable for impact (e.g. days of failure rather than number of failures, etc.)
• Normalize the “Y” variable (e.g. days of failure per million liters produced, rather than just days of failure)

If none of these transformations produces a chart for which the Pareto principle applies, then we can conclude that it likely does not apply for this association. Where the Pareto principle applies, the few most important causes are good targets for potential improvements that may have a big impact. Where the principle does not apply, the biggest causes may still be targeted, but the choice is less clear, and CQI teams may instead prefer to focus on the most modifiable (easiest to change) causes, or on other “X” variables besides the one in question.

Step 2: Create a more detailed process map

Using the results of the above analyses, the CQI team is now in a position to develop more detailed process maps for the process to be improved. The team should first review the original process map developed in the DEFINE step.

Example: Process map

![Detailed Process Map 1](image)

*Figure 45. Detailed Process Map 1*

Next, add detail to the process map:

• Add any additional process steps identified during the MEASURE and ANALYZE steps.
• Add in additional information about the intermediate outputs produced at each process step.
• Add the elapsed time (mean, median, estimated typical duration, or 95% confidence interval, as appropriate) for each process step
• Add in the error or defect rate for each process step
• Add in the capacity or “throughput” of each step (i.e. “20 samples per day,” or “6 communities per week…”)
• Add in any other useful details or attributes of process steps

These characteristics can be customized as needed.
This detailed process map can now be analyzed to identify the following:

- Which step(s) produce the most rejects and defects?
- Which steps are bottlenecks that control the rate of the overall process?

**Step 3: Develop a focused problem statement**

Based on the patterns identified in the data, the CQI team can further refine the problem statement developed in the DEFINE stage. This refinement can include adding greater specificity with respect to the following:

- Where the problem occurs
- When the problem occurs
- The specific nature of the problem

Some illustrative examples are provided below.

There is no hard and fast rule as to when a problem statement is sufficiently focused. However, CQI teams should seek to make problem statements specific enough to address the problem in question and generate a meaningful improvement.
Table 18. Focusing Problem Statements

<table>
<thead>
<tr>
<th>Broad/ Vague Problem Statement</th>
<th>Somewhat Focused</th>
<th>Narrowly focused statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low functionality</td>
<td>Boreholes are routinely Not working</td>
<td>Boreholes are routinely nonfunctional for 7 days or more during the dry season</td>
</tr>
<tr>
<td>Absentee promotors in District A</td>
<td>Absentee promotors who also work as school teachers in District A</td>
<td>Absentee promotors who also work as school teachers in District A</td>
</tr>
<tr>
<td>Sanitation adoption in Schools</td>
<td>Sanitation adoption By girls in rural schools in the Northern Region</td>
<td>Low sanitation adoption By girls in rural schools in the Northern Region</td>
</tr>
</tbody>
</table>

**Activity:** Create a focused problem/opportunity statement:

- Review the CQI team’s current problem/opportunity statement. Identify opportunities to focus on.
- Review the results of the above analyses: what information can be used to further refine the problem statement?
- Integrate the additional information and develop a new focused problem/opportunity statement that the whole team can agree on. Updated the project charter with this statement.

**Step 4:** - Identify potential root causes for the patterns you observe in the data

Now that the CQI team has a more focused problem statement, the team can work to identify the root causes of the problem or opportunity specified in that statement. To do this, the team will first develop hypotheses about why the problem is occurring, or how the greatest opportunity can be realized. A three-part process can be used to do this:

- Brainstorming potential root causes
- Organizing these root causes into a cause-and-effect diagram
- Selecting likely causes (or causal chains) to validate

**Brainstorming**

The purpose of brainstorming is to generate lots of ideas quickly. In order to get the most out of this activity, it can be helpful to do the following:

- Encourage creativity
- Involve everyone on the CQI team
- Generate excitement and energy
- Separate people from ideas they suggest
For your brainstorming session, gather the CQI team together with a large paper flip chart, chalk board, or whiteboard. Tackle the question:

*What are some possible root causes of this problem/opportunity?*

Aim to write down at least 10-20 responses, and to capture at least one response from each person present.

- **The Five Whys**

Next, use a technique call the “five whys” to push for deeper causes underlying each of the responses provided. To apply this technique, go one by one through each response and ask “why does this occur?” Then write the response, and for that cause, ask again “why does this occur?” Continue until deep potential root causes have been identified for each response. This may not require asking why exactly five times (it could be more or it could be fewer), but the name of the exercise is intended to drive the group towards deeper and deeper potential root causes.

For example, if we are asking why 40% of nonfunctional handpumps in the Northern Region of Ghana remain broken down for more than 1 week after failure, we might brainstorm several possible causes. For each, we ask “why does this occur?” So if a CQI team member suggests that handpumps often remain broken for 1 week or more because government water and sanitation teams are slow to respond to repair requests at certain times of the month, we would again ask “why does this occur?” The team might consider and respond that this is because the government maintenance teams have exhausted their fuel allowances at that time of the month. We would then ask “why does this occur?” The team might respond that this is because their budget has no allocation for travel to the field to make repairs. We would then ask, “why does this occur,” etc...
Once you have brainstormed your potential root causes, it is time to organize them using a cause-and-effect diagram, also called a Fishbone diagram or Ishikawa diagram (after Kaoru Ishikawa, who is credited with inventing this approach to mapping potential root causes).

The steps to creating a cause-and-effect diagram are as follows:

- List the potential root causes the CQI team has identified
- Sort these into groups by common theme: for example, “waterpoints have low flow in dry season,” and “in certain regions, water is unavailable for several months each year,” might both be grouped into a category called “seasonality problems,” or similar. Aim to sort causes into 3-6 main groups, if possible.
- On a large blank piece of paper, a flip chart, a chalkboard, or whiteboard, construct a box at one end, and write the CQI team’s focused problem statement in that box.
- Then draw a single long arrow all the way across the length of the workspace, ending at that box, as in the example below. This is the spine of your fishbone diagram:
Next, draw large arrows inwards towards the spine. Label each of these large arrows with a statement representing one of the categories of potential causes identified in the CQI team’s grouping and brainstorming session.

Then, for each major arrow, ask “why does this occur?” Where reasons are generated, add these to the diagram as minor arrows pointing towards the major arrows, as in the diagram below. Remember, if the facilitator can write clearly enough, up to five levels of potential root causes can be listed.

**Figure 49. Cause-and-effect Diagram, Part 1**

- High number of seasonality problems
  - Waterpoints have low flow rates in dry
  - Pump unable to lift water from depths in
  - Pump not done in wet

- Long delay in repairing
  - WSMTs lack spare
  - WSMTs have few trained mechanics
  - Pump unable to lift water from depths in

- Low waterpoint functionality in XYZ state
  - Follow-up training of WSMTs rare
  - Members do not meet regularly

**Figure 50. Cause-and-effect Diagram, Part 2**

- High number of inactive WSMTs
  - No set meeting schedule
  - Members all have other jobs
  - No clear leadership
  - Team members have valuable skills
When constructing cause-and-effect diagrams, remember to ensure that connected arrows represent statements linked by potential causality, and not just lists of things, people, and events. For example, the following chain shows potential causal linkages:

Example 1 (correct): Inadequate siting methods → Wells too shallow → Seasonal water shortages → Low waterpoint functionality

However, in this second example below, while the arrows connect related ideas, these ideas do not share potential causal linkages, but are just an assortment of words connect by arrows:

Example 2 (incorrect): Sustainability → Teamwork → Communities → Capacity Building → Low waterpoint functionality

When constructing cause-and-effect diagrams, while we do not yet know the TRUE root causes of our problem/opportunity, we do want to ensure that each chain of arrows represents a potential causal chain. To ensure that we have accomplished this, we can use something called the “might cause” check. In this exercise, we start with each bone in our diagram that has no other bones pointing towards it (i.e. each smallest bone, or potential root cause). For each of these, we construct the following sentence: “[Smallest bone] might cause [Next bone], which might cause [next bone], which might cause… [Main bone], which might cause [Head/problem statement].” If this sentence makes sense (even if it does not turn out to be true), then the causal chain passes the “might cause” check. If we try this with our two examples above, we can see that Example 1 passes the “might cause” check, but example 2 does not. Note that the grammar does not need to be perfect for a causal chain to pass, as long as it conceptually makes sense.
Might Cause Check

<table>
<thead>
<tr>
<th>Might Cause Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>No set meeting schedule</td>
</tr>
<tr>
<td>might cause</td>
</tr>
<tr>
<td>which might cause</td>
</tr>
<tr>
<td>which might cause</td>
</tr>
<tr>
<td>which might cause</td>
</tr>
</tbody>
</table>

Figure 51. The “might-cause” check

- Prioritizing potential root causes to investigate:
  - Once we have added all major groups of causes (main bones) to the diagram, and brainstormed as many potential root causes for these as possible (smaller bones), and once our fishbone diagram has been reviewed using the “might cause” check, the diagram is complete. A CQI team member should take a picture of the diagram, and type it up for reference.
  - Now the CQI team should review the diagram. It will likely have 3-6 main bones, 10-20 secondary bones, and potentially dozens of tertiary and/or quaternary bones. This translates into a very large number of potential causal chains. The CQI team cannot easily investigate each of these causal chains at once. As a result, it will be useful to prioritize those potential causal chains that the CQI team thinks are most likely. Review the cause-and-effect diagram, and select 1-5 potential causal pathways to test first. These correspond to identified potential root causes.

Step 4: Validate root causes

In order to validate identified potential root causes, we will use analysis tools such as those described above to test for a cause-and-effect relationship between the identified potential root causes and our
outcomes of interest. In some cases, we will have sufficient data available to do this. In other cases, some additional data may need to be collected.

**Ensure that all needed data are available to test our potential root causes**

The CQI team should confirm that adequate data are available on “Y” outcome variables, “X” variables associated with the potential root causes, as well as other related process variables in the potential causal chain. If sufficient data are not available, additional data may need to be collected.

**Use basic and/or advanced statistical methods to explore relationships between potential root causes and outcomes of interest**

This may include using some of the tools addressed earlier in this section. If both X and Y variables of interest are continuous, we can use scatter plots and regressions, as in Figures 41-42, to test for potential associations. In other cases, either “X”, “Y”, or both may be discrete variables. If Y is discrete and X is continuous, we can use stratified histograms to determine whether different values of X are associated with different values of Y. For example, if we want to test the hypothesis that a drilling team gets many dry boreholes because they do not spend sufficient time siting the borehole before drilling, we can compare the time spent drilling boreholes that resulted in dry wells vs the time spent drilling boreholes that resulted in wet wells. If we see a distinctly different pattern between these two histograms, it is likely that an association exists between siting time and drilling success.
In the above hypothetical example, we see that the time spent siting boreholes that resulted in dry wells tended to be less than the time spent siting wet wells. This suggests an association between these two variables.

Similarly, we could also use stratified histograms to explore the relationships between discrete “X” variables and continuous “Y” variables. For example, if our “X” variable is drilling method and our “Y” variable is the yield of the resulting borehole, we could also use stratified histograms to explore the relationship:
In the case that both our “X” and “Y” variables of interest are continuous, we must express our data in tabular format. We can express results in a pivot table, as in the below example:

Table 19. Pivot Table

<table>
<thead>
<tr>
<th>Fee Collected?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>74</td>
<td>5</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

In this example, we tabulate the numbers of water systems that are functional vs. nonfunctional in communities with a fee collection system in place and communities without. We could also express the results as percentages functional vs. nonfunctional for each fee collection condition. In this case, we see
that 89% of systems are functional in communities with a fee collection system, while 42% are functional in communities without, suggesting an association between fee collection and functionality.

6.1.4 Hypothesis testing

However, in the above examples, while visual inspection of graphs and tables can provide a useful indication of an association between “X” and “Y” variables, we sometimes want more conclusive evidence. In these cases, we can use statistical methods to do “hypothesis testing,” where we calculate the statistical probability that groups are truly different, based on the information we get from samples of those groups.

Significance

In the above pivot table example, we can use a chi squared test to calculate the probability that the difference between the two groups (89% vs 42% functionality) arises out of change (i.e. coincidence). We typically use a probability cutoff value of 5% to determine whether two groups are “significantly” different. If the probability that the groups are the same is less than 5% (or a probability of 0.05), we are comfortable concluding that they are, in fact, different, and the apparent association does not arise by chance. Using the chi squared test, we calculated this probability as p = 0.00004. This is less than our cutoff probability of 0.05, so we conclude that there is a significant association between fee collection and functionality.

We can use several other statistical methods for hypothesis testing as well. Depending on the types of “X” and “Y” variables we are interested in, we can use univariable and multivariable linear or logistic regressions, analysis of variation (ANOVA), t-tests, and a variety of other statistical tests, regressions, and methods. In all cases, it is important to recall that association does not imply causation: our methods can tell us if X and Y variables are related, but it is often difficult to directly demonstrate causality without performing a controlled experiment. However, in many cases a strong association with a plausible causal explanation is enough information for CQI teams to consider potential root causes validated, to prioritize these root causes with respect to the strength of the association (how likely the association between X and Y is to be significant) and the effect size (how much a given change in X affects Y), and move on to the IDENTIFY step of CQI.

Effect size

Significance is a measure of how LIKELY it is that an association exists between X and Y; effect size is a measure of how BIG the association between “X” and “Y” variables is. In general, we are most interested in associations that are both big and likely. Many statistical tests will allow us to calculate some measure of significance and some measure of effect size. There are many different ways this can be calculated. Often, we will express this as a “correlation coefficient” (as in logit and linear regressions), an “Odds Ratio,” as in logistic regressions, or another statistic indicating effect size. These statistics can also be expressed as a range, or confidence interval. For example, we might express the association between drilling method and water source functionality by saying:

\[
p = 0.0037^*\\ \text{OR} = 1.64 \ (1.29-2.75)
\]
In this hypothetical example, we are saying that the probability of no association between X and Y is only 0.37% (less than our cutoff of 5%, so we assume that an association exists – this association is statistically significant.

We also determine the effect size: the odds ratio for this association is 1.64. That means that a mechanically drilled well is 1.64 times as likely as a manually drilled source to be functional on the day of the visit (or 64% more likely to be working). Because we cannot be certain that the true value of the effect size is EXACTLY 1.64, it is helpful to provide a 95% confidence interval for the effect size. In this case, we provide the RANGE of values within which we are 95% sure that the true effect size lies. In this case, we can be 95% confident that the true value is between 1.29 and 2.75. That is, mechanically drilled sources are between 1.29 times and 2.75 times more likely to be functional than manually drilled sources in this example, with the most likely effect size being 1.64. It is not necessary for all members of the CQI team to understand all the details of significance and effect size. However, it is helpful if at least one member of the team is familiar with these concepts.

Generally, it is enough to say that those associations that are statistically significant and have large effect sizes are likely to be the most important. CQI teams may find many different associations in the ANALYZE stage. As the teams use these results to IDENTIFY improvement packages, it may be useful to pick the most important associations (and validated root causes) to focus on when developing improvements. Prioritizing those validated root causes that have significant associations with outcomes of interest and a large effect size may be one good way to do this. In addition, it may be helpful to prioritize those validated root causes that are “modifiable,” that is, that the CQI team may be able to change. For example, it would be easier for the CQI team to change the borehole drilling method than to control a variable such as annual rainfall in the project area, even though both may be important factors affecting water system functionality. By analyzing the data, identifying potential root causes, and using statistical tools to validate some of those root causes, the CQI team should be able to develop a short list of X factors that are significant predictors of Y outcomes, are modifiable, and have moderate to large effect sizes, and to prioritize these for focus in the next CQI step: IDENTIFY.

7. Identify

7.1. Overview/Steps

The results of the data analysis process will help inform key decisions made during IDENTIFY, the next step in the CQI process. In this stage, the CQI team will systematically identify improvement packages to strengthen WaSH programs.

7.1.1 Review Goals

Generate, evaluate, and select solutions to the problem statement developed in the DEFINE step

7.1.2 Main questions

- What solutions are likely to address the problem?
- Do they address the root causes of the problem or superficial causes?
- Is the solution feasible?
• Is the solution affordable?
• Is the Solution sustainable?
• Is the solution likely to work?
• How can the solution be improved in each of these areas?

7.1.3 Steps
• Generate solutions
• Evaluate solutions
• Select improvement package

7.1.4 Output
Selected improvement package for implementation

7.1.5 Lean Solutions
• Types of waste
• Strategies for reducing waste.

7.2. Generate and Select Solutions
The CQI team should now be ready to develop, implement, and evaluate targeted solutions. Any solutions that the CQI team identifies should target the root causes of the specified problem and incorporate key findings from the ANALYZE step. Up until now, the CQI process has been rooted in what is actually happening in the present. The IDENTIFY step will challenge us to pivot, using creativity to envision what could happen in the future once we introduce changes to the system. The general approach to the IDENTIFY step begins with brainstorming ideas for possible solutions; structured decision-making tools are then used to select and improve one or more of these solutions. Finally, a plan is developed to implement these solutions. To do this, its helps to:

- **Brainstorm** many ideas, drawing on the weird and wild as well as the tried and true.
- **Select** solutions using structured decision-making tools; teams can decide which criteria will be used to assess alternative solutions and then evaluate alternatives through testing (if possible), or through scoring against these criteria.
- **Develop** plans—including tasks and timelines, budgets and lists of resources and stakeholders.
- **Pilot** the selected solution(s)—trying the solution(s) out on a small scale to see whether they will work under real-world conditions.
- **Implement** plans that include methods for monitoring and verifying the results.
- Interpret the results to **quantify** the effects of the implemented solution(s).
- **Evaluate** the overall results and the methods used to achieve them.
Generating possible solutions begins with brainstorming. To do this, the CQI team should review the process and its (now verified) causes. Then, several creative exercises are available to help the team brainstorm. While brainstorming, the CQI team’s goal is not to come up with fully thought-out ideas. Rather, the team should generate several pieces of possible solutions that can later be combined to create alternative solutions. To help you brainstorm, follow these simple guidelines:

- **Think like a child:** Use imagination and think about problems on their most basic levels
- **Challenge the rules:** come up with a list of perceived rules in WaSH development that suggest that this problem cannot be solved. Now seek to break these rules
- **Set a deadline:** Give yourself a set, limited amount of time to develop a solution that you will stick with
- **Get rid of excuses:** List and remove any barriers to the success of the project

### 7.2.1 Brainwriting

Brainwriting is a brainstorming exercise. Brainwriting consists of individual team members writing down potential solutions on pieces of paper. The papers are passed around, so each member of the CQI team has the opportunity to either add a new idea or enhance other’s ideas, building upon what previous team members have written. To successfully conduct a brainwriting session, follow these steps:

- **Team members brainstorm ideas on a written form**
  - Each team members takes five minutes to write down three solution ideas on the first row of the form (example form below)
  - Team members pass forms to the right
  - Each team member adds another three ideas to the second row of the form
  - Add ideas by:
    - Enhancing an idea already on the sheet
    - Writing a variation of an idea on the sheet
    - Writing a completely new idea
  - Repeat for as many rounds as you have team members
At the end of the brainwriting session, you will create a short list of solutions that has been developed by group discussion and vote on a few (often 3-5) preferred ideas. Later, we will discuss how to further develop these ideas and make final selections using tools such as a prioritization matrix or Pugh matrix.

7.2.2 Idea box

Another useful tool for brainstorming is the Idea Box. To create an Idea Box, you will list the key parameters of a solution across the top of a piece of paper. These parameters should be:

- Necessary for the solution
- Sufficient (collectively) for the solution to work
- Minimal overlap between solutions

After listing the parameters, you will generate different ways to address each parameter through programming. Remember to write every idea down, even if it seems unrealistic. Imagination is the key to any effective brainstorming activity. The following diagram is an example of an Idea Box for improving drinking water quality:
### 7.2.3 Building on creative ideas

It is likely that you will identify many ideas during the brainstorming process. Some ideas that are generated using these brainstorming activities will be too farfetched or unrealistic to ever be implemented. However, even these ideas do not have to be abandoned, as they are based in a desire to address a problem that has not yet been solved. Instead of discarding these ideas, use a technique that allows you to build on these ideas.

- Start by drawing a line with notches on it that will be used as a scale from the most farfetched idea to a perfect idea, with a threshold of acceptability somewhere along the scale.
- Write each idea from your brainstorming session on an individual square of paper or sticky note and place it on the scale you just drew. Discuss the ideas that fall to the left of the threshold as a team and ask:
  - What is the strength of this idea? What made someone think of it in the first place?
  - How could we incorporate that strength into a workable idea?
- Write down any new ideas generated in this way and add them to your list of potential solutions

<table>
<thead>
<tr>
<th>Idea Box: Improve water quality for the consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increase water point functionality</strong></td>
</tr>
<tr>
<td>Rehabilitate boreholes</td>
</tr>
<tr>
<td>Form water committee</td>
</tr>
<tr>
<td>Replace galvanized steel parts with stainless steel</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

### Distributed household water treatment technology

- Provide better storage options
- Continuous piped water into households

### Continuous piped water into households

- Improve household water safety
- Increase water access
- Rehabilitate boreholes
- Form water committee
- Replace galvanized steel parts with stainless steel
- Build new water point
- Pipe water to households

### Increase water point functionality

- Increase water point functionality
- Improve household water safety
- Increase water access
- rehabillitate boreholes
- Form water committee
- Replace galvanized steel parts with stainless steel
- Distribute household water treatment technology
- Provide better storage options
- Continuous piped water into households

### Improve household water safety

- Increase water point functionality
- Improve household water safety
- Increase water access
- Rehabilitate boreholes
- Form water committee
- Replace galvanized steel parts with stainless steel
- Distribute household water treatment technology
- Provide better storage options
- Continuous piped water into households

### Increase water access

- Increase water point functionality
- Improve household water safety
- Increase water access
- Rehabilitate boreholes
- Form water committee
- Replace galvanized steel parts with stainless steel
- Distribute household water treatment technology
- Provide better storage options
- Continuous piped water into households
7.3. Evaluating solutions

By the time you have finished brainstorming solution ideas, you should have lots of potential solutions you want to evaluate. Rather than just voting on which ones to try out, you are better off taking time to do a thorough analysis of the pros and cons for each likely solution. Minimally, think about which criteria pertain to your situation and score each option against those criteria. If you have the time and resources, develop a model or simulation, or pilot solutions so that you can evaluate which might work best in real life. And always check your choices against common sense: just because something looks good on paper does not mean it will work best in practice. There are primary methods for evaluating the potential solutions:

1) Do paper-and-pen analysis (score each option against specified criteria)
2) Model or simulate the solutions
3) Conduct pilot implementations
4) Check against common sense
5) Conduct a “Red Team” analysis—general potential weaknesses of the proposed solution(s), and identify measures to address or mitigate these.

However, for each of these methods, you will need to first develop criteria for evaluating the solutions. There are several tools that we can use for criteria development.

7.3.1 Generating and Weighting Criteria

- Generate Criteria

To generate the criteria by which you will evaluate your potential solutions, your CQI team should begin by brainstorming, using the same approach that your team used to brainstorm possible solutions. To get started, there are a few common criteria used to evaluate proposed changes and solutions:

- Which root causes of problems are attacked and to what extent?
- What is the cost?
  - Cost could include money, time, additional investments needed (e.g. new equipment or staff time)
- What are the potential benefits?
Potential benefits include improvements to the people you are serving, such as savings in time, money, or workload.

How easy will this be to implement?

Ease of implementation is often determined by factors such as length of time, amount of training needed, and how implementers are affected.

What are the potential problems?

How easy will it be to prevent or remedy undesired side effects of the change?

Weight Criteria

Once the criteria for evaluating your program changes have been selected, it is time to weight them. This is done because not all criteria have the same level of importance. Therefore, you must decide which are most important for your project to achieve the outcomes you desire. A useful way to weight criteria is to rank them by a CQI team vote using a technique called “multivoting.”

Multivoting is a technique for narrowing down a long list of items. In this technique, the team goes through a number of rounds of voting, each time cutting the list by about half to two-thirds. It works as follows:

- Count how many criteria there are and divide that number by 3 (e.g., 47 items = 47/3 = 15.6 = 16). This is the number of votes that each team member gets in the first round of voting.
- Have team members distribute their votes. Tally the votes for each item.
- Eliminate from the list any items that received 0-2 votes. If you have a large team (6 or more people), you may also want to eliminate items with only 3-4 votes.
- Count the number of remaining items. Divide that number by 3. That is how many votes people get in the second round (e.g., 47 original items minus 24 eliminated from first round = 23 items; 23/3 = 7.6 = 8 votes).
- Distribute votes again, tally the scores, and again eliminate any items that got few or no votes.
- Continue this pattern until you are down to a manageable number of items (between 2 and 6).

After multivoting has narrowed the list down to a manageable number of evaluation criteria, you will rank the criteria systematically:

- Label the remaining criteria with letters (A, B, C, etc.).
- Each team member scores the criteria by allocating a total of one point among the criteria (e.g: 0.5 pts to A, 0.2 pts to B, and 0.3 pts to C, etc.
- Compute a composite score by adding up the scores from each individual for a particular criterion.
Here is an example of how you might document this ranking system to come up with the final criteria weights that will be used to decide which programmatic improvement will be selected.

### Table 22. Multivoting System for Ranking Evaluation Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Person 1</th>
<th>Person 2</th>
<th>Person 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Easy to implement</td>
<td>0</td>
<td>.4</td>
<td>.25</td>
<td>0.65</td>
</tr>
<tr>
<td>B) Quick timeline (&lt;3 months)</td>
<td>.2</td>
<td>.1</td>
<td>.25</td>
<td>0.55</td>
</tr>
<tr>
<td>C) Greatest impact</td>
<td>.8</td>
<td>.5</td>
<td>.5</td>
<td>1.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

#### 7.3.2 Prioritization Matrix

Now that we have selected and weighted our criteria for evaluating potential solutions, it is time to pick the solution that we will implement. In some cases, you may feel that the solution is obvious. However, by using this approach of ranking and weighting systematically, it may become apparent that the best solution is not necessarily the one that you thought it would be. A prioritization matrix can help you carefully weigh the pros and cons of each potential programmatic improvement.

A prioritization matrix shows all of the alternative solutions and criteria. Team members then rank each option based on which they believe meets the criteria from best to worst. The sum of ranks as chosen by the team for each criterion is then multiplied by the previously determined weight for that criterion for every solution option. These values are then summed across each of the criteria for the all of the solution options. The highest score indicates the best option. Using a prioritization matrix will also provide useful documentation to management and other stakeholders to demonstrate how this decision was made. Remember to remind your team that the highest rank is the best option for each criterion. It is easy to accidentally label an option 1, thinking that it is the best. If the results are very surprising, try checking back to make sure everyone followed the ranking system correctly. Below is an example of a prioritization matrix.
Table 23. Prioritization Matrix

<table>
<thead>
<tr>
<th>Solution</th>
<th>Criteria Weight</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easy</td>
<td>Quick</td>
</tr>
<tr>
<td>A</td>
<td>1.65</td>
<td>.55</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this case, there are three members of the team. Two have chosen to rank solution A as the least easy (1 = most difficult), and one has chosen it as the easiest (4 = least difficult). The total rank (1+1+4=6) is multiplied by the weight (0.65), to give an “Easiness” score for option A (3.9).

Once you have completed the table with everyone’s ranks and scores, you will be able to see which option has the highest score and is likely the best one to choose for the next step, IMPLEMENT. Through this process, you may find that you have selected a solution that may have been previously ignored because of perceived barriers to implementation. However, if impact is much more important to the team than ease of implementation, then a high-impact solution will likely be chosen, while balancing the secondary desire to have a project that is feasible to implement.

7.3.3 Pugh matrix

An alternative to the above prioritization matrix is the “Pugh matrix”. This tool was designed by Stuart Pugh, who was unhappy with the quality of solutions that emerged from simple brainstorming activities. To support the generation of iterative, creative, and robust ideas, he developed a structured matrix tool that focuses on comparing the pros and cons of each idea for improvement. The Pugh matrix works similarly to the prioritization matrix, in that it requires the same weighting procedure for the criteria that you use to evaluate program options. However, in the Pugh matrix, teams set one of the program options as a reference option for each of these criteria and then mark whether the other potential solutions are better than (+), the same as (s), or worse than (-) the reference option with respect to each criterion. Once this is complete, the team totals the weighted number of “+”s and subtracts the weighted number of “-”s for each item to get a final score for that item (the total number of “s”s can be neglected, as these do not affect the score). After this has been done, the team can try to further refine any of the individual characteristics of the proposed improvements so that the winning option performs even better for each of the criteria. Then select the best option (the option with the highest score). It is OK if some options have negative scores. Whichever option has the greatest score should be selected (even if that score is 0). The steps for completing the Pugh matrix are as follows:

1) Generate design concepts (solutions)
2) Develop evaluation criteria
3) Pick a concept as a baseline
4) Score each concept as better than, the same as, or worse than the reference option with respect to each criterion

5) Analyze results: address the negatives and enhance the positives of the best one or two concepts until the “best” possible solution emerges

Table 24. Example Pugh Matrix

<table>
<thead>
<tr>
<th>Key Criteria</th>
<th>Solution 1</th>
<th>Solution 2</th>
<th>Solution 3</th>
<th>Importance Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of implementation</td>
<td>S</td>
<td>+</td>
<td>+</td>
<td>3</td>
</tr>
<tr>
<td>Cost</td>
<td>S</td>
<td>-</td>
<td>+</td>
<td>2</td>
</tr>
<tr>
<td>Higher impact</td>
<td>S</td>
<td>+</td>
<td>+</td>
<td>4</td>
</tr>
<tr>
<td>Ease of implementation</td>
<td>S</td>
<td>S</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Sum of positives</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Sum of negatives</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sum of sames</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Weighted Sum of positives</td>
<td>0</td>
<td>7</td>
<td>3+2+4=9</td>
<td></td>
</tr>
<tr>
<td>Weighted sum of negatives</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Total weighted score</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

S: same; +: better; -: worse

7.3.4 Gather other data

While the two matrix schemes can assist you to make much better decisions about which program improvements to make, sometimes you’ll want to make sure that your chosen solution works well in practice before taking it to scale. You can collect data and information on the likelihood of the decided program improvement being successful by:

- Modeling or simulating solutions: try out an idea under conditions that mimic reality but are not real. For instance, you can have employees pretend to be members of a community where you want to implement a safe water storage program. The employees who are familiar with the communities should be able to identify potential problems with providing this system, and suggest improvements.
- Doing trial implementations – try out the solution in the field, but only for a short period of time, in a limited number of communities, or under other restricted conditions. In the water storage container example, the system can be implemented in three pilot communities. The community members should provide feedback on their experience using the containers.
- Observing an organization that is doing something similar – Get in touch with other implementers to learn from their experiences. You can ask their opinions or you can directly observe the areas in which they are implementing a similar program.
Any of these additional data collection methods can be combined together, and should also be used in parallel with one of the scored matrix approaches detailed above to select and plan a final implementation option.

### 7.3.5 Summary

Now you have a framework for evaluating and identifying potential solutions to the root causes of problems that you have identified in the **ANALYZE** step. Always remember that this approach is guided by the following principles.

- Involve people
- Use creativity techniques to generate alternatives
- Generate and weight criteria
- Evaluate each alternative against the selected criteria
- Be creative in finding ways to get additional information about a potential solution
- If no clear choice emerges, use consensus decision-making to select from among the best options

This point is also a good opportunity to revisit your Project Charter and involvement matrix from the beginning of the project planning to see if there are changes you would make now that you know more about what kind of work is involved in this phase.

### 7.4. Lean solutions

While selecting potential solutions to the problems that you have identified, it is also worth thinking about waste-causing inefficiencies. Waste can be found in all processes and at every level of an organization. It can be found in management systems, communications, human resources, finance, operations, consumer care, and procedures. It is important to remove waste wherever possible because waste adds no value to the goals of your organization or the projects that it implements, and often has negative side effects. Recall the major categories of waste defined earlier:

1. **Correction (Defects and rejects)**
2. **Overproduction**
3. **Over-processing**
4. **Transport**
5. **Inventory**
6. **Motion**
7. **Waiting**
8. **Human Mind**

Also recall the two major drivers of waste:

- Overburden
• Unevenness

In order to avoid and minimize these types and drivers of waste, CQI teams can engage proactively in waste prevention and waste reduction, as described in the IDENTIFY and IMPLEMENT steps.

7.4.1 Waste prevention and waste reduction

In a CQI project, teams work to prevent and reduce waste within a process. Take some time to review the solutions identified by the CQI team, look for potential occurrences of waste, and document ideas of how these types and drivers of waste could be prevented or reduced. Some ideas of common waste prevention/reduction measures are illustrated below:

Reduce steps

By identifying unnecessary steps within a process, teams can reduce the steps and ultimately the time and resources required to complete a process. An example would be joining together multiple field visits and tasks within an operational area each week to reduce wasted movement of people and materials (Figure Xb) instead of traveling back and forth between a base office and community sites every day (Figure Xa). While this particular example may not always apply, there are many other ways to reduce steps and reduce wasted movement in a process.

Reduce clutter

One way to reduce waste may be to reduce clutter within an office, warehouse, or other workspace. By organizing these workspaces, the project can reduce time wasted looking for misplaced materials or data. Reducing clutter can also result in improved flows of materials and personnel within the workspace. Additional space can be created by improving the utilization of available space, and by reorganizing supplies to uncover “hidden” inventories.
**Improve flow**

Wasted time can be reduced through improving the flow of a process. In the example below, the CQI team reorganized the process to eliminate steps and activities that were “Pure Waste” (red) wherever possible, and to increase the speed and efficiency of steps that did not add value but were required for the process to work (yellow). As a result, the improved process (A) took less time than the original process (B) while retaining all of the value-added steps (green).

![Diagram showing improvement in process flow]

<table>
<thead>
<tr>
<th>Community</th>
<th>Project Duration (Months)</th>
<th>Lateness of Project (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.5</td>
<td>0.42</td>
</tr>
<tr>
<td>B</td>
<td>3.5</td>
<td>1.08</td>
</tr>
<tr>
<td>AVG</td>
<td><strong>3.0</strong></td>
<td><strong>0.75</strong></td>
</tr>
</tbody>
</table>

*Figure 56. Improve Flow*
Reduce rework

As noted above, each time the output of a process step does not meet quality standards, the step must be reworked or started over, wasting time and resources. Any improvements that can increase the proportion of outputs from a given process step that meet quality standards will improve the efficiency of the overall process, and reduce waste. One example would be using satellite images and electromagnetic sensors to increase the success rate of a borehole drilling process, thereby reducing the frequency of dry wells and rework.

Figure 57. Reduce Rework

Reduce batching

While batching may be necessary or useful in some processes, in others it can lead to unnecessary waiting, since the first item in a batch is not processed until the last item arrives. If a process can be redesigned to allow just-in-time processing of inputs, this can reduce the waste of waiting, and increase the efficiency of a process. The example below shows some cases in which identifying ways to reduce batching may increase efficiency.

Figure 58. Reduce Batching
7.4.2 Flow (Pull system)

An important solution to Waste can be the use of a “pull system”. The main idea behind a pull system is that downstream processes “pull” work from upstream processes. In a working “pull system,” no one should do or produce anything until it is needed or wanted downstream. In other words, your “customer” pulls product and WaSH services from you, so you produce only what is needed. The customer downstream may be an internal customer who drives the next process in the value stream, or may be an external customer who uses the final product. This pull system approach eliminates intermediate storage and inventory. Here is an example of pull system for eliminating waste in a WaSH process for triggering and executing borehole repair:

![Pull system diagram](image)

*Figure 59. Pull system for eliminating waste*

In the example, parts and labor are procured in response to repair requests from communities or field teams. This may be more efficient than sending repair parts and workers to communities that do not have a need for repairs. While the “just-in-time” principle suggests that parts should not be ordered until the moment they are needed, CQI teams should take into account any delays or uncertainty in their supply chains: for example, if a given part requires 4 weeks to procure from overseas, the CQI team should have a ~6 week supply on-hand, and order replacements each week to replace parts that are used from this supply.

In this situation, the pull system offers an opportunity to eliminate waste in the following ways:

- Waste of waiting: if parts are missing
- Waste of production: In this case there is no excess production of work or products, since work is only done when the problem occurs.
- Waste of inventory: There is no waste of excess product or inventory lying unused

7.4.3 Mistake-proofing

Finally, waste can be eliminated by mistake-proofing or error-proofing processes. Remember that mistakes can occur from a number of causes such as human error, equipment or computer error, use of improper materials, or use of inadequate forms, information or inputs. Errors can also occur because of problems with processes, systems, or methods. Therefore, error-proofing supports and strives towards zero defects. The following are a few examples of the types of errors that can occur:

- Human error
  - Not making observations according to operational definitions
  - Not conducting water quality monitoring tests correctly
  - Not ordering the right materials
Equipment error
- Uncalibrated pH meters

Improper parts, materials, or information
- Missing parts, wrong parts, or defective parts
- Wrong information due to response bias

Process or method error
- Process does not include self-inspection prior sending work on
- Decision-making method does not define what is an acceptable product/service

- Error-proofing devices
The use of error-proofing devices is one type of error-proofing that will reduce or eliminate mistakes that are made. Some examples of this are:

- A control device:
  - Does not allow the task to be completed or the action to be conducted incorrectly (e.g. data entry will not advance until all fields are correctly entered); machine cannot be started if inspection hatch is open, etc.
  - Deals directly with the causes of errors or defects.
  - Has the ability to process items by their characteristics, e.g., dimension (shape, weight, volume, and characters entered).

- A warning device:
  - Warns that an error has occurred in the process.
  - Signals abnormalities in the process.
  - Has an alarm and/or visual control that signals when a process step or material is out of spec or a defect has occurred.

- A shutdown device:
  - Has the ability to stop when a defect is identified.
  - Has process stop buttons or an interlinking cord system—limit switches—scales—counters—guides—etc.

The following are a list common error-proofing tools you may use in WaSH monitoring:

- Checklist of all required tools must be completed and included before a toolkit is assembled for delivery.
- Submission of an electronic monitoring report with a high arsenic level automatically triggers work order for arsenic treatment system in a community.
- Submission of treatment system installation report automatically triggers work order for arsenic removal medium replacement in one year.
- Waterpoint ID entered by scanning barcoded asset tag, rather than manual data entry, to avoid errors during waterpoint monitoring.

Many other types of error-proofing are possible.

Activity: Error-proofing
• Have the CQI team brainstorm possible types of errors that may occur with the new proposed solution. Use the types of errors listed above for ideas.
• For each potential error, suggest error-proofing measures to prevent or detect and fix the error.
• Add these error-proofing measures to the proposed improvement package.
• Document the resulting improvement package, complete with waste prevention/waste reduction measures and error-proofing measures.

Once the improvement package has been documented, the CQI team is ready for the next step: IMPLEMENT.
8. Implement

8.1. Overview/steps
Now that you have validated root causes of the problems affecting your process and identified improvement opportunities, the next step is to IMPLEMENT solutions to the problems that will lead to improvement.

The key steps to IMPLEMENT are to:

1. Develop the plan
2. Mobilize resources
3. Pilot the plan
4. Implement the plan
5. Quantify the results
6. Evaluate the benefits of the improvement

![Figure 60. Implement Steps](image)

8.1.2 Goals
The ultimate goal of IMPLEMENT is to implement the improvements specified in the IDENTIFY step and use evidence to determine whether these improvements produce a measurable change in the problem defined by the CQI team. Problems may not be completely solved in the first iteration of implementation, so this phase allows CQI teams to test options and use data to make adjustments.
8.1.3 Steps
1. Develop the implementation plan based on identified improvements (See IDENTIFY Section).
2. Mobilize resources:
   a. Assess capacity and resources: identify members of your team who can implement the solution.
   b. Determine whether new team members will need to be recruited.
   c. Assess the resources available for implementing the solution.
   d. Identify communities where your organization already has a good relationship and that would agree to serve as pilots for your improvement package (if it is community-based), or other pilot settings, as appropriate. Piloting is detailed later in this chapter.
   e. Build internal capacity to implement the plan. Develop protocols and procedures to standardize the improvement package.
   f. Train team members on implementation. Work with organization leadership to ensure support.
3. Pilot the plan with the identified community. Work with community leaders to implement. Track results of the pilot. What is working and what needs to be improved for optimal performance? Make adjustments to the plan based on the results from your pilot.
4. Implement your plan, starting on a small scale, then rollout to full implementation.
5. Quantify results according to your data analysis plan to display data and evidence of the solution’s impact.
6. Evaluate the benefits of the improvement package and determine what (if anything) went wrong. Make revisions to the solution and begin the CQI cycle again.

Questions to ask when developing an implementation plan:
- Why do you want to make this change?
- Who will it benefit?
- How will it help you reach your organization’s goals?
- What will happen if you do not make this change?

8.1.4 Output
When the IMPLEMENT phase is complete, you should have the following outputs:
- Implemented solutions and their results
- An implementation guide, written by the CQI team, describing the process of implementation, written protocols and preliminary operating procedures, and guidance on how to quantify and track results.

8.2 Implementation planning
8.2.1 What is planning?
When planning for implementation, it is important to be clear about the “why” of a change. Why was this issue identified and why do you want to make the change? What will happen to your project, organization, or impact goals if you do not make the change?
A good plan considers all the elements necessary to implement your project efficiently and successfully, including all the stakeholders who will contribute to or be affected by the plan. It predicts possible failures and errors and includes contingencies for addressing them.

The key actions needed to implement a plan include the following. Each element is described in more detail below.

1. Identify tasks and their timeline for completion. Map out activities and deliverables using one of the methods described below.
   a. Understand the subtasks and plan the time to complete them
   b. Plan for the people and resources needed
   c. Identify who will complete each task
2. Develop a budget.
3. Identify stakeholders who will contribute to the plan, be an end user, or play a part in whether the plan succeeds or fails.
4. Create/leverage a routine monitoring and evaluation structure to measure whether the solution is working. This can tap into existing monitoring systems, or create a new system if none exists.
5. Prepare the responses needed if the plan works and is accepted by users and stakeholders. Consider how it will be scaled up quickly and effectively.
6. Plan for possible and likely failures and errors. Plan for how you will address these potential failures if they occur.

8.2.2 Tasks and Timeline planning
Given the multiple steps involved in implementation planning, as well as the multiple players needed, creating a diagram that links all these aspects together can be helpful for coordinating resources and tracking your timeline. Below are diagram options that can be used according to your planning needs.
Tree diagrams. Tree diagrams help identify components of a task. They are used to arrange and sequence broad and general ideas to create narrow and specific tasks. In planning, this means identifying your major objectives and the means by which you will achieve them.

Planning grids. Planning grids are easy-to-reference summaries of the resources and outcomes for each step in your implementation plan. Typical planning grids contain columns for each step along with the corresponding product, responsibility, due date, participants involved, budget/cost, etc. for your project.
Gantt chart. Gantt charts allow you to see the relationships between different tasks, such as relative sequence, duration, timing, etc.

Gantt charts are useful in:
- Planning projects
- Allocating project resources
- Helping everyone involved with the project understand when tasks must be done, and how one step impacts other steps
- Communicating progress and expectations to others
- Tracking the work on a project and making changes to the plan as necessary
- Comparing the original project plan with the actual outcome in order to learn and make improvements for later projects

Steps to create a Gantt chart:
1. Identify the outcome you wish to achieve (what is the last step in this process?)
2. Identify the deadline for achieving this outcome
3. Identify the first step or starting point
4. Brainstorm all the steps in between
5. Put them in a logical order
6. Assign a length of time for each step
7. Identify the nature of the relationship between steps and adjust timing if needed
8. Label the first row of a table with appropriate time increments and chart the steps

When mapping out tasks in a Gantt chart, it’s important to understand the kinds of relationships between steps in the plan. There are generally five kinds of possible relationships:

- No relationship (the tasks are independent).
- Start-to-end (one task cannot start until another ends).
- End-to-start (one cannot end until another starts).
- Start-to-start (both need to start at the same time).
- End-to-end (both need to end at the same time).

The size and complexity of a Gantt chart depends on what you need it to do for you. If there is a relatively short list of tasks and the relationships between them are mostly “start-to-end,” you can create a simple Gantt chart by hand or with a computer program in just a few minutes.

However, if the CQI solution you have identified has numerous steps, involves delicate timing and limited resources, or there are complex relationships between steps, you will need to invest significant time in developing a Gantt chart that will be a useful tool for your team.

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>MAY</th>
<th>JUNE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implement fluoride monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Update job responsibility lists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Procure field testing kits, mobile phones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Update monitoring database</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Install treatment plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Schedule installation of treatment plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Procure parts and supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Decide what options should be given</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Schedule maintenance of treatment plants</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 62. Gantt Chart*
Process maps. Process maps describe the plan, highlighting the flow of activities and how different people or groups interact within these, and highlighting new procedures within a plan. Process maps have two roles in IMPLEMENT:

1. To lay out an implementation plan from the beginning of deployment.
2. To describe new or revised work procedures. For example, a CQI project may identify that time is being wasted at some aspect of WaSH service delivery. In the example below, a new work procedure is introduced in order to make the water quality test procedures more efficient.

![New Water Quality Test Procedures Flowchart](image)

**Figure 63. Flowchart of Revised Work Procedures**

8.2.3 Budget and resource planning

Planning includes ensuring that your team or organization has adequate funds to see the project through to completion. The diagrams above can be used to determine how resources will be allocated in order to meet implementation deadlines.

Typical budget categories include:

- Materials or supplies
- Equipment rental or purchase
- Subcontractors or outside resources
- Legal expenses
- Shipping charges
- Telephone/fax charges
- Personnel or staff expenses
- Travel
- Production
- Photocopying

*Table 26. Example Budget*

<table>
<thead>
<tr>
<th>Budget category</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials/Supplies</strong></td>
<td></td>
<td><strong>$275</strong></td>
</tr>
<tr>
<td><strong>Travel</strong></td>
<td>3 trips at $100/trip</td>
<td><strong>$300</strong></td>
</tr>
<tr>
<td><strong>Testing</strong></td>
<td>$3.5/sample</td>
<td><strong>$350</strong></td>
</tr>
<tr>
<td><strong>Field Staff</strong></td>
<td>30 hrs @ $5/hr</td>
<td><strong>$150</strong></td>
</tr>
<tr>
<td><strong>Driver</strong></td>
<td>5 days @ $45/day</td>
<td><strong>$225</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$1300</strong></td>
</tr>
</tbody>
</table>

The CQI project may require additional resources from your organization and its staff. This resource information should be included in your plan so that appropriate funds can be allocated and staff responsibilities can be shifted to accommodate the new work, if needed. Some computer programs (such as Microsoft Project) can automatically generate resource usage charts that you can include in your plans.

### 8.3. Reducing or eliminating risk

#### 8.3.1. Failure mode and effects analysis (FMEA)

By anticipating potential problems, you can often take countermeasures to reduce or eliminate risks. A common tool for assessing and planning for problems is the Failure Mode and Effects Analysis (FMEA).
FMEA can help identify specific ways in which a system, intervention, or process may fail in order to develop targeted countermeasures to improve performance, quality, reliability, and safety.

This analysis is typically used in three situations:

1. **Product or service design** - to overcome potential problems that could lead to product failure, safety hazards, or poor service. Each component of a product is tested individually and then installed to identify ways in which it might fail and what the effect would be on the product as a whole.

2. **Process execution** - to overcome problems that could lead to increased defects, safety hazards, or poor quality. In this situation, process performance, inputs, equipment, methods, and environment are analyzed to see how they might fail and the subsequent effect on the process.

3. **Analysis of potential human errors** in process execution - to find ways to error proof the process. Process steps and instructions are analyzed to find places where human mistakes are common. When identified, procedures or instructions can be changed to make mistakes less likely. In other words, make it hard to do the wrong thing.

The following steps are taken in order to conduct an FMEA:

1. Brainstorm potential failure modes, or the ways in which the product, service, or process might fail.

2. Determine risk of each failure mode (RPN = Risk Priority Number)
   - Severity x Occurrence x Detection = RPN

3. Identify ways to reduce or eliminate risk associated with high RPNs.
## FMEA Analysis

### Project: Borehole construction  
Team: Borehole Team  
Date: 9/10 (original)  
10/15 (revised)

<table>
<thead>
<tr>
<th>Item or Process Step</th>
<th>Potential Failure Mode</th>
<th>Potential Effect(s) of Failure</th>
<th>Potential Cause(s)</th>
<th>Occurrence Severity</th>
<th>Occurrence</th>
<th>Current Controls</th>
<th>Detection</th>
<th>RP</th>
<th>N</th>
<th>Recommeded Action</th>
<th>Responsibility and Target Date</th>
<th>&quot;After&quot; Action Taken</th>
<th>Occurrence Severity</th>
<th>Detection</th>
<th>RP</th>
<th>N</th>
<th>Recommended Action</th>
<th>Responsibility and Target Date</th>
<th>&quot;After&quot; Action Taken</th>
<th>Occurrence Severity</th>
<th>Detection</th>
<th>RP</th>
<th>N</th>
<th>Recommended Action</th>
<th>Responsibility and Target Date</th>
<th>&quot;After&quot; Action Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole drilling</td>
<td>Borehole collapse</td>
<td>Stops drilling</td>
<td>Loose soil</td>
<td>4</td>
<td>10</td>
<td>Soil test</td>
<td>2</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Broken drill shaft</td>
<td>Machine vibration</td>
<td>5</td>
<td>10</td>
<td>Machine stops</td>
<td>2</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Backup</td>
<td>Drilling and cleaning rates misaligned</td>
<td>4</td>
<td>7</td>
<td>Machine stops</td>
<td>2</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole development</td>
<td>Borehole collapse</td>
<td>Borehole unusable</td>
<td>Loose soil</td>
<td>4</td>
<td>7</td>
<td>Stress test</td>
<td>7</td>
<td>96</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehold construction</td>
<td>PVC pipe cracked</td>
<td>Reinstallation of tube</td>
<td>Incorrect insertion</td>
<td>4</td>
<td>8</td>
<td>Calibrate equipment yearly</td>
<td>7</td>
<td>224</td>
<td></td>
<td>Calibrate equipment monthly</td>
<td>MKM by 11/15</td>
<td>New calibration schedule</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pad must be replaced</td>
<td>Insufficient drying time</td>
<td>5</td>
<td>9</td>
<td>Drying time standard</td>
<td>9</td>
<td>405</td>
<td></td>
<td>Test concrete curing before removing supports</td>
<td>MER by 11/15</td>
<td>Testing protocol implemented for all new water points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 27. FMEA ANALYSIS
The following steps are used to determine RPNs. The charts below (Sample Severity Rating Scale, Sample Occurrence Rating Scale, Sample Detection Rating Scale) are examples of ones that can be tailored to your project in order to calculate the RPNs.

Steps for determining RPNs:

1. Identify the potential effects of each failure (consequences of that failure) and rate its severity. Examples include: a defective product, wrong water quality test results, or construction delays.
2. Identify causes of the effects and rate their likelihood of occurrence.
3. Rate your ability to detect each failure mode.
4. Multiply the three numbers together.

Table 28. Sample Severity Rating Scale.
Severity = likely impact of the failure.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Criteria. A failure could:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Injure a user or employee</td>
</tr>
<tr>
<td>9</td>
<td>Be illegal</td>
</tr>
<tr>
<td>8</td>
<td>Render the product or service unfit for use</td>
</tr>
<tr>
<td>7</td>
<td>Cause extreme user dissatisfaction</td>
</tr>
<tr>
<td>6</td>
<td>Result in partial malfunction</td>
</tr>
<tr>
<td>5</td>
<td>Cause a loss of performance likely to result in a complaint by users</td>
</tr>
<tr>
<td>4</td>
<td>Cause minor performance loss</td>
</tr>
<tr>
<td>3</td>
<td>Cause a minor nuisance; can be overcome with no loss</td>
</tr>
<tr>
<td>2</td>
<td>Be unnoticed; minor effect on performance</td>
</tr>
<tr>
<td>1</td>
<td>Be unnoticed and not affect the performance</td>
</tr>
</tbody>
</table>
Table 29. Sample Occurrence Rating Scale.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Time Period</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>More than once per day</td>
<td>&gt; 30%</td>
</tr>
<tr>
<td>9</td>
<td>Once every 3–4 days</td>
<td>≤ 30%</td>
</tr>
<tr>
<td>8</td>
<td>Once per week</td>
<td>≤ 5%</td>
</tr>
<tr>
<td>7</td>
<td>Once per month</td>
<td>≤ 1%</td>
</tr>
<tr>
<td>6</td>
<td>Once every 3 months</td>
<td>≤ .03%</td>
</tr>
<tr>
<td>5</td>
<td>Once every 6 months</td>
<td>≤ 1 per 10,000</td>
</tr>
<tr>
<td>4</td>
<td>Once per year</td>
<td>≤ 6 per 100,000</td>
</tr>
<tr>
<td>3</td>
<td>Once every 1–3 years</td>
<td>≤ 6 per million</td>
</tr>
<tr>
<td>2</td>
<td>Once every 3–6 years</td>
<td>≤ 3 per 10 million</td>
</tr>
<tr>
<td>1</td>
<td>Once every 6–100 years</td>
<td>≤ 2 per billion</td>
</tr>
</tbody>
</table>

Table 30. Sample Detection Rating Scale.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Defect caused by failure is not detectable</td>
</tr>
<tr>
<td>9</td>
<td>Occasional units are checked for defects</td>
</tr>
<tr>
<td>8</td>
<td>Units are systematically sampled and inspected</td>
</tr>
<tr>
<td>7</td>
<td>All units are manually inspected</td>
</tr>
<tr>
<td>6</td>
<td>Manual Inspection with mistake-proofing modifications Result in partial malfunction</td>
</tr>
<tr>
<td>5</td>
<td>Process is monitored (SPC) and manually inspected</td>
</tr>
<tr>
<td>4</td>
<td>SPC used with an immediate reaction to out of control conditions</td>
</tr>
<tr>
<td>3</td>
<td>SPC as above with 100% Inspection surrounding out of control conditions</td>
</tr>
<tr>
<td>2</td>
<td>All units are automatically inspected</td>
</tr>
<tr>
<td>1</td>
<td>Defect is obvious and can be kept from affecting customer</td>
</tr>
</tbody>
</table>
8.4. Piloting

8.4.1 What is piloting

Piloting is a small-scale test of the proposed intervention or solution in a context similar to where it will be implemented at full-scale.

A few key characteristics of a pilot are the following:

- Pilots are performed on a small scale in a community or geography that is similar or comparable to where the CQI program will be implemented. Ideally, this is outside the CQI project area. If that is not possible, the pilot should be done in a subset of communities, facilities, departments or other units of the project area or institution.
- Pilots should be big enough to give you an accurate sense of how the plan will succeed during full scale implementation, but not necessarily statistically significant. If the solution is community-based, a typical size is 5-10% of total CQI project size or 5-10 communities, whichever is greater. If the solution is institution-based (such as in schools or healthcare facilities), pilot the plan in 1-3 similar institutions. If it is in a single setting, like an internal change in an organization, pick one or two departments, wards, or teams, and pilot for about a week, or enough time to see the entire plan roll-out and identify challenges and areas for improvement.
- Successful pilots will identify areas to improve the plan through trial and error so that the full-scale implementation is more effective.

8.4.2 Benefits of piloting

Piloting exposes issues in the implementation plan that may not have been predicted during planning. Piloting is conducted before the plan is rolled out so that revisions can be made before full implementation. Other benefits of piloting include:

- Fewer surprises during full-scale implementation
- An improved implementation plan based on lessons learned from piloting
- Increased buy-in
- Ability to get some of the benefits of the improvement quickly
- Reduced risk of failure or unknown complications during full implementation
- Ability to confirm assumed cause-and-effect relationships
- Increased ability to quantify costs and benefits

The one negative aspect to piloting might be the slight delay in full-scale implementation while the pilot is being conducted. It is almost always worth this delay in order to better understand where your implementation plan can be improved, and to minimize the risk of failure.

Piloting is most important in the following situations:
• An improvement package that includes large changes to the current process.
• Costly implementations.
• Changes that involve many different groups or processes.
• Changes that are difficult or costly to reverse.

Iterative piloting is like a miniature CQI cycle within the larger CQI process. Each iteration can be represented as a “Plan-Do-Study-Act” cycle, in which CQI teams plan the change, do data collection (at pilot scale), study the results, and then take appropriate action to implement or modify the intervention (as needed) or scale up (if results are acceptable).

The first two rotations of the PDCA wheel looks like:

➢ **Rotation 1: Iterative Pilot**
   - Plan—Plan for the pilot.
   - Do—collect pilot data on a small scale.
   - Study—Analyze the data.
   - Act—Take action to implement or refine the pilot improvement package.

Repeat Rotation 1 as needed, until performance is acceptable.

➢ **Rotation 2: Implementation**
   - Plan—Plan for the full-scale rollout.
   - Do—Collect data.
   - Study—Analyze the baseline data.
   - Act—Implement or adjust the improvement package based on findings.

The “Study,” or checking the actual implementation performance, part of the rotation is often neglected; however, it is one of the most important to collecting valuable information about how to improve the implementation.

Questions to study are:

   – Was the schedule met?
Were the instructions clear, complete, and followed?
What would have helped the plan be more effective and efficient, or the product perform better?
What barriers and difficulties were encountered?

To check the pilot’s impact, collect baseline data and make before-and-after plots of the results:

Was the improvement sufficient?
Is the improvement capable of achieving the desired results?
Did the pilot verify causal relationships and systems or identify new relationships or opportunities?
Use hypothesis testing as appropriate to verify the impact of your pilot.

<table>
<thead>
<tr>
<th>Some advice on piloting</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Members of the CQI team should be present in person during the pilot to uncover issues and observe results.</td>
</tr>
<tr>
<td>✓ Even though the pilot is a limited test, try to make the conditions of the pilot as realistic as possible. Pilot in areas or communities similar to the intervention areas in geography, socioeconomic conditions, and human resources. Vary input and process variables accordingly in order to account for any major differences between pilot and intervention areas.</td>
</tr>
<tr>
<td>✓ Record the settings used for the input and process variables, which may give insight into unanticipated causal relationships.</td>
</tr>
<tr>
<td>✓ On the planning documentation, leave room for comments and notes and a place to record when each step was done; this will make checking the plan easier.</td>
</tr>
<tr>
<td>✓ Expect that there will be issues that do not arise until full implementation, even for the most elaborate and successful pilots. The aim of the pilots is to get a good improvement package—good, but mostly likely not perfect.</td>
</tr>
</tbody>
</table>

8.5. **Implementing the solution**

Before implementing your improvement package in intervention areas, the CQI project plan should be revised based on the results from the pilot. Examine the plans that were developed prior to the pilot and make adjustments, where needed, to the tasks and timelines, budgets and resources, stakeholder involvement, plans for checking impact, and failure prevention measures.
Follow the steps below to revise the plan:

1. Flowchart new procedures
2. Revise job instructions
3. Prepare data collection forms
4. Provide training
5. Implement on a small scale first then move to full scale
6. Do full-scale implementation
7. Monitor implementation

8.6. Quantify results
As part of the planning step in Implement, your team will develop a data collection and analysis plan for quantifying the outcome. The plan should include a time point for collecting uptake data to understand how the solution has been accepted and utilized.

8.7. Evaluate the benefits of the solution
Once data from uptake surveys have been analyzed, CQI teams should evaluate the solution’s effectiveness and impact. Based on the evaluation, adjustments can be made to the product, plan, or means of implementation for future iterations.

Some questions to guide evaluating the solution:

- Was the solution well received?
- What did users like about it?
- What did users not like about it?
- What were some unforeseen issues with the solution?
- What could be improved in the solution?

The evaluation can be conducted using simple analysis methods such as:

- Control charts and run charts
- Before/after analysis
- Hypothesis testing
- Quality assurance and Statistical process controls
  Statistical process control (SPC) is a method of quality control that uses statistics. Traditionally used for manufacturing lines, it can be applied to any process where it is possible to differentiate between products that have and have not met specifications.
These methods are described in greater detail in the ANALYZE step. Once solutions have been piloted, implemented, and evaluated, the CQI team is ready to put in place measures to sustain and scale effective improvement packages. This process is described in the SUSTAIN step.
9. Sustain

9.1. Overview/steps
You are now ready to begin the last stage of WaSH CQI, the SUSTAIN step. Although you have successfully piloted and implemented your proposed improvements, you are not yet finished. The sustain step ensures that the improvement is working at scale, includes ongoing monitoring to ensure that improvements persist, and includes dissemination of the findings from your CQI process to allow for learning, replication, and adaptation.

**Purpose:** Assess change and ensure sustainability

**Main questions addressed:**
1. How will standardization help your organization achieve desired outcomes?
2. How can the project team recognize when it is time to close-out a project?
3. What is the role of the change leader and how can your organization plan for change?

**Activities:**
1. Document the improvement
2. Standardize processes and procedures
   a. To monitor for sustainability
   b. To disseminate learnings and change practices

**Outputs:**
1. Documented standard operating procedures
2. Updated monitoring strategy
3. Disseminated learnings

9.2. Document the Improvement
Before beginning the sustain phase of the CQI process, you must first document the improvement. This can be achieved by combining records and notes from the previous CQI steps. Elements of a well-documented CQI project include:

- Focused problem/opportunity statement and project charter
- Data collection plan
- Baseline data and analysis report
- Preliminary improvement package
- Pilot report and uptake data
- Impact evaluation

9.3. Standardization: Methods
Standardization helps to ensure that key processes are performed consistently across the organization. The key to standardization is effective systems: we can only achieve reliable and sustained processes if we build a system that causes reliable and sustained processes to happen.
Before a process is standardized, it is important to first identify the best way to carry out that process. Standardization helps to ensure that important elements of the process are performed properly and consistently across the organization. Up-to-date documentation will help to ensure that the standardized process is used effectively. Standardized processes can be changed, but only when data show that an alternative process is better.

9.3.1 Overview of standardization

In reviewing standardization, the CQI team should:

1. Review the benefits of standardization
2. Review the purpose of visual standards and how they might be used to improve project outcomes
3. Understand the benefits of planning for training and project closure
4. Use the standard practices development worksheet to document a standardization procedure
5. Practice using some of the implementation tools presented at the end of this chapter (e.g. SWOT matrix)

9.3.2 Benefits of standardization

Standardization helps us to produce better WaSH services by providing a framework for effectively managing processes and, when necessary, communicating changes in those processes. Standardization can increase the reliability of WaSH services and reduce the costs associated with delivering those services by improving employee performance.

9.3.3 Developing standard practices and procedures

Standardization is achieved by developing a set of standard practices and standard operating procedures (SOPs). Once institutionalized, standard practices and SOPs serve as a written agreement between staff and the organization. This agreement outlines how the job will be done every time, with specific detail regarding each component of the process. In addition, standard practices and SOPs provide a basis for training new staff, a trail for tracing potential problems, and a means for retaining institutional knowledge. They help ensure quality and safety every time the process is performed.

Standard practices and SOPs should provide clear instructions with an appropriate level of detail. Even employees who are not fully trained should be able to pick up an SOP or a written description of any standard practice and perform the process described easily. In developing standard practices and SOPs, your organization should consider priorities and establish best practices for preventing variation (making process outputs more predictable and reproducible). Organizations can use the following to develop more comprehensive standard practices:

- Visual standards,
- Process maps,
- Standard operating procedures (SOPs).
Visual standards

Visual standards allow your organization to show rather than tell staff members the correct way to do something. Standardized work documentation and abnormality tagging are two examples of visual standards.

Standardized work documentation can help show employees the difference between an acceptable and unacceptable product. Figure 65 depicts sample standardized work documentation.

Abnormality tagging involves placing visual tags on abnormal products or features. This helps employees easily identify inferior products that do not meet acceptable quality levels. Abnormality tagging saves operator’s time, technician’s time, and downtime. Figure 66 depicts an example of abnormality tagging.
Process maps
Although different from visual standards, process maps also help employees visualize processes. Process maps are developing earlier in the CQI process, in the DEFINE step, and revisited throughout the CQI process. During SUSTAIN, process maps should be updated and incorporated into standard practices and SOPs.

Standard Operating Procedures (SOPs)
Standard operating procedures (SOPs) should describe, in detail, methods for completing each step of the new process. They should be specific enough that a new staff member with minimal experience in the specific procedure can perform it correctly, and experienced staff following the SOP can obtain reproducible, high-quality results every time.

9.3.4 Training
Once your organization has completed the standard process and SOP documentation, it must conduct training to ensure that everyone is prepared to carry out the new methods. Even experienced employees should be re-trained.

Planning for training
Organizations should be realistic about the amount of time needed for training: it is best not try to fit everything into a single training session if more time is required. Long-term employees may be resistant to change, so CQI teams should be prepared to explain to them why the process has changed, and how this will benefit employees, the organization, and customers.

SOPs, manuals, and other job aids can help to reinforce training principles. Do not expect employees to absorb everything from the initial training. Be prepared to offer additional support through refresher training and performance support. A piloting period, in which employees are able to practice the new methods and receive feedback, could also be helpful. Following the training, organizations should seek to create an atmosphere that welcomes questions and concerns: the most meaningful questions may not arise until employees begin using the new standardized processes and procedures.

Documentation
The training process should be documented to ensure that it can be replicated in the future for new hires. A modified version of the initial training can also be used for refresher training. Documentation helps to ensure consistent messaging throughout all trainings, and may save time and effort when future trainings are performed.

9.4. Project closure
Continuous Quality Improvement is ongoing, but individual initiatives must come to an end. Some organizations may allow quality improvement initiatives to end by simply fading away. This is not good practice. Instead, project closure should be a formalized process with a method for capturing lessons learned and communicating results to all stakeholders.

The process of project closure is about recognizing when it’s time to end a project, and developing a process for close-out. As an organization, you must build awareness for how to successfully close-out a
project. Projects should end when a charter has been fulfilled or project goals have been met. This can be achieved by identifying project close-out indicators. To identify these indicators, project teams should attempt to answer the following question:

**What would indicate that a project has ended well?**

Additionally, a key aspect of project closure must be capturing insights from the initiative, which can help inform future initiatives. Managerial systems should be developed to capture and disseminate these insights if they do not already exist within your organization. Insights should focus on:

1) Results

Sample results questions:

- What helped or hindered the CQI team, and did the team accomplish its mission?
- How will the process improvements be sustained?

2) Work process

Sample work process questions:

- What did the CQI team learn about the organization’s processes that was surprising?
- Are there other processes in the organization that are similar to the ones that that CQI team focused on?

3) Team’s process.

Sample team’s process questions:

- What has this experience taught the team about CQI?
- What advice would your CQI team give to other CQI teams?

Once the project team has brainstormed insights, you must finalize project documents on improvements. Team leaders should record final results and conclusions, including the insights that your team has brainstormed. The completed document should be presented to the sponsors, anyone whose job is changing as a result of the work, any customers who have benefitted from the changes, and any other interested stakeholders. As a final step in the documentation process, the project team should compile recommendations for future work. This should include both recommendations for maintaining the new processes and ideas for future CQI projects.

In addition to distributing the final documents, project leaders should make provisions to ensure that key content is effectively communicated. This is a joint task for the project team and sponsor. Findings should be communicated to employees who could benefit from the lessons learned, management, and if possible, the entire organization. These communication activities should help to lay the groundwork for future projects.

Last, but not least, project close-out is an opportunity to celebrate and recognize key staff who worked hard to ensure project success. Your organization should identify an appropriate way to celebrate the end of a project, such as a lunch or dessert event.
9.5. Planning for change

Change is inevitable, regardless of whether or not an organization plans for it. However, change is not always easy for organizations, even when changes constitute improvements that reduce defects and waste, and increase the quality and efficiency with which an organization achieves its goals. Organizations can use the concept of change management to leverage change in order to achieve a desired outcome. This concept of planning for and leveraging change will be explored in this subsection.

9.5.1 Skills required

In order to effectively manage change, organizations need a combination of leadership, team, and technical skills. Organizations that effectively manage existing process will be better prepared to manage change. However, organizations can only do this if they have the internal skills necessary to do this. Therefore, evaluate whether your organization has the requisite skills already or whether additional trainings or hires need to take place to meet these needs.

9.5.2 Why efforts fail?

Michael Hammer, a founder of the management theory of business, believed that 70% of improvement efforts in the 1990s failed because they did not account for the human variable of change [7]. Key factors in the “human variable” include leadership involvement, employee investment, and interpersonal dynamics.

People side

Most CQI projects will result in change. In order to achieve effective change, organizations must consider the people who are affected by these changes. Focusing on the people side is about helping people make the transition when an institutional change occurs. This type of support is necessary, regardless of whether the change is improvement to an existing process, or introduction of a completely new process. By focusing on the people side, your project will often benefit from increased understanding, commitment, and capability.

Culture

The foundation of organizational culture are shared assumptions and beliefs. Organizations’ values or mission statements, leadership styles, and collective norms all contribute to organizational culture. The Quality Improvement Culture is rooted in 1) a focus on customers, 2) an emphasis on open and transparent work environments, 3) a focus on processes, and 4) a system where high value is placed on data.
9.5.3 The leading change process
The leading change process can be used at the beginning of the project to anticipate additional resources that may be needed to help achieve success with the “people side” of change. Throughout the project, aspects of the leading change process can be used to better achieve project objectives. The leading change process is comprised of the following activities:

1. Making it personal for all employees
2. Understanding and addressing the current situation
3. Communicating a convincing vision and strategy
4. Motivating employees to align with the program objectives
5. Reviewing progress on an ongoing basis and recognizing gains as they occur

9.5.4 Making it personal for all employees
Change leaders are members of your organization who take a personal interest in achieving effective change. These members of your team will reveal themselves by demonstrating a personal understanding of, commitment to, and enthusiasm for CQI principles. You can create a professional environment that fosters “make it personal” attitudes by encouraging employees to use CQI principles in their day-to-day work.

9.5.5 Resiliency checklist
The resiliency checklist is a tool that utilizes self-reflection as a means to encourage team members to “stay the course” when difficulties arise. Team members are encouraged to rate their own behaviors on a scale of one to five using the Resiliency checklist in Table 31. The Resiliency Checklist should be used when specific team members or the entire project encounter difficulty moving forward or if a major disruption occurs. In addition to the checklist, another way to maintain resiliency is to look back on the progress of the project in order to establish whether the disruption is a one-time occurrence or a pattern. Team members should also be encouraged to reflect on their own behavior. Following the reflection activities, team members should outline a plan of action for improving their personal resiliency.
9.6. Facing the current situation toolkit

Effective change leaders have the ability to describe the current state and identify problems with the current state. They are then able to identify a persuasive need for organizational change and inspire a sense of urgency for the desired change. Change leaders have access to four tools that are considered to be part of the “facing the current situation” toolkit: the project charter, communication tools, SWOT matrix, and force field analysis.

9.6.1 Project charter

The project charter is a fantastic tool for communicating the need for change to project stakeholders. It is developed at the beginning of the CQI process, but can be referenced and updated throughout the CQI process as needed.

9.6.2 Communication tools

Effective communication skills are an essential tool for change leaders. Speaking, listening, and inference are the three most important communication skills. If an organization’s CQI team is struggling with communication, then it may be worthwhile to seek outside help from an organization such as Toastmasters®. Toastmasters® is a communication and leadership development program with local chapters worldwide.
9.6.3  SWOT matrix

The Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix is a tool that helps change leaders create an argument for change. Each cell of the matrix answers key questions that help to identify project strengths and opportunities as well as weaknesses and future threats to success. The matrix is used to determine whether the expected future threats warrant a need for change to the current state. If the matrix does indicate that change is needed, change leaders should work to generate a sense of urgency for change.

The SWOT matrix can be an effective tool when you are trying to help stakeholders understand the value of a proposed process change. It can be used both at the beginning of a project and before implementing a proposed project change, either at the pilot level or at larger scale. Table 32 depicts an abbreviated SWOT matrix that a WaSH organizations might prepare if it was considering a change in the transportation and processing of water quality samples from batching to handling each sample when it comes in.

Table 32. Sample SWOT matrix for a WaSH organization

<table>
<thead>
<tr>
<th>Strengths/Opportunities</th>
<th>Current State</th>
<th>Proposed Future State</th>
<th>Need for Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Our productivity and accuracy have been good in the past.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Technicians know the process.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• We could eliminate some handling steps to improve speed without completely changing operations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Opportunities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Faster cycle times mean increased drilling numbers.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• We can vastly improve customer satisfaction.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Less variation in workload.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Less stress for employees.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weaknesses/Threats</th>
<th>Current State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weaknesses</strong></td>
<td></td>
</tr>
<tr>
<td>• Drilling team waits for days to get testing results.</td>
<td></td>
</tr>
<tr>
<td>• We are often overloaded with big batches of samples and often have difficulty processing them all.</td>
<td></td>
</tr>
<tr>
<td>• Other partners that don’t batch are processing faster.</td>
<td></td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td></td>
</tr>
<tr>
<td>• Management and technicians may still be under the mindset that to be “efficient” means batching samples.</td>
<td></td>
</tr>
</tbody>
</table>

The following steps should be followed when constructing a SWOT matrix:

1. Starting with the “current state” or the “proposed future state” columns, brainstorm the strengths/opportunities or weaknesses/threats for each scenario.
2. Compare “strengths/opportunities” and “weaknesses/threats” that were brainstormed for both scenarios.
3. Answer the following question: “Are the strengths and opportunities identified for the future state more desirable than those identified for the current state?” Record the answer in the “need for change” column of the “strengths/opportunities.”

4. Answer the following question: “Are the weaknesses and threats identified for the current state more harmful than those identified for the future state?” Record the answer in the “need for change” column of the “weaknesses/threats” row.

5. Share your results with a small sample of stakeholders and revise as necessary based on their feedback and/or concerns.

9.6.4 Force field analysis

The purpose of force field analysis is to identify the driving and restraining forces that correlate with a change and the actions required to make the change. The project team must first identify the change, then identify the driving and restraining forces associated with that change, followed by the actions associated with each force type. A sample force field analysis table is included in Table 33 below. This exercise should help the project team identify the starting point for action, and should be employed whenever a change is expected to be difficult. It can be particularly helpful when multiple departments are involved in the same project, because it can show how each department’s actions fit into the bigger picture of driving and restraining forces.

Table 33. Sample force field analysis

<table>
<thead>
<tr>
<th>Driving/Positive Forces</th>
<th>Restraining/Negative Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Customer demand for household safe water storage</td>
<td></td>
</tr>
<tr>
<td>• Strong organizational desire to address household water issues</td>
<td></td>
</tr>
<tr>
<td>• Support from management</td>
<td></td>
</tr>
<tr>
<td>Actions:</td>
<td></td>
</tr>
<tr>
<td>• Management visibly involved in kickoff of the new household safe water storage program</td>
<td></td>
</tr>
<tr>
<td>• Additional man power required to distribute containers</td>
<td></td>
</tr>
<tr>
<td>• Current focus on community level not household level</td>
<td></td>
</tr>
<tr>
<td>Actions:</td>
<td></td>
</tr>
<tr>
<td>• hold staffing meeting to determine how best to distribute new responsibilities</td>
<td></td>
</tr>
</tbody>
</table>

The following steps should be followed when undergoing a force field analysis:

1. Define the change that will be analyzed
2. Identify positive/driving forces
3. Identify negative/restraining forces
4. Compare two sets of forces and prioritize the relative importance of each
5. List actions to address each set of forces

9.7. Developing and communicating a compelling vision and strategy
Change leaders are able to create a project vision and a strategy to achieve that vision. The change leader must be able to communicate both the vision and strategy effectively, and use both of these to empower the team to achieve the desired outcome. The change leader must also be able to use effective communication skills to convince stakeholders that achieving the vision will tie into the organization’s high-level strategies. The project charter, project planning tools, communication plan, creativity tools, and elevator pitch are all tools that change leaders can use to communicate their vision and strategy. All but the elevator pitch have been described previously.

9.7.1 Elevator pitch
Change leaders should prepare an “elevator pitch” to sell their vision. An “elevator pitch” is a one- to two-minute long speech that should communicate the key elements of the project vision and the reason for igniting change. It is given this name because it should be short and persuasive enough to be able to convince a stakeholder to support this vision during a chance meeting that takes place while riding a few floors on an elevator (or a “lift” in some countries). Specifically, the short speech should include:

1. Need for change
2. Project goals
3. Progress that has been made on the project thus far
4. Any personal meaning associated with the project
5. Value of the project for the organization

9.8. Aligning employees
Change leaders are responsible for aligning resources necessary to achieve the vision. This entails assembling a committed project team that has time to work on the project, and providing the team with any authority that is required for them to take action. The following project tools can be used to effectively align the members of a project team:

9.8.1 Commitment scale
The purpose of a commitment scale is to identify the level of commitment among different stakeholders involved in the project. People or groups are identified, and their level of commitment (from “hostile” to “enthusiastic support”) is assessed. After synthesizing commitment scale scores, you can identify how to improve the level of commitment to the project. A sample commitment scale is included in Table 34. The X’s represent current level of commitment and the circles represent the level of commitment that is required for successful project completion. The arrows from X to circle represents the amount of change needed for each stakeholder group.
9.8.2 From-to matrix

The “from-to” matrix is intended to capture the anticipated elements of change and stakeholders most likely to be affected in order to prepare employees. The from-to matrix identifies the potential changes initiated by the project, the stakeholder groups most likely to be affected, and the anticipated level of impact (high, medium, or low). A separate matrix should be completed for each key stakeholder group. A sample from-to matrix is included in the figure below. Once all matrices are complete, you should analyze the results, and prepare to pay particular attention to stakeholders that have the most high and medium impacts.
Table 35. From-to matrix

<table>
<thead>
<tr>
<th>Potential change</th>
<th>Key potential changes for stakeholders</th>
<th>Impact on stakeholder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementing the new survey form and the new mobile data collection app will reduce data collection time and allow respondents to get their voices heard more effectively</td>
<td>FEs do 2 surveys per day, then enter data in office</td>
<td>High</td>
</tr>
<tr>
<td>FEs were skipping questions when unable to answer question</td>
<td>Mobile data collection form requires all questions to be answered before survey submitted: FEs trained in new response codes for “Don’t know” and “N/A.”</td>
<td>Medium</td>
</tr>
</tbody>
</table>

9.8.3 Losses and gains chart

The losses-and-gains chart is used to understand the impact that changes will have on stakeholders and to identify strategies that will help stakeholders deal with change. A chart should be completed for each key stakeholder group. The stakeholder profile, anticipated losses and gains, and strategies for helping the stakeholder through anticipated changes are all included in the matrix. A sample losses-and-gains chart is depicted in Table 36.
The resistance checklist is used to identify the type of resistance that may transpire as a result of the project, and the responses that the project team should be prepared to implement. There are six common types of resistance that should be considered:

- Surprise
- Apprehension of the unknown
- Skepticism
- Cynicism
- Complacency
- Change Overload

A sample resistance checklist is included below. The checklist should be completed before the project is implemented. Following implementation, if resistance occurs, the project team can reference the checklist to identify the appropriate responses. The resistance should be re-assessed after the response is implemented, and the process can be repeated as necessary.
Table 37. Resistance Checklist

<table>
<thead>
<tr>
<th>Type of Resistance</th>
<th>Appropriate Responses</th>
</tr>
</thead>
</table>
| **Surprise**                        | ☐ Don’t react defensively  
                                             ☐ Listen  
                                             ☐ Describe the shared vision and improved state  
                                             ☐ State facts clearly but don’t try to “sell it” |
| **Apprehension of the unknown**     | ☐ Listen  
                                             ☐ Describe benefits to stakeholders  
                                             ☐ Communicate a clear plan  
                                             ☐ Share the communication plan  
                                             ☐ Avoid false promises |
| **Skepticism**                      | ☐ Listen  
                                             ☐ Describe benefits to stakeholders  
                                             ☐ Demonstrate why change is urgent |
| **Cynicism**                        | ☐ Listen  
                                             ☐ Don’t argue |
| **Complacency**                     | ☐ Listen  
                                             ☐ Demonstrate why changes is urgent  
                                             ☐ Describe benefits to stakeholders  
                                             ☐ Avoid criticizing past practices |
| **Change Overload**                 | ☐ Listen  
                                             ☐ Map out the concerns  
                                             ☐ Be careful of offering quick solutions  
                                             ☐ Be sympathetic but avoid becoming a counselor |

9.9. Reviewing progress and recognizing gains
Change leaders should review progress on an ongoing basis to ensure that the project stays on-track. This entails active participation in the tollgate review process, recognizing success throughout the project and at the end of the project, publishing progress reports on a regular basis, and communicating the value and accomplishments of the project to all stakeholders.
9.9.1 Tollgate reviews
Before closing out a given CQI project, the team should conduct a tollgate review with the CQI team’s facilitator. To do this, the team shares the progress to date, along with all documentation, with the facilitator, who then reviews the steps and outcomes to help the team determine if the CQI project is ready to be closed out. The review can result in several outcomes, including additional work to augment any of the CQI steps or provide further documentation, the decision to conduct additional improvement cycles within the same project, or the decision to close out the project and move on to a new one. Smaller tollgate reviews can also be conducted at each step in the CQI process, as needed.

9.9.2 Storyboard
A storyboard is a short visual summary of the completed CQI project. The storyboard should highlight key events and moments from the WaSH CQI project by documenting the project from beginning to end. The storyboard should capture the problem statement, the approach, the CQI tools used, the final improvement package developed, major outcomes and lessons learned, and steps taken to sustain and scale the improvement package.

9.10. Anchoring new approaches in culture
New approaches must be anchored in the culture of an organization in order to ensure long-term sustained success. The change leader is responsible for anchoring project improvements to prevent the organization from reverting back to the old processes. This can be achieved by integrating improvements throughout the organization following completion of the project, sharing improvements with other members within the organization at all levels, identifying company polices and measures to support the improvements, identifying barriers to support improved process, training employees outside of the project team on the Quality Improvement mindset, and creating a supportive environment for the project team during and following the project. Several methods for anchoring new approaches in the organizational culture have been identified previously: standardized work methods, force field analysis, and communication tools. One additional systematic method, the use of a “measures and policies chart,” is also available to cement the culture changes in place.

9.10.1 Measure and policies chart
The measures and policies chart is intended to help organizations identify approaches that can be used to help people adapt to and accept changes by creating a system that supports desired behaviors. The chart should be used when behavior change is required, but the current system does not support those changes. To complete a measures and policies chart, you must describe the desired state, list performance measures, list the behaviors reinforced by these measures, and recommend revisions to the measures which are expected to help support the desired behavior change. A sample measures and policies chart is included below.
### Table 38. Sample measure and policies chart

<table>
<thead>
<tr>
<th>#</th>
<th>Process Step</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe desired outcome</td>
<td>Increase the number of water samples that the lab can process on a weekly basis</td>
</tr>
<tr>
<td>2</td>
<td>List current measures of performance</td>
<td>- Number of samples processed per lab tech per day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of samples processed per lab tech per week</td>
</tr>
<tr>
<td>3</td>
<td>List behaviors reinforced by current measures</td>
<td>Lab technicians work individually to meet daily and weekly sample quotas</td>
</tr>
<tr>
<td>4</td>
<td>List suggested revisions to measures</td>
<td>Shift focus from individual lab tech performance to the performance of the entire lab</td>
</tr>
<tr>
<td>5</td>
<td>List new behaviors desired</td>
<td>Lab techs work together to process samples by taking on different roles and responsibilities, so more samples can be processed in the same amount of time</td>
</tr>
<tr>
<td>6</td>
<td>List new measures/ideas to support these behaviors</td>
<td>- Number of samples processed by the entire lab per day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of samples processed by the entire lab per week</td>
</tr>
<tr>
<td>7</td>
<td>List current policies affecting process</td>
<td>Bonus policy rewarding lab tech with greatest number of samples processed each week</td>
</tr>
<tr>
<td>8</td>
<td>List behaviors that are reinforced by current policies</td>
<td>Focus on efficiency is good, but inhibits sharing of workload and peak times</td>
</tr>
<tr>
<td>9</td>
<td>List suggested revisions to policies</td>
<td>Remove bonus policy to discourage competition among lab techs</td>
</tr>
<tr>
<td>10</td>
<td>List new policies/ideas to support desired behaviors</td>
<td>Create incentives to promote team work among lab techs</td>
</tr>
</tbody>
</table>

By implementing these measures, CQI team leaders can help organizations adapt to change, and effectively implement and sustain effective improvement packages.
10. Conclusion

Once a CQI Cycle has been conducted from start to finish, and an improvement package has been successfully implemented, sustained, and scaled, the CQI team may wish to conduct additional cycles within the same project, or conduct a new project. In each new project, team roles and memberships may change. The WaSH organization’s level of knowledge, experience, and confidence with CQI should grow with every cycle. While the changes from any given cycle may not seem outwardly impressive in the short-term, the long-term impact of numerous CQI cycles leading to many effective improvements that are sustained over time can be transformative. While this manual is intended to help organizations apply CQI methods to WaSH programs, the applications of CQI to other aspects of international development, governance, and service delivery are virtually unlimited. We hope that this manual is helpful to you and your organization in sustainably delivering high quality WaSH services. If you have any questions, please feel free to visit our website at www.washmel.org to learn more about our work, access additional resources, or to contact us through the contact link on the site.
11. **Glossary**

Monitoring – routine collection of data on activities, outputs, and/or outcomes to track and understand processes and their performance over time

Monitoring strategy – the strategy and approach used to conduct monitoring: this includes sampling and sample size selection, the tools used for data collection (surveys, methods, tests, etc.),

Evaluation – the use of data to determine the impact of programs and processes. Evaluation can also include the use of data to determine the factors affecting the outcomes of programs and processes.

DMAIIS – DEFINE; MEASURE; ANALYZE; IDENTIFY; IMPLEMENT; SUSTAIN

Quality – Quality is defined as anything that adds value in the eyes of the customer

Defect – A defect is defined as anything that does not meet the needs of the customer

Waste – Waste is defined as anything that does not add value in the eyes of the customer

Customer – The customer is the end user or beneficiary of any process or program

Champions – Champions are stakeholders within an organization who have the authority to allow a project to go forward

SIPOC – A tool used to map a process by identifying the Suppliers, Inputs, Process steps, Outputs, and Customers of a given process

Process – the defined steps through which work is performed

Outcome (Y) – The result or consequence of a process

Process variable/ determinant (X) – any aspect of a process or the environment in which it is performed that may affect the outcome or provide information about the process

Driver – A determinant that primarily or solely determines an outcome

Root cause – A root cause is an underlying factor that substantively contributes to an outcome and that is not substantively caused by other, deeper underlying factors.

Operational definition – A definition of a characteristic that includes sufficient instructions for reproducibly measuring or determining the characteristic in question

Stratification – Dividing data into subgroups or “straata” for analysis on the basis of an observable characteristic across which outcomes of interest may vary

Backlog – A backlog occurs when a process is not capable of operating at a rate sufficient to meet the demands of customers

Bottleneck – A bottleneck is a rate-limiting process step (i.e. a process step with a maximum throughput that is substantively lower than the maximum throughput of all other process steps)

Common cause variation – Common-cause variation is variation in the output or outcome of a process that is due to natural variability or “noise” within the process.
Special cause variation – Special-cause variation is variation in the output or outcome of a process that is due to a specific failure or problem within a process.

Stakeholder – A stakeholder is any person with an interest in the outcome of a process, project, or program.

Indicator – An indicator is a metric that can be calculated to provide insight into the operation and/or performance of a process, project, or program.

Improvement package – An improvement package (also called a change package) is one or more solutions intended to improve a process to increase quality and/or efficiency.

Project charter – A written document that describes how the CQI team will work together over the course of the project.

Structured decision-making tools – tools that allow groups to systematically prioritize a set of criteria and then use them to systematically rank options so that the best option is selected. These tools can help to separate people from ideas and reveal options that best meet a team’s specifications.

Pareto chart - A Pareto chart, named after the Italian Economist Vilfredo Pareto, is a type of histogram that contains bars represented the value or frequency of a categorical variable, in descending order, while the line represents the cumulative total of the same characteristic across all bars. Pareto charts can help to identify relationships in which a few sources account for the majority of the effects (80/20 rule).

Histogram – A histogram is a type of bar chart in which numerical or frequency data are binned so that the height of each bar is proportional to the frequency of the variable and the width is equal to the range of the bin. Histograms can be used to quickly visualize the nature of distributions of numerical or frequency data.

Graph – a graph or plot is any graphical representation of data.

Pivot Table – A pivot table is a type of unweighted cross-tabulation of data that displays how values or occurrences for one or more (usually discrete) variables varies as a function of another discrete variable.

Standard operating procedures – a Standard Operating Procedure, or SOP, is a set of instructions that can be used to standardize a given procedure so that it can be reproducibly and accurately performed by staff.

Parts per million – a part-per-million (PPM) is a unitless measure of concentration corresponding to one unit of the analyte of interest per million units of the overall bulk substance or population in which it is found. When referring to aqueous compounds in water, one part per million corresponds to one milligram per liter (mg/L).

Parts per billion - a part-per-billion (PPB) is a unitless measure of concentration corresponding to one unit of the analyte of interest per billion units of the overall bulk substance or population in which it is found. When referring to aqueous compounds in water, one part per billion corresponds to one microgram per liter (µg/L).
Waste - Waste is defined by the experience of the customer. It is anything that does not add value to the process output (either product or service) and includes activities or purchases that customers would not want to pay for if they knew these things were happening.

Overburden – Overburden occurs when a given process step with fixed capacity receives a workload that exceeds its process capacity, slowing down the entire system.

Unevenness - Unevenness occurs when the workload is extremely uneven, so that the capacity of a process is exceeded at some times, while the workload is far less than what the process can do at other times.
12. Annexes

12.1. categories of waste worksheet

Review each of the potential categories of waste below. Note where this type of waste could occur in your process of interest. Refer to your Process Map for ideas.

<table>
<thead>
<tr>
<th>Category of Waste</th>
<th>Where it may occur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction (Defects and rejects)</td>
<td></td>
</tr>
<tr>
<td>Overproduction</td>
<td></td>
</tr>
<tr>
<td>Over-processing</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
</tr>
<tr>
<td>Inventory</td>
<td></td>
</tr>
<tr>
<td>Motion</td>
<td></td>
</tr>
<tr>
<td>Waiting</td>
<td></td>
</tr>
<tr>
<td>Human Mind</td>
<td></td>
</tr>
</tbody>
</table>
### 12.2. Drivers of waste worksheet

Review each of the drivers of waste below. Note where overburden and unevenness may be occurring in your process of interest. For each instance, ask “why does this occur?” Refer to your Process Map for ideas.

<table>
<thead>
<tr>
<th>Driver of Waste</th>
<th>Where it may occur</th>
<th>Why does it occur here?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overburden</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unevenness</td>
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<td></td>
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</tr>
</tbody>
</table>
### 12.2.1 Project charter template

**Instructions:** Use the template below to develop your project charter. Not all of the items may be pertinent to you, but the more items you can complete, the better off you will be.

#### CQI Project Charter

<table>
<thead>
<tr>
<th><strong>Product/Service</strong></th>
<th><strong>Process Leader</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization</td>
<td>Phone Number for Team Leader</td>
</tr>
<tr>
<td>Regional Sponsor</td>
<td>Email for Team Leader</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Element</strong></th>
<th><strong>Description</strong></th>
<th><strong>Specifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Process</td>
<td>Name of process to be improved.</td>
<td>Water quality at points of care in PHCs</td>
</tr>
<tr>
<td>2. Project</td>
<td>What practical problem will be solved? What is project’s purpose?</td>
<td>Water that is used at points of patient care at primary health care facilities is of poor quality. The objective of the project is to improve the quality of the water (as defined by E.coli MPN) at points of care.</td>
</tr>
<tr>
<td>3. Objective</td>
<td>What metrics will be improved, what is the current performance for those metrics and how much improvement is targeted? Provide specifics on how metrics are computed.</td>
<td><em>(Source functionality metrics and improvement target may be adjusted accordingly to the current water point functionality rate)</em></td>
</tr>
<tr>
<td>4. Process</td>
<td>Which process steps will be considered in this project? What is the first step and what is the last step?</td>
<td>First step is when water is brought into the facility from an external source (borehole, pipes etc.). Last step is after water has been used for patient care.</td>
</tr>
<tr>
<td>5. Business Case</td>
<td>Justification for this project. Why is it important? Why is it critical to business success?</td>
<td>Best health care facilities and training are undermined by unsafe water. Neonatal mortality is high, and sepsis is a primary cause—safe management of water in HCFs is a critical component of reducing sepsis...</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6. Benefit to Internal and External Customers</td>
<td>How will internal or external customers benefit from this project? How does improvement in the metrics that you have selected help them improve their performance?</td>
<td>External customers: patients (improve outcomes) Internal customers are health care staff (reduce complications, readmissions, health-care worker illnesses, faster discharge, more bed space)</td>
</tr>
<tr>
<td>7. Team members</td>
<td>Names and roles of team members.</td>
<td>QI Lead: WV Water/Baby WaSH person Clinic people District health officer Get all people together for one big training, then go to clinics once a week to run this project...</td>
</tr>
<tr>
<td>8. Schedule</td>
<td>Project Start Project Charter Approved Current State Value Stream Map Future State Value Stream Map Project Completion</td>
<td></td>
</tr>
<tr>
<td>9. Support Required</td>
<td>What resources, people, departments are required?</td>
<td></td>
</tr>
</tbody>
</table>
12.3. SIPOC template

Use the template below to map out Suppliers, Inputs, Process steps, Outputs, and Customers for your Process of interest. If more process steps are needed, add them in below the predrawn boxes.

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Inputs</th>
<th>Process</th>
<th>Outputs</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
12.4. data collection template

Complete a copy of the data collection plan template below for each variable that you wish to measure.

Data Collection Plan

What questions do you want to answer?

Being clear about your question will help you make sure you collect the right data.

<table>
<thead>
<tr>
<th>Data</th>
<th>Operational Definition and Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>What (variable name)</td>
<td>Data type (Y or X)</td>
</tr>
</tbody>
</table>

How will you ensure consistency and stability?

What is your plan for starting data collection? (Attach details if necessary.)

How will the data be displayed? (Sketch below.)
12.5. Sample survey
Below is an excerpted example of a WaSH survey.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metadata</td>
<td></td>
</tr>
<tr>
<td>1. Date</td>
<td></td>
</tr>
<tr>
<td>2. Time: Enter hour</td>
<td></td>
</tr>
<tr>
<td>3. Time: Enter minutes</td>
<td></td>
</tr>
<tr>
<td>4. GPS Coordinates</td>
<td></td>
</tr>
<tr>
<td>5. Country</td>
<td></td>
</tr>
<tr>
<td>6. Region</td>
<td></td>
</tr>
<tr>
<td>7. District</td>
<td></td>
</tr>
<tr>
<td>8. Organization collecting the data</td>
<td></td>
</tr>
<tr>
<td>9. Your name</td>
<td></td>
</tr>
<tr>
<td>10. Community ID</td>
<td></td>
</tr>
<tr>
<td>11. Name of community</td>
<td></td>
</tr>
<tr>
<td>Facility Functionality</td>
<td></td>
</tr>
<tr>
<td>12. [Direct Observation] Source type</td>
<td></td>
</tr>
<tr>
<td>Piped water into dwelling</td>
<td></td>
</tr>
<tr>
<td>Piped water to yard/plot</td>
<td></td>
</tr>
<tr>
<td>Public tap/standpipe</td>
<td></td>
</tr>
<tr>
<td>Mechanized borehole</td>
<td></td>
</tr>
<tr>
<td>Borehole with manual pump</td>
<td></td>
</tr>
<tr>
<td>Protected dug well</td>
<td></td>
</tr>
<tr>
<td>Unprotected dug well</td>
<td></td>
</tr>
<tr>
<td>Protected spring</td>
<td></td>
</tr>
<tr>
<td>Unprotected spring</td>
<td></td>
</tr>
<tr>
<td>Rainwater collection</td>
<td></td>
</tr>
<tr>
<td>Pay another person to fetch/ buy filled containers from a vendor</td>
<td></td>
</tr>
</tbody>
</table>
Bottled water- sachet water- or "pure water (sachet water)"
Cart with small tank/drum
Tanker-truck
Surface water (river- dam- lake- pond- stream- canal- irrigation channels)

13. [Direct Observation] Is water available from this source?
   Yes
   No
   Not applicable
   Don’t know
   Decline to state

Only answer if you responded No to Q13

14. Has water been available from this source on any day in the past year?
   Yes
   No
   Not applicable
   Don’t know
   Decline to state

15. [Direct Observation] If the water point is functional, how many pump strokes are needed before water begins to flow?

16. [Direct Observation] Use the timer to record the time required to fill the 20 liter container:
   minutes

17. [Direct Observation] Use the timer to record the time required to fill the 20 liter container:
   seconds

18. [Photo] Take a photograph of the waterpoint

Only answer if you responded No to Q13

19. Why is water not available from this source?
   Water Source Inadequate
   motorized pumps inadequate
   Treatment plants inadequate
   Main storage inadequate
Rising main inadequate
Distribution storage inadequate
Water points (taps) inadequate
Utilization exceeds theoretical demand
Pipes broken
Tap broken
Animals contaminated water
Broken/missing pump handle
Broken/missing chain
Broken/missing pump cylinder
Broken/missing valve
Broken/missing rod
Broken/missing gasket
Broken Handpump (other above ground failure)
Broken handpump (below-ground failure)
Lack of electricity or fuel
Water Vendor Did not come
Facility locked
Not applicable
Don’t know
Decline to state

Only answer if you responded No to Q13

20. Why has the system not yet been repaired?
   Don’t know whom to call
   Repair person did not come
   Parts not available
   Repair person unable to fix system
   Lack of funds to repair or pay fuel/electricity
   Not applicable
Don’t know______
Decline to state______
Other______

Only answer if you responded Piped water into dwelling | Piped water to yard/plot | Public tap/standpipe | Mechanized borehole | Borehole with manual pump | Rainwater collection | Cart with small tank/drum | Tanker-truck to Q12

21. In the past year, has the water system been broken down for more than one day (apart from seasonality problems)? If the water system is currently broken down, mark yes.

Yes_____ 
No_____ 
Not applicable______
Don’t know______
Decline to state______

22. When did this water system last break down? ________________________

Only answer if you responded Yes to Q21

23. Days, weeks, months or years?
Day(s)_____ 
Week(s)_____ 
Month(s)_____ 
Year(s)_____ 

24. For how long was water not available from this source the last time it broke down? [If system is still broken, record time since the system broke.] ________________________

Only answer if you responded Yes to Q21

25. Days, weeks, months or years?
Day(s)_____ 
Week(s)_____ 
Month(s)_____ 
Year(s)_____ 

Only answer if you responded Borehole with manual pump to Q12

26. What was done to repair the water source the last time it broke?
Nothing______
replace chain______
replace gasket/rubber ring______
replace valve______
replace leather or rubber cup______
replace Cylinder______
replace rod______
replace bearing ________
replace metal bottom cage ________
Replace hand pump______
Retrieve fallen cylinder______
Rehabilitate borehole______

Only answer if you responded Piped water into dwelling|Piped water to yard/plot|Public tap/standpipe |Mechanized borehole to Q12

27. What was done to repair the water source the last time it broke?

   Nothing______
   Replace pipe______
   Replace valve______
   Replace pump______
   Replace switch______
   Repair pipe ______

28. Scan the barcode of the watersample ____________________________

29. Water sample ID ____________________________

Only answer if you responded Yes to Q13

30. Are you taking a duplicate sample at this water point?

   Yes______
   No______

31. Scan the barcode of the duplicate watersample ____________________________

32. Water sample ID for duplicate ____________________________
Only answer if you responded Yes to Q13

33. Are you taking a field blank sample at this water point?
   Yes____
   No_____  

34. Scan the barcode of the field blank ________________________

35. Water sample ID for field blank ________________________

Facility Characteristics - questions

36. Who is the facility administrator you are interviewing?
   WaSH committee member____
   Community leader____
   School or institution administrator____
   Private individual____
   Head of household____

37. [Direct Observation] Year the water point was constructed, if visible
   ________________________

38. What year was this water point constructed? ________________________

39. [Direct Observation] Organization that constructed the water point, if visible
   ________________________

40. Which organization constructed this water point?
   ________________________

41. Does more than one family use this facility?
   Yes____
   No____
   Not applicable____
   Don't know____
   Decline to state____

42. How many households use this facility? ________________________

43. How many people use this facility? ________________________
44. How many people were using this facility the last time it was working?
_________________________

Only answer if you responded Yes to Q13

45. Does anyone use this water source for drinking?

Yes______
No______
Not applicable______
Don’t know______
Decline to state______

Only answer if you responded No to Q13

46. Did anyone use this water source for drinking the last time water was available from this source?

Yes______
No______
Not applicable______
Don’t know______
Decline to state______

47. Who in this community manages this water point?

WaSH Committee______
Community Leader______
Private person______
District/local government______
Church______
School______
Vendor______
No one______
Not applicable______
Don’t Know______
Decline to State______
Only answer if you responded Piped water into dwelling | Piped water to yard/plot | Public tap/standpipe | Mechanized borehole to Q12

48. Has this community experienced any pipe breaks in the last week?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

Reliability

49. Is water available from this source at all times?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

50. In the past two weeks, have there been any times when water was not available for a full day or more?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

51. For how many days in the last two weeks was water not available?
   _______________________

Only answer if you responded Yes to Q50

52. Are you able to predict which days water will be available from this source?
   Yes____
   No____
   Not applicable____
   Don’t know____
Decline to state____

53. Is water available from this source at all hours of the day?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

Only answer if you responded No to Q53

54. For how many hours was water not available yesterday? ______________________

Only answer if you responded No to Q53

55. Are you able to predict which hours water will be available from this source?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

56. Are there months during the year that water is not available from this source?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

Only answer if you responded Yes to Q56

57. During which months of the year is water not available from this source?
   January____
   February____
   March____
   April____
   May____
June______
July______
August______
September______
October______
November______
December______
Not applicable______
Don’t know______
Decline to state______

Do people pay to use this water point?
Yes______
No______
Not applicable______
Don’t know______
Decline to state______

Facility Characteristics - observations

58. [Direct Observation] Unique water point ID __________________________

59. [Direct Observation] Implementer’s source ID, if different ________________

60. [Direct Observation] Type of water point
   School WASH point______
   Community WASH point______
   Health Center______
   Private WASH point______

Only answer if you responded Borehole with manual pump to Q12

61. [Direct Observation] What is the pump type?
    India Mk II______
    Afridev______
    Vergnet______
Nira____

Other (specify):________________

Only answer if you responded Piped water into dwelling|Piped water to yard/plot|Public tap/standpipe|Mechanized borehole|Borehole with manual pump|Protected dug well|Unprotected dug well|Protected spring|Unprotected spring|Rainwater collection|Surface water (river, dam, lake, pond, stream, canal,) to Q12

62. [Direct Observation] Is there a latrine within 10 meters of the water point?

Yes____

No____

Not applicable____

Don’t know____

Decline to state____

Only answer if you responded Piped water into dwelling|Piped water to yard/plot|Public tap/standpipe|Mechanized borehole|Borehole with manual pump|Protected dug well|Unprotected dug well|Protected spring|Unprotected spring|Surface water (river, dam, lake, pond, stream, canal,) to Q12

63. [Direct Observation] Is the nearest latrine on higher ground than the water point?

Yes____

No____

Not applicable____

Don’t know____

Decline to state____

Only answer if you responded Piped water into dwelling|Piped water to yard/plot|Public tap/standpipe|Mechanized borehole|Borehole with manual pump|Protected dug well|Unprotected dug well|Protected spring|Unprotected spring|Surface water (river, dam, lake, pond, stream, canal,) to Q12

64. [Direct Observation] Is there human excreta on the ground within 10 meters of the water point?

Yes____

No____

Not applicable____

Don’t know____

Decline to state____
[Direct Observation] Is there animal excreta on the ground within 10 meters of the water point?

Yes______

No______

Not applicable______

Don’t know______

Decline to state______

65. [Direct Observation] Is there a sewer or gutter receiving sewage within 10 meters of the water point?

Yes______

No______

Not applicable______

Don’t know______

Decline to state______

66. [Direct Observation] Is there any ponding of stagnant water within 2 meters of the cement floor of the water point?

Yes______

No______

Not applicable______

Don’t know______

Decline to state______
67. [Direct Observation] Does the water point have a drainage channel?
   Yes_____
   No_____
   Not applicable_____
   Don’t know_____
   Decline to state_____
   Only answer if you responded Yes to Q68

68. [Direct Observation] Is the water point's drainage channel broken, cracked, in need of cleaning?
   Yes_____
   No_____
   Not applicable_____
   Don’t know_____
   Decline to state_____
   Only answer if you responded Yes to Q68

69. [Direct Observation] Is the drainage channel filled with stagnant water?
   Yes_____
   No_____
   Not applicable_____
   Don’t know_____
   Decline to state_____
   Only answer if you responded Yes to Q68

70. [Direct Observation] Is there fencing around the installation adequate to keep animals out?
   Yes_____
   No_____
   Not applicable_____
   Don’t know_____
   Decline to state_____

Only answer if you responded Piped water to yard/plot|Public tap/standpipe|Mechanized borehole|Borehole with manual pump|Protected dug well|Unprotected dug well|Protected spring|Unprotected spring|Surface water (river, dam, lake, pond, stream, canal,) to Q12
Only answer if you responded Piped water to yard/plot | Public tap/standpipe | Mechanized borehole | Borehole with manual pump | Protected dug well to Q12

71. [Direct Observation] Does the water point have a cement floor?
   Yes______
   No______
   Not applicable______
   Don’t know______
   Decline to state______

Only answer if you responded Yes to Q72

72. [Direct Observation] Are there visible cracks on the cement floor around the water point?
   Yes______
   No______
   Not applicable______
   Don’t know______
   Decline to state______

Only answer if you responded Piped water into dwelling | Piped water to yard/plot | Public tap/standpipe | Mechanized borehole to Q12

73. [Direct Observation] Are there signs of leaks in the mains pipes feeding this system?
   Yes______
   No______
   Not applicable______
   Don’t know______
   Decline to state______

Only answer if you responded Piped water into dwelling | Piped water to yard/plot | Public tap/standpipe | Mechanized borehole to Q12

74. [Direct Observation] Are pipes exposed within 10 m of this waterpoint?
   Yes______
   No______
   Not applicable______
   Don’t know______
Decline to state_____

Only answer if you responded Mechanized borehole|Borehole with manual pump|Protected dug well to Q12

75. [Direct Observation] Are there any cracks in the walls of the water point?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

Only answer if you responded Borehole with manual pump|Protected dug well to Q12

76. [Direct Observation] Do the walls of the water point’s concrete pad extend below the surface of the ground at all points?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

Only answer if you responded Mechanized borehole|Borehole with manual pump to Q12

77. [Direct Observation] Are the above-ground parts of the water point hardware loose at the point of attachment to base (which could permit water to enter the casing)?
   Yes____
   No____
   Not applicable____
   Don’t know____
   Decline to state____

Only answer if you responded Borehole with manual pump to Q12

78. [Direct Observation] Is the base of the water point adequately sealed to the concrete pad, so that water cannot enter into the borehole?
   Yes____
   No_____
Not applicable_____
Don't know_____
Decline to state_____

Water Safety
79. [Measure] Concentration of arsenic (ppb) _______________________
80. [Measure] Concentration of fluoride (ppm) _______________________
81. [Measure] Conductivity (µS) _______________________
82. [Measure] pH _______________________

Water Safety - Duplicate Sample
83. [Measure] Concentration of arsenic (ppb) _______________________
84. [Measure] Concentration of fluoride (ppm) _______________________
85. [Measure] Conductivity (µS) _______________________
86. [Measure] pH _______________________

Water Safety - Field blank
87. [Measure] Concentration of arsenic (ppb) _______________________
88. [Measure] Concentration of fluoride (ppm) _______________________
89. [Measure] Conductivity (µS) _______________________
90. [Measure] pH _______________________

Metadata II
91. End time: hour _______________________
92. End time: minute _______________________
93. Write any of your notes here _______________________

_________________________
13. References