



Using Root Cause Analysis to Determine the Source of Total Coliform Contamination

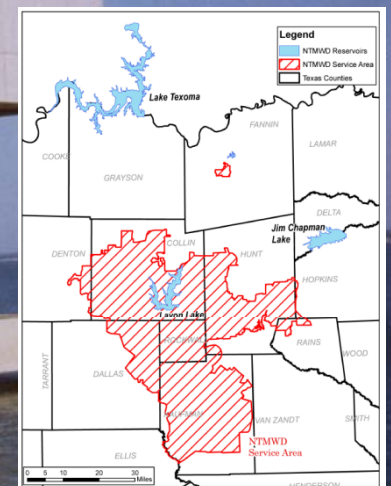
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Presentation Outline

- Overview of North Texas Municipal Water District
- Root Cause Analysis Techniques
- Total Coliform Violation Occurrence
- Investigational Results

North Texas Municipal Water District

- Located in Wylie, Texas
- Created in 1951 as a Special District to Provide Water Service
- 13 Member Cities, 49 Customer Cities
- Provides water to over 1.6 million people
- Average 300 MGD



NTMWD Laboratory

- TNI Accredited
- Staff of 25
- Drinking water, Waste water, Pretreatment
- Performs ~ 200,000+ tests per year
 - 16,000 total coliform samples per year



Root Cause Analysis

4.11 Corrective Action (ISO/IEC 17025:2005(E), Clause 4.11)

4.11.1 General

The laboratory shall establish a policy and a procedure and shall designate appropriate authorities for implementing corrective action when nonconforming work or departures from the policies and procedures in the management system or technical operations have been identified.

NOTE: A problem with the management system or with the technical operations of the laboratory may be identified through a variety of activities, such as control of nonconforming work, internal or external audits, management reviews, and feedback from customers and from staff observations.

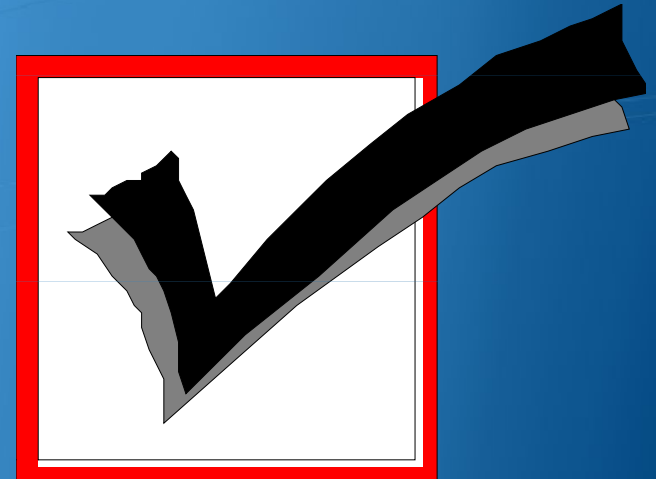
4.11.2 Cause Analysis

The procedure for corrective action shall start with an investigation to determine the root cause(s) of the problem.

NOTE: Cause analysis is the key and sometimes the most difficult part in the corrective action procedure. Often the root cause is not obvious and thus a careful analysis of all potential causes of the problem is required. Potential causes could include customer requirements, the samples, sample specifications, methods and procedures, staff skills and training, consumables, or equipment and its calibration.

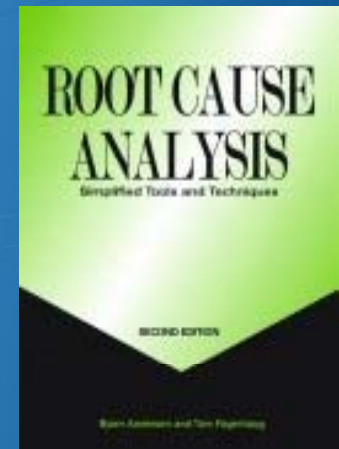
Corrective Action System

- ID Nonconformance
- Immediate Correction
- Root Cause Analysis
- Corrective Action
- Verification/Close-out



Root Cause Analysis

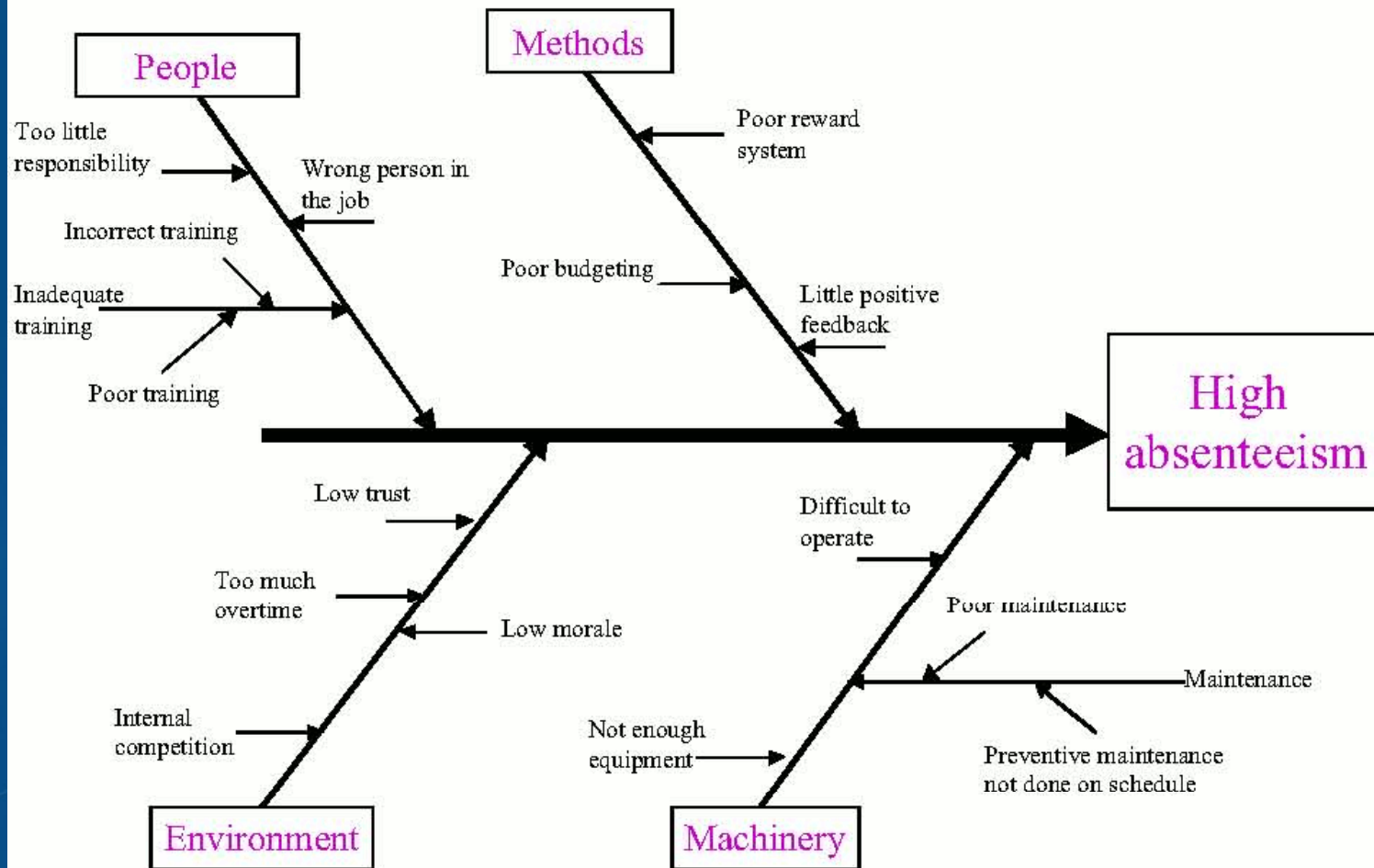
- There are lots of complex tools in the world of “Management Systems”
 - Cause and Effect diagrams (CED)
 - Interrelationship diagrams (ID)
 - Current Reality Trees (CRT)
 - Praedo Charts (PC)
 - Five Whys
 - ...and more
- Tip: *Watch out for Analysis to Paralysis*



Cause And Effect Diagrams (CED)

- Informally called the fishbone diagram
- Easy to use
- Works best when the problem is well defined
- Tends to be difficult to determine the true root cause
- Can get very complicated

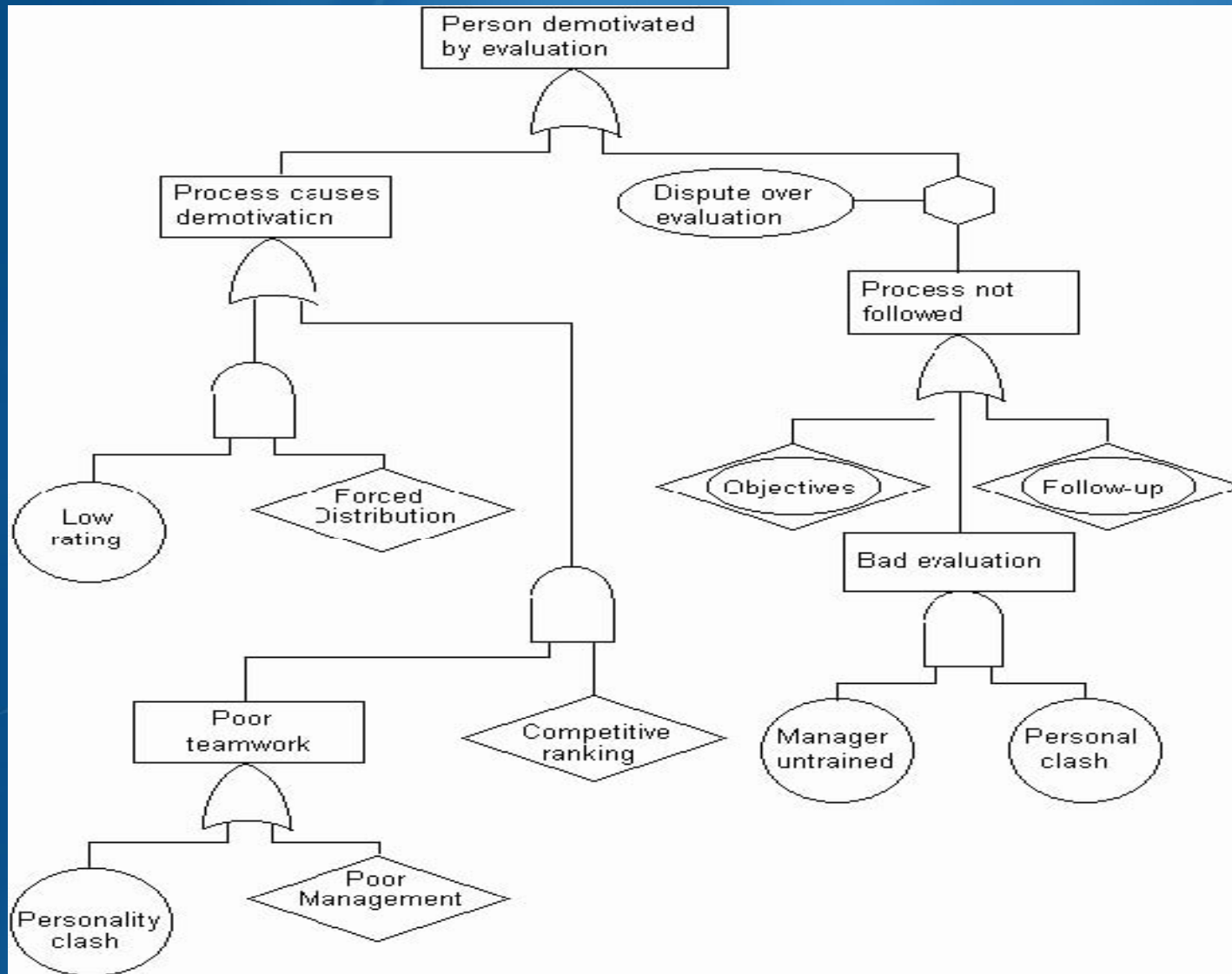
Example of a Cause-and-Effect Diagram



Fault Tree Analysis (FTA)

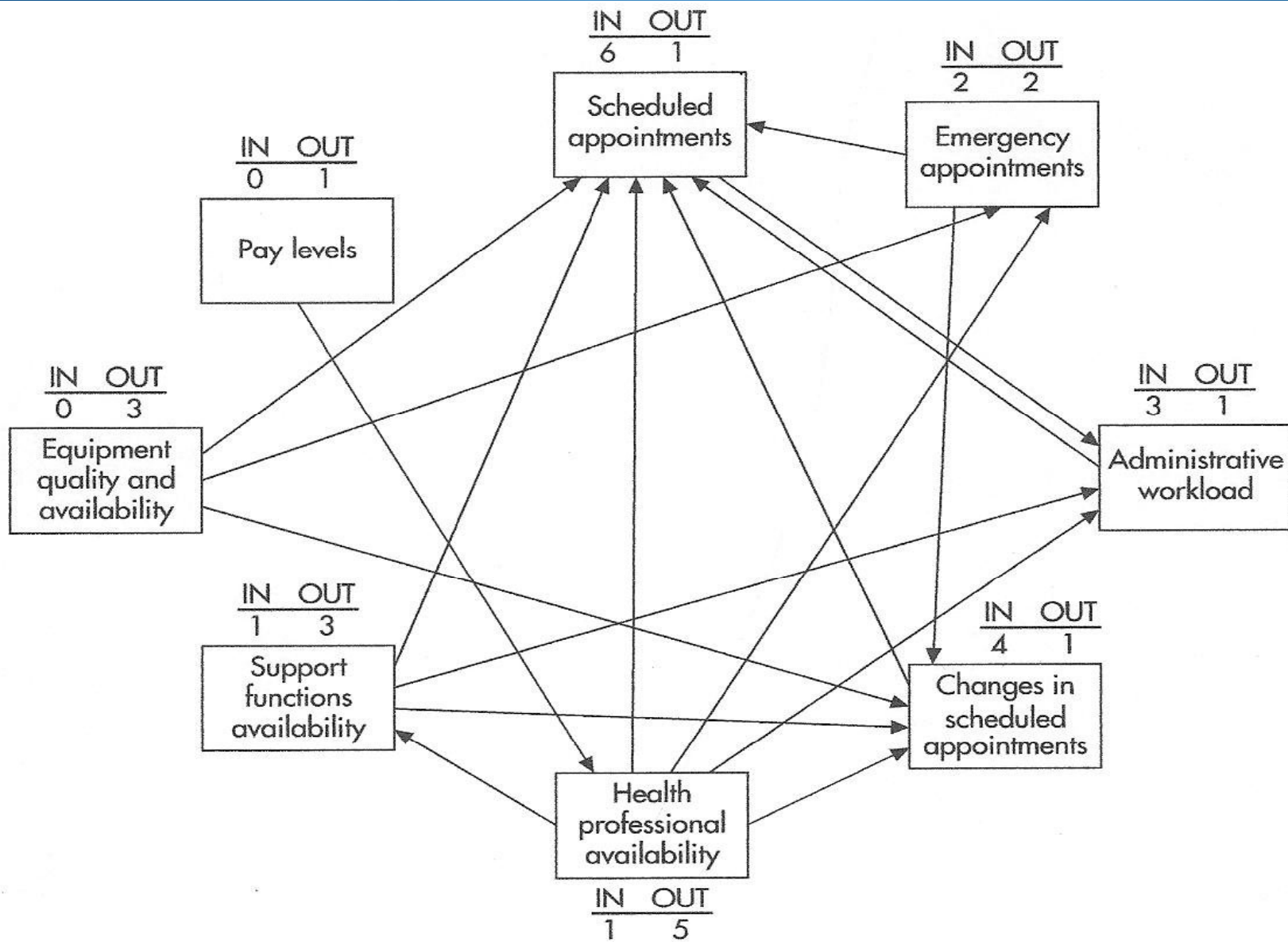
- Similar to Cause and effect diagrams
- Used for reliability and safety analysis
- Uses Boolean logic and flow charts (and/or paths)
- Includes risk assessment
- Qualitative and quantitative analysis

Fault Tree Analysis Example



Interrelationship Diagrams (ID)

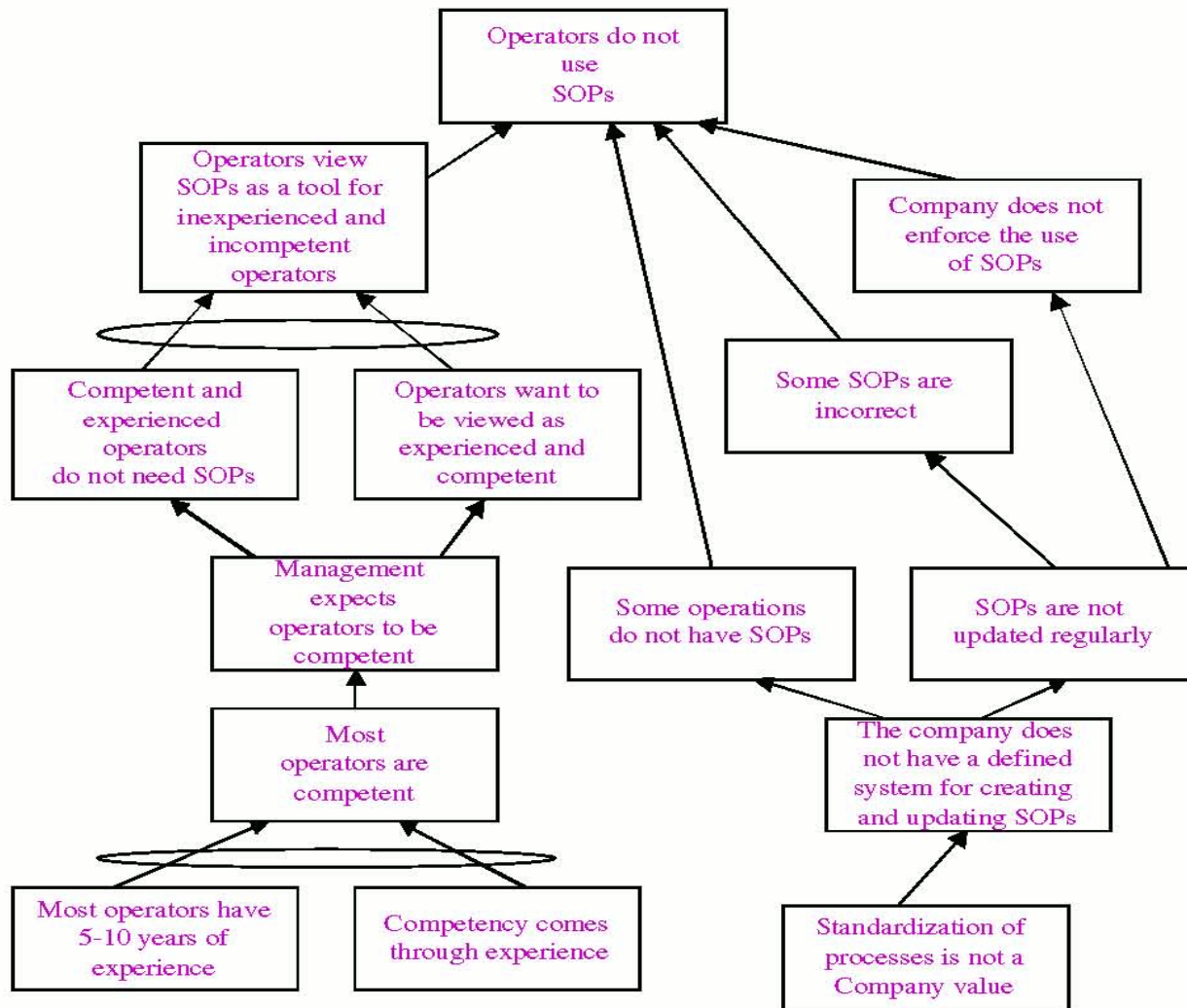
- Used to identify and classify relationships
- Non-linear approach
- Arrows show direction of cause to effect
- Relationships are numerically weighted
- Root cause determined by numeric value



Current Reality Trees (CRT)

- Allows for interrelationships and interdependence of causes
- Starts with effect, works downward with if-then logic
- Complex and rigorous logic
- Time consuming
- Generally well defined root cause

Example of a Current Reality Tree



Five Why Sequence

- Most commonly used for simpler problems
- Easily implemented with small group
- Minimal time
- Linear cause and effect
- Gives single root cause
- Ask why 5 times

“Problem Description” occurred due to “Fifth Why”. This was caused by “Fourth why” mainly because “Third Why” was allowed by “Second why”, and this led to “First Why”.



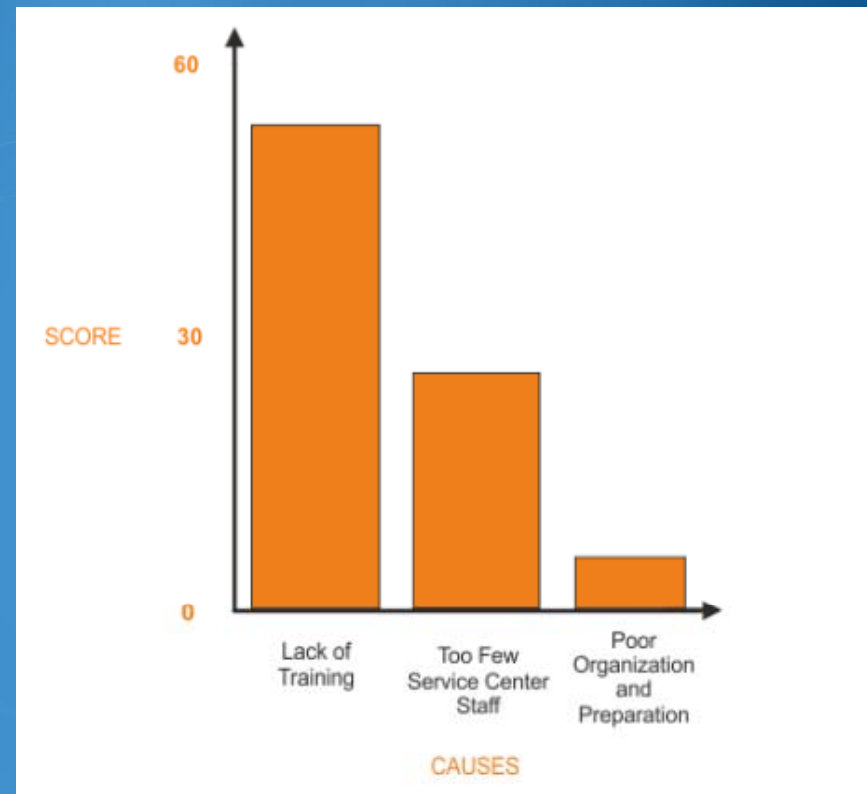
Pareto Analysis

- 20/80 Rule
- Prioritizes problem solving
- Builds on root cause analysis

#	Problem (Step 1)	Cause (Step 2)	Score (Step 3)
1	Phones aren't answered quickly enough.	Too few service center staff.	15
2	Staff seem distracted and under pressure.	Too few service center staff.	6
3	Engineers don't appear to be well organized. They need second visits to bring extra parts.	Poor organization and preparation.	4
4	Engineers don't know what time they'll arrive. This means that customers may have to be in all day for an engineer to visit.	Poor organization and preparation.	2
5	Service center staff don't always seem to know what they're doing.	Lack of training.	30
6	When engineers visit, the customer finds that the problem could have been solved over the phone.	Lack of training.	21

Jack then groups problems together (steps 4 and 5). He scores each group by the number of complaints, and orders the list as follows:

1. **Lack of training** (items 5 and 6) – 51 complaints.
2. **Too few service center staff** (items 1 and 2) – 21 complaints.
3. **Poor organization and preparation** (items 3 and 4) – 6 complaints.

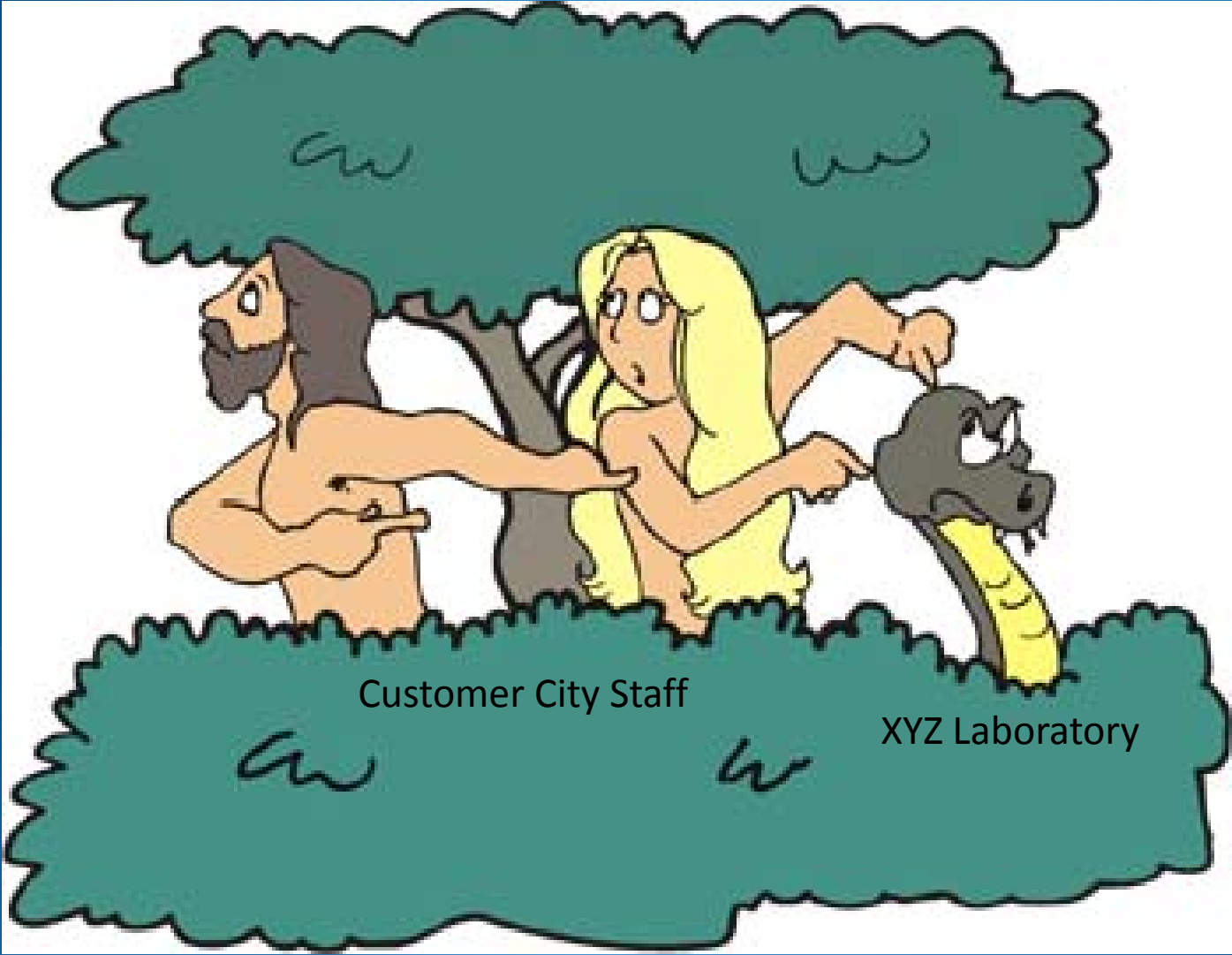


Total Coliform Contamination Event

- NTMWD Customer City required to collect 150 TCR samples per month
- In April 2011, 10% of the samples were positive for total coliform. Average chloramine residual was 2.4 mg/l
 - 4/20 – 2 of 10 samples
 - 4/25 - 5 of 10 samples
 - 4/26 – 14 of 28 samples

NTMWD Poll. Spt.	Site or Sample #	Sample Site Point of Collection	Date Collected	Time Collected	Total Residual Chlorine	Sample Type	Special Location OR - Original City - Distribution UP - Upstream	Final Test Results		Result Verification		No reaction = S	Turned yellow'	Turned yellow	Turned cloudy	Turned cloudy	Turned blue in	Sand or silt pre	Rejected: Enter
								Total Coliform	E. coll	Initials	Date/Time								
01	121	5813 Teppingham	4-26-11	1302	2.4	D		P	A	AA	4-27-11 9:45	/							
02	122	5932 Whittingden		1313	2.6			P	A	AA	4-27-11 9:45	/							
03	123	5813 Misted Breeze		1254	2.7			P	A	AA	4-27-11 9:45	/							
04	124	5732 Ridgehaven		1304	2.9			P	A	AA	4-27-11 9:45	/							
05	125	5908 Fairmount		1244	2.8			P	A	AA	4-27-11 9:45	/							
06	126	6136 Wolf Ridge		1349	2.7			P	A	AA	4-27-11 9:45	/							
07	127	6617 Basalt		1340	2.8			P	A	AA	4-27-11 9:45	/							
08	128	6513 Riverhill		1403	2.7			P	A	AA	4-27-11 9:45	/							
09	129	6405 Lochridge		1326	2.7			P	A	AA	4-27-11 9:45	/							
* 10	130	4813 Nocona	4-26-11	0803	2.1	D		P	A	AA	4-27-11 9:45	/							

Initial Response

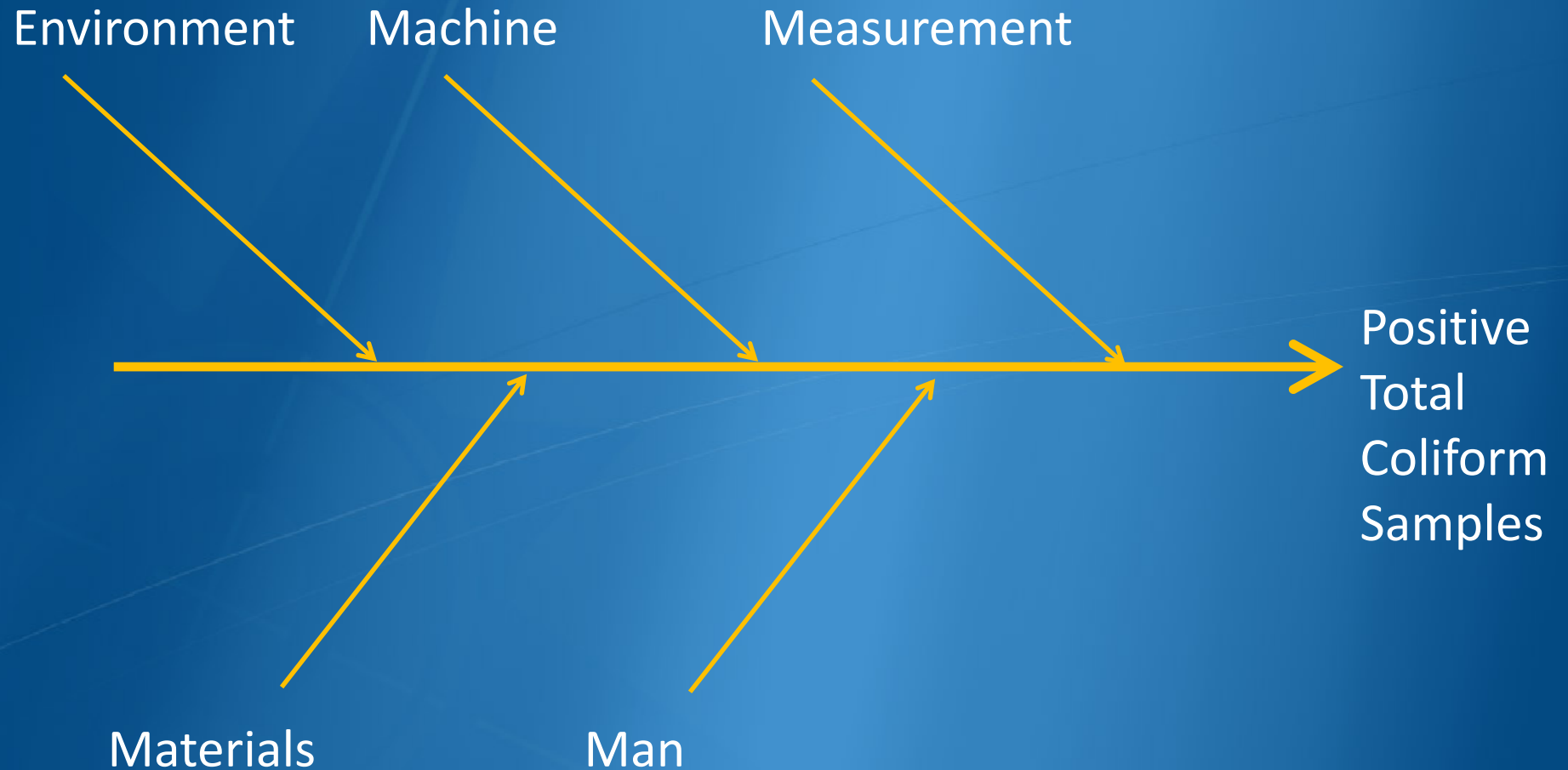


Investigate Root Causes

- Brainstorm all potential causes
 - Man
 - Machine
 - Materials
 - Measurement
 - Environment (Mother Nature)



Cause and Effect Diagram



Cause #1: MAN



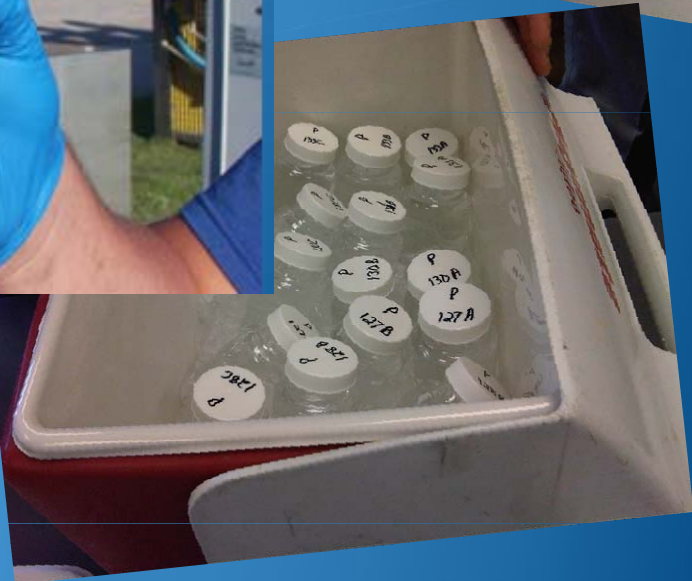
- Was the cause due to a lack of training (the person was unaware of a procedure/process because he/she was never trained)? **No**
- Ineffective training (the person was trained, but still does not understand the procedure/process)? **Maybe**
- Was the document properly interpreted? **Yes**
- Did the recipient understand the information? **Yes**
- Was too much judgment required to perform the task? **No**
- Were guidelines for judgment available? **No**
- Are there distractions in the workplace? **No**
- Is fatigue a mitigating factor? **No**
- How much experience does the individual have in performing this task? **Licensed operator with 1+ yrs experience**

Cause #2: MEASUREMENT



- Any changes in chlorine or pH? **No**
- Were the sample collection procedures unclear, incorrect, conflicting or ambiguous? **Yes**
- Were the sample analysis procedures unclear, incorrect, conflicting or ambiguous? **No**
- Were samples collected using aseptic technique? **Yes**
- Were samples transported properly? **Not always**
- Were all positive samples collected by the same person? **Yes**
- Were all samples analyzed in the same batch? **No**
- Were samples analyzed with samples from other customers? **Yes**

MEASUREMENT



Cause #3: MACHINE



- Was the water bath at the appropriate temperature? **Yes**
- Was water bath a source of contamination? **No**
- Was incubator working properly? **Yes**
- Any operational changes / disruptions in the distribution system? **No**
- Any operational changes / disruptions at treatment plant? **No**



Cause #4: MATERIALS



- Were sample containers sterile? **Yes**
- Were sample containers stored properly? **Yes**
- Were gloves used for sample collection? **Yes**
- Were gloves stored to prevent contamination? **No**
- Was the Colilert 18[©] media contaminated? **No**
- Did samples come in contact with other potentially contaminated surfaces? **Maybe**

MATERIALS



- Sterility checks on bottles ok.
- Colilert media responded correctly to +/- controls.
- 9 out of 10 gloves positive for total coliform.

Cause #5: ENVIRONMENT



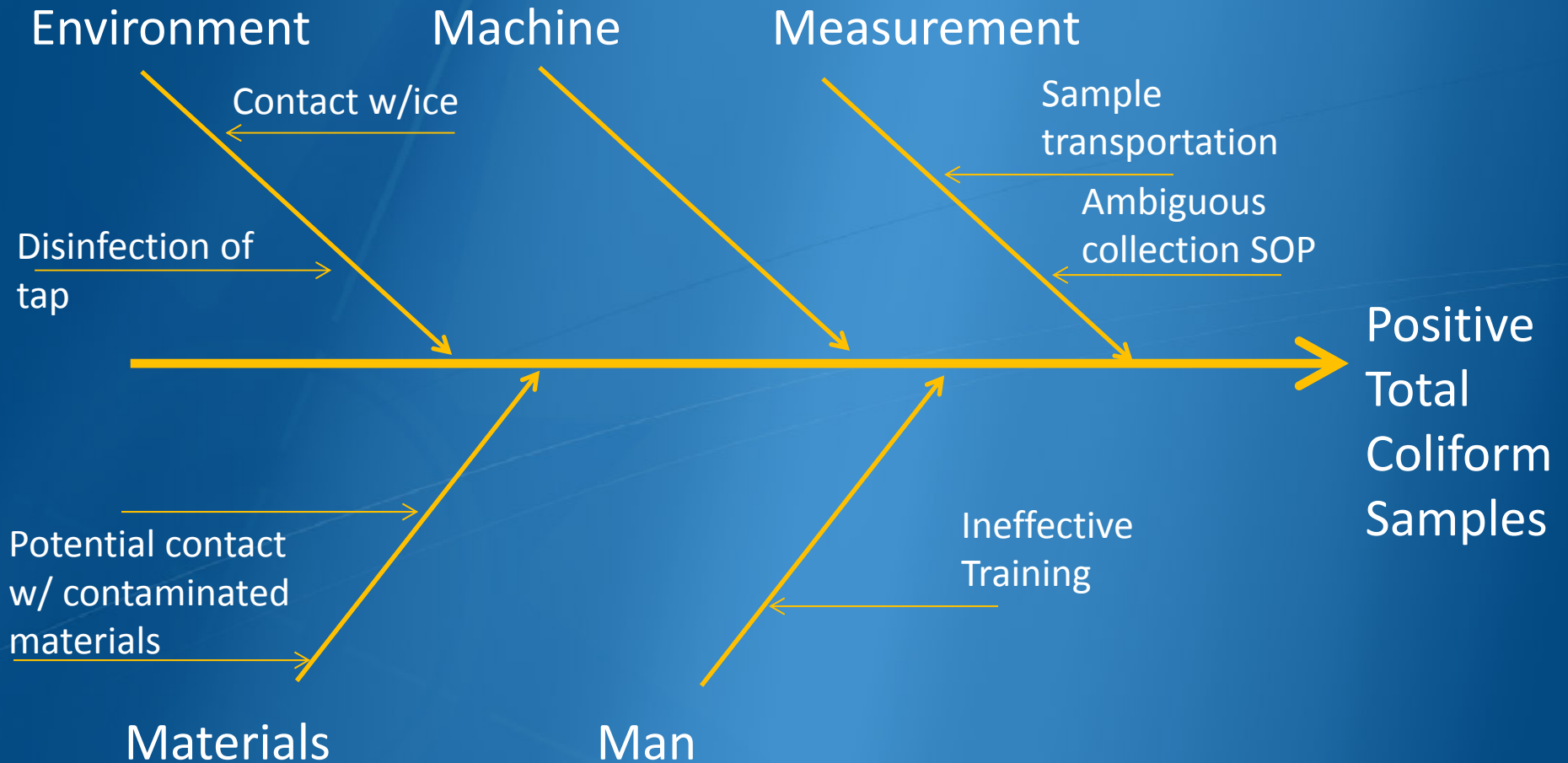
- Were samples from same area of town? No
- Were sample taps disinfected properly? Maybe
- Were samples transported in an iced cooler ? Yes
- Were samples protected from potentially contaminated ice? Not always
- Were samples protected during transport? Yes
- Was laboratory bench disinfected prior to analysis? Yes
- Was sample transport cart disinfected? Yes

ENVIRONMENT



- Surfaces swabbed & found negative for total coliform
 - Laboratory transport cart
 - Laboratory counter
 - Incubator
- Samples analyzed from:
 - Water bath
 - Cooler ice water

Cause and Effect Diagram



Five Why's

1. Why were sample taps not thoroughly disinfected? SOP did not specify a minimum bleach concentration and contact time
2. Why did SOP not specify a minimum bleach concentration and contact time? SOP author did not consider the details
3. Why were samples inconsistently transported in a manner to prevent direct contact with ice/water? Sample collector did not understand potential for contamination
4. Why were gloves stored under truck seat? See above
5. Why did sample collector not understand potential sources of total coliform contamination? Training program did not include sources of total coliform in the environment and potential sources of contamination.

Case Study Conclusion

- Symptom: Contaminated gloves and samples
- Root Cause: Ineffective training that failed to address sources of total coliform in the environment and potential for contamination
- Correction: Removal of contaminated gloves and consistent transport of sample in cages in coolers.
- Corrective Action: Modification of training program to include sources of total coliform in the environment with emphasis on minimization of contamination.

Closing Remarks

- Use Root Cause Analysis to help correct the underlying problem and not just the symptoms.
- Root Cause Analysis is applicable outside of the laboratory.
- Root Cause Analysis is suited for triggered Assessments as required under the proposed Revised Total Coliform Rule

Questions

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