CHAPTER 6: PROBLEM SOLVING—ROOT CAUSE ANALYSIS AND CORRECTIVE ACTIONS

This chapter describes the problem solving process to address compliance issues and to develop long term compliance solutions. Both structured and intuitive methods are presented. Three case studies are presented in Appendix E to illustrate documentation of the seven-step problem solving process.

6.1 The Need for Problem Solving

Over the past ten years, although three and sometimes four external environmental compliance evaluations have been completed for most Navy installations, repeat deficiencies are common. That is, despite the success of audits in identifying compliance problems, corrective actions have not been implemented to permanently prevent recurrence of the deficiencies. Total deficiencies have been reduced as a result of audits, but a minimum number persist. This has been referred to as the "compliance plateau" (Roig and Schneider, 1995).

This section addresses measures that Navy installations should consider to reduce the compliance plateau.

The measures discussed below involve:

- Defining each compliance problem;
- Analyzing its contributing and root causes; and
- Selecting, implementing, monitoring, and, if indicated, modifying corrective or preventive actions to achieve specified results.

Business management literature refers to the full sequence of steps as "problem solving." Problem solving can be as formal or as informal as is needed to achieve the intended results. The term "problem" is defined in Section 6.2.

Formal problem solving has been referred to as "structured problem solving." Structured problem solving, described in detail in Section 6.3, begins and ends with results: a description of the desired results that are not being achieved at the beginning of the process, and verification that the desired results are being achieved at the end. Structured problem solving improves the odds of achieving the desired results by the use of formal steps clearly separated to ensure each is completed effectively before proceeding. Other key aspects of structured problem solving, besides a focus on results, are analysis of causes, consideration of alternative corrective actions, and follow-up on the selected corrective actions to ensure they work as intended. Structured problem solving relies on evidence to validate decisions made at each step.

Informal or intuitive approaches to correcting deficiencies have a role in compliance programs. Where problems pose limited risks to military missions, environmental resources, human health, or budgets, less rigorous problem solving may save time and resources. Intuitive problem solving is addressed here to indicate that some problem solving steps can be abbreviated, not to justify skipping steps or avoiding work or tough decisions. Intuitive approaches that focus on root cause categorization and statistical analysis are discussed in Sections 6.4 through 6.6 below.

In the long term, the cost of repeatedly applying ineffective fixes often will be higher than the cost of solving problems permanently. Achieving a practical minimum of deficiencies at the

least cost and impact depends on good judgment regarding when and how to use structured and intuitive problem solving. Section 6.5 presents guidelines for when to use structured problem solving. Section 6.6 illustrates how root cause categories may be analyzed to reveal problems that otherwise may not be apparent. Section 6.7 makes the case that environmental management offices should not always be the sole decision makers in problem solving. Section 6.8 addresses the role of judgment in problem solving.

6.2 What is a "Problem"?

The word "problem" should be used carefully to avoid ambiguity and confusion.

"Problem" is used here to mean "a situation where there is deviation from expected results, and the causes for the deviation are not known" (Kepner and Tragoe, 1981). Note that this definition specifies that causes are not known. Kepner and Tragoe hold that, if the causes are known, then what is left is not a problem, but a "decision" as to which corrective action to take. This distinction is significant because it helps to prevent "jumping the gun" on identifying causes.

The expected results from internal and external assessments are compliance with regulatory standards, achieving permit requirements, and conformance with policy and environmental management system standards. Although they continue to be modified, regulatory standards and permit requirements are well-defined. Environmental management system standards are less well-defined and are in an early stage of development. Management requirements in OPNAVINST 5090.1B and any Major Claimant or installation orders that address elements of environmental management constitute the minimum relevant standards. Failure to meet requirements or standards is referred to as a "deficiency."

A deficiency is not necessarily the same as a problem. A deficiency should be corrected, but may represent a single instance of a "deviation from expected results." Assessments, particularly external assessments, are limited in time and effort and may not establish whether the deficiency's frequency of occurrence is significant enough to warrant structured or even intuitive problem solving. The installation or owning unit may want to monitor such a situation over time or examine other locations where the deficiency could occur. If the deficiency is an isolated event and does not in itself represent a high risk, "fixing the symptom" may suffice.

Problems may be identified by means other than external and internal assessments. Unpermitted and accidental releases to the environment and regulatory agency inspections can also reveal problems that require concerted problem solving efforts.

6.3 Structured Problem Solving—Step by Step

The references by authors on problem solving listed for this section (see Appendix B) address several useful methodologies that may be helpful in particular cases. They characterize from four to seven steps in these methodologies. The seven-step problem solving process outlined in Figure 6-1 and described below is an amalgamation of the referenced authors' methodologies.

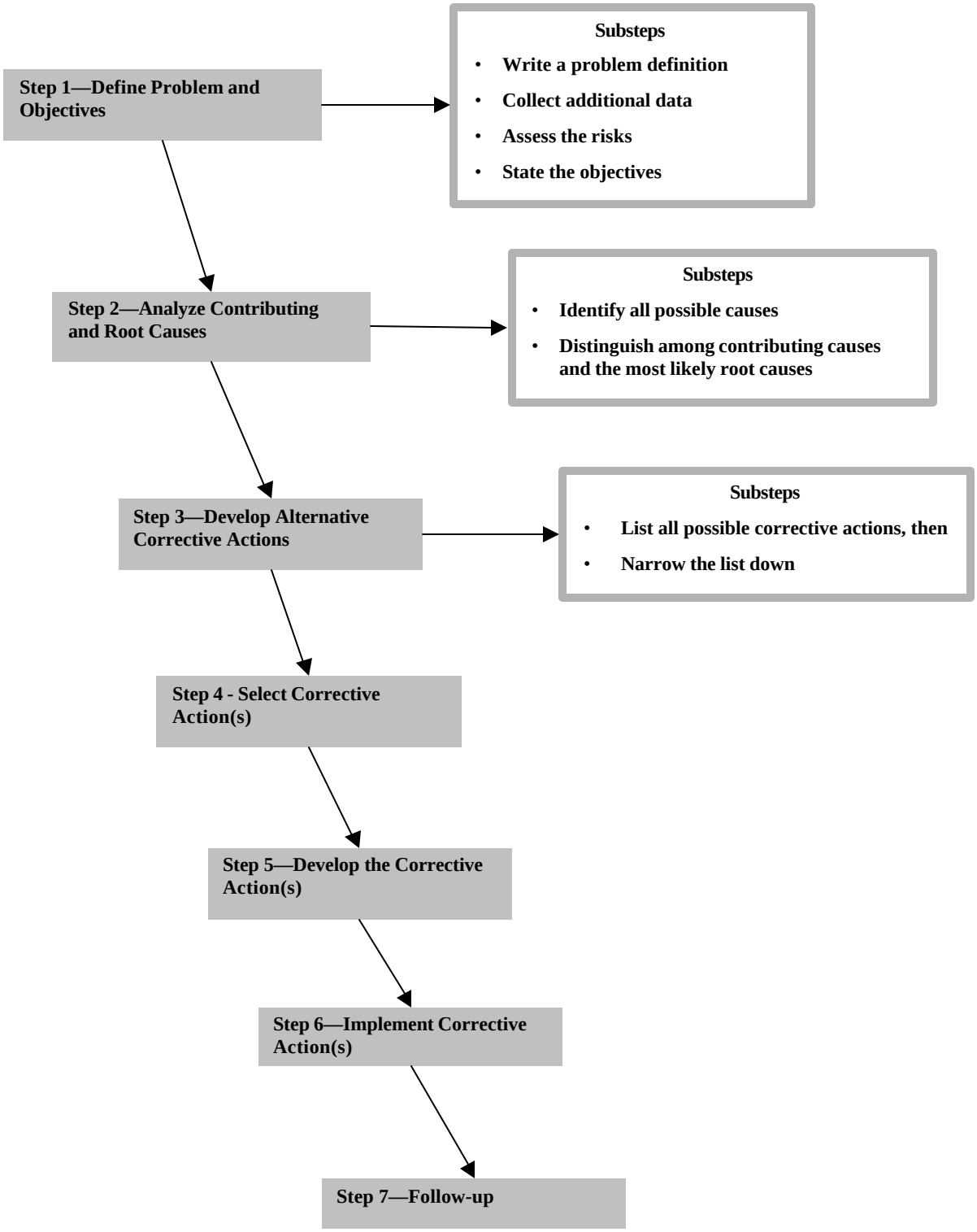

Figure 6-1: The Seven-Step Problem Solving Process

The steps, recommendations, and tools discussed in this chapter are not presented as cookbook recipes to be applied in every situation. Problem solving is a creative process and is, therefore, subject to judgment as will be discussed in Section 6.8.

Appendix E contains three case studies to illustrate the problem solving process and the documentation that might be developed while solving a high-risk compliance problem. Such documentation may be maintained within ACE software's POA&M module or it may be created and updated in traditional paper format.

6.3.1 Step 1—Define Problem and Objectives

Step 1: Process—Problem solving begins with discovery of evidence that requirements or accepted standards — the numerous regulatory and policy requirements— are not being met. Standards for the installation's environmental management system are the relevant policies and procedures documented in OPNAVINST 5090.1B and implementing base orders. Deficiencies revealed during internal or external assessments provide evidence that these standards are not being met.

Step 1 substeps are as follows:

1. Using evidence from the assessment or obtained from other sources, write a problem definition—a concise statement of the results that are not being achieved and how the situation varies from the desired results. The problem definition is a statement of facts. Do not include any assumptions about the causes or the solutions in the problem definition.
2. Collect additional data on the locations, timing, and/or magnitude of similar deficiencies, if needed, in order to adequately characterize the problem and to lay the foundation for cause analysis (see Kepner and Tregoe, 1981). Since at any one time compliance evaluations can only examine a fraction of the practices at an installation, a deficiency may only be the tip of an iceberg. Conversely, a single deficiency may be an isolated, low risk event that does not warrant problem solving.
3. Assess the risks and likely consequences of not correcting the problem permanently. Is the problem likely to lead to mission impairment or intense public scrutiny? Are significant impacts on worker health or natural resources possible, but unlikely? Assessing risks and consequences is particularly important if a number of problems are identified concurrently, so that the installation may prioritize which ones need to be addressed first.
4. Lastly, state the objectives of the problem solving exercise—the desired status after the problem is resolved. Describe the objectives quantitatively, if possible.

Step 1: Tools—An installation-wide inventory of practices with their locations and characteristics would facilitate assessment of the extent of problems.

Step 1: Recommendations—Ensure that all parties involved agree on the problem definition and objectives before proceeding.

6.3.2 Step 2—Analyze Contributing and Root Causes

Step 2: Process—Step 2 may be broken down into two sub-steps:

1. Identifying all possible causes. This sub-step deserves significant effort when previous attempts to solve a problem have been unsuccessful. Using tools mentioned below and

contributions from as many people as reasonable, this sub-step should reach beyond traditions and conventional understanding to develop new perspectives on the problem. Buried within the most unlikely causes may be the wisdom required to permanently resolve obstinate problems.

2. Distinguish among contributing causes and the most likely root causes. Root causes are those that, once corrected, will prevent recurrence of the problem. Other causes may be operating that shape or modify the frequency, location, or magnitude of the problem's symptoms. These are contributing causes. Since the root causes are the ones that guide subsequent steps, it may be easiest to classify causes that are the most readily corrected as the root causes. However, this course may not lead to the effective corrective actions. It is important, therefore, that the selection of root causes be as objective and as well informed as possible. Developing concurrence among involved parties that the root causes are clearly based on the evidence for the problem defined in Step 1 would help ensure objectivity and incorporation of relevant facts.

Step 2: Tools—

Cause and Effect Diagrams—Cause and effect diagrams, also called "Ishikawa diagrams" after the author who described them or "fishbone diagrams" because of their appearance, are a good device for identifying possible causes. As illustrated in Figure 6-2, the diagram is begun by writing out the effect, or short version of the problem, in a box. (Tables 6-1 A-D supplement Figure 6-2 by listing the root cause codes referenced in the fishbone diagram along with their associated root cause categories. The U.S. Army developed the codes and categories used in Tables 6-1 A-D.) Then identify the major categories of factors that influence the problem or effect. The branching links between major categories and the effect statement are the backbone of the fish.

The major categories of factors (or major "bones") shown in Figure 6-2 are:

- Plans and procedures;
- Training;
- Resources; and
- Management.

These categories are compatible with the Tier 1 root cause categories from the Deputy Under Secretary of Defense (Environmental Security) 23 April 1997 memorandum on Root Cause Analysis Methodology and Implementation, which could also be used for the major categories:

- Plans and Implementation;
- Training and General Awareness;
- Command Emphasis/Oversight;
- Resources; and
- Other (External Phenomena).

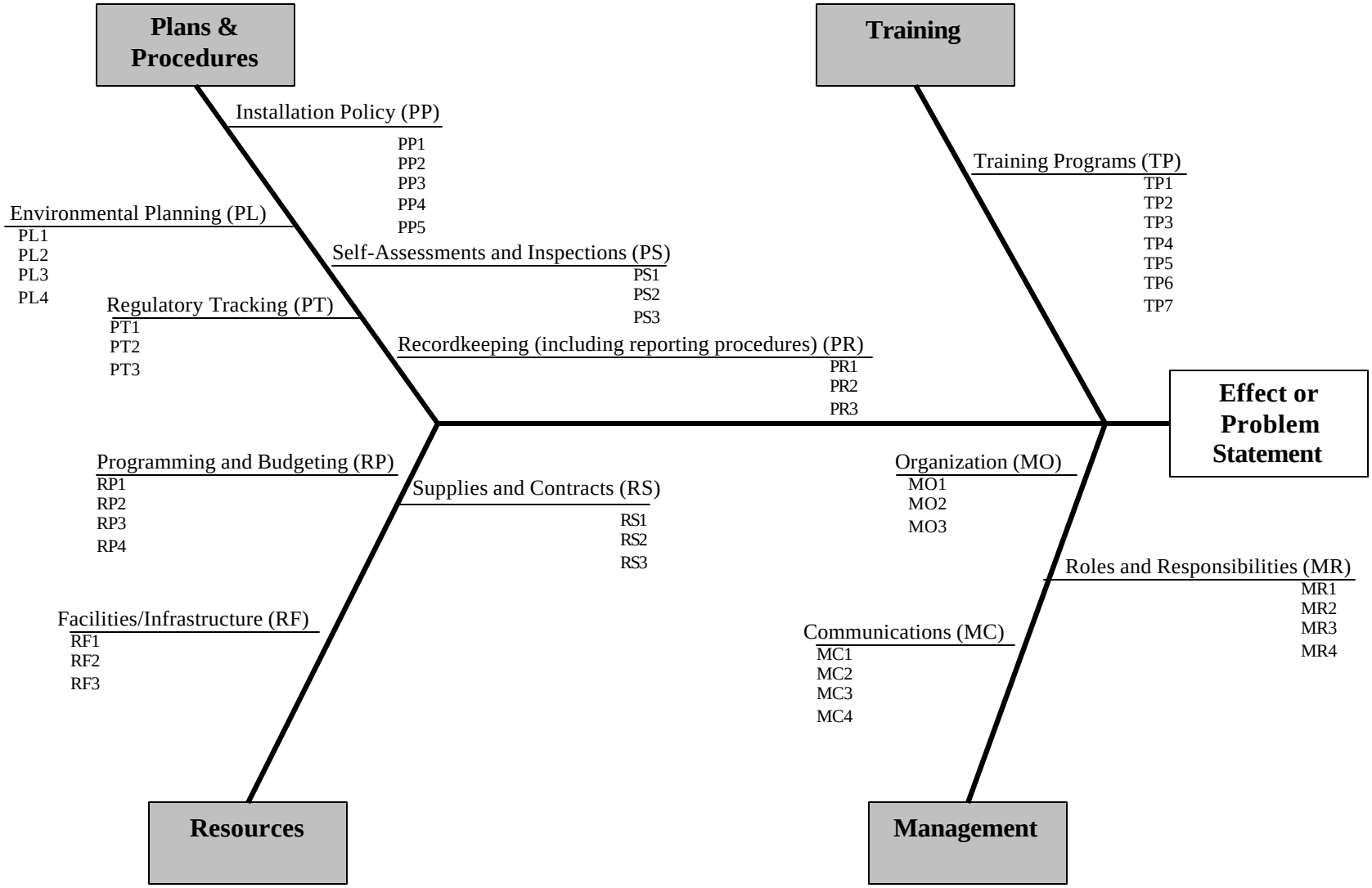

Figure 6-2: Cause and Effect Diagram Showing Possible Root Cause Categories

TABLES 6-1 A–D: ROOT CAUSE CODES DEVELOPED BY U.S. ARMY

Table 6-1a: Root Cause Codes: PLANS AND PROCEDURES (P)	
	Installation Policy (PP)
PP1	Formal policies are not issued from the appropriate level.
PP2	Existing policies conflict with environmental protection initiatives.
PP3	Formal statements of environmental goals and objectives do not exist or are inadequate.
PP4	Environmental requirements are not adequately considered when developing policies.
PP5	Environmental considerations are not adequately integrated into accomplishments of military missions.
	Environmental Planning (PL)
PL1	Environmental management plans and/or procedures are not established (e.g., HW management plans, spill plans, pesticide management plans).
PL2	Environmental management plans and/or procedures are inadequate.
PL3	System is not in place to properly coordinate the review and acceptance of new and/or updated plans and/or procedures with appropriate agencies.
PL4	Plans and/or procedures are not effective and/or properly implemented.
	Regulatory Tracking (PT)
PT1	System is not in place to track new or changing regulations.
PT2	New regulatory requirements are not being incorporated into standard operating procedures (SOPs).
PT3	Regulatory policy is misinterpreted.
	Recordkeeping (including reporting procedures) (PR)
PR1	A tracking system for key regulatory compliance deadlines (e.g.. permit renewals) does not exist or is inadequate.
PR2	Document control system and record retention procedures do not exist or are inadequate.
PR3	No formal mechanism exists to investigate, report, correct, track, or monitor environmental problems or incidents.
	Self-Assessments and Inspections (PS)
PS1	Trained or qualified professionals do not conduct assessments or inspections.
PS2	Inadequate or conflicting guidance exists for conducting internal assessments/inspections
PS3	Appropriate review and follow-up of self-assessment/inspection, execution, and results is not conducted

Table 6-1b: Root Cause Codes: RESOURCES (R)	
	Programming and Budgeting (RP)
RP1	Environmental planning does not include both short-term and long-term programming for resources (i.e., EPR).
RP2	Funds for environmentally related activities are not sufficient.
RP3	Staffing levels are not sufficient to achieve performance goals.
RP4	Strategic and long-term planning of projects with environmental impacts are inadequate or do not exist (i.e., timely awarding of contracts, NEPA documentation, etc.)
	Facilities/Infrastructure (RF)
RF1	Design is inadequate.
RF2	Error occurred in equipment or material selection.
RF3	Systems, facility, equipment, or part failure.
	Supplies and Contracts (RS)
RS1	Supplies have been ordered but have not been received.
RS2	Contract deliverables are not properly identified and/or delivered.
RS3	Control and oversight do not exist over purchased materials, equipment, and services supporting the day-to-day operations and maintenance activities.

Table 6-1c: Root Cause Codes: TRAINING (T)	
	Training Programs (TP)
TP1	Environmental Awareness Training is not provided
TP2	Personnel do not have the technical background and training to perform assigned job tasks.
TP3	Inadequate training needs analysis.
TP4	The training program is not effective.
TP5	Training activities are not documented (i.e., not on file, incomplete, or not current).
TP6	Periodic evaluations of the effectiveness of training programs are not conducted nor formally documented.
TP7	Personnel are not trained on new regulations or policies.

Table 6-1d: Root Cause Codes: MANAGEMENT EMPHASIS (M)	
	Organization (MO)
MOl	Environmental management lacks sufficient organizational stature, independence, and authority (i.e., levels within organization)
MO2	Environmental planning is not afforded the same priority as other organizational functions.
MO3	Environmental management does not participate at key strategic and operations planning meetings.
	Communications (MC)
MC1	Working relationships are ineffective within the organization.
MC2	Personnel concerns are not solicited, addressed, or documented.
MC3	The organization does not have a good working relationship with tenant organizations.
MC4	The organization does not have a good working relationship with external agencies (e.g., regulatory agencies, Major Claimant, community).
	Roles and Responsibilities (MR)
MR1	Environmental responsibilities are not clearly defined for all activities and personnel.
MR2	Environmental responsibilities are not clearly defined in the job description.
MR3	Performance standards are not included in environmental responsibilities.
MR4	Personnel activities are not held accountable for environmental performance

If most problems are traceable to the environmental management system, then the major categories might be based on the four phases of the Deming or Shewhart cycle with an initial category for organization-wide policy and commitment:

- Policy and Commitment
- Plan
- Do (Implement and Operate)
- Check (Measure and Evaluate)
- Act (Review and Improvement)

Still other categories, such as the “4 M’s” (methods/ manpower/ material/ machinery) or the “4 P’s” (policies/ procedures/ people/ plant), could be useful. Figure 6-3 illustrates these various schemes for fishbone analysis.

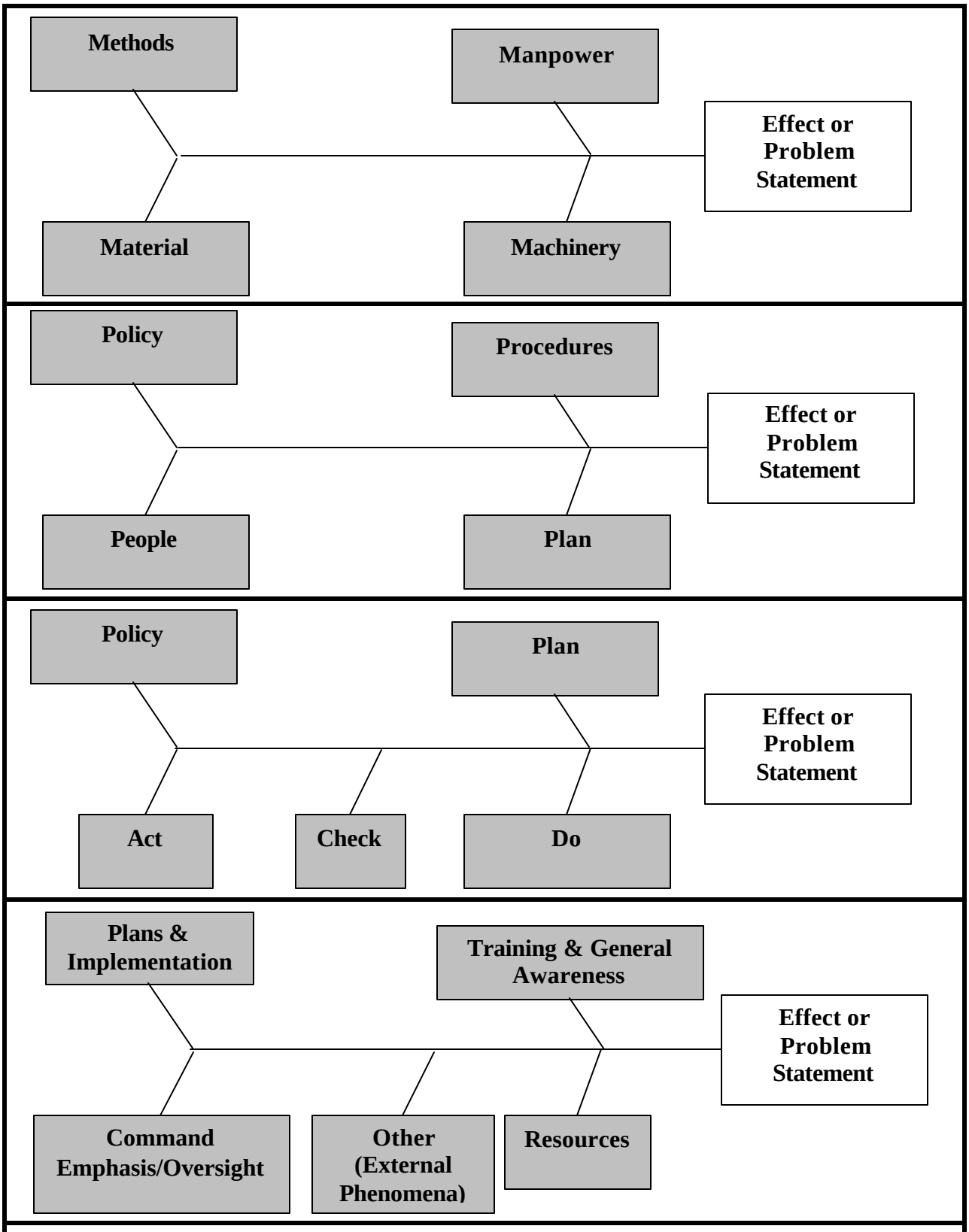

Figure 6-3: Additional Schemes for Fishbone Analysis

The problem solver then fleshes out each category with factors and sub-factors that could contribute to the observed problem. The factors and subfactors illustrated in Figure 6-2 and listed in Tables 6-1 A-D are presented for use during Navy internal and external assessments. A pre-constructed cause and effect diagram such as those in Figures 6-2 and 6-3 could be useful during assessments for guiding discussions among interested parties about possible causes, and for picking a root cause category for each deficiency.

However, a fixed list inevitably suggests causes that, although easy to identify and accept, may not accurately encompass the specific situation at hand. Therefore, constructing a cause and effect diagram should be a creative process when used as a tool during structured problem solving to determine real root and contributing causes. Start with the actual problem statement defined in Step 1 and a list of major categories such as those presented above (or any other that works). Then add factors and sub-factors that are supported by the facts at hand and that emerge from discussions with interested parties.

Brainstorming. If the permanent corrective action must be agreed to or implemented by multiple interested parties, this is a good way to get them working together. Bring all parties together and write the problem definition on a board. Ask for all ideas on what may be causing the problem, and write down all responses before beginning to analyze the validity of any response. Discussion of various brainstorming techniques may be found in any text or training materials on Total Quality Management.

The Five "WHYs?" Once a long list of possible causes has been identified, begin with the problem definition, then repeatedly ask "Why?" to pare the list down and to differentiate between root causes and contributing causes. Debate the answers until they are accepted. Like the cause and effect diagram, this tool leads the problem solver along a path defined by causality, not by tradition and intuition. Typically, asking "Why?" no more than five times will reveal the root cause.

What IS/IS NOT? Often, a deficiency could occur at numerous locations on the installation, but in fact occurs sporadically. Additional data on factors that differentiate between locations where a deficiency does and does not occur may provide ideas for causes as well as corrective actions.

Process Flow Chart. At times, cause and effect relationships that are obvious to some participants will be incomprehensible to others. To clarify and illustrate the situation where such a problem exists, construct a flow chart of the processes or activities. Building a flow chart is an excellent tool when the permanent corrective action may be a modification of parts or all of the process.

Accident/Release Investigation Tools. If the problem to be analyzed is an accident or a release of pollutants to the environment, root cause analysis methods developed by the U.S. Department of Energy (DOE) for nuclear safety may be useful. These methods include:

- Events and Causal Factor Analysis,
- Change Analysis,
- Barrier Analysis,
- Management Oversight and Risk Tree, and

- Human Performance Evaluation

These methods are described, and references for each method are listed, in DOE's *Root Cause Analysis Guidance Document*. (See reference list in Appendix B.) Each method has particular strengths depending on the specifics of the events being analyzed and the conditions at the time the events occurred. Also, cause categories, checklists, and examples provided in DOE's guidance are specific to nuclear reactor safety. However, the theories and practices on which these methods are based could be applicable to a variety of environmental compliance problems.

DOE's root cause guidance also addresses "Kepner-Tregoe Problem Solving and Decision Making" as a root cause analysis method. However, root cause analysis is but one element of Kepner and Tregoe's approach. Their theories provide the basis for the entire problem solving approach that is elaborated in this chapter.

Step 2: Recommendations—Identification of all possible causes may reveal the potential for additional problems that were not occurring or not recognized at the time of the assessment. Responsible decision makers should weigh the potential risks of not taking preventive measures to deal with the new problems. They may also want to initiate a separate problem solving exercise or deal with the issue in tandem with ongoing problem solving.

Attempts to distinguish among irrelevant, contributing, and root causes often broadens participants' perspectives on the problem; in such cases, it may be productive to redefine the problem to correspond to the improved perspective.

Trying to find one, absolute root cause is not always productive; several actions may be required to permanently correct complex compliance and management problems. In a similar vein, a contributing cause for one problem may be the root cause for another.

6.3.3 Step 3—Develop Alternative Corrective Actions

Step 3: Process—The approach for developing alternative corrective actions is similar to that for resolving causes: list all possible corrective actions, then narrow the list down.

Step 3: Tools—

Brainstorming. Use brainstorming to identify as many potential ways to correct the identified causes as possible. If brainstorming was successful in identifying the contributing and root causes, try it again, but try to keep cause analysis separate from alternative development.

Support from Others. Seek advice from the technical services available to Navy installations such as those available through the Navy Environmental Protection Support Service (NEPSS), as discussed in Section 7.2.

Step 3: Recommendations—Priority should be given to modifying or replacing the tangible components of the problem (processes, facilities, and operations) so that the mission they support might be accomplished with less cost or environmental impact. Installations' Pollution Prevention plans may provide some ideas for generating such alternatives.

Capital intensive projects requiring budget submissions are not the only solutions for most compliance deficiencies. Consider measures that deal with procedures, management systems, and people, as appropriate.

Depending on the scope of the alternatives, data collection and analysis may be needed to form a basis for comparison among the short list of alternatives.

The more obstinate or complex a problem and its causes, the more creativity should be encouraged in identifying alternatives. Include people in this step who are most familiar with the operations and facilities involved. Also, consider including people who may have a fresh perspective or have dealt with similar problems before.

6.3.4 Step 4—Select Corrective Action(s)

Step 4: Process—By the time this step is reached, the optimum, permanent solution will be obvious for all but the most complex or obstinate problems. If significant funds are involved, tradeoffs between alternatives are difficult, or other factors complicate the selection, consider applying one of the decision-making tools below.

Step 4: Tools—

Multidisciplinary Assessment. Prepare a thorough comparison of costs, benefits, environmental impacts, implementation considerations, and other significant criteria.

Benchmarking. Query other installations or Navy technical support organizations that may have dealt with similar decisions.

Group Techniques. Some problems will be permanently solved only when all parties involved agree to the solution and accept their roles in implementing and monitoring it. If several alternatives are considered feasible, but no one stands out as the best, consider group techniques such as:

- Nominal group technique—Ask each member of the group to prioritize the feasible alternatives, assign a rank to each with the highest number assigned to the most favored alternative, and use no number twice. Add all numbers for each alternative and select the one with the highest total.
- Pair-wise ranking—Pair each alternative with each of the other alternatives and, with the entire group contributing, pick the preferred one from each pair. The alternative chosen most frequently is selected.
- Multi-voting—If many alternatives remain, reduce the number by giving each member of the group half as many votes as there are alternatives. Count the votes cast for each alternative and devote continuing efforts to the alternatives with the most votes.

Step 4: Recommendations—Consensus among the parties responsible for implementation may be more important than ensuring that the perfect corrective action is selected.

If time or resources are limited and the effectiveness of available alternatives is uncertain, it may be preferable to select whatever action seems best, but agree to reexamine the problem solving record and modify the corrective action should it not work as hoped.

Consider possible unintended consequences of the preferred corrective actions. Many problems are the result of prior solutions and decisions. If you have reached this point and have considered only the problem as stated, ask, for example, whether the leading alternative is going to require more manpower than will be available or if any delay in receiving funds for a

constructed solution would impact the mission. At a minimum, ask the interested parties if they can foresee any unintended consequences of the preferred actions.

An optional verification step following the selection may be needed if consensus among the interested parties is not achieved or uncertainty about the effectiveness of the selected actions remains. Implement one or more of the corrective actions on a trial basis and test the results.

6.3.5 Step 5—Develop the Corrective Action(s)

Step 5: Process—Many corrective actions require the participation of several parties. Success of such corrective actions depends on clear definitions of tasks, responsibilities, resource requirements, and schedules. Prepare a plan for both implementation and follow-up to ensure communication and to maximize cooperation. The plan should address contingencies if the results of the overall solution or of specific tasks are uncertain. If the structured problem solving process has been followed and documented, it should be easy to identify contingencies.

Also consider the need for information collection and following corrective action implementation.

6.3.6 Step 6—Implement Corrective Action(s)

Ensure that all parties understand the desired results and their responsibilities in obtaining them.

Carry out the corrective actions.

6.3.7 Step 7—Follow-Up

Corrective actions are seldom entirely foolproof. Measures to monitor the effectiveness of corrective actions and responsibilities for doing so should have been specified in Step 5. Do the results meet the objectives set in Step 1 of the problem solving process?

The installation should modify its Internal Assessment Plan to incorporate any new or revised inspections or other monitoring methods specified in the corrective action plan.

Implement contingency plans or revisit the problem solving record if necessary.

6.4 The Role of Intuitive Methods

Not every deficiency discovered during internal or external assessments justifies the full, structured problem solving process.

Certainly, some deficiencies are isolated events or have so little risk associated with them that "fixing the symptom" immediately, and devoting the time that would be otherwise used in problem solving to monitor the situation, is the best use of resources.

The causes and corrective actions for some other deficiencies are so obvious that, even if each of the problem solving steps are considered, the entire process requires very little time or discussion. In such cases, an intuitive approach to problem solving may be applicable. For example, the first two steps of the problem solving process may be condensed to the point of just guessing the deficiencies' most likely causes. This is something that evaluators might accomplish on site using a generic fishbone diagram to prompt cause and effect discussions with the representatives of owning units and/or environmental management offices. Similarly,

corrective action selection, implementation, and follow-up are still required, but might be similarly abbreviated, depending on the judgment of the parties involved.

6.5 Application of Structured and Intuitive Problem Solving

Structured problem solving, including documentation of each step and coordination among all interested parties at each step, should be applied in at least the following cases:

- If the deficiency would expose the installation to fines or other penalties if observed by a regulatory agency;
- If releases to the environment that are not allowed or that exceed permit limits could occur as a result of the deficiency;
- If adverse environmental or human health impacts could occur as a result of the deficiency;
- If similar deficiencies were observed at multiple locations aboard the installation or are suspected of occurring repeatedly;
- If the deficiency was found in a previous compliance evaluation; or
- If statistical analysis of root cause categories or an EMS assessment reveals a systemic management problem.

Where the above conditions do not apply, intuitive problem solving may be appropriate. Each of the seven problem solving steps should be considered. However, depth of analysis, the amount of coordination among the interested parties, and the volume of documentation could be less than for more serious problems. Individual steps may be designated for more formal analysis, documentation, or coordination if needed to permanently resolve the problem.

For all deficiencies, evaluators should make the best root cause categorization possible within the time constraints of the evaluation, then propose the categorization to the environmental management office and, if applicable, the owning unit. If there is agreement on the cause, then everyone involved should discuss the corrective action to be recommended by the evaluator in the POA&M.

Documentation of all problem solving exercises, whether structured or intuitive, is essential to the goal of achieving permanent solutions. In the event that a corrective action is not effective, documentation will permit a review of what was tried previously and on what basis it was selected. The POA&M function in the ACE software provides text fields that may be used for documentation of all problem solving facts and decisions. These fields are useful for both external and internal evaluators. Establishing and maintaining traditional paper documentation of problem solving decisions is also an option. In either case, the record should be initiated as soon as a problem is defined, and it should be updated as progress is made in solving the problem.

6.6 Statistical Analysis of Causes

Evaluators and installation personnel can increase the value of root cause categorizations by statistical analysis. Categories that are identified repeatedly, even for low-risk deficiencies, may deserve special attention for problem solving.

Complex mathematical techniques are not required for such an analysis. What is needed is the complete list of all root cause categories that have been identified over some defined period of time—for instance, a year's worth of self-audit inspections or the results of an intensive, installation-wide external compliance assessment. Do not bias the list by excluding either poorly substantiated or highly documented causes. It may even be appropriate to include causes that were judged to be contributing, but not root, causes. Count the number of deficiencies associated with each root cause category, then concentrate on the categories that were identified most frequently. Review of the most frequently assigned categories could indicate systemic problems that may not be revealed by structured problem solving of individual, high-risk deficiencies. Once revealed by this statistical form of root cause analysis, significant problems should be subjected to structured problem solving.

Figure 6-4 illustrates how root cause categorizations may be graphically portrayed to facilitate interpretation of the root cause statistics. In this hypothetical example, categories represented most frequently were related to management of the environmental program. Some causes in this group might result in high-risk deficiencies that may have been related only to minor deficiencies at the time they were observed.

Statistical analysis of causes benefits from standardized, clearly defined lists of causes. Standardization improves consistency of categorization and comparability of results. However, as noted in Section 6.3, structured problem solving depends on detailed, situation-specific analysis of causes. Standardized lists of causes, presented in fishbone diagrams or tiers, can be a useful starting point to foster discussion. Strict adherence to a predefined list of causes, however, should remain in the realm of intuitive problem solving and statistical analysis of causes.

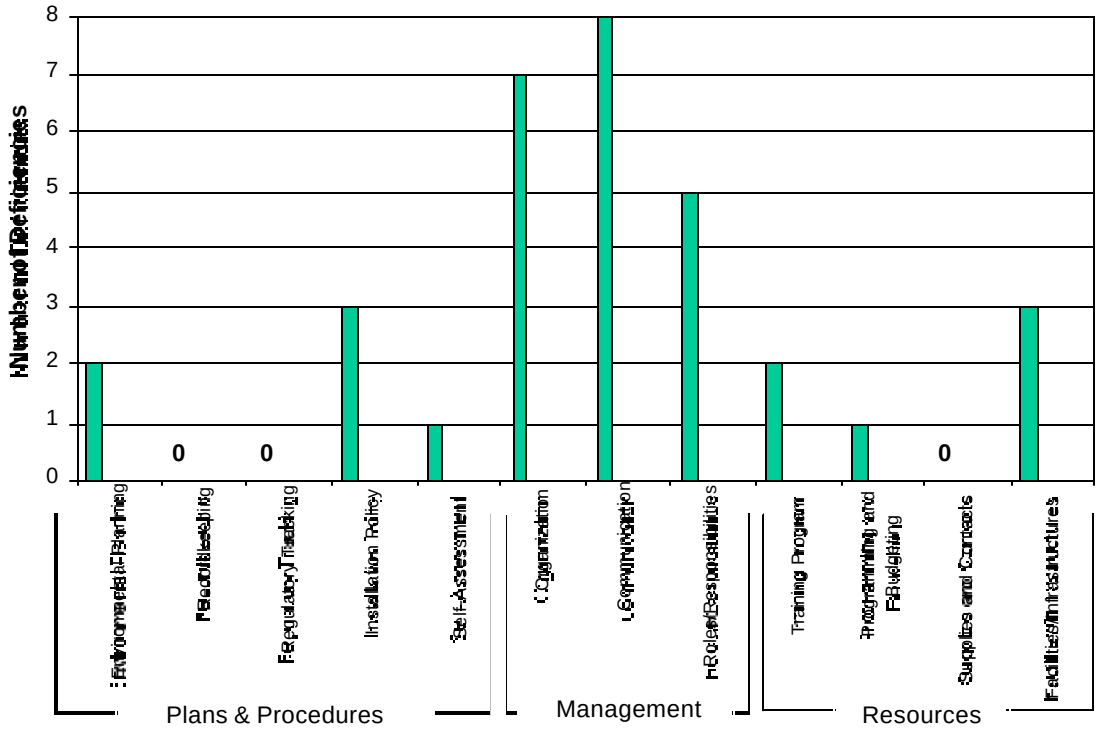

Figure 6-4: Histogram of Hypothetical Audit Findings Illustrating Statistical Root Cause Analysis

6.7 Roles and Responsibilities

A characteristic of many environmental problems on military installations is that several offices or units have an interest. The unit that "owns" the process, facility, or operation that is the source of a problem has an interest in continuing to fulfill its mission. The environmental management office has an interest in maintaining compliance with requirements. The installation's or owning unit's financial and manpower offices have an interest in corrective actions that require additional resources. The installation's Public Affairs office and the Installation Commander have an interest if the problem could impact off-installation environmental media or citizens.

To the extent that multiple interests in an environmental problem are not identified and considered during problem solving, solutions that otherwise appear to be permanent may come undone. Providing interested parties with opportunities to comment or participate in problem solving may avoid later interference.

At a minimum, the installation's environmental management office will be involved. This office, which provides environmental services to all other units, may be directly responsible for some facilities and operations such as hazardous waste tracking, storage, and disposal; and cultural and natural resource management. The environmental management office typically conducts compliance evaluations and hosts external assessments, and in most cases is the logical choice to provide the technical, coordination, and documentation functions required for problem solving.

Many other practices are not "owned" by the environmental management office, but are the immediate responsibility of other units, including tenants. Problem solving must be the ultimate responsibility of the unit owning the practice that is the source or location of a compliance deficiency. Practice owners should, at a minimum, be party to all decisions made during the problem solving process.

External evaluators, by definition, are independent of the parties responsible for the problem. They may have an oversight role, but will seldom have sufficient time on site to be responsible for problem solving. External evaluators can provide a service in identifying deficiencies, defining problems, and picking presumptive root cause categories, but should not be responsible for the effectiveness of corrective actions or decisions leading up to their implementation.

6.8 Use of Judgment

Even the most rigorous application of structured problem solving relies to some degree on the judgment exercised by the involved parties. The keener the judgment and the sounder the evidence developed at each step, the more likely that the selected corrective action will be the expected permanent solution. Structured problem solving can be seen as a means of organizing judgments, validating them with evidence, and communicating them among responsible parties.

By contrast, intuitive problem solving relies mostly or entirely on judgment. At the extreme, individuals jumping to conclusions with little evidence and no experience in structured problem solving run the greatest risk of wasting time and resources on ineffective corrective actions.

The key to using judgment is deciding when and how much to bolster it with:

- An organized approach;
- Additional evidence for validating decisions at particular steps;
- Input from additional people who have an interest in the final results; and
- A commitment to follow up on corrective actions.

One of the benefits of structuring the problem solving process is gaining a new perspective so that past, unsuccessful solutions are not repeated. If problem solvers limit problem solving exercises to comfortable, traditional approaches, then this new perspective, and opportunities to discover permanent solutions, may be lost.

6.9 Resources

The reader who may be tasked to implement the suggestions made in this section should seek additional sources of information and insight. Appendix B lists selected sources with brief comments on their content.

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