Environmental Indicators
in the
Colorado Department of Public Health and Environment

Executive Summary

The Colorado Department of Public Health and Environment (CDPHE) is continuing to develop and implement a Results-Based Management System for the environmental programs as a key lynchpin for the Department's Strategic Plan for the Environment. Results-based management depends on a progressive environmental indicator program for measuring success.

Investigation and research was conducted into environmental indicators, and four alternative approaches were evaluated for use by the three main environmental divisions in CDPHE. Recommendations for implementing a revised approach or bolstering current indicator usage included the following:

1. Eliminate environmental indicator types. The distinctions among types of indicators (cause/operational, environmental condition, response/management) are not currently used and appear to offer little benefit.

2. Place a high priority on improving and integrating the water quality data systems. The current systems do not appear to be supportive of relating actual information to performance measurement and constitute a (real or perceived) barrier to communications around performance measurement.

3. Choose one of the following:

> **3.a If a meaningful linkage among goals, objectives, indicators, activities and performance measurement is desired, implement Alternative 4.** Test the Alternative 4 table by having it completed by division staff, and determine what CEPPA-specific requirements are not met. Evaluate existing division work plans (separate from CEPPA) to see if missing CEPPA needs could be addressed there.
>
> **3.b If the existing tenuous linkage is acceptable, keep the existing CEPPA structure and add environmental indicators by implementing Alternative 2 as a separate document**.
>
> **3.c Use a non-structured environmental indicator approach**. Give up the idea of formal environmental indicators tied to program logic, but select indicators from available environmental measurements.

Additional steps are included in the recommendations section.

TABLE OF CONTENTS

Appendices

List of Tables

Environmental Indicators
in the
Colorado Department of Public Health and Environment

Purpose

The Colorado Department of Public Health and Environment (CDPHE) is continuing to develop and implement a Results-Based Management System for the environmental programs as a key lynchpin for the Department's Strategic Plan for the Environment. Results-based management depends on a progressive environmental indicator program for measuring success.

This report describes the viability of the environmental indicator approach and proposes alternative implementation strategies.

Background

CDPHE Experience

CDPHE has attempted to address environmental indicators as performance measures numerous times in the past. These efforts resulted in changes to reporting structure and measurement protocols, but have not been comprehensively addressed across the environmental divisions. The environmental divisions include the following:

Air Pollution Control (APCD)
Hazardous Materials and Waste Management (HMWMD)
Sustainability Program
Water Pollution Control (WPCD)
Consumer Protection (CPD)

Environmental indicators were investigated by the Department in the early 1990s. As national attention focused on indicators and performance measurement, another round of work occurred in the mid-90s. By the late 90s, EPA and states had formulated the National Environmental Performance Partnership System (NEPPS), which provided the states a performance-based structure for EPA environmental grant planning and reporting. The seven principle components of this system are:

- Increased use of environmental goals and indicators
- New approach to program assessment by states
- Environmental performance agreements
- Differential oversight of programs by EPA
- Performance leadership programs
- Public outreach and involvement
- Joint system evaluation

Conceptually, NEPPS supports the use of demonstrable linkages between program activities, program direction and measurable environmental results.

Subsequent to the NEPPS process, CDPHE has evaluated various ways to continue to integrate performance measurement, environmental monitoring, and program planning and budgeting. In 1998 and 1999, the Department convened the Change Task Force to develop performance measures and environmental indicators through a stakeholder process. In 2002, the Envision process resulted in a Results-Based Management System and Environmental Indicator Model. The Results-Based approach is shown in the figure below:

Meanwhile, on an annual basis, the Performance Partnership Agreement is used to structure work planning and reporting for EPA-funded activities. Annual negotiations between the state programs and EPA explore mechanisms for meeting EPA-directed program requirements.

State of the Art

The concept of environmental indicators has been the subject of much study over the last decade. Academic, governmental and private organizations have contributed to the knowledge base for developing and using indicators to measure environmental quality. More recently, the environmental focus has shifted to a broader view of sustainability and quality of life that includes environmental measures as one component.

Broadening of the approach has introduced significant academic and process components, previously found primarily in the management and economics realms. This has allowed the development of more complicated and data dependent systems that are not easy to support within the narrow confines of most state environmental programs. However, the concept of measuring the performance of environmental regulatory programs though changes in environmental measures has spread internationally, and such programs are now common from Australia to Kiev and Canada to Namibia.

Concurrently, state environmental programs have tended to drift away from the exploration of innovative environmental measurement systems and fall back on the basic EPA-required structure. Compilations made in the mid-90s showed the majority of state programs investigating environmental indicators; however, by the turn of the millennium, many of the state programs had suffered from budget constraints and the need to focus on very program-specific actions rather than complex planning processes. Appendix 1 lists web addresses for state programs identified with indicator efforts.

Indicators In Use

A common element to most environmental indicators is the ease of data collection and reporting. As a result, the indicators in use tend to be similar for each media. Indicators are proposed to meet the following criteria:

- relevant (able to show you something about the system that you need to know,
- easy to understand, especially by people who are not the experts,
- reliable, so the information the indicator provides is trustworthy, and
- timely, so the information is available while there is still time to act.

EPA has established a national set of indicators in the June 2003 Report on the Environment. The indicators compiled in this report are shown in Table 1. This comprehensive list is far beyond what most state environmental programs could routinely compile and track, but does reflect a broad national perspective on potential indicators. In addition, the logic between some specific indicators and environmental improvement is not explicit.

EPA also uses the NEPPS core performance measures as a basis for planning and budget negotiations with state environmental programs. As stated in the 1997 *Joint Statement on Measuring Progress under NEPPS*, "Beyond core performance measures, there are other program output and fiscal reporting requirements we must use to document our various program activities." States are expected to continue reporting this routine program and fiscal tracking information. At the same time, states and EPA Regions are encouraged to work together to review the value and cost of these data exchanges and eliminate low-priority reporting. The measures identified in these negotiations for 2000 are shown in Table 2.

Table 1 Indicator Summary

EPA's Draft Report on the Environment, June 2003

Cleaner Air

Outdoor Air Quality

- Number and percentage of days that metropolitan statistical areas have Air Quality Index values greater than 100
- Number of people living in areas with ozone (8-hour) and particulate matter (PM2.5) levels above the NAAQS
- Ambient concentrations of ozone, 8-hour
- Ambient concentrations of particulate matter (PM2.5)
- Visibility
- Deposition: wet nitrogen and wet sulfate
- Ambient concentration of selected air toxics
- Emissions of particulate matter, sulfur dioxide, nitrogen oxides, and volatile organic compounds
- Lead emissions
- Air toxics emissions
- Emissions (utility): sulfur dioxide and nitrogen oxides

Indoor Air Quality

- US homes above EPA's radon action levels
- Percentage of homes where young children are exposed to environmental tobacco smoke

Global Issues

- Ozone levels over North America
- Worldwide and US production of ozone-depleting substances

Purer Water

Waters and Watersheds

- Water clarity in coastal water
- Dissolved oxygen in coastal waters
- Benthic Community Index (coastal)
- Wetland extent and change
- Sources of wetland change/loss
- Altered freshwater ecosystems
- Percent urban land cover in riparian areas
- Agricultural lands in riparian areas
- Changing stream flows
- Atmospheric deposition of nitrogen
- Nitrate in farmland, forested, and urban streams and ground water
- Total nitrogen in coastal waters
- Phosphorous in farmland, forested, and urban streams
- Total phosphorous in coastal waters
- Phosphorous in large rivers
- Atmospheric deposition of mercury
- Chemical contamination in streams
- Sediment contamination of inland waters
- Sediment contamination of coastal waters
- Pesticides in farmland streams and ground water
- Toxic releases to water of mercury, dioxin, lead, PCBs, and PBTs

Table 1 (cont'd)

Drinking Water

Population served by community water systems that meet all health-based standards

Recreation on and in the water

Number of beach days that beaches are closed or under advisory

Consumption of Fish and Shellfish

Percent of river miles and lake acres under fish consumption advisory

Contaminants in fresh water fish

Number of watersheds exceeding health-based national water quality criteria for mercury and PCBs in fish tissue

Better Protected Land

Land Use

Extent of developed lands

Extent of urban and suburban lands

Extent of agricultural land uses

Extent of grasslands and shrublands

Extent of forest area, ownership and management

Chemicals in the Landscape

Quantity and type of toxic substances released and managed

Agricultural pesticide use

Fertilizer use

Pesticide residues in food

Potential pesticide runoff from farm fields

Risk of nitrogen export

Risk of phosphorous export

Waste and Contaminated Lands

Quantity of municipal solid waste (MSW) generated and managed

Quantity of RCRA hazardous waste generated and managed

Quantity of radioactive waste generated and in inventory

Number and location of municipal solid waste (MSW) landfills

Number of RCRA hazardous waste management facilities

Number and location of Superfund national priority list sites

Number and location of RCRA corrective action sites

Human Health

Health Status of the US

Life expectancy

Cancer mortality

Cancer incidence

Cardiovascular disease mortality

Cardiovascular disease prevalence

Chronic obstructive pulmonary disease mortality

Asthma mortality

Asthma prevalence

Cholera prevalence

Cryptosporidiosis prevalence

E. coli O 157:H7 prevalence

Hepatitis A prevalence

Salmonella prevalence

Typhoid fever prevalence

Table 1 (cont'd)

Shigellosis prevalence

Environmental Pollution and Disease

Blood lead level
Cardiovascular disease mortality
Chronic obstructive pulmonary disease mortality
Cholera prevalence
Typhoid fever prevalence

Measuring Exposure to Environmental Pollution

Blood lead level
Blood mercury level
Blood cotinine level
Urine organophosphate level to indicate pesticides

Ecological Condition

Landscape Condition

Extent of ecosystem/land cover types (forests, farmlands, urban/suburban, grasslands/shrublands, fresh waters, coasts and oceans)

Biotic Condition

At-risk native species
Benthic Community Index
Population trends of invasive and native non-invasive bird species
Tree condition

Chemical and Physical Characteristics

Nitrate levels in streams by ecosystems

Ecological Processes

Terrestrial Plant Growth Index
Movement of nitrogen

Hydrology and Geomorphology

Changing stream flows
Soil erosion

Natural Disturbance Regimes

Forest disturbances: fire, insects and disease

Ecological Conditions as an Environmental Result

(no indicator specified, system approach recommended)

Table 2 FY 2000 NEPPS Core Performance Measures

WASTE

Subject Area: Enforcement and Compliance Assurance

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
	1. Environmental and/or public health benefits achieved through concluded enforcement activities (e.g., case settlements, injunctive relief, etc.)[1] 2. Rates of significant noncompliance for selected regulated populations.[2] 3. Percentage of significant non-compliers (SNCs) that have been returned to compliance or otherwise addressed.[3] 4. Results of using State alternative compliance approaches (e.g., audit laws or policies, small business compliance policies, XL projects) and compliance assistance.[4]	5. Total number of inspections conducted at major facilities, and the percent of total universe of regulated sources inspected in negotiated priority areas (e.g., industry sectors, geographic areas).[5] 6. Enforcement actions[6] (e.g., case referrals, orders, notices) taken, by media.[7] 7. Number of facilities/entities reached through each type of compliance assistance activity.[8]

Notes/Comments:

1. *Pilot measure:* Volunteer states will be sought to participate with EPA in pilot test use of Case Conclusion Data Sheet or comparable approaches to analyzing benefits achieved from enforcement activities.
2. All states continue to provide facility-specific compliance information through automated data systems. Volunteer states will be sought to participate with EPA in development of statistically valid compliance rates.
3. All states continue to provide facility-specific compliance information through automated data systems.
4. *Pilot measure:* Volunteer states will be sought to provide EPA with data on evaluation of the results of compliance incentives and compliance assistance efforts. Provide narrative description of alternative compliance approaches.
5. All states continue to report facility-specific data through automated data systems. Negotiate means for reporting information on inspections of facilities not covered by current data systems.
6. The question of whether this term should be enforcement activity or actions was submitted to the ECOS Compliance Committee and full membership in February 1999. Receiving no feedback, the change was made to the more clearly defined term, enforcement actions.
7. All states continue to provide facility-specific compliance information through automated data systems.

8. *Pilot measure:* Volunteer states will be sought to participate with EPA in pilot to provide data on compliance assistance activities. Describe any current reporting a pilot State does on compliance assistance activities.

Waste Management, Underground Storage Tank and Remediation Programs

- Measures to be further defined/clarified by ASTSWMO during Spring/early Summer of 1999
- Measures shown below represent one category of measures--recommended mandatory core performance measures developed by the ECOS-EPA Design Team. The Design Team also proposed two other categories of measures--negotiable measures and state initiative measures--that are not presented here because they would be voluntary. Please contact Ron Hammerschmidt (tel. 785/296-1535) or Roger Kanerva (tel. 217/785-5735) to obtain a copy of the complete package.

Subject Area: Prevention

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
None.[1]	None.[1]	None.[1]

Notes/Comments:

1. While the ECOS/EPA Waste Measures Design Team believes that this is an important area in which to measure performance, no national CPMs have been proposed. The Design Team did propose potential negotiable (voluntary) and/or state-specific measures to measure prevention.

Subject Area: Safe Management

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
	1. Percent of hazardous waste managed at Treatment, Storage, and Disposal Facilities (TSDFs) with approved controls in place.[1] 2. Percent of Underground Storage Tanks (USTs) meeting requirements.[2]	

Notes/Comments for Safe Management

1. Proportion of hazardous waste (HW) being managed at regulated facilities confirmed to meet applicable requirements. (Universe covered, inspection cycles, and confirmation criteria specified by authorized state programs.)
   Covers HW streams as reported by state into the Resource Conservation and Recovery Information System (RCRIS) and Biennial Reporting System (BRS).

Includes facilities with operating permits, post-closure permits or operating under a state or federal order. Includes boilers and industrial furnaces that burn hazardous waste.

2. Requirements for leak detection and upgrade requirements in each state.
   Numbers of Underground Storage Tanks (USTs) reported.

Subject Area: Cleanup

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
	3. Resource Conservation and Recovery Act (RCRA) Corrective Action sites (area) cleaned up.[1] 4. National Priority List (NPL) sites (area) cleaned up.[2]	5. Leaking Underground Storage Tank (LUST)/UST cleanup site status.[3]

Notes/Comments:

1. Area (e.g., acres), as determined by State, for high priority sites that need no further action beyond operation/maintenance.
2. Area (e.g., acres), as determined by State, for sites that need no further action beyond operation/maintenance.
3. Status covers number of confirmed releases, number of cleanups intitiated, and number of cleanups completed, as reported by each state.

Subject Area: Environmental/Public Health Impacts

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
6. Groundwater releases controlled.[1]	7. Human exposures controlled.[1]	

Notes/Comments:

1. At RCRA Corrective Action sites designated as high priority for RCRIS reporting as of 12/98.
   At NPL sites as documented by each state or EPA.

WATER

Subject Area: Protection of Public Health

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
1. Number of: a) community drinking water systems and percent of population served by community water systems, and b) non-transient, non-community drinking water systems, and percent of population served by such systems, with no violations during the year of any federally enforceable[1] health-based standard.	2. Estimated number of community water systems (and estimated percent of population served) implementing a multiple barrier approach[2] to prevent drinking water contamination.[3]	3. Percent of river miles and lake acres that have been assessed for the need for fish consumption advisories and compilation of State-issued fish consumption advisory methodologies, as reported through the National Listing of Fish and Wildlife Advisories.

Notes/Comments

1. EPA will develop language clarifying meaning of "federally enforceable," i.e., includes more stringent State standards.
2. EPA and States will expeditiously define "multiple barrier approach". ECOS will adopt this measure only upon agreement to the definition by the ECOS Water Committee.

Subject Area: Protection of Ecological Health, Protection of Public Health

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
4. Number and percent of assessed river miles, lake acres, and estuary square miles that have water quality supporting designated beneficial uses, including, where applicable, for: a) fish and shellfish consumption; b)	5. Number and percent of impaired, assessed river miles, lake acres, and estuary square miles that a) are covered under Watershed Restoration Action Strategies, and b) were restored to their designated uses during the reporting period. (The reporting period is two years.)	6. The TMDL status for each State, including: a) the number of TMDLs identified on the 1998 303(d) list that the State and EPA have committed to produce in the two year cycle; b) the number of TMDLs submitted by the State to EPA; c) the number of State-established TMDLs

recreation; c) aquatic life support; d) drinking water supply. (The reporting period is two years.)		approved by EPA; and d) the number of EPA-established TMDLs. (This cumulative measure would be jointly reported by EPA and the State.)

Subject Area: Reduction of Point Source and Non-point Source Pollutant Discharges

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
	7. Percent of POTWs that are beneficially reusing all or a part of their biosolids and, where data exists, the percent of biosolids generated that are beneficially reused.	8. Number and percent of facilities that have a discharge requiring an individual permit: a) that are covered by a current individual NPDES permit; b) that have expired individual permits; c) that have applied for but not been issued an individual permit, and d) that have individual permits under administrative or judicial appeal. 9. Number of storm water sources associated with industrial activity, number of construction sites over five acres, and number of designated storm water sources (including Municipal Phase I) that are covered by a current individual or general NPDES permit. 10. Number of permittees (among the approximately 900 CSO communities nationwide) that are covered by NPDES permits or other enforceable mechanisms consistent

		with the 1994 CSO policy. 11. Number and percent of approved pretreatment programs audited in the reporting year. Of those, the number of audits finding significant shortcomings and the number of local programs upgraded to achieve compliance. 12. EPA will report to Congress on the pace of the Clean Water State Revolving Fund (CW SRF) Program. (EPA and States are working to develop an outcome measure for the CW SRF.) 13. Number of EPA approvals of State submitted upgraded Nonpoint Source Programs (incorporating the nine key elements outlined in the national *Nonpoint Source Program and Grants Guidance for FY 1997 and Future Years* jointly transmitted by EPA and ASWIPCA).

AIR

Air and Radiation Programs

Subject Area: Improve air quality for Americans living in areas not meeting the National Ambient Air Quality Standards (NAAQS)

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
1. Trends in ambient air quality for each of the criteria pollutants (NAAQS).	2. Emission reductions since 1990 for each of the criteria pollutants (NAAQS) 3. Number of nonattainment areas (and their associated populations) that reach attainment for each of the criteria pollutants (NAAQS), including the number of ozone nonattainment areas that meet the one-hour ozone standard.	4. Redesignation of areas attaining the current NAAQS, revocations of the PM 10 and one-hour ozone NAAQS for areas attaining them, and designations of areas for the new ozone and revised PM10 NAAQS.

Subject Area: Reduce air toxic emissions and health risks [2]

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
5. Trends in emissions of toxic air pollutants as reflected in EPA's National Toxics Inventory.	6. Reduction in air toxic emissions from 1990 levels. [3]	7. State progress in collecting and compiling ambient and emission source data for toxics to better understand the nature and extent of the air toxics problem

Subject Area: Improve indoor Quality [4]

Core Environmental Indicator	Core Program Outcome Measure	Core Program Output Measure
8. Estimated increase in the number of people experiencing healthier indoor air in residences and schools.	9. Number of homes with elevated radon levels that are fixed. (EPA will estimate the number of effected people.)	10. Number of homes tested for radon.

Associated Reporting

- Air quality and emissions data such as that currently reported to AIRS/AFS
- Number of operating and major NSR permits issued
- Number of PM2.5 ambient monitoring sites deployed
- Percentage of total MACT standards for major sources that have been promulgated by EPA
- Percentage of promulgated MACT standards for major sources implemented
- Number of continuous emissions monitoring audits completed (needed to verify the accuracy of the program outcome). On a voluntary basis, share with EPA the results of any State oversight of sources with CEMS, in order to verify the accuracy of reported emissions (more than just audits).
- On a voluntary basis, share with EPA the results of any analyses of environmental monitoring data (deposition, surface water, ecological) conducted by the State. This information will enhance the ability of EPA to report on the environmental indicator.

Footnotes:

1. As stated in the 1997 *Joint Statement on Measuring Progress under NEPPS*, "Beyond core performance measures, there are other program output and fiscal reporting requirements we must use to document our various program activities." States are expected to continue reporting this routine program and fiscal tracking information. At the same time, States and EPA Regions are encouraged to work together to review the value and cost of these data exchanges and eliminate low-priority reporting.
2. New investments in data collection, management, quality assurance and reporting could be anticipated for risk reduction, human health and ecological effects measures.

3. 1990 is the baseline data made public as part of the Cumulative Exposure Project. The ECOS Air Committee will work with EPA's Office of Air and Radiation to determine how to present the 1990, 1993 and 1996 data sets. This work may point to a better baseline year, which could lead to a modified measure in the future.

4. Air Core Performance Measures #8, #9, #10, dealing with indoor air and radon, are usually outside the responsibility of state environmental agencies and, therefore, ECOS takes no position on these measures.

This page intentionally left blank.

EPA also requires reporting of progress towards Government Performance and Results Act (GPRA) Goals, which may be included in the Performance Partnership Agreement between the state and EPA. GPRA Goals are shown in Table 3.

One outcome of the structure provided by EPA and the reliance on available data is relative consistency among states as to the environmental indicators and performance measures used. Table 4 shows a compilation of state indicators by media, and additional details are shown in Appendix 2.

Colorado reports on a wide variety of performance measures, but has designated a small number of environmental indicators, as shown below:

Clean Air

- Maintain trend of National Ambient Air Quality Standards (NAAQS) improvements and maintain trends of increasing number of "good" days as measured by the Air Quality Index (AQI) level
- Number of days the visibility standard is exceeded in Denver
- Annual increase in Vehicle Miles traveled (VMT) in the Denver metro area

Clean Water

- Number of public water systems experiencing various types of MCL violations (including filtration requirements under the surface water treatment rule)
- Percent of streams supporting designated uses
- Percent of lakes supporting designated uses

Hazardous Waste

- Hazardous waste compliance rates and return to compliance after enforcement
- Continuing progress at remediation sites
- Decreased toxic releases (based on TRI Report)

These indicators are not identified as to type of indicator (described in a subsequent section), and their utility for directing program activities has been questioned during interviews for this report, as discussed below. CPD measures were excluded from this study due to their complexity.

Table 3 Government Performance and Results Act (GPRA) Goals Established by EPA

Air and Radiation

1. Number of nonattainment areas that meet the one-hour ozone standard (in GPRA as APG)
2. Number or areas redesignated attainment for the one-hour ozone standard (in GPRA as APM)
3. Number of areas maintaining attainment for the one-hour ozone standard (in GPRA as APM)
4. Number of areas that have the one-hour standard revoked (in GPRA as APM)
5. Areas designated for the new PM2.5 NAAQS (In GPRA as APM)
6. Number or areas redesignated for the new PM2.5 NAAQS (in GPRA as APM)
7. Number of areas maintaining the new PM2.5 NAAQS (in GPRA as APM)
8. Nationwide air toxics emission reductions from stationary and mobile sources combined, from 1993 levels (in GPRA as APG & APM)
9. Obtain data for building the year 20__ national toxics inventory (APM)
10. Students/staff experiencing improved Indoor Air Quality in schools (APM)
11. Number of people living in radon-mitigated homes (APM)

Water

1. Population served by community water systems with no violations during the year of any federally enforceable health-based standards that were in place by 1994
2. Population served by non-transient, non-community drinking water systems with no violations during the year of any federally enforceable health-based standards that were in place by 1994
3. Percent of river miles assessed for the need for fish advisories and compilation of state-issued fish consumption advisory methodologies
4. Number and percent of assessed river miles, lake acres, and estuary square miles that have water quality supporting designated beneficial uses, where applicable, for fish and shellfish consumption
5. Number and percent of impaired assessed river miles, lake acres, and estuary square miles that a) are covered under Watershed Restoration Action Strategies and b) were restored to their designated uses during the reporting period
6. Number of TMDLs scheduled to be completed by the end of FY 2001
7. Number of TMDLs established by EPA
8. Number of state-established TMDLs approved
9. Number of TMDLs submitted by the state
10. Percent of POTWs beneficially reusing all or part of their biosolids and, where data exist, the percent of biosolids generated that are beneficially reused
11. Number and percent of facilities with a discharge requiring an individual permit that a) are covered by a current individual NPDES permit, b) have expired permits, c) have applied but not been issued a permit, and d) have a permit under appeal
12. Percent of states with current permits for construction sites over five acres
13. Percent of states with current permits for all industrial activities operating within the state
14. Percent of permittees (among the approximately 900 CSO communities nationwide) that are covered by NPDES permits or other enforceable mechanisms consistent with the 1994 CSO policy

15. Percent of approved pretreatment programs audited in the reporting year. Of those, the number of audits finding significant shortcomings and the number of local programs upgraded to achieve compliance
16. EPA will report to Congress on the pace of the Clean Water State Revolving Fund program.
17. Number of EPA approvals of state submitted upgraded NPS programs (incorporating the nine key elements outlined in national Non-point Source Program and Grants Guidance for FY97 and future years)

Solid Waste and Emergency Response

1. Number of LUST cleanups completed
2. Number of high priority RCRA facilities with human exposures controlled
3. Number of high priority RCRA facilities with groundwater releases controlled
4. Percentage of USTs in compliance with the December 22, 1998 deadline

Table 4 Environmental Indicators Used by States

Air

1. Composite parameters/indexes
2. Acid rain
3. Specific Parameters

Ozone	Nitrogen dioxide
Benzene	Carbon dioxide
Formaldehyde	Sulfur dioxide
VOCs	Carbon monoxide
Ozone precursors	Mercury
CFCs	Lead
Particulates	Pesticides

4. Toxics/carciniogenics
5. Vehicle miles traveled
6. Visibility
7. Indoor air
8. Maintenance plans
9. Odor

Water

1. Drinking water
2. GW Impacts
3. Releases
4. Discharges to SW
5. SW Impacts
6. Uses protected

Land, Waste and Materials

1. HW management
2. Releases
3. Cleanup
4. SW management
5. Land use

Interview Results

Interviews were conducted with 36 CDPHE staff and 19 external stakeholders selected by the environmental division directors, excluding CPD, to determine their perspectives on performance measurement and environmental indicators. Individuals interviewed are listed in Appendix 3.

The interviews revealed areas of general agreement, areas where opinions differed but some agreement was expressed, and many individual comments. Briefly, areas of general agreement were as follows:

- The environment in Colorado is generally good, and the Department should do more to communicate that, possibly through the use of indicators.
- Because the environmental quality is generally high, changes in environmental quality tend to be relatively small and harder to relate to specific impacts (or indicators).
- The Department needs to align performance and results to show relationship between programs and values.
- Performance measures or indicators should relate to meaningful health or environmental change, and less to process (bean counting).
- Indicators may need to be qualitative as well as quantitative.
- Many of the most significant impacts on the environment are outside CDPHE control, complicating the use of environmental indicators.
- The water quality data base needs to be upgraded to integrate data across the programs and include more useful interpretative tools.
- A more consistent and integrated environmental data and indicator system across the environmental divisions is desirable.
- Integration of Department data with data collected by others may allow for better measurement of impacts and support broader indicators.
- Indicators serve as performance measures for different audiences, and different audiences are interested in different measures. In order to satisfy most audiences, indicators may need to be developed at differing levels of detail.
- The Department needs to make better use of the Internet and should require electronic submissions of both data and text.

Comments with less than general agreement included:

- Environmental indicators provide a reality check on program impact.
- Department only focuses on human health and not the environment; therefore, we have little understanding of environmental impacts.
- Should consider relationship between environmental data and health data, and look for health indicators. Alternately, relationships between health and environment are poorly understood, and health data is hard to quantify and of questionable quality.
- Water quality is a biological system, and biological indicators should be used. We lack an understanding of ecologic systems; therefore, it is hard to identify meaningful ecologic indicators.

In addition, some comments related to specific indicators, as shown below:

- We should develop and maintain data for mercury levels in fish.

- Toxic Release Inventory data should be used more extensively.
- Indicators should relate to affected populations (number of fishkills, population on systems in compliance, etc.)
- Miles of stream meeting standards is a meaningless indicator if the stream is empty due to water diversions.
- Environmental measures should be normalized for population or economic parameters to make meaningful indicators.
- Indicators should include compliance and number of illegal sites addressed, citizen complaints, etc.
- Indicators should reflect relative risk (to health).
- Indicators should include topical information, such as the smoke from Wendy's kitchens, the brown cloud, etc.
- Data and indicators should be presented on a more localized basis, such as for watersheds, airsheds, geographic areas, etc.
- Can we quantify the impacts of changes in fuels?
- Does ozone need a meteorological indicator?
- Do not base indicators for episodic problems on average data.

A synthesis of interview comments and observations is included in Appendix 5 for internal interviews and Appendix 4 for external interviews.

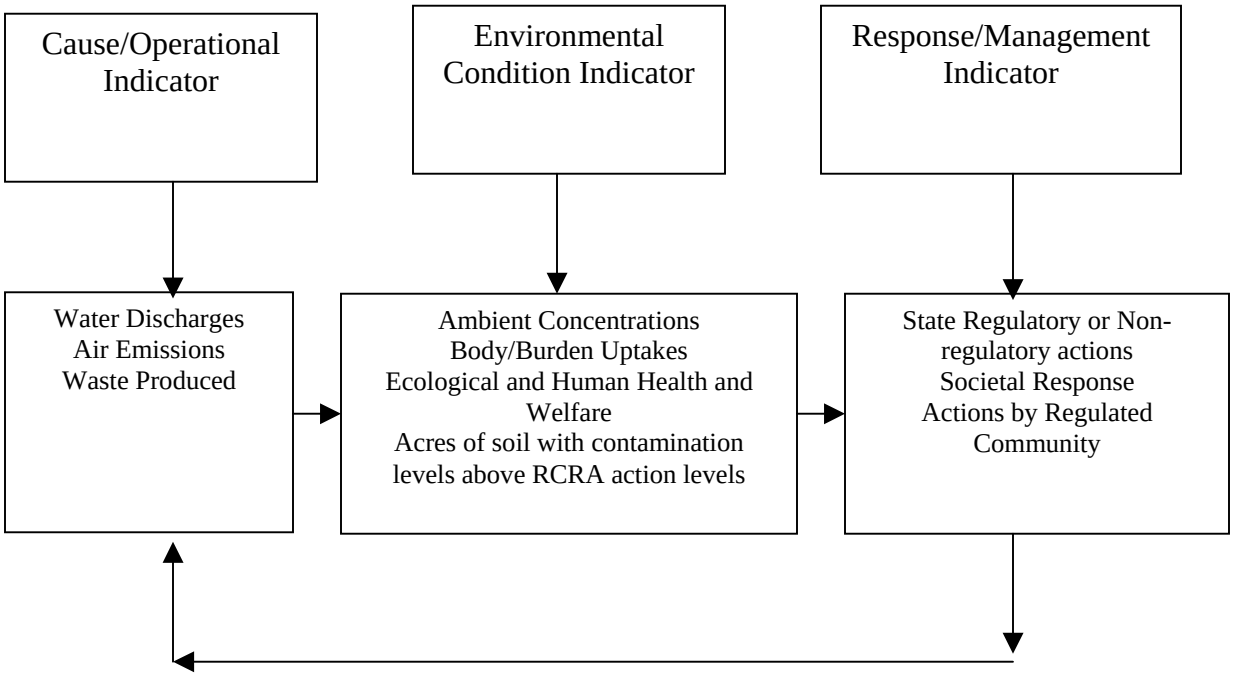
Indicator Models

The burgeoning science of environmental indicators has created many different models for the logic linking specific activities to environmental measures. Some of the models in use by different organizations are described below:

Colorado

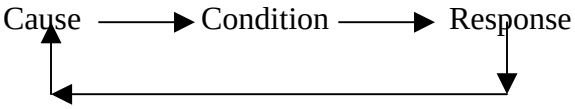
As developed in the Envision process in 2002, environmental indicators are measures of environmental quality that are used to assess the status and trends of environmental conditions. There are three types of indicators the Department uses to measure or indicate environmental progress in its results-based management system:

- Cause/Operational Indicator: What is contributing to or causing the problem? Links industry/commercial/consumer practices with external environment, e.g., burning fossil-fuel. (These tell the local/public story.)
- Environmental Condition Indicator: Measures environmental quality, e.g. ambient pollutant concentrations, number of violation days. (These tell the national story.)
- Response/Management Indicator: Measures our/society's efforts to reduce or mitigate environmental impacts; specifically, are our strategies working? (These tell the agency's story.)



New Jersey

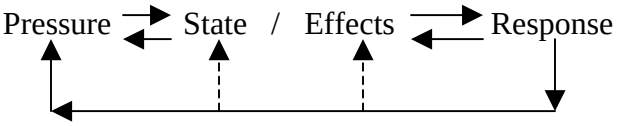
New Jersey has one of the earlier indicator models put in use, which served as a starting point for various state environmental indicator programs based on its logic and simplicity. While this process was successful in structuring a results-based approach, it was never fully institutionalized and integrated into the routine workings of the programs. Recent administrations have downplayed the role of indicators and streamlined the process to focus on specific problems.



- Cause – discharges, emissions
- Condition – ambient conditions, body burden/uptake, ecological or human health and welfare
- Response – societal response; action by state, EPA or region; action by regulated community, public, etc.

California

California has developed a slightly more intricate model, the Environmental Protection Indicators for California (EPIC), that is similar to the New Jersey approach. EPIC attempts to articulate a common process across all environmental programs without disrupting the existing programs. Implementation of this process is expected to continue over the next few years.



- Pressures – Stresses placed on the environment by human activity or natural causes
- State/ Effects – Condition of the environment, human or ecological health
- Response – Government or societal actions; some may be directed at state or effects

Minnesota

The Minnesota Pollution Control Authority (MPCA) uses a somewhat less academic approach tying the reorganization of their environmental programs to a functional basis. This move shifted much of the focus of the environmental programs to the regions, allowing more flexibility to deal with regional problems.

- Goals - convey MPCA's long-term mission for environmental quality: clean and clear air; fishable and swimmable lakes and rivers; uncontaminated ground water and land; and, sustainable ecosystems.
- Objectives - mid-range, measurable targets against which progress is measured toward achieving long-range goals.
- Outcome measures - specific means by which the MPCA evaluates progress toward meeting environmental goals and objectives. Outcome measures are expressed as pressures (such as releases, emissions or discharges) or states (such as concentrations, environmental effects or exposure rates).
- Strategies - multiple activities and tasks needed to attain environmental goals and objectives. Strategies may involve more than one program and can affect multiple environmental media (i.e., air, water, land).

Indicators may be regional rather than statewide, allowing the most important issues locally to receive a higher priority than they might if rolled into statewide concerns.

European Environment Agency

In relation to policy-making, environmental indicators are used for three major purposes.

1. To supply information on environmental problems, in order to enable policy-makers to value their seriousness.
2. To support policy development and priority setting, by identifying key factors that cause pressure on the environment.
3. To monitor the effects of policy responses.

This framework is named the DPSIR Framework (Drivers, Pressures, State, Impact, Responses):

Drivers - social and economic developments exert Pressure on the environment
Pressure – changes the State of the environment; this leads to
Impacts – on human health, ecosystems and materials
Response impacts elicit a societal Response that feeds back on the Driving forces, or on the state or impacts directly, through adaptation or curative action.

Indicators can be identified throughout the process:

- Indicators for driving forces describe the social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns.
- Pressure indicators describe developments in release of substances (emissions), physical and biological agents, the use of resources and the use of land. The pressures exerted by society are transported and transformed in a variety of natural processes to manifest themselves in changes in environmental conditions.
- State indicators give a description of the quantity and quality of physical phenomena (such as temperature), biological phenomena (such as fish stocks) and chemical phenomena (such as atmospheric CO2-concentrations) in a certain area.

- Impact indicators describe impacts on the social and economic functions on the environment due to pressure on the environment.
- Response indicators refer to responses by groups (and individuals) in society, as well as government, attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment.
- Performance indicators compare (f)actual conditions with a specific set of reference conditions. They measure the distance(s) between the current environmental situation and the desired situation (target): 'distance to target' assessment.
- Efficiency indicators measure the improvement in performance.

Florida

All state agencies are required to use a standard process for budget and work planning:

- Trends and Condition Analysis – Uses a Strength, Weakness, Opportunity and Threat (SWOT) analysis of current conditions and expected trends to identify Strategic Issues,
- Strategic Issues – Critical challenges or fundamental policy concerns that affect the nature of a public condition and must significantly impact the health, safety or welfare of the public,
- Strategic Goals - Chart the future direction of the agency in accomplishing its Mission and realizing/solving a strategic issue,
- Objectives - For each goal, provide specific, measurable, intermediate ends that mark progress toward achieving the goal,
- Outcomes - Indicators of the actual impact or public benefit of a service.

This process is updated annually, projecting out five years. The focus of this approach is on performance measurement rather than indicators, such that an actionable integration occurs between budget and performance. This creates a value chain for each program.

The Florida Department of Environmental Protection uses a four-tiered measurement system to evaluate the agency's performance in meeting its mission. This tiered system provides policy makers with an understanding of the relative health of natural resources while providing the necessary context within which to evaluate the changing conditions of those resources.

- Tier 1: Environmental and Public Health Outcome Indicators that track long-term trends in the condition of Florida's natural resources, public health and general environmental quality.
- Tier 2: Behavioral and Cultural Measures that track compliance rates, best management practices, volunteerism and other behaviors that impact environmental quality.
- Tier 3: Department Outputs and Activities that track the traditional measures of program performance, such as numbers of inspections, numbers of compliance assistance activities, or numbers of violations.
- Tier 4: Resource Efficiency Measures that track the agency's budget, the cost of services, and the cost effectiveness of interventions used to solve environmental problems.

The tiered format provides the framework for problem identification and solution. Changes in a given issue at the Tier 1 level can be better understood in light of the information provided by the lower tiers. The second tier relates measurements of behavior to the changes in the quality of the resource, such as the state of compliance for all regulated facilities. The third tier details the specific activities of the agency, while the fourth tier provides an assessment of the costs associated with conducting those activities. This "tiering" of performance data allows one to understand the underlying causes of problems and to design appropriate interventions.

Colorado Model Alternatives

The Colorado Environmental Performance Partnership Agreement (CEPPA) identifies the overall goal, short term goals, objectives and performance measures for each program. The current logic structure for CDPHE performance measures used in the CEPPA and division work plans varies among the environmental divisions.

The APCD structure was developed to answer the question "How?" going down and "Why?" going up, meaning that the logic of the structure flows both from high level goals (clean air) down to program activities (compliance inspections) and from specific activities up to the goals. One direction provides a planning basis for determining how to accomplish specific goals, and working back from the activities demonstrates results from the activities.

The WQCD uses a similar structure, but is less directed to specific environmental outcomes, instead focusing on statutory requirements, including the Clean Water Act and the Safe Drinking Water Act. Rather than being related to environmental outcomes, high level goals are functional; for example, "Monitor chemical, physical and biological conditions in all state waters so that water quality decisions are well supported with adequate data."

The HMWMD logic combines attributes of both of the above programs. Compliance-based activities are supported through a more functional structure ("Ensure protection of public health and environment through achieving compliance of regulated facilities by implementation of an effective compliance, monitoring and enforcement program."), and remedial activities are more outcome oriented ("Manage projects to achieve cleanups that are: protective of human health and the environment, on schedule, cost-effective and reflect community concerns.")

Each of these structures works to describe the context of the short-term goals, objectives and performance measures towards overall goals; however, the linkage to environmental results is not uniformly explicit, and the environmental indicators do not necessarily reflect program performance. Furthermore, the indicator structure presented above (cause/operational, environmental condition, response/management) is not used to select, create or monitor environmental progress. In most cases in the CEPPA, indicators are generated from program activities, but not specifically called out.

Alternative Approaches

One alternative approach would align the goals, sub-goals and objectives with indicators, as defined in the current Colorado model. This would take the form:

Alternative 1

Strategic Goals	Sub-Goals	Strategic Objectives	Environmental Indicators		
			Cause/Operational Indicator	**Environmental Condition Indicator**	**Response/Management Indicator**
Protect Clean Air	Achieve air quality that protects and preserves human health	Protect the National Ambient Air Quality Standards		Ensure that trends of improving air quality continue	Ensure that ten-year maintenance plans are established so that emissions are maintained below established budget levels for designated maintenance areas

This structure brings in the indicators as defined, but does not support correlation to programmatic activities.

A second model would eliminate the distinctions among indicators and essentially add them to the CEPPA structure. This would take the form:

Alternative 2

Strategic Goals	Program Goals	Sub-Goals	Objectives	Environmental Indicators
Protect Clean Air	Achieve air quality that protects and preserves human health	Protect the National Ambient Air Quality Standards	Ensure that trends of improving air quality continue	Maintain trends of National Ambient Air Quality Standards improvements and maintain trend of increasing number of "good" days as measured by the Air Quality Index level
				Annual increase in vehicle miles traveled in the Denver Metro area

This structure allows greater context for indicators, but may complicate the justification for activities for which there is no specified environmental indicator.

A third alternative would use the types of indicators (cause/operational, environmental condition, response/management) to define or support goals and objectives, as shown below:

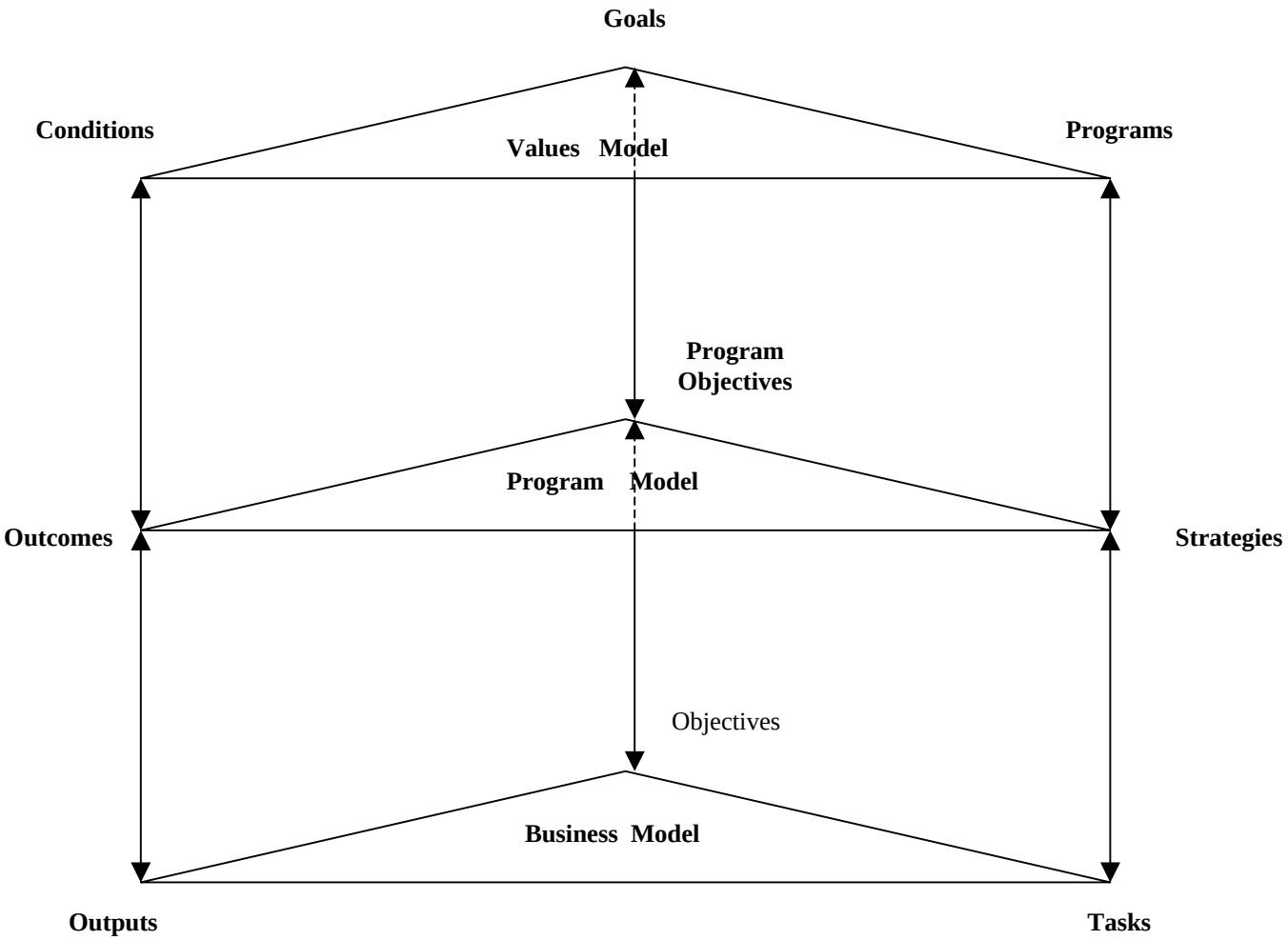
Alternative 3

Strategic Goals	Cause/ Operational Indicator	Sub-Goals	Environmental Condition Indicator	Strategic Objectives	Response/ Management Indicator
Protect Clean Air	Population and industrial growth causes decreased air quality	Achieve air quality that protects and preserves human health	Trends of air quality	Protect the National Ambient Air Quality Standards	Ensure that ten-year maintenance plans are established so that emissions are maintained below established budget levels for designated maintenance areas
			Public exposure to toxic chemicals	Protect citizens from exposure to air toxics	Ensure that 90% of toxic and hazardous emissions are subject to standards developed either by the EPA or the state

Each of the above approaches utilizes to varying degrees the existing structure of either the indicator or strategic plan concept. Another approach would be less reliant on these existing structures and would base the planning and indicator/performance measurement on a different model:

- Each Colorado environmental **Value** reflects a **Condition** that can be addressed through specific **Goals** implemented by identified **Programs**. This arrangement is represented by the ***Values Model***.
- Each specific **Goal** in turn can be expanded into **Program Objectives** that reflect **Outcomes** achieved by specific **Strategies**. This is represented by the ***Program Model***.
- Each **Strategy** is composed of **Tasks** that produce an **Output** achieving an **Objective**. This arrangement is represented by the ***Business Model.***

Each successive model layer represents greater detail and more specificity. Indicators can be chosen at any level to represent the progress towards the environmental value. Where in the model an indicator is selected depends on the purpose of the reporting and the audience for the information. The general public may want to understand only that a given media's condition is improving. The regulated community or program customers may wish to understand the outcomes related to certain programmatic objectives, while grantors or legislators may wish to evaluate performance by reviewing program output. Clarifying the purpose and the audience for the reporting allows for the selection of appropriate indicators.



This approach results in a structure as shown in Table 5.

Appendices 6 through 9 include completed alternative tables for each media based on recent CEPPA language. Having more knowledgeable individuals complete the tables would provide greater accuracy and more meaningful information.

This page intentionally left blank.

Table 5 Colorado Model Alternative 4

Values Model			Program Model			Business Model		
Goals	**Programs**	**Conditions**	**Program Objectives**	**Strategies**	**Outcomes**	**Objectives**	**Tasks**	**Outputs**
Protect Clean Air	Air Pollution Control	Achieve air quality that protects and preserves human health	Protect the National Ambient Air Quality Standards	Ensure that 10 year maintenance plans are established for designated maintenance areas	Emissions are maintained below established budget levels	Attain and maintain existing standards for criteria pollutants	Reduce criteria pollutants through the ongoing operation of mobile source strategies	
							Reduce criteria pollutants through operation of stationary source control strategies-MACT implementation	
			Protect citizens from exposure to air toxics	Ensure that 90% of toxic and hazardous emissions are subject to standards developed either by the EPA or the state		Attain and maintain existing standards for air toxics	Reduce air toxics through the ongoing operation of mobile source strategies	

This page intentionally left blank.

Alternative Analysis

Each of the above alternatives provides a basis for integrating a logic structure with environmental indicators to demonstrate the performance of program activities. The CEPPA currently strives for this connection; however, is relatively unsuccessful at demonstrating the connection between work activities and indicators. Alternatives 1 through 3 provide a logic connection between program goals and objectives and indicators; however, they are not effective in connecting indicators to work activities. Alternative 4 attempts to close the logic connection from goals and objectives to activities and indicators. In general terms, Alternative 4 allows this connection to be created in a reasonable manner, however, may not significantly reduce the burden on the CEPPA to document activity "beans."

If the CEPPA burden for defining logic and indicators could be shifted to and supplanted by Alternative 4, the CEPPA could become a simple work plan with the details necessary to describe the activities. Completion and refinement of the Alternative 4 table would require some effort for all programs, but having knowledgeable individuals completing the table would provide greater accuracy and more meaningful information. A greater challenge would be to negotiate the changes (reductions) in the CEPPA and the shift to a work plan basis with EPA or other CEPPA audiences.

Alternative 1 and 3 preserve the three categories of environmental indicators (cause/operational, environmental condition, response/management), but Alternative 2 eliminates this distinction. In essence, Alternative 4 also eliminates this distinction by allowing the selection of indicators anywhere across the logic structure. To date, the indicators have not been used in such a manner that the distinctions among types of indicators is important, and in reviewing Alternatives 1 and 3, it is not clear that these distinctions are actually meaningful.

Another consideration is the degree to which the current (or even future) indicators drive the program activities. The assessment performed in this report does not support that connection. In a few instances, indicators are used to reflect progress, but are not the measures used to determine program direction. Alternative 2 would best support maintaining the current less-than-perfect alignment of indicators with performance or activities; however, Alternative 4 would best support the development of a meaningful relationship among these components.

In terms of flexibility for development and future modification, Alternative 4 provides a broad structure and multiple options for defining indicators across the structure. To use a simplistic example, the other alternatives specify the column where the indicator resides, but Alternative 4 would allow an appropriate indicator to be selected from anywhere in the table. Furthermore, the structure of Alternative 4 allows for the identification of fundamental program elements at three different levels and a separate work plan with activity details. If one area of a program is less mature and developed than others, Alternative 4 still provides a structure to identify functions for future development.

A summary of alternative comparisons is provided below:

Attribute	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Compatability with existing indicators	Good correlation to existing indicator structure	Eliminates distinction among indicator types	Good correlation to existing indicator structure	Can include existing indicators, but uses a different approach
Compatibility with existing CEPPA	Maintains current relationship; not necessarily effective for all media	Maintains current relationship; not necessarily effective for all media	Maintains current relationship; not necessarily effective for all media	Would replace or supplant current CEPPA structure, but may require separate work plan
Flexibility	Structure may be difficult to make more meaningful	Structure may be difficult to make more meaningful	Provides a framework adaptable to shifting needs, but may be difficult to restructure	Extremely flexible
Ability to link goals, indicators, activities and performance measures	Weak	Weak	Weak, but probably more viable than 1 or 2	Excellent
Implementability	Medium effort required to integrate indicators with performance structure	Medium effort required to integrate indicators with performance structure	Medium effort required to integrate indicators with performance structure	Moderate effort required to shift to this structure; work plans require minimal effort. Major effort may be required to negotiate new structure with EPA.
Other factors	Can be used to perpetuate existing system with minimal effort	Best choice to perpetuate existing system, but requires abandonment of indicator distinctions	Can be used to perpetuate existing system with minor effort	Change in approach; abbreviates CEPPA, but adds a work plan deliverable for each program

Recommendations/Follow up

The evaluation of environmental indicators and the preceding analysis has led to the following recommendations:

1. **Eliminate Environmental Indicator Types**. The distinctions among types of indicators (cause/operational, environmental condition, response/management) are not currently used and appear to offer little benefit.

2. Place a high priority on improving and integrating the water quality data systems. The current systems do not appear to be supportive of relating actual information to performance measurement and constitute a (real or perceived) barrier to communications around performance measurement.

3. Choose one of the following:

> **3.a If a meaningful linkage between goals, objectives, indicators, activities and performance measurement is desired, implement Alternative 4.** Test the Alternative 4 table by having it completed by division staff, and determine what CEPPA-specific requirements are not met. Evaluate existing division work plans (separate from CEPPA) to see if missing CEPPA needs could be addressed there.
>
> **3.b If the existing tenuous linkage is acceptable, keep the existing CEPPA structure and add environmental indicators by implementing Alternative 2 as a separate document**.
>
> **3.c Use a non-structured environmental indicator approach**. Give up the idea of formal environmental indicators tied to program logic, but select indicators from available environmental measurements.

In addition to the above recommendations, some additional steps are suggested:

A. Explore the linkages between environment and health. Convene the public health and environmental sides of the department to discuss connections between environmental (air, water, waste) and health data and impacts.

B. Consider non-quantifiable indicators. For areas where meaningful environmental indicators remain elusive, evaluate whether qualitative evaluations can be used in lieu of quantitative measurements.

C. Merge functional reporting data where compatibility exists among the programs, such as for permits, compliance, enforcement and customer assistance.

D. Develop a better understanding of environmental impacts and use in performance evaluation. Determine actual impact to ecologic systems through training and cross-training and access to research. Develop a better understanding of natural resource damages (NRD) and NRD process among staff.

E. Get the message out. Improve and integrate communications to interested audiences through use of the web sites, standard FAQs, and routine reporting. Incorporate our successes and be proactive in communications.

Environmental Indicator References

The Brindle Group Inc. and Tetra Tech EM Inc., Environmental Conditions and Directions Study, prepared for the Colorado Department of Public Health and Environment, Pollution Prevention Program for the Governor's Pollution Prevention Advisory Board, May 2002

California Environmental Protection Agency Office of Environmental Health Hazard Assessment, Environmental Protection Indicators for California (EPIC), April 2002

Colorado Center for Healthy Communities, The Colorado Index, 2002

Colorado Department of Health and U.S. Environmental Protection Agency, Proceedings of the Mid-America Conference on Environmental Indicators, Colorado Springs, CO, January 9-12, 1994

Colorado Department of Public Health and Environment and the U.S. Environmental Protection Agency Region 8, FY01 Colorado Performance Partnership Agreement End of Year Assessment Indicators Update, April 2002

Colorado Department of Public Health and Environment and the U.S. Environmental Protection Agency Region 8, Colorado Environmental Performance Partnership Agreement – FY2003, October 2002

Colorado Department of Public Health and Environment Water Quality Control Division, Status of Water Quality in Colorado, February 2002

Colorado Department of Public Health and Environment Water Quality Control Division, Water Quality in Colorado 2000

Colorado Governor Bill Owens, Colorado Naturally, 2000(?)

The Colorado Trust, The Colorado Forum on National and Community Indicators, 1996

Environmental Results Management Systems Initiative Workgroup and Green Mountain Institute for Environmental Democracy, Moving from Planning to Action by Measuring What Counts, August 2000

Florida Department of Environmental Protection, Florida and the Environment: Naturally, 2001

Florida Department of Environmental Protection, People, Progress, and the Environment, Agency Strategic Plan for FY 1998-2003

The H. John Heinz III Center for Science, Economics and the Environment, The State of the Nation's Ecosystems, 2002

Maryland Department of the Environment, Managing Maryland for Results, Fiscal Year 2001 Workplan

Mayne, John, Office of the Auditor General of Canada, Addressing Attribution Through Contribution Analysis: Using Performance Measures Sensibly, June 1999

Minnesota Department of Natural Resources, Natural Resources Stewardship 2001, Key Indicators of Progress, A Progress Report, January 2001

Minnesota Planning Environmental Quality Board, Smart Signals, An Assessment of Progress Indicators, March 2000

Minnesota Pollution Control Agency, Five Year Strategic Plan FY 2001-2005, November 2000

National Science Foundation Advisory Committee for Environmental Research and Education, Complex Environmental Systems: Synthesis for Earth, Life, and Society in the 21st Century, January 2003

New Jersey Department of Environmental Protection Division of Science and Research, New Jersey's Environment 1998

Oregon Progress Board (SOER Science Panel), Oregon State of the Environment Report 2000 Statewide Summary, September 2000

U. S. Environmental Protection Agency, America's Children and the Environment, Measures of Contaminants, Body Burdens, and Illnesses, Second Edition, EPA 240-R-03-001, February 2003

U. S. Environmental Protection Agency, EPA Strategic Plan, September 1997

U. S. Environmental Protection Agency Managing for Improved Results Steering Group, Managing for Improved Results, November 2002

U. S. Environmental Protection Agency Office of Air and Radiation and Florida State University Florida Center for Public Management, National Air and Radiation Indicators, July 1997

U. S. Environmental Protection Agency Office of Environmental Information and the Office of Research and Development, EPA's Draft Report on the Environment 2003, EPA-260-R-02-006, June 2003

U. S. Environmental Protection Agency Office of Environmental Information and the Office of Research and Development, EPA's Draft Report on the Environment Technical Document, EPA-260-R-02-006, June 2003

U. S. Environmental Protection Agency Office of Solid Waste and Emergency response and the Program for Environmental Policy and Planning Systems (PEPPS) of the Institute of Science and Public Affairs of the Florida State University, Waste Indicator System for the Environment, April 2003