Technical Guidance for Assessing Environmental Justice in Regulatory Analysis

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Message from the Administrator

Technical Guidance for Assessing Environmental Justice in Regulatory Actions

At the U.S. Environmental Protection Agency we come to work every day with the important responsibility of protecting the environment and the health of all Americans, including minority populations, low-income communities and indigenous peoples – some of the most vulnerable to environmental and public-health concerns. This document, the *Technical Guidance for Assessing Environmental Justice in Regulatory Actions*, marks a significant development in our efforts to fulfill that responsibility, providing the information and direction our analysts need to assess environmental-justice concerns during regulatory analysis.

First identified as a priority in Plan EJ 2014, the technical guidance describes methods for analysts to use when assessing potential environmental-justice concerns in national rules, enhancing our ability to perform some of the most crucial work we do. The technical guidance presents key analytic principles and definitions, best practices and technical questions to frame the consideration of environmental justice in regulatory actions. It also includes recommendations that are designed to enhance the consistency of our assessment of potential environmental-justice concerns across all regulatory actions. In focusing on how to consider environmental justice in rulemaking, it provides a key complement to the May 2015 *Guidance on Considering Environmental Justice During the Development of Regulatory* Actions (U.S. EPA, 2015a), which provides information on when to conduct an environmental-justice assessment. Both documents also reinforce the importance of the meaningful involvement of the public and key stakeholders throughout the rulemaking process.

Developed with participation from the public and the EPA's Science Advisory Board, the technical guidance reflects the EPA's strong commitment to transparency and to grounding its decisions in the highest quality science. It also directly supports the commitment to environmental justice established by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.*

By improving our ability to conduct strong, consistent analysis of environmental justice in regulatory actions, the technical guidance marks a major milestone in our continued efforts to ensure environmental justice is considered in the agency's work. Looking ahead, we are confident that it will bring better protection to America's vulnerable populations for years to come.

Gina McCarthy

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Acronyms and Abbreviations

ADP	–	Action Development Process
CAFO	–	Concentrated Animal Feeding Operation
CDC	–	Centers for Disease Control and Prevention
CEQ	–	Council on Environmental Quality
CPI-U	–	Consumer Price Index for all Urban Consumers
CRA	–	Cumulative Risk Assessment
DQO	–	Data Quality Objectives
DSW	–	Definition of Solid Waste
EGU	–	Electric Generating Unit
EJ	–	Environmental Justice
E.O.	–	Executive Order
EPA	–	Environmental Protection Agency
GHG	–	Greenhouse Gas
GIS	–	Geographic Information System
HHRA	–	Human Health Risk Assessment
HIA	–	Health Impact Assessment
IQG	–	Information Quality Guidelines
MATS	–	Mercury and Air Toxics Standards
NAAQS	–	National Ambient Air Quality Standards
NEPA	–	National Environmental Policy Act
NHANES	–	National Health and Nutrition Examination Survey
NPDES	–	National Pollution Discharge Elimination System
NRC	–	National Research Council
NYCHANES	–	New York City Health and Nutrition Examination Survey
OMB	–	Office of Management and Budget
ORD	–	Office of Research and Development
PM	–	Particulate Matter
RCRA	–	Resource Conservation and Recovery Act
SAB	–	Science Advisory Board

Disclaimer: *This document identifies internal Agency policies and recommended procedures for EPA employees. This document is not a rule or regulation and it may not apply to a particular situation based upon the circumstances. This guidance does not change or substitute for any law, regulation, or any other legally binding requirement and is not legally enforceable. As indicated by the use of non-mandatory language such as "guidance," "recommend," "may," "should," and "can," it identifies policies and provides recommendations and does not impose any legally binding requirements.*

Section 1: Introduction

The United States Environmental Protection Agency (EPA) defines environmental justice (EJ) as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.[1] The EPA further defines the term *fair treatment* to mean that "no group of people should bear a disproportionate burden of environmental harms and risks, including those resulting from the negative environmental consequences of industrial, governmental, and commercial operations or programs and policies" (U.S. EPA, 2011a).[2]

In implementing its EJ-related efforts, the Agency has expanded the concept of fair treatment to consider not only the distribution of burdens across all populations, but also the distribution of reductions in risk from EPA actions. For example, the Agency encourages staff to evaluate the distribution of burdens by paying special attention to populations that have historically borne a disproportionate share of environmental harms and risk. At the same time, it encourages Agency staff to examine the distribution of positive environmental and health outcomes resulting from regulatory actions (U.S. EPA, 2015a).[3]

The purpose of this document, the *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (referred to throughout this document as the *EJ Technical Guidance*), is to outline particular technical approaches and methods to help Agency analysts (including economists, risk assessors, and others) analyze potential EJ concerns for regulatory actions.[4] Senior EPA managers will also find this document useful for understanding analytic expectations and ensuring that potential EJ concerns are appropriately considered and addressed in the development of regulatory actions. The guidance recommends analysts use a screening analysis to identify the extent to which a regulatory action may raise potential EJ concerns that need further evaluation, and what level of analysis is feasible and appropriate (see Section 3.2). Factors that can be used in determining the appropriate level and type of analysis include proximity of sources to low-income populations, minority populations, and/or indigenous peoples; unique exposure pathways; and a history of EJ concerns associated with the pollutant being regulated (see Sections 4.2 and 6.1 for more detail). Based on the results of this screening, this guidance provides

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[1] For more information, see the EPA's Environmental Justice website: http://www.epa.gov/environmentaljustice/.

[2] Executive Order (E.O.) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, calls on each covered Federal agency to make achieving environmental justice part of its mission "by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." The term *effects* is typically interpreted within the EPA as a reference to risks, exposures, and outcomes and is sometimes used interchangeably with the term *impacts*. E.O. 12898 is available in full at: http://www.archives.gov/federal-register/executive-orders/pdf/12898.pdf.

[3] Note that the EPA's *Toolkit for Assessing Potential Allegations of Environmental Injustice* (https://www.epa.gov/sites/production/files/2015-04/documents/toolkitej.pdf) differs from this technical guidance in that it is mainly designed to help investigate allegations of environmental injustice in a particular geographic area (for example, as a result of a permitting or enforcement decision that pertains to a particular facility). The broader scope of this technical guidance is to aid analysts in evaluating potential EJ concerns that may arise due to EPA regulatory actions.

[4] E.O. 12866 (1993) defines a regulatory action as "any substantive action by an agency (normally published in the Federal Register) that promulgates or is expected to lead to the promulgation of a final rule or regulation, including notices of inquiry, advance notices of proposed rulemaking, and notices of proposed rulemaking."

a suite of methods that can be applied depending on the type of available data, availability of resources, and time needed to conduct the analysis.

This document is intended for use alongside other Agency guidance, including guidance on human health risk assessment (HHRA) and economic analysis (see Appendix A).[5] In particular, it complements the Agency's *Guidance on Considering Environmental Justice During the Development of Regulatory Actions* (referred to throughout this document as the *EJ Process Guidance*), which is "designed to help EPA staff incorporate EJ into the process followed at the EPA for developing regulations, also known as the Action Development Process (ADP)." The *EJ Process Guidance* accomplishes this task "by describing the legal and policy frameworks at the EPA for rule-writers to consider EJ; identifying the information rule-writers should consider" when evaluating whether there are potential EJ concerns for the regulatory action under development; "highlighting the kinds of questions about EJ that rule-writers should ask and address in each step of developing a regulation; and providing strategies and techniques for achieving meaningful involvement of minority populations, low-income populations, tribes, and indigenous peoples at key stages" in the regulatory ADP (U.S. EPA, 2015a).[6]

Together, the two documents – the *EJ Technical Guidance* and the *EJ Process Guidance* - provide guidance to analysts and rule-writers on how regulatory actions can be responsive to E.O. 12898 as well as consistent with the EPA's EJ policies and *Plan EJ 2014* (U.S. EPA, 2011a).[7] The *EJ Process Guidance* refers readers to the *EJ Technical Guidance* (this document) for recommendations on how to evaluate potential EJ concerns using quantitative and qualitative methods. Likewise, this document refers readers to the *EJ Process Guidance* for details on how to integrate EJ into the EPA's ADP.

This technical guidance will evolve with advances in the state of the science, data, and analytic methods available to Agency analysts. Regarding risk assessment, this technical guidance currently is limited to a discussion of how to integrate EJ into the planning phase of an HHRA. The EPA has developed and continues to refine methods and guidance on a variety of topics relevant to conducting analyses of potential EJ concerns in the context of a regulatory action. Such references are noted in sections of this document and future updates to the *EJ Technical Guidance* may include more detail on these topics.

1.1 How Is This Guidance Document Organized?

The first four sections of this guidance establish the objectives, definitions, main analytic considerations, and context for an assessment of potential EJ concerns in support of EPA regulatory actions:

- **Section 1: Introduction** provides background and outlines the main objectives of the *EJ Technical Guidance*. Appendix A provides links to additional guidance that may be helpful to the analyst when assessing potential EJ concerns.

- **Section 2: Key Definitions** reviews key EJ concepts from E.O. 12898 that are expected to influence analytic considerations. In particular, the section discusses how to define potential EJ concerns, disproportionate impacts, population groups of concern, and meaningful involvement.

- **Section 3: Key Analytic Considerations** discusses three questions that analysts should strive to answer when conducting an analysis of potential EJ concerns, provides a basic framework to guide the analysis of

[5] See also the *Plan EJ 2014: Legal Tools* available at: https://www.epa.gov/sites/production/files/2015-02/documents/ej-legal-tools.pdf. It reviews the main legal authorities under the environmental and administrative statutes administered by the EPA that may help to advance environmental justice (U.S. EPA, 2011b).

[6] The *EJ Process Guidance* recommends that rule-writers and decision makers respond to three core questions throughout the ADP: (1) How did your public participation process provide transparency and meaningful participation for minority populations, low-income populations, tribes, and indigenous peoples?; (2) How did the rule-writers identify and address existing and/or new disproportionate environmental and public health impacts on minority populations, low-income populations, and/or indigenous peoples?; and (3) How did actions taken under #1 and #2 impact the outcome or final decision? (U.S. EPA, 2015a).

[7] Information about the EPA's EJ activities and policies can be found here: http://www.epa.gov/environmentaljustice/. The EPA's historical EJ policies include: *The EPA's Environmental Justice Strategy* (U.S. EPA, 1995); *1996 Environmental Justice Implementation Plan* (U.S. EPA, 1996); Memo from Stephen L. Johnson: *Reaffirming the U.S. Environmental Protection Agency's Commitment to Environmental Justice* (U.S. EPA, 2005a); and Memo from Lisa P. Jackson: *Next Steps: Environmental Justice and Civil Rights* (U.S. EPA, 2009a).

potential EJ concerns, and presents the EPA's four main recommendations to guide assessments of EJ for EPA regulatory actions, including a list of identified best practices.

- **Section 4: Contributors to Potential Environmental Justice Concerns** identifies factors that may contribute to potential EJ concerns, and highlights the key reasons why environmental health risks may be unevenly distributed across population groups.

The main technical sections of this document provide guidance for considering EJ in two specific contexts: planning for an HHRA (Section 5) and development of a regulatory analysis (Section 6):

- **Section 5: Considering Environmental Justice when Planning a Human Health Risk Assessment** provides technical guidance on incorporating potential EJ concerns into the planning phase of an HHRA, including descriptions of currently available methodologies and tools. Appendix B provides examples of approaches for incorporating potential EJ concerns into the planning stages of exposure and dose-response assessments.

- **Section 6: Conducting Regulatory Analyses to Assess Potential Environmental Justice Concerns** provides technical guidance on integrating potential EJ concerns into regulatory analyses. In particular, this section discusses how to identify and evaluate the feasibility and appropriateness of different analytic approaches, methods, and tools for assessing potential EJ concerns; the types of information that should be included in the assessment; other analytic considerations that could affect results; and when and how to consider costs and non-health impacts in the assessment.

This guidance assumes that an analyst may wish to consult only one of the two sections on human health risk assessment and the development of a regulatory analysis to address a specific context. As a result, the sections present some parallel information about key concepts and methods. This overlap is by design, and is appropriate given that different analytic experts will access and rely on different sections of the document for different purposes within the larger context of EPA regulatory action development.

The final section of the document (Section 7) describes identified near-term research priorities related to the analysis of potential EJ concerns:

- **Section 7: Research Priorities to Fill Key Data and Methodological Gaps** provides information on research goals to improve assessment of EJ at the EPA.

Section 2: Key Definitions

This section briefly defines and discusses key terms, including those from E.O. 12898, that are important for the analyst to understand before conducting an analysis of potential EJ concerns. These key terms include: potential EJ concern; disproportionate impacts; minority populations; low-income populations; and indigenous peoples; subsistence populations; and meaningful involvement.

2.1 Potential EJ Concern and Disproportionate Impacts

A *potential EJ concern* is defined as "the actual or potential lack of fair treatment or meaningful involvement of minority populations, low-income populations, tribes, and indigenous peoples in the development, implementation and enforcement of environmental laws, regulations and policies" (U.S. EPA, 2015a). For analytic purposes, this concept refers more specifically to "disproportionate impacts on minority populations, low-income populations, and/or indigenous peoples that may exist prior to or that may be created by the proposed regulatory action" (U.S. EPA, 2015a).[8]

For this technical guidance, the term *disproportionate impacts* refers to differences in impacts or risks that are extensive enough that they may merit Agency action. In general, the determination of whether there is a disproportionate impact that may merit Agency action is ultimately a policy judgment which, while informed by analysis, is the responsibility of the decision maker.[9] The terms *difference* or *differential* indicate an analytically discernible distinction in impacts or risks across population groups. It is the role of the analyst to assess and present differences in anticipated impacts across population groups of concern for both the baseline and proposed regulatory options, using the best available information (both quantitative and qualitative) to inform the decision maker and the public.[10] See Text Box 2.1 for examples of the ways in which differences in impacts have been characterized for a regulatory action.

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[8] Appendix A to the Council on Environmental Quality's (CEQ) *Environmental Justice: Guidance Under the National Environmental Policy Act* (NEPA) provides guidance on key terms in E.O. 12898, including the term "disproportionately high and adverse human health effects." It discusses several factors that a decision maker may consider when determining whether human health effects are disproportionately high and adverse: "whether the health effects, which may be measured in risks and rates, are significant (as employed by NEPA), or above generally accepted norms; whether the risk or rate of hazard exposure by a minority population, low-income population, or Indian tribe to an environmental hazard is significant (as employed by NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group; and whether health effects occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards" (CEQ, 1997).

[9] As noted in the *EJ Process Guidance*, a finding of disproportionate impacts is neither necessary nor sufficient for the EPA to address adverse differential impacts. In particular, "the Agency's statutory and regulatory authorities provide a broad basis for protecting human health and the environment and do not require a demonstration of disproportionate impacts in order to protect the health or environment of any population, including minority populations, low-income populations, and/or indigenous peoples" (U.S. EPA, 2015a).

[10] The *baseline* is defined as "the best assessment of the way the world would look absent the proposed action" (Office of Management and Budget, 2003).

Text Box 2.1: Characterizing Differences in Impacts for a Rule or Regulation

Recent regulatory actions have used a number of different phrases to describe differences in the size, type, or distribution of environmental and health impacts among populations, both in the baseline and as a result of regulatory changes. Terminology varies with specific context, and examples include: “the potential for disproportionate impacts,” “overrepresentation of” minority populations, low-income populations, or indigenous peoples near sources, and “notably higher.”

For instance, the notice of proposed rulemaking for the Definition of Solid Waste (U.S. EPA, 2011c) states:

> “In general, some communities will have a higher percentage [of minority and/or low-income members] than the comparison population, while some will have a lower percentage. As long as these differences have a regular, or uniform, distribution, they generally would not indicate potential for disproportionate adverse impact. However, if the number of communities with a higher percentage of minority and/or low-income population is greater than that of the comparison populations, then there is a potential for disproportionate adverse impact. The higher the average differences between the potentially affected communities and the comparison group, the greater the potential for a disproportionate adverse impact.”

The notice of proposed rulemaking for National Emission Standards for Hazardous Air Pollutants for Polyvinyl Chloride (U.S. EPA, 2011d) describes its demographic analysis as follows:

> “An analysis of demographic data shows that the average percentage of minorities, percentages of the population below the poverty level, and the percentages of the population 17 years old and younger, in close proximity to the sources, are similar to the national averages … at the 3-mile radius of concern. These differences in the absolute number of percentage points from the national average indicate a[n] … over-representation of minority populations, populations below the poverty level, and the percentages of the population 17 years old and younger, respectively.”

The Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline (U.S. EPA, 2010a) states:

> “Demographic factors that can affect risk of lead-related effects in children include residential location, poverty, and race. As noted in previous EPA actions on lead, situations of elevated exposure, such as residing near sources of ambient lead, as well as socioeconomic factors, such as reduced access to health care or low socioeconomic status can also contribute to increased blood lead levels and increased risk of associated health effects from air-related lead. Additionally, as described in the National Ambient Air Quality Standard (NAAQS) for Lead, children in poverty and black, non-Hispanic children have notably higher blood lead levels than do economically well-off children and white children, in general.”

2.2 Population Groups of Concern Highlighted in E.O. 12898

E.O. 12898 identifies a number of population groups of concern in considering potential EJ implications of a regulatory action. These include: minority populations, low-income populations, and indigenous peoples.[11] It also mentions "populations who principally rely on fish and/or wildlife for subsistence," a group that may overlap with other population groups of concern by virtue of unique exposure pathways. This section provides information for analysts on how to define the population groups of concern specifically mentioned in the Executive Order.[12]

It may be useful in some contexts to analyze these population categories in combination – for example, low-income minority populations – or to evaluate diversity within the population groups of concern (e.g., life stage, gender), particularly when some individuals within population groups may be at greater risk for experiencing adverse effects. In addition to the information below, analysts should rely on the Office of Management and Budget (OMB) or other official federal agencies (e.g., United States Census Bureau), when available, for definitions of the additional population groups that are relevant to a specific regulatory action. Note that analysis of additional population groups is not a substitute for examining the population groups explicitly mentioned in the Executive Order.

2.2.1 Minority Populations and Indigenous Peoples

The OMB provides minimum standards for "maintaining, collecting, and presenting data on race and ethnicity for all federal reporting purposes. The standards have been developed to provide a common language for uniformity and comparability in the collection and use of data on race and ethnicity by federal agencies" (OMB, 1997). The OMB defines six racial and ethnic categories:

- American Indian or Alaska Native;
- Asian;
- Black or African American;
- Native Hawaiian or Other Pacific Islander;
- White; and
- Hispanic or Latino.

Note that these categories are not necessarily mutually exclusive and cannot simply be added to estimate a total population. For example, Hispanic or Latino is an ethnic category and, as such, may overlap with several categories based on race. Statistical data collected by the federal government, such as the United States Census Bureau (Census Bureau), adhere to this classification system.[13]

The OMB also does not define what constitutes a minority population. For purposes of E.O. 12898, the term *minority* means "individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic" (CEQ, 1997). A population is identified as minority in an area affected by the policy action if "either (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than

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[11] The term *population groups of concern* is used instead of *subpopulations* to be inclusive of "population groups that form a relatively fixed portion of the population (e.g., groups based on ethnicity)." See the EPA's Early Life Stages website: http://www.epa.gov/children/early-life-stages.

[12] This section borrows extensively from Chapter 10 of the EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2014a).

[13] For the OMB definitions, see the OMB's *Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity*: http://www.whitehouse.gov/omb/fedreg_1997standards/. Beginning with the 2000 Census, the federal government began to collect more detailed information on race. Respondents could select more than one category. The OMB provides guidance on how to aggregate from 63 different race categories to a smaller subset to yield the first five categories listed above and four frequently-reported double race categories (OMB, 2000).

the minority population percentage in the general population or other appropriate unit of geographic analysis" (CEQ, 1997). A minority population exists "if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds" (CEQ, 1997). When analysts are evaluating potential EJ concerns under NEPA, they "may consider as a community either a group of individuals living in geographic proximity to one another, or a geographically dispersed/transient set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect" (CEQ, 1997).

While the OMB does not define the term *indigenous*, it defines someone who identifies as an American Indian or Alaska Native as a person "having origins in any of the original peoples of North and South America (including Central America) and who maintains tribal affiliation or community attachment" (OMB, 1997). The EPA provides a more detailed definition for the purposes of the *EPA Policy on Environmental Justice for Working with Federally Recognized Tribes and Indigenous Peoples* (U.S. EPA, 2014b) to include state-recognized tribes; indigenous and tribal community-based organizations; individual members of federally recognized tribes, including those living on a different reservation or living outside Indian country; individual members of state-recognized tribes; Native Hawaiians; Native Pacific Islanders; and individual Native Americans.

2.2.2 Low-Income Populations

The OMB has designated the Census Bureau's annual poverty measure, produced since 1964, as the official metric for program planning and analysis by all Executive branch federal agencies in *Statistical Policy Directive No. 14*, though it does not preclude the use of other measures (OMB, 1978). The CEQ's *Environmental Justice: Guidance Under the National Environmental Policy Act* (1997) also suggests analysts use "annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P-60 on Income and Poverty" to define low-income populations. As with minority populations, low-income populations include a geographically dispersed group of individuals that "experiences common conditions of environmental exposure or effect" (CEQ, 1997).

The Census Bureau's annual poverty measure uses a set of income thresholds that vary by family size and composition to determine the households that live in poverty. If a family's total income falls below the threshold, then that family and every individual in it is defined as being in poverty. This measure of poverty has remained essentially unchanged since its inception.[14] It does not vary geographically, though it is updated for inflation using the Consumer Price Index for All Urban Consumers (CPI-U). It also does not take into account capital gains or non-cash benefits such as public housing, Medicaid, and food stamps (U.S. Census Bureau, 2011a).

The ability of the official poverty measure to adequately capture regional and other differences in economic well-being within this population has been the subject of ongoing debate. In particular, the National Research Council (NRC) recommended that the official measure be revised because "it no longer provides an accurate picture of the differences in the extent of economic poverty among population groups or geographic areas of the country, nor an accurate picture of trends over time" (Citro and Michael, 1995). In response, the OMB convened an interagency group in 2009 to define a supplemental poverty measure based on the NRC recommendations. A Supplemental Poverty Measure was included in the Current Population Reports, Series P-60, for the first time in 2010 (U.S. Census Bureau, 2011b). For example, unlike the official poverty measure, it accounts for "co-resident unrelated children" (such as foster children), any cohabiters, and their children, and uses a broader resource measure to account for out-of-pocket medical expenses and in-kind benefits. It also improves on the traditional measure of poverty by adjusting for differences in housing prices and family size by metropolitan statistical area.[15]

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[14] The Census Bureau produces single-year estimates of median household income and poverty by state and county, and poverty by school district as part of its *Small Area Income and Poverty Estimates*. It also provides estimates of health insurance coverage by state and county as part of its *Small Area Health Insurance Estimates*. These data are broken down by race at the state level and by income categories at the county level.

[15] The NRC recognizes that income-based measures such as the official or supplemental poverty thresholds are not necessarily the best measure of relative poverty since they do not account for differences in accumulated assets across households. The Supplemental Poverty

Unlike its treatment of poverty, the Census Bureau does not provide an official definition of *low income*. An analyst may characterize low-income populations more broadly than just those that fall below the poverty threshold (e.g., to include families whose income is above the poverty threshold but still below the average household income for the United States). Additional socioeconomic characteristics typically collected by U.S. statistical agencies (e.g., Census Bureau), such as educational attainment, baseline health status, and health insurance coverage, may also be useful for characterizing low-income populations. Another possible measure is the percent of people who are chronically poor versus those who experience poverty on a more episodic basis (Iceland, 2003).[16]

Finally, the Census Bureau makes available a number of cross-tabulations between poverty measures and other socioeconomic characteristics of interest such as race, ethnicity, age, sex, education, and work experience; these can be useful in developing more specific population descriptions.

2.2.3 Populations that Principally Rely on Subsistence Consumption of Self-Caught Fish and Wildlife

E.O. 12898 identifies the need to analyze the human health risks of "populations with differential patterns of subsistence consumption of fish and wildlife … whenever practical and appropriate." This category identifies populations based on particular pathways of exposure, and may overlap with those defined on the basis of income and race/ethnicity.[17]

The CEQ's *Environmental Justice: Guidance Under the National Environmental Policy Act* (1997) describes the two main components of this definition: differential patterns and subsistence consumption. *Differential patterns* are "differences in rates and/or patterns of subsistence consumption by minority populations, low-income populations, and Indian tribes as compared to rates and patterns of consumption of the general population." The term *subsistence consumption* is defined as "dependence by a minority population, low-income population, Indian tribe or subgroup of such populations on indigenous fish, vegetation and/or wildlife, as the principal portion of their diet." See Section 4.2.2 for a discussion of unique exposure pathways.

While federal statistical agencies do not specifically track individuals and population groups who subsist on fish or wildlife, the EPA has conducted consumption surveys in specific geographic areas to inform policy formulation. If fish and wildlife consumption is a substantial concern for a particular regulatory action, analysts should refer to existing EPA guidance on fish and wildlife consumption surveys when collecting these data (e.g., U.S. EPA, 1998a, 2011e). Analysts may also investigate whether these types of survey data are available from other federal agencies, or from state, tribal, or local governments. However, per EPA guidance on fish and wildlife consumption surveys, they should verify that any survey data used in an EJ analysis accords with appropriate parameters and methodology for that specific analysis (U.S. EPA, 1998a).

Measure tries to capture inflows of income and outflows of expenses, which are likely correlated with short-term poverty since many assets are not easily convertible to cash in the short run (Short, 2012).

[16] This type of measure is reported in the U.S. Census Bureau's *Survey of Income and Program Participation*.

[17] The overlap between populations that principally subsist on fish and wildlife and minority populations, low-income populations, or indigenous peoples is an important consideration when evaluating potential EJ concerns in a risk assessment. As part of a risk assessment, analysts are encouraged to evaluate as appropriate all consumption/contact patterns and rates that are relevant from an EJ perspective, including those associated with populations that subsist on fish and wildlife.

2.3 Meaningful Involvement

The *EJ Process Guidance* defines the term *meaningful involvement* as indicating that "1) potentially affected populations have an appropriate opportunity to participate in decisions about a proposed activity [i.e., rulemaking] that will affect their environment and/or health; 2) the population's contribution can influence [the EPA's] rulemaking decisions; 3) the concerns of all participants involved will be considered in the decision-making process; and 4) [the EPA will] seek out and facilitate the involvement of population's potentially affected by EPA's rulemaking process" (U.S. EPA, 2015a).

The EPA is committed to engaging all stakeholders as it develops and implements Agency regulatory actions, but the Agency recognizes that special attention is often needed to ensure meaningful involvement in the process by minority populations, low-income populations, tribes, and indigenous peoples. While ensuring meaningful involvement in the regulatory action development process as a whole is beyond the scope of this guidance document, the *EJ Process Guidance* includes a detailed section on achieving meaningful involvement for regulatory actions. It provides resources that rule-writers can use to help decide what type and level of public involvement is appropriate and reviews best practices when developing opportunities for meaningful involvement (see also the EPA's Public Involvement Policy (U.S. EPA, 2003a)).

Meaningful involvement intersects with analytic considerations in several important respects. First, if the analysis of potential EJ concerns is explained in plain language, then key assumptions, methods, and results will be more transparent and easier to understand. This can further a clear understanding of the potential EJ implications of a regulatory action and allow for more substantive engagement by community members and other interested parties during public comment periods. Second, it may be possible for analysts to request information early in the process (for instance, by asking for public comment in the proposal) regarding unique exposure pathways or end points of concern, as well as data sources that could improve the analysis of potential EJ concerns. Text Box 2.2 highlights several examples of activities taken to ensure meaningful involvement in the analysis of EJ issues for recent regulatory actions. Section 5.3.1.5 also discusses meaningful involvement in the context of a human health risk assessment.

Text Box 2.2: Meaningful Involvement: Examples of Efforts to Ensure Involvement in the Analysis of Potential EJ Issues During the Regulatory Action Development Process

EPA regulatory actions have included steps to encourage involvement by affected communities in the analytic process when evaluating potential EJ issues, as illustrated in the following examples:

As part of the proposed rulemaking for National Emission Standards for Hazardous Air Pollutant Emissions in the chromium electroplating industry (U.S. EPA, 2010b), the EPA asked for public comment on its analysis of potential EJ issues:

> "The EPA offers the demographic analyses in this rulemaking as examples of how such analyses might be developed to inform such consideration and invites public comment on the approaches used and the interpretations made from the results, with the hope that this will support the refinement and improve utility of such analyses for future rulemakings."

The regulatory impact analysis for the Final Mercury and Air Toxics Standards (MATS) Rule (U.S. EPA, 2011f) describes activities taken to ensure meaningful involvement:

> "The EPA defines 'environmental justice' to include meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. To promote meaningful involvement, the EPA publicized the rulemaking via newsletters, EJ list serves, and the internet, including the Office of Policy's [Regulatory Development and Retrospective Review Tracker (formerly known as the Regulatory Gateway) at: http://yosemite.epa.gov/opei/RuleGate.nsf/.] During the comment period, the EPA discussed the proposed rule via a conference call with communities, conducted a community-oriented webinar on the proposed rule, and posted the webinar presentation online. The EPA also held three public hearings to receive additional input on the proposal."

> "Once this rule is finalized, affected [electric-generating units (EGUs)] will need to update their Title V operating permits to reflect their new emission limits, any other new applicable requirements, and the associated monitoring and recordkeeping from this rule. The Title V permitting process provides that when most permits are reopened (for example, to incorporate new applicable requirements) or renewed, there must be opportunity for public review and comments. In addition, after the public review process, the EPA has an opportunity to review the proposed permit and object to its issuance if it does not meet CAA [Clean Air Act] requirements."

Section 3: Key Analytic Considerations

This section provides an overview of the questions analysts should aim to answer when conducting an analysis of potential EJ concerns, provides an overarching framework for structuring the analysis, and makes four broad recommendations designed to ensure consistency across assessments.

3.1 Analyzing Differential Impacts

The analysis of potential EJ concerns for regulatory actions should address three questions:

- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?[18]
- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for the regulatory option(s) under consideration?
- For the regulatory option(s) under consideration, are potential EJ concerns created or mitigated compared to the baseline?

The term *environmental stressor* (or *stressor*) encompasses the range of chemical, physical, or biological agents, contaminants, or pollutants that may be subject to a regulatory action. *Baseline* is defined by the OMB as "the best assessment of the way the world would look absent the proposed action" (OMB, 2003); Section 6.2 of this document provides more information on characterizing the baseline for a regulatory action.

To answer each of the three questions, an analyst should characterize differential impacts for population groups of concern relative to a comparison population group. Comparison population groups are discussed in greater detail in Section 6.5.2.

The extent to which an analysis is able to address all three questions will vary due to data limitations, time and resource constraints, and other technical challenges that vary by media and regulatory context. The EPA encourages analysts to document key reasons why a particular question cannot be addressed, to help identify future priorities for filling key data and research gaps. In addition, due to the inherent limitations and uncertainties associated with analyses of potential EJ concerns, sensitivity analysis around key assumptions is particularly important for clearly communicating results to the public.

[18] As noted in Section 2.1, this question is asking whether there are discernible differences in impacts or risks to minority populations, low-income populations, or indigenous peoples that exist prior to or that may be created by the proposed regulatory action and that are extensive enough that they may merit Agency action. Differences in impacts or risks may include differential exposures, differential health and environmental outcomes, or other relevant effects. The subsequent analytic questions here are intended to prompt assessment of differences in anticipated impacts across population groups of concern for the baseline and proposed regulatory options, and to prompt the presentation of these results to decision makers to support their determinations regarding potentially actionable disproportionate impacts.

3.2 Identifying Objectives, Data, and Other Information

The purpose of a regulatory analysis is to "anticipate and evaluate the likely consequences" of a regulatory action in a way that informs the public and decision makers (OMB, 2003).[19] Before conducting a detailed analysis of potential EJ concerns, analysts should first help inform the process for identifying what level of assessment is feasible and appropriate to support the regulatory action. Feasibility is based on a technical evaluation of the data and methods available (for instance, the availability of data at a disaggregated level, data quality, availability of methods to analyze such data, and availability of evidence from the peer-reviewed literature, community input, and other information). Appropriateness is informed by relevant policy, budgetary, and statutory considerations.

As a first step, the *EJ Process Guidance* encourages the use of a screening-level analysis to help identify the extent to which a regulatory action may raise potential EJ concerns that need to be evaluated further as part of the regulatory action development process. Current EPA guidance does not prescribe or recommend a specific approach or methodology for conducting screening-level analysis. See Section 6.1 for a more detailed discussion of the types of factors an analyst could consider as part of a screening-level analysis.

To help inform the decision of what level of analysis of potential EJ concerns is feasible and appropriate, analysts should also identify data that would support a quantitative analysis. In some circumstances, available data may not be sufficient to perform a quantitative evaluation, but it may be possible to develop a meaningful qualitative analysis (see Sections 6.1 and 6.3 for more information). Documentation of the process of identifying what level of analysis is feasible is encouraged and ensures transparency when communicating with the public.

In cases where a screening-level analysis identifies potential EJ concerns in need of further evaluation, the analysis should aim to accomplish the following:

- ***Identify EJ objectives early in the process:*** Analysts should communicate with decision makers regarding how E.O. 12898 or applicable EPA policies or statutes interact with the evaluation of potential EJ concerns for a regulatory action.

- ***Understand the contributors to potential EJ concerns early in the process:*** Recognizing underlying contributors is important for properly assessing potential EJ concerns (see Section 4) and can aid in the design of regulatory options.

- ***Identify and characterize population groups of concern early in the process:*** E.O. 12898 identifies relevant population groups of concern. An early priority of analysts should be to identify these population groups within the context of a particular regulatory action to inform data collection and analysis, and the development of reliable inferences from the results.

- ***Identify comparison groups early in the process:*** Early selection of one or more comparison groups allows analysts to collect data and identify analytic approaches relevant for the evaluation of differential impacts borne by population groups of concern relative to other demographic groups.

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[19] E.O. 12866 (1993) expects agencies to consider "distributive impacts" and "equity" when choosing among alternative regulatory approaches, unless prohibited by statute. The OMB's Circular A-4 also states that "regulatory analysis should provide a separate description of distributional effects (i.e., how both benefits and costs are distributed among sub-populations of particular concern) so that decision makers can properly consider them along with the effects of economic efficiency … Where distributive effects are thought to be important, the effects of various regulatory alternatives should be described quantitatively to the extent possible, including the magnitude, likelihood, and severity of impacts on particular groups" (OMB, 2003). However, Circular A-4's focus is on benefits and costs, while the focus of E.O. 12898 is on human health or environmental effects, which is generally at least one step prior to the monetization of benefit categories covered in the EPA's *Guidelines for Preparing Economic Analyses* (2010c), hereafter referred to as the *Economic Guidelines*.

- ***Identify data, methods and analytical needs early in the process.*** Analysts should evaluate quantitative and qualitative data and methodological needs for an analysis of potential EJ concerns early to ensure that they are duly considered and reasonably accommodated. Data and methods availability influence the scope and complexity of an assessment and may inform the extent to which potential EJ concerns are considered in the decision-making process.
- ***Identify the potential for hot spots early in the process.*** In some cases, extensive differences in effects among population groups of concern may occur in only a few geographic locations. Referred to as *hot spots*, these locations are typically exposed to localized concentrations of emissions from one or more sources along with other stressors. In these cases, it may be appropriate to tailor the analysis to evaluate impacts in a few specific areas. Identifying the potential for hot spots early helps analysts develop appropriate sources of data and analytic techniques, which may differ from those used for a broader analysis.

3.3 Recommendations for Analyses of Potential EJ Concerns

This technical guidance makes four main recommendations designed to ensure consistency across assessments of potential EJ concerns for regulatory actions. The recommendations are not intended to be prescriptive and do not mandate the use of a specific approach. Rather, they encourage analysts to conduct the highest quality analysis feasible, recognizing that policy considerations as well as technical challenges may affect what is possible within a particular regulatory context.

1. Analysts should use their best professional judgement to decide what combination of quantitative and qualitative analysis is possible and appropriate.
    - For regulatory actions where impacts or benefits will be quantified, some level of quantitative analysis for EJ is recommended (see Section 6 for a discussion of methods).
    - When achievable, analysts should present information on estimated health and environmental risks, exposures, outcomes, benefits and other relevant effects disaggregated by income and race/ethnicity.
    - When such data are not available, it may still be possible to evaluate risk or exposure using other metrics (e.g., prevalence of affected facilities as a function of race/ethnicity or income, evidence of unique or atypical consumption patterns or contact rates) in a scientifically defensible way.
    - When impacts or benefits will not be quantified or disaggregated by race/ethnicity or income, analysts should present available quantitative and/or qualitative information that sheds light on potential EJ concerns (see Sections 6.1 and 6.3).
2. Analysts should integrate applicable questions during the planning and scoping and problem formulation stages of a risk assessment conducted for the regulatory action (see Section 5.3.2).
3. Analysts should follow best practices appropriate to the analytic questions at hand. Text Box 3.1 outlines current best practices that may be helpful for evaluating potential EJ concerns. If it is not feasible for analysts to follow these best practices, then analysts are encouraged to explain the reasons for their use of different approaches.
4. Analysts should consider the distribution of economic costs (i.e., private (compliance) and social costs) from an EJ perspective when appropriate, feasible, and relevant (see Section 6.6.1).[20]

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[20] See the EPA's *Economic Guidelines* (U.S. EPA, 2010c) for information on defining costs.

Text Box 3.1: Current Best Practices that May be Helpful for Evaluating Potential EJ Concerns

- Use the best available science while relying on current, generally accepted Agency procedures for conducting risk assessment and economic analysis.
- Use existing frameworks and data from other parts of the regulatory analysis, supplemented as appropriate.
- Be consistent with the basic assumptions underlying other parts of the regulatory analysis, such as using the same baseline and regulatory option scenarios.
- Use the highest quality and most recent data available. Discuss the overall quality and main limitations of the data (e.g., completeness, accuracy, validation).
- Discuss available evidence on factors that may make population groups of concern more vulnerable to adverse effects (e.g., unique pathways; cumulative exposure from multiple stressors; and behavioral, biological, or environmental factors that increase susceptibility).
- Identify unique considerations for subsistence populations when relevant.
- Carefully select and justify the choice of a comparison group (discussed in Section 6.5.2).
- Carefully select and justify the choice of the geographic unit of analysis and discuss any particular challenges or aggregation issues related to the choice of spatial scale.
- Show changes in potential differences in impacts (i.e., analyze and compare effects in baseline and across policy scenarios).
- Present summary metrics for relevant population groups of concern and the comparison group, not just data on each population group or area.
- When data allow, characterize the distribution of risks, exposures, or outcomes within each population group, not just average impacts, with particular attention paid to the characteristics of populations in the higher percentiles.
- Disaggregate data to reveal important spatial differences (e.g., demographic information for each facility/place) when feasible and appropriate.
- Discuss the severity and nature of the health consequences for which differences between population groups have been analyzed.
- Clearly describe data sources, assumptions, analytic techniques, and results.
- Discuss key sources of uncertainty or potential bias in the data (e.g., sample size, using proximity as a surrogate for exposure) and how they may influence results.
- When possible, conduct sensitivity analysis for key assumptions or parameters that may affect findings.
- Make elements of EJ assessments as straightforward and easy for the public to understand as possible.

Section 4: Contributors to Potential Environmental Justice Concerns

The purpose of this section is to highlight the key factors that contribute to the uneven distribution of environmental health risk across population groups. This section is intended to help analysts identify factors within communities that may contribute to potential EJ concerns and merit further investigation and analysis. To provide a more complete understanding of how these factors are interrelated, the section begins with a brief overview of the relationship between social context and environmental risk.

4.1 Social Context and Environmental Health Risk

Minority populations, low-income populations, and indigenous peoples often experience greater exposure and disease burdens than the general population as a whole, which can increase the risk of adverse health effects from environmental stressors among these populations.[21] For example, many studies have established that sources of environmental hazards are often located and concentrated in areas that are dominated by minority populations, low-income populations, or indigenous peoples (Bullard et al., 2007; Faber and Krieg, 2002; Faber and Krieg, 2005; Government Accountability Office, 1983; Maantay, 2001; United Church of Christ, 1987; Wilson et al., 2002). In addition, studies show that these population groups often experience higher exposures to environmental hazards associated with the places where they live, work, and play (Apelberg et al., 2005; Marshall, 2008; Morello-Frosch and Jesdale, 2006; Morello-Frosch et al., 2001; Sexton et al., 2007; Thompson et al., 2003; Woodruff et al., 2003). Finally, these population groups tend to be most burdened with adverse health conditions that either have environmental triggers or affect similar physiological systems as environmental pollution, such as cardiovascular disease, preterm birth, low birth weight, and asthma (Akinbami, 2006; Akinbami et al., 2012; Glover et al., 2005; Keenan and Rosendorf, 2011; Lara et al., 2006; Martin, 2011; Martin et al., 2010). Pre-existing disease and adverse health conditions can increase susceptibility to the effects of exposure to environmental hazards (Schwartz et al., 2011a).[22] In summary, due to a range of existing physical, chemical, biological, social, and cultural factors, population groups of concern may be more exposed to environmental toxins, or may suffer greater ill effects from exposures of similar magnitude, because they may have a compromised ability to cope with and/or recover from such exposures (U.S. EPA, 2003b).

Both high exposures and increased individual susceptibility to environmental stressors may lead to a predisposition to higher health risks among minority populations, low-income populations, or indigenous peoples (Schwartz et al., 2011a). As a result, in an assessment of potential EJ concerns, it is important to assess both the potential for higher exposures to a given environmental stressor and the potential for higher susceptibility to adverse effects of the stressor for population groups of concern. Potential contributors to differential health risk and adverse health impacts can thus be identified based on how they may increase exposure or how they may increase susceptibility in response to exposure.

Social context is critical when considering differences in exposure to stressors and resulting adverse health outcomes among certain population groups (e.g., low income, minority). The term *social context* refers

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[21] The term *racial/ethnic minority* is often used in the literature upon which this section is based to define what is referred to in E.O. 12898 as "minority populations."

[22] An individual who is susceptible is one who is more responsive to exposure (Schwartz et al., 2011a) or one who has an increased likelihood of sustaining an adverse effect (U.S. EPA, 2003b).

broadly to all social and political mechanisms that generate, configure, and maintain social hierarchies. These mechanisms can include the labor market, the educational system, political institutions, and cultural and societal values (Solar and Irwin, 2010). Social context has been recognized as a critical root cause of societal stratification into different social positions (e.g., race/ethnicity, income, occupation). Social stratification in turn is associated with differential exposure, susceptibility to stressors, and consequences (Solar and Irwin, 2010). Social context and social stratification together can shape determinants of health such as:

- Material circumstances (e.g., neighborhood and housing conditions/quality, green space, walkability, access to fresh foods, and the work environment);
- Behavioral and biological factors (e.g., nutrition, smoking, genetic factors);
- The health care system (e.g., access to and interaction with health care providers and resources);
- Psychosocial circumstances (e.g., stressful living conditions and relationships, availability of coping and support mechanisms) (Solar and Irwin, 2010; McEwen and Tucker, 2011; Couch and Coles, 2011); and
- Ecological and natural resource factors (e.g., traditional subsistence lifestyles, climate change impacts) (Harper et al., 2007).

The literature has proposed a number of conceptual frameworks to explicitly integrate social context contributors to differential health risks/impacts into the exposure-disease paradigm, and to highlight potential pathways through which these contributors may interact with environmental exposures to yield health differences (Gee and Payne-Sturges, 2004; Morello-Frosch and Jesdale, 2006). Though the proposed pathways in these frameworks have not all been tested, they are insightful and offer integrated approaches for considering pathways through which multiple factors may increase exposure or susceptibility.

4.2 Contributors to Higher Exposure

The steps for performing an exposure assessment require that an analyst: (1) identify the source of the environmental stressor and the media that transports that contaminant; (2) determine the contaminant concentration; (3) determine the exposure scenarios, pathways, and routes of exposure; (4) determine the exposure factors related to human behaviors that define time, frequency, and duration of exposure; and (5) identify the exposed population. Exposure factors are related to human behavior and characteristics and determine an individual's exposure to an agent (U.S. EPA, 2011e).

A good starting point for identifying factors that may contribute to differential impacts and merit further review is to focus on those that contribute to higher exposure among population groups of concern.[23] Contributors to the potential for higher exposure among minority populations, low-income populations, or indigenous peoples include:

- Proximity to emission sources;
- Unique exposure pathways;
- Physical infrastructure (e.g., housing conditions, water infrastructure);

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[23] The terms *exposure* and *dose* are very closely related and are therefore often confused (Zartarian et al., 2007). An exposure does not necessarily lead to a dose, but there cannot be a dose without a corresponding exposure (U.S. EPA, 2011e; Zartarian et al., 2007). See the glossary of this document for definitions of *exposure* and *dose*.

- Exposure to multiple stressors/cumulative exposures; and
- Community capacity to participate in decision-making (Nweke et al., 2011; U.S. EPA, 2007a).

4.2.1 Proximity to Emission Sources

Proximity to emission sources is the most studied indicator of high exposure in the EJ literature. Proximity to an emission source is only a surrogate measure for exposure (because it does not incorporate key determinants such as time-activity patterns), but several studies have found positive associations between residence near a pollution emissions source and adverse health outcomes (Brender et al., 2011).[24] In addition, studies have found that areas with a larger proportion of minority populations, low-income populations, or indigenous peoples are more likely to have pollution emission sources such as a hazardous waste site, high traffic roadway, or industrial site (e.g., Apelberg et al., 2005; Guinier et al., 2003).

4.2.2 Exposure Pathways

Exposure pathways describe the means by which exposure to a given stressor occurs. Higher exposures may be related to non-traditional pathways that stem from behaviors of a specific group of individuals who have shared ideas, values, learned traditions and life experiences that are embedded in socially grounded processes. The social constructs of culture and ethnicity may to varying extents capture shared learned traditions and/or life experiences, thus providing a window into how exposure pathways may vary across social groups (NRC, 2002). Specific examples of exposure pathways for environmental stressors that relate to cultural context or ethnicity are documented in the academic literature (Anderson and Rice, 1993; Ernst, 2002a, b; Ernst and Thompson Coon, 2001; McKelvey et al., 2011; Peterson et al., 1994). In addition, a detailed review of unique exposure pathways and a conceptual model to aid the identification of such pathways are discussed in detail elsewhere (Burger and Gochfeld, 2011; Gochfeld and Burger, 2011). Examples of shared behavior that may yield atypical pathways of exposure to environmental stressors and potentially higher exposures include subsistence fishing, consumption of ayurvedic (i.e., alternative) medicines among Asians, sweat baths among Native Americans (Gochfeld and Burger, 2011), and occupationally-related pathways such as farmworker children facing potential exposures from "take home" residues in their parents' clothing or from pesticide drift (Harrison, 2011).[25]

Exposure pathways are also related to factors such as behavioral and physiological stages of growth and development that may occur during a particular life stage (U.S. EPA, 2011e). For example, individuals in all populations alter their eating patterns as they grow older (e.g., infants' diets consist primarily of milk products). Object-to-mouth behavior and crawling are examples of behaviors that are associated with infants and toddlers (U.S. EPA, 2013a). Such behavior increases exposure to environmental stressors that may exist in higher concentrations in toys and in contaminants that accumulate on floors or carpets, for example.

4.2.3 Physical Infrastructure

For some environmental stressors, physical infrastructure may contribute to increased exposure. In particular, residents living near potential emission sources may experience increased concentrations of contaminants due to damaged or substandard structural and building conditions. Housing, in particular, has been well studied as a potential contributor to environmental exposure. For instance, housing in the United States built before 1978 may contain lead-based paint, exposure to which can impair cognitive function in children and lead to lower IQ. In addition, substandard housing conditions such as water leaks, poor ventilation, dirty carpets, and pest infestation can lead to an increase in mold, dust mites, and other allergens associated with poor health (Commission to Build a Healthier America, 2008; U.S. Department of

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24 Residential proximity does not imply that exposures and health risks are occurring but only that the potential for exposure is increased (NRC, 1991).

25 Ayurvedic medicines are taken as part of a Hindu traditional medicine practice of the same name.

Housing and Urban Development, 2001; Thorne et al., 2009). A higher proportion of minorities live in substandard housing (Jacobs, 2011). Therefore, examining how housing may increase exposure to a given stressor is helpful for uncovering whether particular minority populations, low-income populations, or indigenous peoples may experience higher exposures.

Other types of infrastructure such as transportation and drinking water infrastructure may also be associated with higher exposure to environmental stressors. For example, in Southern California, minority and low-income neighborhoods have twice the traffic density of the rest of region; the potential for greater exposure to hazards from traffic is therefore higher in these neighborhoods (Houston et al., 2004). Differential exposure related to drinking water infrastructure is less examined. However, some evidence indicates that access to piped water and shared water systems may affect exposure, as may older housing with lead pipes (VanDerslice, 2011).

4.2.4 Multiple Stressors, Multiple Sources, and Cumulative Impacts

Numerous studies describe minority populations, low-income populations, or indigenous peoples that are impacted by exposure to multiple environmental hazards, such as contaminants from industrial facilities, landfills, and leaking underground tanks, transportation-related air pollution, poor housing, pesticides, and incompatible land uses (e.g., see Brender et al. (2011) for a summary of some recent literature). Localized concentrations of environmental emissions from one or more sources along with other stressors (i.e., hot spots) are typically located near multiple pollution sources, and are a source of concern for residents in many communities throughout the country (U.S. EPA, 2010a; California Environmental Protection Agency, 2015; Bullard, 2005; Greenberg and Schneider, 1996).

Recognizing the potential harm associated with multiple stressors from one or more pollution sources or exposure pathways, the EPA has described a framework for assessing the cumulative risk of adverse effects associated with multiple stressors (U.S. EPA, 2003b). Additionally, exposure to a stressor may occur across several sources (e.g., air emissions from several facilities in different industries). An analysis that considers risks from only one source can inaccurately characterize the potential for health risks if the populations for which risk is being estimated are also exposed to a stressor from the other sources. For example, a single source might emit low levels of a stressor, but when considered across all sources to which a population is exposed, the exposure may be sufficient to result in a health risk or concern. As noted in Section 4.2.1 above, emission sources for environmental pollutants have been found to often be concentrated in locations dominated by minority populations, low-income populations, or indigenous peoples (Bullard et al., 2007; United Church of Christ, 1987), making the consideration of multiple sources important to consideration of health risk to these populations. The presence of non-chemical stressors, such as crime, in these populations may also exacerbate the effects of some chemical exposures (e.g., changes in immunological response due to increased presence of stress hormones (Gee and Payne-Sturges, 2004)).

The EPA's *Framework for Cumulative Risk Assessment* (U.S. EPA, 2003b) provides guidance on planning and undertaking an assessment of cumulative impacts when evaluating the range of both chemical and non-chemical stressors that may be relevant to potential EJ concerns. The science supporting assessments of such cumulative impacts is evolving, however, and the data and analytical tools needed to develop informative, scientifically sound analyses of these effects may not be available in many cases. Presently, the data and methodology limitations may lead to current applications of cumulative risk assessment at the EPA being focused on mixtures of chemicals. Additionally, current applications may involve use of epidemiology studies (discussed in Section 5). When available, these studies may indicate multiple chemical exposures and other factors that may modify or increase the risk of an adverse outcome from exposure to a regulated stressor.

4.2.5 Community Capacity to Participate in Decision-Making

Community capacity is a multidimensional concept that includes factors such as leadership, participation, skills, resources, community power, and social and organizational networks (Freudenberg et al., 2011).

Communities with a relatively high proportion of minority populations, low-income populations, or indigenous peoples may have lower community capacity, and this may contribute to potential EJ concerns. The capacity of communities to participate in the decision-making process is a crucial determinant of the success of civic engagements in terms of preventing high burdens of emitting sources and exposure to environmental stressors. Political mechanisms, for instance, can influence the potential for exposure to environmental stressors at the community level, given the role of such mechanisms in facility siting and permitting. Political mechanisms give rise to opportunities for civic engagement, such as zoning meetings or other community planning meetings, which provide communities with opportunities to participate in decisions pertaining to the quality of their environment. When communities are unable to participate effectively in decision-making, they may be more likely to be the recipients of negative environmental consequences, including impacts associated with emissions sources.

Though meaningful involvement is related to the community's capacity to participate in the decision-making process, these topics are not discussed in depth in this guidance document. Some additional information about meaningful involvement can be found in Section 2.3, Section 5.3.1.5, and Text Box 2.2 (see also U.S. EPA (2015a)).

4.3 Contributors to Higher Susceptibility

A person's susceptibility to an environmental stressor is an important determinant of both the occurrence and severity of an adverse effect. Some factors that may influence susceptibility include genetics, diet, nutritional status, pre-existing disease, psychological stress, co-exposure to similarly acting toxics or chemicals, and cumulative burden of disease resulting from exposure to all stressors throughout the course of life (Schwartz et al., 2011a, b). Also known as risk-modifiers or effect-modifiers, these factors may influence the health-related outcome of exposure through biological interactions at the individual level. Another noteworthy potential risk-modifier is socioeconomic status, which does not by itself elicit a biological interaction, but has a complex and robust association with many health states (Schwartz et al., 2011b), and may influence factors such as diet, nutrition, and access to health care and consequently health status. Several examples of how these risk modifiers may increase risk are discussed in papers by Schwartz et al. (2011a, b).

Some groups of individuals within minority populations, low-income populations, or indigenous peoples may also have higher susceptibility to the effects of some stressors compared to others in these populations. This greater susceptibility may be related to age and the stages of physiological and behavioral growth and development, referred to as *life stages* (U.S. EPA, 2011e). Susceptible groups based on life stage can include children, the elderly, pregnant women and/or women of childbearing age, and immuno-compromised individuals, as well as workers in certain occupations, depending on the target health endpoint and the stressor. For example, infants and young children are more likely to experience adverse neurological health effects from lead in the environment due to a combination of factors including life stage (U.S. EPA, 2013a). As previously stated, these groups may also have exposure pathways (e.g., hand-to-mouth behavior of very young children) or may be exposed to multiple exposure sources (e.g., workers that are both exposed occupationally and also reside in neighborhoods with high ambient concentrations of air pollution) that when combined with higher susceptibility can further increase the risk for adverse health effects.

The concepts of susceptibility and vulnerability can be used to identify population groups of concern. For example, profiles can be constructed that combine available data on baseline health and demographic information to identify susceptible or vulnerable population groups and then use various combinations of demographic, education, poverty, and air quality data to describe them (Fann et al., 2011). Further discussion about considering susceptibility and exposure factors in risk assessments for EJ analyses can be found in Section 5.3 and Appendix B.

Section 5: Considering Environmental Justice when Planning a Human Health Risk Assessment

This section provides guidance to Agency analysts on integrating the consideration of potential EJ concerns into the planning phase of a human health risk assessment conducted to support a regulatory action. In particular, the *EJ Technical Guidance* recommends that, to the extent possible, evaluation of potential EJ concerns be integrated into an HHRA rather than conducted as an add-on or separate analysis of differences in risks across population groups of concern. Integration ensures that an analyst can effectively consider differential health risks for minority populations, low-income populations, or indigenous peoples. This recommendation is consistent with the EPA's *Framework for Human Health Risk Assessment to Inform Decision Making*, referred to in this document as the *HHRA Framework* (U.S. EPA, 2014c), which identifies EJ as one of several overarching considerations for which "early consideration and discussion … can enhance the utility of the risk assessment." The *HHRA Framework* also notes "... the potential for inclusion of analyses involving these topics is an important consideration in the planning stage for an assessment."

5.1 Introduction

An analyst planning an HHRA in support of a regulatory action should seek information early in the process that is relevant to the three analytic questions outlined in Section 3.1 (and repeated here):

- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?
- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for the regulatory option(s) under consideration?
- For the regulatory option(s) under consideration, are potential EJ concerns created or mitigated compared to the baseline?

These questions help an analyst evaluate whether a potential EJ concern already exists and whether, for each of the regulatory options under consideration, a potential EJ concern is likely to be created or mitigated by the affected stressors. The role of an analyst is to plan and conduct an HHRA that presents results – and the appropriate context for those results – in a transparent manner so that the decision maker can incorporate consideration of differential risks across population groups into risk management decisions.

Human health risk assessment is a complex and iterative process, and the science and practices that support it continue to evolve. This technical guidance is therefore designed to allow analysts to incorporate new information into the risk assessment process as it becomes available through research and method development efforts, or as needs for information evolve. Likewise, analysis of potential EJ concerns in HHRA should evolve to incorporate improved risk assessment methodologies and guidance. The EPA has developed and continues to develop methods and guidance on key risk assessment topics such as cumulative risk assessment, dose-response assessment, and exposure assessment. These documents, as well as tools and approaches generated by EPA offices and regions, will, over time, help to improve analyses of potential EJ concerns. The EPA is also involved in ongoing research activities designed to advance risk assessment. Some of these efforts are specifically focused on better understanding the impact of susceptibility and variability on dose-response. Another focus is how various risk factors beyond chemical exposures (e.g., poor nutrition, stress, access to health care, and lower socioeconomic status) may be utilized in HHRA to improve the scientific basis for estimating risks at the community level. It is expected that this *EJ Technical Guidance* will be updated to incorporate new analytical tools, as appropriate.

The remainder of this section is organized into two parts. Section 5.2 provides an overview of key concepts in HHRA. Section 5.3 describes how potential EJ concerns can be considered in the planning stage of an HHRA. Additional information on this topic can be found in Appendix B, which provides examples of ways to incorporate potential EJ concerns into the planning stages of exposure and dose-response assessments.

5.2 Overview of Key Concepts

This section briefly discusses key concepts relevant to considering potential EJ concerns in an HHRA. For more information on these concepts generally, see the EPA's *Framework for HHRA Framework* (U.S. EPA, 2014c). In addition, the EPA has published guidance on all steps of the HHRA process; links to some of these documents can be found in Appendix A. The Agency's Risk Assessment website provides basic information about environmental risk assessments and offers a set of links to key EPA tools, guidance, and guidelines.[26] Links to sites of particular relevance to EJ are included throughout this chapter.

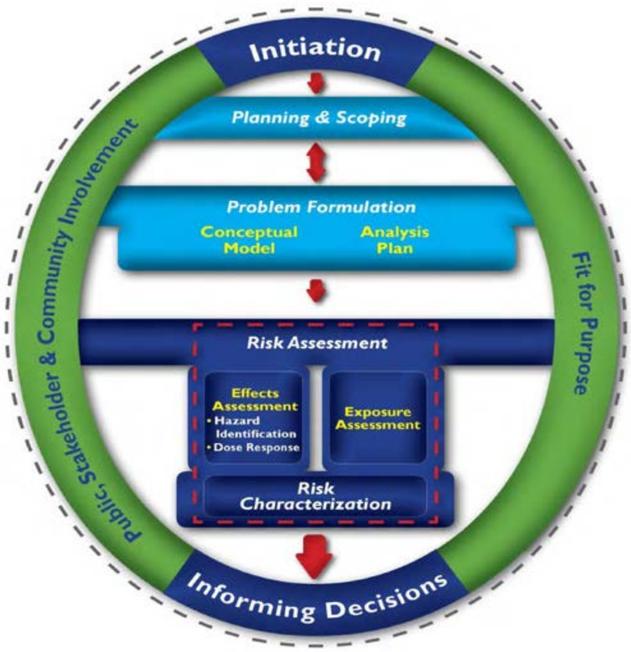
5.2.1 Human Health Risk Assessment to Inform Decision-Making

The EPA's *HHRA Framework* (U.S. EPA, 2014c) highlights the roles of initial planning and scoping, as well as problem formulation in designing a risk assessment to serve a specific and documented purpose (Figure 5.1).

In accordance with longstanding Agency policy and congruent with EJ principles, the *HHRA Framework* emphasizes the importance of scientific peer review as well as public, stakeholder, and community involvement throughout the process. EJ can be considered at any point in the HHRA process, but the planning and scoping and problem formulation phases set the foundation of the HHRA.

Figure 5.1: Framework for Human Health Risk Assessment to Inform Decision-Making

Adapted from: U.S. EPA (2014c)



[26] See the EPA's Risk Assessment website: www.epa.gov/risk.

The classic risk assessment process itself (Figure 5.2) includes a series of four steps: effects assessment (including hazard identification and dose-response assessment), exposure assessment, and risk characterization. The HHRA process is not strictly linear and sequential; steps are often performed together in an integrative fashion. Risk characterization, in particular, incorporates information from all of the other steps and provides the basis for communicating the results to decision makers and the public.

Adapted from: U.S. EPA (2014c)

Figure 5.2: Steps in Human Health Risk Assessment

The basic analytic process of an HHRA can be employed to characterize the nature, probability, and magnitude of current or future risks of adverse human health effects related to exposure to environmental stressors (e.g., chemical, physical, or biological agents) for population groups of concern. An HHRA can include both quantitative and qualitative expressions of risk (NRC, 1983; U.S. EPA, 2014c), and can incorporate different types of assessments depending on the nature of the regulatory decision that the assessment is intended to inform. For example, a prioritization exercise for regulatory consideration may use only a screening assessment with very conservative default values. In contrast, a national regulatory action may require a rigorous assessment of several types of potential health effects and exposure scenarios to support an in-depth examination of benefits.

5.2.2 Fit-for-Purpose

Fit-for-purpose refers to the step in the risk assessment framework that ensures that risk assessments and associated products are suitable and useful for their intended purpose(s), particularly for informing choices among risk management options (U.S. EPA, 2014c). Accordingly, throughout the process of planning and performing HHRAs, it is important to evaluate whether the assessment is effectively addressing the information needs of decision makers. The NRC (2009) recommends that the EPA maximizes the utility of risk assessment by assuring that risk assessments are tailored to the problems and decisions at hand. The EPA considers the utility of risk assessment (the extent to which it is fit for purpose) as a continuous assessment throughout the HHRA process, rather than as a separate step during or after a risk assessment is completed.

Consistent with E.O. 12898 and other EPA policies regarding EJ, one part of the fit-for-purpose planning discussion should be to ensure that the analysis will provide useful information on how policy options might affect distribution of risks across population groups of concern. Addressing the fit-for-purpose question early and throughout the HHRA process ensures that the risk assessment adequately addresses the purpose for which it is intended; in the context of EJ, this typically includes information for decision makers on the distribution of risk across specific population groups. The risk assessment methods used to consider potential

EJ concerns will vary with the environmental problem being addressed, and the scope of the HHRA will be affected by statutory mandates and limitations in data, methods, time, and resources; a robust fit-for-purpose process ensures that these limitations do not limit the usefulness of the analysis.

To ensure that an HHRA sufficiently identifies and characterizes potentially differential risks, it is recommended that an analyst do the following for the specific policy context under consideration:

1. Identify those types of individuals or population groups that potentially could experience higher risks relative to the average or comparable individuals in the general population as a result of the policy change;
2. Clearly state the reasons why an identified population group (or life stage within a population group) may potentially experience higher risk than the average person;
3. Estimate and characterize the potential for differences in risk for affected groups; and
4. Present the results to decision makers in a complete and transparent manner.

5.2.3 Multiple Exposures and Cumulative Effects

Multi-stressor or cumulative risk assessment (CRA) is an approach that the EPA considers for characterizing how risks may disproportionately affect one group relative to another and is an area of much scientific interest. The EPA defines CRA as the evaluation of the combined risks from aggregate exposure to multiple agents or stressors (both chemical and non-chemical) (U.S. EPA, 2003b). The NRC (2009) defines CRA as "evaluating an array of stressors (chemical and non-chemical) to characterize – quantitatively to the extent possible – human health and ecologic effects, taking into account factors such as vulnerability and background exposures." Because of data and methodology limitations, current applications of CRA focus largely on chemical mixtures and/or single chemicals from multiple sources. However, the framework described in the EPA's *Framework for Cumulative Risk Assessment* (U.S. EPA, 2003b) is broadly applicable in evaluating the range of both chemical and non-chemical stressors relevant to potential EJ concerns. Text Box 5.1 summarizes the EPA's guidance to date on CRA.[27]

An effects-based approach may be useful to analysts in examining the potential impacts of exposures relevant to potential EJ concerns. This approach may involve the use of epidemiological data to focus first on health outcomes of concern (i.e., those types of diseases or conditions with a higher prevalence within or across populations). Epidemiology studies may not isolate the individual effects of different stressors that may affect a population at the same time (co-occurring). However, when available, these studies may help an analyst to characterize the cumulative impacts of multiple stressors (Levy, 2008). Epidemiological studies may also employ stratification to identify effect modification, which can provide insight on the risk of an adverse outcome from co-exposure to another chemical or due to an additional physical, environmental, social, or biological stressor that may be necessary to consider when evaluating potential EJ concerns.

[27] While this broader definition of *cumulative risk* considers multiple agents or stressors (both chemical and non-chemical), it is important to acknowledge that the Food Quality Protection Act also requires the EPA to evaluate aggregate risks of one chemical from multiple sources and/or cumulative exposures to multiple chemicals with similar mechanisms of toxicity (U.S. EPA, 2002a).

Text Box 5.1: Guidance on Cumulative Risk Assessment

Guidance on Cumulative Risk Assessment, Part 1: Planning and Scoping (U.S. EPA, 1997a)
http://www.epa.gov/risk/guidance-cumulative-risk-assessment-part-1-planning-and-scoping

General Principles for Performing Aggregate Exposure and Risk Assessment (U.S. EPA, 2001)
http://www.epa.gov/sites/production/files/2015-07/documents/aggregate.pdf

Guidance on Cumulative Risk Assessment of Pesticide Chemicals that have a Common Mechanism of Toxicity (U.S. EPA, 2002a)
http://www.epa.gov/sites/production/files/2015-07/documents/guidance_on_common_mechanism.pdf

Framework for Cumulative Risk Assessment (U.S. EPA, 2003b)
http://www.epa.gov/risk/framework-cumulative-risk-assessment

Concepts, Methods, and Data Sources for Cumulative Health Risk Assessment of Multiple Chemicals, Exposures and Effects: A Resource Document (U.S. EPA, 2007b)
http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=190187

5.2.4 Potential Challenges of Applying HHRA in an EJ Context

The EPA's Science Advisory Board (SAB) has consistently said that it is appropriate for the EPA to use the risk assessment model as the primary means to quantify adverse health impact from chemicals in the environment (e.g., SAB, 2002, 2006, 2010, 2011). This recommendation was echoed by the panel that reviewed this *EJ Technical Guidance* (SAB, 2015). HHRA may be required by common practice or statute.[28] It should also be noted that some of the EPA's enabling statutes require that data used in assessments underlying a regulatory action be peer-reviewed and publicly available.

Use of an HHRA in evaluating potential EJ concerns raises some important considerations, which are described below.

5.2.4.1 HHRA can be difficult to understand

HHRA, particularly quantitative hazard and exposure assessment, is a highly technical discipline. Some authors (e.g., Corburn, 2002) have noted that community stakeholders, even when offered the opportunity to participate in risk management decisions, are at a disadvantage in the policy discourse: "To prepare, no less critique, these assessments takes a sophisticated understanding of complex issues of animal and human toxicology, physiology, epidemiology, mathematical models, exposure measurements, and statistical probabilities" (Corburn, 2002). Some authors feel that the complexity of HHRA can lead to a lack of transparency and accountability (SAB, 2015). Moreover, the HHRA is framed in terms of the risk of some adverse outcome. EJ advocates or analysts may often be more interested in broader concepts of health, beyond the absence of a particular adverse effect (Austin and Schill, 1994).

[28] See U.S. EPA (2011b), NRC (2009), and Institute of Medicine (2013) for a description of some statutory requirements and influences on differences among risk assessment practices in support of regulatory action).

5.2.4.2 Technical limitations and data gaps can affect HHRA

Established methods are not available for modeling the effects of many non-chemical stressors that are important to an analysis of potential EJ concerns. Such stressors (e.g., nutritional deficits, stress) may interact with chemical stressors to exacerbate or mitigate health outcomes; the ability to model such interactions is still in the nascent stages of development.

Similarly, HHRA may be limited by a lack of data relevant to potential EJ concerns. For example, data on the quantitative role played by non-chemical stressors may be limited. In addition, the results of studies of certain populations may not be generalizable to some populations with potential EJ concerns, such as when the research is conducted on healthy, white, male adults (Corburn, 2002; Payne-Sturges, 2011).[29] The limited utility of national data for informing health disparities and the limitations of extrapolating community-level data from national surveys have also been noted (Nweke et al., 2011). The NRC (2009) recognizes that "[d]ecisions regarding risks and risk changes expected under various risk-management options are informed by the availability of risk assessments." In the same report, the NRC (2009) notes that "[t]he goal of achieving accurate, highly quantitative estimates of risk, however, is hampered by limitations in scientific understanding and the availability of relevant data, which can be overcome only by the advance of relevant research." Section 7 of this document provides a discussion of EPA research priorities for improving the analysis of potential EJ concerns.

5.2.4.3 It can be difficult to incorporate cumulative impacts of multiple, dissimilar stressors into HHRA

Many communities with potential EJ concerns are likely to be exposed to multiple stressors through multiple pathways. HHRA has most often been conducted on a chemical-by-chemical basis using single exposure-to-effect pathways. Assessments have also evaluated the risk associated with exposure to multiple chemicals that act by similar mechanisms. The feasibility of broadening the scope of HHRA is limited by lack of data (e.g., information on background exposure or health status) and a dearth of sufficiently complex, validated models. In addition, incorporating non-chemical stressors is often hampered by lack of data. While the SAB (2015) continues to recommend use of HHRA, it encourages the EPA to develop further guidance for quantitative and/or qualitative evaluation of cumulative impacts. See Text Box: 5.1 for information on EPA's guidance documents on cumulative risk assessment.

5.2.4.4 HHRA typically lacks effective public involvement

HHRA has been criticized by some for often having limited consideration of public perceptions of risk (Corburn, 2002). HHRA methods typically do not consider public attitudes toward risk. HHRA does not encompass (or at least does not quantify) factors such as fairness, distribution of risk, voluntariness, responsibility, control, trust, reversibility, and identifiable victims (Corburn, 2002), though these may be identified in the course of risk management discussions. Payne-Sturges (2011) notes that "when affected citizens actively participate in the process to better understand science and inform policy responses, better decisions emerge as a result."

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[29] In the absence of scientific data to fully characterize the range of responses to chemical exposures, the EPA employs default assumptions, such as uncertainty factors used in non-cancer risk assessments, to account for human variability. As noted by the SAB (2015), however, "…the use of uncertainty factors in developing dose-response assessments for an individual level chemical might address the general population as a whole, but does not specifically address differential or disproportionate vulnerability of an environmental justice community."

5.2.5 Health Impact Assessment

Health impact assessment (HIA) is a tool that provides a way of examining the relationship between social factors and health. HIA promotes a broad definition of health, using both qualitative data and quantitative information, typically considering a broader spectrum of health determinants than are included in a traditional HHRA. HIA has been described as "a systematic process that uses an array of data sources and analytic methods, and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population. HIA provides recommendations on monitoring and managing those effects" (NRC, 2011).

The definition of health used by HIA reaches beyond the absence of disease or infirmity to consider complete physical, social, and mental health. HIA provides recommendations to address disproportionate health effects, mitigate potential adverse health effects, and bolster potential beneficial health effects of the proposed decision. Health determinants such as the quality of housing, access to services, and social cohesion, as well as exposure to contaminants, may be examined in an HIA to identify the disproportionate human health and/or environmental effects of a proposed decision and its alternatives on minority populations, low-income populations, and indigenous peoples, as well as vulnerable populations such as children and the elderly (NRC, 2011).

The HIA process typically emphasizes meaningful public engagement that focuses on empowering vulnerable and affected populations to participate in decisions that have the potential to affect their lives.[30] Effective input from the public can do the following:

- Provide local knowledge of health and existing conditions;
- Identify areas of concern and issues of interest that might not be readily apparent to those outside the community;
- Offer contextual/cultural perceptions and experiences; and
- Assist in identifying and refining the HIA scope and recommendations.

The EPA has developed several case studies to explore ways in which HIA can be used to engage the public and to incorporate potential EJ concerns and public health considerations into local environmental decision-making processes. One EPA-led HIA focused on environmental conditions in an elementary school and community center in a low-income, immigrant community in Springfield, Massachusetts and analyzed how proposed renovations could influence health and wellness of facility users, especially among vulnerable populations. Another EPA-led HIA assessed how a proposed green street project in the Proctor Creek community in Atlanta, Georgia, could potentially affect public health. Both of these HIAs included extensive public participation throughout the process; utilized best-available qualitative and quantitative data; examined health determinants in the environmental, social, and economic sectors to evaluate cumulative human health effects; and analyzed and provided recommendations to address any disproportionate health impacts on vulnerable groups. Two additional EPA-led HIA case studies include an examination of the potential health impacts of proposed code changes for onsite sewage disposal systems in Suffolk County, New York, and an evaluation of a separate effort in Atlanta's Proctor Creek focused on the expansion of green infrastructure in the watershed. More detailed descriptions of the case studies can be found at the EPA's Health Impact Assessments website, which can be accessed at http://www2.epa.gov/healthresearch/health-impact-assessments.

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[30] Equity is one of the core values of HIA, the others being democracy, sustainability, ethical use of evidence, and comprehensiveness of approach. The role of HIA in promoting equity, however, goes well beyond examining existing health inequities and considering the distribution of potential health impacts across affected populations (i.e., identifying disproportionate impacts of a decision).

The EPA has not attempted to apply HIA in support of national regulatory actions, which generally use HHRA, but HIA could potentially serve as a complement to HHRA in the national context in certain circumstances (e.g., hot spots) for evaluation of the cumulative impacts and potential EJ concerns.

5.3 Considering Potential EJ Concerns when Planning a Human Health Risk Assessment

To implement E.O. 12898 and the EPA's EJ policies, it is important that HHRAs conducted in support of regulatory actions explicitly consider health risks that may disproportionately accrue within minority populations, low-income populations, or indigenous peoples, as these demographic attributes may reflect underlying vulnerability and susceptibility to environmental stressors. Also, the burden of health problems and potentially disproportionate environmental exposures associated with race/ethnicity and income may overlap with other susceptibility factors such as life stage, genetic predisposition, or pre-existing health conditions (see Section 4 for further discussion). For example, the burden of environmental exposures and resulting health problems is often borne disproportionately by children from low-income communities and minority communities (Israel et al., 2005).

The planning and scoping and problem formulation phases are key elements of the *HHRA Framework* (see Figure 5.1 above). In the planning and scoping phase, analysts define the process for conducting the risk assessment and establish its analytic scope. The problem formulation step focuses on the specific hypotheses and technical approach of the HHRA; important outcomes of this step are a conceptual model and an analysis plan for the assessment (U.S. EPA, 2014c). As discussed below, the consideration of EJ in each part of the risk assessment planning process is important to ensuring an effective assessment.

5.3.1 Planning and Scoping

Consistent with EPA guidance (U.S. EPA, 2014c), the key aspects of planning and scoping of an HHRA are the following:

- Context, Purpose, and Scope of the Risk Assessment (Section 5.3.1.1);
- Overarching Considerations (Section 5.3.1.2);
- Responsibilities, Resources, and Timeline (Section 5.3.1.3);
- Planning Scientific Peer Review or Other Review Steps (Section 5.3.1.4); and
- Public, Stakeholder and Community Involvement (Section 5.3.1.5).

Each step of planning and scoping for an HHRA is discussed briefly here with an emphasis on where potential EJ concerns may enter the discussion. Risk assessors and other analysts should consult EPA guidance documents on risk assessment for more information (see Appendix A; U.S. EPA, 2014c; U.S. EPA, 1997a).

5.3.1.1 Context, Purpose, and Scope of the Risk Assessment

Context. EPA risk assessments occur in specific policy contexts that inform the scope, purpose, and risk management objectives. Many EPA risk assessments are done to inform specific decisions that guide the development of regulatory actions. In other cases, such as a response to a newly identified environmental concern, careful consideration of the purpose and associated objectives, including decisions being informed, is essential to the development of a risk assessment that provides the information needed. Planning for the risk assessment should clearly identify the decision that will be supported by the analysis and specify the boundaries for the assessment, detailing what will not be addressed in the risk assessment.

To frame the context for an analysis, an analyst should identify any complementary requirements between the triggering statutory authority and E.O. 12898 that focus on identifying and addressing potentially disproportionate risks. In addition to the specific policy context, other contexts may help frame an evaluation of potential EJ concerns within an HHRA. For example, background exposure to chemicals from multiple sources, or an enhanced background risk for a relevant adverse health outcome due to other factors, are important contexts for assessing disproportionate risk. Communities with potential EJ concerns also may experience disproportionate risks due to higher susceptibility (e.g., due to life stage or pre-existing health conditions) or other factors influencing exposures (e.g., behavioral patterns or proximity to sources of exposure).[31]

Purpose. The planning and scoping phase includes explicit consideration of the nature of the question (or hypothesis) that the assessment seeks to address, with the goal of developing or clarifying the broad dimensions and elements of the assessment. Specifically, this step defines the assessment and management objectives and purpose. In complex situations, clear articulation of the overall purpose or end use of an assessment may involve extensive interaction among the assessment team and the range of stakeholders to establish a common understanding. In addition, in this step analysts may develop a high-level review of data needs and limitations to ensure that the results will adequately inform decision makers (NRC, 2009).

The particular purpose for which an assessment will be used and its scale (e.g., regional or national) often will have significant implications for the scope, level of detail, and approach of an assessment. Key considerations at this stage include:

- What decision is to be informed by the risk assessment, when is the decision anticipated, and what are the risk management options?
- What legal or statutory requirements affect risk management options and the level or type of analysis? (U.S. EPA, 2014c)

To ensure that an HHRA generates useful information, risk managers and analysts should develop concise statements of risk management and analytical objectives that incorporate potential EJ concerns. As risk managers and analysts develop these objectives, it is important to frame them so they generate responses to the main EJ analytic questions from Section 3.1 (See Text Box 5.2 for an example). Related analytical objectives for evaluating potential EJ concerns within an HHRA should identify anticipated outputs of the assessment. Analytical objectives should concisely identify the evidence to be collected; the direction and structure of the planned evaluation for potential EJ concerns; the analytical methods to be employed (e.g., between socioeconomic group comparisons); the type of data required; and the scope of the analysis (e.g., national versus local scale).

[31] As an example, primary NAAQS are required to protect public health, including the health of sensitive (or at-risk) groups, with an adequate margin of safety. Where low-income or minority groups are among the at-risk populations (e.g., particulate matter in 2013 review), the Administrator's decision will be based on providing protection for these and other at-risk populations and life stages. In other cases, the NAAQS will be established to provide protection to the at-risk populations and would also be expected to provide protection to other populations (including low-income and minority populations not included within the at-risk groups). Where low-income and minority populations are identified as at-risk and where the data are available, they may be a focus of an accompanying HHRA.

Text Box 5.2: Incorporating Potential EJ Concerns for the Definition of Solid Waste Rule; Examples of Risk Management and Analytic Objectives

Regulatory Context: The Resource Conservation and Recovery Act (RCRA) gives the EPA authority to regulate hazardous wastes. Hazardous wastes may (1) cause, or significantly increase, mortality or serious irreversible or incapacitating reversible illness, or (2) pose a substantial present or potential hazard to human health or the environment when improperly managed. Hazardous wastes are a subset of solid wastes; materials that are not solid wastes are not subject to regulation as hazardous wastes. Thus, the definition of "solid waste" plays a key role in defining the scope of the EPA's authority under RCRA.

The EPA has historically interpreted "solid waste" to include certain materials that are destined for recycling (U.S. EPA, 1980). Under the 2008 RCRA Hazardous Waste Definition of Solid Waste (DSW) rule, the EPA sought to clarify how the definition of solid waste applies to hazardous secondary material recycling in a way that both encourages recycling and is protective of human health and the environment (U.S. EPA, 2008a). Based on concerns raised by environmental and community groups about the 2008 DSW rule, the EPA conducted a reassessment, resulting in significant revisions that were finalized in the 2015 DSW final rule (U.S. EPA, 2011g, 2015b).

Risk Management Objective for Potential EJ Concerns: Review the 2008 DSW rule to evaluate the potential for increased risk to human health and the environment from discarded hazardous secondary materials intended for recycling. Incorporate the results of that review into regulatory revisions to the 2008 DSW rule.

Translating Risk Management Objective to Questions: (1) What hazards could pose risks to human health and the environment from recycling of hazardous secondary materials, including accidental releases of hazardous secondary materials resulting in differential risks to minority populations, low-income populations, or indigenous peoples?, and (2) What is the likelihood of such hazards occurring under the requirements of the 2008 DSW rule compared to pre-2008 DSW hazardous waste regulations?

Analytical Objectives for Potential EJ Concerns: (1) Evaluate whether the populations potentially affected by the 2008 DSW rule have different socioeconomic characteristics (i.e., minority populations, low-income populations, or indigenous peoples) than the general population; (2) Evaluate whether other factors that affect the potential for differential risk to minority and/or low-income communities are present under the 2008 DSW rule.

Translating Analytical Objectives to Questions: (1) Do communities surrounding facilities potentially affected by the 2008 DSW rule have a higher percentage of minority populations, low-income populations, or indigenous peoples relative to the comparison population (i.e., national or state population)? (2) Are the communities potentially affected by the 2008 DSW rule also affected by other potential sources of pollution (*e.g.*, industrial facilities, landfills, transportation-related air emissions, lead-based paint, leaking underground storage tanks, pesticides, incompatible land uses)? (3) Are there other factors that may contribute to higher susceptibility (*e.g.*, life stages, nursing mothers) among minority and/or low-income populations? (4) Does the 2008 DSW rule reduce the ability for potentially impacted communities to participate in the decision-making process?

Scope. Scoping is an important step in the planning process for a risk assessment. It refers to establishing the boundaries of the assessment (e.g., what population groups, health effects, chemicals, and exposure pathways will be included in the assessment). Analysts should integrate applicable scoping questions into the planning stages of a risk assessment that supports a regulatory action. Stakeholder involvement may be particularly informative as part of the scoping exercise (U.S. EPA, 2014c).

At this step, most EPA assessment projects focus on identifying and considering information available in these areas:

- Sources of contaminants;
- Stressors, associated effects, susceptible populations, and life stages;
- Exposure routes and pathways;
- Stakeholder concerns; and
- Any spatial or temporal aspects of exposure.

Examples of questions that can aid in scoping for potential EJ concerns are (see also Text Box 5.3):

- **Which population groups, as defined by attributes such as geographic location, ethnicity or race, gender, or baseline health status, should be part of the assessment?** While an evaluation of potential EJ concerns focuses on minority populations, low-income populations, and indigenous peoples, in some instances diversity within these population groups due to the presence of effect-modifying factors (i.e., factors that alter an individual's reaction to exposure such as pre-existing disease conditions or life stage) may mean that some types of individuals are at greater risk for experiencing adverse effects. In identifying target population groups for the assessment of differential risks, an analyst should consider the extent to which effect-modifying factors may explain demographically-defined differences. If an analyst decides to assess population groups defined by effect-modifying factors, the rationale for this decision and the associated methods should be transparently documented.

- **What health endpoints are to be addressed by the assessment?** Defining health endpoints clearly in the planning phase of the HHRA focuses the risk assessment and increases the transparency of the process. When selecting health endpoints, an analyst should consider whether specific health endpoints may be significant in population groups of concern. In making this selection, it is important to evaluate whether health endpoints for a given exposure differ across population groups. This type of information is most often found in epidemiology and toxicology studies, such as those focused on the modifying effects of social context on environmental risk. It may not be possible to identify all health endpoints upfront. Some information found in toxicity assessments may only define the potential for an adverse health outcome for specific stressors.

- **What exposure routes and pathways are relevant, do specific exposure pathways potentially lead to specific effects, and what exposure scenarios should be modeled?** In establishing the scope of the evaluation for potential EJ concerns, an analyst should evaluate whether population groups of concern may have different exposure routes, pathways, or contact scenarios from the general population. Scoping for an exposure assessment should include timing of exposure, both historical and current. Unique exposure pathways based on life stages and other relevant categories may also be considered. Different pathways of exposure (e.g., inhalation, dermal, ingestion) may produce different effects with varying levels of severity.

Text Box 5.3: Example of Scoping Questions for Integrating EJ Considerations into Exposure and Dose-Response Assessments

For consideration of potential EJ concerns in exposure assessment, the following scoping questions may be useful:

- Based on the use and release patterns of the environmental stressor of concern, are there population groups that might be more highly exposed?
- Are exposure variabilities predominantly a spatial phenomenon (e.g., due to contaminant hot spots)? Is proximity to source a reasonable proxy for estimating exposure to stressors of concern?
- Can exposure variability be estimated using ambient contaminant concentrations, either measured or modeled? Are data available or can data be modeled at a reasonable spatial scale appropriate for available demographic data?
- Are bio-monitoring data available for the population groups of concern, including those with potentially elevated exposure?
- Do the physical and/or chemical properties of the stressor indicate a potential for long range transport (e.g., volatile, persistent), especially stressors that may also bioaccumulate?
- Are there population groups that may experience greater exposure to stressors because of their unique food consumption patterns, behaviors, or use of certain consumer products?

For explicit consideration of EJ in dose-response assessment based on available epidemiological data, risk assessors should consider scoping questions such as:

- What demographic and population groups are most relevant from a risk perspective for the stressor in question?
- Do population-specific dose-response functions exist for particular minority populations, low-income populations, or indigenous peoples?
- Are the spatial and temporal scales of the studies supplying the dose-response function comparable to the spatial and temporal scales of the assessment of potential EJ concerns, from both an exposure and an outcome perspective?

Depending on the nature of the assessment, it can be helpful to consult with representatives from affected population groups and other stakeholders when identifying exposure routes, pathways, and other information for constructing exposure scenarios for an HHRA.[32] Community and stakeholder knowledge may provide information not known to an analyst or undocumented in the literature (e.g., unusual pathways or unique behavior patterns that may alter exposure to an environmental stressor and may affect estimates of intake or pathways to be examined from a pollution source to the exposed population). The EPA has developed extensive guidance on community and stakeholder involvement for this purpose (U.S. EPA, 2003c).

At the completion of the scoping step, analysts will have a set of boundaries for the HHRA that can be incorporated into problem formulation (see Section 5.3.2) to produce a detailed plan for the assessment.

[32] The Paperwork Reduction Act requires that an Information Collection Request be submitted for collecting information (e.g., surveys) from more than nine people (44 U.S.C. 3501).

5.3.1.2 Overarching Considerations

The *HHRA Framework* discusses EJ, children's environmental health protection, and cumulative risk assessment as overarching considerations in planning and scoping (U.S. EPA, 2014c). Additional overarching considerations or themes may be identified in the future or in the context of a particular national regulatory process (e.g., single chemical assessment of lead or mercury).

5.3.1.3 Responsibilities, Resources, and Timeline

The HHRA planning phase includes allocation of responsibilities for members of the assessment team and clarifying how the assessment team will interact with decision makers and stakeholders. This phase also includes describing or establishing the available and required resources, including staffing, budget, and time needed for the assessment.

Consideration of potential EJ concerns is cross-disciplinary in nature due to its cultural, economic, and demographic elements. Early identification of skill sets needed for the assessment enables managers to identify the most appropriate analytical team at the outset of the planning process. Areas of expertise that may be pertinent to consideration of potential EJ concerns include social epidemiologists and experts on cumulative risk.

5.3.1.4 Opportunities for a Scientific Peer Review or Other Review Steps

The need for and timing of scientific peer review or other reviews are considerations in planning and scoping activities (U.S. EPA, 2014c).[33] Peer review is a documented process conducted to ensure that activities are technically supportable, competently performed, properly documented, and consistent with established quality criteria (U.S. EPA, 2014c). When an HHRA that incorporates potential EJ concerns is subject to scientific peer review, the key expertise needed may include community representatives with technical expertise and public health scientists with community and EJ experience. Peer review usually involves a one-time or limited number of interactions by the independent peer reviewers with the authors of the work product. An assessment also may benefit from other types of input (such as peer involvement and public comment) that differ from peer review. Planning and scoping for the assessment includes discussion of whether and what types of reviews will be included in light of the context and constraints for the assessment, including schedule and resources (U.S. EPA, 2014c).

5.3.1.5 Public, Stakeholder and Community Involvement

Stakeholder involvement is integral to both the HHRA process and the broader consideration of potential EJ concerns. As previously mentioned, engaging stakeholders in the HHRA process may help analysts identify stressor sources, highlight adverse health effects, and address risk perception issues. To foster meaningful participation of members of communities that are the focus of the HHRA process, it may be important to recognize and address conditions that could reduce or hinder a community's ability to participate in the regulatory action development process. These could include time and resource constraints, lack of trust, lack of information, language barriers, and difficulty in accessing and understanding complex scientific, technical, and legal resources. See Section 2.3 and the *EJ Process Guidance* (U.S. EPA, 2015a) for more details on meaningful involvement. Also see chapter 3 of the *HHRA Framework* (U.S. EPA, 2014c) for a discussion of how to involve the public, stakeholders, and the broader community in the risk assessment process.

A key element of successful public involvement is effective risk communication. The EPA's *Seven Cardinal Rules of Risk Communication* begins with a basic tenet that people and communities have a right to participate in decisions that affect their lives. This document notes the goal of risk communication is to produce an informed public that is involved, interested, reasonable, thoughtful, solution-oriented, and

[33] Guidelines for the peer review process are available in the EPA's *Peer Review Handbook*: http://www.epa.gov/osa/peer-review-handbook-4th-edition-2015.

collaborative (U.S. EPA, 1988). Effective risk communication can assist in and is essential to identifying and addressing potential EJ concerns and can ensure that relevant information is accessible to affected communities and population groups of concern who may not be familiar with the data and analyses used by the EPA to evaluate public health risks.

The Presidential/Congressional Commission on Risk Assessment and Risk Management suggests using the following questions to identify potential stakeholders:[34]

- Who might be affected by the risk management decision?
- Who has information and expertise that might be helpful?
- Who has been involved in similar risk situations before?
- Who has expressed interest in being involved in similar decisions before?
- Who might reasonably or unreasonably feel they should be included?

Analysts and risk managers can consult the *Framework Implementing EPA's Public Involvement Policy* (U.S. EPA, 2003c) for general guidance for scoping a public involvement process.[35] When EPA actions or decisions may affect tribes, the EPA has instituted a tribal consultation policy that provides clear guidance for when, how, and on what issues consultations with tribal governments should occur (U.S. EPA, 2011h). To ensure that stakeholders participate meaningfully in the HHRA, the approach for soliciting information should be specific, involve interactive dialogue that is designed to elicit specific responses, and include accommodations for population groups with limited English proficiency. Elements of such a dialogue could include specific questions about the types of data or models that are needed for analysis of potential EJ concerns.

5.3.2 Problem Formulation

Problem formulation is the part of the assessment that articulates the purpose for the assessment, defines the problem, and establishes a plan for analyzing and characterizing risk (U.S. EPA, 1998b). Problem formulation draws from the regulatory, decision-making, and policy contexts to inform the technical approach of the HHRA and to systemically identify the major factors to be considered in the risk assessment. An effective problem formulation also defines clearly the dimensions of the risk assessment, including the basis of – or necessity for – the risk assessment (U.S. EPA, 2014c).

In considering EJ, problem formulation focuses on identifying whether minority populations, low-income populations, or indigenous peoples may experience differential risks relative to the general population or other appropriate comparison group (see Section 6.5.2). Specifically, this involves: 1) clarifying the source and characteristics of the stressors that are relevant to potential disproportionate risks, 2) identifying factors that may influence exposures that contribute to those risks, and 3) characterizing susceptibilities or vulnerabilities of the populations with potential EJ concerns that may exacerbate differences in exposure or risk. Key products of problem formulation are the assessment endpoints, a conceptual model, and an analysis plan. Since planning and scoping is an interactive, nonlinear process, substantial re-evaluation is an anticipated step in the development of all problem formulation products.

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[34] See the EPA's Presidential Commission on Risk Assessment and Risk Management website: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=55006&CFID=55036505&CFTOKEN=43224210.

[35] Broad information related to communicating during the risk assessment process can be found at http://www.epa.gov/risk/risk-communication. The EPA's efforts to engage communities in regulatory actions is summarized at http://www.epa.gov/open/expanding-public-awareness-and-involvement-development-rules-and-regulations. The EPA also provides specific recommendations regarding outreach to tribes on its Environmental Protection in Indian County: Consultation and Coordination with Tribes website: http://www.epa.gov/tribal/forms/consultation-and-coordination-tribes.

The sections below describe the two important outcomes of problem formulation – the conceptual model and the analysis plan – in the context of considering potential EJ concerns.

5.3.2.1 Conceptual Model

For considering potential EJ concerns, the conceptual model addresses the following:

- How and to what degree identified risk factors contribute to differences in exposure and/or risk;
- The strength and direction of relationships between these factors and exposure and/or risk;
- Identification of data needs by characterizing relationships as low, medium, and high uncertainty; and
- Scope of the assessment as to potential EJ concerns given current scientific understanding.

A conceptual model includes both a written description and a visual representation of the stressor(s), the exposed population(s), actual or predicted relationships between population groups of concern and the regulated stressor to which they may be exposed, and the endpoint(s) that will be addressed in the risk assessment as well as the relationships among them (U.S. EPA, 2014c). The specific challenges of integrating consideration of potential EJ concerns into the risk assessment can be addressed in the conceptual model, and the analysis may use Figure 5.1 as a guide in describing potential sources of drivers of potential EJ concern. U.S. EPA (2014c) provides descriptions of, resources on, and examples of conceptual models.

Below in Text Box 5.4, examples of EJ-related questions are presented that may be raised during problem formulation in the context of proximity to sources of pollution. For additional sample problem formulation questions, see U.S. EPA (2002b).

5.3.2.2 Characterizing the Stressor and its Sources

The properties of the stressor, its sources, and their relationships to differential risks are important inputs to the HHRA. In considering information on the characteristics of stressors and sources, analysts can incorporate information specific to consideration of potential EJ concerns (e.g., the likelihood that the source of the stressor is located in areas where minority populations, low-income populations, or indigenous peoples live relative to areas where other population groups live). Where relevant and appropriate, analysts can also identify the distribution of any additional sources of the stressor that are not the focus of the regulatory action, because these sources may contribute to differential risks. For example, a stressor may be present in environmental media due to background concentrations (e.g., resulting from historical or past industrial activity, or naturally occurring) in areas with minority populations, low-income populations, or indigenous peoples.

5.3.2.3 Identifying Differences in Exposures that May Lead to Differential Risks

Differential exposures can be an important indicator of differential risks. Differences in exposures across population groups may arise from many causes, including those described earlier, such as proximity to pollution sources, employment in certain occupations, or exposures to multiple sources of a specific stressor (Brender et al., 2011; Burger and Gochfeld, 2011). For example, if other sources tend to be co-located with the source in question, it may contribute to important differences in patterns of exposure to the stressor. Even in situations where a regulated source of the stressor is not located in geographic areas primarily consisting of minority populations, low-income populations, or indigenous peoples, other sources of the stressor may contribute to differential exposures and, ultimately, to differential risks.

Text Box 5.4: Examples of EJ-Related Questions to Consider During Problem Formulation

Characteristics Related to Proximity to a Stressor or Source

- What are the sources of the stressor?
- Is the source located in geographic areas with greater minority populations, low-income populations, or indigenous peoples?
- Are other sources of the stressor more prevalent in geographic areas with greater minority populations, low-income populations, or indigenous peoples?
- Are there historical releases or uses of the stressor in such areas?
- Is the concentration of the stressor in the relevant ambient media higher in geographic areas with greater minority populations, low-income populations, or indigenous peoples?
- Does each stressor have multiple sources that should be evaluated?

Differential Exposures to a Stressor

- Do minority populations, low-income populations, or indigenous peoples have higher body burdens of the contaminant?
- Are these population groups more likely to experience current or historically higher exposures to the stressor from sources other than the one under consideration?
- Are there particular life stages within these population groups that may be more at risk to higher exposure to the stressor?
- Are there products/consumer goods that contain the stressor?
- Are these products/consumer goods used at noticeably higher rates among minority populations, low-income populations, or indigenous peoples?
- Are there cultural practices that are unique to these population groups versus the general population?
- What is the frequency of occurrence of the cultural practice and its duration?
- What is the frequency of occurrence of an atypical activity and its duration?
- Is proximity to the emitting source an important factor in the assessment?
- What geographic scale is important to highlight different exposures between demographic groups for the pollutant in question (e.g., U.S. Census tract, block, block group, neighborhood, tax parcel, ZIP Code, or county)?

Population Characteristics

- What are the rates of the adverse health outcome of concern among minority populations, low-income populations, or indigenous peoples?
- Are the rates of the adverse health outcome of concern higher among these population groups?
- What factors or conditions are known to modify the effect of the regulated contaminant?
- How are these modifying factors or conditions distributed across demographic groups?
- Do minority populations, low-income populations, or indigenous peoples have a higher prevalence of modifying effects or conditions?
- Are there more members of these population groups employed in specific professions known to have higher risks of the adverse health outcome?

Patterns of exposure can be location-specific or population group-specific, depending on the scale of the assessment and the types of data available. Analysts considering the potential for differences in exposure can investigate issues such as relevant cultural practices, consumer products use, group differences in body burdens of the contaminant, and co-exposures to multiple stressors that may affect the body's ability to detoxify a particular contaminant (e.g., factors that may influence metabolism). Social patterns related to exposure could also be evaluated across other characteristics of population groups of concern, such as life stage or gender, or within multiple social strata (e.g., low-income minority) to yield unique and important perspectives on population groups most at risk. For example, exposure patterns for blood lead show that non-Hispanic black children between the ages of one and six who live below the Census-defined poverty level have the highest median blood lead concentration in the United States (U.S. EPA, 2013a).

"Populations who face environmental inequities may be identified in national exposure databases but may not be located in discrete spatial communities. Such databases might identify [population groups] who face a disproportionate adverse health outcome, but unless they live in a community that is spatially identified, it is difficult to address common exposures using conventional risk assessment approaches … Broad-scale surveys, site-specific surveys, and national databases are beneficial, and can be used to identify environmental inequities among [groups] that are not spatially related" (Burger and Gochfeld, 2011).

There are many sources of exposure data. Some exposures can be evaluated using bio-monitoring data on chemical hazards, for example the National Health and Nutrition Examination Survey (NHANES). NHANES is designed to collect data on the health and nutritional status of the U.S. population. The NHANES is designed to be a representative sample of the civilian, non-institutionalized population in the United States, based on age, gender, and race/ethnicity (Centers for Disease Control and Prevention (CDC), 2009). Due to its sample design, NHANES cannot be used to provide exposure data for small geographic units or co-located individuals (U.S. EPA, 2003d). Nevertheless, it is an important information resource for identifying differences in exposure.[36] For more detailed information on using bio-monitoring data to evaluate exposure differences, see the exposure assessment examples in Appendix B.

For some stressors that are dispersed locally in ambient media (e.g., air toxics), proximity to the source is sometimes used as a surrogate in considering the potential for differences in exposure.[37] Section 6.4.3 discusses use of proximity methods for evaluating potential EJ concerns.

In some cases, a screening analysis using measured or estimated concentrations of a stressor in ambient media that are correlated with race/ethnicity or income can identify differential exposures. For example, analysts may have information from ambient air quality monitors or estimated ambient air concentration data averaged over a period of time. However, monitoring data may not always be adequate to

[36] Some limitations of data available through NHANES can be addressed by location-specific surveys such as the New York City Health and Nutrition Examination Survey (NYCHANES) and other site- and population specific surveys that may be conducted for reasons other than EJ considerations. Some limitations to the availability of primary site- and population-specific surveys are cost and the amount of time required for to conduct these surveys.

[37] Methods for estimating exposure using the concept of proximity are well developed and are extensively reviewed in Chakraborty et al. (2011). There are multiple other factors that influence exposures differences for air toxics, including local meteorology and chemical characteristics of the chemical of interest (U.S. EPA, 2004 Chapters 8 and 11).

evaluate differences in exposure for small geographic units (e.g., census tracts). See Appendix B for an example of estimating exposure using ambient concentration data.

States, tribes, and local governments may have relevant monitoring data. Case studies or other qualitative approaches may also offer some insight into potential impacts when data are not available for all areas affected by the regulatory action.

In the problem formulation step, it is important to articulate clearly how population groups of concern may be exposed to a stressor. Atypical or unique exposure pathways are often important in assessing potential EJ concerns.[38] New pathways can be identified during or after planning as new data become available. For example, biomonitoring data acquired during scoping and problem formulation may suggest the presence of unexpected differences, resulting in a focused inquiry.

Alternatively, analysts may seek new information about certain exposure pathways to ensure a comprehensive evaluation of the range of exposures in the population groups of concern. Conceptual frameworks of the type discussed in Section 4 may be useful for identifying and collecting data on these exposure pathways. Examples of questions that are helpful for extracting information about unique exposure pathways also are presented above in Text Box 5.4.[39]

5.3.2.4 Population Characteristics

Population characteristics refer to those attributes shared by individuals within a population group that influence the likelihood of exposure to the stressor and the risk of an adverse health outcome from this exposure. These characteristics range from those with direct effects, such as pre-existing disease conditions, chronic disease, age, medication status, and immune status, to those with more indirect influences, such as a lack of access to resources (e.g., health care), negative social conditions, age of housing as a function of race/ethnicity and income, a specific type of occupation, income status, access to transportation, and poor educational status.

Understanding population characteristics is an important step toward identifying factors that may affect an individual's resilience (i.e., the ability to withstand or recover from exposure to a stressor). Such information also highlights how these characteristics are distributed in the population groups of interest from an EJ perspective. Appendix B provides examples of integrating these characteristics into a dose-response assessment.

Information on population characteristics that may modify exposure or toxicity can be identified in the literature, including epidemiological and toxicological studies of effect-modifying factors. For example, if the evidence supports the conclusion that population groups with lower educational status have higher risk, this information could be used in the assessment to characterize the potential for differential risks among population groups of interest. Sample questions to guide collection of information on population characteristics are presented above in Text Box 5.4.

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[38] Examples of such exposure pathways include exposure to heavy metals from the use of non-traditional medicines (Ernst and Thompson Coon, 2001; Ernst, 2002a, b), exposure to mercury from high consumption rates of fish (Anderson and Rice, 1993; Peterson et al., 1994), exposure to pesticides tracked into homes by family members from their places of work (Simcox et al., 1995), and exposure to inorganic mercury from the use of contaminated cosmetic products for body maintenance purposes (McKelvey et al., 2011).

[39] The *Exposure Factors Handbook* also has exposure factors data stratified by race/ethnicity (U.S. EPA, 2011e).

5.3.2.5 Analysis Plan

The analysis plan is the final stage of problem formulation. It describes intentions for the assessment developed during the planning and scoping process, and it provides details on technical aspects of the risk assessment. The analysis plan may include these components: (a) the assessment design and rationale for selecting specific pathways to include in the risk assessment; (b) a description of the data, information, methods, and models to be used in the analyses (including uncertainty analyses), as well as intended outputs (e.g., risk metrics); (c) quality assurance and quality control measures; and (d) the associated data gaps and limitations. In some cases the analysis plan will specify a phased or tiered risk assessment approach to facilitate management needs; it may describe scientific review (such as external peer review); and it may specify public stakeholder and community involvement (U.S. EPA, 2014c).

5.3.2.6 Identify Data, Models, Tools and Other Technical Resources

As with any other assessment, a central challenge for an analyst in the HHRA planning process is identifying the data, tools, and models that are already available or that need to be generated to complete an EJ assessment. Data selection should be based on the context, risk management and analytic objectives, and scope of the analysis. (Appendix B provides sample questions to help identify data and model needs when planning for exposure assessment and dose-response assessment.)

Data Identification. As previously mentioned, a key planning element for identifying data relevant to EJ analyses is consultation with stakeholders, including communities that may have access to data useful for improving the characterization of exposure and risk. Other data that can be used to evaluate potential EJ concerns within an HHRA include exposure data, epidemiological data, toxicity (including susceptibility) data, and fate and transport data. Relevant data can be location-specific or population group-specific, or, ideally, both. Relevant data may also include ambient concentration data (e.g., from air monitoring stations and water quality measures), or public health data such as disease incidence.

Exposure data may include intake data such as consumption or contact rates, routes of exposure, behavior data for estimating contact rates, concurrent exposures to other stressors that are of toxicological relevance, biomonitoring data, or emissions data. Extensive discussion about use of exposure data in the EJ context is available in the peer-reviewed literature. Burger and Gochfeld (2011), for example, discuss the types of unique exposure pathways that may occur in population groups of concern, and suggest that the first step in improving risk methodology is to recognize and account for unique exposure sources (e.g., tattoos and sweat baths, culturally significant toys, mercury used in religious practices) and the corresponding exposure pathways. If a chemical bioaccumulates, for example in fish, it would pose greater risks to populations who eat more local fish for subsistence or cultural reasons (see Fitzgerald et al. (2005) for another example).

Health risk data could include incidence data specific to populations with potential EJ concerns, historical population-specific disease or illness rates, and toxicological data, such as that found in the EPA's Integrated Risk Information System database.

Model and Tool Identification. Risk assessment employs a range of models and tools to estimate ambient concentrations of stressors, exposure, amounts of stressors likely to reach the target organ (e.g., effective dose), risks for a specific health endpoint, locational vulnerability to health impacts, and other key factors.

A challenge for incorporating potential EJ concerns into an HHRA can be ensuring that input parameters for models are representative of population groups of concern. Traditional defaults used for inputs in HHRAs may not adequately reflect the demographic characteristics of these population groups. Within the research community and among state and local agencies, several new tools and models reflect recent methodological advances for addressing potential EJ concerns. The EPA also has developed improved models and tools with a specific focus on EJ, such as Environmental Benefits Mapping and Analysis Program (BenMAP). BenMAP is designed to provide the type of input that is particularly useful in a regulatory analysis and can be adjusted to highlight particular population groups. More recently, the Agency released EJSCREEN, a census tract-level mapping tool that organizes demographic and environmental data that could prove useful to HHRA planning for evaluating potential EJ concerns.[40] Text Box 5.5 identifies several recent tools that can be used to support EJ planning within an HHRA.

Identifying Data Quality and Data Gaps. Assessing potential EJ concerns may be aided by rapidly developing data and tools; thus, it is important that the HHRA planning process include a clear discussion of data available to characterize key uncertainties, data quality, and lack of data that may affect methodology development and/or results.

In some cases, lack of data may prompt a decision to limit the scope of an analysis of potential EJ concerns within an HHRA. It is recommended that such decisions be clearly documented. Documentation is particularly important in an EJ context because stakeholders often provide comments about how to proceed when there is a lack of data. In some instances, clear documentation of lack of data may lead to changes in the design of the regulatory action to facilitate better monitoring in EJ communities.[41]

To promote further the quality of data used in planning risk assessments, risk analysts should review the EPA's Information Quality Guidelines (IQG) and Data Quality Objectives (DQO) (U.S. EPA, 2012a). IQGs and DQOs help increase the integrity, objectivity, and quality of data when analyzing potential EJ concerns.[42]

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[40] EJSCREEN is available at: www.epa.gov/ejscreen.

[41] For example, comments from stakeholders during the NOx NAAQS rulemaking process resulted in siting additional monitors "in susceptible and vulnerable communities" (U.S. EPA, 2010d). Likewise, outreach to vulnerable communities living near refineries during the risk and technology review for petroleum refineries resulted in discussion, and ultimately incorporation, of fence line monitoring of benzene emissions, into the final rule in part in order to provide communities with access to data on what is being released into their neighborhoods (U.S. EPA, 2015c).

[42] For more information on IQGs and DQOs , visit the EPA's Information Quality Guidelines website (http://www.epa.gov/quality/epa-information-quality-guidelines) and the EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* report (http://www.epa.gov/sites/production/files/documents/guidance_systematic_planning_dqo_process.pdf).

Text Box 5.5: Examples of Models, Tools, and Technical Resources for Evaluating Potential EJ Concerns within a Human Health Risk Assessment

Data Resources

- Geospatial Platform http://www.geoplatform.gov
- U.S. Census American Fact Finder http://factfinder2.census.gov/
- EPA Report on the Environment http://www.epa.gov/roe/
- EnviroAtlas http://enviroatlas.epa.gov
- Eco-Health Relationship Browser http://enviroatlas.epa.gov/enviroatlas/Tools/EcoHealth_RelationshipBrowser/introduction.html
- America's Children and the Environment Report, Third Edition http://www.epa.gov/ace/
- CDC Tracking Program-Funded State and Local Health and Environmental Tracking http://ephtracking.cdc.gov/showStateTracking.action
- CDC Environmental Public Health Indicators http://ephtracking.cdc.gov/showIndicatorsData.action
- National Air Toxics Assessment (EPA Office of Air and Radiation (OAR)) http://www.epa.gov/national-air-toxics-assessment
- The EPA's Air Quality System http://www.epa.gov/aqs
- The EPA's Integrated Risk Information System Database http://www.epa.gov/IRIS/
- National Library of Medicine, Toxicology and Environmental Health Information Program https://www.nlm.nih.gov/pubs/factsheets/tehipfs.html
- State or county public health and environmental databases
- County Health Ranking and Roadmaps http://www.countyhealthrankings.org/
- Superfund site information http://cumulis.epa.gov/supercpad/CurSites/srchsites.cfm
- RCRAInfo http://www.epa.gov/enviro/facts/rcrainfo/search.html
- State databases for state-regulated facilities
- Water Data and Tools http://www.epa.gov/waterdata
- Advisories and Technical Resources for Fish and Shellfish Consumption http://www.epa.gov/fish-tech
- Find Information about Your Beach http://www.epa.gov/beaches/find-information-about-your-beach
- NOAA Harmful Algal Bloom Operational Forecast System http://tidesandcurrents.noaa.gov/hab
- Water Quality Portal http://www.waterqualitydata.us/

Guidance and References

- EPA Risk Assessment Portal http://epa.gov/risk/
- EPA Community Action for a Renewed Environment http://www.epa.gov/care/
- Air Toxics Risk Assessment Reference Library http://www.epa.gov/fera/risk-assessment-and-modeling-air-toxics-risk-assessment-reference-library
- Recent state legislation on a broad range of environmental issues http://www.ncsl.org/issues-research/energyhome/energy-environment-legislation-tracking-database.aspx
- Recent state legislation on environmental justice http://gov.uchastings.edu/public-law/docs/ejreport-fourthedition1.pdf
- California Environmental Protection Agency Cumulative Impacts Assessment Methodology http://oehha.ca.gov/ej/cipa123110.html
- CDC Health Disparities and Inequalities Report: http://www.cdc.gov/minorityhealth/CHDIReport.html

Models and Tools

- Office of Pesticide Programs Models http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment
- BenMAP (OAR) http://www.epa.gov/benmap
- Community-Focused Exposure and Risk Screening Tool (C-FERST) http://www.epa.gov/healthresearch/community-focused-exposure-and-risk-screening-tool-c-ferst
- EJSCREEN http://www2.epa.gov/ejscreen
- Community Cumulative Assessment Tool (under development by Office of Research and Development) http://www.epa.gov/sites/production/files/2015-09/documents/shc_2015_ccat_poster.pdf
- Office of Research and Development Methods, Models, Tools, Databases http://www.epa.gov/research/methods-models-tools-and-databases

Section 6: Conducting Regulatory Analyses to Assess Potential Environmental Justice Concerns

This section discusses how to assess whether a regulatory action has potential EJ concerns using information generated from human health risk, exposure, or other assessments, and how to incorporate the information into regulatory analyses.[43] In particular, it discusses methods that may be useful for answering the three analytic questions from Section 3.1 of this document, which are repeated here:

- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?
- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for each regulatory option under consideration?
- For each regulatory option under consideration, are potential EJ concerns created or mitigated compared to the baseline?

These questions provide the framework for analyzing the effects of a regulatory action on population groups of concern. The methods used to analyze these impacts will vary depending on the availability of data, time, and other resources and should be based on the context, scope, and scale of analysis, as discussed in further detail below. Per the recommendations in Section 3.3, the most appropriate analytic method for a particular regulatory action could be purely quantitative, qualitative, or a mixture of both. Regardless of the approach, the highest quality and most relevant data should be applied in a manner consistent with the EPA's data quality guidelines (U.S. EPA, 2012a) and the EPA's *Peer Review Handbook* (U.S. EPA, 2015d).

Generally, the EPA has a preference for quantitative analyses to complement other quantitative regulatory analyses (e.g., benefit-cost analysis, risk assessment) that are often conducted for regulatory actions. Section 3.3 recommends some level of quantitative analysis, as supported by the available data, to address the questions above for regulatory actions where impacts or benefits will also be quantified. When information on exposures, health and environmental outcomes, and other relevant effects by population groups is available, an analyst may be able to characterize the baseline and likely response to a change in exposure quantitatively for each policy option. In cases where such data are unavailable, it may still be possible to evaluate risk or exposure using other quantitative metrics (e.g., prevalence of affected facilities as a function of race/ethnicity or incomes).

When impacts or benefits will not be quantified or disaggregated by race/ethnicity or income, analysts should present available quantitative and/or qualitative information that sheds light on potential EJ concerns. Qualitative assessment is particularly appropriate when high quality and relevant quantitative data are not available for evaluating potential EJ concerns.

This section is organized as follows: Section 6.1 discusses how to use a screening approach to evaluate the feasibility of conducting a quantitative or qualitative assessment of potential EJ concerns; Section 6.2

[43] While the focus in this section is on population groups mentioned in E.O. 12898, the methods discussed may be applied to any population group of concern.

defines baseline, regulatory scenarios, and incremental changes for an analysis of potential EJ concerns; Section 6.3 reviews the data and information needed to assess potential EJ concerns; Section 6.4 summarizes a number of methods for assessing differences in impacts across population groups; Section 6.5 discusses analytic issues, including comparison group definitions and geographic issues relevant for analyses where the source of emissions is identifiable and health effects are fairly localized and spatially distinguishable; and Section 6.6 discusses costs and non-health impacts.[44] Appendix C provides examples of how EJ analyses have been conducted in a variety of recent regulatory actions.

6.1 Screening for Potential EJ Concerns

EPA analyses have often assumed that potential EJ concerns do not exist when the regulatory action is expected to reduce overall environmental burden due to strengthening of the standard. However, this assumption may not fully consider the distributional effects associated with a regulatory action.

As discussed in Section 3.2, a screening-level analysis may help inform the extent to which a regulatory action raises potential EJ concerns that should be evaluated further as part of the regulatory action development process (also, see U.S. EPA, 2015a). This screening-level analysis should support conclusions about potential distributional effects that ensure transparency in the regulatory action development process, and provide the decision maker and public with usable information about the expected effects of the policy. This screening-level analysis also will assist decision makers in deciding whether it is feasible and appropriate for analysts to conduct a more in-depth analysis of potential EJ concerns.[45]

While there is no single prescribed method for conducting a screening analysis to evaluate feasibility, the analyst should review the quality and availability of data, availability of defensible methods to analyze the data, and the peer-reviewed literature and stakeholder input that might be used to evaluate potential EJ concerns. Such information may include the following:

- Proximity of regulated sources to minority populations, low-income populations, and/or indigenous peoples;
- Number of sources that may be impacting these populations;
- Nature and amounts of different pollutants that may be impacting these populations;
- Any unique exposure pathways associated with the pollutant(s) being regulated;
- Stakeholder concern(s) about the potential regulatory action; and
- History of EJ concerns associated with the pollutant(s) being regulated.

By reviewing available data, peer-reviewed literature, and stakeholder input, the analyst may be able to initially assess potential EJ concerns associated with the regulatory action, while also identifying whether more detailed information is available to conduct a more in-depth analysis.

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[44] The material discussed in Section 6 is generally consistent with Chapter 10 of the *Economic Guidelines*, though there are a few key differences. First, the *Economic Guidelines* apply to regulatory analyses for economically significant rules (i.e., rules with benefits or costs in excess of $100 million in any year); the *EJ Technical Guidance* applies to a broader array of regulatory actions. Second, Chapter 10 says little about the generation of underlying information, such as from a risk assessment (U.S. EPA, 2010c).

[45] Recall from Section 3.2 that feasibility is informed by a technical evaluation of available data and methods while, appropriateness is informed by relevant policy, budgetary, and statutory considerations.

A variety of tools and methods are available to the analyst to support a screening-level analysis. For instance, EJSCREEN provides data on 12 environmental indicators and six demographic variables, generally at block group resolution, across the United States.[46] This information can help provide an overview of places where EJ may warrant greater consideration. The tool has a number of limitations in a regulatory context, including the fact that it is a snapshot of past exposure, may not include sources of exposure relevant to the regulatory action, and is limited to information on proximity to risk. However, it may provide a useful high-level screen of potential EJ concerns. When using EJSCREEN, the 80th percentile is a suggested starting point for the purpose of identifying geographic areas in the United States that may warrant further consideration, analysis, or outreach. That is, if any of the EJ indexes for the areas under consideration are at or above the 80th percentile nationally, then further review may be appropriate. See Appendix H in the EJSCREEN Technical Documentation for more information (U.S. EPA, 2015e).

An analyst can also evaluate the feasibility of conducting a more in-depth EJ analysis by examining:

- Scientific literature that discusses the effects of the pollutant(s) being regulated on minority populations, low-income populations, and/or indigenous peoples;
- Information received from stakeholders via public comments, technical reports, press releases, or other documentation discussing the impacts of the pollutant(s) being regulated and these populations, including information about other stressors that may be important;
- Availability of data disaggregated by geography (e.g., census tracts, counties) for populations that may be in close proximity to the pollutant(s) being regulated, or may otherwise be impacted by the pollutant(s) (e.g., through workplace exposures); or
- Availability of methods for conducting a more in-depth analysis, such as proximity-based approaches, risk-assessment, mixed methods, and more, as discussed below.

If the scientific literature and data are unavailable or of insufficient quality for an analyst to characterize how risk/exposure or health outcomes are distributed across population groups of concern, an analyst is encouraged to characterize the issue qualitatively and discuss any evidence, key limitations, and sources of uncertainty highlighted in the published literature (U.S. EPA, 2010c).

6.2 Defining Baseline, Regulatory Scenarios and Incremental Changes

The first step in any regulatory analysis is to identify the baseline conditions. The OMB (2003) defines the *baseline* as "the best assessment of the way the world would look absent the proposed action." It includes the characteristics of current populations and how they are affected by pollutant(s) prior to the regulatory action under consideration. As the OMB definition implies, however, the baseline is not a static concept. In particular, the OMB notes that an analyst may need to consider the evolution of the market, compliance with other regulations, and the future effect of current government programs and policies, as well as other relevant external factors to provide a projection of future baseline conditions. Major demographic changes in the baseline may also be relevant in an EJ context.

Per the recommendations in Section 3.3, the definition of the baseline for the analysis of potential EJ concerns, including the geographic scope, year of analysis, health effects and other impacts, should be consistent with other parts of the regulatory analysis. See Chapter 5 of the EPA's *Economic Guidelines* (U.S. EPA, 2010c) for a more detailed discussion of baseline issues.

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[46] See the EPA's EJSCREEN website: www.epa.gov/ejscreen. California has also developed its own EJ screening tool called CalEnviroScreen that incorporates additional variables available state-wide. In addition, the environmental and demographic factors are "summed" to provide a measure of cumulative impacts on communities. More information is available at the California Office of Environmental Health Hazard Assessment's Environmental Justice website: www.oehha.ca.gov/ej.

The next step in the analysis is to examine the distribution of impacts under one or more *regulatory scenarios* – different configurations of the regulatory action being considered. This analysis is based on a prediction of how the world will look once the regulation is in place, including how effects are related to the characteristics of the affected populations. For the analysis of potential EJ concerns, the analyst should examine how the exposure, health or environmental impacts, or other outcomes of the regulatory action are distributed across minority populations, low-income populations, or indigenous peoples for the preferred regulatory option as well as any other options being considered, to the extent it is practicable to do so.[47] Again, the regulatory options or scenarios used in the EJ analysis should be the same exact scenarios used in the other parts of the analysis (e.g., benefit-cost analysis) to facilitate comparisons across analyses.

The differences between the impacts in the baseline and the impacts for the regulatory options under consideration are typically referred to as the incremental changes associated with each of the regulatory options. Incremental changes reflect the improvement (or possibly decrement) in effects of pollutant(s) on specific populations that can be attributed to the regulatory options.

With these three sets of information – impacts in the baseline, the regulatory scenarios, and the incremental changes associated with the regulatory options – the analyst can provide a detailed depiction of the distributional effects associated with a regulatory action (thus answering all three analytic questions from Section 3.1). Assuming the analyst has all three sets of information, it is important to understand the different information that each provides.

As assessment of the baseline can provide information on whether or not pre-existing disparities are associated with the pollutant under consideration. This analysis provides a depiction of how the pollutant and its effects are distributed across population groups prior to any regulatory action. It could be the case that effects of a pollutant are more concentrated in one population group (e.g., African-Americans or low-income households), and this is useful information for understanding the distribution of the pollutant under consideration. If pre-existing differences occur across population groups, the decision maker may want to take this into consideration when making decisions about the regulatory action; mechanisms or choices associated with implementation, for example, may allow the EPA to address pre-existing disparities.

An assessment of the regulatory scenario(s) should indicate how the pollutant and its effects are distributed for the regulatory options under consideration. It is important to note that these scenarios are based on ex-ante predictions, which may not always include a level of detail that is disaggregated enough across population groups to facilitate a rigorous EJ analysis. Ideally, the analyst would be able to provide an indication of how the pollutant is distributed across populations for the options being considered, either quantitatively or qualitatively. There may be some options for which the distribution of the pollutant across population groups of concern is more equitable than others.

Finally, it is helpful for the analyst to provide information on the incremental changes associated with the regulatory options under consideration. The incremental change compares the baseline with each of the options and shows how each option improves (or degrades) environmental quality across population groups.

Of note is the difference between the distribution of effects in the regulatory scenarios and the distribution of the incremental change. In a regulatory scenario, a lack of differences in the distribution of effects across population groups in the regulatory options being considered might be considered an ideal situation. It indicates that post-regulation there are no differences in outcomes across population groups;

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[47] Typically in a regulatory analysis, multiple scenarios or options are considered, such as a preferred option, one option that is more stringent, and one option that is less stringent. The OMB recommends "… you generally should analyze at least three options: the preferred option; a more stringent option that achieves additional benefits (and presumably costs more beyond those realized by the preferred option; and a less stringent option that costs less (and presumably generates fewer benefits) that the preferred option" (OMB, 2003, Section E.3).

everyone is experiencing the same environmental quality post-regulation. However, one might be tempted to look for the distribution of the incremental change which is considered an "even change," since it is revealed through an examination of the distribution of incremental changes only. An "even change" indicates that the regulatory scenario results in a constant reduction in environmental risk across the population. The concern with using this measure is that it could perpetuate pre-existing or baseline differences across population groups. If there are differences in the distribution of outcomes in the baseline and everyone is afforded the same reduction in risk then there remain differences in environmental outcomes after the regulatory action is in place.[48] While understanding the distribution of effects in the regulatory scenarios and the distribution of the incremental change are both useful for understanding potential EJ concerns, knowing the distribution of the effects in the regulatory scenario is likely more informative for evaluating potential EJ concerns.

6.3 Data and Information to Assess Potential EJ Concerns

This section describes the types of data needed to assess potential EJ concerns, as well as the way in which information from the analysis can be summarized and presented. In general, the type of analysis that can be conducted depends upon the type of data available and its quality. In some cases, spatially disaggregated individual-level data may be most appropriate and relevant for conducting an analysis of potential EJ concerns. In other cases, distance as a proxy for risk may be the best available relevant metric for conducting the analysis. At times qualitative information will be the best available information for the analysis. In all cases, analysts should use the highest quality and most relevant data and information, as discussed below. Text Box 6.1 gives an example of how data quality may affect the level of analysis in an air quality context.

Recognizing the importance of data quality, information needed to conduct an EJ analysis may include:

- Demographic characteristics (i.e., race, ethnicity);[49]
- Income data (e.g., median household income or percent below poverty level);
- Health data (e.g., hospital and emergency admissions, race/ethnicity-stratified mortality rates, race/ethnicity-stratified asthma, or other morbidity rates);
- Other triggers or co-stressors that may be confounders (e.g., indoor air concentrations);
- Risk coefficients stratified by socio-economic variables (e.g., race/ethnicity, income);
- Location of pollution sources (e.g., latitude/longitude coordinates, zip code, county locator);
- Proximity to the nearest source(s) (e.g., distance in miles); and
- Distribution of economic costs, when relevant (see Section 6.6.1).

Often these data may be available only for the baseline scenario. For example, the analyst may have baseline demographic information, such as the percent of the population that is low-income near the sources, and no information on the projected distribution of health effects for the policy scenarios. While such limitations may preclude quantitative analysis of the distribution of outcomes under policy options, it is still useful for analysts to provide baseline information, supplemented with available qualitative information, when evaluating potential EJ concerns.

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[48] See Maguire and Sheriff (2011) for more information.

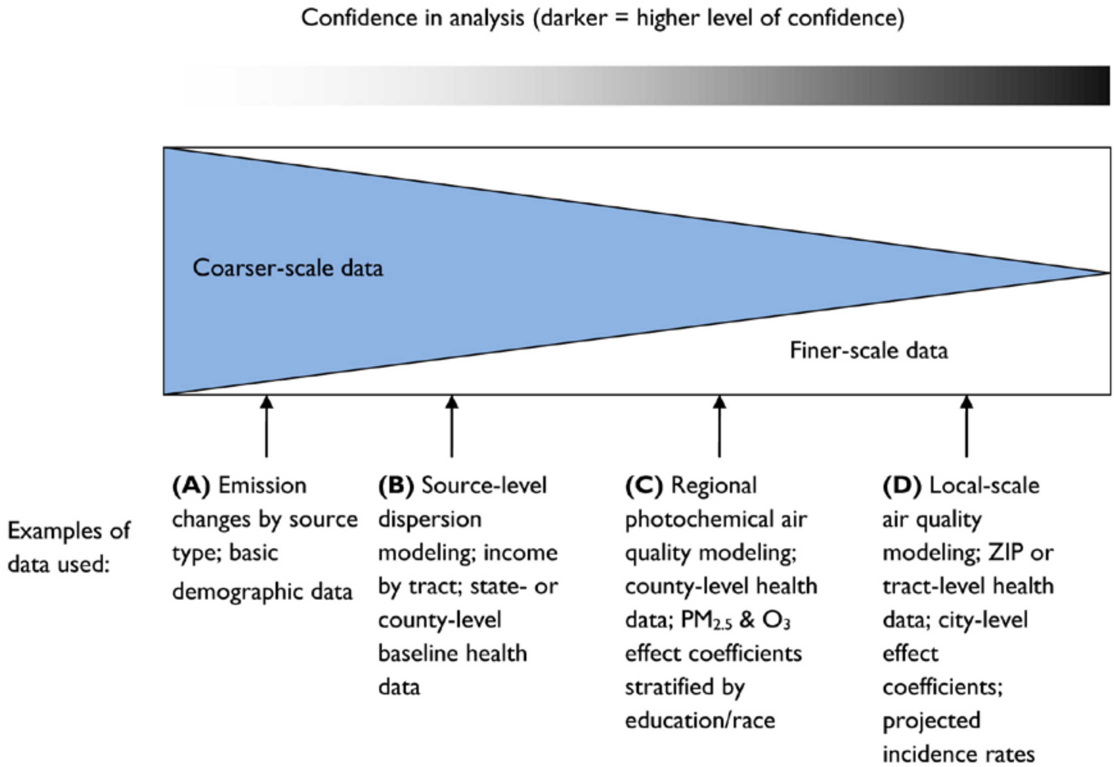
[49] Other demographic information can be included in the analysis, such as age, gender, education, but at a minimum the race and ethnicity of the affected population should be included when available.

Data quality can be evaluated in a variety of ways. Both the EPA and the OMB have IQGs that should be followed when evaluating whether data are of sufficient quality for use in analyses of potential EJ concerns (see U.S. EPA, 2002c; OMB, 2002). These guidelines establish internal mechanisms for ensuring that quality procedures are followed (e.g., data quality managers and plans) and establish that data should have objectivity, integrity, and utility when used in decision-making. Objectivity means the information is accurate, clear, and unbiased. Integrity means the information is protected from unauthorized changes. Public input and comment periods, peer review, and other input from experts help ensure data are of sufficient quality and adhere to the principles outlined above.

Regardless of the analytic methods used, information used to assess potential EJ concerns should be presented in a transparent way, and should include the following:

- Information about the specific populations and individuals affected by the regulatory action;
- Main exposure pathways and expected health and environmental outcomes;
- Evidence for why risk, exposure, or outcomes may vary by population group;
- Relevant geographic scale;
- Descriptions of the main methods of analysis used;
- Summary statistics for the baseline and each regulatory option (both the mean and distribution) by population group;
- An easy-to-understand description of what the summary statistics show;
- Conclusions based on the information available;
- Robustness of results across options presented; and
- Data quality and limitations that affect conclusions regarding potential differential impacts.

Text Box 6.1: Data Quality and Spatial Resolution in the Context of Air Regulations



An analyst's ability to address how a regulatory action changes the distribution of risk across population groups of concern depends on the quality and spatial resolution of the data available. Finer-scale air quality, health, and socioeconomic data allow one to assess the distribution of air pollution impacts across key population groups of concern and to have greater confidence in the conclusions drawn from these data. When air quality data are lacking or only available at a coarse-level, the ability to assess change in risk across populations and other conclusions is more limited.

An example in limited data environments: Using race-stratified county-level mortality and morbidity data, an analyst can calculate population-weighted mortality rates by county. The analyst can then use a highly aggregated baseline air quality modeling projection (e.g., 12 or 36 km) to identify population groups most exposed to air pollution. Using geographic information system (GIS) tools, it is possible to combine the two sources of data. The coarse geographic scale of air quality information may inhibit the analyst's ability to detect meaningful differences in impacts among and between groups. When risk coefficients are unavailable, it is not possible to estimate health impacts separately for each population group.

An example in data-rich environments: Using finely resolved air quality data, an analyst can identify at a highly disaggregated level (e.g., 1 km) population groups that experience the highest exposure to air pollution. An analyst can also identify population groups who exhibit the highest baseline incidence or prevalence rates for air pollution health impacts at the zip code-level. Using GIS modeling tools, an analyst can join the two data sources. Using race-specific or standard risk coefficients the analyst can then estimate health impacts for each population group.

6.4 Analytic Methods

A variety of transparent, scientifically defensible methods can be used to analyze potential EJ concerns associated with regulatory actions. The choice of analytic method is most often driven by the data availability. In some cases, the analyst will have data at the individual level for the pollutant(s) being regulated, allowing for a detailed, rigorous analysis. In other cases, the distribution of ambient environmental quality indicators (e.g., pollutant concentrations) or stressors from regulated sources (e.g., waste sites or permitted facilities) may be useful proxies for individual level impacts. In some cases, information may be limited to the proximity of the affected population to the regulated source. Analysts may also rely on a combination of these methods when analyzing a regulatory action. The conclusions that can be drawn from the analysis will vary depending on the method used.

Considerable uncertainty may exist about key relationships and endpoints, such as how a reduction in emissions, or other types of releases, from a given source translates into ambient environmental quality and how it, in turn, translates into the human health impacts of interest. This is particularly problematic if these uncertainties differ across population groups. For instance, if an overexposed population group is more susceptible (i.e., it experiences greater health effects per unit of exposure), then using exposure as a proxy will underestimate the health risk posed by a stressor to that group. On the other hand, if local proximity to a pollutant source is used as a proxy for a risk that is much more widely distributed, it could overstate potential differences in risk. The analyst should select the method that is most appropriate for the available data, recognizing time and resource constraints. The sections below discuss five commonly-used methods and tools for assessing and presenting information about potential EJ concerns: summary statistics, visual displays, proximity-based analysis, use of exposure data, and qualitative approaches. For each approach discussed, we highlight key advantages and limitations.[50]

Regardless of the analytic approach taken, analysts should follow best practices appropriate to the questions under consideration. Current best practices that may be helpful for evaluating potential EJ concerns are outlined in Text Box 3.1. If it is not feasible to follow a particular best practice, the analyst should explain why this is the case.

6.4.1 Summary Statistics

A variety of simple summary measures can be used to characterize the distribution of health and environmental impacts in the baseline and regulatory options for population groups of concern relative to appropriate comparison groups. For example, the concentration of minority or low-income individuals in affected areas (e.g., counties, states, regions, within three miles of facilities) allows the analyst to examine the relationship between affected areas and a comparison group (the national or regional average concentrations of low-income or minority people), on average. The number or percentage of areas where the percent of minority or low-income individuals exceeds the state/national average provides a different measure, by showing the percent or number of areas that differ from a comparison group, regardless of population size or density. Critical in this approach is selecting the appropriate comparison group; Section 6.5.2 provides a more detailed discussion of factors to consider when selecting a comparison group.

Summary information should be sufficiently disaggregated so that the public can discern how risk, exposure, and/or health effects vary for different types of individuals within a population group, to the extent that such a detailed presentation is supported by underlying data. For instance, exposure or health outcomes can be presented for income quantiles in addition to presenting this information for those above or below a particular poverty threshold. Likewise, information on risk, exposure, and/or health effects can be presented for the average-exposed individual in each population group as well as a maximally exposed individual (see examples in Appendix C). If particular communities are substantially affected, an

[50] Health Impact Assessment (HIA) is an emerging area of research and is discussed in Section 5.

analyst can present summary statistics at a locally disaggregated level as well as for the nation as a whole.

Main Advantages of Summary Statistics

- Can be relatively straightforward to calculate;
- Provide a broad overview of effects;
- Can quickly convey information, particularly about large differences in effects;
- Can be easy to communicate to decision makers and public; and
- Can be used with a variety of types of data.

Main Limitations of Summary Statistics

- Often only report information for the average household or community in a geographic area;
- Can easily mask important information about the full distribution of effects;
- Do not necessarily offer insight into relative contribution of various factors to the distribution of risk or exposure; and
- Cannot be used to identify potential hot spots.

6.4.2 Visual Displays

Visual displays, such as maps, charts, and graphs, are a common method for presenting information when stressor and demographic groups are geographically distributed. Visual displays can communicate baseline levels of air pollutants or clusters of hazardous waste sites and then overlay the demographic profile and baseline health status of various population groups of concern. In this way, analysts can identify potential hot spots where high levels of pollution are found in communities with minority populations, low-income populations, or indigenous peoples.

Visual displays can communicate a large amount of information in an easily comprehensible form (see examples in Appendix C). However, these displays have been criticized for leading to erroneous conclusions regarding impacts if not carefully calibrated. For instance, it can be difficult to discern differences between baseline and regulatory options unless differences are large or the display has a high enough resolution. However, differences not discernible on a map may still be important.[51] For this reason, visual displays are only suggestive of potential effects and should be combined with more precise analytic techniques to further refine conclusions.

Advantages of Visual Displays

- Provide a broad overview of effects;
- Can quickly convey information, particularly about large differences in effects; and
- Can be useful for communicating information to a general audience.

Disadvantages of Visual Displays

[51] See Chakraborty and Maantay (2011) for further discussion of the limitations of using GIS for EJ analyses.

- Can be difficult to show smaller differences;
- May only be suggestive of differences in impacts;
- Can be difficult to apply in cases where main exposure is through product use or other non-spatial pathway; and
- May require the analyst to have knowledge of GIS-based software.

6.4.3 Proximity-Based Analysis

While use of actual exposure data is generally preferred, proximity or distance to a pollutant or source is an approach commonly used in the literature as a surrogate for a direct measure of risk or exposure when such information is not available (United Church of Christ, 1987; Baden and Coursey, 2002; Cameron and Crawford, 2003; Wolverton, 2009). Using a proximity-based approach, it is possible to compare the demographic and socioeconomic characteristics of population groups affected by a particular source (e.g., a waste site or permitted facility) to the demographic and socioeconomic characteristics of population groups unaffected by the source. Appendix C provides examples illustrating how this method has been used for regulatory actions at the EPA. It is important to note that proximity-based approaches should not be used if the risks associated with the stressor of concern are not reasonably correlated with the geographic location of its source. One example is pollutants found in drinking water systems, as exposure can be more dependent on characteristics in the distribution system than on geographical proximity to a pollutant source or the treatment plant.

For practical reasons, the boundary of an affected versus unaffected area is usually based on a Census-defined geographic area (e.g., census tract) or a GIS-defined concentric buffer (e.g., a specified radius around a site that reflects the distance a particular pollutant may travel). When mapping the location of polluting sources, it is therefore critical to have accurate spatial information on sources. Analysts must decide what distance from the facility most accurately reflects the community's exposure to a stressor; no single specific distance is appropriate for all analyses. Buffer-based approaches around an emissions source can be designed to approximate actual risk and exposure, although the approach to designing the buffer should be uniform around each source. It is also possible to use more continuous measures of distance such as distance to the nearest polluting site or, when additional information is available, an emission-weighted distance measure. In some cases, it may be possible to use dispersion models to select a buffer that approximates the effect of atmospheric conditions (for instance, wind direction and weather patterns) on exposure; these types of models are data-intensive.[52]

Regardless of how the boundary is defined, proximity-based approaches typically assume that the effects of the stressor occur only within the designated boundary (i.e., people located outside the boundary do not suffer ill effects from the stressor) and that all individuals residing within the boundary are equally exposed.[53] The results of proximity-based analyses may also vary with different geographic units of analysis (e.g., Ringquist, 2005; Mohai and Saha, 2007). For this reason, an analyst should explore alternative geographic units or distances when defining proximity to a source, and describe the choices and assumptions that are used in selecting particular buffers.

The two groups – individuals located near and far from the source – can be compared on the basis of simple statistical or regression estimation techniques. Statistical tests on summary data can be used to

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[52] For an overview of proximity analysis, including a discussion of various spatial analysis techniques used in the literature, see Chakraborty and Maantay (2011) and Mohai and Saha (2007).

[53] Chakraborty and Maantay (2011) address how to account for areas with more than one pollutant source, which are typically treated the same as those with only one source. One can account for this through the use of a count regression technique. However, each pollutant source is treated as identical with regard to its effect on the health of the surrounding community. In reality, these sources could vary widely in size, age, and production techniques resulting in differing amounts of pollution released into the environment.

identify whether, on average, statistically discernible differences exist in the characteristics of the two groups. Regression techniques, such as a binary logit, also can be used to make this comparison formal (where 1 is used as a dummy variable to indicate areas where one or more sources are located, and 0 indicates areas with no sources of the stressor). A statistically significant coefficient on a demographic variable such as poverty indicates a measurable difference in the variable across geographic areas with and without stressor sources.

Advantages of Proximity-Based Analysis

- Provides a quantitative analysis of the characteristics of communities surrounding locations;
- Can be a statistically rigorous approach if supported by data;
- Accounts for where individuals reside, providing a proxy for exposure when other more detailed information is unavailable; and
- Can be used to identify potential hot spots.

Disadvantages of Proximity-Based Analysis

- Requires accurate information on location of sources;
- Proximity to a source is a proxy for actual exposure should not be used if risks associated with the stressor of concern are not reasonably near the geographic location of its source and generally cannot be used to definitively establish a causal relationship;
- Exposure is often defined as a binary indicator instead of a continuous measure;
- Typically does not account for where individuals work or recreate; and
- Requires knowledge of GIS or other statistical tools.

6.4.4 Use of Exposure Data

When data are available, analysts may choose to use emissions or other ambient concentration data combined with fate and transport modeling to examine distributional effects at a disaggregated level. For instance, criteria air pollutants are monitored nationally, while hazardous air pollutants modeling results are available through the EPA's National Air Toxics Assessment. These monitoring data can be combined with demographic data and air dispersion modeling results to generate baseline and regulatory distributions of pollutants by population groups of concern. Appendix B discusses this in more detail.

In cases where disaggregated information is available on the types of activities that result in differences in exposure across population groups of concern, it may be possible to characterize differences in various health effects due to the regulatory action. In some cases, it also may be possible to combine exposure data with information on differences in risk across population groups.

Advantages of More Advanced Quantitative Methods

- Represent the most detailed and rigorous type of analysis; and
- Provide the most direct source of information on exposures or other outcomes.

Disadvantages of More Advanced Quantitative Methods

- Require detailed data at a fine geographic scale;

- Are more complex to implement; and
- Provide results in a form that may be more challenging to communicate to the public.

6.4.5 Qualitative Approaches

While the EPA has a preference for using quantitative data and analysis to support the regulatory process, it is not always feasible to do so, particularly with respect to analysis of potential EJ concerns.[54] Often the data are not available at a sufficiently disaggregated level to allow for quantitative consideration of the distribution of impacts at the baseline and across regulatory options. At other times, only partial information may be available. In either case, the use of qualitative information or methods may be an appropriate supplement. Qualitative methods may be particularly useful for offering insight into people's values, behaviors, motivations, or cultures, or when providing context with regard to cumulative impacts, which are often omitted from quantitative assessment.

Analysts should use their best judgment when evaluating the appropriate use of quantitative and qualitative information for analysis of potential EJ concerns.

Qualitative approaches can range from a survey of existing literature to more formal analysis with one or more of the following characteristics:

- Employ a variety of empirical materials, such as case study, personal experience, introspection, life story, interview, observational, historical, interactional and visual texts;
- Involve gathering empirical materials using some form of observation or interviewing method;
- May be iterative, with initial results informing later choices of observation sessions and/or interview questions; and
- May rely on primary or secondary data sources, or a combination of the two.

Most, if not all, regulatory actions include some level of qualitative discussion to add important details to the description of differences in impacts across population groups. See Tesch (2013) for a discussion of many different types of qualitative analyses. Text Box 6.2 provides a brief description of several examples of qualitative analyses from recent regulatory actions.

Advantages of Qualitative Approaches

- Useful when data are unavailable for conducting a quantitative analysis; and
- Allow analysts to incorporate hard-to-quantify information, such as cultural factors and other vulnerabilities.

Disadvantages of Qualitative Approaches

- Can be difficult to summarize results succinctly;
- Results can be uncertain, and the degree of uncertainty can be difficult to characterize; and
- Can be difficult to compare to other quantitative information, such as benefit-cost analysis or risk assessment.

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[54] The EPA's *Economic Guidelines* (U.S. EPA, 2010c) provides a discussion of how to consider qualitative information in the context of benefit-cost analysis (see Chapters 7 and 11, specifically).

Text Box 6.2: Examples of Qualitative Analysis of Potential EJ Concerns

Agricultural Worker Protection Standard Revisions (U.S. EPA, 2015f)

> The analysis of potential EJ concerns and overall benefit analysis include qualitative discussions of factors that may cause farm workers to be more susceptible to pesticide exposure and to have a larger risk of harm from exposure. These reasons include higher acute and chronic exposures than that of the general public, poor nutrition due to food insecurity, lack of access to healthcare, language barriers, low educational attainment, and low-income.

National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category – Phase I (U.S. EPA, 1997b)

> The analysis of potential EJ concerns focuses on dioxin exposures from contaminated fish caught near bleached craft mills. While much of the EJ analysis is quantitative, this analysis also includes case studies on health benefits to Native American subsistence fishers on the Penobscot and Lower Columbia Rivers.

Hazardous Waste Management System: Modification of the Hazardous Waste Program; Hazardous Waste Lamps (U.S. EPA, 1999)

> The analysis of potential EJ concerns qualitatively discusses potential routes of exposure and likely affected populations. For example, crushing of lamps can occur during handling and transport and this would likely decrease post-regulation, thus reducing mercury exposures to populations of concern.

6.5 Analytical Considerations

Regardless of the analytic approach taken, an analyst will make a number of key decisions that can have a substantial effect on the results of the analysis, including: the geographic scope of the analysis; the comparison group; how to identify spatially and aggregate effects across affected and unaffected (i.e., comparison group) populations; and temporal considerations. Each is discussed below.

An important general strategy in analyzing potential EJ concerns is the use of sensitivity analyses. Due to the uncertainties associated with all of the analytic decisions discussed below, sensitivity analysis around key assumptions is often critical for clearly communicating results to the public.

6.5.1 Geographic and Temporal Scope

The geographic scope of analysis for an EPA regulatory action is often the entire United States since requirements typically apply nationwide. However, in some cases, regulatory action effects may occur mainly at a sub-national level, with requirements that have regional patterns or effects that are expected to be concentrated in particular regions or states. In such cases, it may make sense for an analyst to analyze and present differences in health and environmental outcomes across population groups of concern at both a national and a sub-national level. The scope of the analysis should match the scope used in other parts of the regulatory analysis (e.g., benefit-cost analysis). Because the geographic scope can affect the results of the analysis (see Baden et al., 2007), the analyst should make certain that the scope is relevant for the regulatory action under consideration.

Text Box 6.3: Choosing a Comparison Group – Recent Examples

A variety of methods can be used to define a comparison group. For the final Mercury and Air Toxics Standards (MATS) Rule (U.S. EPA, 2011f), analysts examined mortality risk associated with fine particulate matter by race, income, and poverty level for people living in high risk counties (i.e., in the counties identified as experiencing the top five percent of risks from exposure). The comparison group was defined as people living in counties not facing a high mortality risk.

For the proposed (but now withdrawn) Reporting Rule for Concentrated Animal Feeding Operations (U.S. EPA, 2011i), analysts began by comparing the socioeconomic characteristics of census tracts with concentrated animal feeding operations (CAFOs) to an average U.S. census tract without a CAFO. However, "data on minority and low-income populations were heavily dominated by populations in urban census tracts." Because CAFOs are located in rural areas of the country, the EPA decided it was appropriate to exclude urban census tracts and instead compared the socioeconomic characteristics of each census tract with a CAFO to the characteristics of the average rural census tract.

In general, the period of time over which the analysis is conducted (i.e., time horizon) should also be consistent with other parts of the regulatory analysis, such as the benefit-cost analysis. However, in some situations a different time horizon may be appropriate when considering EJ. For example, relocation of polluting activities could affect potential EJ concerns with impacts that occur on a time horizon that differs from other impacts considered in the regulatory analysis, in which case the analyst may want to consider those relocated activities separately. If such situations arise, the analyst should clearly articulate the reasons for selecting an alternative time horizon.

6.5.2 Comparison Group

To evaluate impacts on population groups of concern, information needs to be presented in relation to another group, typically referred to as a comparison group. The way in which the comparison group is defined can have important implications for evaluating differences in health, risk, or exposure effects across population groups of concern.

It is possible to define the comparison group as individuals with similar socioeconomic characteristics across different areas in the state, region or nation (i.e., within-group comparison) or as individuals with different socioeconomic characteristics within an affected area (i.e., across-group comparison). Ideally, the comparison group for an across-group comparison is as similar as possible to the population group of concern, but without the socioeconomic characteristics defining the group of concern. For example, the analyst could compare low-income households to high-income or average income households within the same three-mile radius of an emitting facility affected by the regulatory action.

Consistent with E.O. 12898 and the EPA's EJ policies, an across-group comparison is generally the more relevant to policy assessment. It is unlikely, however, that the same comparison group will be appropriate in every instance. It may make sense in some contexts to define the comparison group at a sub-national level to reflect differences in socioeconomic composition across geographic regions (see Text Box 6.3 for examples from recent regulatory actions). For instance, because of larger populations in urban areas, the results of the analysis are often dominated by effects in these areas. However, if a regulatory action primarily affects rural areas, inclusion of urban areas in the comparison group may not be valid. Specifically, the lack of discernable differences in effects for population groups of concern living in

unaffected urban areas may dominate the aggregate results, thus masking potential differences in effects for populations of concerns located in rural areas. For this reason, it is important to articulate clearly how the comparison group is defined in the EJ analysis. Analysts also should consider presenting information in multiple ways to provide a complete depiction of results.

Some have argued (e.g., Bowen, 2001) that restricting the comparison group to a sub-national level may be more defensible than a national level comparison in some instances, given heterogeneity in industrial development and economic growth and the inherent differences in socioeconomic composition across geographic regions (e.g., relatively more Hispanics reside in the Southwest). However, Ringquist (2005) notes that placing restrictions on comparison groups may "reduce the power of statistical tests by reducing sample sizes" or bias the results against finding disproportionate impacts because such restrictions reduce variation in socioeconomic variables of concern.

Because comparison groups can be defined in a number of valid ways, it can be useful to use a variety of definitions in order to provide a more complete depiction of potential impacts. In selecting a comparison group, an analyst should evaluate how different comparison groups affect the way information is conveyed.[55] Analysts should also carefully document the criteria used to choose the comparison group for a particular regulatory action. When appropriate and practicable, an analyst may wish to conduct sensitivity analysis using alternate definitions of the comparison group.

6.5.3 Spatial Identification and Aggregating Effects

The spatial distribution of health outcomes is a relevant consideration for some regulatory actions, such as those that reduce emissions from point sources that have fairly localized effects. In other cases, the regulatory action's effects may be more widespread, and spatial distribution is not as relevant. For instance, the effects of a national regulatory action on a chemical product do not depend on the spatial distribution of production facilities, but on variation in the purchase, use, transport, and disposal of the product.

When human health outcomes are spatially distributed, analysts need to determine how to spatially identify and aggregate affected and unaffected (i.e., comparison group) populations. The nature of the stressor should guide an analyst's choice of the geographic area of analysis. Some air pollutants, for example, may travel long distances, affecting individuals hundreds of miles away from the source and thereby making it appropriate to choose a relatively large geographic area. In contrast, water pollutants or waste facilities may have more localized effects, making it appropriate to select relatively small areas for analysis. Likewise, an assessment of local impacts from point sources may call for more spatially resolved air quality, demographic, and health data than those that affect regional air quality. The quality and type of data available also affect the spatial resolution of the analysis. Using more than one geographic area of analysis to examine the robustness of results may also be useful since effects are unlikely to be neatly contained within geographic boundaries and results may be sensitive to the choice of the geographic area of analysis (Mohai and Bryant, 1992; Baden et al., 2007).

Census-based geographical delineations and definitions often align with topographical features such as rivers, highways, and railroads. As a result, they may exclude a portion of the affected population that experiences the same adverse impacts of a stressor despite being separated by some physical feature. While Census-based definitions are easily accessible and offer many options with regard to geographic scale, use of GIS software allows for a potentially more flexible approach. GIS-based methods enable analysts to define spatial buffers around an emissions source that are more uniform in size and that are easier to customize to reflect the appropriate scale and characteristics of the emissions being analyzed

[55] For example, a comparison group of all minorities in the United States, while informative about the burden of risk among minorities, will not directly provide information about whether this burden is *higher* among minorities relative to non-minorities.

(e.g., fate and transport) for a given policy action. Buffers can be created and combined with Census data in a number of ways, including selecting the Census units such as tracts or block groups that intersect the buffer circle, selecting tracts with centroids captured by the buffer circle, using the geo-processing capabilities of GIS to intersect the buffer circle with the tract polygon, and transferring the attributes from tracts to the buffer area using area-weighting or populations-weighting.[56] The method selected should be the one that is most appropriate for the specific regulatory action. Mohai and Saha (2006, 2007) show that a distance-based approach (i.e., measuring distance from a facility as opposed to using a predefined unit like a census tract) provides a more complete comparison of effects.

Analysts should also be aware of a number of challenges that frequently arise when using geospatial data. Some statistical techniques rely on assumptions that are regularly violated by these types of data (Chakraborty and Maantay, 2011). For instance, when data are spatially autocorrelated – that is, locations in closer proximity are more highly correlated with the variable of interest than those further away – then the assumption that error terms are independently distributed is violated (see Chakraborty and Maantay, 2011). In addition, analysts should be aware of the potential for the "modifiable aerial unit problem" when aggregating geo-spatial data. The modifiable aerial unit problem refers to the fact that results can be sensitive to the level of aggregation used in the analysis. Results may differ depending on the unit of analysis; small geographical units (e.g., census tract) may provide different results than when results are aggregated across units (see Mohai and Bryant, 1992; Baden et al., 2007; Shadbegian and Wolverton, 2015). Analysts are encouraged to discuss the choice of the aerial unit, as it will vary with the pollutant and data used in the analysis, and to provide a transparent description of their choice.

6.5.4 Identification and Analysis of Potential Hot Spots

Hot spots refer to localized populations and communities that may face potential EJ concerns. These locations are often identified using quantitative proximity analyses as a screening approach. Relevant issues in a local setting may include exposure pathways and drivers of differential susceptibility. It is important to note that hot spots may result from pre-existing conditions (i.e., conditions that exist prior to the regulatory action), such as other stressors within the community. It is also possible that new hot spots are created as a result of the regulatory action. To the extent that the analyst is able to identify hot spots, either in the baseline or as a result of the regulatory action, such information may be considered in the decision-making process.

A screening-level analysis may help identify the potential for hot spots early in the analytical process. In addition, information received via public comments can yield insights into potential hot spots. Methods that can be used to analyze them may vary. For example, in cases where there are a relatively small number of potential hot spots identified, in-depth qualitative analysis may be useful. See Grineski (2009), Rao et al. (2007), Arcury et al. (2014), and Schwartz et al. (2015) for examples of qualitative discussions of hot spots. To identify whether a national level regulatory action results in potential hot spots, more sophisticated approaches may be required (e.g., fate and transport modeling).

6.5.5 Statistical Significance and Other Considerations

Analysts should bear in mind that a statistical difference does not necessarily indicate that the difference is meaningful from a policy perspective. For instance, an analyst may find that low-income households are more likely to be located near a pollution source than wealthier households, and that this effect is statistically significant (i.e., the effect is statistically distinguishable from zero, and not due to sampling error). However, the difference in likelihood between these types of households could still be quite small. Analysts will need to examine what the coefficient estimate implies (e.g., how different is poverty across these geographic areas), and summarize and report those differences in a manner appropriate for policy relevance. Analysts should also note that many of the demographic and socioeconomic characteristics often

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[56] The ESRI, Inc. software suite provides a summary review in the ArcGIS help files for proximity analysis: http://resources.esri.com/help/9.3/arcgisengine/java/gp_toolref/geoprocessing/proximity_analysis.htm.

included in these types of regressions are highly correlated with each other, making it difficult to interpret the meaning of a coefficient on any given variable. Finally, analysts should also consider other factors aside from demographic and socioeconomic characteristics that may have influenced the location of stressor sources. Regression techniques are able to partially control for these factors, while the use of statistical tests on summary data cannot. See Sadd et al. (1999) and Pastor et al. (2001, 2006) for examples of how researchers have approached these issues.

It is also important for analysts to be aware of and discuss the biases and limitations that are introduced when proximity or distance is used as a substitute for risk and exposure modeling (see Chakraborty and Maantay, 2011). Given the analytic challenges associated with proximity-based analysis, analysts may only be able to draw limited conclusions regarding the possibility of differences across populations groups.

Finally, it is important to address and characterize uncertainty. When statistical analysis is used, information such as confidence intervals and variance should be presented. In cases where statistical analysis is not used, uncertainty can be discussed by highlighting limitations in the literature, caveats associated with results, or gaps in the data.

6.6 Assessing the Distribution of Costs and Other Impacts

This section addresses when it may be appropriate to evaluate the distribution of costs across population groups of concern and the evaluation of non-health impacts. By costs, we specifically refer to economic costs (i.e., compliance costs and/or social costs) as defined in U.S. EPA (2010c).

6.6.1 Distribution of Economic Costs

This *EJ Technical Guidance* mainly focuses on methodologies and approaches to assess the potential for differential health impacts associated with regulatory actions on population groups of concern. However, certain directives (e.g., E.O. 13175 and OMB Circular A-4) identify the distribution of economic costs as an important consideration in regulatory analysis. These issues are relevant, but challenging. The economics literature also typically considers both costs and benefits when evaluating distributional consequences of an environmental policy in order to understand their net effects on welfare. For instance, Fullerton (2011) discusses six possible types of distributional effects that may result from an environmental policy: higher product prices; changes in the relative returns to capital and labor; the distribution of scarcity rents (i.e., excess benefits due to restricted nature of a good, such as pollution permits); the distribution of environmental benefits; transitional effects of the policy (e.g., changes in employment); and the capitalization of environmental improvements into asset prices (e.g., land or housing values). That said, the consideration of economic costs in an EJ context is likely to be challenging given a lack of data and methods in many instances.

In the context of EJ, the distribution of health or environment effects alone might convey an incomplete – and potentially biased – picture of the overall burden faced by population groups of concern. For instance, if costs are unevenly distributed such that low-income households bear a larger relative share, it is possible that they may experience net costs even after accounting for environmental improvements.

Whether to undertake an analysis of economic costs as it pertains to EJ is a case-by-case determination. It will depend on the relevance of the information for the regulatory decision at hand, the likelihood that economic costs of the regulatory action will be concentrated among particular types of households, and the availability of data and methods to conduct the analysis.[57] Analysts should coordinate with economists

[57] Note that there may be other impacts of a regulatory action (e.g., employment effects) beyond direct compliance and (indirect) social costs, but understanding how all impacts vary across population groups of concern may not be feasible. For example, data on the distribution of changes in employment across low-income and minority populations may be difficult to assess.

from the Office of Policy when evaluating the potential relevance of economic costs for EJ and the degree to which they can be discussed or analyzed.

In many cases, analysis of economic costs from an EJ perspective will not substantially alter the assessment of distributional impacts for population groups of concern. For instance, often the costs of regulatory action are passed onto consumers as higher prices or changes in wages that are spread fairly evenly across many households. When these price increases are small, the effect on an individual household also will likely be relatively small. When this is the case, further analysis is unlikely to yield additional insights regarding distributional effects.

However, in some circumstances further exploration of the distribution of economic costs may offer substantial insight because costs are expected to differentially burden populations of concern. For example, further analysis may be warranted when costs to comply with the regulatory action represent a noticeably higher proportion of income for population groups of concern; when some population groups are less able to adapt to or substitute away from goods or services with now higher prices; when costs are concentrated on some types of households (e.g., renters) more than others; when there are identifiable plant closures in or relocation of facilities away from neighborhoods in which populations of concern reside; or when behavioral changes in response to the costs of the regulatory action leave populations of concern less protected than other groups.

While the Agency continues to investigate ways in which to improve incorporation of economic costs into an analysis of potential EJ concerns, it recognizes that, even in cases where the information would be relevant, data or methods may not exist for full examination of the distributional implications of costs across population groups of concern. For example, the EPA may expect pollution control costs to be passed on to electricity consumers in the form of higher prices that differentially affect budget-constrained households in particular regions more than others. To evaluate the effects of the regulatory action properly, the Agency would need to understand whether and if so, how, costs are passed through as rate increases (which differs by state); how these increases are broken down between residential and commercial customers; what assistance is available for low-income consumers; how consumption patterns differ by race and income; and how these consumption patterns may be altered in response to electricity price changes. Likewise, if environmental improvements associated with the regulatory action are unevenly distributed, demand for housing in particular neighborhoods may affect rental prices for housing. This, in turn, may result in households moving to other locations that have a different risk and exposure profile.

While a static analysis may be possible in some circumstances, it is challenging to anticipate and model the dynamic effects of a regulatory action on migratory patterns and other types of behavioral change. For example, spatial sorting models have been used in the literature to examine responses to regulation but they typically focus on a particular city or region.[58] In addition to methodological limitations, incomplete data may limit the ability of the analyst to fully characterize the distribution of costs across population groups of concern. In particular, available data may only shed light on baseline distributions, without anticipating the distribution of costs in cases when the regulatory action is expected to result in indirect behavioral changes through changes in price.[59] Due to method and data limitations, it might not be possible to predict the total impact of a regulatory action on different populations. In these instances, the

[58] Likewise, while hedonic price methods may be useful for demonstrating how changes in environmental quality factor into housing prices, predicting the effect of such price changes on household migration by race or income may be infeasible.

[59] Data for exploring differential consumption patterns in the baseline may be available from the Consumer Expenditure Survey, which provides information on the purchase of goods and services across different types of households. The baseline distribution of electricity and other energy prices by household type is also available from the Energy Information Administration. In addition, industry-specific data sources on baseline household consumption patterns may be available for certain types of products or services related to the regulatory scenarios under consideration. When such disaggregated data are available, it is unlikely they will show distribution according to race/ethnicity; information by income class is more likely.

issue can be qualitatively discussed, and the limitations and assumptions associated with characterizing cost impacts should be fully explained.

When analyzing the distribution of costs, other considerations include the time frame associated with the analysis and the use of partial versus general equilibrium analysis. For instance, it is possible that all or almost all consumers face similar price changes due to a regulatory action, but in the short run budget-constrained households may face more difficulties accommodating the higher prices. In contrast, higher automobile prices due to a regulatory action will initially affect higher income households who purchase new cars more frequently; over a longer period of time, however, these higher prices will also affect lower-income households due to higher prices for used cars. More extensive studies could possibly consider the use of dynamic general equilibrium analysis to examine first and second-order costs and their implications for changes in wages and prices across households over time. However, such analyses are typically very resource- and time-intensive, are usually only utilized in cases where a large number of sectors are expected to experience significant impacts – either directly or indirectly - as the result of a regulatory action, and are generally focused on medium- to long-run impacts (U.S. EPA, 2010c).

6.6.2 Other Impacts

While this technical guidance mainly focuses on tools that analysts may use to evaluate differences in health impacts across population groups of concern, the distribution of non-health impacts associated with environmental stressors affected by the regulatory action may also be important to consider. For instance, certain groups may place a higher value on a cultural resource (e.g., spiritual or scared sites). If a regulatory option impacts those resources, then the groups with a higher value will experience a different impact than groups that do not place a value on the cultural resource. Likewise, some regulatory options may differentially affect access to particular aquatic amenities for recreation for different population groups.

Quantifying changes in non-health outcomes may be challenging, however. Often, data on the distribution of baseline conditions for non-health endpoints are not easily available or are difficult to quantify, and/or are not suitable for analyzing the impacts of a regulatory action. For instance, data on some ecosystem services (e.g., cultural uses of specific ecosystems) in the United States are quite limited in availability compared to baseline health data, such as mortality incidence. Likewise, data and models to assess how various regulatory options affect non-health endpoints may not be available.

Given these challenges, this guidance is currently not prescribing any specific requirements regarding an analysis of how the distribution of non-health impacts may be affected by the regulatory action. When the distribution of non-health impacts is difficult to quantify, analysts may consider a qualitative discussion of non-health endpoints affected by the regulatory action, relying on methods of data collection such as those discussed in Section 5.3.2.2. For example, as part of this discussion, analysts may note any non-health endpoints that are of particular cultural importance for population groups of concern, discuss how they may be distributed across population groups of concern in the baseline, and describe how they may be affected by the regulatory action under consideration when feasible. When data are available, analysts may also rely on them in the evaluation.

Section 7: Research Priorities to Fill Key Data and Methodological Gaps

The challenges associated with incorporating EJ considerations into EPA regulatory analysis vary across programs. In general, the EPA relies on peer-reviewed literature to support decision-making for regulatory actions. Addressing environmental justice is no exception. High quality, scientific peer-reviewed data, methods, tools, and findings are necessary to support the conclusions drawn from prospective analyses of potential EJ concerns. For the purposes of identifying research priorities related to the intersection of EJ and regulatory actions, *data gaps* include situations where data are missing all together, limited in scope, too disaggregated to be useful, or inaccessible. *Methodological gaps* are areas where there is insufficient peer-reviewed literature addressing to support the use of a particular method or approach. The research required to address important data and methodological gaps may be short-term or long-term, depending upon such factors as the complexity of the issue begin studied, the extent to which conventional or new research techniques are required, and the amount of resources available.

Developing research plans and strategies to address the breadth of EJ issues is an iterative process and one that involves multiple stakeholder engagement. To that end, this section provides a summary of data and methodological gaps identified through interviews with EPA program office staff, input from the public, and responses from the SAB review of a preliminary version of the *EJ Technical Guidance*. To obtain Agency input, the EPA collected information through numerous brainstorming sessions with program office management and staff who write or inform the development of regulatory actions. Fourteen sub-offices across nine program offices participated in these discussions. In addition, the EPA conducted a public comment period to gather feedback on the draft *EJ Technical Guidance* prior to conducting the external peer review through the SAB. Finally, in the EPA's charge to the SAB when it reviewed the *EJ Technical Guidance*, the Agency specifically asked the SAB to identify potential research priorities relevant to analysis of potential EJ concerns for regulatory actions. Together, recommendations from these groups provide the impetus for understanding and identifying research priorities related to data, methods, tools, and information for assessing potential EJ concerns in regulatory analysis.

Recommendations for research priorities relate to several broad topics: 1) building consistency in common terminology and definitions; 2) strengthening the human health risk assessments for inclusion of EJ-related issues; 3) risk communication, community outreach, and meaningful engagement; and 4) incorporating EJ considerations into regulatory analyses.

7.1 Common Terminology and Definitions

The general need for common terminology and definitions was frequently highlighted by EPA program offices in the series of brainstorming sessions. In particular, analysts expressed concern that terms currently used to define population groups of concern and disproportionate impacts are unclear or are used inconsistently in regulatory actions, and concluded that clear and consistent terminology is an important prerequisite for incorporating EJ considerations into regulatory analysis. Analysts reported needing basic information about appropriate definitions for race and ethnicity, as well as other ways to identify vulnerable populations. While race, ethnicity, and income are often used to characterize populations of concern, analysts asked for research into what additional variables may be useful for characterizing vulnerable populations, both in the context of potential impacts from climate change and from other environmental stressors. For example, unique community practices (such as subsistence fishing), genetic predispositions, access to health care, education, geography, and other factors may be associated with increased vulnerability to environmental stressors. Research into ways to define and identify such variables would require consideration of data availability at the relevant geographic scale needed for EJ analysis.

7.2 Strengthening Human Health Risk Assessment for Considering EJ

The following sections describe the research priorities relevant to HHRA identified by EPA program offices, the public, and the SAB.

7.2.1 Planning and Scoping and Problem Formulation

Problem formulation is a process for generating and evaluating preliminary hypotheses about why health effects may be associated with specific stressors. Because the planning and scoping for a risk assessment and the problem formulation step rely on defining the regulatory question, the language and terminology need to be clear and concise to lay a strong foundation for the analysis. To that end, the recommendations received emphasized a need for clear definition of terms such as chemical versus non-chemical stressors in the context of cumulative risk assessments. More specifically, respondents recommended research to evaluate the impact of adopting various assumptions and definitions in the risk assessment. For example, this research would inform how different income level thresholds used to define lower income populations could introduce large variability in the establishment of reference populations for the risk assessment.

7.2.2 Effects Assessment

As outlined in Section 5.2, effects assessment includes both hazard identification and dose-response assessment. *Hazard identification* is the process of identifying the type of hazard to human health (e.g., cancer, birth defects) posed by the exposure of interest. In an EJ context, one can ask, "What health problems may be caused by the pollutant(s) and how might populations vary in their response?" *Dose-response assessment* addresses the relationship between the exposure or dose of a contaminant and the occurrence of particular health effects or outcomes. In an EJ context, one can ask, "What are the health problems at different exposures, and do these effects vary by type or incidence in populations of concern?"

Research recommendations for effects assessment focus on the need to better understand the links between demographic characteristics and the responses to environmental stressors that are associated with adverse health outcomes. Respondents also provided recommendations for developing tools to integrate community characteristics, social conditions, and cultural influences into risk assessments. For example, current data suggest that communities with potential EJ concerns may be exposed to a greater number or amount of environmental pollutant(s) based on proximity to waste sites, landfills, congested roadways, and manufacturing facilities. Such communities may experience co-exposure to multiple chemical and nonchemical agents that may contribute to variability in individual responses.

Research recommendations indicate a need for clarification of the variability in human responses across different populations, and for a better understanding of existing factors that might drive differences in population-level responses.

Risk assessment uses a variety of dose-response models and tools to estimate the dose or concentration relationships for adverse health effects. Research recommendations highlighted the need to ensure that dose-response modeling accounts for differences in susceptibility associated with populations with potential EJ concerns. An important first step would be to produce a comprehensive review of each relevant dose-response function that includes an analysis of baseline risk variation across different population groups. This information would enable risk analysts to consider the range of population-specific risk distributions along the dose-response curve.

7.2.3 Exposure Assessment

The SAB notes that the Agency should invest in research for better understanding actual exposures rather than relying on standard models of fixed behavior. A critical area for research is the development of cumulative risk assessment and cumulative impact assessment methods for multiple chemicals and non-chemical stressors. Numerous scientific and public stakeholder communities are calling for the Agency to move beyond the single-chemical risk assessments and toward a broader, more holistic type of environmental risk assessment. The communities of concern and susceptible populations need to be identified and, in those situations, there is also a need for specific information on existing environmental conditions (e.g., air quality, drinking water quality, emission rates, housing conditions, proximity to landfills, etc.) Input by a community regarding its values and traditions are important data needs in constructing the cumulative assessment.

7.2.4 Risk Characterization

The final step in the risk assessment paradigm is the characterization of risk. Risk characterization strives to provide a clear and integrated discussion of the overall findings, key areas of uncertainty, overall data quality, and data deficiencies that may affect methodology development and the overall conclusion. Recommendations for research in this area include improved knowledge about geographical shifts of the U.S. population and variation in baseline risk by life stage and population group. Research is needed for understanding and inclusion into the risk assessment of toxicokinetic and toxicodynamic differences across life stages, especially for infants and children. Results of this research will support judgment of the adequacy of default assumptions to account for unique differences among different populations.

In addition, knowing whether or not differential exposure across groups is a potential EJ concern requires reviewing the EPA's position on differential risk versus exposure. There may be examples in which a regulatory action has no increased risk (e.g., everyone falls below a certain acceptable level of risk), but a differential exposure still exists.[60] Also needed are consistent criteria for defining differential impact on a community with potential EJ concerns and valid indicators of associated adverse health impacts.

7.3 Risk Communication, Community Outreach, and Meaningful Engagement

As emphasized in Section 5.3.1.5, the involvement of stakeholders is integral to both the HHRA process and to the broader consideration of potential EJ concerns. Engaging stakeholders in the HHRA process may help analysts identify stressor sources, highlight adverse health effects, and address risk perception issues. Recommendations pointed to the need for research on appropriate ways to collect and use community-generated information in the EPA's regulatory analyses. Respondents also recommended studies of effective means of outreach to communities with potential EJ concerns, including how to measure the effectiveness of that communication approach on a continuous basis.

7.4 Incorporating EJ into Regulatory Analysis

In developing analyses of potential EJ concerns for regulatory actions, an analyst should first evaluate its feasibility based on availability of data, tools, and methods. Research priorities related to these topics are identified below.

[60] See Section 5 and the glossary of this guidance for discussion and definitions of exposure and risk.

7.4.1 Evaluating the Feasibility of an Assessment of Potential EJ Concerns

To conduct assessments of the potential EJ concerns associated with regulatory actions, it is necessary to have relevant, appropriate, and adequate data. Often, data most relevant to an EJ analysis are not disaggregated by race, ethnicity or income, which is necessary to better understand the distributional effects of a particular regulatory action. For example, while relevant data may be available at a national, aggregate level, such data are not always available at a finer resolution, such as at the community level, that allows for an analysis of potential EJ concerns tied to the likely impacts of a regulatory action. EPA program offices identified several specific data gaps:

- Lack of monetized benefits for some health endpoints;
- Finer resolution air quality data and alternative ways to collect them;
- Vehicle fleet composition across communities;
- Emissions rates and activities across sources;
- Product usage by demographic characteristics;
- Housing distance from highways;
- Characteristics of workers by industry;
- Drinking water quality across communities;
- Data on subsistence fishers and where they live; and
- Information on non-monitored areas.

Collaboration with other federal agencies to facilitate the sharing and access to data sources was identified as a priority. Currently, access to data at other federal agencies, states, localities, universities, and non-government organizations varies. The SAB encourages the Agency to be creative in considering data sources and methods of analysis.

7.4.2 Evaluating Baseline and Incremental Changes

Evaluating baseline conditions and incremental changes is essential for an analysis of potential EJ concerns. It is necessary to identify whether pre-existing disparities exist and if so, how those change as a result of the regulatory action. Agency analysts indicated a need to better understand how to identify baseline conditions, particularly how to disaggregate information across population groups of concern. In addition, respondents noted a need to understand how to incorporate pre-existing conditions into the baseline. A public comment (per process described above) suggested that further research into the effect of infrastructure on exposure (including drinking water and wastewater systems) would help inform the evaluation of baseline conditions.

To better evaluate incremental changes associated with a regulatory action, program offices expressed a need for: dose-response curves that vary by demographic characteristics; information on how to consider exposures during critical life stages, such as childhood; and the link between genetic factors or behaviors that could give rise to greater susceptibility. Another frequently-noted methodological gap is information on how to incorporate non-chemical stressors into the analysis and consideration of cumulative effects.

7.4.3 Methods to Assess Potential EJ Concerns

Agency program offices identified the need for better methods, or consensus on methods, for presenting the results of analyses of potential EJ concerns to ensure that metrics are useful and relevant, various options can be ranked within and across population groups of concern, and appropriate methods for characterizing the distribution of risk are used. EPA program offices asked that specific consideration be given to whether inequality metrics could be an effective, useful tool in the context of an analysis of potential EJ concerns. Respondents noted a need for research into the appropriate methods to capture potential EJ concerns in specific regulatory contexts. For example, it is not clear how to analyze potential EJ concerns in the context of global pollutants or mobile sources for which it is difficult to characterize transport of pollutants over long distances. Standard methods such as proximity-based approaches are not useful in these cases. Alternatively, a regulatory action such as a reporting rule could indirectly affect health by affecting how information is provided.

Agency program offices also identified as a methodological gap the role that qualitative analysis can play in assessing environmental justice in regulatory analysis. Regulatory actions associated with greenhouse gases, for example, could benefit from qualitative analysis of how climate change may differentially affect one or more population group(s) where data precludes a quantitative assessment. Research also is needed into whether and how to scale up qualitative case studies to larger regional and national contexts.

7.4.4 Analytical Considerations

Analysts pointed to a lack of methodological tools to account for behavioral responses to proposed regulatory actions when analyzing their distributional impacts. This particular research gap is likely broader than just analyses of potential EJ concerns, but can be particularly important for understanding who is ultimately affected by the regulatory action.

Finally, analysts identified the need to investigate downstream chemical effects relevant to evaluating potential EJ concerns and potential risk mitigation options; for example, chemical environmental fate and its effects on exposure are important considerations.

7.5 Other General Recommendations

The SAB identified additional research priorities that fall outside of the topics described above. Specifically, the SAB identified the need for cross-agency research planning. The SAB's opinion is that strategic thinking on longer-term research priorities and leveraging research interests at other federal agencies, such as the U.S. Department of Health and Human Services and the CDC, would go far in addressing the needs expressed by EPA analysts. In particular, the SAB suggested a brainstorming session with sister agencies that could help better identify and address long-term research needs.

In addition, the SAB noted the need for increased staffing and hiring for conducting EJ analysis in the future. While economists and risk assessors form the core group of analysts undertaking EJ analysis, the SAB feels that EJ analysis would be advanced by also incorporating expertise from psychologists, sociologists, and anthropologists.

7.6 Next Steps

A wide range of EJ-related research activities that may address some of the identified research gaps are already underway at the EPA. Each program office engages in research to address specific needs and concerns. In addition, the EPA's Office of Research and Development (ORD) actively pursues and supports research to improve EJ consideration in the regulatory process. An EJ Research Roadmap has been developed to highlight the role of ORD science in addressing potential EJ concerns (U.S. EPA, 2014d).[61] It

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[61] See http://www.epa.gov/sites/production/files/2015-12/documents/environmental_justice_research_roadmap_partner_review.pdf for updates to the ORD EJ Research Roadmap.

provides an inventory and analysis of the EPA's EJ-related research activities, and serves as a useful resource for EPA programs, external stakeholders, and the public.

The EPA is a science-based agency. As such, it is committed to the pursuit of research related to EJ and regulatory action to better meet the needs of Agency analysts, decision makers, and the public in support of scientifically sound regulatory decisions that protect the health of all communities.

Glossary

Adverse effect: a biochemical change, functional impairment, or pathological lesion that either singly or in combination adversely affects the performance of the whole organism or reduces an organism's ability to respond to an additional environmental challenge.

Agency action: includes rules, policy statements, risk assessments, guidance documents, and models that may be used in future regulatory actions, and strategies that are related to regulations.

Background exposures: potential exposures to stressors due to background levels of both naturally occurring and anthropogenic sources.

Baseline: describes an initial, status quo scenario that is used for comparison with one or more alternative scenarios. In typical regulatory analyses, the baseline is defined as the best assessment of the world absent the proposed regulatory or policy action.

Bioaccumulation: the uptake of organic compounds by biota from either water or food. Many toxic organic chemicals attain concentrations in biota several orders of magnitude greater than their aqueous concentrations, and therefore, bioaccumulation poses a serious threat to both the biota of surface waters and the humans that feed on these surface-water species. Sometimes used interchangeably with "bioconcentration," see http://toxics.usgs.gov/definitions/bioconcentration.html.

Comparison group: other groups about which information is presented, in relation to population groups of concern, in order to describe impacts of a regulatory action. See Section 6.5.2.

Contaminant: a substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects. Also, see "stressor."

Cumulative risk assessment: an analysis, characterization, and possible quantification of the combined risks to human health or the environment from multiple agents or stressors.

Disproportionate impacts: in this document, refers to differences in impacts or risks that are extensive enough that they may merit Agency action. See Section 2.1.

Dose: the amount of a substance that enters a target in a specified period of time after crossing an exposure surface.

Dose-response assessment: a determination of the relationship between the magnitude of an administered, applied, or internal dose and a specific biological response. Response can be expressed as measured or observed incidence, percent response in groups of subjects (or populations), or as the probability of occurrence within a population. See Section 7.2.2.

Effects: refers to risks, exposures, and outcomes and is sometimes used interchangeably with "impacts."

Effect-modifier: factors that may influence susceptibility, and may include genetics, diet, nutritional status, pre-existing disease, psychological stress, co-exposure to similarly-acting toxics, and cumulative burden of disease resulting from exposure to all stressors throughout the course of life.

Environmental justice: the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Exposure: human contact with environmental contaminants in media including air, water, soil, and food.

Exposure assessment: an identification and evaluation of the human population exposed to a contaminant or stressor, describing its composition and size, as well as the type, magnitude, frequency, route and duration of exposure.

Exposure pathway: the course a chemical or contaminant takes from its source to the person being contacted.

Fair treatment: the principle that no group of people should bear a disproportionate burden of environmental harms and risks, including those resulting from the negative environmental consequences of industrial, governmental, and commercial operations or programs and policies.

Hazard: inherent property of an agent, contaminant, or situation having the potential to cause adverse effects when an organism, system, or population is exposed to that stressor.

Hazard identification: the process of identifying adverse effects to human health (e.g., cancer, birth defects) posed by the exposure of interest. See Section 7.2.2.

Health impact assessment: a systematic process that uses an array of data sources and analytic methods, and considers input from stakeholders to identify the potential effects of a proposed regulatory action, policy, or project on the health of a population and the distribution of those effects within the population.

Hot spot: a geographic area with a high level of pollution/contamination within a larger geographic area of lower or more "normal" environmental quality.

Human health risk assessment (HHRA): the process used to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals or other stressors in contaminated environmental media, now or in the future.

Indigenous peoples: includes state-recognized tribes; indigenous and tribal community-based organizations; individual members of federally recognized tribes, including those living on a different reservation or living outside Indian country; individual members of state-recognized tribes; Native Hawaiians; Native Pacific Islanders; and individual Native Americans. A reference to populations characterized by Native American or other pre-European North American ethnicity or cultural traits. See Section 2.2.1.

Life stage: a distinguishable time frame in an individual's life characterized by unique and relatively stable behavioral and/or physiological characteristics that are associated with development and growth that are characterized by economic resources.

Low-income populations: a reference to populations characterized by limited economic resources. The OMB has designated the Census Bureau's annual poverty measure as the official metric for program planning and analysis, although other definitions exist. See Section 2.2.2.

Meaningful involvement: indicates that potentially affected populations have an appropriate opportunity to participate in decisions about a proposed activity (i.e., in this document, rulemaking) that will affect their environment and/or health; the population's contribution can influence the EPA's regulatory action decisions; the concerns of all participants involved will be considered in the decision-making process; and the EPA will seek out and facilitate the involvement of population's potentially affected by the EPA's regulatory action development process. See Section 2.3.

Minority populations: populations of individuals who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. See Section 2.2.1.

Pollutant: an emitted substance that is regulated or monitored for its potential to cause harm to the health of individuals or to the environment. Also, see "stressor."

Population groups of concern: in this document, minority populations, low-income populations, and indigenous peoples in the United States and its territories and possessions. See Section 2.2.

Potential environmental justice concern: in this document, where the opportunity exists for a group of people to experience disproportionate impacts resulting from…on minority populations, low-income populations, or indigenous peoples that exist prior to or may be created by a proposed regulatory action. It can also indicate the actual or potential lack of fair treatment or meaningful involvement of minority populations, low-income populations, or indigenous peoples in the development, implementation, and enforcement of environmental laws, regulations, and policies. See Section 2.1.

Proximity or contaminant analysis: analytical approach using spatial data to estimate a populations' risk or exposure to a stressor when direct measurement of risk or exposure is unavailable. See Section 6.

Quantitative methods: explaining phenomena by collecting numerical data that are analyzed using mathematically-based methods (in particular, statistics).

Qualitative methods: encompasses a wide range of methods, such as interviews, case studies, discourse analysis, and ethnographic research. A key distinction from quantitative methods is that qualitative methods do not necessarily collect numerical data, and therefore frequently cannot provide numerical results. See Section 6.4.5.

Regulatory action: a subset of Agency actions conducted in direct support of a rulemaking; means any substantive action by an agency (normally published in the Federal Register) that promulgates or is expected to lead to the promulgation of a final rule or regulation, including notices of inquiry, advance notices of proposed rulemaking, and notices of proposed rulemaking. Also, see "Agency actions."

Regulatory analysis: a tool used to anticipate and evaluate the likely consequences of regulatory actions.

Regulatory scenarios: different configurations of or options for the regulatory action being considered. See Section 6.2.

Risk: the probability of an adverse effect in an organism, system, or population caused under specified circumstances by exposure to a contaminant or stressor.

Risk analyst/assessor: one who plans and conducts a risk assessment. In particular, the risk analyst provides a transparent description of all aspects of the risk assessment (e.g., default assumptions, data selected and policy choices) to make clear the range of plausible risk associated with each risk management option.

Risk management: in the context of human health, a decision-making process that accounts for political, social, economic and engineering implications together with risk-related information in order to develop, analyze and compare management options and select the appropriate managerial response to a potential chronic health hazard.

Social context: refers to all social and political mechanisms that generate, configure, and maintain social hierarchies. These mechanisms can include the labor market, the educational system, political institutions, and cultural and societal values. See Section 4.1.

Source: the origin of potential contaminants; frequently a facility or site.

Stakeholders: broadly defined as interested persons concerned with the decisions made about how a risk may be avoided, mitigated, or eliminated, as well as those who may be affected by regulatory decisions.

Stressor: a stressor is any physical, chemical, or biological entity that can induce an adverse response. Stressors may adversely affect specific natural resources or entire ecosystems, including plants and animals, as well as the environment with which they interact. In this document, the term is used to encompass the range of chemical, physical, or biological agents, contaminants, or pollutants that may be subject to a rulemaking.

Subsistence populations: minority populations, low-income populations, or indigenous peoples (or subgroups of such populations) subsisting on indigenous fish, vegetation and/or wildlife, as the principal portion of their diet see Section 2.2.3.

Susceptibility: increased likelihood of an adverse effect, often discussed in terms of relationship to a factor that can be used to describe a population group (e.g., life stage, demographic feature, or genetic characteristic). In this document, the term refers to an individual's responsiveness to exposure.

Summary statistics: descriptive statistics which provide an overview of available data and may include the mean, median, mode, interquartile mean, range, and/or standard deviation, etc. See Section 6.4.1.

Vulnerability: physical, chemical, biological, social, and cultural factors that result in certain communities and population groups being more susceptible or more exposed to environmental toxins, or having compromised ability to cope with and/or recover from such exposure.

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Appendix A: Select Examples of EPA Guidance, Guidelines, and Policy Documents

This appendix contains a list of document references with associated Web links for EPA guidance, guidelines, and policy documents that may be helpful to analysts when evaluating potential EJ concerns for regulatory actions.

TOPIC AREA	TITLE	PUBLICATION YEAR	WEB LINK
Economics	*Guidelines for Preparing Economic Analyses*	2010	http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf
	Environmental Justice, Children's Environmental Health and Other Distributional Considerations (Chapter 10 of *Guidelines for Preparing Economic Analyses)*	2014	http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-10.pdf/$file/EE-0568-10.pdf
Action Development Process	*Guidance on Considering Environmental Justice During the Development of Regulatory Actions*	2015	http://www.epa.gov/environmentaljustice/resources/policy/considering-ej-in-rulemaking-guide-final.pdf
Human Health Risk Frameworks	*Framework for Human Health Risk Assessment to Inform Decision Making*	2014	https://www.epa.gov/sites/production/files/2014-12/documents/hhra-framework-final-2014.pdf
	Framework for Assessing Health Risk of Environmental Exposures to Children	2006	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=158363
Other Health Risk Guidance	*Microbial Risk Assessment Guideline: Pathogenic Microorganisms with Focus on Food and Water* (Interagency Microbial Risk Assessment Guideline Workgroup)	2012	http://www.epa.gov/sites/production/files/2013-09/documents/mra-guideline-final.pdf
	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	2005	http://www.epa.gov/ttnatw01/childrens_supplement_final.pdf
	Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures	2000	http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=4486
	Technical Support Document on Risk Assessment of Chemical Mixtures	1990	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=35770
	Guidelines for the Health Risk Assessment of Chemical Mixtures	1986	http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=22567
Exposure Assessment	*Exposure Factors Handbook*	2011	http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
	Guidelines for Exposure Assessment	1992	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=15263#Download
Risk Characterization	*Risk Characterization Handbook*	2000	http://www.epa.gov/risk/risk-characterization-handbook
Cumulative Risk Assessment	*Considerations for Developing a Dosimetry-Based Cumulative Risk Assessment Approach for Mixtures of Environmental Contaminants (Final Report)*	2009	http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=172725

TOPIC AREA	TITLE	PUBLICATION YEAR	WEB LINK
	Concepts, Methods, and Data Sources for Cumulative Health Risk Assessment of Multiple Chemicals, Exposures and Effects: A Resource Document (Final Report)	2007	http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=190187
	Framework for Cumulative Risk Assessment	2003	http://www.epa.gov/sites/production/files/2014-11/documents/frmwrk_cum_risk_assmnt.pdf
	Guidance on Cumulative Risk Assessment of Pesticide Chemicals that have a Common Mechanism of Toxicity	2002	http://www.epa.gov/sites/production/files/2015-07/documents/guidance_on_common_mechanism.pdf
	General Principles for Performing Aggregate Exposure and Risk Assessments	2001	http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/general-principles-performing-aggregate-exposure-and
	Guidance on Cumulative Risk Assessment: Planning and Scoping	1997	http://www2.epa.gov/sites/production/files/2015-01/documents/cumrisk2_0.pdf

Appendix B: Example Approaches to Address Potential EJ Concerns When Conducting Exposure and Effects Assessments

The planning, scoping, and problem formulation processes provide a key opportunity to ensure that potential EJ concerns are incorporated into a human health risk assessment (HHRA). This appendix provides several key EJ-specific questions to consider when designing an exposure or dose-response assessment. It describes the implications of each question for the data gathering and analytic work that may be necessary to address them. Also included are examples of analyses from the peer-reviewed literature and/or U.S. government analyses, which may suggest approaches for an analyst to consider during planning, scoping, and problem formulation.

Planning for an Exposure Assessment

Patterns of exposure to stressors across population groups of concern may vary for a number of reasons. Variation may be predominantly a spatial phenomenon, if exposure is highest within close proximity to pollution sources and that is where the population group of concern is most likely to reside. Exposure differences may reflect variation in behaviors (e.g., subsistence anglers) or exposures due to specific dietary or cultural practices of a population group (e.g., exposures to pesticides in reeds used for basket weaving). Exposure may reflect unique aspects of the use or application of the chemical (e.g., exposures to pesticide applicators) or it may be affected by yet other factors that vary by population group. Text Box B.1 illustrates how five scoping questions (below) for integrating EJ into an exposure assessment could be posed to evaluate dietary risks from pesticide residues.

Text Box B.1: Example of Scoping Questions for Integrating EJ Considerations into Assessments of Dietary Risk from Pesticide Residues

To ensure that EJ considerations are explicitly considered in dietary risk assessments for pesticides, risk assessors could consider the following scoping questions when evaluating whether risk concerns may exist.

- Based on the pesticide use patterns, are there population groups that might be more highly exposed to pesticide residues because of their unique consumption patterns (e.g., ethnic diets; subsistence consumers)?
- Is it likely that the pesticide or its metabolites/degradates will bioaccumulate such that increased exposure and risk might be expected for certain population groups (e.g., life stages; subsistence consumers of fish, shellfish, game)?
- Is the pesticide used on, or likely to be found in, foods that are consumed in substantially higher amounts by certain ethnic or other population groups (e.g., lemon grass)?
- Does the pesticide have an atypical or unusual use pattern that could result in unusual exposures for certain population groups (e.g., use in non-traditional agriculture, or locally-restricted use)?
- Do the physical and/or chemical properties of the pesticide indicate a potential for long range transport (e.g., volatility, persistence), especially pesticides that may also bioaccumulate?
- Are there other groups within the population groups of concern (e.g. based on life stage) who might be more highly exposed through their diet to the pesticide?

Questions and Key Considerations

1. Based on the use and release patterns of the environmental stressors of concern, are there population groups that might be more highly exposed?

Environmental stressors may be used and released in a variety of circumstances. However, even when the stressor is intended for use in a particular circumstance or location, unintended releases can result. For instance, the stressor could migrate to an unintended location. One example of this is spray drift from pesticide applications that result in drift falling on "off-target" locations, which may lead to increased exposure to certain populations (e.g., farmers, migrant workers, children, sprayers). Text Box B.2 discusses how the potential risk for exposure due to pesticide application and residues can be calculated using drift modeling and other methods while accounting for evaporation of aerosols (i.e., volatilization), and the potential effects to bystanders. Some factors for consideration when evaluating the use and release patterns of environmental stressors include evaluating the potential for risks due to intended use and potential migration of the stressor, prevalence of use, environmental fate, and the toxicological characteristics of the stressor.

2. Are exposure variabilities predominantly a spatial phenomenon (e.g., due to contaminant hot spots)? Is proximity to source a reasonable proxy for estimating exposure to stressors of concern?

For environmental stressors that are dispersed locally in ambient media, exposure may be effectively captured using proximity to the source as a surrogate measure. Further detail about these methods can be found in the recent review by Chakraborty et al. (2011) and Section 6.

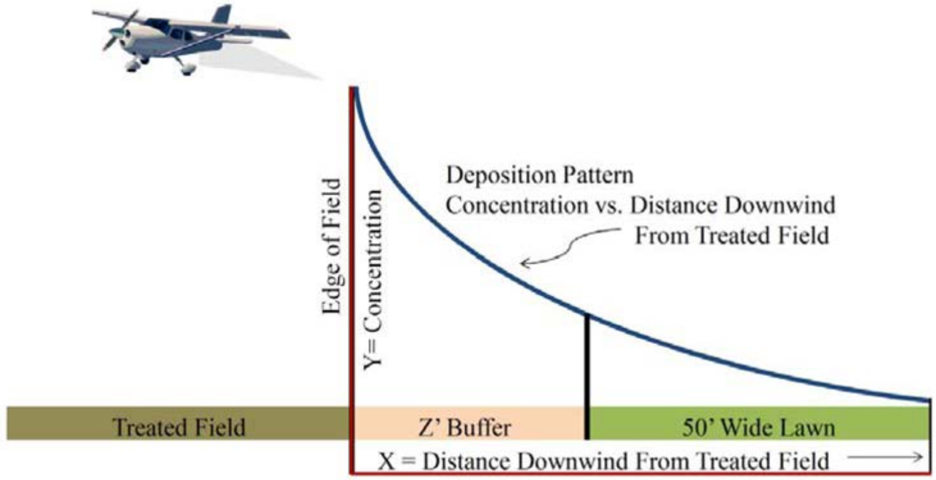
Text Box B.2: Pesticide Spray Drift Risk Assessment to Bystanders

Farm workers and their families often live near the fields where they work, and can be exposed to pesticides in a manner different from other population groups because of this proximity. While direct measures of the degree of drift in the vicinity of fields may be difficult or impossible to obtain, exposure estimates from these residues may be calculated using drift modeling and methods employed for typical residential risk assessments.

Spray drift can be characterized as the movement of aerosols and volatile components away from a treated area as a result of the application process. Bystanders, defined as those who live on, work in or frequent areas adjacent to treated fields, can be exposed to spray drift directly or by contact with resulting deposited residues (e.g., children playing on lawns next to treated fields). The degree of such impacts is governed by many processes (e.g., application method, nozzles used, release height) and the conditions at the time of application (e.g., wind speed and direction).

To model potential high-end exposure to people living near treated agricultural fields (e.g., via deposition on residential turf), the EPA used AgDRIFT (V2.1.1) and AgDISP (V8.26) to provide deposition values for residential lawns, as a fraction of the application rate, at different distances downwind of a treated field. Analysis of spray drift evaluates risks from pesticides similar to how they are evaluated for use on turf because this scenario represents the highest potential for exposure that can be associated with spray drift and considers different life stages, including children at different developmental stages. Data from pesticide studies that determined turf residue levels and dissipation rates after application are often available, and in the absence of these data, default assumptions can be used. This information is used in conjunction with the standard residential methods to estimate exposure from treated turf, including exposures from all pertinent routes for both adults and children.

Conceptual Model for Spray Drift Modeling (U.S. EPA, 2012c)



For more information, see draft EPA guidances under development on the consideration of spray drift in pesticide risk assessment (White et al., 2013; U.S. EPA 2013b).

3. Can exposure variability be estimated using ambient contaminant concentrations, either measured or modeled? Are data available or can data be modeled at a reasonable spatial scale appropriate for available demographic data?

Ambient concentrations can be used to identify and assess spatial variability in exposure that may contribute to exposure differences between population groups. Two types of ambient concentration information exist: data from ambient air quality monitors, and modeled estimates of ambient concentrations averaged over a period of time. Monitoring data generally offer a more accurate estimate of the level of exposure to a stressor. However, obtaining monitoring data at a level of geospatial resolution that allows for the evaluation of differences may not be feasible for a number of reasons, including these: (1) some environmental stressors may not be routinely monitored (e.g. consumer products); and (2) coverage for routinely monitored stressors is insufficient to provide the level of geospatial resolution required to discern differences as most monitoring data are available only down to the county level. This lack of detail is problematic given that racial, ethnic, and income diversity, as well as differences in ambient concentrations, could vary widely with the level of geospatial resolution. An example of an alternative strategy for evaluating multi-pollutant settings is provided in Text Box B.3.

Modeled data can sometimes serve as a surrogate for monitoring data. Ambient air quality modeling methods have been developed to estimate ambient concentrations of a plume beyond its point of release, based on relevant factors such as meteorology and chemical characteristics (e.g., reactivity and solubility). However, the predictive accuracy of models is not comparable across stressors. Important considerations for using modeled data should include the predictive accuracy of the model for the stressor in question, and the ability to predict ambient concentrations for smaller geospatial units such as census tracts. Data provided at a larger geospatial scale than the census tract may not support assessment of differences in exposure. An analyst may consider the use of screening models to highlight concerns about exposure differences, which can be evaluated in greater detail with more sophisticated models at a later stage.

Text Box B.3: Detroit Multi-Pollutant Pilot Project Incorporating EJ

The EPA conducted a peer-reviewed case study (Fann et al., 2011) to test whether a multi-pollutant, risk-based pollution control strategy represented a viable alternative to a traditional pollutant-by-pollutant approach to air quality. This case study was designed using spatially resolved air quality, population, and baseline health data in the Detroit metropolitan area. The authors performed both within-group and across-group comparisons of exposure and risk. The objective of the case study was to demonstrate how states might design air quality attainment strategies that met multiple goals: (1) attaining a tighter National Ambient Air Quality Standard (NAAQS); (2) maximizing human health benefits of air quality improvements; and (3) achieving a more equitable distribution of air pollution-related risk.

The study characterized the costs, benefits and risk inequality implications of two alternative emission control scenarios constructed by Wesson et al. (2010) for the Detroit metropolitan area: a more traditional approach to pollution reduction for NAAQS compliance, and achieving compliance using a multi-pollutant strategy that maximized population risk reduction in the area. The assessment for potential EJ concerns followed four basic steps: (1) identify and model exposure to population groups susceptible and/or vulnerable to $PM_{2.5}$-related mortality and morbidity impacts in the baseline, based on fine scale air quality modeling and population characteristics including education attainment, race and poverty level; (2) design an emission control strategy that maximized air quality improvements among these population groups, primarily by reducing emissions of directly-emitted $PM_{2.5}$, which exhibits a strong spatial gradient; (3) compare the multi-pollutant, risk-based strategy with the traditional pollution control strategy for attainment by modeling the air quality impacts of each strategy and comparing the results with the baseline scenario; and (4) calculate the change in exposure/risk inequality from the baseline using economic measures to assess whether a multi-pollutant risk-based strategy results in a more equal distribution of exposure and risk than a traditional pollution control strategy. The findings from this study revealed that the population risk reduction approach produced greater net benefits.

Risk-Based, Multi-Pollutant Modeling Framework (Fann et al., 2011)

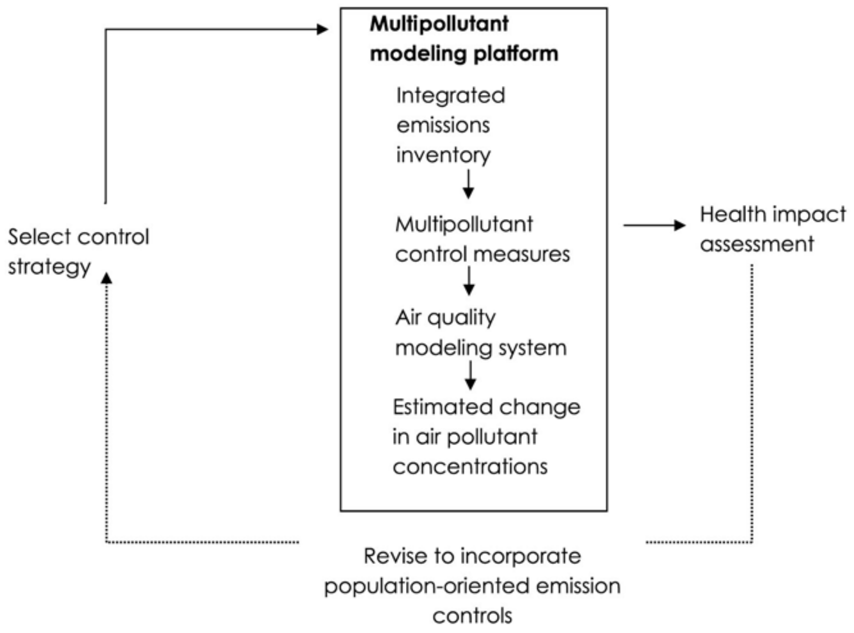


Fig. 1. Risk-based, multipollutant modeling framework.

Additional information about the Detroit multi-stressor project can be found at http://www3.epa.gov/scram001/modelingapps_mp.htm.

4. Are bio-monitoring data available for the population groups of concern, including those with potentially elevated exposures?

Although analysis using bio-monitoring data can be time consuming, it may be the most accurate way to estimate exposures for population groups of concern. A literature search for previous assessments of differential exposure using survey data should be conducted prior to beginning such an analysis. An important resource to consider is the National Report on Human Exposure to Environmental Chemicals generated by the United States Centers for Disease Control and Prevention (CDC, 2009). Human exposure data in this report are presented by life stage, race/ethnicity and income to the extent that such detailed breakouts are possible.

When using exposure biomarkers to draw inferences about exposure differences for a source-specific regulatory action, an analyst should carefully consider the extent to which measured levels reflect exposure, and also whether biomarkers represent total exposure to an environmental stressor from multiple sources. Comparisons at this stage are often focused on point estimates or, at most, deterministic models rather than complex probabilistic models. An analyst may use simple, well-established comparative methods such as ratios to examine between-population group comparisons, or may apply more complex approaches such as analysis of variance or regression techniques as needed. Comparisons may focus on particular segments of the distribution or on the percent of a population group represented within a percentile group. Sometimes, several years of data may need to be combined to obtain sufficient sample size to conduct analysis in the tail of the distribution, though this would be subject to possible resource, analytic, and data constraints.

As discussed in Section 5.3.2 of this document, use of biomonitoring data has both benefits and limitations. While a large population survey (e.g., National Health and Nutrition Examination Survey or NHANES) may suggest the existence of exposure difference, locale- or site-specific surveys (e.g., NYCHANES) can yield more detailed insights into the dimensions of the differences. For example, analysis of NHANES data from 1999-2004 demonstrated that total organic blood mercury levels among New Yorkers was on average three times higher than the U.S. population, and highest among Asian New Yorkers. The NYCHANES data provided the additional perspective that among Asians, the levels were highest among foreign-born Chinese New Yorkers (Kass, 2009).[62]

5. Are there population groups that may experience greater exposure to stressors because of their unique food consumption patterns, behaviors or use of certain cosmetics?

When planning for an assessment of potential EJ concerns, an analyst can consider whether the population group of concern has higher levels of exposure to a stressor due to food consumption patterns that differ from those of the general population (e.g., unique ethnic diets or subsistence living), behaviors (e.g., pica), or through use of imported cosmetics (e.g. dyes used for kumkum and bindi body art). Understanding potential exposures from these types of sources will allow more accurate estimates of exposures to the stressor of concern. Differences in exposures from ingestion may be due to several factors, including regional variation in dietary habits, and cultural, ethnic or religious practices. A population group of concern may consume certain foods at higher rates than members of other groups or consume parts of animals or plants not commonly consumed by the general population. For example, children in tribal communities may consume as much as fifteen times more fish than children in the general population (U.S. EPA, 2011e). Additionally, some population groups may eat food predominantly from specific locations. Likewise, subsistence fishers may consume fish far more frequently and obtain it only from local waterways. If fish from these waterways have higher levels of a contaminant, subsistence fishers may have higher exposure levels both due to their increased consumption of fish and their dependence on particular water sources (U.S. EPA, 2011e). Similar to foods, some cosmetics may contain lead. An analyst can evaluate the exposure pathway (e.g. dermal or inhalation), frequency of use, and identify the populations most likely to use these products in unique ways (Burger and Gochfield, 2011).

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[62] Combining inferences from different surveys should be done with a clear and cautious understanding of the key attributes of each survey, including its design, the intended use of the data, how this intended use may bias the sample, statistical characteristics of each survey, and use of validated laboratory methods, among other considerations.

Planning For an Effects Assessment

As noted in Section 7.2.2, Effects Assessment includes hazard identification and dose-response assessment. Planning, scoping, and problem formulation for the effects assessment of HHRA presents another opportunity to incorporate potential EJ concerns into a risk assessment. Planning, scoping, and problem formulation play key roles in identifying potential population groups of concern that may exhibit particular sensitivity to a stressor. This is also the point at which the analyst can consider how demographic characteristics might modify effects seen in the general U.S. population. The analyst can consider whether factors particular to a population may alter the dose-response relationships of the contaminants in question. For example, stress level is a recognized effect-modifier that may alter the dose-response curve for lead.

Below are a few key questions and sample responses that highlight the types and scale of analytic work that may be required to adequately integrate potential EJ concerns into effects assessment.

Questions and Key Considerations

1. What demographic and population groups are most relevant from a risk perspective for the stressor in question?

The purpose of asking this question is two-fold: (1) defining the susceptible and/or vulnerable population groups and (2) considering what dose-response or concentration-response information is available for those population groups. The goal should be to achieve as close a match as possible between the information available in the literature and the characteristics of the population (i.e., care should be taken not to fit a dose-response function to a population group to which it does not apply). To answer this question, the analyst may need to consider stratification by race/ethnicity and income, or factors such as educational level, access to health care, and baseline disease prevalence.

2. Are there population-specific effect assessments for minority populations, low-income populations, or indigenous peoples?

In answering this question, an analyst can investigate these factors:

- Are there known or identified effect modifiers?
- For identified factors that modify hazards of interest, how are they distributed among minority populations, low-income populations, or indigenous peoples?
- Are effect modifiers distributed differently among various life stages within population groups?

To answer these questions, a review of relevant literature is necessary to identify potential sources of population group-specific dose-response information or data on effect modifiers (see Text Box B.4).

3. Are the spatial and temporal scales of the study or studies supplying the dose-response function consistent with the spatial scale of the assessment of potential EJ concerns, from both an exposure and outcome perspective?

Ideally, the dose-response functions chosen should match as closely as possible the geographic scale of the proposed analysis for potential EJ concerns. An analyst may introduce measurement errors if dose-response functions from studies conducted over smaller geographic areas are applied at a more aggregate scale to evaluate potential EJ concerns. For example, if the study assigned each subject in the cohort a county-level average, the study could underestimate the true relationship between exposure and outcome for an analysis of potential EJ concerns at a finer spatial scale. Likewise, if the exposure in the study is acute, it cannot be applied directly to an analysis for potential EJ concerns where the exposure of interest is chronic; rather, the exposure duration being modeled in the regulatory analysis should be considered.

Analysts may consider adjusting the geographic scale of an analysis for potential EJ concerns for this reason, and also may need to change the scope if detailed data on factors such as baseline health are available only at a certain scales (e.g., at the local urban level or at the acute exposure level).

Text Box B.4: Concentration-Response Functions Stratified by Demographic Factors

The literature on particulate matter (PM) provides examples of concentration-response functions stratified by demographic factors that may be indicative of socioeconomic status. In particular, the proposed PM NAAQS (U.S. EPA, 2012b) includes a distributional analysis of the estimated relative risk of $PM_{2.5}$-related mortality modified by race and educational attainment for counties projected to exceed baseline and rolled-back $PM_{2.5}$ standards. This analysis uses dose-response functions stratified by educational level from Krewski et al. (2009). Although dose-response functions modified by race were not available, the analysis relied on county-level baseline mortality rates stratified by race with the non- race-specific functions.

Similarly, Fann et al. (2011) incorporates educational attainment-specific dose-response functions from Krewski et al. (2009), noting that: “Krewski et al. find that educational attainment is inversely related to all-cause PM mortality risk, noting that ‘[a]lthough the reasons for this finding are unknown . . . level of education attainment may likely indicate the effects of complex and multifactorial socioeconomic processes on mortality or may reflect disproportionate pollution exposures” (Fann et al., 2011, pp. 912).

Appendix C: Examples of Analyses of Potential EJ Concerns from Regulatory Actions

This appendix presents summary information about data sources and methods used to assess potential EJ concerns in recent EPA regulatory actions.

Example C.1. Lead Renovation, Repair, and Painting Program Rule (U.S. EPA, 2008b,c)

Under the Toxic Substances Control Act, the Lead Renovation, Repair, and Painting Program rule requires that firms performing renovation, repair, and painting projects that disturb lead-based paint in homes, child care facilities and pre-schools built before 1978 have their firm certified by the EPA (or an EPA authorized state), use certified renovators who are trained by EPA-approved training providers and follow lead-safe work practices.

Summary of Potential EJ Concerns of the Regulatory Action

Through the 1940s, paint manufacturers used lead as a primary ingredient in many oil-based interior and exterior house paints. Lead paint remains in some older homes, and, particularly during or after renovation, can pose human health hazards through exposure by inhalation or ingestion. Lead causes neurotoxic effects in children and cardiovascular effects in adults. Renovation, repair, and painting activities that disturb lead-based paint create hazards. The Lead Renovation, Repair, and Painting Program rule reduces lead exposure to individuals living in renovated units and their neighbors by containing lead contamination from renovation activities and reducing the amount remaining after renovation is completed.

Because renters usually have no influence in selecting renovation contractors or renovation work practices, and because renovations often take place between tenancies, renters may experience the most benefit from the rule. The EPA qualitatively assessed how the rule could impact minority or low-income households, including relative changes in risks and benefits accrued. The EPA also used Census data to identify individuals living below the federal poverty level, as well as Blacks and Asians, are more likely to live in rental housing compared to other households.

Qualitative Discussion of Relative Changes in Risk to Low-income and Minority Populations

Approach: The analysis presented a qualitative discussion of how minority individuals or individuals in poverty could be affected by the rule. The discussion considered a range of scenarios, including behavior changes by landlords to avoid regulation.

Results: The analysis qualitatively assessed that disadvantaged groups would experience no new risks from the rulemaking, and would likely experience human health benefits. For example, see the excerpt below:

> "Because these disadvantaged groups [racial minorities and low-income households] are more likely to reside in rental and older housing, they are more likely to be affected under the options that emphasize regulating older and/or rental housing. In addition, individuals and children with food insecurity (i.e., those who do not have healthy diets or do not eat enough because of poverty) are more susceptible to ill health effects from lead dust. Thus, they stand to accrue greater benefits under all of the options considered.
>
> Following the work practice, cleaning, and cleaning verification steps specified in the rule will increase the costs for renovation, repair and painting activities covered by the rule. These additional costs may lead some lower income homeowners or some landlords of properties in lower income neighborhoods to avoid using certified renovators or recommended practices. The incremental costs of the rule's work practices are

typically below $200. These costs are likely to be a small part of the total cost of the renovation, repair, and painting projects. EPA believes that these costs are unlikely to result in significant changes in consumer behavior. If however, the increased costs result in more projects being undertaken by uncertified firms or by do-it-yourselfers, the risks in these instances would be the same as in the baseline and would not constitute new risks resulting from the rule. EPA believes that the rule would result in new risks only if the increased costs caused individuals to delay work such as painting until lead-based paint began peeling and chipping, creating a lead hazard. This is expected to occur infrequently given the rule's low cost per event."

Demographic Analysis of Individuals Living Below the Federal Poverty Level and Minority Populations Potentially Affected by the Rule

Approach: This analysis used Census data to identify individuals living below the poverty threshold in owner-occupied housing compared to individuals living in renter-occupied housing for a range of housing age cohorts. The analysis considered housing built prior to 2000, prior to 1980, prior to 1960, and prior to 1950. Separately, the analysis also compared the rate of home ownership and renter status among Whites, Blacks, and Asians. The EPA also conducted a similar analysis to examine the distribution of potentially affected children in four types of non-parental care arrangements (i.e., relative, non-relative, day care center, and no weekly non-parental care arrangement) for children from families below and above the poverty threshold and by race. The main data source on child-occupied facilities is from a statistical report by the National Center for Education Statistics.

Results: The EPA found that these groups may experience relatively greater benefits from the rule. Individuals living below the federal poverty level were much more likely to be renters than homeowners, based on 2000 Census data. Additionally, for each age of housing considered, renters were more likely to fall below the federal poverty level than owner-occupants. The analysis compared these groups in Table C.1 below.

Table C1. Number and Percentage of Householders Below Poverty by Year Housing Built, by Tenure

	Owner Occupied Housing		Renter Occupied Housing	
Year Housing Built	Total Below Poverty	Percentage Below Poverty Out of All Pre-2000 Owner Housing	Total Below Poverty	Percentage Below Poverty Out of All Pre-2000 Rental Housing
Pre-2000	4,371,712	6.26%	8,086,254	22.67%
Pre-1980	3,133,302	4.49%	6,059,817	16.99%
Pre-1960	1,765,185	2.53%	3,100,214	8.69%
Pre-1950	1,167,604	1.67%	2,093,142	5.87%

Source: Table 8-49 in U.S. EPA (2008c)

The EPA used Census data to show that Blacks and Asians resided in rental housing at a higher rate than Whites, suggesting that a rule impacting rental housing units would confer proportionally greater benefits to these population groups of concern. Table C2 below presented the statistics used.

Table C2. Number and Percentage of Householders by Race, by Tenure in 2000

Race	Total	Percentage Owner	Percentage Renter
White Alone	83,715,168	71.27%	28.73%
Black/African American Alone	11,977,309	46.33%	53.67%
Asian Alone	3,117,356	53.24%	46.76%

Source: Table 8-50 in U.S. EPA (2008c)

The information on child-occupied facilities demonstrates that children under the age of six from families under the poverty threshold are more likely to be cared for by a relative compared to those from families above the poverty threshold. This is also the case for Black, non-Hispanic and Hispanic children compared to White, non-Hispanic children. Hispanic children are also more likely to receive no child care on a weekly basis from anyone other than their parents compared to children from other races and ethnicities. It is difficult to judge how the rule will impact lower income and minority children, however, because some of these childcare arrangements may not qualify as child occupied facilities under the rule. In addition, there is no information on whether child care is occurring in pre-1978 buildings or whether lead-based paint is present in the facility. The data also exclude children attending kindergarten. Thus, based on the information available it is unclear which children are likely to benefit from the requirements of the rule.

Example C.2. Greenhouse Gas (GHG) Emission Standards for Medium-Heavy Duty Trucks (U.S. EPA, 2011j)

This national program sets GHG emissions and fuel efficiency standards for medium-heavy duty trucks. The standards will begin with model year 2017 with final standards met by 2025. The program is expected to decrease GHG emissions by about one billion metric tons and also significantly decrease emissions of criteria pollutants, including carbon monoxide, fine particulate matter, and sulfur dioxide. The program will decrease ozone levels by decreasing hydrocarbons and nitrogen oxides, precursors to ozone formation. The EPA assessed the potential EJ impacts of reductions in emissions for both GHG and criteria pollutants.

Summary of Potential EJ Concerns of the Regulatory Action

GHG emissions contribute to the broad impacts of climate change, which can include localized effects of heat and severe weather events, as well as broader impacts on infrastructure and production that can affect prices of goods and services throughout the economy. Exposure to non-GHG co-pollutants such as ozone, PM2.5 and toxics is associated with a range of adverse health effects. The EPA reviewed the literature on the relationship between emissions related to this rule (i.e., GHG and non-GHG emissions) and sensitive sub-populations. With regard to non-GHG emissions, the literature indicates that those living near highways and areas with greater traffic density are more likely to be affected by emissions of non-GHG co-pollutants through higher rates of various health effects, such as cardiovascular disease. The EPA found that the rule would provide benefits to those populations living near highways and areas with high traffic density.

Literature Review on Impacts from Greenhouse Gas-Induced Climate Change

Approach: The EPA conducted a review of the scientific assessment literature on climate change to identify potential EJ implications of GHG emission standards. The EPA summarized the qualitative conclusions from the assessment literature about the relationship between sensitive populations and GHG-induced climate change.

Results: The literature indicated that vulnerable populations are more likely to experience adverse impacts from GHG-induced climate change (see the regulatory impact analysis for specific references). Excerpts from this review include the following:

> "Within settlements experiencing climate change, certain parts of the population may be especially vulnerable; these include the poor, the elderly, those already in poor health, the disabled, those living alone, and/or indigenous populations dependent on one or a few resources. In addition, the U.S. Climate Change Science Program stated as one of its conclusions: 'The United States is certainly capable of adapting to the collective impacts of climate change. However, there will still be certain individuals and locations where the adaptive capacity is less and these individuals and their communities will be disproportionally impacted by climate change."

Literature Review on Non-Greenhouse Gas Impacts

Approach: For criteria pollutants, the EPA concluded that it was not practicable to conduct a quantitative analysis of non-GHG impacts on minority and/or low income populations. Instead, similar to the GHG impacts, the EPA summarized relevant literature that qualitatively documents the links between of the effects of non-GHG impacts in the context of traffic-related air pollution and populations of concern.

Results: Studies have documented that populations near major roads experience greater risk of certain adverse health effects from non-GHG pollutants, including all-cause and cardiovascular mortality, cardiovascular effects such as heart rhythm changes, heart attacks, and cardiovascular disease, and respiratory effects such as childhood asthma onset or exacerbation and pulmonary function deficits (see the RIA for references). The EPA considered the literature documenting these impacts and the types of populations affected. For example, see the excerpt below:

> "There is a large population in the United States living in close proximity of major roads. According to the Census Bureau's American Housing Survey for 2007, approximately 20 million residences in the United States, 15.6 percent of all homes, are located within 300 feet (91 meters) of a highway with 4+ lanes, a railroad, or an airport. Therefore, at current population of approximately 309 million, assuming that

population and housing are similarly distributed, there are over 48 million people in the United States living near such sources. The HEI [Health Effects Institute] report also notes that in two North American cities, Los Angeles and Toronto, over 40 percent of each city's population live within 500 meters of a highway or 100 meters of a major road. It also notes that about 33 percent of each city's population resides within 50 meters of major roads. Together, the evidence suggests that a large U.S. population lives in areas with elevated traffic-related air pollution. People living near [major] roads are often socioeconomically disadvantaged. According to the 2007 American Housing Survey, a renter-occupied property is over twice as likely as an owner-occupied property to be located near a highway with 4+ lanes, railroad or airport. In the same survey, the median household income of rental housing occupants was less than half that of owner-occupants ($28,921/$59,886). Numerous studies in individual urban areas report higher levels of traffic-related air pollutants in areas with high minority or poor populations."

"Students may also be exposed in situations where schools are located near major roads. In a study of nine metropolitan areas across the United States, Appatova et al. (2008) found that on average greater than 33 percent of schools were located within 400 meters of an Interstate, U.S., or state highway, while 12 percent were located within 100 meters. The study also found that among the metropolitan areas studied, schools in the Eastern United States were more often sited near major roadways than schools in the Western United States. Demographic studies of students in schools near major roadways suggest that this population is more likely than the general student population to be of non-white race or Hispanic ethnicity, and more often live in low socioeconomic status locations. There is some inconsistency in the evidence, which may be due to different local development patterns and measures of traffic and geographic scale used in the studies."

Example C.3. National Pollutant Discharge Elimination System (NPDES) Concentrated Animal Feeding Operation (CAFO) Reporting Rule (U.S. EPA, 2011i)

The proposed CAFO Reporting Rule presented two options for the EPA to obtain facility information from CAFOs to support implementation of the NPDES program and to ensure that CAFOs are complying with Clean Water Act requirements. Under the proposed rule, the EPA would require CAFOs to respond to information requests published in the Federal Register, unless a state provides the information on behalf of a CAFO. The EPA later withdrew the proposed rule.

Summary of Potential EJ Concerns of the Regulatory Action

Manure, litter, and process wastewater from CAFOs contains nutrients, pathogens, heavy metals, and smaller amounts of other elements and pharmaceuticals. Discharges of these wastes can impact water quality. The information collected under this rule would benefit minority and low-income populations by providing easier access to information on nearby CAFOs with potential effects on neighboring communities. To plan for rulemaking outreach to EJ communities, the EPA used a geo-spatial analysis to identify areas with high densities of populations of concern that also contained large livestock operations.

Spatial Analysis to Identify Co-Location of CAFOs and EJ Communities

Approach: The EPA used spatial analysis to identify areas of the United States with high densities of CAFOs and populations of concern. This approach used USDA data on large livestock operations to identify the concentration of CAFOs by county, overlaid with Census data for rural Census tracts on the densities of minority populations and populations reporting income below the Census-defined poverty level. To align public Census of Agriculture data with the EPA's NPDES CAFO thresholds for large operations, the EPA used a custom USDA data tabulation for this analysis. Based on field experience, the EPA also assumed that large livestock operations generally served as a reasonable proxy for CAFOs. The beef sector is one exception, and the EPA used the Census of Agriculture category of "cattle on feed" rather than "beef cows" generally. The combined map visually revealed geographic regions in the U.S. with high densities of CAFOs and minorities and individuals below the poverty level.

Results: The EPA identified four geographical regions where the Agency planned to target its rulemaking outreach (illustrated in Figure C1 below). These rural areas have both high densities of CAFOs and high densities of minorities and individuals living below the poverty level, as shown in the map below. As stated earlier, the EPA ultimately withdrew this proposed rule.

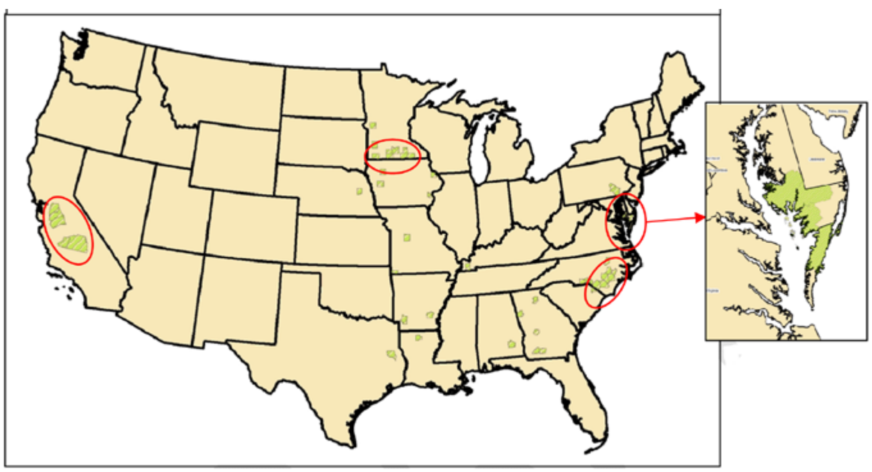

Figure C1. Overlaps of Rural Counties with High Densities of CAFOs and Populations of Concern

Source: Figure 3 in U.S. EPA (2011i)

Example C.4. Mercury and Air Toxics Standards (MATS) (U.S. EPA, 2011f)

MATS will reduce emissions of mercury, arsenic, chromium, lead (and other toxic metals), and acid gases (such as hydrochloric acid) from both new and existing coal and oil-fired electric utility steam generating units (EGUs) and, as a co-benefit, will reduce the emissions of criteria pollutants such as (SO_2) and fine particulate matter ($PM_{2.5}$). Additionally, the rule updates the new source performance standards for new fossil-fuel-fired EGUs. The rule requires affected EGUs to update their Title V operating permits to reflect new requirements, a process that involves formal public review. Once mercury emitted into the air reaches water, microorganisms can change it into methylmercury, a highly toxic form that builds up in fish. In its regulatory impact analysis, the EPA examined the effects of freshwater fish consumption by recreational fishers on IQ loss. The EPA also examined potential EJ concerns by focusing on some high-risk populations known to have higher than average freshwater fish consumption levels.

Summary of Potential EJ Concerns of the Regulatory Action

Mercury: Mercury is a metal that causes a number of neurodevelopmental problems, when ingested as methylmercury. Children are especially vulnerable to mercury exposure, and exposure in utero or at young ages can lead to permanent impacts such as lowered IQ and behavioral issues. Exposure to mercury (as methylmercury) occurs primarily through consumption of fish. Subsistence fishers, who are likely to be low-income and from minority populations (including, for example, African American, Southeast Asian, and some Native American communities), consume self-caught freshwater fish at much higher rates than the national average. By reducing mercury emissions, MATS will reduce mercury exposures by decreasing mercury concentrations in fish. The EPA assessed the effects of the rule on population groups through a single exposure pathway – fish consumption. The EPA used a literature-supported demographic analysis to identify populations that are located near water bodies with mercury concentration data, and likely to have higher-than- average exposure to mercury in fish.

Non-Mercury Air Toxics Emissions: Exposure to air toxics other than mercury (e.g., arsenic and chromium) is associated with a range of health effects (e.g., cancer, respiratory effects, reproductive effects, nervous system effects) and communities near EGUs may receive higher levels of exposure to air toxic releases. The EPA used a proximity analysis to identify and describe populations living near EGUs.

PM2.5 Formation: In addition to reducing air toxics emissions, MATS is expected to reduce emissions (as a co-benefit), of $PM_{2.5}$ and SO_2 (a precursor to $PM_{2.5}$). To assess the impacts of lower exposure to $PM_{2.5}$ concentrations, the EPA modeled changes in emissions and exposure to characterize spatial and demographic distributions of changes in health effects from the rule.

Literature Review and Demographic Analysis to Examine Mercury Exposure:

Approach: In the core analysis of the benefits of reduced mercury emissions from MATS, the EPA estimated the changes in mercury exposure among pregnant women based on recreational fish consumption using national-average rates. In addition, the EPA specifically estimated the impact of MATS on populations with higher-than-average daily fish consumption by estimating baseline and projected changes in IQ loss resulting from methylmercury exposures in populations with subsistence fishers.

To identify these high-risk populations, the EPA conducted a literature review to identify population groups most likely to fall into the high risk category for mercury exposure based on higher-than-average daily fish consumption. The review identified six high-risk population groups, including African-American and White low-income recreational and subsistence fishers in the Southeast, female low-income recreational and subsistence fishers, Hispanic and Laotian subsistence fishers, and Chippewa/Ojibwe Tribe members in the Great Lakes area.

To assess the impacts of changes in mercury exposure to these populations under the MATS rule, the EPA used the same general analytical approach taken in the nationwide analysis of recreational fishers, which based exposure scenarios on populations in proximity to freshwater resources with mercury fish tissue estimates. However, the analysis of high-risk populations used a smaller distance radius (20 miles) for fish caught, reflecting the lower mobility of subsistence fishers, and used county-level growth projections to estimate the number of individuals in each population group at highest risk for mercury exposure in 2016 with and without the rule. When growth projections were not available for a specific subgroup, the EPA used the closest available estimate (i.e., growth rates for all Asian-Americans were used for the Laotian subsistence fisher population).

For the analysis of high-risk populations, the EPA estimated the distribution of risk for the entire subpopulation nationwide and estimated the mean, median, 90th, and 95th percentile distributions of fish consumption. The EPA also estimated national subpopulations for each group of subsistence fishers based on the populations in census tracts with at least 25 members of a given high-risk group. The EPA did not monetize the ranges of estimated avoided IQ losses in these six subpopulations.

Results:

The analysis presents information about the distribution of the demographics in a series of maps. Figure C2 shows the forecasted growth in African-American populations below the poverty level in the baseline (i.e., absent the rule); the RIA also displays similar maps for each of the other five high-risk groups.

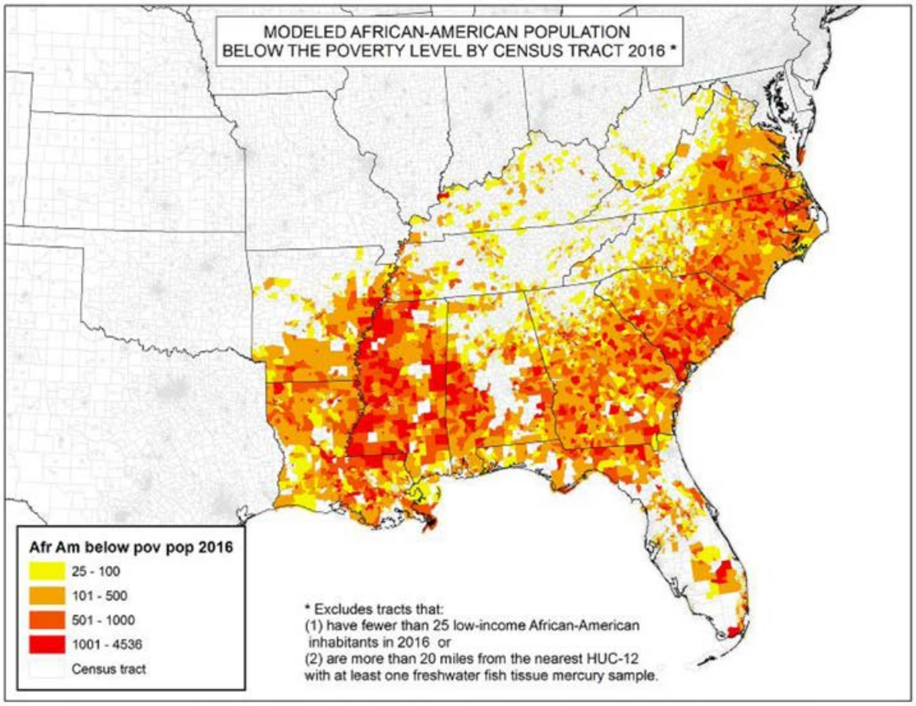

Figure C2. Forecasted Population Growth for African-American Populations below the Poverty Level by Census Tract in 2016

Source: Figure 5-6 in U.S. EPA (2011f)

Proximity Analysis to Examine Impacts from Non-Mercury Air Toxics Emission Reductions

Approach: In addition to the analysis conducted to examine impacts of the rule from mercury exposure, the EPA used a proximity-based approach to compare the aggregate average demographic composition (i.e., by ethnicity/race, age, and education) of Census blocks within a five kilometer radius of specific EGUs covered by the rule to the national average. This approach is used as a proxy for exposure to hazardous air pollutants such as nickel and chromium, for which the health effects are expected to be localized.

Results: The proximity analysis found that the percent of the population around EGUs that were minorities was 12 points higher than the national average. (37 percent vs. 25 percent).The population of African Americans and the population living below the poverty line were also slightly higher surrounding EGUs. The EPA did not estimate specific changes in exposure to these populations resulting from the rule.

Risk Modeling to Examine Impacts from Reduced formation of $PM_{2.5}$

The EPA characterizes the distribution of mortality risk associated with $PM_{2.5}$ in the baseline and after implementation of the final rule. Proximity-based analysis is not a good proxy in this case because criteria air pollutants often travel long distances from sources, and because the formation of $PM_{2.5}$ is governed by a series of complex reactions in the atmosphere. Using methods generally consistent with those used in other parts of the regulatory analysis, mortality risk associated with $PM_{2.5}$ in the baseline is examined across population groups by county. There are two differences in methodology between the EJ analysis and the benefits analysis for the rule. First, the baseline mortality rates differ from what is used in the regulatory analysis in order to stratify by race. Second, mortality risk coefficients differ to allow for variation by education level (instead of applying the same risk coefficient across all socioeconomic groups).

There are a variety of ways to define a comparison group. For the final MATS Rule, analysts examined mortality risk associated with fine particulate matter by race, income, and poverty level for people living in high risk counties (i.e., in the top five percent). The comparison group was defined as people living in counties not facing a high mortality risk.

Results: Using a photochemical grid air quality model and BenMAP (a GIS-based tool that estimates health impacts based on air pollution concentrations), the EPA estimates changes in mortality risk in the baseline and after implementation of the final rule for individuals living in counties with the highest $PM_{2.5}$ mortality risk in 2005 (defined as the top five percent), stratified by race, income, and educational attainment. Finally, the analysis compares the change in risk for people living in high risk counties to that for people living in other counties. An example of a table used to present this information is included as Table C3. It shows the estimated change in the percentage of all deaths attributable to $PM_{2.5}$ with and without implementation of MATS in 2016 for each population, by race. The EPA concluded that populations that are living in high risk counties experience reductions in mortality risk that are at least as great as for those populations living in other counties, and this occurred regardless of race.

Table C3. Estimated Change in the Percentage of All Deaths Attributable to $PM_{2.5}$ Before and After Implementation of MATS by 2016 for Each Populations, Stratified by Race

Year	Race			
	Asian	Black	Native American	White
Among populations at greater risk				
2016 (pre-MATS rule)	4.3%	4.4%	4.4%	4.5%
2016 (post-MATS rule)	4.1%	4.1%	4.2	4.3%
Among all other populations				
2016 (pre-MATS rule)	3.2%	3.1%	3.1%	3.3%
2016 (post-MATS rule)	3.0%	2.9%	2.9%	3.1%

Source: Table 7-17 in U.S. EPA (2011f)

Example C.5. Formaldehyde Standards for Composite Wood Products Implementing Regulations Proposed Rule (U.S. EPA, 2013c)

The Formaldehyde Emissions Standards for Composite Wood Products rule proposes requirements under the Toxic Substances Control Act to implement formaldehyde emissions standards for hardwood plywood, medium-density fiberboard, and particleboard sold, supplied, offered for sale, imported to, or manufactured in the United Sates. The proposed requirements include provisions for testing, product labeling, recordkeeping, third-party certification, and product inventory.

Summary of Potential EJ Concerns of the Regulatory Action

Formaldehyde, a hazardous air pollutant, is found in resins used in the manufacture of composite wood products. Other indoor sources include household products (e.g., glues, carpets, cosmetics) and combustion processes (e.g., cigarette smoke, kerosene space heaters). Formaldehyde can cause sensory irritation and contribute to certain cancers (e.g., nasopharyngeal cancer). In children, formaldehyde is associated with changes in pulmonary function and increased risk of asthma. The EPA assessed the benefits of the proposed rule by population group to describe the relative impacts of the proposed rule for indigenous peoples and race/ethnic groups, as well as for low-income populations.

Quantitative Exposure Analysis to Estimate Health Effects for Specific Populations

Approach: The Economic Analysis for the proposed rule estimated and monetized the health benefits from reduced cases of nasopharyngeal cancer and sensory irritation, endpoints for which sufficient information exists to estimate monetary benefits. The main analysis modeled scenarios varying by climate zone, housing type, and age and employment status to assess exposure to emissions from composite wood products. The exposure scenarios broadly considered emissions from new home construction and major renovations, as well as temperature, humidity, and time spent inside the home. The analysis disaggregated the health impacts for minority populations and tribal populations, as well as for low-income populations (i.e., those living below Census poverty levels). The EPA used toxicological concentration-response (C-R) functions derived from the literature to estimate changes in cancer and non-cancer risks from reduced emissions. Demographic data from the American Community Survey and American Housing Survey allowed the EPA to estimate the number of cancer and non-cancer cases avoided by population group. Benefits for nasopharyngeal cancer and sensory irritation were monetized using standard valuation models (e.g., value of mortality risk, cost-of-illness). All of the quantified cases were monetized. The other avoided cancer and non-cancer effects were not quantified, due to the lack of C-R functions.

Results: The proposed emissions standards would reduce health impacts for all affected populations, with individual benefits varying by population and income group. Minority populations (including indigenous peoples) and low-income populations accrued more benefits relative to other groups. The analysis estimated that minorities represent about 35 percent of the affected population and accrue about 39 percent of the total quantified benefits. Low-income individuals compose 12 percent of the total affected population and accrue an estimated 14 percent of the total quantified benefits. Total quantified benefits for the proposed rule were $20 million to $48 million per year using a three percent discount rate and $9 million to $23 million per year using a seven percent discount rate. Table C4 represents the distribution of the benefits for the proposed rule.

Table C4. Comparison of Relative Benefits Accrued to Populations of Concern

Population Type	Share of Total Population	Share of Total Quantified Benefits
Race and Ethnicity		
Non-Hispanic White	65%	61%
Non-Hispanic Black	12%	13%
Non-Hispanic Other	7%	8%
Hispanic	15%	18%
Non-Hispanic Native American or Alaskan Indian	0.6%	0.6%
All Individuals	**100%**	**100%**
Income		
Individuals Living Below Poverty Line	12%	14%
Individuals Living Above Poverty Line	87%	85%
All Individuals	**100%**	**100%**

Source: Table ES-15 in U.S. EPA (2013c)

Example C.6. National Pollutant Discharge Elimination System – Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities; Final Rule (U.S. EPA, 2014e, f)

The Cooling Water Intake Rule, also referred to as 316(b), reduces impingement and entrainment of fish and other aquatic organisms at cooling water structures used by certain electric power generating and manufacturing facilities regulated under the Clean Water Act. The rule sets limits for the location, design, construction and capacity of these facilities through the National Pollutant Discharge Elimination System permit system. During the process of withdrawing water to provide cooling at these facilities billions of organisms are removed and killed. These species include fish and larvae, sea turtles and other aquatic life that are either impinged (i.e., pressed against water intake screens) or entrained (i.e., drawn into the water intake system). The loss of these species adversely affects the ecosystem, including the food web, nutrient cycles, biodiversity, and aquatic life. This rule establishes best technology available (BTA) requirements that will reduce losses from impingement and entrainment.

Summary of Potential EJ Concerns of the Regulatory Action

The water withdrawn from water bodies to cool electric power generating and manufacturing facilities can adversely impact the ecosystem in affected water bodies. These adverse impacts can include reductions in recreation and commercial fishing opportunities, wildlife viewing and other "non-use benefits" (i.e., benefits that accrue to those who do not directly use the resources). Minority and low-income communities are often located in close proximity to these facilities, and therefore are at greater risk from these adverse impacts.

Analysis of Potential EJ Concerns

Approach: In order to examine potential EJ concerns from this rule, the EPA examined the distribution of the benefits of this final rule across different population groups. Most of the facilities affected by the rule are located in the eastern United States. The EPA specifically examined (1) individuals living within a 50-mile radius of affected facilities and (2) any additional anglers living outside the 50-mile radius but within 50 miles of the river segments, or reaches, nearest to facilities. Individuals living in proximity to facilities and anglers located further away are more likely to use the affected water bodies for recreational fishing or wildlife viewing, for example, and therefore would be affected by the rule.

The EPA used 2010 Census data and the Fish Consumption Module (U.S. EPA, 2014f) to collect information on the socioeconomic characteristics of individuals and anglers within the two groups listed above and then compared these characteristics to statewide averages. This information was combined with 2010 census data to examine the socioeconomic characteristics of affected populations. Specifically, the EPA examined the percent of the population with an annual household income of less than $25,000 and the percent Hispanic; black or African American; Asian, Native Hawaiian, or Pacific Islander; American Indian; and Alaskan Native.

Results: A total of 47 states have facilities that are impacted by this rule. Within those states, 34 have a lower percentage of low-income individuals residing near facilities compared to the state average. The EPA indicates that this could imply low-income individuals receive fewer benefits from this rule than higher-income people, however, the differences tend to be small and not statistically significant.

With respect to minority populations, the EPA finds that there are a greater percentage of minority populations living in proximity to affected facilities compared to the state averages. On average, the percent of the population residing near affected facilities that is minority exceeds state averages by 1.34 percent. However, again, such a difference is small and not statistically significant. The EPA concludes that low-income and minority populations do not receive a smaller share of the benefits of this rule.

Example C.7. Disposal of Coal Combustion Residuals from Electric Utilities Final Rule (U.S. EPA, 2015g, h)

The Coal Combustion Residuals (CCR) Final Rule requires CCR landfills and surface impoundments to adhere to location restrictions, design and operating criteria, ground water monitoring, closure requirements, and post-closure care to reduce the risk of contaminants leaking into ground water and being emitted into the air as dust, as well as to reduce the risks of catastrophic failure of CCR surface impoundments. The benefits of this rule include reduced cleanup costs and damages from structural failure associated with surface impoundments; reduced ground water contamination and the associated remediation costs and natural resource damages; increased beneficial use of CCR in the future (e.g., reductions in air emissions and avoided energy and water consumption); reduced incidence of cancer due to reductions in consumption of fish contaminated by CCR; mitigated IQ losses from exposure to mercury and lead; improvements in air quality around coal-fired power plants, and more.

Summary of Potential EJ Concerns of the Regulatory Action

Although populations within the water catchment areas of coal-fired power plants with surface impoundments appear to have disproportionately high percentages of minority and low-income residents relative to the nationwide average, populations located within 1 mile of plants with landfills and surface impoundments do not. Because landfills are less likely than impoundments to experience surface water runoff and releases, catchment areas were not considered for landfills. Because the CCR rule is risk-reducing, with reductions in risk occurring largely within surrounding surface water catchment zones around, and within ground water beneath, coal-fired electric utility plants, the EPA concluded that the rule will not result in new disproportionate risks to minority or low-income populations.

Proximity Analysis

Approach: The EPA examined the baseline characteristics of communities living within: (1) 1 mile of existing CCR landfills and impoundments and (2) watershed catchment areas downstream of existing surface impoundments. The 1-mile radius selected for the analysis reflects an assessment of the distance over which possible risks may be experienced by communities in proximity to CCR landfills and impoundments. To capture the relevant population for water catchment areas, the EPA examined the populations that would receive surface water runoff and releases from CCR surface impoundments within 24 hours from a coal-fired power plant under average water flow conditions.

Results: Results show that approximately 16.1 percent of the population living within 1-mile of CCR surface impoundments are minority and 13.2 percent are low-income (i.e., live below the poverty line), compared to an average of 24.8 percent and 11.3 percent for the U.S as a whole. Results also show that approximately 16.6% of the population living within 1-mile of CCR landfills are minority and 8.6% are low-income. The population near the watershed catchment areas is larger than that within 1 mile of facilities and results show slightly higher percentages of minority individuals and low-income individuals in this area. Specifically, 28.7 percent of the population in the catchment areas are minority (compared to 24.8 percent for the U.S. as a whole, and 18.6 percent live below the poverty line compared to 11.3 percent for the U.S. as a whole. See U.S. EPA 2015f, Section 9.7.3 for more information.[63]

While these analyses only examine the baseline distribution of the population and therefore reflect the population experiencing the baseline risk associated with proximity to CCR, the CCR rule reduces risk. The populations living in close proximity will likely benefit from these reductions in risk, including the slightly higher averages of minority populations and low-income populations living near coal-fired power plants and surface impoundments. However, the rule will result in the closure of some surface impoundments. In this case, the risk for those populations will be reduced but the overall distribution as reflected in the above analysis could change.

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[63] U.S. EPA (2015h), Section 8.3 provides a detailed description of the EJ analysis for this rule. However, the tables in this section do not reflect the final analysis, as indicated at the beginning of the section. The information reported here reflects the updated information in the final rule as presented in Section 9.7.3.

Example C.8. Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, Final Rule (U.S. EPA 2015i, j)

The Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category regulatory action sets limits under the Clean Water Act on the levels of toxic metals and other pollutants in wastewater discharged from power plants. Steam electric plants generate steam as a by-product of producing electricity. The steam contains toxic metals and other pollutants that are discharged into surface waters, causing harmful health effects and environmental effects.

Summary of Potential EJ Concerns of the Regulatory Action

The steam discharged from power plants contains toxic metals and pollutants that can cause severe health effects such as cancer and lower IQ in children, as well as environmental impacts such as deformities and reproductive effects in fish and wildlife. Minority and low-income communities are often located in close proximity to these facilities, and therefore are at greater risk from the discharges. In addition, some of these communities consume high amounts of fish caught in affected waterbodies.

Distribution of Benefits among Population Groups in Affected Areas

Approach: The benefit-cost analysis for the Steam Electric final rule estimated and monetized effects, including avoided cardio-vascular disease, IQ loss, and cancer from lead and/or arsenic exposure (U.S. EPA, 2015j). The EPA also estimated the benefits of a number of other impacts such as avoided disposal costs and improved recreation. In the EJ analysis, the EPA examined the characteristics of the population affected by the rule, proximity to affected waters, exposure pathways, cumulative impacts, and susceptibility (e.g., reliance on subsistence fishing for food consumption). The EPA analyzed the potential EJ concerns associated with this rule in two ways: (1) a proximity analysis examining characteristics of the populations living in proximity to waters (also called reaches) affected by steam electric power plant discharges and (2) an analysis of the health effects from consuming fish caught by low-income and minority populations living within 50 miles of affected reaches (sometimes referred to as subsistence anglers or subsistence fishers).

Socioeconomic Characteristics of Populations Residing in Proximity to Steam Electric Generating Plants

Approach: To examine the characteristics of populations most likely to be affected by the final rule, EPA examined the percent of the population living below the poverty line and the percent of the population in different race and ethnic minority groups within one mile, three miles, 15 miles, 30 miles and 50 miles of the reaches receiving discharges from the approximately 1,100 affected units. The EPA examined the characteristics in census block groups compared to state and national averages. The EPA used data from the 2006-2010 Census Bureau's American Community Survey to identify affected populations, as indicated in Table C5 below.

Table C5. Socio-economic Characteristics of Communities Living in Proximity to Receiving Reaches

Distance from receiving reach	Total population (millions)	Percent minority	Percent below poverty level
1 mile	0.2	20.7%	16.4%
3 miles	1.1	23.4%	15.3%
15 miles	14.0	29.8%	13.6%
30 miles	37.4	31.5%	13.1%
50 miles	57.3	29.9%	13.1%
United States	**306.3**	**36.0%**	**13.9%**

Source: Table 14-1 in U.S. EPA (2015j)

Results: The percent of the population that is below the poverty line is greater the closer the community is to the affected waters (or receiving reach), while the percent of the minority population generally increases as distance from the reach or surface waters increases. The EPA compared these results to state averages, as indicated in Table C6 below. The EPA finds that there are no systematic differences in demographic characteristics of populations living in proximity to affected waters.

Table C6. Socio-economic Characteristics of Affected Communities, Compared to State Average

Distance from receiving reach	Number of States with Affected Communities[a]	Number of States where Affected Communities… are Poorer … than the State Average	have a Higher Proportion of Minority Population … than the State Average	are Poorer and have a Higher Proportion of Minority Population … than the State Average
1 mile	37	11	17	10
3 miles	37	10	17	7
15 miles	38	21	16	19
30 miles	42	22	16	21
50 miles	45	19	9	12

Source: Table 14-2 in U.S. EPA (2015j)

Distribution of Human Health Impacts and Benefits

The EPA also examined the distribution of the benefits associated with reductions in harmful contaminants in fish caught in waters affected by the rule. Specifically, the EPA examined the impacts on recreational anglers and subsistence anglers, including specific exposures to lead and mercury from consumption of fish in affected waters, and specific health endpoints (i.e., IQ decrements in children and cardio-vascular disease). The distribution of health effects is estimated as a function of age, gender, race/ethnicity and reach water quality (see U.S. EPA (2015j) for details on how the analysis was conducted). Table C7 shows the results. As indicated, subsistence fishers incur 7 to 17 percent of the IQ decrements, but only represent 5 percent of the population. Recreational fishers represent 83 to 93 percent of the IQ decrements and are 95 percent of the population. Because the rule reduces exposure, however, there should be no adverse impacts to subsistence fishers.

Table C7. Distribution of Baseline IQ Point Decrements by Pollutant and Fishing Mode (2021 to 2042)

Pollutant and Exposed Population	Subsistence Fishers (5 percent of population)		Recreational Fishers (95 percent of population)		Total	
Children Exposed to Lead	5,302,873	6.8%	72,840,929	93.2%	78,143,802	100%
Infants Exposed to Mercury	166,415	16.9%	818,907	83.1%	985,322	100%

Source: Table 14-6 in U.S. EPA (2015j)

Example C.9. Clean Power Plan Final Rule (U.S. EPA, 2015k, l, m)

The Clean Power Plan Final Rule establishes guidelines for states to follow in developing plans to reduce greenhouse gas emissions from existing fossil fuel-fired electric generating units (EGUs). Under this rule, states will develop programs to reduce emissions of carbon dioxide (CO_2), the primary greenhouse gas pollutant, to meet state-specific goals established by the EPA. Implementation of the emission guidelines established under this rule is anticipated to reduce CO_2. In addition, the rule is expected to reduce emissions of SO_2, NO_2 and directly emitted $PM_{2.5}$. By reducing emissions of these pollutants, the CPP provides significant climate and health benefits, including fewer premature deaths, fewer asthma and heart attacks, and fewer hospital admissions, among others.

Summary of Potential EJ Concerns of the Regulatory Action

In the EPA's 2009 Endangerment Finding (U.S. EPA, 2009c) cited in this rule, the EPA found that poor, elderly, very young, those already in poor health, the disabled, those living alone, and indigenous peoples may be particularly vulnerable to climate change risks. Specifically, the poor have limited resources to engage in adaptive capacities to mitigate the impacts of climate change, and may be more dependent on resources such as local water and food supplies that could be impacted by climate change. Native Americans also possess particular vulnerability to climate change when unique cultural and natural resources of importance to them are impacted. Scientific literature published since the 2009 Endangerment Finding have strengthened these findings.

Because low-income populations, minority populations, indigenous peoples, and others may be particularly vulnerable to climate impacts, reductions in CO_2 under the Clean Power Plan will provide benefits in terms of reductions in global climate impacts. In addition, an important co-benefit of this rule is a reduction in the adverse health impacts of air pollution on low-income communities and communities of color in closest proximity to power plants. To better understand how ancillary co-pollutant emission reductions from the Clean Power Plan Final Rule may affect vulnerable populations, the EPA conducted a proximity analysis (U.S. EPA, 2015l) to assess the characteristics of populations living near fossil fuel-fired EGUs affected by the emissions guidelines. In addition, the rule establishes that states will conduct meaningful engagement with communities during the development of their individual plans.

Proximity Analysis

Approach: Using the screening tool, EJSCREEN and data from the 2008-2012 American Community Survey, the EPA examined the race, ethnicity and income of communities living within three miles of EGUs affected by the rule compared to the national average. This information is reported at the national level as well as by state and EGU.

Results: The analysis shows that the percentage of the population that is minority or low-income within 3 miles of EGUs is greater than national averages. As indicated in Table C8 below, 52 percent and 39 percent of the population living within three miles of EGUs is minority and low-income, respectively, compared to 36 percent and 34 percent in the nation as a whole. The average percent minority within three miles of EGUs is only 32 percent (compared to 36 percent minority in the nation as a whole), reflecting the fact that there is wide variability in the composition of communities around EGUs. The average percent minority within three miles of EGUs is 37 percent, greater than the average for the nation. Table C8 also indicates that 37 percent of the communities within three miles of EGUs (i.e., "study areas") have minority populations that are greater than the national average and 57 percent of the communities have low-income populations that are greater than the national average. Because the Clean Power Plan reduces other ancillary co-pollutants from these EGUs, the EPA expects an important co-benefit of this rule to be a reduction in the adverse health impacts of air pollution for low-income and minority communities in closest proximity to power plants.

Table C8. Minority or Low-Income Populations within 3 miles of EGUs

Table 1 - Category-wide Total

Demographic Summary	Population	Minority	Low Income	Linguistically Isolated	Without a HS Diploma	Age 0 - 4	Age 65+
STUDY AREA SUMMED TOTAL	36,336,812	52%	39%	9%	19%	7%	12%
NATIONAL TOTAL & AVG	309,138,711	36%	34%	5%	14%	7%	13%
NATIONAL MEDIAN		26%	30%	1%	11%	6%	12%

Table 2 - Hypothesis Test 1 (Average Population)

H_0: Average % of study area populations in Category X = National % in Category X

H_1: Average % of study area populations in Category X ≠ National % in Category X

# of Study Areas >= 100 total population (N)	977

STATISTIC	Minority	Low Income	Linguistically Isolated	Without a HS Diploma	Age 0 - 4	Age 65+
STUDY AREA AVERAGE %	32%	37%	4%	17%	6%	14%
STANDARD DEVIATION	0.817%	0.442%	0.177%	0.282%	0.064%	0.149%
T STATISTIC	-5.3193	7.0645	-7.5412	9.8723	-9.3276	4.9141
P-VALUE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Table 3 - Hypothesis Test 2 (Occurrence)

H_0: % of study areas with population in Category X above National Median = 50%

H_1: % of study areas with population in Category X above National Median ≠ 50%

STATISTIC	Minority	Low Income	Linguistically Isolated	Without a HS Diploma	Age 0 - 4	Age 65+
% STUDY AREAS > NATIONAL MEDIAN	47%	67%	45%	68%	45%	57%
STANDARD DEVIATION	1.598%	1.501%	1.593%	1.493%	1.593%	1.583%
T STATISTIC	-1.5696	11.4865	-2.8593	12.0328	-2.8593	4.4927
P-VALUE	0.1168	< 0.0001	0.0043	< 0.0001	0.0043	< 0.0001

STATISTICAL SIGNIFICANCE LEVEL

No Significance (P >= 0.05)
Significant (P < 0.05)
Significantly Less (P < 0.05 and T Stat is negative)

Source: Tables 1-3 in U.S. EPA (2015l)

Meaningful Engagement

The EPA recognizes that meaningful involvement with communities is integral to the Clean Power Plan Final Rule. As such, the rule (U.S. EPA, 2015m) specifies that states need to conduct meaningful engagement with their communities and other stakeholders during the initial and final process of submitting their state plans for implementing the rule. Such engagement includes outreach to communities, sharing and soliciting input on the state plan throughout its development, opportunities for public comment, listening sessions, public hearings, and more.

Example C.10. Agricultural Worker Protection Standard Revisions Final Rule (U.S. EPA, 2015f)

The Agricultural Worker Protection Standard Revisions final rule updated and revised existing worker protection regulations under the Federal Insecticide, Fungicide, and Rodenticide Act. The revised Worker Protection Standard (WPS) strengthens existing information, protection, and mitigation measures for agricultural workers and pesticide handlers on certain farms, forests, nurseries, and greenhouses. The EPA expects the changes to the WPS regulations will reduce the risk of illness or injury from occupational exposure to pesticides. The new requirements include improved training, clarified requirements for personal protective equipment, and updated response measures for accidental exposures.

Summary of Potential EJ Concerns associated with the Regulatory Action

Occupational tasks performed by workers and handlers create a significant risk of pesticide exposure. Agricultural workers face occupational exposure to a wide range of pesticides and pesticide residues and may experience various short- and long-term health risks, including headaches, seizures, asthma, bronchitis, and cancers. Pesticides transported by clothing and footwear can impact children and families. Research shows that agricultural workers may have difficulty entering the health care system to receive treatment due to economic and language barriers. The EPA considered the demographic characteristics of the affected populations and concluded that the rule increases the level of environmental protection for these populations, which include high percentages of low-income and Hispanic workers.

Qualitative Discussion of Relative Risk Borne by Low-Income Populations and Minority Populations

Approach: The EPA presented a qualitative discussion of how low-income populations and minority populations could be affected, as well as estimates of prevented illnesses based on incident data. The EPA did not include a separate EJ analysis. Rather, it included a discussion of why potential EJ concerns are integral to the rule and its impacts. Throughout the development of this proposed rule, the Agency has used research on the demographic characteristics, work habits, and culture of the worker and handler populations to revise the WPS to ensure it provides effective protection. Information for the assessment and development of the rule was gathered through field research and interaction with workers, handlers, worker and handler representatives, and stakeholders. The EPA extensively engaged farmworker representatives, and when possible, worked directly with workers and handlers, to solicit their feedback on the current regulation and ideas for improvement.

Results: The EPA found that the affected population consists primarily of minority individuals and low-income individuals, to whom benefits would accrue. Low literacy rates, a range of non-English languages spoken by workers and handlers, geographic isolation, difficulty accessing health care, and immigration status of workers and handlers pose challenges for this workforce. According to the 2011-12 National Agricultural Worker Survey, 70 percent of agricultural workers originated from Mexico or from Central and South America, and over 55 percent of respondents reported a total family income below $22,500 (roughly equivalent to the 2011 federal poverty level for a family of four).[64] In its introduction, the analysis documents the role of potential EJ concerns in the rule (U.S. EPA, 2015f, page 6):

"There are several reasons that environmental justice considerations are especially important for the agricultural employees covered by the WPS.

- Because of their occupation, workers and handlers face more potential exposure to pesticides than the general public, and may be subject to multiple exposures of different pesticides over the course of their working life.
- Language barriers and challenges for this workforce make it difficult for workers and handlers to participate in making decisions about the risks they face as they perform their jobs.

[64] For more information on the 2011 federal poverty level, see the annual poverty guidelines published by the Department of Health and Human Services: https://aspe.hhs.gov/report/federal-register-january-20-2011-volume-76-number-13.

- Workers, handlers and their families may be subject to a higher risk of harm than non-agricultural workers. Children and adolescents may be especially vulnerable to pesticide exposure, because their body systems are still developing. Poverty, poor nutrition and lack of access to health care can exacerbate the risks from this exposure.

- The cumulative effects of occupational pesticide exposure can have long term impacts on the health of worker and handler communities."

Based on a literature review and an analysis of reported pesticide illnesses, the benefit-cost analysis for this rule quantified benefits from avoided healthcare costs and lost productivity due to acute incidents, and qualitatively documented the health benefits from chronic exposure. These benefits would accrue to the populations indicated above (i.e., primarily minority individuals and low-income individuals).

Example C.11. Definition of Solid Waste Final Rule (U.S. EPA, 2014g, 2015b)

In 2008, the EPA revised the Definition of Solid Waste (DSW) rule to exclude certain hazardous secondary materials (HSM) from regulation as hazardous waste under RCRA Subtitle C. Specifically, HSM, if properly recycled, would not be required to meet Subtitle C regulations for recordkeeping, disposal, and other requirements. Instead, HSM would undergo recycling rather than disposal, and the rule aimed to increase safe recycling of such materials by offering these exclusions. In 2010, the EPA examined potential EJ concerns with the 2008 rule by considering the potential changes in the behavior of facilities handling hazardous secondary materials, and by analyzing the communities surrounding these facilities. The EPA finalized its EJ analysis in 2014, incorporating comments from peer review and public comment and identifying mitigation measures. To ensure that the exclusions would encourage legitimate recycling and mitigate environmental and health effects from hazardous substances, the EPA revised the DSW rule in 2015 to strengthen requirements for safe handling, notification, and recordkeeping of HSM.

Summary of Potential EJ Concerns of the Regulatory Action

Hazardous secondary materials include toxic and flammable substances that can harm human health and the environment in many ways, causing both chronic (e.g., long-term carcinogenic and non-carcinogenic health effects) and acute (e.g., fire and explosion injuries) hazards. The EPA examined two common, high-volume types of HSM, spent solvents and electric arc furnace dust, to assess changes in risk, and identified both potential increases and decreases in risk from managing these wastes as HSM. Specifically, the EPA's analysis revealed that the 2008 rule could potentially increase risks to human health and environment through several changes to management, such as potential increased accumulation of HSMs onsite, uncertainty about how HSM materials might be contained, and reduced facility oversight. To identify whether minority and low-income population groups of concern would potentially face differential impacts from the rule, the EPA quantitatively analyzed the demographic composition of communities surrounding potentially affected facilities.

Proximity Analysis to Determine Demographic Characteristics of Communities Near Potentially Affected Facilities

Approach: To assess the characteristics of potentially affected communities, the EPA identified facilities likely to take advantage of DSW exclusions and increase HSM recycling. Using geospatial methods, the EPA mapped the locations of affected facilities and the estimated demographic characteristics of populations of concern in proximate areas, including racial minorities, children under five, and low-income populations.

Using 2010 Census Data and 2006-2010 American Community Survey five-year estimates, the EPA analyzed the demographics of populations within a three kilometer radius of each affected facility. When a facility's buffer zone intersected multiple Census block groups, the population size and characteristics of the community surrounding the facility were estimated using area-weighted apportionment from all intersecting Census block groups.

In a community-level analysis, the EPA considered the demographic composition of communities around affected facilities, relative to state and national comparison populations. The higher the average difference in demographic characteristics between the potentially affected communities and the comparison group, the greater the potential differential impact.

In a population-level analysis, the EPA considered the total potentially affected population compared to the total population to evaluate (1) whether potentially affected communities are more likely to include populations of concern compared to comparison populations, and (2) whether members of population groups of concern make up a greater proportion of the potentially-affected population compared to comparison populations.

Results: In the community-level analysis, facilities identified by the EPA as having environmental problems associated with hazardous waste recycling demonstrated differential impacts relative to both national and state comparison populations. Additionally, facilities that had notified the EPA of intent to manage HSM and hazardous waste generators likely to recycle under the rule were also more likely to be located near low-income communities at both the national and state level. Table C9 illustrates these results.

Table C9. Community-Level Analysis of Potential Disproportionate Impacts of the DSW Exclusions to Minority and Low-Income Communities

	National Comparison % communities with higher minority representation (average difference)	National Comparison % communities with higher low-income representation (average difference)	State Comparison % communities with higher minority representation (average difference)	State Comparison % communities with higher low-income representation (average difference)
Notification Facilities (60 total)	26.7% (-11.84%)	51.7% (1.17%)	48.3% (0.23%)	68.3% (5.25%)
Damage Case Facilities (250 total)	52.4% (6.97%)	68.0% (8.65%)	52.4% (7.20%)	71.2% (8.98%)
Hazardous Waste Facilities (2,115 total)	46.8% (1.37%)	59.7% (4.17%)	53.5% (5.07%)	60.4% (4.37%)
Non-Hazardous Industrial Waste Facilities (25 total)	36.0% (-4.0%)	48.0% (-0.08%)	44.0% (-0.82%)	44.0% (-0.73%)

Source: U.S. EPA (2014g), Executive Summary, p.12

The population-level analysis shows that that the affected communities surrounding facilities with higher proportions of minority or low-income individuals also have significantly higher total populations. Table C10 illustrates these results.

Table C10. Population-Level Analysis of Potential Disproportionate Impacts of the DSW Exclusions to Minority and Low-Income Communities

	National Comparison Minority Population Affected Population Ratio Demographic Ratio	National Comparison Low-Income Population Affected Population Ratio Demographic Ratio	State Comparison Minority Population Affected Population Ratio Demographic Ratio	State Comparison Low-Income Population Affected Population Ratio Demographic Ratio
Notification Facilities (60 total)	0.83 0.89	1.00 1.00	1.39 1.26	1.31 1.21
Damage Case Facilities (250 total)	2.45 1.64	1.60 1.36	2.28 1.49	1.76 1.46
Hazardous Waste Facilities (2,115 total)	1.68 1.42	1.26 1.19	1.41 1.22	1.09 1.06
Non-Hazardous Industrial Waste Facilities (25 total)	1.23 1.14	1.13 1.09	1.41 1.22	1.09 1.06

Source: U.S. EPA (2014g), Executive Summary, p.13

Review of qualitative and geospatial data to identify other vulnerability factors

Approach: Other factors may contribute to higher susceptibility to disease from multiple stressors, such as cumulative effects of other environmental stressors, unique exposure pathways, ability to participate in decision-making, and access to infrastructure to help avoid exposure. To identify communities that face additional vulnerability factors, the EPA gathered data on other pollution, health, lifestyle characteristics, and infrastructure for the area with 3 km radius around the 61 notification facilities:

- Other facilities reporting to the EPA environmental programs (such as the Toxics Release Inventory (TRI))
- Cancer and neurological hazard incidence rates (using the 2002 National Scale Air Toxics Assessment)
- Public participation (using Census data for education and English literature)
- Number of hospitals
- Incidence of medically underserved population

Results: The EPA compiled data on factors that may increase vulnerability via multiple exposures to affected communities. Communities around all notification facilities had multiple facilities reporting to EPA. Twenty-six facilities had communities with cancer rates greater than the 80^{th} percentile, and twenty-seven facilities were above the 80^{th} percentile in neurological hazard rates. Twenty-seven facilities had no hospital facilities within 3 km. The EPA did not quantify the impact of these factors.