ENVIRONMENTAL IMPACT ASSESSMENT

1. Introduction

In January 1970 the National Environmental Policy Act (NEPA) became law in the United States. It was intended as a federal response to increasing domestic problems of environmental pollution and natural resource degradation. At that time it was hard to imagine that the law would become the cornerstone of a new applied science of environmental impact assessment (EIA) and its basic elements would be replicated in over 100 countries around the world. These countries have adapted specific mandatory planning procedures for the evaluation of proposed actions that may impact environmental quality.

These procedures include: a preliminary screening for significance of impacts; a scoping process to consider alternatives and to focus subsequent analysis on the most significant impacts; and the preparation of an environmental assessment (EA) document which is subject to some form of public review or comment.

The field of environmental impact assessment (EIA) is becomingly increasingly important to the chemical industry and to those using chemical technologies. EIA requirements are sometimes applied directly to some chemical industries or to projects with certain chemical technologies, such as hazardous waste treatment. Although requirements vary greatly, chemical industries can be subject to EIA requirements because the proponent is public, the proposed action occurs on public lands, the proposed action is publicly funded or funded by a development bank, or a specified government approval requirement "triggers" EIA requirements. A chemical industry also can be affected if the proposed action is likely to adversely affect environmentally significant areas or species.

A shift in emphasis has occurred in EIA in recent years toward regional or "place-based" approaches. This dovetails with the greater use of strategic environment assessments (SEA) of plans, programs and policies and an increasing effort to integrate EIA, environmental planning, and environmental management. Chemical industry choices, regarding, eg, locations for new facilities can be greatly influenced by such strategic planning endeavors.

EIA can be relevant to a chemical industry even when EIA "requirements" are not involved. Sometimes a new or expanded chemical facility can be very controversial. A voluntary EIA procedure, whereby environmental impacts are systematically and openly identified, documented and managed, can help anticipate and respond to community and agency concerns. Government agencies, familiar with EIA procedures and methods, can be more comfortable with documents and planning processes that conform to "good practice" EIA. Also, EIA can extend and complement corporate and public sector environmental and social objectives, policies and auditing procedures, eg, environmental management systems (EMS). Increasingly, EIA and other corporate environmental performance instruments are being linked and integrated.

In view of these connections between EIA and the chemical industry it is prudent to be aware of this rapidly evolving field and of its potential implications for the chemical industry. This article highlights the general characteristics of the field: its definition; origins; evolution; and types. It provides an overview of EIA institutional arrangements, as legislation, regulations, guidelines, regulatory systems, and reforms. It describes EIA processes and methods. It identifies emerging trends shaping future EIA requirements and practices.

2. General Characteristics

2.1. EIA Defined. EIA is a systematic process of:

- Determining and managing, which includes identifying, describing, measuring, predicting, integrating, communicating, and involving and controlling,
- Potential, or real, impacts that are direct and indirect, individual and cumulative, and the likelihood of occurrence
- Proposed, or existing, human activities such as projects, plans, programs, legislation, activities, and their alternatives
- Environment, which incompasses physical, chemical, ecological, cultural, human health, social, economic, built, and interrelationships. (1)

EIA is an interdisciplinary field of study that draws upon both the natural and social sciences. It is an interprofessional field that both encompasses a core body of knowledge, skills, and methods, and integrates the knowledge and skills of numerous other applied professions and disciplines. EIA seeks to advance environmental values and ethical principles. It is formalized through institutional arrangements. It is linked to decision-making. Hence it is political because power is exerted. It results in positive and negative environmental changes.

2.2. Origins of EIA. EIA have been linked to public concerns with the natural environment extending back to at least the 18^{th} century (2). The origins of social impact assessment (SIA), in the sense of applying scientific analyses to demographic and health concerns, have been traced back to the 17^{th} century (3). But the history of EIA, as a legislated and regulated procedure for assessing the

environmental effects of proposed actions, is customarily viewed as beginning with the introduction of the National Environmental Policy Act (NEPA) in the United States in 1969. Since that time EIA has expanded rapidly, particularly over the past two decades (SIA is treated here as a subset of EIA). By 1996 it had spread to over 100 countries in six continents. It is widely applied at different government levels and by international aid agencies to both public and private undertakings.

2.3. Evolution of EIA. The evolution of EIA has varied greatly among jurisdictions. But the general pattern has been a broadening of the initial focus on individual physical and biological effects to encompass an increased concern with direct and indirect, individual and cumulative social, cultural, human health, and ecological effects. The initial emphasis was on large capital projects. More stress is now being placed on assessing (to varying degrees) the effects of policies, plans, programs, legislative proposals, technologies, products and trade agreements. Over time EIA methods have become more sophisticated. Links have been forged with related fields that include planning, risk assessment, and environmental management. Increased attention has been devoted to transboundary effects, eg, on the neighboring jurisdictions and on the global commons, to EIA applications in developing countries by aid agencies, to EIA legislation by developing countries, to institutional capacity building, to such global issues such as climate change, biodiversity, and sustainability, and to enhancing the quality and effectiveness of EIA practice at both the regulatory and applied levels (4).

2.4. EIA Objectives. Many objectives have been advanced for EIA (5). Most directly it has sought to incorporate, from an early stage, environmental information and interpretations into planning and decision-making procedures and documents. Better environmental analysis, it is hoped, will result in more informed and balanced decision-making, more environmentally sound undertakings, and an enhanced environment not dominated by technical, cost and economic considerations. The regulatory regime associated with EIA is expected to alter organizational values, attitudes and behavior, and to contribute to more open, systematic, accountable, and effective organizations and decision-making. EIA also has been described as a means of facilitating public, professional and scientific involvement in decision-making and of contributing to inter and intra-agency coordination. Increasingly, EIA is viewed as one instrument among many for achieving broader environmental objectives such as sustainability. After more than thirty years there remains considerable uncertainty and much debate regarding the extent to which these objectives should or have been achieved.

2.5. EIA Types. There are numerous impact assessment types that fall under the EIA umbrella. Examples are given in Table 1.

Opinions vary regarding the appropriate scope of each impact assessment type. Consequently, the impact assessment types overlap. Also, there are other assessment forms, for example, gender, environmental justice, climate impact, fiscal impact, trade agreement, regulatory and global effects, that could be viewed as distinct impact assessment types, as subsets or as methods. Although debatable, EIA is defined broadly, for the purposes of this article, to encompass all impact assessment types.

Table 1. **Impact Assessment Types**

Impact assessment	What is assessed?
ecological	potential ecosystem impacts
social (SIA)	consequences on people and on how people and communities interact with their surroundings
economic	impacts on how people make a living, on material well-being, and on economic activities
strategic environmental (SEA)	environmental impacts of a policy, plan or program and its alternatives, generally within policy sectors
cumulative effects (CEA)	impacts of an action when combined with other past, present and reasonably foreseeable future human activities
technology (TA)	effects on society from new or modified technology
human health impact (HIA)	human health impacts of a proposed action
sustainability appraisal or SA	extent to which action contributes to or undermines ecological and societal sustainability
life cycle (LCA)	environmental effects of products, processes, systems and services during their life cycles
integrated environmental (IEA)	the ecological, economic, social and institutional effects of societal activities and government policy, across policy sectors

3. EIA Institutional Arrangements

3.1. EIA Legislation, Regulations and Guidelines. EIA institutional arrangements begin with legislation, regulations, guidelines and case law. Increasingly EIA requirements from the senior government levels in the United States, Canada, Europe and Australia can be accessed at government web sites. EIA legislation and regulations identify the purpose and objectives of the legislation. They define the environment and environmental effects. In most jurisdictions social and economic effects are either not considered or only indirect social and economic effects are addressed. Sometimes the purpose of EIA legislation is defined broadly but the scope of requirements within the body of the legislation is more narrowly defined.

EIA requirements generally specify what "triggers" the process action type, proponent type, environment type, a combination. They sometimes indicate what does not trigger EIA requirements. The procedures for making discretionary judgments regarding the application of EIA requirements are usually outlined. EIA requirements detail the content requirements for different EIA document types, eg, overview documents, detailed analyses, SEAs. They identify procedural stages, specify decision points, describe the roles of the major parties in the process, outline agency review procedures and detail document circulation, review and approval procedures. They indicate other government requirements that may be integrated into EIA requirements. They include provisions for public access to project-related information and documents. They commonly outline decision-making criteria, include timing limits, describe documentation requirements, specify agency and public notification and involvement procedures, indicate links to other government levels, include procedures for addressing

transboundary effects, provide for post-approval follow-up, and cross reference other policies and requirements.

EIA guidelines generally address procedures for preparing various EIA document types, for interagency coordination, and for public and other government notification and involvement. More specific advice is sometimes provided for various EIA activities such as scoping, alternatives analysis, cumulative effects assessment (CEA), project characteristics descriptions, significance interpretation, for various impact types, which can include climate change, ecological, heritage, health, for certain project types, eg, mining, pipelines, for public policy links, eg, environmental justice, the precautionary principle, biodiversity, and to facilitate good practice with effective public participation. Checklists and training materials are sometimes provided to guide document preparation and process design and management. Proposal-specific requirements are prepared in many jurisdictions.

3.2. EIA Regulatory Systems. Stepping back from the myriad of detailed EIA requirements to appreciate the broad patterns can be conducive to better understanding an EIA regulatory system as it as and as it is evolving and for reforming, refining and more effectively implementing and applying EIA requirements and guidelines. The initiative for making such system changes need not reside only with government. Other parties, including industry, can assume an important role.

EIA systems tend to start with the questions of what should trigger the application of EIA requirements and which set of requirements should be applied. Such "screening" questions can focus on various actions (what), on proponents (who) or on environments (where). Each screening decision involves significance judgments, whether it is important enough to institute EIA requirements, or to warrant EIA requirement "a" or "b". Most EIA systems involve action, proponent and environment combinations. How these elements are combined depends on whether the role of EIA requirements is primarily seen as building environmental considerations into proponent or action-related decision-making or protecting and enhancing the environment. The first objective tends to be emphasized in proponent driven EIA systems as occur in the United States and Canada and in action-driven EIA systems as occurs in Europe. These systems only indirectly consider the second objective, usually by means of other regulatory requirements that are selectively built into the EIA review process. The preservation and enhancement of highly significant environmental areas and species tends to be the focus with environment driven EIA systems as occurs in Australia. Incorporating environmental considerations into proponent and action decision-making tends to be a secondary concern with such systems.

EIA regulatory systems, to varying degrees, include requirements and provide guidance concerning individual EIA activities. EIA requirements tend to identify objectives, specify minimum requirements and include general performance standards or criteria. EIA guidelines tend to offer good practice guidance. A balance is generally sought between ensuring a consistent level of adequate practice and not stifling innovation and necessary proposal and setting specific adjustments.

Integration and coordination are central attributes of EIA regulatory systems. EIA requirements and guidelines tend to briefly refer to interconnections

among EIA process activities. They generally include extensive horizontal coordination procedures pertaining to, for example, links to related laws, regulations and permits, connections to related policies, programs and plans, interactions with related projects and activities, and interrelationships with the actions of other government departments and agencies. EIA regulatory systems also refer to vertical coordination mechanisms. These include links to other (state/provincial/territorial, municipal) government levels, interconnections among EIA types (such as from policies, down through programs, plans and projects), and procedures for interacting with the public, with businesses and with non-government organizations.

Extra-territorial connections are sometimes cross-referenced in EIA requirements. Such links include, for example, impacts on neighboring countries, impacts on the global commons such as oceans, impacts from development aid and the application of international environmental standards and protocols. EIA requirements and guidelines, to varying degrees, consider EIA knowledge base connections. These links are addressed by, for example, sponsoring applied environmental and EIA research, provisions to integrate scientific, technical, community and traditional knowledge, environmental monitoring requirements, and guidance regarding the conduct of interdisciplinary analyses.

3.3. EIA Reform. EIA requirements and guidelines are a "moving target". Most jurisdictions provide for the periodic review and reform of EIA requirements. Major reviews have recently occurred in both the United States and Canada. Sometimes one EIA regulatory system is replaced with a fundamentally different system as occurred in Australia, or supplementary EIA requirements are introduced. The new SEA requirements in Europe are an example. Or existing systems are refined and modified after a major public review as occurred in Canada. Frequently annual reviews or audits of the performance of EIA regulatory systems are conducted to refine procedures and to "red flag" areas requiring attention. Informal refinements, elaborations and adjustments to procedures and guidelines occur in a continuing effort to optimize system performance and to keep abreast of "good practice". Such efforts are furthered by effectiveness reviews of EIA system components, by EIA follow-up studies, by EIA document quality assessments and though the sponsoring of applied research. Sometimes reforms are externally imposed by judicial decisions.

The nature of EIA regulatory reform varies among jurisdictions. The general thrust in the United States and Canada, at the federal level, has been toward higher quality data, documents and analyses, clarified requirements, improved guidance, more efficient and effective interagency and intergovernmental procedures, better communications and coordination, and enhanced public access to information and involvement (6,7). The United States has addressed substantive environmental concerns through proposed measures to facilitate adaptive management in EIA, to further the use of ecosystem and "place based" EIA approaches, and to better integrate procedural with substantive environmental requirements (8). Canada has addressed environmental substance by reforms that strengthen follow-up, that recognize the value of regional studies, and that facilitate the use of community and traditional knowledge. Both jurisdictions acknowledge the need to more effectively assess alternatives and to improve social, cultural and economic analyses. Europe has concentrated more

on advancing the use and effectiveness of SEA and on clarifying the interconnections between EIA procedural requirements and substantive environmental policies and requirements (9).

4. EIA Processes and Methods

4.1. EIA Activities. Figure 1 presents an example EIA process. In practice there are multiple EIA process design and management choices. EIA process activities also are highly interactive and often occur in different forms at different stages in the EIA process.

Screening. Screening determines if and which EIA requirements will be applied to a proposed action. Screening requirements should ensure actions with likely significant environmental impacts are thoroughly assessed, actions with an uncertain potential for significant impacts are assessed in sufficient detail to make reliable significance judgments, and actions with no or very limited anticipated environmental impacts are either subject to an overview analysis or are not assessed. Screening attempts to apply consistent, explicit and appropriate decision rules that focus on what matters environmentally.

Scoping. Scoping identifies potentially significant issues, options, impacts and affected parties. It then focuses and plans the overall EIA process. Stakeholder participation is crucial to scoping success. Numerous value judgments and preliminary evaluations occur in scoping.

Need and Proposal Characteristics. Need flows from the purpose of the proposed action. It should be defined sufficiently broadly that all reasonable alternatives for meeting the need are considered. Proposal characteristics focus on those proposal attributes most likely to induce impacts, especially on sensitive and significant environmentally components and systems. Such proposal attributes are generally the departure point for identifying alternative means and mitigation measures. Proposal characteristics evolve, at progressively greater levels of detail, through the EIA process.

Alternatives Analyses. Alternatives analyses focus on available choices for avoiding and minimizing adverse environmental effects and for enhancing benefits. They explore how to meet the need and how to implement the proposed action. Examples of the many types of alternatives are institutional, technological, location, design, construction, operations, energy conservation, pollution control, waste management, mitigation, and after use. Alternatives can be screened for acceptability. They also can be compared to one another or against a base case. Alternatives analyses should be explicit and consistent. There should be clearly defined, substantiated, and applied criteria and evaluation procedures. Procedures for generating and evaluating alternatives are inherently subjective. They are generally best undertaken with considerable agency and public involvement.

Baseline Analysis. Baseline analyses characterize historical, current and likely future environmental conditions, assuming no proposed action or its alternatives. Baseline analyses support screening, scoping, alternatives evaluation, impact prediction, and mitigation and monitoring activities, although at varying

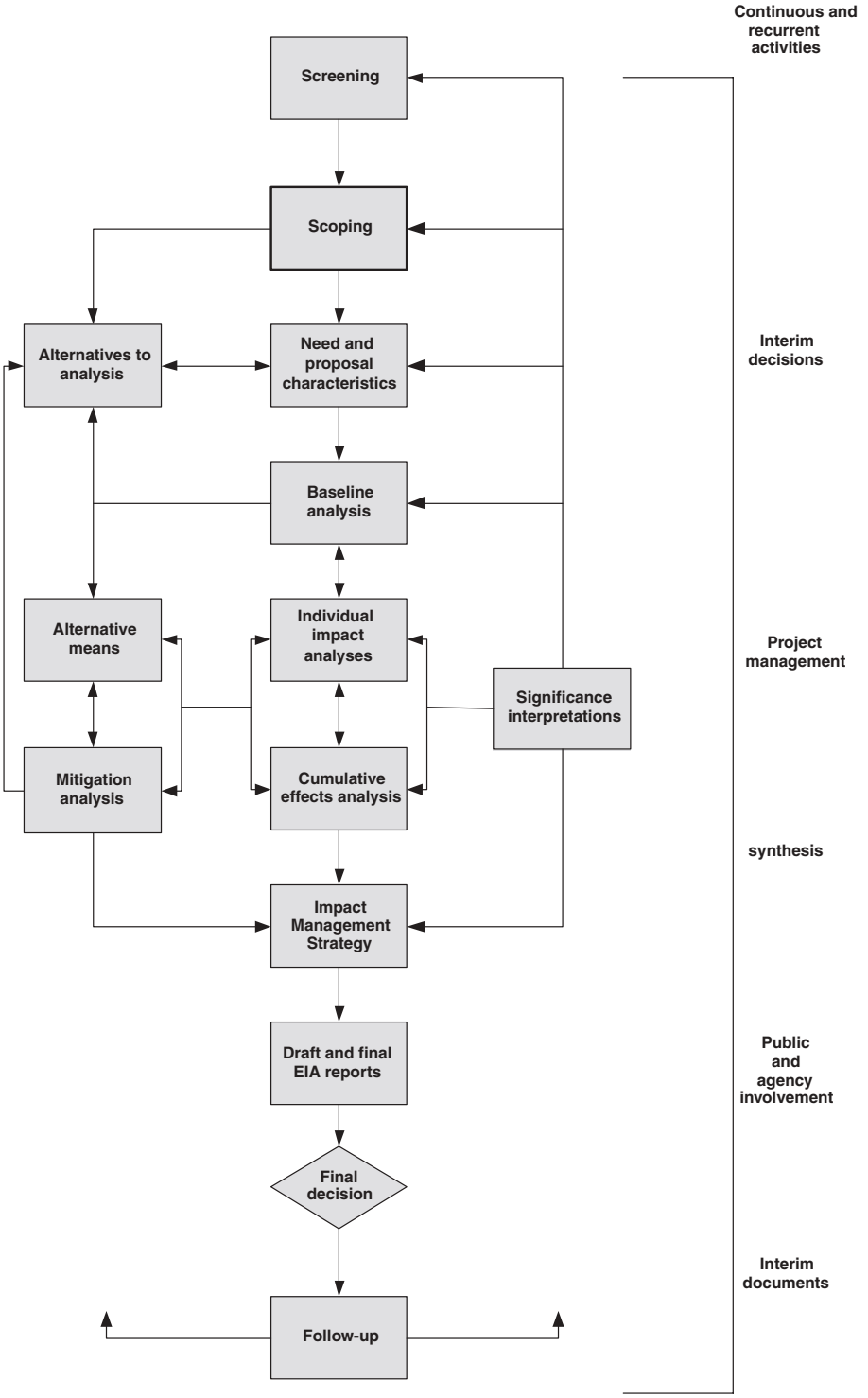

Fig. 1. Example of EIA Process.

levels of detail. Appropriate temporal, spatial, administrative, and ecological boundaries are crucial to effective baseline analysis. Future environmental conditions should match the duration and spatial extent of potential effects. Effective baseline analyses focus on the sensitivity and significance of environmental components, functions, processes and systems.

Impact Analysis. Impact analysis identifies and characterizes impacts resulting from the proposed action and in conjunction with other activities (CEA). It also identifies uncertainties, reduces uncertainties where practical and indicates the implications of uncertainties. Impacts can be characterized in many ways such as magnitude, temporal distribution, spatial distribution, distribution by population group, probability, reversibility, positive/negative, direct, indirect, and cumulative. Impact analysis occurs both within and among environmental specialties. Examples of environmental specialties include air, surface water, soil, noise, visual, ecological, cultural, social, and economic. Impact analysis incorporates both qualitative and quantitative data. It occurs at different levels of detail depending on the EIA process activity.

Significance Interpretation. Significance interpretation or determination involves subjective judgments about importance. It includes such judgments as important enough to be considered, to require more detailed analysis, to warrant stakeholder involvement, to necessitate mitigation, enhancement or compensation, to provide a basis for rejection or acceptance of the proposed action, or its alternatives, or to require monitoring. Significance judgments can apply to environmental components or interactions, to uncertainties, to proposal characteristics, to impacts, to public or agency concerns, and to management methods. Although often informed by technical procedures, significance judgments are subjective, value-based, context-dependent and because they are linked to decisions, political. There are both significance thresholds and significance scales. Sometimes individually insignificant impacts when combined, as cumulative impacts, become significant.

Management. Management is used in several ways. Management, as a control function, is recurrent in every activity. Management can take the form of mitigation enhancement or compensation. There also are monitoring (baseline, source, compliance, effects, mitigation effectiveness), auditing (eg, prediction accuracy), emergency response, financial security, environmental liability and contingency measures. An impact management strategy can integrate individual management measures.

Synthesis. Synthesis takes many forms. Interrelationships among proposal elements, linkages among environmental components, aggregation in evaluation, CEA, the integration of study team inputs and documentation, the integration of individual actions and tasks within strategies, the reaching of overall conclusions in decision-making in the EIA process are examples. Both data and perspectives are combined. Full integration (eg, disciplinary barriers, irreconcilable value differences) is often neither possible nor desirable. Synthesis is often uncertain. It involves many value judgments. There is no single best way to integrate. Synthesis tends to begin with the exploration of interrelationships. Information loss is inherent to synthesis. Managing and considering the implications of such losses is an essential feature of synthesis. Synthesis is often nonadditive and tends to be a collaborative activity.

Documentation. EIA reports generally describe the EIA process and document the outcomes of each activity. Usually there are draft and final EIA documents. Decision makers, interested publics and government agencies generally review EIA documents. Executive summaries, summary reports and other summary materials are usually prepared and broadly distributed. The EIA reports generally are linked directly to regulatory requirements. The role of public and agency involvement is commonly fully documented. Details of the public involvement program are often provided in a separate support report. Support materials are usually provided in technical appendices and in supplementary reports. Interim documents are often prepared. It is good practice to provide a clear rationale for all assumptions, findings, interpretations, conclusions and recommendations. Post-approval documents are increasingly being required.

Participation. Public and agency participation increasingly occurs in all or most EIA activities. Participation procedures vary by activity and by stakeholder group. Greater stress is being placed on earlier and more continuous EIA involvement. More emphasis is being placed on offsetting procedural inequities and on involving traditionally unrepresented and underrepresented groups and interests, including surrogates for future generations. Participation increasingly extends beyond approval. It encompasses communications, education, involvement, negotiations and collaboration activities. Greater use is being made of alternative dispute resolution, such as facilitation or mediation, to identify, clarify, reconcile and accommodate conflict, to build and maintain consensus, and to contribute to environmentally sound outcomes.

Review and Decision-making. There are often several formal (eg, screening, scoping, review of draft and final EIA reports) and informal (eg, need, alternatives analysis, baseline analysis, impact analysis, impact interpretation) decisions in the EIA process. Decision-making increasingly extends to post-approval monitoring and auditing. Early and ongoing agency involvement is generally desirable. Early integration of approval requirements is especially important. Increasing emphasis is being placed on auditing EIA quality and on assessing the effectiveness of the EIA process. Duplication or decision-making gaps are sometimes a problem in the EIA review process. Resource and expertise deficiencies inhibit the review process in some jurisdictions. Highly centralized review procedures can limit adaptations to suit local conditions and needs.

4.2. EIA Process Design and Management Choices. As illustrated in Figure 1 EIA activities are highly interrelated. They can be continuous (eg, project management), recurrent (eg, interim documents and decisions) or occur in different forms (eg, progressive refinement of proposal characteristics, progressively greater level of detail in baseline and impact analyses). There are many EIA process design and management choices available (10). The EIA process can be reduced to a few basic activities and events or can be extremely complex. EIA activities can be subdivided, combined, or rearranged. There are numerous possibilities available for feed forward and feedback loops. Some interconnections are more important than others.

The process can be linked (in different ways) to proposal planning, decision-making, related environmental decisions, related fields and related activities. Choices are available regarding the treatment of both inputs and outputs. Example inputs include EIA requirements, public and agency concerns and

preferences, roles and responsibilities, environmental substance, knowledge, values and experience, and methods. Example outputs include documents, decisions, and environmental changes. The EIA process can vary depending on the effect types being assessed, the proposal type, the setting type, and the proponent type. Adjustments are always necessary to account for unique proposed action and setting characteristics.

Opinions vary among EIA commentators and stakeholders concerning whether, to what extent and in what ways EIA requirements and processes should be more rigorous, rational, environmentally substantive, practical, democratic, collaborative, ethical or adaptive. These themes, both individually and collectively, have significant EIA requirements and EIA process and management implications (11).

It is helpful to understand the range of available EIA process design and management choices. It is even more important to appreciate which blends of choices are more effective under which categories of situations. EIA quality and effectiveness analyses can contribute to such endeavors. Given the subjective nature of such choices, it is usually preferable to involve interested and affected parties in making EIA process design and management decisions.

4.3. EIA Methods. General EIA methods (eg, checklists, matrices, networks, models) can be adapted and applied at different levels of detail to various EIA activities. EIA methods vary in their characteristics, strengths, limitations and suitability for different EIA activities, settings and proposal types. Many EIA methods are derived from other fields of practice. There are task and participant-oriented EIA methods. Often the two are merged, for example, stakeholder involvement in model construction and adaptation. Method types vary among EIA activities. Table 2 lists several methods commonly applied during various EIA activities.

Methods can be screened and compared using explicit criteria (a consistent way to consider methods' strengths and limitations). The criteria may vary by EIA activity, by setting type and by proposal type. A clear explanation of and rationale for the methods applied should be provided. Experiences in other fields, such as risk assessment, futures research, policy evaluation, urban and regional planning, can help derive, refine and apply methods. Most EIA activities combine technical analysis/synthesis and participant involvement methods.

Numerous methods are adapted and applied in EIA practice by natural scientists involved in geology and soils, climatology, hydrology, terrestrial, freshwater and coastal ecology and by social scientists involved in sociology, economics, anthropology, psychology, archaeology, and by applied scientists. Technical personnel apply risk assessment, noise analysis, air quality analysis, groundwater analysis, water quality analysis, visual and landscape analysis, and transportation analysis methods in EIA. Procedural specialists use project management, public participation, alternative dispute resolution, legal requirements and procedures, and document preparation methods in EIA. Synthesis skills, methods and procedures are critical to coordinate and integrate individual specialty analyses and to prepare focused and understandable synthesis and summary documents.

Chemical industry proposals and proposals involving chemical technologies, subject to EIA requirements, can involve many of these specialties. Public

Table 2. **Examples of Methods**[a]

Methods	Roles
Screening	
Application of criteria, standards and checklist questions	To ensure that screening is comprehensive and consistent
Application of acceptability thresholds (eg, regulatory standards, carrying capacity)	To ensure that there are clear distinctions between actions subject/not subject to EIA requirements and type of requirements that apply
Overview analyses (eg, field visits, secondary source reviews)	To ensure screening appropriate to circumstances, when screening involves discretionary judgments
Dialogue with stakeholders and experts (eg, workshops)	To ensure stakeholder understanding of and support for screening requirements and applications
Scoping	
Study design	To guide scoping and overall EIA process
Checklists, matrices, computer aids and models	To identify potentially significant impacts and interactions
Problem analysis and idea generation techniques	To identify potentially significant impacts, issues and interactions
Comparable project and setting analyses	To identify likely issues and impacts
Overview analyses of primary and secondary data sources and preliminary field visits	To adapt proposed action to local circumstances
	To identify local issues and potential thresholds
Consultation procedures (eg, community meetings, hot lines, open houses)	To identify community perspectives on issues
	To identify key community groups and leaders
Proposed Action	
Event trees, fault trees, networks and models	To identify action components likely to generate potentially significant impacts
	To trace interactions between proposed action and environmental components and systems
Sensitivity analyses	To identify implications of alternative assumptions
	To lay groundwork for alternatives and mitigation measure generation
Environmental management policies, programs and operations	To provide context for proposed action characteristics
	To reduce likelihood that action or action components will generate significant adverse impacts
Baseline Analysis	
Clear objectives, hypotheses, categories, indicators and measures	To guide and structure the baseline analysis
Primary data, secondary data, remote sensing, geographic information systems and community profiles	To generate reliable data base
Data collection, compilation, analysis, interpretation and management programs, manuals and guidelines	To structure baseline analysis

Table 2 (*Continued*)

Methods	Roles
Case studies and control communities and environments	To help ground forecasting of likely future environmental conditions
Forecasting (eg, trend extrapolation, pattern identification, probabilistic forecasting) and risk and uncertainty analysis and management methods	To identify range of potential future conditions
	To isolate major uncertainties and potential implications
Checklists, statistical analyses, experiments, models (conceptual, physical, mathematical), network diagrams, stepped matrices, linear graphs	To ensure that baseline analysis is systematic, coherent, focused and structured
	To systematically explore interactions
Public involvement methods (eg, surveys, interviews, small group meetings)	To integrate community and traditional knowledge into baseline analyses
Impact Analysis	
Impact hypotheses, categories and indices	To systematically structure impact analysis
Historical and comparable project/setting reviews, case studies and experiments	To help differentiate likely changes with and without proposed action
Field and social surveys, literature reviews, expert workshops, community meetings, interviews with agency officials, community leaders and members of non-government organizations	To identify potential impacts To identify impact issues from multiple perspectives
Checklists, matrices, overlays, network diagrams	To ensure impact analysis is comprehensive, systematic and focused
Agency guidelines, policies and requirements	To ensure public policy priorities addressed
Communications and meetings with environmental specialists	To identify interactions among impacts
Trends extrapolation, field or laboratory experiments, models (conceptual and quantitative, physical, mathematical, analogue), simulations, modeling, statistical analyses	To predict potential and likely future conditions
Computer expert systems and group interaction methods (eg, workshops, charrates, Delphi, brainstorming)	To integrate a range of perspectives into impact predictions
Human health and ecological risk assessment, confidence limits, safety margins and sensitivity analyses, precautionary principle, decision analysis, game theory, hedging away from large losses	To systematically address potential human health and ecological risks
	To systematically address uncertainties and implications of uncertainties
Significance Interpretation	
Thresholds (eg, legal, technical, judgmental, functional, receptor/sensitivity/significance, public preference, sustainability)	To clearly differentiate between significant and non-significant impacts
Criteria (eg, generic – extent, duration, frequency, probability, reversibility, magnitude and significance criteria)	To indicate factors that went into significance determinations

Table 2 (*Continued*)

Methods	Roles
Scaling systems (eg, no, minor, moderate, major)	To differentiate degrees of significance
Technical qualitative and quantitative significance determination methods (eg, analytical hierarchy process, concordance analysis, thresholds analysis)	To combine scaling levels for different criteria in a transparent and consistent manner as a basis for decision-making
Holistic techniques (eg, conceptual and quantitative models, scenarios, network diagrams)	To address significance at a systems level
Participation techniques (eg, nominal group process, interactive community forum, focus groups, workshops)	To interpret significance from multiple perspectives in an interactive setting
Support methods (eg, public involvement techniques, data collection and analysis, communications, impact distributional analyses, statistical analyses, group interaction methods)	To ensure a sound foundation for application of significance interpretation methods
Synthesis and Cumulative Effects Analysis	
Questionnaire checklists	To scope cumulative impacts To provide a consistent beginning for cumulative effects assessment
Umbrella concepts and principles (eg, sustainability, pollution prevention, precautionary principle, biodiversity)	To provide a framework for integrating and structuring analysis
Teamwork procedures (eg, adaptive environmental assessment and management, scenario building, panel evaluation)	To systematically identify and explore cumulative effects in a flexible and interactive forum To integrate expert opinion
Analytical approaches (eg, spatial analysis, network analysis, interactive matrices, systems analysis, ecological modeling, expert opinion, biogeography analysis)	To organize information To explore interrelationships and characterize systems To analyze interactions among effects (no normative evaluation or prescription)
Planning and evaluation approaches (eg, multi-criteria evaluation, programming models, land suitability evaluation, process guidelines, carrying capacity analysis)	Incorporates normative evaluation into procedure
Consultation procedures (eg, workshops, open houses, advisory committees)	To integrate perspectives and values of interested and affected parties
Alternatives Formulation and Evaluation	
Exploration of need, problems, opportunity and objectives	To ensure analysis assesses options for better meeting need, resolving problem, taking advantage of opportunity and satisfying objectives
Comparable project and setting reviews	To identify reasonable alternatives To identify environmentally benign and sustainable alternatives

Table 2 (*Continued*)

Methods	Roles
Idea generation (eg, brainstorming, analogies and metaphors, comparison with ideal, forced relationship, free association)	To creatively identify range of plausible options that might not be customarily considered
Expert and public involvement methods (eg, surveys, advisory committees, dialectical scanning, plebiscites, Delphi)	To draw upon public and expert knowledge and perspectives
	To identify, explore and evaluate, in an interactive forum, potential options
Network diagrams, fault trees, event trees, scenarios, models	To work back from environmental impacts to impact sources as a means of determining where alternative means and mitigation needed and most likely to be effective
Screening evaluation methods (eg, comparisons against regulatory standards, conjunctive screening, overlaps and constraint mapping, lexicographic screening, dominance analysis)	To provide a clear and consistent basis for excluding clearly unacceptable and inferior alternatives
Quantitative and qualitative evaluation techniques (eg, social cost benefit, graphical approaches, goals achievement matrix, additive models, pairwise comparison, closest to ideal, mathematical programming, concordance analysis)	To provide a systematic, traceable procedure for determining the preferred alternative when multiple criteria and multiple stakeholders
Supported by scaling, ranking and weighting methods	To help ensure that evaluation methods are consistent and explicit
Supported by uncertainty and sensitivity analyses	To facilitate evaluation when major uncertainties
Participation	
Consultation (eg, information in, information out, two-way information flow, continuous involvement as with advisory committees, formal involvement as with litigation)	To inform and involve the public
	To provide the EIA process with public issues, knowledge and perspectives
Communications (eg, publicity, dialogue, enhanced dialogue)	To enhance public, proponent and regulator understanding
	To ensure that information is relevant, accurate and unbiased
Mutual education (eg, community education, proponent, regulator and specialist education, mutual education)	To enhance public, proponent and regulator knowledge
	To foster mutual, social, collaborative and transformative learning
Negotiations (eg, unassisted, third party assistance, third-party decision-making)	To avoid and reduce conflict
	To develop mutually acceptable decisions
	To ensure a just and equitable process and outcome

Table 2 (*Continued*)

Methods	Roles
Collaboration (eg, joint and collaborative planning, joint management, creative collaboration)	To build consensus, trust and support for decisions
	To foster collaborative and creative problem-solving
	To obtain tangible environmental benefits
Delegated decision-making (eg, voluntary siting processes)	To bring decision-making close to the people
	For the people and communities affected by a decision to make the decision
	To correct power imbalances
Management	
Mitigation and enhancement measures (eg, physical, operational, statutory, accepted practice, negotiated)	To prevent, avoid, reduce or rectify adverse impacts
	To maximize benefits especially for those most affected and most disadvantaged
Compensation measures and local benefits (eg, payments in kind, or cash, impact related, equity related)	To redress or offset negative impacts that occur despite mitigation
Monitoring (ie, repetitive measures of environmental values) (emissions and effluents, environmental,	To detect changes caused by external influences
Contingency measures	To aid in detecting and providing timely responses to potential problems and unanticipated impacts
Community liaison	To identify and resolve issues
Auditing and evaluation	To systematically and periodically document and review monitoring results
	To determine actual impacts relative to objectives and forecasts for purposes of EIA enhancement
Impact management (all of the above)	To integrate individual impact management measures into a coherent strategy
Project management	To design, guide, control and adapt EIA process and document preparation and review
	To coordinate and integrate specialist analyses and procedural actions (eg, public and agency involvement)
	To link EIA process to decision-making and to related actions

[a]Sources: Barrow, 1997; Canter, 1995; Gilpin, 1995; Glasson, Therivel and Chadwick, 1999; Morgan, 1998; Morris and Therivel, 2001. See General References for complete citation.

and government agencies are often particularly concerned with human health and ecological risks from chemical or chemical waste emissions or effluents. Addressing the risks and uncertainties associated with acute and chronic air emissions and with potential surface and groundwater contamination are often especially important. Exposure to both humans eg, by breathing emissions or

consuming local crops and livestock, and ecological receptors should be considered. Comparisons against regulatory standards often only partially address the pathways between chemicals and receptors. Frequently, quantitative risk assessment, the systematic consideration of uncertainties, risk and uncertainty management, and an open and collaborative approach to perceived risks also are necessary.

5. New Directions and Emerging Priorities

EIA is far from static. Good practice necessitates being aware of emerging patterns and of being on the "leading edge" of this rapidly changing field.

5.1. EIA and Environmental Management. Private corporations and public agencies are increasingly using environmental management systems (EMS) to proactively and independently demonstrate their performance in addressing environmental and social concerns. An EMS can frame a proposed project EIA by providing environmental policies, planning and management review procedures, checking and corrective action protocols, and implementation and operational procedures (12). An EMS ensures that an environmental management structure, with clearly defined environmental policies, responsibilities, training procedures, controls, communications and monitoring and auditing procedures, is already in place (13).

EMS can provide an environmental and impact prediction baseline, a focused means of effectively anticipating, avoiding and minimizing potential adverse environmental impacts, a structure for instituting mitigation and monitoring measures, and a departure point for community liaison and agency review. Life cycle assessment (LCA), an EMS tool, can help systematically and comprehensively assess a proposed action and its alternatives over the life of an activity (14). Some adaptations are necessary because of the differences between EIA and EMS (15).

5.2. EIA Quality, Effectiveness and Good Practice. The EIA "learning curve" has accelerated in recent years with the greater use of EIA quality—a tool for assessing EIA institutional arrangements, documents, processes and methods—and EIA effectiveness—a tool for assessing the direct and indirect outputs from EIA regulatory regimes and from EIA processes, documents and methods—procedures (16). More "good practice" EIA, SEA and SIA principles and guides also are available, including one that places impact assessment in a corporate context (17–20). EIA quality and effectiveness analyses systematically apply performance standards and criteria to EIA institutional arrangements and practices. The principles and guides address such matters as definitions, core values, objectives, basic, operating and guiding principles, performance criteria, process steps, activities, variables and good practices.

The increased stress on EIA quality, effectiveness and good practice demonstrates that simply meeting current EIA requirements is necessary but not sufficient. Environmental professionals also need to consider evolving standards of good regulatory and applied practice. By doing so they will satisfy professional ethical standards and anticipate emerging general and likely future project-specific EIA requirements and guidelines.

5.3. Broadening and Reorienting EIA. *Social and Economic Impacts.* EIA literature and good practice guides are devoting more attention to direct and indirect impacts on people and on how people make a living, material well-being and economic activities impacts. EIA commentators and practitioners commonly acknowledge that physical/biological and social/economic impacts are highly interrelated, that cumulative effects cannot be adequately addressed if social and economic effects are not fully considered, and that public concerns often focus on potential social and economic impacts. EIA requirements, to this point, have largely lagged behind in adequately addressing social and economic concerns. This gap will not necessarily remain.

EIA Procedural and Outcome Fairness, Equity and Justice. The fairness of the EIA process and the fairness of the distribution of outcomes from the process has received greater attention in recent years. Proactive efforts have been made in Canada, for example, to offset procedural inequities, such as through the provision of participant funding, and to include traditional and community knowledge. Increased emphasis is being placed on determining and offsetting inequities in the distribution of impacts and benefits, especially for the disadvantaged. The U.S. Council on Environmental Quality (U.S.CEQ) (21) and the U.S. Environmental Protection Agency (U.S. EPA) have both issued guidance documents for incorporating environmental justice concerns into documents prepared under the NEPA (22).

EIA and Sustainability. Sustainability is about the long-term maintenance of necessary and desirable natural, social and economic environmental attributes. When integrated with EIA both positive and negative impacts are assessed, instead of the current focus on adverse impacts. Proposed actions and alternatives are evaluated in terms of if and the extent to which they contribute to or undermine ecological and especially local societal sustainability. The scope of EIA is broadened to encompass sustainability visions and global and future generational interests. Impacts are viewed from a systems perspective. More emphasis is placed on ecological, social and economic interdependencies, on protecting the most vulnerable, the poor and the disadvantaged, on optimal resource use and management, and on empowering local communities. Sustainability was initially integrated into the purposes and objectives of EIA requirements in Australia, Canada and Europe, for example. Increasingly it is being used as a performance standard for assessing proposed actions.

Uncertainty and Precaution. Uncertainty is about gaps in data, knowledge or understanding. Precaution, or more commonly the Precautionary Principle (PP) or Approach, addresses the dilemma of what to do when scientific knowledge is incomplete and there is a threat of serious adverse consequences. There are usually uncertainties associated with every EIA activity. There are many methods for reducing and managing uncertainties, including moving toward a more adaptive EIA process. Integrating the PP into an EIA process can, depending on the interpretation adopted, result in project rejection, impact amelioration, a greater burden of proof on proponents, proceeding with caution or building a reasonable case that a proposed action is safe.

The United States has focused on the systematic (formal, where practical) consideration of data quality, risks and uncertainties, in combination with a more adaptive environmental management approach. Other jurisdictions, such

as Canada, Europe and Australia, also address uncertainties, usually less formally. However, they sometimes apply, albeit hesitantly, the PP in EIA practice. Either way determining, interpreting and managing uncertainties and designing and managing adaptive EIA processes are receiving greater attention.

Collaborative EIA Processes. Historically, EIA tends to entail technical, rational document preparation, and decision-making procedures. Public and agency concerns and perspectives are treated as process inputs, usually directed toward the more "subjective" EIA activities, such as scoping, alternatives evaluation, significance interpretation and decision-making. The public tends to be dissatisfied with selective, periodic and limited public involvement, when they believe that proposed actions could seriously affect their lives. Sometimes such public involvement procedures exacerbate conflict. Often, they underestimate public knowledge. Frequently they gloss over the subjective nature of most EIA activities and mask implicit biases. Arguably, all interested and affected parties have a "right" to be directly involved in procedures that can affect their day-to-day lives.

Increasingly, EIA processes are becoming more collaborative. Collaborative EIA processes involve more than periodic, tightly circumscribed, public involvement. They include two-way information exchanges. They incorporate more continuous forms of public participation, sometimes as advisory committees. They provide for and facilitate dialogue, mutual education, negotiations and joint and creative planning, management and collaboration. Facilitators, mediators and other third parties often aid the procedure. Sometimes measures, such as participant funding, facilitate the involvement of traditionally underrepresented parties. Proponents sometimes are reluctant to become involved in such procedures. They tend to argue that they will be too costly, time-consuming and divisive. They also tend to fear that they will lose control of the process. In practice, technical procedures, with limited provision for public involvement, can be more divisive. The resulting confrontations can heighten opposition and result in greater costs, longer delays and higher failure rates.

CITED PUBLICATIONS

1. D. P. Lawrence, *Environmental Impact Assessment*, John Wiley & Sons, Inc., New Jersey, NJ, 2003, p. 7.
2. R. B. Smythe, in R. Clark and L. Canter, eds. "The Historical Roots of NEPA" *Environmental Policy and NEPA*, St. Lucie Press, Boco Raton, Fla., 1997.
3. H. A. Becker, *Social Impact Assessment: Method and Experience in Europe, North America and the Developing World*, UCL Press Ltd., London, 1997.
4. B. Sadler, *Environmental Assessment in a Changing World - Final Report*, International Study of the Effectiveness of Environmental Assessment, Canadian Environmental Assessment Agency and International Association for Impact Assessment, June 1996.
5. D. P. Lawrence, *Impact Assessment* **15**, 3–13 (1997).
6. The NEPA Task Force, *Modernizing NEPA Implementation*, Report to the Council on Environmental Quality, Sept. 2003.
7. Government of Canada, *Canadian Environmental Assessment Act*, Office Consolidation, Nov. 2003.

8. United States Council on Environmental Quality (U.S. CEQ), *The National Environmental Policy Act – A Study of Its Effectiveness After Twenty-Five Years*, CEQ, Executive Office of the President, 1997.
9. European Union, *Directive 2001/42/EC of the European Parliament and the Council on the Assessment of the Effects of Certain Plans and Programs on the Environment*, European Parliament and the Council of the European Union, Luxembourg, 27 June 2001.
10. D. P. Lawrence, *J. Environmental Assessment Policy and Management* **3**, 437–464 (2001).
11. D. P. Lawrence, *Environmental Impact Assessment*, John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.
12. B. Ridgway, *J. Environmental Assessment Policy and Management* **1**, 393–406 (1999).
13. M. C. J. Burgham, S. H. Brassat, W. A. Ross and D. A. R. Thompson, *Impact Assessment and Project Appraisal* **16**, 155–161 (1998).
14. A. Tukker, *Environmental Impact Assessment Review* **20**, 435–456 (2000).
15. J. M. Loney and co-workers *Environmental Practice* **5**, 321–329 (2003).
16. D. P. Lawrence, *Project Appraisal* **12**, 219–232 (1997).
17. International Association for Impact Assessment (IAIA), *Principles of Environmental Impact Assessment Best Practice,* IAIA and Institute of Environmental Assessment, UK, IAIA, Fargo, ND, 1999.
18. International Association for Impact Assessment (IAIA), *Social Impact Assessment International Principles*, IAIA, Fargo, ND, May 2003.
19. Interorganizational Committee on Principles and Guidelines for Social Impact Assessment, "Principles and Guidelines for Social Impact Assessment in the USA", *Impact Assessment and Project Appraisal* **21**, 231–250 (2003).
20. International Association for Impact Assessment (IAIA), *Impact Assessment in the Corporate Sector*, IAIA, Fargo, ND, May 2002.
21. U.S. CEQ, *Environmental Justice Guidance Under the National Environmental Policy Act*, U.S. CEQ, Washington, D.C., 1997.
22. U.S. EPA, *Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analyses*, Office of Federal Activities, Washington, D.C., 1998.

GENERAL REFERENCES

C. J. Barrow, *Environmental and Social Impact Assessment*, Arnold, London, 1997.
L. W. Canter, *Environmental Impact Assessment*, 2nd ed., McGraw-Hill, Inc., New York, 1995.
R. E. Bass, A. I. Herson and K. M. Bogden, *The NEPA Book: A Step-by-Step Guide on How to Comply With The National Environmental Policy Act*, Solano Press Books, Point Arena, Calif., 2001.
H. Becker and F. Vanclay, *The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances*, Edward Elgar, Northhamton, Mass., 2003.
R. J. Burdge, *A Conceptual Approach to Social Impact Assessment*, 2nd ed., Social Ecology Press, Middleton, Wisc., 1998.
C. H. Eccleston, *Environmental Impact Statements*, John Wiley & Sons, Inc., New York, 2000.
A. Gilpin, *Environmental Impact Assessment – Cutting Edge for the Twenty-First Century*, Cambridge University Press, 1995.

J. Glasson, R. Therivel and A. Chadwick, *Introduction to Environmental Impact Assessment*, 2nd ed., UCL Press, London, 1999.
D. P. Lawrence, *Environmental Impact Assessment*, John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.
R. K. Morgan, *Environmental Impact Assessment – A Methodological Perspective*, Kluwer Academic Publishers, London, 1998.
P. Morris and R. Therivel, eds., *Methods of Environmental Impact Assessment*, 2nd ed., Spon Press, London, 2001.
L. Orlolano, *Environmental Regulation and Impact Assessment*, John Wiley & Sons, New York, 1997.
M. R. Partidario and R. Clark, eds., *Perspectives on Strategic Environmental Assessment*, Lewis Publishers, Inc., Boco Raton, Fla., 1999.
R. Therivel, *Strategic Environmental Assessment in Action*, Earthscan Publishers, Ltd., London, U.K., 2004.
C. Wood, *Environmental Impact Assessment: A Comparative Review*, 2nd ed., Longman Group, United Kingdom, 2002.

WEB SITES

Australian EIA – http://www.deh.gov.au/assessments/eianet
Canadian Environmental Assessment Agency (CEAA) http://www.ceaa.gc.ca
European EIA – http://europa.eu.int/comm/environment/eia/home.htm
International Association for Impact Assessment (IAIA) – info@iaia.org.www.iaia.org
National Association of Environmental Professionals (NAEP) – www.naep.org
U.S. National Environmental Policy Act (NEPA Net) – http://nepa/nepanet.htm

DAVID P. LAWRENCE
Lawrence Environmental