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Quality Science in the Courtroom: U.S. EPA Data Quality and Peer Review Policies and Procedures Compared to the Daubert Factors

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Protection of the environment is critically dependent on the quality of data used in decision making. Whether the decisions are part of the scientific process or relate to application of the laws governing people and their living conditions, good quality data are required/needed by two disciplines with distinct differences. This paper examines some differences between science and the law, provides a brief history of science in law, discusses the effects of law on science, compares United States Environmental Protection Agency (U.S. EPA) guidance and U.S. Supreme Court credible science criteria. This paper further speculates on the future use of science data by the courts. © 2000 AEHS

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Introduction

Scientists and quality assurance professionals are often reminded of the over-arching threat, "If you are unlucky, your data may go to court and it must be defensible". From the scientist's perspective, that can sound insulting, implying that some anonymous criteria may not be met. If a scientific expert follows the scientific method, measures accurately, ensures the accuracy and precision of the results, and interprets the outcome correctly . . . why worry about the courtroom? Good science is good science!

Lawyers working in the area of technology and science need science and defensible data to win a favorable judgement in court. The science theories and data needed to prove a legal claim or defense are identified as evidence. For this evidence to be useful in court, the evidence must be admissible. For the evidence to be admissible, the evidence must be relevant and authentic. Unfortunately, these attributes are not always easily measurable.

Scientific and legal disciplines have different perspectives. Robert A. Bohrer, a law professor at California Western School of Law, San Diego, describes three basic differences between law and science (Bohrer, 1997):

- science is digital—it focuses on measurement; law is analogical—it focuses on precedent;
- science is predictive, general, and replicable; law is retrospective and particular;
- science is objective and universal; law is normative and contingent.

There are a host of disciplines within law where science concepts are routinely applied, including intellectual property (patent, copyright, and trademark) law, water law, construction law, environmental law, medical malpractice, product liability, criminal law, and natural resources law. The legal community works with science concepts and data in a dynamic way, constantly confronted by new issues regarding science including, for example:

- DNA techniques used now for purposes of identification of individuals in criminal and civil proceedings as well as individuals who may be susceptible to certain diseases;
- cloning techniques and their application in humans and food products;
- environmental forensic studies (Wait, 2000).

Applications of science in the practice of law and the overall impacts of legal requirements on the scientific community are too broad to consider in this paper. This paper adopts the perspective of the scientist and focuses on the use of evidence at trial. It provides a general background on important cases, legal rulings, and legal principles that lawyers consider when evaluating acceptability and admissibility of scientific evidence.

History

This section summarizes some basic information about admissibility of scientific evidence including common law, the Frye rule, Federal Rules of Evidence, and the Daubert Rule. The Daubert Rule is also discussed in light of its application in other cases.

U.S. Common law

"Common law is a body of law that develops and derives through judicial decisions, as distinguished

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from statutory enactments" (Black, 1991). As such, "common law" is all the legislative and case law background of England and the American colonies before the American revolution. Under common law, triers (judges) had no "standard guidelines" to determine admissibility of scientific evidence. Today, U.S. law is a mixture of common law and statutory law.

Admissibility

A short discussion of the requirements of admissibility of evidence is necessary to provide an understanding of the fundamental aspects of this paper. For any evidence to be admitted it must be relevant. All trial courts make a preliminary determination of admissibility. This job involves a preliminary assessment of whether the evidence is relevant, authentic, and trustworthy. In short, can the evidence be properly applied to the facts in this case? This is the traditional "gatekeeping" function of courts. The Daubert Factors are, in a sense, reliability factors and can become critical points in admissibility of scientific evidence.

The Frye Rule

The Frye Rule was the first standard applied to the admissibility of scientific data, and is still used in more than 20 states. The case history follows: *Frye v. United States* [54 App. D.C. 46, 293 F. 1013, 1014 (Cir.1923)] Frye confessed to murdering a doctor. He later retracted his confession and offered a weak alibi. To support his alibi, Frye tried to introduce as evidence the fact that he passed a "systolic blood pressure deception test". This test was a precursor of the modern polygraph, or "lie detector". The trial court rejected this evidence. The appellate court upheld the lower court's finding:

> Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone, the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, *the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs* [emphasis added].

The italicized part of the above quote became known as the "Frye Rule". This rule was widely used to determine whether expert testimony should be considered at trial. The court did not elaborate on the meaning of the phrase "general acceptance". This resulted in a lot of debate on the scope and application of the rule.

Federal Rules of Evidence

The Federal Rules of Evidence were codified in 1975, more than 50 years after *Frye v. United States*. The rules were enacted by Public Law 93–595, approved January 2, 1975, and have been amended by Acts of Congress, and further amended by the United States Supreme Court, 106th congress, 1st session. "These rules (were) construed to secure fairness in administration, elimination of unjustifiable expense and delay, and promotion of growth and development of the law of evidence to the end that the truth may be ascertained and proceedings justly determined" (Federal Rules of Evidence Rule 102). These rules are currently under revision to make them compatible with the *Daubert* decision.

Federal Rule 104 concerns general questions of admissibility and relevancy. Federal Rules 403, 702, and 703 relate directly to scientific testimony. Excerpts from these rules are presented. The important point here is that these rules are the window through which the court may examine, evaluate, and decide on the quality of the data that is being used in expert scientific testimony.

> *Rule 104 provides*:
> "*a. Questions of admissibility generally*. Preliminary questions concerning the qualification of a person to be a witness, the existence of a privilege, or the admissibility of evidence shall be determined by the court, subject to the provisions of subdivision (b). In making its determination it is not bound by the rules of evidence except those with respect to privileges.
> *b. Relevance conditioned on fact*. When the relevance of evidence depends upon the fulfillment of a condition of fact, the court shall admit it upon, or subject to, the introduction of evidence sufficient to support a finding of the fulfillment of the condition." (Federal Rules of Evidence, Rule 104).

> *Rule 403 provides*:
> "Although relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by considerations of needless presentation of cumulative evidence." (Federal Rules of Evidence, Rule 403).

> *Rule 702 provides*:
> "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness *qualified* as an expert by *knowledge*, *skill*, *experience*, *training*, *or education*, may testify thereto in the form of an opinion or otherwise" (emphasis added) (Federal Rules of Evidence, Rule 702).

> *Rule 703 provides*:
> The facts or data in the particular case upon which an expert bases an opinion or inference may be those perceived by or made known to the expert at or before the hearing. If of a type reasonably relied upon by experts in the particular field in forming opinions or inferences upon the subject, the facts or data need not be admissible in evidence (Federal Rules of Evidence, Rule 703).

There was a lot of debate on whether or not the Federal Rules of Evidence replaced the Frye Rule. Soon after the codification of the Federal Rules of Evidence, criticism was aimed at some federal judges who interpreted the 1975 rules as allowing that almost any testimony said to be "scientific" to be presented to a jury. Some critics argued that courts were issuing decisions based on pseudo-scientific testimony that had little basis in reality.

The Daubert Rule

The Daubert Rule represents the first of three recent United States Supreme Court rulings giving guidance on admissibility of scientific theory and evidence. The case history follows.

Daubert v. Merrell-Dow Pharmaceuticals, Inc., 509 U.S. 597 (1993): Daubert and Schuller are children born with birth defects. They and their parents sued, alleging that the birth defects had been caused by the mothers' ingestion of Bendectin, a prescription drug marketed by Merrell-Dow. Merrell-Dow brought a motion for summary judgment, introducing a declaration by an expert epidemiologist that no link had been found between Bendectin and birth defects after more than 30 published studies involving over 130,000 patients. Daubert and Schuller countered with a series of declarations describing animal and pharmacological studies indicating a possible link. None of these studies had been published or subjected to peer review. The district court ruled that the Daubert and Schuller's expert opinions were inadmissible, citing *Frye v. United States*, because they did not reflect accepted scientific thought. The court of appeals affirmed, and the Supreme Court granted review.

The Supreme Court majority held that an expert theory on causation need not be generally accepted as reliable in the relevant scientific community in order to be admissible. Expert witnesses are governed by Federal Rules of Evidence 702, which supersedes the Frye text. Nothing in the legislative history behind the Rule suggests the "general acceptance" standard used by the district court. Contained in the Rule 702 terminology are several requirements; the opinion must involve "knowledge", implying that it must have been the result of scientific inquiry, not speculation. Also, the basic rules of relevance, such as probative value *v.* prejudicial effect, remain in place. Essentially, the district judge must perform a gatekeeping role, only permitting into evidence that which is sound from a scientific and methodological perspective. However, something methodologically sound from a scientific point of view need not be generally accepted.

In this case, the expert's research was prepared solely for the purposes of the litigation; it had not been subject to peer review nor had it received comment by the scientific community, and the experts had not explained their methodology nor verified it by reference to objective sources. The proposed testimony also failed the "fit" test because it tended only to prove that Bendectin increased the risk of limb reduction, rather than that it was more likely than not that it caused plaintiffs' reduction.

The Daubert case explicitly contemplates that the district courts will have a gatekeeping role with respect to scientific expert evidence. While declining to adopt a definitive checklist or test, the Supreme Court noted that one way to ensure the relevancy and reliability of scientific evidence is by reading FRE Rule 702 in conjunction with Rule 104(a). Rule 104(a) allows the judge to "make a preliminary assessment of whether the testimony's underlying reasoning or methodology is scientifically valid and properly can be applied to the facts at issue" (Daubert 509 U.S. 597, 1993). Those factors include:

(1) Does the theory or technique involve testable hypotheses?
(2) Has the theory or technique been subject to peer review and publication?
(3) Are there known or potential error rates and are there standards controlling the technique's operation?
(4) Is the method or technique generally accepted in the scientific community?

Technically, the Daubert case is used extensively as a citation or precedent in federal actions. Since Daubert, additional Supreme Court cases have tested the ruling and the applicability of the Daubert factors. Application of the Daubert Rule in the *Joiner v. General Electric* case resulted in additional guidance; that case history follows.

The Daubert Rule in the *General Electric Company v. Joiner* Case

General Electric Company v. Joiner, 522 U.S. 136, 146 (1977): Beginning in 1973, Joiner worked as an electrician in the city's Water & Light Department, a position requiring him to work with and around the city's electrical transformers. Throughout Joiner's employment, all of the city's transformers should have used as a coolant a mineral oil based dielectric fluid that was free of polychlorinated biphenyls (PCBs). However, in 1983, the city discovered PCB contamination in the dielectric fluid used in some of its transformers. From 1983 to 1993, the city conducted tests and concluded that almost one out of every five of the transformers tested presented a PCB hazard.

When a transformer was in need of repair, it was Joiner's duty to open it, drain out the dielectric fluid, bake the core of the transformer dry of dielectric fluid, make repairs, refill the transformer with fresh mineral oil dielectric fluid, and then test the transformer. These repairs required that Joiner stick his hands and arms into the dielectric fluid. Joiner testified that dielectric fluid got all over him at times, that he would swallow a small amount of dielectric fluid when it splashed into his mouth, and that dielectric fluid had splashed into his eyes on several occasions. In 1991, at the age of 37, Joiner was diagnosed with lung cancer. The Joiners' theory of the case was that while Joiner's history of cigarette smoking and his family history of lung cancer may have predisposed him to developing lung cancer, his exposure to PCBs and their derivatives polychlorinated dibenzofurans ("furans") and polychlorinated dibenzodioxins ("dioxins") served to promote his small cell lung cancer.

The case had drawn intense interest from corporate America. Lawyers for the United States Chamber of Commerce, the National Manufacturers Association, the Chemical Manufacturers Association, the American Medical Association, and a half dozen others filed briefs urging the court to block the lawsuit.

Joiner sued General Electric (maker of transformers) and Monsanto (maker of PCBs). The judge in the District Court ruled that the expert testimony offered in support of Joiner's claim was not admissible under the Daubert rule because the *experts' conclusions were not supported by the scientific papers they cited.*

On 15 December 1997, the Supreme Court strengthened the power of judges to keep so-called "junk science" out of the courtroom by stating that:

> the District Court did not err in excluding the expert testimony at issue. The animal studies cited by respondent's experts were so dissimilar to the facts presented here, i.e. the studies involved infant mice that developed alveologenic adenomas after highly concentrated, massive doses of PCBs were injected directly into their peritoneums or stomachs, whereas Joiner was an adult human whose small cell carcinomas allegedly resulted from exposure on a much smaller scale that it was not an abuse of discretion for the District Court to have rejected the experts' reliance on those studies. Nor did the court abuse its discretion in concluding that the four epidemiological studies on which Joiner relied were not a sufficient basis for the experts' opinions, since the authors of two of those studies ultimately were unwilling to suggest a link between increases in lung cancer and PCB exposure among the workers they examined, the third study involved exposure to a particular type of mineral oil not necessarily relevant here, and the fourth involved exposure to numerous potential carcinogens in addition to PCBs. Nothing in either Daubert or the Federal Rules of Evidence requires a district court to admit opinion evidence which is connected to existing data only by the *ipse dixit* of the expert.

The relevance of this case to the quality of science lies in the opinion made by an expert based on scientific research conducted by other scientists. The experts' opinion was not, in essence, peer reviewed. This emphasizes the fact that an expert must base an opinion on relevant data.

The Daubert Rule in the *Kumho Tire Co. v. Carmichael* Case

Both the Daubert and Joiner cases dealt with the Daubert Factors as applied to "science". The triers' role as gatekeeper were again further expanded when the Supreme Court ruled that the Daubert Rules apply to all expert testimony (e.g. lab data and engineering reports) as well.

> *Kumho Tire Co. v. Carmichael*, 526 U.S. 137 (1999): When a tire on the vehicle driven by Patrick Carmichael blew out and the vehicle overturned, one passenger died and the others were injured. The survivors and the decedent's representative, respondents here, brought this diversity suit against the tire's maker and its distributor (collectively Kumho Tire), claiming that the tire that failed was defective. They rested their case in significant part upon the depositions of a tire failure analyst, Dennis Carlson, Jr., who intended to testify that, in his expert opinion, a defect in the tire's manufacture or design caused the blow-out. That opinion was based upon a visual and tactile inspection of the tire and upon the theory that in the absence of at least two of four specific, physical symptoms indicating tire abuse, the tire failure of the sort that occurred here was caused by a defect. Kumho Tire moved to exclude Carlson's testimony on the ground that his methodology failed to satisfy Federal Rule of Evidence 702, which says: "If scientific, technical, or other specialized knowledge will assist the trier of fact . . . , a witness qualified as an expert . . . may testify thereto in the form of an opinion". Granting the motion (and entering summary judgement for the defendants), the District Court acknowledged that it should act as a reliability "gatekeeper" under *Daubert v. Merrell Dow Pharmaceuticals Inc.*, 509 U.S. 579, 589, in which this court held that Rule 702 imposes a special obligation upon a trial judge to ensure that scientific testimony is not only relevant, but reliable. The court noted that Daubert discussed four factors—testing, peer review, error rates, and "acceptability" in the relevant scientific community—which might prove helpful in determining the reliability of a particular scientific theory or technique, id., at 593, 594, and found that those factors argued against the reliability of Carlson's methodology. On the plaintiffs' motion for reconsideration, the court agreed that Daubert should be applied flexibly, that its four factors were simply illustrative, and that other factors could argue in favor of admissibility. However, the court affirmed its earlier order because it found insufficient indications of the reliability of Carlson's methodology. In reversing, the Eleventh Circuit held that the District Court had erred as a matter of law in applying Daubert. Believing that Daubert were limited to the scientific context, the court held that the Daubert factors did not apply to Carlson's testimony, which it characterized as "skill or experience based".

The Supreme Court in this case held that the Daubert factors may apply to the testimony of engineers and other experts who are not scientists because:

(1) The Daubert "gatekeeping" obligation applies not only to "scientific" testimony, but to all expert testimony;
(2) A trial judge determining the admissibility of an engineering expert's testimony may consider one or more of the specific Daubert factors;
(3) The court of appeals must apply an abuse of discretion standard when it reviews the trial court's decision to admit or exclude expert testimony.

U.S. EPA Quality Assurance *v.* the Daubert Factors

How does the U.S. EPA Quality System relate to the Daubert Rule today? "Quality Assurance is the thread that weaves through diverse disciplines . . ." (Brilis, 1998). The EPA has developed a Quality System to manage the quality aspects of its environmental data collection, generation, and use. The goal of the EPA Quality System is to ensure that its environmental data are of sufficient quantity and quality to support the data's intended use. The EPA Quality System requires that each EPA Office, Region, and Center develops and implements supporting Quality Systems. EPA's Quality System requirements also apply to extramural agreement holders (i.e. contractors, grantees, and other recipients of financial assistance from EPA). The EPA Quality System is based on ANSI/ASQC E4-1994 (American National Standard, 1995). This approach includes a traditional emphasis on management and organization, descriptions of roles and responsibilities, project and program planning, implementation processes, and assessment processes. The body of the EPA Quality System includes both requirement ("R") and guidance ("G") documents.

Environmental research and data analyses performed by and for the EPA are often done under conditions and purposes that may be subject to the Daubert factors. Such data, and/or theories expressed, as well as expert opinions, might better withstand scrutiny under Daubert because of the presence of

Table 1. Comparison of Daubert Factors with USEPA requirements and guidance documents

The "Daubert Factor"	EPA QA Analogy
Does the theory or technique involve testable hypotheses?	EPA QA/G-4 DQO Process before implementation of project. EPA QA/G-9 DQA Process after completion of project.
Has the theory or technique been subject to peer review and publication?	EPA *Peer Review Handbook*.
Are there known or potential error rates and are there standards controlling the technique's operation?	EPA QA/G-4 DQO Process before implementation of project. EPA QA/G-9 DQA Process after completion of project. EPA QA/R-5 Requirements for Quality Assurance Project Plans—Interim Final.
Is the method or technique generally accepted in the scientific community?	EPA *Peer Review Handbook*.

EPA quality and peer review programs, both of which support the concept of "quality science". Individual processes in the Quality System can be considered to support specific aspects of the Daubert Rule. Other EPA processes also support assurance of the implementation of "quality science". The EPA peer review policy is described in *EPA Peer Review Handbook* (EPA 10-B-98-0001) which can be found on the Internet at http://www.epa.gov/ostwater/WET/pdf/prhandbk.pdf.

The principle documents that relate the EPA Quality System to the Daubert Rules are available through the Internet at http://www.epa.gov/quality/qa_docs.html. Specifically, these include:

- EPA QA/G-4 Guidance for the Data Quality Objectives Process (EPA/600/R-96/055). http://www.epa.gov/quality/qs-docs/g4-final.pdf
- EPA QA/G-4D Data Quality Objectives Decision Errors Feasibility Trials (DEFT) Users Guide and Software (EPA/600/R-96/056). http://www.epa.gov/quality/qs-docs/g4d-final.pdf and http://www.epa.gov/quality/qs-docs/deftv4.exe
- EPA QA/G-4HW Guidance for the Data Quality Objectives Process for Hazardous Waste Sites (EPA/600/R-00/007). http://www.epa.gov/quality/qs-docs/g4hw-final.pdf
- EPA QA/R-5 Requirements for Quality Assurance Project Plans—Interim Final. http://www.epa.gov/quality/qs-docs/r5-interim-final.pdf
- EPA QA/G-9 Guidance for Data Quality Assessment: Practical Methods for Data Analysis (EPA/600/R-96/084). http://www.epa.gov/quality/qs-docs/g9-final.pdf
- EPA QA/G-9D Data Quality Evaluation Statistical Toolbox (DataQUEST) Users Guide and Software (EPA/600/R-96/085). http://www.epa.gov/quality/qs-docs/g9d-final.pdf and http://www.epa.gov/quality/qs-docs/dquest96.exe

Table 1 compares the Daubert Factors with EPA guidance and requirements documents.

Discussion

Application of the Daubert Factors to environmental programs and their supporting data requires an assessment of exactly what the legal concepts are and what are the actual processes to which they apply in an environmental program. The Daubert factors look specifically at the theory or technique and some areas associated with the theory or technique (e.g. peer review, error rates, standards for control, and general acceptance).

Critical questions might be: Does Daubert attempt to "codify" what scientists do as a matter of routine process to ascertain and assure accuracy and reliability? Is this a marriage of courtroom and laboratory to ensure that a judge fulfills his/her role in being scientifically deputized? What are the science-related theories or techniques involved in environmental programs? Theories and techniques may be based on one or more disciplines such as:

- experimental design
- engineering design
- sampling
- chemistry/biology
- quality assurance
- statistical analysis
- risk assessment
- risk management

When do the Daubert Factors come into play? Maybe not at all. The Daubert Factors would most likely apply to novel situations where a standard approach to performing the operation does not exist. For example, if the investigation activity is predetermined according to a known method and the analytical work is performed according to a known method (i.e. EPA and ASTM methods), then discussions about what might constitute needed proof for a hypothetical situation may be totally unnecessary. For much of the environmental work performed on a routine basis, this approach may simply not be necessary. However, when the activity requires the application of scientific expertise, the criteria outlined in the Daubert Factors make sense when looking at admissibility of scientific evidence. The EPA has promoted "Performance-based" methods which allow for the analysis of environmental contaminants using new or novel methods. In these cases the Daubert Factors are more likely to come into play.

How should scientists respond to the complex implication of law on the process of science? Scientists should focus on the overlying charge that forms the basis for all credible work, that is to "assure that environmental data used to support [Agency] decisions are of adequate quality and usability for their intended purpose". Policy and Program Requirements for the Mandatory Agency-wide Quality System (EPA Order 5360.1 CHG 1 July 1998) http://www.epa.gov/quality/qs-docs/5360-1.pdf. Note that the "intended purpose" is key to the establishment of clear objectives for the project, the associated measurements, and their associated quality control criteria (Maney and Wait, 1991; Wait and Douglas, 1995). Each of the Daubert Factors may not be requirements and the end result is not good or bad, depending on the objective; the resulting information can be considered good, better, or best for assisting lawyers in using the overall result to support the original objectives.

From 1993 to 2000 a great number of cases cite the Daubert decision. As such, the authors believe that scientists should consider the following criteria if they wish to have conducted testing or to have produced data that would be considered defensible. While considering these criteria, one may want to consider the impact of addition or omission of these criteria on how they would support the data's intended use.

Planning criteria

- Planning was performed;
- persons planning this work are knowledgeable (expert and trained);
- planning was documented;
- the plan was reviewed;
- the plan included a clear objective(s);
- the plan included readily identifiable measurements to achieve the objectives;
- the plan stated specific QC criteria for the measurements;
- the plan referenced sampling and analytical procedures;

Implementation criteria

- The activity was implemented as planned to the extent possible;
- any significant changes to the plans during implementation were approved and documented;
- there was documented management overview of the implementation;
- there was documented quality assurance overview of the implementation;
- corrective action regarding problems noted during overview was taken and documented;
- the personnel performing the work were trained;
- the records that were kept were accurate;
- the supplies used met requirements;
- measurement devices were calibrated;
- problems encountered were recorded;
- problems were resolved (and documented).

The result and assessment criteria

- Quality control criteria were met;
- report conclusions are supported by data;
- the data were validated;
- the report was reviewed;
- review comments were addressed;
- results are comparable to results from similar work.

Sample authenticity criteria

- Chain-of-custody was maintained;
- sample identity was maintained;
- sample integrity was not compromised;
- sample records were consistent with good record keeping practices.

Data integrity criteria

- Data output records were well maintained;
- computer hardware and software was controlled;
- the quality of any secondary data used is known.

The above information resembles the body of items one might consider in either a Quality Management Plan or a project-specific technical specifications document, such as a Quality Assurance Project Plan.

Scientists and lawyers have similar interests that are based on the overall objectives of the scientific effort. In some cases, quality control needs to focus on a single sample, when that sample might be used to prove the need for enforcement. In other cases, quality control needs to focus on a larger process such as the characterization of a site and potential cleanup. Still in other cases, quality control needs to focus on the proof of a research experiment that looks at a single technology application on a very small area or amount of material. In all cases, planning should consider the overall objective of the process considered during application of scientific techniques or theories.

Conclusion

The future holds many changes and challenges for the environmental forensic scientist. The demand by the legal profession for environmental forensic experts has increased since the inception of the U.S. EPA. This demand has been and will be intensified by the problems of environmental contamination and the lawsuits brought against individuals and corporations by citizens, employees, and public agencies.

We predict that environmental forensic scientists, using advanced analytical techniques and decision making tools such as models and geographic information systems, will become more adept at gathering and analyzing data about complex environmental problems. They will use this data in increasingly sophisticated ways to answer the numerous questions surrounding an environmental case.

The state of quality of science in the courtroom is still evolving as the courts continuously consider the quality of evidence. In the area of environmental forensics, cases where novel scientific theories and/or techniques are employed will have the greatest impact on, or be impacted by, such evolution. The peer-reviewed quality assurance procedures developed by EPA provide valuable guidance that is not only helpful to regulators, but also to litigators and the courts. Recent trends towards the use of performance-based methods, especially those using novel techniques, beg the users to ensure that quality assurance and quality control policies and procedures are in place to assure defensible evidence. However, policies and procedures alone are not enough. Policies and procedures must be implemented and their use must be documented. The case of *Brocklesby v. U.S. and Jeppesen & Co.* [767 F.2d 1288 (1985)] highlights this fact. In this case, Jeppesen claimed that the defective data was obtained from the Federal Aviation Administration (FAA), and therefore no liability should be placed on Jeppesen. The court held that it was incumbent upon Jeppesen to verify the FAA's data by following its own Standard Operating Procedures, which require Jeppesen to verify the integrity of the data.

Additionally, the use of qualified experts that can translate complex and novel scientific methodologies is becoming increasingly important. Indeed, the court may more often retain their own experts to assist judges in deciphering the technicalities of a case. While one may have highly defensible data, the communication of the evidence to the lay person is critical in making a convincing presentation.

Environmental forensic scientists are first and foremost analysts, and their unique abilities will have an increasingly extensive application in the environmental arena. Therefore, it is recommended that environmental forensic scientists be involved from the beginning of the project. That is, to ''plan the investigation, and investigate the plan''.

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Notice

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