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CERCLA Nanotechnology Issues

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EXECUTIVE SUMMARY

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9601 *et seq.*, deals with risks to human health and the environment posed by uncontrolled releases of hazardous materials.

In the context of a rapidly emerging nanotechnology and nanomaterials sector, existing CERCLA mechanisms would be useful primarily to provide response and liability authority if releases of nanoscale materials prove hazardous to human health or the environment. The retrospective CERCLA liability framework is probably most valuable as a backup tool to deal with adverse consequences that are unanticipated or that otherwise elude environmental regulation. Certain provisions of the statute may also operate prospectively to regulate current use and disposal of nanomaterials classified as hazardous.

The functional core of the statute is the "hazardous substance" definition, which serves as the gateway to the substantive response, liability, funding, and reporting mechanisms. The single greatest challenge for applying CERCLA to nanomaterials is deciding whether they fall within this definition. This paper assumes that nanomaterials exist or can be created that will have adverse effects on human health or the environment and therefore can be classified as "hazardous." Because of the unique properties of nanomaterials, it is further assumed that such adverse effects may manifest themselves upon low-level exposure or release. The means of validating these assumptions and their applicability to different classes and uses of nanomaterials are beyond the scope of this paper.

Despite the practical challenges posed by this threshold definitional question, it is possible to conclude that the existing statutory framework is readily adaptable to nanomaterials that are identified, now or in the future, as "hazardous substances." The following discussion focuses on the major elements of the statute and the challenges posed by their application to nanomaterials. It also comments on elements of CERCLA for which nanomaterials present special considerations.

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I. TRIGGERING THE STATUTE: "HAZARDOUS SUBSTANCES" AND RELEASE REPORTING

A. Designation of Hazardous Substances (Section 102)

Virtually all of CERCLA's substantive liabilities and enforcement authorities turn on the statutory definition of "hazardous substances." Release, use, or detection of materials within this category serves to bring the statute to bear on facilities, their owners and operators, and a variety of activities and events.

CERCLA defines "hazardous substances" in the broadest possible terms. In addition to a CERCLA-specific list, the category includes listed or characteristic "hazardous waste" under the Resource Conservation and Recovery Act (RCRA), and materials designated as hazardous or toxic under numerous other statutes.[2] Under CERCLA Section 102(a), the U.S. Environmental Protection Agency (EPA) has omnibus authority to list substances "which, when released into the environment may present substantial danger to the public health or welfare or the environment."[3]

Before considering how these concepts may apply to nanotechnology, it is useful to recall their origin. CERCLA cast a wide net to assure that government would have the authority to react to events and conditions that endanger human health and the environment, and that responsible parties would shoulder a fair share of costs. The broad-spectrum approach to hazardous substances reflects legislative intent to leave no room for jurisdictional hairsplitting. This fundamental philosophy is a hallmark of the statute.

Upon enactment and in the decades since, CERCLA has built on a broad foundation of received knowledge to define what should qualify as a "hazardous substance." Chemicals of concern were and have been defined by reference to extant medical and epidemiological knowledge. Incorporation of regulatory decisions under media-specific programs such as RCRA, the Clean Water Act, the Clean Air Act, and the Occupational Safety and Health Act (OSH Act) brings into the net materials identified as appropriate for regulatory control because of their environmental and human health effects. Those programs also provide conceptual frameworks for risk assessment. CERCLA draws these diverse elements into a comprehensive, flexible mechanism for dealing with environmental harms not regulated under other programs.

When it comes to nanomaterials, no comparable base of knowledge exists today. Yet paradoxically, the CERCLA hazardous substance definition can readily accommodate the fluid and evolving nature of the nanotechnology sector.

The limited studies available today would probably not support the designation of any existing nanomaterial as a CERCLA hazardous substance. Considering the diversity of nanomaterials and the pace and breadth of nanotechnology innovation, the gap between the

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2 *See* CERCLA § 101(14), 42 U.S.C. § 9601(14).

3 42 U.S.C. § 9602(a).

sector and the environmental knowledge necessary to regulate it seems likely to persist and even expand. These problems are compounded by the fact that nanoscale forms of some elements or compounds may present concerns not normally associated with conventional forms of the same materials. Carbon 64 fullerenes and carbon nanotubes, for example, appear to behave differently than bulk elemental carbon; nanoscale aluminum particles may present an explosion hazard not normally associated with metallic aluminum. But nanomaterials may also behave differently in the sense that "hazardous" properties may not persist in the natural environment. Small particles that present exposure concerns in pure form may agglomerate, disperse, or react, for example, and thus may not pose the kind of "substantial danger" that the hazardous substance definition requires "when released into the environment." Issues like these seem likely to pose ongoing challenges for classification of nanoscale materials.

The power under CERCLA Section 102 to list new "hazardous substances" provides EPA ample authority to meet such challenges: EPA can classify nanomaterials as hazardous if it concludes that they present "substantial danger to the public health or welfare or the environment." This definition is flexible enough to permit EPA to define "danger" as appropriate for a given material. The built-in cross-references to other statutes moreover operate to extend CERCLA's reach in parallel with other regulatory decisions about specific nanomaterials.

Once a material is designated a "hazardous substance," it and actors associated with it are subject to the statute regardless of regulatory status at the time of production, use, or disposal. In other words, should adverse effects of a nanomaterial become apparent after release and exposure, the decision to classify it as a "hazardous substance" would operate, as it did upon enactment in 1980, to trigger the portions of the statute oriented toward remedying past mistakes.

B. Release Reporting and "Reportable Quantities" (Sections 102, 103)

The reporting requirement of CERCLA Section 103 operates in conjunction with the "hazardous substance" definition to bring the statute into play when a release to the environment occurs. Section 103 requires reporting of hazardous substance releases that exceed "reportable quantity" thresholds defined pursuant to Section 102. EPA's authority to promulgate regulations defining reportable quantities[4] goes with the hazardous substance listing authority and provides ample power to set reportable quantities for nanomaterials deemed hazardous.

For nanomaterials, the concept of a "reportable quantity" runs up against much the same knowledge gap as does the "hazardous substance" definition. Since CERCLA was enacted, it has typically been possible not only to identify materials that should be deemed hazardous, but also to define a threshold level of regulatory concern that could be translated into a CERCLA "reportable quantity." For nanomaterials, both questions turn on information yet to be developed.

The concept of a "reportable quantity" also highlights a conceptual problem distinct from the state of current knowledge. It has long been a fundamental assumption of

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[4] CERCLA § 102(a), 42 U.S.C. § 9602(a).

environmental regulation that larger quantities of regulated material pose greater risk.[5] This relation may not hold for a nanomaterial that causes toxic or hazardous effects at low volumes or weights. For this reason, it is not clear that the seemingly conservative default quantity threshold of one pound[6] would be adequate for all nanoscale materials.

II. RESPONSE/REMEDIATION

A. Federal Authority to Respond

1. Removal/Remedial Authority; Funding (Section 104(a)-(d))

2. Information Gathering (Section 104(e))

3. Property Acquisition (Section 104(j))

4. Brownfields Revitalization (Section 104(k))

5. Superfund (Sections 111, 112)

CERCLA authorizes direct governmental action to address environmental contamination upon discovery, regardless of the passage of time since the act or omission giving rise to it, and regardless of whether such acts or omissions were lawful at the time. These powers include authority to conduct and fund removal and remedial action and to coordinate action by state and tribal authorities,[7] to compel disclosure of information from private parties,[8] and to acquire property needed to conduct remedial action.[9] Complementary authorities include funding for response actions and "peripheral matters,"[10] and for brownfields evaluation.[11]

For nanomaterials, these powers are important for two reasons. The first harks back to the statute's origins -- EPA could respond to a hazardous nanomaterial release or condition under the statute just as it has for hundreds of sites over the last quarter-century. There is nothing unique about nanoscale "hazardous substances" that would constrain this authority or impair the statute's operation.

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5 *See* Hester, "Small Stuff, Big Challenges: RCRA and CERCLA in the New World of Nanoscale Materials" (ELI/Woodrow Wilson Institute presentation, May 25, 2005).

6 *See* CERCLA § 102(b), 42 U.S.C. § 9602(b).

7 CERCLA § 104(a)-(d), 42 U.S.C. § 9604(a)-(d).

8 CERCLA § 104(e), 42 U.S.C. § 9604(e).

9 CERCLA § 104(j), 42 U.S.C. § 9604(j).

10 CERCLA §§ 111, 112, 42 U.S.C. §§ 9611, 9612.

11 CERCLA § 104(k), 42 U.S.C. § 9604(k).

The second is crucial in light of the limited knowledge currently available about the environmental fate and transport of nanoscale materials. Nothing in the statute would prevent EPA from deciding *in the future* to classify a nanomaterial as hazardous and then invoking its response authority to address conditions arising from preceding releases or actions. In such a scenario, CERCLA would operate precisely as it did upon enactment to impose "retroactive" liability for historic practices.

After-the-fact responses would be no more desirable for future problems associated with nanoscale materials than they were for the drum dumps uncovered in the 1980s. The immediate question, however, is whether the statutory authorities under CERCLA would be available in that eventuality. The answer is that they would be. The sole qualification is again technical rather than legal -- as discussed above, the threshold question is whether a given nanomaterial should be treated as a "hazardous substance." For nanomaterials deemed to fall within that category, the statutory response authorities could operate without modification.

B. Risk Assessment

1. Materials

a. ATSDR; coordination with TSCA and FIFRA (Section 104(i))

b. ATSDR funding (Section 111(m))

2. Releases/Sites

Within the CERCLA framework, risk assessment operates at two levels. One is the threshold determination of whether a substance warrants regulatory concern. The other is whether a given site warrants response or remediation.

As to the first of these, CERCLA expressly provides for coordination between EPA and the Agency for Toxic Substances and Disease Registry (ATSDR).[12] It also contemplates that research on materials or substances should be coordinated with similar programs of toxicological testing under the Toxic Substances Control Act (TSCA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).[13] There is nothing unique to nanomaterials that would require modification of this basic structure. Considering the scope of research already in progress and the existing level of interagency coordination, there is no evident reason to think that the framework defined by the statute cannot be effective in developing information necessary to make regulatory decisions about nanomaterials.

As to the second, evaluation of releases and sites proceeds under the authority of CERCLA Section 105, which authorizes the National Contingency Plan (NCP) and the National Priorities List (NPL),[14] the Hazard Ranking System,[15] and coordination with state-led response

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12 CERCLA § 104(i), 42 U.S.C. § 9604(i).

13 CERCLA § 104(i)(5)(C), 42 U.S.C. § 9604(i)(5)(C).

14 CERCLA § 105(a), 42 U.S.C. § 9605(a).

actions.[16] Conditions associated with nanomaterials can be addressed within these authorities. Their application is again constrained only by the current state of knowledge, in this context the lack of information about the environmental fate and effects of nanomaterials.

C. Mechanics/Standards of Response and Remediation

1. NCP (Section 105, 40 C.F.R. Part 300)

2. Cleanup Standards (Section 121)

a. Standards and Practices Development -- OSWER, etc.

3. Nanomaterials as Remediation Technology

4. Public Participation in Remedial Action Plan Development (Section 117)

CERCLA response actions proceed under criteria stated in the NCP, with remedial actions selected in accordance with Section 121. The general rules applicable to remedial actions include the preference for permanent remedies that reduce the volume, toxicity, or mobility of hazardous substances.[17] The degree of cleanup is defined by reference to the general concept of assuring protection of human health and the environment.[18] Implementation includes state and public involvement under CERCLA Sections 121(f) and 117, respectively.[19]

EPA has authority under these provisions to define remediation objectives and select remedies for releases of hazardous nanoscale materials. No general or site-specific standards, criteria, or best practices yet exist for such releases. But their development falls within the existing mandates of EPA's Office of Solid Waste and Emergency Response and Office of Site Remediation and Enforcement; complementary research may be conducted under the aegis of the Office of Research and Development. These authorities and structures seem capable of serving without modification as vehicles for developing information necessary to define response and remediation objectives for hazardous nanomaterial releases.

In this context, nanomaterials present an interesting dichotomy -- their potential adverse effects must be balanced against their potential utility as remediation tools. EPA's National Center for Environmental Research lists remediation among possible "applications,"[20]

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15 CERCLA § 105(c), 42 U.S.C. § 9605(c).

16 CERCLA § 105(h), 42 U.S.C. § 9605(h).

17 CERCLA § 121(b)(1), 42 U.S.C. § 9621(b)(1).

18 CERCLA § 121(d), 42 U.S.C. § 9621(d).

19 42 U.S.C. §§ 9621(f), 9617.

20 *See* "Nanotechnology: Research Projects," available at http://es.epa.gov/ncer/nano/research/index.html (visited May 1, 2006).

-- for example, nanomaterials may promote degradation of chlorinated hydrocarbons. The idea of using nanomaterials to mitigate known risks of "conventional" hazardous substances is in tension with concerns about the environmental and health effects of the nanomaterials themselves. This tension has prompted the UK's Royal Society and Royal Academy of Engineering to argue that the use of free nanoparticles in environmental applications such as remediation should be prohibited until appropriate research has demonstrated that benefits outweigh risks.[21] Presumably risks posed by nanoscale materials in a remediation context will be evaluated not only in light of the risks they pose given the usual considerations of environmental setting, fate and transport, and potential receptors, but also in light of their benefits in reducing the hazards posed by other pollutants.

For present purposes, it is sufficient to note that the existing statutory authorities provide ample latitude to explore the positives of nanomaterials as well as the negatives.

III. COMPENSATION/LIABILITY/ENFORCEMENT MECHANISMS

A . Core Section 107 "Polluter Pays" Concept

1. "Response Costs"

2. Natural Resource Damages

3. Federal Lien

4. Settlement Authority and Procedures (Section 122)

CERCLA's liability provisions provide means to impose and allocate responsibility for releases of hazardous nanomaterials. CERCLA Section 107 expresses the central liability concept -- persons standing in certain well-defined relationships to "hazardous substances" are jointly and severally responsible for response costs. These potentially responsible parties (PRPs) may be the owners of facilities where hazardous substances are now located, the owners or operators at the time of disposal, or generators, transporters, or disposers of hazardous substances. These familiar PRP categories can apply to facilities and operations involving nanomaterials that fall within the hazardous substance definition.

It would of course be preferable to anticipate and avoid adverse effects of nanomaterials through regulation under other programs. Given the rapid pace of nanotechnology and nanomaterial development and marketing, however, regulatory decision-making may have difficulty keeping up. If we assume that nanomaterials may warrant classification as "hazardous substances," it seems prudent to assume as well that unanticipated problems will arise after releases have occurred.

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21 *See* The Royal Society and Royal Academy of Engineering, "Nanoscience and nanotechnologies: opportunities and uncertainties" (2004) at 46-47, Section 5.4, Paragraph 44, available at http://www.nanotec.org.uk/finalReport.htm (visited May 14, 2006).

The CERCLA liability framework can be expected to function perfectly well in the latter scenario, serving as a backstop for consequences that other programs fail to anticipate or avoid. Its ability to do so reflects its historic origin as a reaction to discovery of hazardous materials at uncontrolled disposal sites -- sites created, in many instances, in violation of no contemporaneous legal requirements. CERCLA embodies a legislative policy judgment that the need to protect human health and the environment warrants the imposition of strict joint and several liability, even if the conduct in question was lawful at the time and the liability is in effect retroactive. The statute is intrinsically backward-looking. It provides a means of second-guessing risk assessment judgments and of assuring that persons within the statutory categories of PRPs, bear the costs of late-emerging external costs.

These concepts can readily be adapted to evolving knowledge about the fate and environmental effects of nanomaterials. Perhaps more importantly, the statute's notorious burdensomeness can be a significant deterrent in a sector where rapid change taxes the capacities of prospective regulatory tools. The specter of retroactive CERCLA liability, with all it implies, provides a powerful incentive for developers and manufacturers to assure that their nanomaterials are produced, used, and disposed of safely.

In the context of nanomaterials, it is particularly appropriate that CERCLA Section 107 imposes no minimum or quantity threshold. It is axiomatic that liability attaches upon the release of any amount of hazardous substance.[22] Thus, although certain other portions of the statute tie affirmative reporting and disclosure obligations to mass triggers, for example the release reporting, reportable quantity, emergency planning, and toxic release disclosure authorities discussed in Part IV below, release of any amount of a hazardous substance can give rise to Section 107 liability. The de micromis exemption of Section 107(o) does not materially alter this conclusion. Although it defines presumptive thresholds below which persons in the "arranger" or "transporter" categories[23] are not liable, it is subject to an exception for situations in which materials disposed of contribute significantly to costs of response or natural resource restoration.[24] The de micromis exemption does not apply at all to current owners of CERCLA "facilities," or to persons who owned such facilities when hazardous substances were released. In those important categories, the rule remains unqualifiedly that any release triggers liability.

Complementary liability provisions address natural resource damages,[25] the federal superlien for response costs,[26] and authority to settle claims and grant covenants not to

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22 *See, e.g.*, *Goodrich Corp. v. Town of Middlebury*, 311 F.3d 154, 161 (2d Cir. 2002), *cert. denied*, 537 U.S. 937 (2003); *A&W Smelter and Refiners, Inc. v. Clinton*, 146 F.3d 1107, 1110-11 (9th Cir. 1998).

23 CERCLA § 107(a)(3) and (4), 42 U.S.C. § 9607(a)(3) and (4).

24 CERCLA § 107(o)(2), 42 U.S.C. § 9607(o)(2).

25 CERCLA § 107(f), 42 U.S.C. § 9607(f).

26 CERCLA § 107(l), 42 U.S.C. § 9607(l).

sue and contribution protection.[27] Like the core liability principles, all could function without modification in the context of hazardous nanomaterial releases.

B. Collateral Enforcement Tools

1. Information Requests (Section 104)

2. Unilateral Orders (Section 106)

3. Financial Responsibility and Guarantor Cost Recovery (Section 108)

a. "Classes of Facilities" (Section 108(b))

4. Civil Penalties (Section 109)

5. Whistleblower Protection (Section 110)

6. Special Notice Procedures (Section 122(e))

There is nothing unique to nanomaterials that would affect the operation of the collateral CERCLA enforcement mechanisms listed above. For nanomaterials denominated "hazardous substances," for sites warranting attention consistent with the NCP, and with respect to persons within the categories of "responsible parties" under Section 107, these CERCLA liability provisions can be expected to operate with respect to nanoscale materials as they have with respect to conventional "hazardous substances."

C. Contribution and Related Issues (Section 113(f))

1. Contribution (Section 113(f)(1))

2. Contribution Protection (Section 113(f)(2))

CERCLA's contribution and contribution protection mechanisms complement the basic liability framework and similarly can be expected to operate as they stand with respect to liability for nanomaterial releases.

D. Incidental Liability Provisions: Exemptions, Safe Harbors, Defenses

1. Fiduciaries (Section 107(n))

2. De Micromis PRPs (Section 107(o))

3. MSW (Section 107(p))

4. Contiguous Properties (Section 107(q))

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[27] CERCLA § 122, 42 U.S.C. § 9622.

5. Prospective Purchaser (Section 107(r))

6. De Minimis Settlements (Section 122(g))

7. Recyclers (Section 127)

Since 1980, several categories of liability exemptions and qualifications have been engrafted onto the basic CERCLA liability framework. These provisions do not pose any unique problems as applied to nanomaterials.

The technical question of quantity thresholds arises in several of these categories. The "de minimis" category is expressed in relative terms, as a comparison with the danger posed by other hazardous substances at a facility, so there is no problem with a numerical threshold. The "de micromis" category is defined by a quantity threshold (110 gallons of liquid, 200 pounds of solid) that might be problematic for nanomaterials, but at least part of the disposal must have occurred before April 1, 2001, so it is unlikely disposal of nanomaterials will fit within the definition in any event.

A similar question may arise as to the municipal solid waste (MSW) exemption of Section 107(p), which applies to "waste generated by a household" or waste generated by certain other entities that is "essentially the same as" household waste and that contains hazardous substances in relatively the same proportion. As nanomaterials come into more widespread use, residual quantities may be expected to show up in MSW. It is unclear whether these materials would appear in forms, amounts, or concentrations that would call into question the continued appropriateness for the MSW exemption. This possibility should be noted, however, as another manifestation of the larger question about whether existing quantity thresholds are adequate to deal with nanomaterials. If so, however, Section 107(p)(2) already provides that the exemption shall not apply if EPA determines that the MSW "has contributed significantly or could contribute significantly, either individually or in the aggregate, to the cost of the response action or natural resource restoration."[28] That determination is not judicially reviewable.[29] The statute is thus again flexible enough to cope with any special concerns that might arise in connection with nanomaterials in the municipal solid waste stream.

IV. COLLATERAL AND INCIDENTAL ELEMENTS/SUBPROGRAMS

A. SARA Title III

1. Emergency Planning Notification (SARA Title III Section 302, 42 U.S.C. § 11002)

2. Emergency Release Notification (SARA Title III Section 304, 42 U.S.C. § 11004)

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[28] 42 U.S.C. § 9607(p)(2).

[29] CERCLA § 107(p)(3), 42 U.S.C. § 9607(p)(3).

3. Hazardous Chemical Inventory Reporting (SARA Title III Sections 311 and 312, 42 U.S.C. §§ 11021, 11022)

4. Toxic Release Reporting (SARA Title III Section 313, 42 U.S.C. § 11023)

These SARA Title III programs share the fundamental premise that emergency planners and members of the public need information about the presence and release of materials that are hazardous, extremely hazardous, or toxic. For nanomaterials falling within these categories, the same premise applies.

Aside from the subcategory of "extremely hazardous substances," these programs rely on well-settled CERCLA definitions. Unsurprisingly, the major question would appear again to be whether the default mass-based thresholds for these programs are valid for nanoscale materials that are classified as "hazardous substances." For extremely hazardous substances in general, for example, the default EPCRA Threshold Planning Quantity (TPQ) is 10,000 pounds, but 500 pounds "if the solid exists in a powdered form and has a particle size less than 100 microns."[30] The minimum threshold level for inventory reporting is 500 pounds for the TPQ for extremely hazardous substances, and 10,000 pounds for all other hazardous chemicals. There is no statutory restriction, however, on EPA's authority to set these values lower if warranted; the Extremely Hazardous Substance lists appended to 40 C.F.R. Part 355 identify numerous materials with TPQs of one pound. This conclusion would have to be reconsidered, however, if continuing research and development revealed that the weight and risk of nanomaterials or classes of nanomaterials are wholly independent. As the nanotechnology sector continues its rapid change and growth, the adequacy of these threshold levels will require continuing attention.

If a Material Safety Data Sheet must be maintained on premises pursuant to the OSH Act, then Tier 1 and Tier 2 inventory requirements of Sections 311 and 312 automatically apply. As a practical matter, the SARA Title III obligations follow automatically from the OSH Act determination -- subject again to the distinct question of whether the default weight thresholds are adequate in light of the type and degree of risk posed by a given nanoscale material.

CONCLUSION

The current state of knowledge concerning the environmental and health effects of nanomaterials poses practical difficulties in applying CERCLA. It is probably correct to say that most of the scientific and technical predicates for applying the statute to nanomaterials do not yet exist.

This knowledge gap is not as problematic under CERCLA as it is for environmental statutes that focus on current activities. Indeed, CERCLA was purpose-built to cope with the unanticipated adverse consequences of previously accepted practices. It expanded existing law by creating a totally new concept -- liability for conditions that exist today, no

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30 40 C.F.R. § 355.30(e)(2)(i).

matter when the conduct giving rise to them occurred. This concept fits the paradigm of adverse consequences that may arise in the future from as-yet unknown properties of nanomaterials.

Only technical input is needed to apply the statutory authorities to nanomaterials. When we can answer the questions of whether nanomaterials are hazardous, and if so, in what ways and in what amounts, the CERCLA machinery will be available to address adverse consequences.