CLOSING SESSION: An Overview

Title: *Energy Damage and the Ten Countermeasures Strategies*

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Abstract:

A major class of ecologic phenomena involves the transfer of energy in such ways and amounts, and at such rapid rates, that inanimate or animate structures are damaged. The harmful interactions with people and property of hurricanes, earthquakes, projectiles, moving vehicles, ionizing radiation, lightning, conflagrations, and the cuts and bruises of daily life illustrate this class.

There are ten strategies for reducing the human and other losses that make this class of social concern. These are identified in logical sequence and copiously illustrated by tactics widely employed. The reduction of animate and inanimate damage due to interaction with most environmental hazards, including pollutants, drugs, and microorganisms can be approached in the same manner, as can strategies for population control. Appendices provide additional examples and four illustrative case studies concerned respectively with reducing: losses associated with femoral fractures among the elderly; thermal energy damage to children and others; drownings; and mob damage to the White House or other private or public building.

ENERGY DAMAGE AND THE TEN COUNTERMEASURES STRATEGIES

An important landmark is reached in the evolution of a scientific field when classification of its subject matter is based on the relevant, fundamental processes involved rather than on descriptions of the appearances of the phenomena of interest. In illustration, a fundamental turning point was reached when the debilitation and progressive susceptibility to bruising of shipboard scurvy could for the first time be classified as the process resulting from a deficiency of consumption of something variously present in fruits and vegetables (much later identified as ascorbic acid, Vitamin C). In fact, such transition from classifications consisting essentially only of a description of appearances to those based on fundamental processes is basic to scientific progress generally; hence, examples abound from the full gamut of scientific concerns.

Additional illustrations, among the many, include the classificatory and conceptual transitions that followed recognition:

a. That rocks could be grouped on the basis of the processes involved in their formation – as, sedimentary, igneous, metamorphic.

b. That the variations among the Galapagos finches studied by Darwin were the result of differential ecologic processes.

c. That earthquakes were one aspect of tectonic processes.

d. That the epidemic disease of the young which could for decades only be described as "infantile paralysis" was a rare variant of a commonplace process initiated by infection with one of several similar and previously unknown viruses, and

e. That plague was a process in which a specific pathogen, *Pasteurella pestis*, rats, fleas, and people interacted.

Extrarational Explanations in the Absence of Process Knowledge

Before such conceptual and hence classificatory advance, lacking an understanding of process, and therefore of the possibility of human intervention or avoidance, phenomena of concern to people have commonly been attributed to extrarational factors. "Luck", "chance", "accident", "fate", and similar terms are the hallmarks of such ignorance and perhaps of a human necessity for explaining it away (Haddon, 1968). The distinction between the way in which people tend to deal with the understood as opposed to the merely known-about is illustrated nicely by the renowned anthropologist Malinowski. He found that Trobriand natives viewed the hazards outside the reef, which they did not understand, in ways more supernatural than they viewed those inside the reef, which they did understand. As he wrote, "It is most significant that in the lagoon fishing, where man can rely completely upon his knowledge and skill, magic does not exist, while in the open-sea fishing, full of danger and uncertainty, there is extensive magical ritual to secure safety and good results". (Malinowski, 1948, p. 31).

Divine Punishment as an Explanation in the Absence of Process Understanding

The Book of Job epitomizes another commonplace aspect of human response to the undesirable happenings not yet understood – and therefore not yet categorized – in process terms. The events are explained as divine retribution for shortcomings. The suffering of oneself, someone else, or some group occurs because it is divine and well deserved punishment. Therefore, unless the sin can be expiated by appropriate change in behavior, it may be "too bad" but there is nothing else to be done to ameliorate the personally or societally undesirable happening unless it is an increase in efforts at human reform.

Expanded Classificatory Sets, and Different Sets

The transition to understanding of underlying, relevant processes commonly results in more than just a relabeling of past groupings (Haddon, 1968). Usually the phenomena previously recognized have been "the tip of the iceberg" and the recognition of underlying process adds much more. Thus, in the case of what was originally termed "infantile paralysis", it was found that the infectious process routinely involved hundreds of individuals subclinically for each person ill enough to be diagnosed. Moreover, parallel illustrations are legion, not only from medicine but widely from other sciences as well.

For example, understanding the actual nature of earthquakes is to classify them conceptually as one aspect of a far broader range of tectonic process; and understanding the origins of a butterfly or clam is to identify it in terms of its life cycle, a process classification. Understanding the process involved in eclipses is to classify them as one aspect of celestial mechanics.

Another frequent result of transition to process-based understanding is regrouping of phenomena not merely in expanded sets, but in new sets that do not bear a one-to-one correlation with the old. Figure 1 illustrates this. As process (or, to use a related (medical) term, etiologic) understanding advanced, the set of phenomena formerly referred to as "wasting" was, in effect, parcelled out to such process-defined sets as tuberculosis, amebiasis, protein deficiency, and a host of others (Haddon, 1968).

More relevant here is to view the process in reverse; that is, from the standpoint of the etiologic or process sets in picking up pieces of many pre-existing descriptive sets, as illustrated in Figure 2 (Haddon, 1968).

Thus, syphilis, the etiologic set based on the infectious agent, *Treponema pallidum*,picked up parts of previous descriptive sets, such as paresis, gummas, penile lesions, rashes, certain gastric lesions, certain abnormalities of the growing ends of bone, and many others, but not all of those in any one of the earlier descriptive sets. Again, an important point is that there is usually not in such transitions a one-to-one relationship between the earlier, descriptive ways of looking at the phenomena and those process-based which are substituted for them (Haddon, 1968).

The foregoing is brief background for that which follows, an introduction to the classification of certain widespread, important phenomena defined and grouped in terms of a small number of closely parallel processes. Most of the included phenomena are not yet regarded in process terms by the implicit and explicit classifications still applied to them by most professionals and laymen. Yet there is widespread, implicit and at least qualitative recognition of the processes

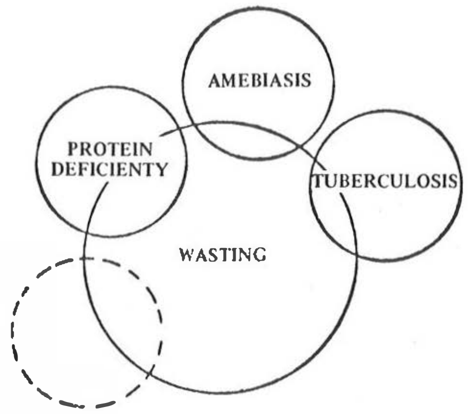

Figure 1. An illustration of the parcelling out to etiologically defined sets of the components of a descriptively defined set of pathology

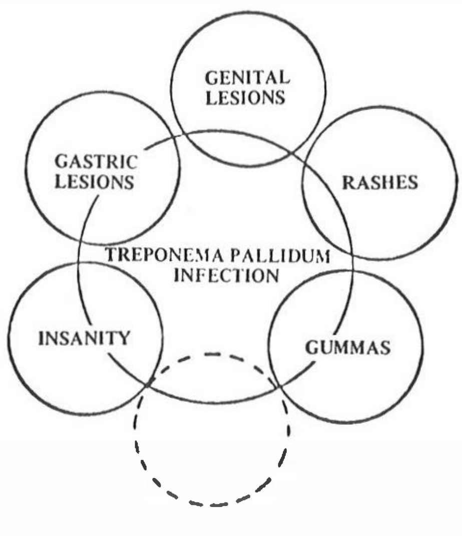

Figure 2. An illustration of the incorporation of portions of various descriptively defined sets of pathology into an etiologically defined set

themselves, because cultures, past and present, abound in actions directed at changing the outcome of these processes through intervention at specific points in their sequences.

Energy Damage Processes

The phenomena of concern are those involved when energy is transferred in such ways and amounts, and at such rapid rates, that inanimate or animate structures are damaged (Baker, 1972; Haddon, 1963; 1967; 1968; 1970a; Haddon, Suchman and Klein, 1964). Much of the remainder of this paper closely follows Haddon (1970a). The harmful interactions with people and property of hurricanes, earthquakes, projectiles, moving vehicles, ionizing radiation, lightning, conflagrations, and the cuts and bruises of daily life illustrate this class.

Ten Strategies for Reducing These Losses

Several strategies, in one mix or another, are available for reducing the human and economic losses that make this class of phenomena of social concern. In their logical sequence, they are as follows:

The *first* strategy is to prevent the marshalling of the form of energy in the first place: preventing the generation of thermal, kinetic, or electrical energy, or ionizing radiation; the manufacture of gunpowder; the concentration of U-235; the build-up of hurricanes, tornadoes, or tectonic stresses; the accumulation of snow where avalanches are possible; the elevating of skiers; the raising of babies above the floor, as to cribs and chairs from which they may fall; the starting and movement of vehicles; and so on, in the richness and variety of ecologic circumstances.

The *second* strategy is to reduce the amount of energy marshalled: reducing the amounts and concentrations of high school chemistry reagents, the size of bombs or firecrackers, the height of divers above swimming pools, or the speed of vehicles.

The *third* strategy is to prevent the release of the energy: preventing the discharge of nuclear devices, armed crossbows, gunpowder, or electricity; the descent of skiers; the fall of elevators; the jumping of would-be suicides; the undermining of cliffs; or the escape of tigers. An Old Testament writer illustrated this strategy in the context both of the architecture of his area and of the moral imperatives of this entire field: "When you build a new house, you shall make a parapet for your roof, that you may not bring the guilt of blood upon your house, if any one fall from it" (Deuteronomy 22:8). This biblical position, incidentally, is fundamentally at variance with that of those who, by conditioned reflex, regard harmful interactions between man and his environment as problems requiring reforming imperfect man rather than suitably modifying his environment.

The *fourth* strategy is to modify the rate of spatial distribution of release of the energy from its source: slowing the burning rate of explosives, reducing the slope of ski trails for beginners, and choosing the reentry speed and trajectory of space capsules. The third strategy is the limiting case of such release reduction, but is identified separately because in the real world it commonly involves substantially different circumstances and tactics.

The *fifth* strategy is to separate, in space or time, the energy being released from the susceptible structure, whether living or inanimate: the evacuation of the Bikini islanders and test personnel, the use of sidewalks and the phasing of pedestrian and vehicular traffic, the elimination of vehicles and their pathways from community areas commonly used by children and adults, the use of lightning rods, and the placing of electric power lines out of reach. This strategy, in a sense also concerned with rate-of-release modification, has as its hallmark the elimination of intersections of energy and susceptible structure – a common and important approach.

The very important *sixth* strategy uses not separation in time and space but separation by interposition of a material "barrier": the use of electrical and thermal insulation, shoes, safety glasses, shin guards, helmets, shields, armor plate, torpedo nets, antiballistic missiles, lead aprons, buzz-saw guards, and boxing gloves. Note that some "barriers" such as crash padding and ionizing radiation shields, attenuate or lessen but do not totally block the energy from reaching the structure to be protected. This strategy, although also a variety of rate-of-release modification, is also separately identified because the tactics involved comprise a large, and usually clearly discrete, category.

The *seventh* strategy, into which the sixth blends, is also very important – to modify appropriately the contact surface, subsurface, or basic structure, as in eliminating, rounding, and softening corners, edges, and points with which people can, and therefore sooner or later do, come in contact. This strategy is widely overlooked in architecture with many minor and serious injuries the result. It is, however, increasingly reflected in automobile design and in such everyday measures as making lollipop sticks of cardboard and making some toys less harmful for children in impact. Despite the still only spotty application of such principles, the two basic requisites, large radius of curvature and softness, have been known since at least about 400 B.C., when the author of the treatise on head injury attributed to Hippocrates wrote: "Of those who are wounded in the parts about the bone, or in the bone itself, by a fall, he who falls from a very high place upon a very hard and blunt object is in most danger of sustaining a fracture and contusion of the bone, and of having it depressed from its natural position; whereas he that falls upon more level ground, and upon a softer object, is likely to suffer less injury in the bone, or it may not be injured at all . . ." (Hippocrates, 1939, p. 147).

The *eighth* strategy in reducing losses in people and property is to strengthen the structure, living or nonliving, that might otherwise be damaged by the energy transfer. Common tactics, often expensively under-applied, include tougher codes for earthquake, fire, and hurricane resistance, and for ship and motor vehicle impact resistance. The training of athletes and soldiers has a similar purpose, among others, as does the treatment of hemophiliacs to reduce the results of subsequent mechanical insults. A successful therapeutic approach to reduce the osteoporosis of many post-menopausal women would also illustrate this strategy, as would a drug to increase resistance to ionizing radiation in civilian or military experience. (Vaccines, such as those for polio, yellow fever, and smallpox, are analogous strategies in the closely parallel set to reduce losses from infectious agents.)

The *ninth* strategy in loss reduction applies to the damage not prevented by measures under the eight preceding – to move rapidly in detection and evaluation of damage that has occurred or is occurring, and to counter its continuation and extension. The generation of a signal that response is required; the signal's transfer, receipt, and evaluation; the decision and follow-through, are all elements here – whether the issue be an urban fire or wounds on the battlefield or highway. Sprinkler and other suppressor responses, firedoors, MAYDAY and SOS calls, fire alarms, emergency medical care, emergency transport, and related tactics all illustrate this countermeasure strategy. (Such tactics have close parallels in many earlier stages of the sequence discussed here, as, for example, storm and tsunami warnings.)

The *tenth* strategy encompasses all the measures between the emergency period following the damaging energy exchange and the final stabilization of the process after appropriate intermediate and long-term reparative and rehabilitative measures. These may involve return to the pre-event status or stabilization in structurally or functionally altered states.

Separation of Loss Reduction and Causation

There are, of course, many real-world variations on the main theme. These include those unique to each particular form of energy and those determined by the geometry and other characteristics of the energy's path and the point or area and characteristics of the structure on which it impinges – whether a BB hits the forehead or the center of the cornea.

One point, however, is of overriding importance: subject to qualifications as noted subsequently, there is no logical reason why the rank order (or priority) of loss-reduction countermeasures generally considered must parallel the sequence, or rank order, of causes contributing to the result of damaged people or property. One can eliminate losses in broken teacups by packaging them properly (the sixth strategy), even though they be placed in motion in the hands of the postal service, vibrated, dropped, piled on, or otherwise abused. Similarly, a vehicle crash, per se, need necessitate no injury, nor a hurricane housing damage.

Failure to understand this point in the context of measures to reduce highway losses underlies the common statement: "If it's the driver, why talk about the vehicle." This confuses the rank or sequence of causes, on the one hand, with that of a loss-reduction countermeasure – in this case "crash packaging" – on the other.

There are, nonetheless, practical limits in physics, biology, and strategy potentials. One final limit is operative at the boundary between the objectives of the eighth and ninth strategies. Once appreciable injury to man or to other living structure occurs, complete elimination of undesirable end results is often impossible, though appreciable reduction is commonly achievable. (This is often also true for inanimate structures, for example, teacups.) When lethal damage has occurred, the subsequent strategies, except as far as the strictly secondary salvage of parts is concerned, have no application.

There is another fundamental constraint. Generally speaking, the larger the amounts of energy involved in relation to the resistance to damage of the structures at risk, the earlier in the countermeasure sequence must the strategy lie. In the ultimate case, that of a potential energy release of proportions that could not be countered to any satisfactory extent by any known means, the prevention of marshalling or of release, or both, becomes the only approach available. Furthermore, in such an ultimate case, if there is a finite probability of release, prevention of marshalling (and dismantling of stockpiles of energy already marshalled) becomes the only, and essential, strategy to assure that the undesirable end result cannot occur.

For Each Strategy an Analogous Opposite

Although the concern here is the reduction of damage produced by energy transfer, it is noteworthy that to each strategy there is an opposite focused on increasing damage. The latter are most commonly seen in collective and individual violence – as in war, homicide, and arson. Various of them are also seen in manufacturing, mining, machining, hunting, and some medical and other activities in which structural damage often of a very specific nature is sought. (A medical illustration would be the destruction of the anterior pituitary with a beam of ionizing radiation as a measure to eliminate pathologic hyperactivity.) For example, a maker of motor vehicles or of aircraft landing-gear struts – a product predictably subject to energy insults – could make his product more delicate, both to increase labor and sales of parts and materials, and to shorten its average useful life by decreasing the age at which commonplace amounts of damage increasingly exceed in cost the depreciating value of the product in use. The manufacturer might also design for difficulty of repair by using complex exterior sheet metal surfaces, making components difficult to get at, and other means.

The type of categorization outlined here is similar to those useful for dealing systematically with other environmental problems and their ecology. In brief illustration, various species of toxic and environment-damaging atoms (such as lead), molecules (e.g., DDT and heroin), and mixtures (garbage and some air pollutants, among others) are marshalled, go through series of physical states and situations, interact with structures and systems of various characteristics, and produce damage in sequences leading to the final, stable results.

Similar comments can be made concerning the ecology of some of the viral, unicellular, and metazoan organisms that attack animate and inanimate structures; their hosts; and the types of stages of damage they produce. Actual and potential birth control and related strategies and tactics can be somewhat similarly categorized. Thus, in brief, beginning on the male line: preventing the marshalling of viable sperm (by castration or certain pharmacological agents); reducing the amount of sperm produced; preventing the release of semen (or of one of its necessary components, e.g.,by vasectomy); modifying the rate of spatial distribution of release of semen (as in hypospadias, a usually developmental or traumatic condition in which the urethra opens on the underside of the penis, sometimes near its base); separating semen release in space or time from the susceptible ovum (e.g., continence, limiting intercourse to presumably nonfertile periods, cotius interruptus, and preventing a fertile ovum from being present when sperm arrive); separation by interposition of a material barrier (e.g.,condoms, spermacidal creams, foams, jellies); increasing resistance of the ovum to penetration; making the ovum infertile, even if penetrated; prevention of implantation of the fertilized egg; abortion; and infanticide.

Sufficient differences among systems often exist, however – for example, the ecology of the agents of many anthropod-borne diseases is quite complex, and the life cycles of organisms such as schistosomes require two or more different host species in sequence – to preclude at this time many generalizations useful across the breadth of all environmental hazards and their damaging interactions with other organisms and structures.

A Systematic Analysis of Options

It has not generally been customary for individuals and organizations that influence, or are influenced by, damage due to harmful transfers of energy to analyze systematically their options for loss reduction, the mix of strategies and tactics they might employ, and their cost. Yet, it is entirely feasible and not especially difficult to do so, although specific supporting data are still often lacking. In fact, unless such systematic analysis is done routinely and well, it is generally impossible to maximize the pay-offs both of loss-reduction planning and of resource allocations.

Such analysis is also needed to consider properly the problems inherent in the use of given strategies in specific situations. Different strategies to accomplish the same end commonly have different requirements; in kinds and numbers of people, in the disciplines involved, in material resources, in capital investments, and in public and professional education, among others. In the case of some damage-reduction problems, particular strategies may require political and legislative action more than others. And, where the potential or actual hazard exists across national boundaries, correspondingly international action is commonly essential.

The types of concepts outlined in this note are basic to dealing with important aspects of the quality of life, and all of the professions concerned with the environment and with the public health need to understand and apply the principles involved -- and not in the haphazard, spotty, and poorly conceptualized fashion now virtually universal. It is the purpose of this brief note to introduce the pathway along which this can be achieved.

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APPENDIX A

This appendix gives additional examples of tactics classified by the strategy categories into which they fall. The strategies, identified sequentially I–X, are:

I. To prevent the initial marshalling of the form of energy.

II. To reduce the amount of energy marshalled.

III. To prevent the release of energy.

IV. To modify the rate of spatial distribution of release of energy from its source.

V. To separate in space or time the energy being released from the susceptible structure.

VI. To separate the energy being released from the susceptible structure by interposition of a material barrier.

VII. To modify the contact surface, subsurface, or basic structure which can be impacted.

VIII. To strengthen the living or nonliving structure which might be damaged by the energy transfer.

IX. To move rapidly in detection and evaluation of damage and to counter its continuation and extension.

X. All those measures which fall between the emergency period following the damaging energy exchange and the final stabilization of the process (including intermediate and long-term reparative and rehabilitative measures).

Dismantling nuclear bombs and preventing production	I
Limiting nuclear bomb size and manufacture	II
Total nuclear use-ban treaty	III
Plastic surgery	X
Making polo goal posts to yield on impact	VII
Old tires on sides of tugs	VI
Railroad under-and overpasses	V
Parachutes	IV
Fire alarms	IX
Seeding an established hurricane	IV
Built-in automobile crash padding	VII
Fallout shelters	VI
Sanding icy sidewalks	III
Aircraft carrier arresting gear	IV
Keeping people out of dry woods	III
Fire doors	VI
Boiler safety valves	IV
Opening volcanoes to achieve controlled release	IV
Lubricating San Andreas Fault to cause a succession of small slippages (MacDonald, 1969)	IV

Aircraft landing and takeoff priorities	V
Skin grafts for burns	X
Diver's decompression routine	IV
Hanging padding in horse stalls	VI
Wrapping padding on goalpost supports	VI
Window washers' belts	III
Fire retardant clothing	IV
Sunburn lotion that blocks U.V.	VI
Chaining tigers	III
Not moving flowerpots over onto windowsills	III
Stopping hemorrhage	IX
Banning explosives in tunnels or under "air rights" buildings	V
Skiers' "pre-season conditioning"	VIII
Mouth-to-mouth resuscitation	IX
Teaching Braille to a blinded soldier	X
Use of retaining walls to prevent California mud slides	III
Storm cellars in tornado areas	V and VI
Underground disposal of radioactive wastes	V and VI
Snuggling auto bumpers in sheet metal	Opposite of V
Causing earthquakes by damaging streams (MacDonald, 1969)	Opposite of I
Spacesuits	A variety of VI
Smoking in bed	Opposite of III
Pointing a spear; edging a sword	Opposite of VI
Fences around transformer stations	VI to achieve V
Skin tanning in relation to subsequent sun exposure	A naturally occurring illustration of VIII
Release bindings on skis	A variety of III, preventing further energy release
Earmuffs	A variety of VI
Reducing amount of explosive in each shipment	II
Playing with matches in pine woods	Opposite of III
Welders' goggles and helmets	VI
Fire fighters' suits	VI
Fire escapes	V
Lengthening fuses on explosives	V (to allow the lighter to avoid injury)
Roadside ("breakaway") poles that yield gently when hit	VII
Lowering crib heights to reduce brain and other injuries when infants fall out	II
Preventing the conception of tigers to prevent subsequent human injury	I
Developing less expensive fender repair methods	X
Stopping a would-be suicide from jumping	III
Reduce the calibre and number of firearms in private hands	II
Eliminate utility poles from roadsides	IV
The electrical fuse	A variety of III. It could be argued that the disconnection is usually achieved by V or VI (barrier, air), but whatever the physical means, the primary strategy is to prevent (further) release of energy

APPENDIX B

This appendix gives four case studies, applying the fundamental approach to provide systematic, basic options analysis of four important public problems. The tactics and over-all statements are *not* intended as definitive. They are illustrative only, and not necessarily practical. Furthermore, these will not treat questions of priorities for optimum strategy-influence on the end results, a subject touched on elsewhere (Haddon, 1968, 1972). The first three of these examples are from (Haddon, 1973). As in Appendix A, the strategy options are labeled I–X in logical, consecutive order.

CASE STUDY A

Reducing the Losses Associated with Femoral Fractures Among the Elderly

This mechanical energy-damage problem has customarily been conceived as a problem primarily of preventing falls and of treatment once injured. Systematic analysis gives a richer range of options, an analysis more likely to identify ways for greater loss reduction.

I. Do not raise patients above their surroundings. Do not allow the high-risk elderly to stand. What does not go up cannot come down. Note that the "potential energy," the release of which in falling produces damage, is a characteristic of the falling person or other body and that from the standpoint of injury to that same body cannot be regarded as being transferred to it at the moment of impact. The same point holds for the "kinetic energy" released when a person, for example, is injured walking or running into a wall.

II. If patients and other high-risk elderly must be raised, raise them less far, or for shorter intervals. Keep beds lower. Use wheelchairs instead of walking, and housing into and in which steps, stairs, and inclines are eliminated.

III. Keep them from falling. Use measures that retard deterioration of, or improve sensori-motor and musculo-skeletal status and performance. Eliminate occasions and means for tripping. Improve coefficients of friction of underfoot surfaces and of shoes. Make sure shoe heels are broad and not worn unevenly. Repair heels. Provide handgrips, canes, and walkers, bedrails, and as necessary, restraints.

IV. Provide walkers, wall handgrips or other means for reducing rate of fall, for example, when tripped. (The author is not certain of good sample tactics for IV.)

V. and VI. Since the falling person carries her own energy, separation is, in this context, in a sense, theoretically impossible.

VII. Cover impactable floor and other surfaces with energy managing barriers – "crash-padding." This technique, used in vehicles and elsewhere, is a largely ignored tactic for reducing femoral damage. In hospitals and other environments of and for the elderly it has considerable potential, since impact forces decrease directly with increase in stopping distance (Baker, 1972; Haddon, 1967;1972). Eliminate, soften, and/or round sharp points, protruding corners, and edges. Soften bathroom and other microenvironmental hardware and structures.

VIII. Increase relevant musculo-skeletal strength. Development of measures that reverse or lessen post-menopausal and other osteoporosis and of soft tissue weakening. Ideally, these should be "passive" rather than "active" (Haddon, Goddard, 1962), that is, as with pasteurization, chlorination, fluoridation, vaccination, food enrichment, and vehicular air bags and other crashpackaging tactics, as little as possible or no active co-operation should be required on the part of the individuals to be protected (Haddon, Goddard, 1962). *If* effective in reducing osteoporosis, addition of an essential mineral to deficient water supplies would illustrate this tactic and principle (Goggin, Haddon, Hambly and Hoveland, 1965). The same point concerning passive approaches being preferable holds generally whenever possible for all strategies.

IX. Emergency medical care. Splinting. Orthopedic surgery. Prostheses. Casts. Traction.

X. Intermediate medical care, long-term reparative and rehabilitative care.

It should be noted that the reduction of mechanical energy-damage to the brains of infants produced by falls from cribs can be similarly analyzed and that the tactics are similar, and in some cases identical (Haddon, 1970b).

CASE STUDY B

Reducing Thermal Energy Damage to Children and Others

As a practical matter, analyses of the thermal-damage problem must include consideration of circumstances that can produce heat quickly. This is the case especially in relation to strategy options I–IV.

I. Do not keep gasoline, old newspapers, and other flammables in the house. Do not make dwelling units flammable. Do not allow bedding, nightclothes, sweaters, saris, and appropriate other garments to be flammable. Eliminate space and floor heaters (Haddon, 1964, pp. 206-7 and 597-9; Brown, 1961; Waller, 1961).

II. Reduce the amount of such items. Reducing brewing temperatures for coffee and tea.

III. Stop smoking in bed, in storage areas, in explosives plants. Keep coffee cups and other hot items out of reach of infants and small children. Improve their stability and handles (?, eliminate handles). Keep matches, cigarettes, and people out of dry woods.

IV. Fire retardant paints. Cups that spill at a different rate or in different direction.

V. Don't brew or use coffee and tea when small children are or will be near. Use blowtorches and other hot items at a distance from people to be protected. Don't use night clothes.

VI. Interpose thermal insulation. Firedoors.

VII. Make the hot object of material that has both low heat content and inability to transfer heat at hazardous rates, for example, the glass doors of some household ovens (most are not yet adequately designed in this respect), and the double-walled (with air between) design of some Japanese teacups.

VIII. Make people more resistant to heat in a way somewhat analogous to sun-tanning, for example, by use of salt-tablets.

IX. Organize equivalent of poison control centers. Organize for quick response in bringing emergency medical care and the burned together. Make sure, require, and enforce that ambulance and other emergency personnel are very well able to deal with burns.

X. Grafting and other cosmetic surgery. Psychotherapy. Retraining.

CASE STUDY C

Reducing Drownings

Drownings are the result not of energy damage, per se, but in essence of interference with energy exchange. As such, they are a prime illustration of a closely related class of ecologic phenomena (Haddon, 1963; 1967) and can be approached just as easily with this basic options analysis.

Other members of this group include: carbon monoxide and cyanide poisoning; and the various forms of strangulation and nonaqueous suffocation. Frostbite and the varieties of cardiac and vascular malfunction causing interference with the energy exchange provided by the circulating blood provide additional illustrations (Haddon, 1967).

Identifying options for reducing losses of this type succumbs to essentially the same approach, the difference being that the environmental hazard central to the analysis is not one of the forms of energy, but rather the cause of such interference with energy exchange – water, by definition, in the case of drowning:

I. Prevent the synthesis or aggregation of water. Do not collect it. Prevent rainfall, do not build swimming pools.

II. Reduce the amount marshalled. Produce or bring together cup- not pool-fuls. Reduce precipitation.

III. Prevent its release to site of concern. Do not open the dam, tap, or hydrant.

IV. Modify the rate of aggregation or spatial distribution of the water aggregated. Control rate of release from source, use sluice gates. Seep through ground rather than flow through irrigation ditches. Make shallow.

V. Separate the water and the target population. Route streams away from play areas. Clam at low tide; cross estuaries when the water has receded; cross while not in flood, e.g., the legendary crossing of the Red Sea (Exodus 14:21-29).

VI. Interpose material barrier. Dykes, sea walls, fences around swimming pools. Well and culvert covers. Use flotation gear, fence mask and snorkel, diving suit, submarine, or diving bell.

VII. Modify the water. Spray, vaporize, or freeze.

VIII. Make the people less susceptible to drowning. Teach swimming, including breath-holding. Increase vital capacity. Develop gills.

IX. Emergency response. Teach lifesaving, including retrieval from water, resuscitation. Air-sea rescue operations. Equip boats and littoral with life preservers, boats, ropes and ladders (for ice breakthroughs).

X. Intermediate and long-term reparative and rehabilitative measures. In the case of drowning, this strategy usually has little to offer.

CASE STUDY D

Reducing Mob Damage Losses to the White House or Other Private or Public Building

Mobs, other than through coercion, example, and interference with normal social intercourse, most commonly produce damage through the application of energy in excess of the thresholds of target animate and inanimate structures. All crowds have muscle power, and hence can potentially damage by transfer of mechanical energy, as with rocks, fists, and breaking down doors and other barriers. Some mobs also have other forms of energy with which to damage. These include explosives – whether as bombs or in firearms – and incendiary devices, and, though from a quantitative standpoint often dissimilar both in range and in their potential targets, the same general, qualitative analysis applies equally to them as to all cases within the general class.

Using the same strategy-option nomenclature given above, the following illustrate the options for reducing possible damage to the White House. This is an example of a commonplace contemporary and historic problem also illustrated by moats, castle walls, Renaissance palace architecture, the Kremlin, and the apparent policy in Roman Britain of encamping troops at a distance from headquarters to lessen the likelihood of damage from their rioting.

I. Prevent crowd formation.

II. Keep crowds small. Limit the number of persons allowed in Lafayette Park (across the street from the White House). Proposals under recent Presidents to level a nearby block for a public and parade assembly area fundamentally violate this principle.

III. Prevent crowd from becoming unruly. That is, permit only "peaceful assembly."

IV. Modify rate and spatial distribution of the mob's energy release, as with water hoses, tear gas, arrests.

V. Only allow demonstrations at more distant loci – the Washington Monument grounds, or in West Potomac Park. Phase for less convenient days and times, or those when there is less to damage.

VI. Barriers. Fences, doors, moats, hedges, walls, and ornamental pools. Park buses interposed in lines bumper-to-bumper.

VII. Prevent carrying or availability of devices used to localize mechanical force: brass knuckles, chains, knives, loose benches.

VIII. Strengthen structure. Force-resistant exteriors and glazing, locks, reinforced framing, fireproofing.

IX. Emergency response. Signal generation and transfer, evaluation, decision, command, dispatch of response from nearby, and control.

X. Cleanup and stabilization.

Finally, several miscellaneous points seem especially noteworthy in this context:

The various poisoning problems, including lead poisoning and all drug addictions, are also readily susceptible to such basic, and very similar, options (and causal) analyses.

Since basic analysis in the energy damage problem field and its use must be based primarily on physics, as must many aspects of more quantitative work, some subtlety of understanding of physics is very helpful. For example, the "Tigers" (Haddon, 1970a) categories are not merely boxes in a classification scheme; the first eight reflect fundamental aspects of the physical world.

Moreover, the phenomena so represented are rapidly occurring, typically transient subsets of the ecology of energy flows, distributions, and changes. It is important that the relationships between these derivatives of the larger sets be understood in relation to them.