A Study of Direct and Indirect Costs Resulting from a Radiological Attack by Terrorists

M.E. Young, J. McFee, J. Langstead
Shaw Environmental and Infrastructure, Inc.
9201 E. Dry Creek Road, Centennial, CO 80112-2818
E. Day, PELL Resources Co., Manassas, VA 20112, USA

ABSTRACT

An uncontrolled release of radioactivity caused by a terrorist attack is expected to result in an "incident of national significance" and have the potential consequence of a significant economic impact. The magnitude of the economic impact and the range of impacted entities are somewhat controversial. This paper will discuss the elements and methodology that comprise the buildup of an estimate for a specific critical infrastructure. The radiological attack event was studied by the Department of Homeland Security (DHS) to estimate the health and economic impacts of a radionuclide attack. The cost estimate was based on response actions outlined in the DHS National Response Plan [1] and the Environmental Protection Agency (EPA) Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents [2]. A response plan was developed to support the options for the estimate. Several response and cleanup options were evaluated to determine a range of potential costs. It is the breakdown of the cost elements and their relative size that is discussed in this paper.

The first step in the estimating process was the development of the terrorist attack characteristics that were to be estimated. Example response timelines were developed to determine what immediate operational response actions are possible to mitigate the attack consequences. Based on the attack assumptions, costs were estimated for a number of response and remediation options that may be employed. Finally, each parameter was evaluated to account for the range of values possible and its effect on the total cost.

Cost estimates were based on data from standard references, internet searches on specific subjects, and information from recent terrorist activities. These costs were broken down into Microeconomic Level Costs (primarily associated with Medical Treatment, Remediation, and Business Interruption) and Macroeconomic Level Costs (primarily associated with the value of life lost, security improvement, and property values losses).

Macroeconomic level costs were included for the Lost Value of Life Compensation for victims at same rates as WTC and post incident security improvements detection capability requirements, similar to airline security improvement after 9/11. Microeconomic level costs included medical treatment, drinking water system remediation, and direct business losses. The significant conclusion from this study is that although all costs are high, macroeconomic level costs outweighed the microeconomic level costs by about an order of magnitude.

INTRODUCTION

The purpose of this paper is to qualify the range of economic impact on the nation if a drinking water distribution system is attacked through introduction of radioactive material. This paper assesses the economic consequences of example terrorist attacks on a drinking water distribution system and provides rough order-of-magnitude cost estimates for example attacks. The selected examples attacks include a residential community of 100,000 people and a smaller portion of the same system at a higher concentration leading to a lethal dose. Distinct cost estimates were developed for the attacks, based on different assumptions on response, remediation, and recovery.

The technical approach taken to develop example economic consequences estimates for the example attack scenarios is shown in Figure 1. The first step in the estimating process is the development of the terrorist attack characteristics that will be used to develop the costs. Example response timelines were developed to determine what immediate operational response actions are possible to mitigate the attack consequences. Based on the attack assumptions, costs are estimated for a number of response and remediation options that may be employed. Finally, each parameter was evaluated to account for the range of values possible and its effect on the total cost. Each step in the approach is discussed below.

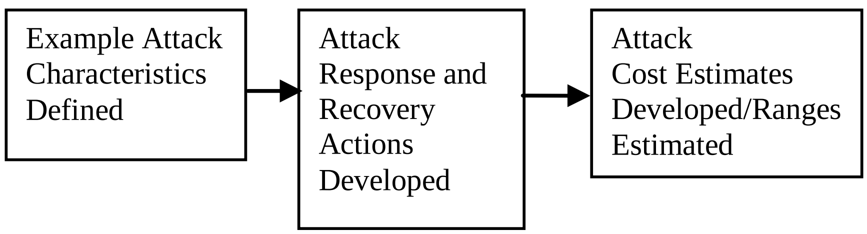

Fig. 1. Technical approach

Description of Example Attacks

Attack characteristics will drive the economic impacts of the attack and must be defined as the first step in consequences estimation. Detailed attack examples were developed and presented in the "Task 3, Radionuclide Contamination, Development of Attack Scenarios" report [3]. This study estimates the costs and economic impact associated with the residential attack scenario using a stolen or recovered sealed source.

The cost study looked at two attack variants. The first is an attack on a distribution system serving approximately 100,000 people at cancer causing levels, hereafter referred to as the system-wide attack. The 100,000 person community was purposely selected to support simple scaling to higher and lower affected populations. The system-wide attack (100,000 people) assumes the introduction of the radionuclide into a large transmission pipeline serving that population.

The second is an attack on a smaller portion of the system. The LD_{50} attack requires higher concentrations than the system-wide attack so a smaller pipeline is targeted. This pipeline can serve approximately 10,400 people, depending on use.

Consequences of the Attack

The consequences of an attack include substantial contamination of the Municipal Water System (MWS) distribution system and substantial fatalities in both the system-wide and LD_{50} attack. The contamination to the system will be driven by the attack characteristics and system parameters such as adsorption and desorption of radionuclides on the system biofilm, sediment, and scale. The adsorption and desorption in the system is an unknown variable that will effect the extent that the system will remain contaminated after the attack and will require remediation. Both the system-wide attack and the LD_{50} produced fatalities comparable to the 9/11 attacks. The system-wide attack produced several times more fatalities than the LD_{50} attack.

The methods and assumptions used to estimate the early fatalities and latent cancer fatalities are discussed in detail in the "Task 3, Radionuclide Contamination, Development of Attack Scenarios" report. The methods used in this cost estimate improve upon those methods by calculating the fatalities for a defined MWS and accounts for the:

- Size of the MWS attacked;
- Concentration of radionuclides in each attack;
- Duration of the attack;
- Percentage of the population in the attacked system that would likely drink the water;
- Latent cancer fatalities; and
- Removal of early fatalities from latent cancer fatality predictions.

Description of Example Response

The response to a radionuclide attack on a MWS would follow the response guidelines in the DHS National Response Plan (DHS, 2004) and the Environmental Protection Agency Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents (EPA, 2003). The responses are nearly identical for both attack variants, but on different scales.

Timelines were developed based on the likely time the attack would be detected or announced. Figure 2 summarizes the timeline used for the cost estimates. These timelines are important because they dictate what response options are possible to mitigate the attack. It is unlikely that a terrorist attack would be detected in time to shut down the system before consumption of the contaminated water. This assumption is based on the complete absence of detection equipment capable of real-time detection of a radionuclide attack.

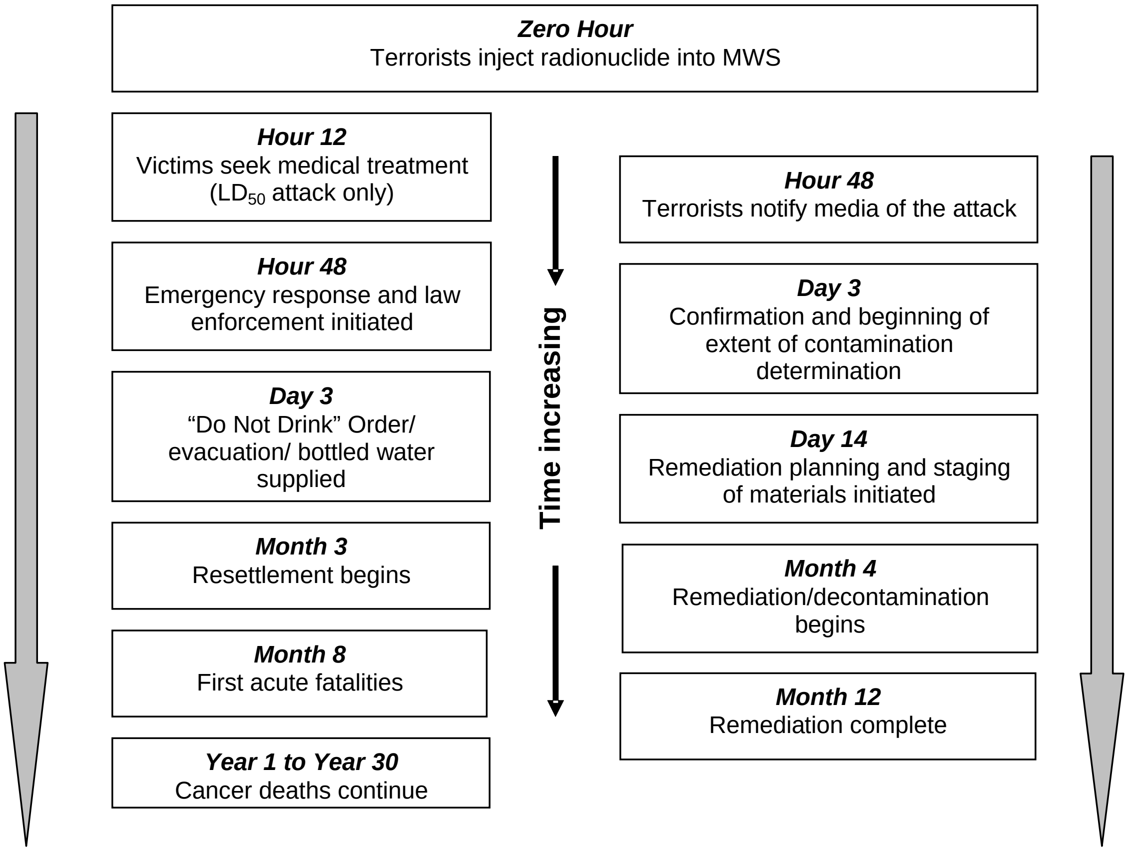

Fig. 2. Timeline summary

The timelines for the two attack variants are different due to the different doses delivered. The system-wide attack example is at cancer causing concentrations that would not have a high enough dose to cause prompt symptoms associated with acute radiation syndrome. Because the health effects are not obvious for many days after the system-wide attack, the population may not know they have been attacked.

Several possible means of detecting the system-wide attack are possible. Delayed identification is likely to be from secondary effects. It is possible that some laboratories in the attacked area might detect an attack during their normal operations and notify authorities. It is also possible that some hazmat units, medical, or industrial facilities with detection equipment may detect the attack. It is also possible but unlikely that law enforcement might catch the terrorists in the act, and notify the MWS. If the attack is not detected, the terrorist may call the authorities or news outlets to announce the attack, presumably after any chance to mitigate the attack through immediate operational response actions is past (48 hours). Unless one of the other threat warnings routes discussed above transpires, the first indication of a system-wide attack may be from terrorists, and emergency response actions will be very limited.

The response timeline for an LD_{50} attack starts with the first victims with acute radiation syndrome (radiation sickness) arriving at emergency rooms with symptoms. The initial symptoms include vomiting, nausea, and lack of energy. The symptoms progress to fever, diarrhea, and disturbance of electrolyte balance. Once the medical personnel notice common symptoms in a large portion of emergency room patients, they may notify the health department of an illness pattern of unknown origin. Symptoms are similar to other diseases and it may take some time ruling out other causes, such as food poisoning, before radiation sickness is determined. The delay in recognition of the radiological nature of accidents has been documented by researchers [4]. It took an average of 22 days to recognize four recent radiation accidents

[4]. This delay is very significant since there are medical treatment techniques that can be used to prevent absorption of radionuclides in the victim's bodies and speed excretion of radionuclides from the bodies if administered shortly after exposure.

Once the medical personnel establish the connection to radiation, the source (drinking water) is still not known. The water maybe suspected and the MWS notified. Eventually the connection to drinking water will be made and notifications conducted. The most optimistic timeline for notification of the MWS would be about 24 hours after the attack and may be much longer.

This timeline, with MWS notification at 24 hours plus, is important in that it is probable that notification will not occur before the attacked population consumes the contaminated drinking water. This lack of notification during the attack also precludes immediate operational response actions that limit the consequences, such as isolation of the effected system and/or public "Do Not Drink" orders. This lack of ability to stop the exposure to the population during the time the attack is occurring and the high activity mass is moving through the system, has significant cost implications in health impacts discussed later in this report. Finally, the timeline is important in that it dictates confirmation methods that may be used, as discussed below.

Crisis Management/Emergency Response

The timelines previously presented limits crisis management/emergency response options. Since the population probably cannot be prevented from being exposed during the attack, there are few mitigating activities possible. If the recognition that the attack is radiological is made early, treatment of victims with agents to prevent absorption of the radionuclides by the body and more rapidly pass radionuclides from the body is possible. These methods diminish in effectiveness as time between ingestion and treatment increases. Evacuation and housing of people in the attacked area will probably be required until characterization and risk assessments are completed. Alternate water sources will be required until the system is remediated. Law enforcement will be required to secure the crime scene, maintain order, and pursue perpetrators. Details are discussed in the Attack Cost Estimate section below.

Establishment of Final Remediation Goals

The EPA will make the decisions on final remediation goals which will be based on risk based action levels. EPA Response Protocol Toolbox states in Module 6, Section 3.1.4 that "For known or expected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper limit of lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} (1 in 10,000 and 1 in 1,000,000 respectively)...". Radionuclides would be considered known or suspected carcinogens. It is expected that risk based action levels will require the remediation of the MWS.

Remediation

There are a large number of remediation options and combinations that could be selected to mitigate the attacks. Remediation options for the MWS distribution system include: no further action; decontamination; replacement; and decontamination and relining. Remediation options for addressing home contamination include: no further action; decontamination; point-of-use systems; replacement; and home buyout.

Attack Cost Estimates

Overview

Costs are estimated for the two attack variants and the different options that might be selected during emergency response, remediation, and recovery. Many possible options may be used in an actual attack and the estimated costs presented in this report are examples of possible range of costs to provide rough order-of-magnitude estimates for planning purposes. The actual attack costs will depend on a large number of variables that are event and site specific. The example attack scenario cost estimates discuss and quantify the big costs. It is unlikely that the economic impact of a terrorist attack on a MWS distribution system will achieve the threshold limits the terrorists would want to achieve. Based on our estimates, the attack will cost in the range of $ 5.6 billion/year averaged over a 15 year period for the example system-wide attack and at least $2.8 billion/year for an example attack on a smaller portion of the system using high radionuclide concentrations averaged over a 15 year period.

Coping with the impact of the radiological disaster of Chernobyl placed a huge burden on the national budgets of Ukraine and Belarus. A massive expenditure toward the social benefits to “victims” has resulted in 5-7% annually of the Ukraine government spending still 20 years later.[5] The major categories of costs are shown in Figure 3. For all major costs the results are discussed in the text and summarized and totaled in Table I. These cost are designed to illustrate the potential costs from the two types of terrorist attacks previously described and are provided as examples only since the actual costs of an attack will depend on a wide variety of parameters, such as the target attacked, the radionuclide used and the strength of the radionuclide source.

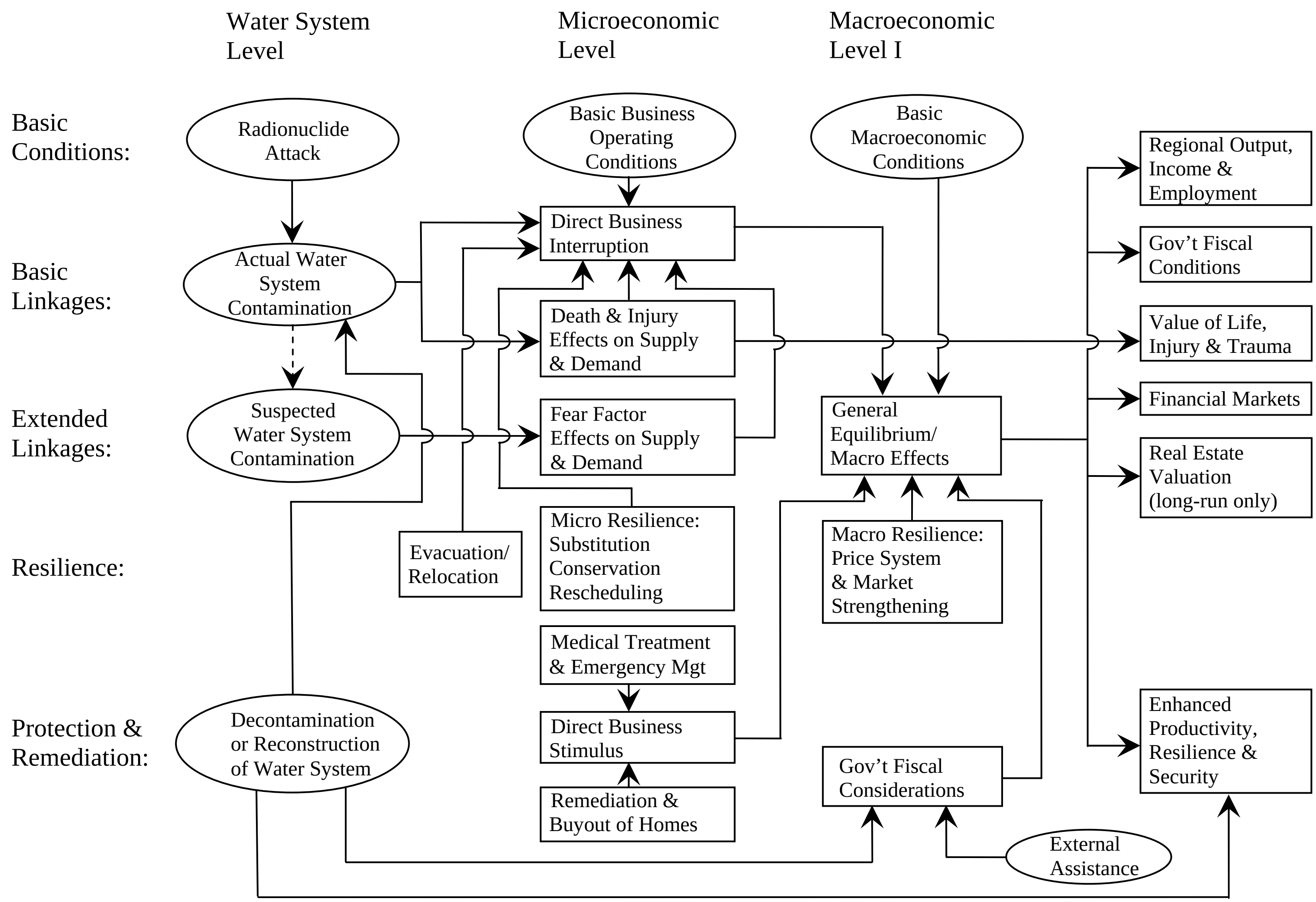

Fig. 3. Estimating the total economic impacts of a radiological attack on a municipal water system (from Rose, 2006 [6])

Table I. Major Categories of Loss (in millions of 2006 dollars)

	System-wide Attack	LD_{50} Attack
Cost Component	Dollar Value/Time Unit	Dollar Value/Time Unit
Fatalities (Cancer)	$50,000/15 years	$8,000/15 years
Global Security Improvements	$25,000/2 yrs	$25,000/2 yrs
Fatalities (Early)	$0/several months	$8,000/several months
House Plumbing Replacement	$1,700/1 year	$180/1 years
Residential Property Value	$1,700/1 yrs	$180/1 yrs
Direct Business Interruption	$1,642/1st year[b] $243/avg year	[c]
Treatment of Cancer Monitoring Non-cancer Illness Psychological Treatment Radiation Syndrome Disposition of Dead	$1,500/15 yrs $1,600/15 yrs $900/15 yrs $270/3 yrs $0 $18/1 yr	$230/15 yrs $50/15 yrs $27/15 yrs $10/3 yrs $380/15 yrs $38/1 yr
Extended Linkages (Losses)[d,e] (Fear Factor)	$458/ 1 yr	$458/ 1 yr
General Equilibrium (Losses)[f] (not including direct effects)	$411/1st yr $62/avg yr	[c]
MWS Distribution System Replacement	$440/1 year	$38/1 year
MWS Distribution System Decontamination	$138/1 yr	$16/1 yr
House Plumbing Decontamination	$49/1 yr	$19/1yr
Emergency Response Law Enforcement Characterization	$125/1 yr $52/1 yr $6/1 yr	$13/1 yr $52/1 yr $6/1 yr
Commercial Property Value	$84/2 yrs	$17/2 yrs
Total[g]	At least $84,000	At Least $42,000

[b] Assumes the following:
1) Value-added of $100 per person per day
2) First year business declines by 75% first quarter, 50% second quarter, 25% remaining quarters
3) After first year assumes business decline improves 1% per year from 25%. Also assumes resilience improves 3% per year from base of 50%.

[c] not computed.

[d] Assumes "Fear Factor" affects neighboring communities totaling population of 500,000 for 3 month period. Also assumes 10% drop in productivity.

[e] Multiplier of 1.25 also applied to Direct Business Interruption from fear factor. Also assumes 90% resilience since no actual damage is incurred.

[f] General Equilibrium "multiplier" applied to Direct Business Interruption Base. Multiplier value based on typical I-O & CGE model multiplier values for regions with populations of 100,000; also implicitly includes price reallocation associated with price changes. Total (not discounted) over 15 years is $1,265.

[g] Some of the extended linkage costs and general equilibrium costs express different aspects of the same costs and to avoid double counting costs they were not included in the total.

Individual Costs Elements

The costs were estimated based on the scenarios previously discussed. The attack characteristics were defined, the response was developed, remediation options were developed based on the projected contamination, and finally the consequences were estimated. While the original estimate was developed considering large numbers of potential costs, only a dozen proved to be significant when compared to the others. The major costs of the study are presented below in order of significance.

The Value of Life Lost

The families of the September 11 fatalities were paid an average of 2.1 million dollars by the government, per victim. The predicted number of fatalities for both the system-wide attack and the LD_{50} attack were used to calculate the cost of the value of life lost.

Mandated Post-Incident Security Improvements

After the September 11 attacks, the United States introduced a wide range of requirements to improve the security of air travel. A major contamination attack on a PWS could provoke a similar response. If it was decided that radiation detection systems should be required on the 160,000 MWS in the country, the cost would be substantial. A recent EPA document surveyed the state-of-the-art in detection systems for radiation detection in MWS [7]. The units available were in the range of $75,000 each. Assuming that one system will be required for each 5,000 people served by medium, large, and very large public water systems; the cost would be $21 billion. The cost to install detection systems at sensitive target facilities such as military bases, government office complexes, financial institutions, and national landmarks (assume 10,000 facilities), would be $4 billion. This cost estimate is the same order-of-magnitude cost as the airport security upgrade required after the September 11 attacks. It is also the same order-of-magnitude to upgrade the U.S. power grid, which has not been funded.

Residential Property Value Losses

The cost to the residential property values is easier to estimate in this example. The example system-wide attack hits 40,000 homes. Assuming a value of $211,000, per house and it losses 20 percent of its value, the total loss for the system-wide attack would be $1,700 million. The LD_{50} attack cost would be $180 million.

Household Plumbing Remediation

The very low ingested activity required to produce an unacceptable cancer risk will probably require remediation of the household plumbing and replacement of the water heater based on MWS chemical contamination experience. The decontamination, remediation and recovery options for the house plumbing include: no action, chemical decontamination of the piping, point-of-use treatment systems, replacement of piping, and replacement of housing. The cost of each of these options is discussed below.

The plumbing replacement option replaces all the plumbing and fixtures in each house and surveys water use areas for contamination. The cost of this option for the system-wide attack is estimated at $42,000 per house times 40,000 houses, or $1.7 billion. The costs for this option for the LD_{50} attack would be $42,000 per house times 4,160 houses, or $180 million.

Direct Business Interruption (from Rose 2006 [6])

The estimate of direct business interruption was calculated are based on the following assumptions:

1) The annual net product (value-added) of the city is $3.65 billion (based on average U.S. GDP figures per capita of $100 dollars per person per day in 2005).
2) Business interruption pattern for the first year:
    - 1st quarter--75%
    - 2nd quarter--50%
    - 3rd and 4th quarters--25%
    - Resilience of only 10% in the first year.
3) Business interruption pattern for years 2-15: Business decline reduces by 1 percent per year from 25 percent annually (the economy never recovers pre-disaster levels but only 90 percent of them, because of lost markets and stigma from the attack).

Cancer Monitoring

Monitoring for cancer in the exposed population of 73,000 people who actually drank the water during the attack on the 100,000 residential system will be necessary for the next 30 years after an attack because one in three exposed individuals are predicted to die from the excess cancer risk caused by the attack. The study accounts for the leukemia deaths which would occur in the first five years [8]. The cancer screening costs depend on the type of cancer screened for. Doctor visits, test costs, and interpretation vary from $400 to $6000 per screening. The example assumes an average screening cost of $1,700 per person every other year. A total of 23,900 cancer fatalities will occur in the exposed population of 73,000, assuming that the 2,390 leukemia fatalities occur at year 5 and the other cancer death occur on an average of 15 years after the attack, the monitoring cost would be $1,600 million. The monitoring cost estimate for the LD_{50} attack would be $50 million.

Treatment of Cancer

Treatment of cancer caused by the attack will be a major cost. There are a maximum of 23,900 excess cancer fatalities predicted in the system-wide attack. The average total cost of cancer treatment according to the Congressional Budget Office (CBO) is $61,000 [9]. Total cancer treatment costs equals 23,900 cancers times $61,000 per cancer for treatment, or $1.5 billion. The total cancer treatment costs for the LD_{50} attack using the same formula equals $230 million.

Treatment of Non-cancer Illness

The cost of other non-cancer illnesses in the population is hard to define. There have been reports of increases in non-malignant diseases in the population exposed to the Chernobyl disaster [10]. The Ukrainian government agency Chernobyl Interinform in Kiev reported in March 2002 that 84 percent of the three million people in Ukraine who had been exposed to radiation were registered as sick [10]. It is unclear what portion of this illness can be attributed to radiation exposure rather than poverty and poor lifestyle choices. While the non-cancer illness is established, some studies attribute the non-cancer illness to stress rather than radiation exposure. Assume each exposed person in our attack examples has one additional illness per year at an average cost of $500 per illness (including doctor visits, tests, and treatment). To calculate the number of non-cancer illnesses we have to account for the cancer fatalities that will reduce the population potentially effected. A total of 23,900 cancer fatalities will occur in the exposed population of 73,000, assuming that the 2,390 leukemia fatalities occur at year 5 and the other cancer deaths occur on an average of 15 years after the attack the cost would be $904 million. The non-cancer illness cost estimate for the LD_{50} attack would be $27 million.

Extended Linkage Losses (from Rose 2006 [6])

Assumes "Fear Factor" affects neighboring communities totaling population of 500,000 for 3 month period. Also assumes 10% drop in productivity and a multiplier of 1.25 applied to Direct Business Interruption from fear factor. Total extended linkage losses for the system-wide attack estimated at $458 million.

Drinking Water System Replacement

Numerous MWS personnel consulted have consistently stated that they would probably have to replace the entire system if a radionuclide attack occurred. The replacement of the entire MWS involves the excavation and removal of all impacted MWS equipment, followed by replacement with new equipment. The impacted equipment would be considered low-level radioactive waste and would probably be buried at the Nevada Test Site (NTS), the DOE's primary low level waste disposal facility. All radioactive waste, for all options, is assumed to go to NTS because of the national event nature of the attack and probable government remediation. If the waste was to go to a commercial radioactive waste disposal site, the costs would be an order-of-magnitude higher. The cost estimate also includes equipment sizing to fit into disposal containers and transport to NTS. The advantage of this option would be that no portion of the contaminated system would remain to produce on-going additional exposure to the population. Another advantage is that the option would receive the highest public support. The total cost of this option for the system-wide attack is estimated to be $440 million. The total cost of this option for the LD_{50} attack is estimated to be $38 million.

General Equilibrium Losses (from Rose 2006 [6])

General Equilibrium "multiplier" applied to Direct Business Interruption Base. Multiplier value based on typical I-O & CGE model multiplier values for regions with populations of 100,000; also implicitly includes price reallocation associated with price changes. It is estimated at $411 million in the first year and $62 million in following years.

Treatment of Acute Radiation

Treatment of acute radiation syndrome would be a cost for the LD_{50} attack. This treatment may include: antibiotic prophylaxis, diluting or blocking agents, purgatives, laxatives, enemas, ion exchange resins, chelating agents, blood transfusions, and stem cell transplants. The level of treatment will be dependant on attack-specific considerations such as the delay between exposure and treatment, radionuclide, activity ingested, number of casualties, and many others. The costs are dependant on the type of treatment given all the LD_{50} attack victims. This cost could vary by at least four orders-of-magnitude. Given this uncertainty, this study assumes a treatment cost of $50,000 per person ingesting water in the LD_{50} attack. The estimated treatment cost would be $380 million, given these assumptions.

Treatment of Psychological Illness

Treatment of post-traumatic stress disorder (PTSD) and severe depression will be another major cost. Studies show that rates of PTSD are greater following events caused by deliberate violence than after natural disasters. The Oklahoma City bombing and the Paris subway bombing, experienced 34 percent and 41 percent PTSD respectively, in surviving victims. Those actually exposed to mass violence have been shown to develop PTSD 67 percent of the time according to one study. Estimates of the PTSD for the September 11 attacks ranged from 7.5 to 40 percent. Lower estimates around 20 percent are reported for people living near the World Trade Center but not victims of the attack. Based on the Oklahoma City treatment results, it took 36 months of treatment to reach remission for those that recovered. One-third did not remit. This study took the conservative approach that the September 11 victims with PTSD rates are not well defined. A formula was developed that used the average the rates for the population near the WTC (20 percent), with the rates for the Paris (41 percent) and Oklahoma City (34 percent) terrorist attacks and assumed that 30 percent of the population attacked will develop PTSD. This assumption is conservative since there will be stress from predictions that 1/3 of the victims will die from cancer and the publics fear of radiation, in addition to the reaction to a terrorist attack. Treatment costs estimates ranged from $1,100 to $4,000. Assuming that half those with PSTD will refuse treatment, 50 percent with PSTD will be treated for 36 months, 9 percent will not remit at an average yearly cost of $2,500, the cost estimate for the system-wide attack would be $270 million. The cost estimate for the LD_{50} attack would be $10 million.

Total Example Costs

The costs for the system-wide attack and the LD_{50} attack are shown in Table I. Note that since some macroeconomic costs include certain costs in different forms they were not added to the total attack costs. Total costs should be looked at as being at least the total cost shown and may be higher. Note that a system-wide attack at cancer causing concentrations produces significantly more causalities than a LD_{50} attack. The example costs of a system-wide attack are twice the costs of an LD_{50} attack. These costs are comparable to the 9/11 attack costs. While these cost estimates are only for example attack scenarios they tell us that this type attack warrants further attention. Note that in this cost study the system and home remediation costs, including waste management of radioactive wastes, are a relatively minor component of the total costs.

CONCLUSION

Cost estimates were developed for an example attack on a 100,000 person drinking water system at cancer causing concentrations of radionuclides and an example attack on a smaller portion of the same system.

The highest cost for the system-wide attack estimate was the value of life lost. This cost was the second highest cost for the LD_{50}

The second highest cost for the system-wide attack was the estimated cost of post-incident security improvements, comparable to those implemented after 9/11 for the airline industry. Detections equipment to detect radionuclide concentrations capable of producing cancer if consumed is current very expensive and labor intensive.

Remediation costs to replace the contaminated drinking water systems, including waste disposal of radioactive wastes, was found to be only about 0.5% of the total costs estimated. The costs to replace household plumbing contaminated by the attack, including radioactive waste disposal, was found to be only 2 % of the total costs.

The estimated total cost of the system-wide attack was greater than $84 billion. The estimated total cost of an attack at LD50 concentrations was greater than $42 billion. These costs are comparable to the 9/11 attack costs and illustrate that this type of attack is significant and warrants further attention.

REFERENCES

1. U.S. Department of Homeland Security (DHS), 2004, National Response Plan. December.
2. U.S. Environmental Protection Agency (EPA), 2003 Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents, Interim Final, December.
3. Shaw Environment & Infrastructure (Shaw), 2006. Task 3, Radionuclide Contamination, Development of Attack Scenarios. March.
4. Bertho, J., 2004, The Medical Diagnosis and Treatment of Radiation Overexposed People, Institut de Radioprotection et de Surete Nucleaire, July
5. The Chernobyl Forum, IAEA, 2005, Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine; pg27
6. Rose, A., 2006, Comments on DHS 2006 Draft Domestic Municipal End-to-End Water Architecture Study, Chapter IX, Economic Impacts of A Contamination Incident, September
7. US Environmental Protection Agency, 2005, "Technologies and Techniques for Early Warning Systems to Monitor and Evaluate Drinking Water Quality: State-of-the-Art-Review," Office of Research and Development, National Homeland Security, Research Center, December 2005.
8. U.S. Environmental Protection Agency (EPA), 1999. Federal Guidance Report No. 13, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, 402-R-99-01. September.
9. Congressional Budget Office (CBO), 2000, PAY-AS-YOU-GO Estimate, H.R. Breast and Cervical Cancer Prevention and Treatment Act of 2000, October.
10. Chernobyl Info, 2006, Overview of Health Consequences