RISK ASSESSMENT METHOD ON CHEMICAL ACCIDENTS

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1. INTRODUCTION

This document is an adaptation of an original English document published by the United Nations Environment Program (UNEP) as part of its Awareness and Preparedness for Emergencies at Local Level program (APELL).

The APELL publication suggests 10 steps for implementing the program, and the original English document, "Hazard Identification and Evaluation in a Local Community," attempts to resolve Step 2 of the APELL process: **Evaluate the risks and hazards which may result in emergency situations in the community.**

2. DEFINITIONS

Accident: an unintended and unexpected event, occurring suddenly and causing injury to people, property, or the environment.

Dimensioned damage estimate: an estimate of the level of damage which can be expected from a hazard in a certain kind of accident.

Worst case: the possible event with the worst consequences. There are three types:

1. The consequences are so limited that the risk is unimportant, whatever the probability of the event.
2. The consequences are so serious that the probability of the event must be very small if there is to be a tolerable level of risk. In extreme cases, the lack of effective safety measures makes the risk intolerable.
3. The worst possible consequences are irrelevant, since the probability is so low that the risk is negligible.

Disaster: is here taken from a local viewpoint to mean several deaths and tens of severely injured survivors, damage to property to a value of several million US dollars, or long-term damage to the environment.

Hazard: is the source or **origin** of a risk, a **threat** that could cause an accident.

Accident event sequence: is the unavoidable but indirect consequence of another accident or circumstance.

Probability: is an expected scale of events (accidents) within a certain period of time.

Risk: is the probability of an accident occurring within a certain time.

Risk analysis: is the systematic identification and evaluation of risk objects and hazards.

Risk objects: are the industries, warehouses, communication channels, etc., containing a hazard or risk source.

3. LIVING WITH RISK

There is no such thing as zero risk. Nothing can be made 100% safe.

The authorities responsible for environmental protection, health, civil protection, etc., should know more about the hazards present in the area and the circumstances that could lead to a disaster.

Industry must know its products, raw materials, by-products, and waste, and the hazards associated with them.

In many places the authorities, the community, and industry are removed from the need to predict and prevent technological accidents, since they are separated by lack of communication, even though they share the common interest: SAFETY.

The identification, evaluation, and ranking of risk objects will make the threats more visible. It will therefore assist in making the protection of people, property, and the environment more effective. There are two aspects of the term "risk" here:

- The **probability** of an accident occurring within a certain time.
- The **consequences** for people, property, and the environment.

A risk can rarely be calculated with mathematical precision, but it can often be estimated with sufficient accuracy.

Hazard analysis is an attempt to weigh the consequences of an accident against the probability of such an accident occurring. The probability and consequences of an accident may be reduced if the causes and effects of the hazard are identified.

Study of the consequences of an accident is also important, in view of the chain reactions it may produce.

Developments in society are resulting in the concentration of industry in a single place, leading to an increase in the transportation of hazardous materials that may result in damage to the environment and harm to the residents of a community.

The constant demand for improved efficiency and increased capacity often lead to the use of more sophisticated equipment and more dangerous processes in industry. This implies the need for effective joint management of risk by industry, the authorities, and the community.

The people responsible for making decisions in industries where the greatest risks of major accidents exist must recognize the need for effective handling of these "technological risks." There are several reasons for this:

- The health and safety of employees and residents of the nearby community.
- The avoidance of damage to property, the environment, and the company's means of production.
- Industry's need for good relations with the authorities and the general public if it is to develop in a positive way.
- The need for uninterrupted production in order to maintain reliable delivery and good customer relations .
- The cost of damage to company property and the property of nearby residents, which could jeopardize the company's survival.

An accident can also affect the general public's attitude toward industry. The pressure of public opinion can force a company to close down. It is not enough for a company to rely on insurance payments when there is a way of preventing the hazards and the probability of an accident occurring.

The management of these hazards to prevent accidents is therefore needed in industry, supported by the involvement of local authorities. This work should cover both practical and administrative matters, as well as management routines.

Efforts to prevent accidents demand full commitment and substantial resources, especially in high-risk industries.

People's anxiety about threats to their life, health, property, and the environment is rarely based objectively on the real risks involved, and hence the results of risk analysis should be disseminated. Some of the most serious sources of risk are traveling by car, smoking, and consuming alcohol. However, these risks do not cause much anxiety, since they are part of daily life.

The risks to which people expose themselves by choice in activities such as rock-climbing, skiing, sailing, skin diving, driving a car or other motor vehicle, and riding bicycles are often many times higher than the risks associated with nuclear accidents, large chemical leaks, and fires. However, people feel greater anxiety about technological accidents because of their ignorance or lack of precise knowledge about the probabilities, causes, and effects of such accidents.

4. PROCEDURE

4.1 Basis and Background for Risk Analysis

The objectives and scope of the study should be established, based on a map of the area. The purpose of the analysis should also be established.

An analysis map should be drawn up, containing only **relevant** objects, such as:

- Road and rail networks, airports
- Buildings
- Business districts, stores, warehouses
- Industries
- Docks
- Power lines
- Wastewater treatment plants
- Natural gas and oil pipelines
- Dams, lakes, and rivers
- Mines
- High and low-lying areas
- Schools
- Hospitals

A list of companies operating in the area under study.

Hazardous materials should be indicated, noting the largest quantities.

With respect to the transport of hazardous materials, a registry should be established of the quantities and types of materials regularly transiting through the area.

Information on accidents that have occurred in the area are also of vital use in the study.

The number of residents in the area is of critical importance for risk analysis, in addition to the hours of heaviest concentration (workers, students, etc.).

4.2 Inventory

A **list** should be made of the objects and their potential hazards for inclusion in the analysis. The map provides a starting point, but a visit to the location of the risk object should always be made, especially for objects that are predicted to be major threats, such as:

Risk Objects	Hazards
Docks	Variable quantities of many hazardous materials, cranes, vehicles.
Warehouses	Variable quantities of many hazardous materials, vehicles.
Ships	Hazardous materials (chlorine, liquid petroleum (L.P. gas) ammonia, caustic soda, phosphorus, etc.).
Railways	Hazardous materials (chlorine, L.P. gas, ammonia, caustic soda, etc.).
Canals	Hazardous materials.
Airports and aircraft	Fuel, hazardous materials in transit, cargo vehicles.
Processing Industries: Refineries, petrochemical, inorganic chemical, paint, pharmaceutical, steel/metal, paper, and textile plants	Pressure vessels, storage tanks, processing equipment with hazardous materials, catalysts, hazardous waste, high voltage electricity.
Other Industries: Plastics, rubber, lumber	Pressure vessels and storage tanks with hazardous materials.
Hydroelectric power stations	High voltage electricity, dammed water.
Thermal power stations	Inflammable substances, pressure vessels, high pressure steam, hot water, high voltage electricity.
Gas pipelines	Inflammable gas under pressure.
Other pipelines	Inflammable and poisonous materials hazardous to the environment, pressurized pipelines.
PEMEX terminals	Inflammable, poisonous materials hazardous to the environment.
Department stores	Combustible and poisonous materials, aerosol sprays.
Building materials warehouses	Large quantities of wood and combustible and poisonous materials.
Hardware stores	Combustible and explosive materials.
Water treatment plants, swimming pools	Hazardous materials, such as chlorine.
Hospitals	Infectious waste, hazardous and poisonous chemical materials.
Schools	Hazardous chemical materials.
Hotels	Fuels, pressure vessels.
Silos	Combustible dust.
Quarries, tunnels	Unstable rocks, contaminated water, poisonous gases, heavy-duty machinery.
Roads	Vehicles, hazardous materials.

4.3 Identification

A simplified format can be applied to both an installation and a geographical area: "Inventory of Risks to the Community."

Risk Objects (Column 1). What risk objects are being analyzed? Start by making a list of the best known risk objects already included in the inventory (4.2).

Operation (Column 2). What kind of operation is being carried out? Note the generic operations taking place with risk objects in this column, such as:

- Manufacturing, purification, mixing, packing
- Storage, loading and unloading
- Transportation
- Sales
- Production and distribution of energy
- Maintenance, repairs.
- Food production and preparation, gardening
- Medical treatment, teaching, leisure activities, sports

Hazard (Column 3). What hazards (quantity) are involved in the operations? List the substances or forms of energy that might cause an accident. Indicate the quantities of hazardous chemical substances and other relevant information, such as:

- Solvents (1,000 liters)
- Inflammable paint (3,000 liters)
- L.P. gas cylinders (100 X 20 kg)
- Wood (300 m^3)
- Pesticides (6,000 liters)

Type of Risk (Column 4). What kinds of risk can be caused by the hazards, individually or in combination with others? The various hazards listed in Column 3 represent various kinds of risks, such as:

- Landslide
- Flood
- Explosion
- Collision
- Derailment

Threatened Objects (Column 5). Where are the threatened objects and how vulnerable are they? Threatened objects are people, the environment, and property. If the hazards to people, the environment, and property are not serious, the risk objects should be eliminated from the list in Column 1.

INVENTORY OF RISKS TO THE COMMUNITY

Community: ____________

Object/Area: ____________

Object	Operation	Hazard (quantity)	Risk-Type	Threatened Object	Consequences	Seriousness				Pb	Pr	Comments
						L	E	P	S			
Identification					Evaluation	Classification				Degree		
1	2	3	4	5	6	7	8	9	10	11	12	13

L = Life
E = Environment
P = Property

S = Speed
Pb = Probability
Pr = Priority

Threatened object	Consequences
People	
Workers Visitors People living nearby Service personnel Children Elderly people	Anxiety, injuries, deaths
Environment	
Sea, lakes, rivers, canals	Collision of vessels, drowning, hazardous spills
Drinking water	Pollution, bad taste, sabotage
Recreational areas	Hazardous spills, fires
Nature reserves	Hazardous spills
Agriculture lands	Hazardous spills
Forests	Fires
Property	
Airports	From minor damage to complete destruction
Railway stations	Collisions--from minor damage to complete destruction
Vehicle and rail tunnels	Collisions, smoke--from minor damage to complete destruction
Docks	Collisions, hazardous spills--from minor damage to complete destruction
Hospitals	From minor damage to complete destruction
Schools	
Hotels	
Theaters	
Stadiums	
Movie theaters	
Industries	Explosions, fires, spills and releases of hazardous materials--from minor damage to complete destruction

4.4 Evaluation

Consequences (Column 6). This part of the analysis should provide answers to the following questions: How can threatened objects be affected (people, the environment, property)? What are the consequences? What are the nearby danger zones? Are risk, contamination, and industrial simulators available (critical radii of affected areas)?

In many cases a rough estimate of the consequences of a potential accident may be made, for which consultation with experts is suggested.

The value of commercial and government computer software is inestimable in simulating risks. These aids may be obtained from the studies of industrial risks in the area or from SEMARNAP, where such studies may be available to the public.

In view of its technical and economic accessibility the package recommended is Simulation of Contamination and Industrial Risks (SCRI), which is used for the risk analyses that the authorities require of high-risk industries.

In Column 6, for each threatened object listed in Column 5 note the events whose **consequences** would most affect people, the environment, and property:

- Fire
- Explosion
- Spill
- Contamination
- Damage to infrastructure: sewerage systems, drinking water distribution, and water treatment plants, etc.

Factors Affecting Hazards and Risks

The following factors should be considered when assessing hazards and risk objects:

- The presence of hazards (type, quantity, and potential)
- Extreme conditions, e.g., when dealing with hazardous substances
- The effects of storing several substances together
- Unlabeled or poorly marked containers of chemical products
- The distance to critical threatened objects and the minimum distance allowed for the elimination of adverse effects
- Appropriate action by people so that:
    - → The risk of damage is avoided
    - → The rescue services and threatened objects are warned and kept well-informed
    - → Rescue work is effective

- The importance of properly functioning safety equipment
- The effects of natural forces such as rain, snow, and wind
- The probability and possible effects of acts of sabotage

4.5 Classification: Seriousness

Seriousness is estimated on a scale of 1 to 5, according to the effects on life (deaths and injuries), the environment, property, and the speed with which these effects spread. The classes of seriousness should be noted in the columns corresponding to each item noted in Column 6.

Seriousness or Consequences for Life and Health (Column 7). How seriously can people be affected?

Class	Characteristics
1. Unimportant	Temporary slight discomfort
2. Limited	A few injuries, long-lasting discomfort
3. Serious	A few serious injuries, serious discomfort
4. Very serious	5-20 deaths, 20-100 seriously injured, up to 500 people evacuated
5. Catastrophic	More than 20 deaths, hundreds of seriously injured, more than 500 people evacuated

Seriousness or Consequences for the Environment (Column 8). What would be the impact on the environment and for how long?

Class	Characteristics
1. Unimportant	No contamination, localized effects
2. Limited	Simple contamination, localized effects
3. Serious	Simple contamination, widespread effects
4. Very serious	Heavy contamination, localized effects
5. Catastrophic	Very heavy contamination, widespread effects

Seriousness or Consequences for Property (Column 9). What would be the cost of deaths, hospitalizations, environmental cleanup, and property damages?

Class	Total Cost (in millions of new Mexican pesos)
1. Unimportant	Less Than 0.5
2. Limited	0.5 - 1.0
3. Serious	1.0 - 5.0
4. Very serious	5.0 - 20
5. Catastrophic	More than 20

Speed of Development (Column 10). How fast would the effects spread and within what time frame?

Class	Characteristics
1. Early and clear warning (indications)	Localized effects, no damage
2.	
3. Medium	Some spreading, small damage
4.	
5. No warning	Hidden until the effects are fully developed (explosion)

4.6 Determination of Degree

In determining degree, it is important to know the "worst case scenario," although this is not necessarily the decisive factor in emergency planning. The priority for the work should be to find risk objects and hazards and to classify the threats in the following order:

- People
- Environment
- Property

In order to assign "degree" to a risk object, it will be necessary to make a rough evaluation of the various classes of consequences (columns 7 to 10) and ultimately establish the final priorities (Column 12) based on the probabilities of the events (Column 6) occurring (Column 11).

Probability (Column 11). What are the probabilities of the events occurring? How might they occur? What experience has there been?

Class	Characteristics
1. Improbable	Less than once per 1,000 years
2.	Once per 100-1,000 years
3. Quite probable	Once per 10-100 years
4.	Once per 1-10 years
5. Very probable	More than once per year

Assigning Degrees of Risks (Column 12). What priority is given to the risk objects? What would be the consequences for people, the environment, and property? What resources would be needed to contain the accident? Would resources be available to deal with the results of the accident? Based on the probability of occurrence of a given event and its consequences (from unimportant to catastrophic), it is possible to obtain a matrix indicating degree on a scale of priority ranging from A to E.

EXAMPLES

2D: Seveso, Italy. In July 1976 an 4-5 km^2 area was exposed to dioxin; 250 people suffered injuries and 600 were evacuated. International aid was needed for the diagnosis and treatment of the injured and for chemical analyses and decontamination.

1E: BHOPAL, India. In December 1984 a cloud of poisonous gas was released.

1E: SAN JUANICO, Mexico. In September 1984 there was a propane gas explosion.

Comments (Column 13). This column is for noting "worst case scenarios," "Estimates of the Extent of Damage," local emergency plans, safety areas, etc.

4.7 Presentation of Results

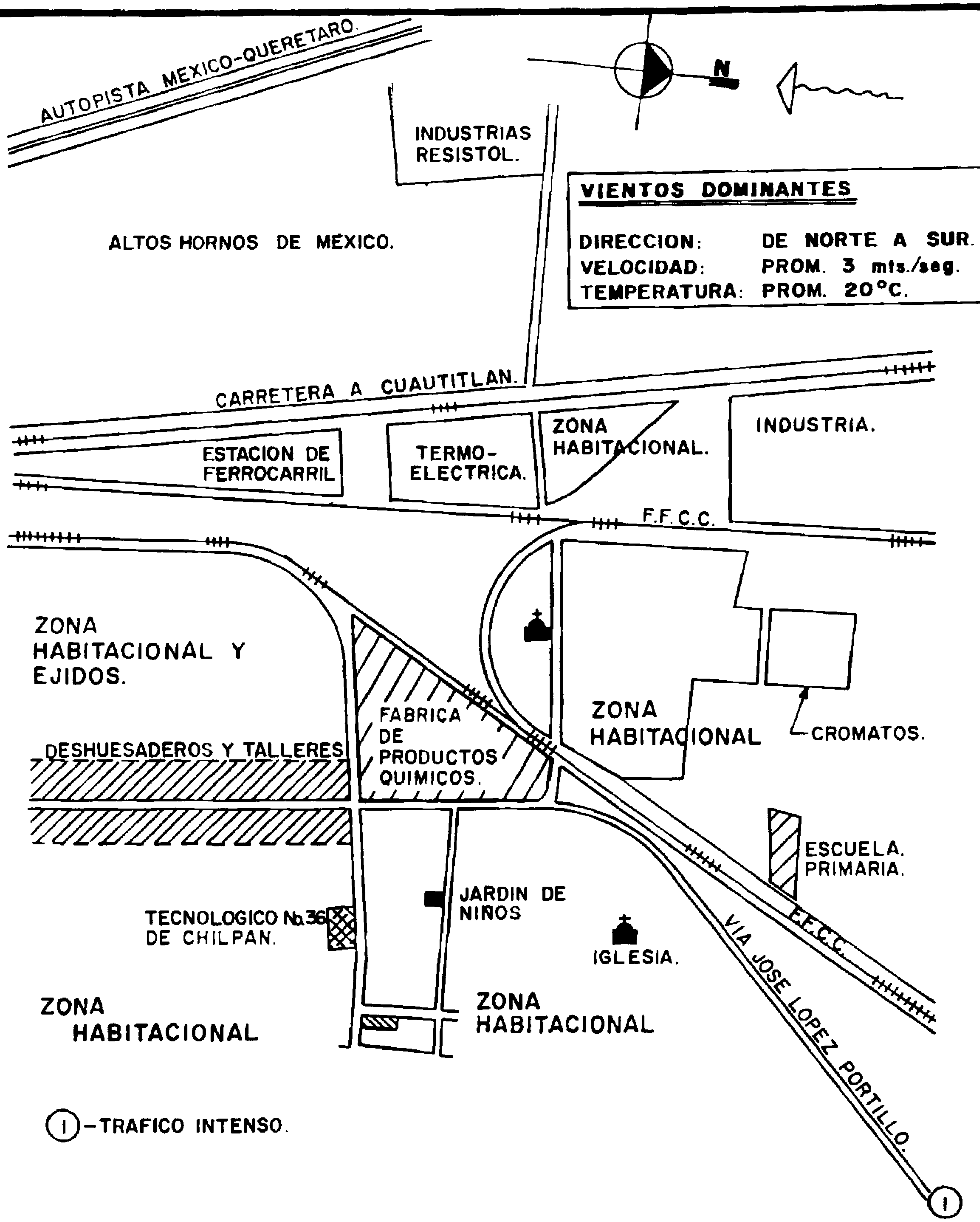
At the end of the analysis a large amount of information will be available on risk assessment, which will be useful for the authorities, companies, the community, and volunteer aid systems. However, it will be difficult to manage this information, since it cannot be accurately visualized. It is therefore desirable to transfer these data onto a risk map to facilitate comprehension of the information and provide a valuable tool for emergencies.

The risk map will provide information on the location of the most hazardous risk objects for a given community that can affect its residents, the environment, and property.

These kinds of analyses are performed by new enterprises and by those considered to be of a highly hazardous nature, such as chemical industries. The analyses are presented under the name of "Risk Studies, Modality of Risk Analysis," and should be accompanied by an accident prevention program for company installations (internal level) and for the surrounding area (external level).

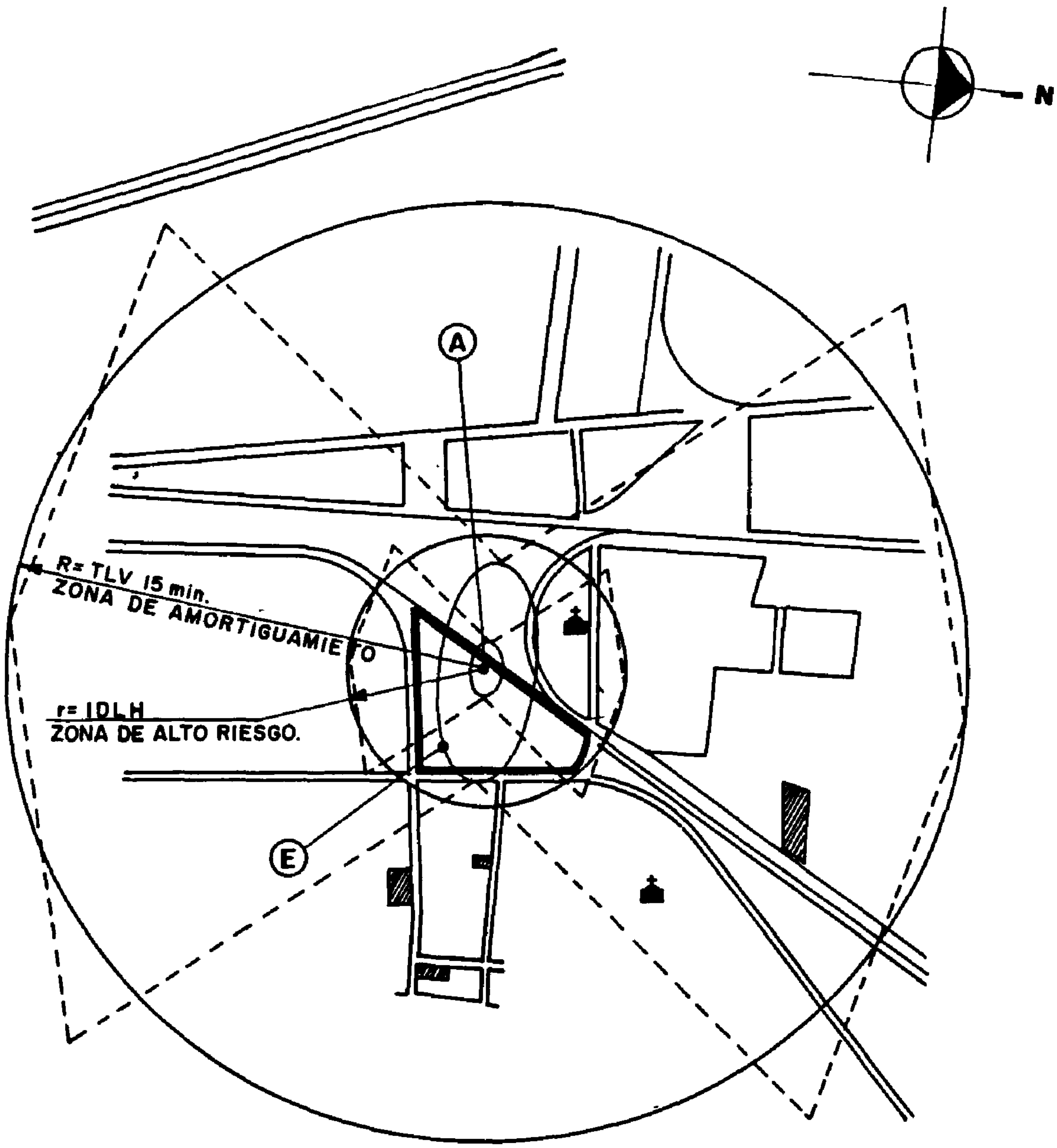
On conclusion of the risk identification and assessment, the results should be transmitted to the authorities, the community, and the companies in question in order to continue with Point 3 of the APELL program: **Have participants review their own emergency plans for adequacy relative to a coordinated response.**

ANNEXES



CROQUIS DE LOCALIZACION

ESCALA: 1:7500.



RADIOS CRITICOS.

Ⓐ CLORO r= 237.0 IDLH Y R= 837.0 TLV 15 min.

Ⓔ FOSFORO BLANCO

EL MATERIAL PERMANECE EN EL DIQUE

ESCALA: 1:12,500