# EXAMPLES OF THE CLASSIFICATION OF SCIENCE-BASED RISK INFORMATION TO FACILITATE PUBLIC COMMUNICATION

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## The Risk Classification Concept

The first steps in the effective communication of scientific data to the public about risk is to summarize the data, present that summary in a way and in terms that the public can understand, and then link it to what it means that the public to whom it is communicated should think and do. For example, this is exactly what local weather reporters do on the evening news when they make statements such as "there's a good chance of rain tomorrow morning, take your umbrella to work". Public communications like this may seem simple, straightforward, and even familiar on the surface, but a great deal of pre-statement conceptual planning, data collection, and data analysis likely went on long before any such statement is actually issued. The process is best begun by developing a relatively simple "risk classification typology" long before a particular event occurs, generating agreement about that typology among stakeholders and risk management partners as part of the typology adoption process, educate the public about the typology, and then use the typology to classify risk to provide the public with "scientific information" in all subsequent events.

**Classes in a typology.** Risk classification typologies that are developed to communicate scientific data and information to the public must be simple to be effective. Effective typologies typically have four classes in them, e.g., Level 1, Level 2, Level 3, and Level 4, although some effective typologies have fewer classes while others may have more but typically no more than five classes.

**Name typology classes.** The classes in the typology should be named with words that *make sense to the public*, but that also provide a way to group scientific data into discrete classes. For example, "Level 1 = No Contamination", "Level 2 = Slight Contamination", "Level 3 = Moderate Contamination", and "Level 4 = Heavy Contamination". The public understands scales such as "none, low, medium, and high." The general public does not understand much more than that, and it is not appropriate and can actually be counterproductive to provide people in the general public with more detailed risk information than that when they are at risk and are faced with making self-protective action decisions . But the use of such a scale or typology like this also requires that clear guidelines be developed so that all the different arrays of scientific risk data that can be collected are readily directed into one of the classes in the typology.

**Select public actions for each typology class.** Clear and discrete public actions should then be described for each of the classes in the typology. This may likely mean that development of a typology requires that health science be added to the natural and physical science needed to complete the typology. For example, "Level 1 = No Contamination, Do Nothing"; "Level 2 = Slight Contamination, Use Caution"; "Level 3 = Moderate Contamination, Take Protective Actions"; and "Level 4 = Heavy Contamination, Evacuate & Stay Away."

## Existing Risk Classification Typologies

Risk classification typologies for public consumption exist in a variety of forms and types for almost the full array of hazards that threaten our nation. Some of these have been in place for decades, are familiar to most people, and a few are so well-know that they are *American icons* while others are rarely used and are relatively unknown. Some are well-developed while others are not well developed at all and many others are somewhere in between. Yet others clearly link typology classes to the scientific information and data that would constitute entry into that class and then to appropriate public actions, while others are less clear. However, what they all share in common is the basic concept that raw risk information is not directly communicated to the public during times of danger and that risk information is classified into a relatively simple scale or typology for consumption by the general public. The text which follows reviews some scale examples from a much larger set of existing scales from a range of federal agencies that use risk classification typologies to communicate risk to the American public. Much more could be said about each of the classification schemes presented below and many more scales could have been reported; the reader is referred to the web sites of the various federal agencies for more information than is presented in this white paper.

## Air Quality Scale

Air quality monitoring and information dissemination is the responsibility of the Environmental Protection Agency (EPA) as regulated under the Clean Air Act of 1970 (amended in 1974 and 1977). Under the Act, the EPA was directed to identify and publish a list of known air pollutants and to establish national ambient air quality standards for the identified air pollutants. The EPA developed an Air Quality Index (AQI) as a uniform system of measuring pollution levels and to describe what precautionary steps may be appropriate if levels rise into the unhealthy range.

States monitor the daily levels of five pollutants for which EPA has established national ambient air quality standards: ground level ozone (smog), particulate matter, sulfur dioxide, carbon monoxide, and nitrogen dioxide. These five pollutants may be harmful to all persons, but especially to persons who have develop sensitivities, children and adults who are active outdoors, people with respiratory and cardiovascular diseases, and the elderly.

Each of the five pollutants have separate numerical health-protection standards, but are converted to a uniform scale ranging from 0 (good) to 500 (hazardous) and are accompanied by a color symbolizing levels of health, The six categories are: (1) *Green* = 0-50 AQI, good air quality; (2) *Yellow* = 51-100 AQI, moderate air quality; (3) *Orange* = 101-150, unhealthy for sensitive groups air quality; (4) *Red* = 151-200 AQI, unhealthy; (5) *Purple* = 201-300 AQI, very unhealthy air quality; and (6) *Maroon* = 301-500 AQI, hazardous air quality.

## Avalanche Risk Scale

Avalanche risk information is provided to the public in order to inform people about general avalanche conditions. A cooperative venture between the National Weather Service (NWS) in the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Forest Service (USFS) seeks to enhance public information and warnings for avalanche in order to disseminate this information and warnings to back-country and mountain travelers. Avalanche risk information is ranked on a five level scale with the following classes: (1) low, (2) moderate,

(3) considerable, (4) high, and (5) extreme danger levels. Danger levels are color-coded and include advisories regarding the probability and trigger mechanisms, degree and distribution of danger, and recommended actions for persons traveling in the back country.

**Chemical Stockpile Emergency Classes**

The U.S. Army and local officials develop and maintain emergency plans for events associated with all sites that house part of the nation's chemical stockpile. These plans include a standardized event/risk classification scheme to facilitate communication to off-post authorities to facilitate emergency response and public protection. The system expedites crucial decision and notifications, establishes a common language between on-post and off-post emergency responders, and fosters a clear understanding of necessary responses at all levels. The classification system in place has four levels.

**Non-surety Emergency Notification.** Events are likely to occur or have occurred that may be perceived as a chemical surety emergency or that may be of general public interest but which pose no chemical surety hazard. This includes non-surety material emergencies. The installation notifies designated off-site points of contact and no action is required.

**Limited Area Emergency.** Events are likely to occur or have occurred that involve agent release outside engineering controls or approved chemical storage facilities with chemical effects expected to be confined to the chemical limited area. This level will be declared when the predicted chemical agent no-effect dosage does not extend beyond the chemical limited area where the event occurs. The installation provides emergency notification to the designated points of contact in the emergency zone and in the state. Emergency response officials go to a level of increased readiness in the event of an off-post response is required.

**Post Only Emergency.** Events are likely to occur or have occurred that involve agent release with chemical effects beyond the chemical limited area. Releases are not expected to present a danger to the off-post public. This level will be declared when the predicted chemical agent no-effect dosage extends beyond the chemical limited area but does not extend beyond the installation boundary. The installation provides emergency notification to the designated points of contact in the emergency zone and in the state. Emergency response organizations mobilize to be capable of immediate action. Precautionary protective actions may be initiated in potentially affected areas near the installation boundary.

**Community Emergency.** Events are likely to occur or have occurred that involve agent release with chemical effects beyond the installation boundary. This level will be declared when the predicted chemical agent no-effects dosage extends beyond the installation boundary. The installation provides emergency notification to the designated points of contact in the emergency zone and in the state. The installation will recommend protective actions. All emergency response organizations mobilize. Protective actions prescribed in the local emergency plan are implemented.

**Earthquake Scales**

The Earthquake Hazards Reduction Act of 1977 established the National Earthquake Hazards Reduction Program (NEHRP). The overall goals of this program are to reduce loss of

life and property from earthquakes, and to mitigate the severe socioeconomic disruption that could be induced by a catastrophic earthquake. A range of federal agencies participate in this program, and each works toward the accomplishment of one or a mix of principal NEHRP activities. These include hazard delineation and assessment, seismic design and engineering research, preparedness planning, and earthquake hazard public awareness. Basic research is funded by the National Science Foundation; however, it is the U.S. Geological Survey (USGS) that holds program and operational responsibility to conduct research that could lead to public earthquake predictions and warnings.

**Time-frame "prediction" scale:** Although the science of earthquake prediction is far from developed, a scale for ranking general earthquake hazards information and specific predictions and warnings has existed since the 1980s. It was used for some time after it was conceived, but it is rarely if ever referred to today. Predictions are classified into three classes based on time-frame: (1) long-term, (2) intermediate-term, and (3) short-term. A long-term classification can rest on earthquake potential studies, while short-term classification would result from actual "prediction" research which has fallen out of favor.

**Richter magnitude scale.** The Richter magnitude scale for earthquakes is one classification typology that has achieved iconic stature with the American public. This scale was developed by Charles Richter and Beno Gutenberg in 1935. The Richter magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs (adjustments are included to compensate for the variation in the distance between the various seismographs and the epicenter of the earthquake). The scale is logarithmic in that each whole number increase in magnitude represents a tenfold increase in measured amplitude; in terms of energy, each whole number increase corresponds to an increase of about 31.6 times the amount of energy released. The following Richter magnitude scale is what has reached iconic stature even though the earthquake effects that it describes are only applicable to the earthquake's epicenter and not to the entire geographical area experiencing the same earthquake: (1) *Micro Earthquake* = less than 2.0 Richter magnitude, not felt; (2) *Minor Earthquake* = 2.0-2.9 Richter magnitude, not felt but recorded; (3) also classified as *Minor Earthquake* = 3.0-3.9 Richter magnitude, often felt but rarely causes damage; (4) *Light Earthquake* = 4.0-4.9 Richter magnitude, noticeable shaking of indoor items, rattling noises, significant damage unlikely; (5) *Moderate Earthquake* = 5.0-5.9 Richter magnitude, can cause major damage to poorly constructed buildings over small regions, at most slight damage to well-designed buildings; (6) *Strong Earthquake* = 6.0-6.9 Richter magnitude, can be destructive in areas up to 160 kilometers (100 miles) across in populated areas; (7) *Major Earthquake* = 7.0-7.9 Richter magnitude, can cause serious damage over large areas; (8) *Great Earthquake* = 8.0-8.9 Richter magnitude, can cause serious damage in areas several hundred miles across; (9) also classified as *Great Earthquake* = 9.0-9.9 Richter magnitude, devastating in areas several thousand miles across; and (10) *Epic Earthquake* = 10.0 + Richter magnitude, never recorded.

## Heat Information Classes

Heat waves are forecasted by the local Weather Forecast Offices (WFOs) of the NWS in NOAA. Warnings, advisories, and statements are provided by a WFO to local media outlets. "Extended forecasts" communicate the likelihood of high levels of heat and humidity 48 hours prior to the event. "Short term forecasts" include temperature, humidity, and heat index levels.

"Special weather statements" are issued within days of the event and provide information on protective actions for those at risk. Additionally, "heat advisories" are issued to local planners to prepare for future responses.

**Hurricane Scales**

The NWS within NOAA operates three hurricane centers which take the lead in issuing hurricane forecasts and warnings for the nation. Multiple scales are used to classify different dimensions of scientific information for release to the public regarding hurricane risk information.

**Wind Speed Scale.** Hurricane risks include high winds and wind speed is the basis for the classification of hurricanes into classes which range from 74 mph (a "category 1 hurricane") to 156 mph (a "category 5 hurricane").

**Storm Surge Scale.** Hurricane risk also includes storm surge which is a combination of wind driven water, normal tides, and wind driven waves. Although a scale to classify information made public about storm surge does not yet exist, work to develop such a scale has begun and is now being seriously addressed since the failure of levees in New Orleans during Hurricane Katrina. Many expect a scale to communicate classified hurricane storm surge risk to the public to be soon released.

**Probability Scale.** The probability of a hurricane is classified into: (1) "bulletins", (2) "watches", and (3) "warnings" in reference to location, predicted hurricane path, intensity, timing, and probability of landfall.

**Landslides and Debris Flows Classifications**

The USGS has a three category scale to gauge landslide risk information that is made public. The categories are: (1) "a degree of risk great than normal", (2) "a hazardous condition that has recently developed or has only recently been recognized", and (3) "threat that warrants consideration of public response to an impending event. The time, place, and magnitude of impending landslides—the elements needed for linking scientific information to effective public actions—can only be predicted in areas of the nation that have benefited from detailed geological and engineering studies. Development of regional real-time landslide public warnings is underway. One example of this type of system was developed for the San Francisco Bay Area by the USGS in cooperation with NOAA and its NWS.

**Nuclear Power Plant Accident Classes**

Emergency preparedness for commercial nuclear power plants in the U.S. is based on cooperative arrangements between the Nuclear Regulatory Commission (NRC) and the Federal Emergency Management Agency (FEMA) in the Department of Homeland Security (DHS) and includes a risk or accident classification system for notifying the public is a problem occurs at a plant. The full range of problems and risks that could occur are grouped into four general event classification levels to frame how that information is presented to the public and these follow.

**Unusual Event.** The first event level is labeled as an "unusual event". This classification level is used for all off-normal incidents or conditions at the plant for which no significant degradation of safety has occurred or is expected. Any releases of radioactive material which may have occurred or are expected to occur are minor and constitute no appreciable health hazard. An unusual event is a minor incident, often non-nuclear, such as a plant worker injury or severe weather. No public action is required.

**Alert.** The second event level is an "alert". It is used to classify event that involve an actual or potential substantial degradation of safety, combined with a potential for limited uncontrolled releases of radioactivity from the plant. This is still a relatively minor incident, and no public action is required.

**Site Area Emergency.** The third event level is a "site area emergency". It is used to classify an event that involves actual or likely major failures of plant functions needed for protection of the public, combined with a potential for significant uncontrolled releases of radioactivity. Sirens within the 10-miles emergency planning zone around the plant would sound, alerting the pubic to tune to local radio and television stations for official information. Non-essential plant personnel would evacuate. This category involves a serious incident, such as a reactor coolant leak or fire in a safety system.

**General Emergency.** The fourth and highest level is a "general emergency". It classifies an event involving actual or imminent substantial core degradation and potential loss of containment integrity with a likelihood of significant uncontrolled releases of radioactivity. This is the most sever emergency. Sirens within the 10-mile zone would sound, alerting people to tune to local radio and television stations for official information. Some public protection measures would be likely.

## Terrorism Levels Scale

The Homeland Security Advisory System was designed to provide a comprehensive means to disseminate information regarding the risk of terror acts to federal, state, and local authorities and to the public. The system has five risk level categories of graduated threat conditions that increase as the risk of the threat increases. At each threat condition level, federal departments and agencies are expected to implement a corresponding set of protective measures to further reduce vulnerability or increase response capability during a period of heightened alert. Threat conditions are assigned by the Attorney General in consultation with the Secretary for Homeland Security.

There are five threat classes in the typology and each is defined by a different color: (1) *Green or Low Condition* = there is a low level of terrorist attacks; (2) *Blue or Guarded Condition* = there is a general risk of terrorist attacks; (3) *Yellow or Elevated Condition* = there is a significant risk of terrorist attacks; (4) *Orange or High Condition* = there is a high risk of terrorist attacks; (5) *Red or Severe Condition* = there is a severe risk of terrorist attacks.

**Tornado Scales (and the familiar generic NWS classes)**

The National Weather Service (NWS) in NOAA has statutory responsibility for providing a severe local storm watch and warning service including tornadoes for the nation. The watch service is available to the general public, the emergency management community, and to marine and aviation interests. It is provided by the NWS's Storm Prediction Center (SPC) which is co-located with the National Severe Storms Laboratory in Norman, Oklahoma. The SPC prepares guidance products for severe weather watches for NWS forecasters at each of the 122 field Weather Forecast Offices which issue public: (1) forecasts, (2) watches, and (3) warnings (a familiar NWS risk typology that profiles probability) for tornadoes, severe thunderstorms, and flash floods.

However, it is the Fujita-Pearson Scale (which is popularly known as the Fujita Scale) that remains the classical risk classification typology for tornadoes. It can briefly be described as follows: *Fujita 0* = gale intensity, 40-72 mph wind speed, some damage to chimneys, breaks branches off trees, pushes over shallow-rooted trees, and damages sign boards; *Fujita 1* = moderate tornado, 73-112 mph wind speed, peels surface off roofs, mobile homes pushed off foundations or overturned, moving autos pushed off the roads, and attached garages may be destroyed; *Fujita 2* = significant tornado, 1113-157 mph wind speed, considerable damage, roofs torn off frame houses, mobile homes demolished, boxcars pushed over, large trees snapped or uprooted, and light object missiles generated; *Fujita 3* = severe tornado, 158-206 mph wind speed, roof and some walls torn off well constructed houses, trains overturned, most trees in forests uprooted; *Fujita 4* = devastating tornado, 207-260 mph wind speed, well-constructed houses leveled, structures with weak foundations blown off some distance, cars thrown and large missiles generated; *Fujita 5* = incredible tornado, 261-318 mph wind speed, strong frame houses lifted off foundations and carried considerable distances to disintegrate, automobile sized missiles fly through the air in excess of 100 meters, trees debarked, steel reinforced concrete structures badly damaged; and *Fujita 6* = inconceivable tornado, 319-379 mph wind speed, these winds are very unlikely, the small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds, missiles such as cars and refrigerators would do serious damage that could not be directly identified as F6 damage, if this level is ever achieved evidence for it might only be found in some manner of ground swirl patterns for it might never be identifiable through engineering studies.

**Volcano Scales**

The USGS Cascades Volcano Observatory provides information statements and staged alert levels to emergency operation management. These scaled alert levels range from information statements about unusual or notable events, and three levels of alert include: (1) unrest, (2) advisory, and (3) alert notices. Notifications are accompanied by brief explanatory text to clarify hazard implications and are updated with changing phenomena.

The intense unrest beneath Long Valley Caldera beginning in 1978 spurred the USGS to develop in 1991 and update in 2020 a more detailed volcano risk scale. A four-level color code scheme is used to quickly and simply convey scientific judgment about either an impending eruption of the severity of an eruption in progress. Levels of concern color codes are as follows: (1) green = the volcano is in its normal dormant state and there is no immediate risk, (2) yellow = the volcano is restless which requires a "watch", (3) orange = intense unrest and eruption is

likely which requires that the USGS Director to issue a formal "hazard warning"; and red = an eruption is in progress.

**Wildland Fire Classes**

The National Weather Service (NWS) produces fire weather forecasts for fire protection agencies while assessments of fuel moisture, vegetation greenness, and topography are produced by the U.S. Forest Service. NWS forecasts include predicted weather, temperature, relative humidity, wind speed and direction, and lightning activity level. The NWS uses a two level classification scheme to call public attention to fire danger comprised of *"Red Flag Watches"* and *"Red Flag Warnings"*. These are posted to indicate weather phenomena that may or will increase fire danger. Specific criteria include low relative humidity, very dry and unstable air, very strong and shifting winds.

**Winter Storms Typology**

Local NWS Weather Forecast Offices (WFOs) are responsible for forecasting winter storms and providing watches and warnings. *Watches* alert the public that a storm has formed (or may be forming in the near future and will (or may) approach the area. A *warning* means that a storm is imminent and immediate action should be taken to protect life and property. These warnings are issued under several categories such as *heavy snow warnings* = greater than four to eight inches; *snow squalls* = brief intense falls of snow accompanied by gusty surface winds; *blowing and drifting snow*; and *blizzards* = low temperatures and strong winds that cause decreased visibility and sometimes whiteout conditions