RESPONSE CAPABILITIES AND CONNECTIVITY FOR ARCHAEOLOGICAL HERITAGE SITES UNDER CRISIS CONDITIONS, OR WHAT I LEARNED FROM MY NEIGHBOR’S EARTHQUAKE

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During the past two decades major earthquakes have devastated major World Heritage Sites in China, Mexico, Nepal, Iran, Japan, and numerous other countries. In the same period floods have ravaged sites in Thailand, Poland, Mexico, China, Austria, and other places around the world. Sometimes these events threaten World Heritage Sites or other famous locations but frequently their principal impact falls places little-known beyond national boundaries. Advances in global communications technology as well as more robust professional networks may make us aware of danger and damage, emphasizing the consequences for our cultural heritage. Yet despite increased awareness of the combined impacts the reality is that most such events strike widely-separated points on the globe and it is the responsibility of individual governments, national organizations and agencies, and local bodies to respond. While fortunately in any year few places are overwhelmed by the frequently and extent of devastation paradoxically this limited likelihood that any given group of professionals, experts, and managers will gain much experience in preparing for or responding to such events. Their relative rarity means we need to take maximum advantage of opportunities to learn from each other and that sharing knowledge across boundaries and disciplines must be a priority.

CONCEPTUAL FRAMEWORK

For most locations earthquakes and floods fall into a class of events identified as Low-Probability High-Consequence (LPHC) in nature. That is, in any given year the probability there will be such an event is low......it may never happen in the lifetime of someone living in a particular place. But the event, when it happens, will cause considerable disruption, i.e., have high consequences. LPHC events may be man-made as well as natural; the nuclear meltdown at Chernobyl, the toxic gas leak at Bhopal, the collapse of Banqiao dam in China, or even the election of Donald Trump in the United States might be addressed in LPHC terms. On the surface they may seem very different yet they share the characteristics that the probability they will happen is so low they receive little consideration prior to the event and the impact is so great it provokes major losses and dislocations. Sometimes there is a tendency to describe them as an “Act of God”, a description excusing a lack of anticipation and planning. Their rarity, diversity, and potential impacts are such they present immense challenges to planners and response strategy design.

The lp/hc problem domains are inherently ill-structured, multi-layered, and characterized by consequences with low likelihoods, high severities, and numerous pervasive uncertainties. Decision making is typically complex, multi-tiered and non-transparent with conflicting objectives and multiple perspectives (Luxhoj and Coit, 2006).

Although in this paper we restrict ourselves to a very limited subset of LPHC events, i.e., addressing the need to attend to the possibility of earthquakes and flooding at World Heritage Sites, we need to recognize these are imbedded in diverse disciplinary fields, professional specialties, international experience, and historical events. When we refer to history here we are not thinking of archaeoseismology but more recent cases where we have more extensive
documentation and access to detailed data or descriptions of organizational, community, and individual behavior. In this respect heritage managers tend to focus on a specific event such as an earthquake affecting Site X or flooding at Site Y rather than classes or categories of events. This can lead us to overlook the extensive analysis and literature on LPHC experience to be found in other contexts. Who in cultural heritage would turn to the Chatham House (UK) assessment of responses to a volcanic eruption in Iceland for insights on issues regarding communications and decision-making in the face of an LPHC event (Lee and Preston, 2012)? Yet there is much to be gained by learning from insurance analysts debating risk management, disaster response specialists engaged in post-event analysis, the extensive gray literature produced by governments and nonprofit organizations after a LPHC event, or publications such as the *International Journal of Disaster Risk Reduction*. Hence we start our presentation with a plea to think and search broadly even when considering the probable circumstances of a specific LPHC event. The significance of LPHC crises is such that we cannot remain within narrow perspectives simply because they are familiar and comfortable; the stakes are too important for such parochialism.

**THE MEXICAN EXPERIENCE**

Mexico is widely recognized for its rich, engaging natural and cultural heritage. Unfortunately it is also a country where earthquakes and floods represent serious threats to heritage sites and the people who visit or live from them. And as Mexico has more than World Heritage Sites than any other Latin American country its regrettable history of natural threats to heritage protection must be used to our advantage by studying not only the threats themselves but at the ways in which different stakeholders respond to them. It is very easy to be so overwhelmed by the drama of crisis that we are distracted from our responsibilities of analysis and learning. What lessons might we draw from Mexico’s difficult history of addressing floods and earthquakes at World Heritage Sites? Does this experience have application in other settings and other countries?

Given the number of sites and their vulnerability to earthquakes or floods the total number of incidents is relatively high even though most sites have little history of LPHC events. One exception is the World Heritage Site of Monte Alán in the southern state of Oaxaca. Along the Pacific coast the Pacific tectonic plate is pressing under the North American plate, making the region one of the most seismically-active in the Western Hemisphere. In consequence Monte Alán experiences frequent seismic activity, though most of it is below the threshold of human perception. On September 30, 1999, an earthquake of 7.4 on the Richter scale roiled Monte Alán, damaging at least 23 structures and putting at risk hundreds of visitors and employees. It took nearly 200 architects, archaeologists, other professionals, and laborers a year to rehabilitate the site, a challenge made more complicated due to pressures from the many stakeholders dependent on the World Heritage Site as a source of employment and income (Robles Garcia, 2009).

As we will report here in the aftermath of this quake Monte Alán undertook not only its physical reconstruction but a series of actions intended to anticipate future LPHC events. Some of these were to improve the flow of information useful for planning preservation and response efforts. Others were to safeguard staff and visitors. These actions were tested by another severe earthquake September 8, 2017. However lamentable these two events might be, the earthquake of September 8, 2017, provided an opportunity to test the performance and value of measures taken after the LPHC experience of September, 1999. Is there any evidence the measures taken after that earthquake may have reduced the negative impacts or facilitated preservation after September, 2017? And are there lessons that could be transferred to other World Heritage Sites or to other LPHC venues?

As a consequence of the 1999 earthquake 23 archaeological structures suffered moderate to severe damage, the support facilities and administrative offices at Monte Alán were knocked from service, and utilities such as electricity and communication no longer functioned. The earthquake affected a wide region and therefore the World Heritage Site found that its needs for construction materials, trucks, and skilled manpower had to compete with many other urgent demands; hospitals, schools, commerce, bridges, and housing all expected their needs to take priority. Indeed one very important lesson from this experience is one cannot assume that in a LPHC event other stakeholders will subordinate their interests to the priorities of a heritage site. And some observers will argue the immediate needs of the human population must receive...
preference, even if this priority may expose heritage elements to the risk of further damage. Shortly after the earthquake it began to rain heavily, meaning structures split open by the event were then exposed to soaking rains provoking erosion.

**Lesson One: Know your structures and their vulnerabilities**

Exploration and restoration of platforms, temples, plazas, and other structures began in the 1930s and has continued intermittently to the present. Across decades archaeologists have extended tunnels to the center of structures, opened and closed excavations, rebuilt collapsed or damaged elements, and otherwise modified the site as it existed prior to exploration. A strong emphasis on the built environment meant relatively little attention had been devoted to understanding soil mechanics, drainage systems, or the implications of interventions taken decades before but largely forgotten. The earthquake caused old tunnels to collapse, unsupported walls to break apart, and prolonged vibration to weaken or destroy supports. A archaeological site that to the naked eye looked solid and timeless proved very vulnerable to major seismic activity.

Response to the 1999 damage included a major investment in documentation systems addressing both the physical characteristics of the structures and careful charting of the interventions undertaken in the process of restoration. For example, the severity of the earthquake revealed that across centuries water filtering into the interior or foundations of structures had created empty spaces that could then collapse. To respond to this some structures were dismantled stone block by stone block, drainage systems installed, the clay soil originally used as fill was replaced by gravel to facilitate movement of water, and then reassembled. All of this work was carefully documented, a time-consuming and expensive task that proved extremely useful in September, 2017, as the meticulous records not only demonstrated how, in many instances, the work undertaken had been able to withstand the recent earthquake, but also made it far easier to plan restoration. After the 1999 event no-one knew whether the next earthquake would come in 5 years or 200 years but the necessary knowledge base had been put in place.

**Lesson Two: Do not stop thinking about tomorrow**

If the 1999 earthquake demonstrated to site managers and agency directors the need to update and broaden their knowledge of the site and its structures it also showed them the importance of understanding dimensions of the site that previously had received little attention. While great earthquakes fortunately are low-probability events Oaxaca's location in one of the most seismically-active zones in the Western Hemisphere means it is subject to frequent vibration. Even six months after the earthquakes of September, 2017, southern Mexico experiences 6-10 earthquakes daily ranging between 2.8 and 3.9 on the Richter scale. Most of these pass unnoticed to a population going about its daily activities but it means structures are subjected to a recurring low-level vibration.

To better understand this Monte Alban how has, thanks to the generosity of the Japanese government, its own seismograph station. This permits continuous monitoring of earth movements that may have cumulative effects. The seismograph is supplemented by simple plaster patches stretched across cracks and joints. These are readily monitored visually to detect localized movement or settling by a structure. These patches and the seismograph also have sensitized staff to the simple impacts caused by moving vehicles around the site. And the seismograph alerted the staff to the peculiar phenomenon of seismic activity appearing to take place at roughly the same time every day. This was not nature at work but the seismograph was capturing the passage of aircraft taking off from the nearby airport. Pilots would bank close to the mountain location of the archaeological zone to give their passengers a fine view of the site, unaware their effort was subjecting the structures to the equivalent of several more low-level earthquakes daily. These applications of technology facilitate continuous monitoring of conditions otherwise like to escape human detection.

**Lesson Three: Do not forget people**

On a low-visitation day in the off-season Monte Alban might receive just a few hundred visitors, many of them local school children. But at peak periods such as the week between Christmas and New Year's Day the site may be overwhelmed by 8-9000 visitors daily. The earthquakes of
1999 and 2017 occurred in September, a month when the summer crush has departed. There are no guarantees, however, that an earthquake will not devastate the area precisely when a high visitor load is already stretching facilities and personnel to their limit. One response to this has been to create systems of special operations for high-capacity periods that serve double purpose as drill for managing crowds under difficult circumstances. In peak periods every staff member knows exactly what specific tasks they must do, from monitoring the movement of traffic up and down the single road to the site to overseeing teams of local community volunteers (including schoolchildren from nearby villages), assisting first aid personnel, or otherwise stepping out of their regular responsibilities. The seasonal nature of these special operations mean they act as periodic practice drills for an LPHC event. In the event of an earthquake in a high-capacity period there is no need for panic or improvisation as everyone understands their role in keeping the site running.

CONCLUSION
By their nature LPHC events impose great stress on organizational operations. Their infrequency in any given location requires that we learn from experience wherever we can find it, recognizing it might be outside our professional arena, discipline, or region. Best practices require learning, sharing and applying.

BIBLIOGRAPHY


