Communicating with Future Generations – Major Obstacles to Overcome – 15008

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ABSTRACT

The Department of Energy (DOE) Carlsbad Field Office (CBFO) is responsible for managing activities related to the disposal of transuranic (TRU) and TRU-mixed waste in the geologic repository at the Waste Isolation Pilot Plant (WIPP), 2150 feet (655 meters) below the land surface, at the WIPP, near Carlsbad, New Mexico. The Environmental Protection Agency (EPA) regulations Title 40 Code of Federal Regulations Part 191.14(c) [1] and Title 40 Code of Federal Regulations Part 194.43 [2] require a Passive Institutional Controls program be developed for the WIPP. The primary purpose of the Passive Institutional Controls program is to indicate the location of the repository and the risk it presents to an intruder, thus reducing the likelihood of inadvertent human intrusion into the repository. A plan was put into place during the 1990's with records management and storage, awareness triggers, permanent marker design concepts, including languages, graphics and engineered drawings, plus testing schedules for materials and structures. This work included the thoughts of expert panels and individuals. The plan held up under peer review and met the regulatory requirements. But will it really work? Will future generations a thousand years, two thousand years, or seven thousand years from now really be able to decipher and understand the message? This is the challenge international constructors, operators, and regulators of repositories for the disposal of any hazardous materials must face. It is important to explore the history of language, both written words and graphics; and what we can learn from the past to assist us in communicating with the future.

INTRODUCTION

In 1996, DOE presented a Passive Institutional Controls (PIC) program to the EPA as part of the application for certification of the WIPP repository. This program was developed over several years, and at great expense, and provided a plan for design and material testing of permanent markers, a plan for records management development, and a plan for awareness triggers determination. The main function of the Passive Institutional Controls program is to inform and warn future generations of the presence of long-lived radioactive wastes buried at the WIPP site in the Chihuahuan desert. For the first 100 years after cessation of disposal operations, the rooms are closed and the shafts leading underground are sealed. The WIPP is mandated by law to institute Active Institutional Controls with fences, gates, and armed guards on patrol. After the Active Institutional Controls are removed, a plan must be in place on how to warn and inform future generations of the consequences of intrusion into the geologic repository disposal area. This communication plan must take into account the changes expected in languages and communication forms for hundreds to thousands of years.

THE WIPP PIC's PROGRAM

EPA regulations specify that radioactive waste disposal systems must employ measures to preserve knowledge about the location, design, and contents of the disposal system. This can be

accomplished through “(1) Permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location design, and contents of a disposal system.” (Title 40 Code of Federal Regulations Part 191.12). EPA also expected the Department of Energy, in the Compliance Certification Application [3], to estimate the period of time Passive Institutional Controls are expected to endure and be understood. EPA provided in the regulation for DOE to potentially assume some Passive Institutional Controls credit in the performance assessment in the form of reduced likelihood of human intrusion over several hundred years.

EPA also identified in its certification guidance document that “change in language, technology, and political institutions cannot be predicted over thousands of years, PICs and their messages cannot be assumed to last in perpetuity.” For this reason, neither the disposal regulations nor the compliance criteria require that PICs be shown to be effective for 10,000 years. In addition, there is no guarantee that a person will obey an admonition not to disturb the site, even if he or she has read and understood it. EPA therefore intends that PICs serve only to avert “unintentional” intrusions into the repository (e.g., resource exploration resulting from lack of knowledge of the presence of radioactive waste). EPA also intends that PICs be designed to survive “as long as possible” using “available technology and materials.”

DOE presented to EPA in 1996 a PICs program that included a records management plan; awareness triggers program and a detailed description of the permanent markers to be used for the WIPP site. DOE proposed eight different markers in the PICs program including large monoliths, small buried discs, a buried storage room and an information center all of which have planned messages written in seven different languages including English, French, Arabic, Chinese, Spanish, Russian, and Navajo. The Department of Energy proposed to take 700 years of credit for PICs being 99% effective in reducing future human intrusion in the performance assessment calculations. EPA determined that DOE complied with the requirements of 40 CFR 194.43 because the measures proposed were comprehensive, practicable, and likely to endure and be understood for a long period of time. However, EPA denied the request for credit of 99% reduction in human intrusion likelihood for 700 years after closure, as they felt no quantitative value of the probability that it can be defended. CBFO’s WIPP PICs program in place today meets the regulatory criteria, but complete feasibility of implementation is questionable, and may not be in conformance with international guidance being developed.

INTERNATIONAL ACTIVITIES

The Nuclear Energy Agency (NEA) is coordinating a study called the "Preservation of Records, Knowledge and Memory Across Generations" to provide the international nuclear waste repository community with a guide on how nuclear record archive programs should be approached and developed. DOE has been and will continue to cooperate and participate in this project with the intent to take what knowledge is gained and apply that to the WIPP PICs program. The Records, Knowledge and Memory project is now moving into Phase II with emphasis on cultural heritage, the contextualization of data for later use, the identification of mechanisms for Records, Knowledge and Memory transfer, and on implementing a culture of Records, Knowledge and Memory in organizations to create a link between organizations and the siting communities. International cooperation has been identified as vitally important to ensure that a wide range of approaches and experiences are considered when developing a shared

meaning for message preservation and shared methods for Records, Knowledge and Memory preservation.

INTERGENERATIONAL EQUITY

Intergenerational equity is a moral obligation that we “hold the natural and cultural environment of the Earth in common both with other members of the present generation and with other generations, past and future” [4]. International guidance currently under development suggests that the intergenerational equity principle strives to warn the future generations, however, in doing so not to unduly burden present generations. Building markers and monuments that are out of proportion to communicate the risk to future generations is not in keeping with generational equity. With this in mind the CBFO is developing conceptual plans for re-evaluating and revising the current WIPP PICs program. A part of any PICs program must include the records to be archived, the languages and signs used to convey messages to the future and also the archive methodologies and communication formats and storage. The physical attributes of a PICs program, the cultural heritage and community involvement aspects of keeping the knowledge alive and transferrable within the current and then onto the next generations will also be considered.

EXPLORING HISTORIC MESSAGES

Rock art studies are a sub-discipline of archaeology. The field encompasses many important archaeological research areas including methods, interpretation, analysis techniques, and most importantly archaeological theory. Bruce Trigger, author of *A History of Archaeology Thought,* explains that there are three epistemologies when it comes to archaeology: positivism, extreme relativism, and moderate relativism. "Positivist epistemologists maintain that society and culture exert no significant influence on the development of archaeology, which is shaped by explicit theories being tested in the light of adequate evidence and according to proper scientific methods" [5]. For those worrying about the future generations understanding the messages of today, this is comforting. However, it is just as likely that extreme relativists are correct in their assumptions regarding archaeology. "Extreme relativists argue that the interpretation of archaeological data is so influenced by the intellectual persuasions, class interests, ethnic loyalties, gender prejudices and personal self-interest of archaeologist that objectivity is impossible" [5]. What does this do to all of the interpretations archaeologists have made regarding petroglyphs of the past? Are the messages being subjectively interpreted?

To some extent, it is beneficial to examine language as an argument. English archaeologists are interpreting rock art and petroglyphs into their spoken language. *Poronkusema* is a Finnish word that describes one thing, a unit of measure. In English, it takes a sentence to explain the meaning of that one word. If the Finnish had to draw it on a stone, it would most likely be a picture of a deer, for the meaning of *Poronkusema* is the distance a reindeer can comfortably travel before needing a break, or around 4.7 miles, 7.5 kilometers [6]. Another example is the Sanskrit word *Kalpa* that means the passing of time on a grand cosmological scale [6]. If drawn, perhaps they would draw planets, or the sun. How would English, French, or German archaeologists interpret this drawing? Would they surmise that it means the passing of time on a grand cosmological scale? These are two examples of words in other languages that have no translation; a strong argument for extreme relativists.

Approximately 50 miles northwest of Las Vegas, Nevada lay a region known as Gold Butte. This is an area that many indigenous tribes called home, including a branch of the Anasazi, the Patayan, and the Southern Paiute. A depiction of 21 Bighorns in a line of varying types of sheep, along with other markings at the bottom is shown in Figure 1. Although there is no exact time frame of when these markings were made, we do know that the Anasazi left the region around 1000 C.E. [7].

Fig. 1. Bighorn Sheep in Gold Butte, Mesquite, Nevada.

In December 2013, the Journal of Archeological Science made the claim that the ancient rock art in Figure 2, which is found in the Winnemucca Lake sub-basin in Nevada, is the oldest in North America. These petroglyphs are over 10,000 years old and are located in an area that has been submerged at times by the now barren lake [8].

Geologists and archaeologists can roughly decipher the age of rock art. However, are the messages being lost? What were the inhabitants trying to convey? The answer could be a simple story perhaps, with no important consequential directions to be followed for the human inhabitants of today. Hypothetically, suppose the rock art was intended to be a warning. Today's language has changed to such an extent the warning message might very well not be received as it was intended.

Fig. 2. Ancient Rock Art in Winnemuca Lake in Nevada.

COMMUNICATION OBSTACLES

Effective communication of active and passive institutional controls used to warn future generations of the hazards WIPP contains after closure will occur when the transmitted messages are received and understood the way they were intended. Communication is prepared and sent using the human mind and since humans are not perfect, the process of sending and interpreting is inherently imperfect. There are many obstacles to overcome in communicating with future generations of the hazards found in the underground of the WIPP repository.

“Nu scylun hergan hefaenricaes uard.” Can you understand this? Neither can I. This roughly translates to “Now we must honor the guardian of heaven.” It is Old English taken from Caedmon’s Hymn that was written in the mid-800s. This is an example of a language obstacle. The State of New Mexico has large English, Spanish and Indian American-speaking populations. Multiple languages and a variety of vocabularies, even in the small area surrounding WIPP, presents communication challenges. And regardless of the medium the message is presented, it is critical that the message is understandable or the communication will not give the intended effect.

Language barriers also occur when the message sent is inappropriate, too descriptive or too brief. If the message is any of these things, the clarity and accuracy of the message can be affected. Words that are unclear, overcomplicated, unfamiliar or too technical can be confusing and create a misunderstanding. Short, simple phrases or words may be the best method of communicating to future generations.

It is also important to recognize the WIPP project is a very technical, science-based project with very unique terms and technical jargon. The target audience to receive the message is a member of the public with no knowledge of technical terms or WIPP specific jargon. How can WIPP communicate effectively to people outside of this technical field? How can the warnings be

communicated in a simple way that anyone can understand? In fact, communicating this message is almost like explaining the dangers in a simple way to a child with no technical knowledge or familiarity with the WIPP. Written communication should be clear and direct. The use of ambiguous or vague words should be prohibited. Is it possible to devise a way to measure feedback from the person receiving the message, and to evaluate the effectiveness and accuracy of the message? Could the feedback be used as a method for creating awareness in the mind of the sender (the current generations), and adapting the message for the receivers (the future generations)?

Cultural barriers are found in different generations, genders, economics, politics, and cultural backgrounds. For example, linguistic expert Daniel Everett argues that "Language was invented by humans and can be reinvented or lost" [9]. That is a frightening prospect to consider when deciding the best way to disseminate information a hundred, five hundred, or even a couple of thousand years from now. The proposed DOE information center with planned messages in seven different languages fails to account for the change and development in language, unless of course DOE plans on employing future generations consistently to rewrite the messages in the current vernacular. Even then, words can take on new meanings, or lose importance over time. Terms such as *cool, bad,* and *hot* are examples of words that have taken on new meanings in a relatively short amount of time. *Floppy disk, cassette,* and *card catalogues* are words and phrases that have lost importance to this generation. The language used by DOE would have to be simple enough to minimize change, but complex enough to describe the danger. Is this a possible combination?

Face-to-face communication is a relatively old way of business for many cultures today. Technological advancements have influenced how professionals in this generation conduct business. Many professionals now use smart phones, text messages, emails and even teleconferences and videoconferences as the medium for most of their communication processes. Have you ever misinterpreted the tone intended in an email or text message? If so, this can be an example of a communication barrier because the contents of the message were not received or understood the way it was intended.

Men and women have different strengths for interpreting information. Men are generally better at interpreting abstract or visual messages. Women are generally better at interpreting language or identifying with emotional messages. For this reason, it is critical to obtain both perspectives during the preparation and interpretation of the intended message.

Physical barriers can be as simple as a closed door or a wall. A physical barrier such as a wall or fence can be symbolic of things you want to keep out and things you want to keep separate from. It is a dividing line that can mark the boundary of a territory or property. The intended purpose of a physical barrier would be to warn future generations to stay away, but what if they are built so ornately that they do the exact opposite and attract attention. On the other hand, what if the physical barrier wasn't significant enough and ends up being missed or ignored. What is the right amount of size, material and ornament needed for a physical barrier to be effective?

For example, west of Las Vegas is an area known as Red Rock Canyon National Conservation Area. Approximately 180 million years ago, large, heavy dinosaurs roamed this canyon leaving fossilized footprints [10]. Much later, thousands of years ago native people drew upon the red

sandstone leaving another type of mark. Not until 1990 was special legislation supported to designate the area the 7th National Conservation Area. Before this time, the area was known as the Red Rock Recreation Lands [10]. The name implies that hundreds of thousands, if not millions of people, before 1990, went to Red Rock Canyon to explore, to touch, to see, to camp, even to dig. Even today, people can approach some of the rock arts closely enough to touch and photograph it. Imagine this being the case with radioactive waste buried under the white sand of the southeastern New Mexico desert. Teleport forward a thousand years; a new discovery has been made. An ancient civilization has left a type of monument in the sand with strange markings on them that appear to be words. People flock to the area to view the strangeness, and eventually a team of future archaeologists decide that they should dig further to see if there are more artifacts.

The takeaway from this example is not whether harm might be done to an area such as the WIPP or Red Rock Canyon National Conservation Area; that can be debated. The intention of the example is to demonstrate how easy it is for areas, that at one time were most likely thought of as greatly important to a society, can become forgotten in a few generations. And, even when rediscovered, the importance of the area can be lost for a time before acts are taken to protect it.

Perceptual barriers can be created by the sender or created internally by the receiver of the message. This barrier occurs when there are misperceptions from the message and therefore, the message was not effective. The attitude of the sender can affect the success of how the message was received. Could there be attitudes in the message we will be sending that is sabotaging our efforts to communicate effectively? The sender should evaluate the message to ensure there is not dismissive or sarcastic language that could be misinterpreted. It is important to recognize that people who may need to interpret messages could very likely not have the same level of understanding, knowledge or perception of the message.

For example, the Japanese tsunami stones contained warning messages that were concise and understandable: “Do not build below this stone”. However, the perception of danger was different. Unfortunately, the message intended on warning stones did not have the desired effect. Many residents built below the stones, close to the water and their boats. Technology and advancements in warning systems had lulled the Japanese coastal towns into a false sense of security. That was not the only reason the stones did not have the desired effect. “For most Japanese today, the stones appear relics of a bygone era, whose language can often seem impenetrably archaic” [11]. The language used in the warnings contributed to the lackadaisical approach by the villagers. Warning future generations of dangerous, and life threatening buried radioactive waste face the same challenges.

When we evaluate the intended messages, it will also be important to review the multiple layers and forms of communication to make sure they are consistent and do not contain information gaps that could cause confusion. And if we want to instill oral traditions and stories to be passed down to the next generation, how can we ensure the messages will be communicated if knowledgeable individuals become too conservative with distributing the information? Can the role for the public to communicate the message be defined and how do we expect them to communicate the task effectively and over time? There could eventually be a lack of knowledge about the project and could create a fear of capability to communicate or properly explain it effectively because it was once active generations ago. What if the message does not seem

important or seems worthless or no longer seems valuable enough to pass on to future generations? What if the message loses it "newness," the receiver becomes complacent and the messages start to get ignored because nothing is perceived to be a danger? Could the oral or written message be too overly simple that it is open for interpretation, explanation or assumption regarding the message?

We can conclude, to some relative degree, humans, technology and languages have evolved. How can WIPP and should WIPP take the action to evolve with these changes and continue to evaluate the message that was sent and confirm it is still appropriate and understandable? Perhaps, someday there will be a machine to do all thinking for us and we won't have to consider how communication is perceived or interpreted. Perhaps, communication barriers will evolve so drastically and become entirely new concepts than what we know today. Since we assume, based on historical changes and adaptations we have seen in our lifetime, people and situations will continue to evolve. Perhaps the PICs program should evolve into a living program and adapt as people and situations evolve.

DISCUSSION

From the beginning of humankind, communication was most likely taking place. Through grunts, groans, crying and gestures, babies make their needs, wants and desires known to their parents much as early humans probably communicated in the beginning of time. As humankind developed and more complex verbal languages were created, we can surmise the verbal passing on of knowledge and experiences between individuals and groups took place. We will probably never know if the first drawings and graphic representations were attempts to communicate with future generations, or an attempt to document a significant event in the individual's life experience. The earliest cave drawings that some contribute to the Neanderthals [12] dated close to 41,000 years ago may indicate humankind's early attempts to communicate with future generations. Although the cave drawings have been successfully preserved for a long period of time, the information needed to understand the meaning or intention is lacking. Although communication with the unknown generations has points of failure, DOE is committed to identifying the obstacles to overcome and learning lessons from the past to develop conceptual plans for re-evaluating and revising the current WIPP PICs program.

CONCLUSIONS

Implementing a PICs program for WIPP involves establishing the framework for communicating with future generations to indicate the location of the repository and the risk it presents. A program plan prepared by DOE in 1996 met the regulatory requirements, but it is difficult to guarantee how effective it will be for generations to come. Exploring historic messages by examining written words and graphics certainly provides some insight for communicating with future generations. Scientists agree that these historic communications, in most cases, are open for interpretation and not-yet-fully understood. The underlying challenge for the WIPP is to ensure the message sent will be received as DOE intended. There are perhaps many communication obstacles to consider and to overcome. For example, what can WIPP learn from the failure of the Japanese tsunami stones? The stones communicated, in a very simple way, the dangers, but the warnings were ultimately ignored by the people due to the false sense of security found in the latest technology and advancements in warning systems.

The PICs program for WIPP is intended to mark the location of the repository and to communicate the dangers to future generations. To meet this requirement, DOE will spend time and use currently available resources and technology to continue developing a framework and then implement a PICs program that meets the requirements of Title 40 Code of Federal Regulations Part 194.43. DOE acknowledges future generations will not be represented in the development of the PICs program, so the current generation must consider the most responsible approach. The international community, in the form of the NEA's Records, Knowledge and Memory project, has taken up the question of what a nuclear records archive program should look like and what burden should be put on today's generation to inform the future. As DOE goes through re-evaluating and revising the WIPP PICs program over the next few years, alignment with the expected international guidance is desired, while developing a financially efficient program for the American tax payer.

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