Geological Report Documenting and Opposing Use of the Holtec Site in New Mexico to Store High Level Nuclear Wastes

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Introduction

First, in Part I, I present three geologic reasons that demonstrate why it is inadvisable to temporarily or permanently store SNF/HLNW (spent nuclear fuel/high level nuclear waste) at the Holtec proposed temporary storage site halfway between Carlsbad and Hobbs, New Mexico. These three reasons deal with (1) the presence of **fresh and saline waters** on the area's surface and in the subsurface, (2) the abundant **evaporite karst** features in the region, and (3) the presence of **petroleum industry activity** (exploration, drilling, fracking, and wastewater injection) in the area.

Second, in Part II, I present six major reasons that oppose the transport and storage of SNF/HLNW at the Holtec site. Each of these six points individually provides sufficient reason to deny giving Holtec an NRC license for its temporary storage proposal and together they provide overwhelming refutation of the proposal. These six reasons deal with (1) **surface storage** of nuclear waste, (2) moving the waste a **second time**, (3) **externality theory**, (4) **risk analysis,** (5) **transportation risks**, and (6) **storage canister failure**.

Part I.

Several Geological Reasons Make It Inadvisable, even Dangerous, to Store High Level Nuclear Wastes at Holtec's Proposed ELEA Temporary Storage Site in New Mexico

1. Introduction: Why the Region's Surface and Subsurface Geology Make High-Level Nuclear Waste Disposal Inadvisable.

The Holtec HI-STORE Consolidated Interim Story Facility (CISF) is a facility that proposes to store Spent Nuclear Fuel/High Level Nuclear Waste (SNF/HLNW) halfway between Carlsbad and Hobbs, NM. The area around the CISF was chosen by the Eddy-Lea [County] Energy Alliance or ELEA. The acronym HI-STORE refers to Holtec International's HI-STORM UMAX technology used to store the waste in shallow subsurface silos containing hundreds of steel canisters in a grid. Each canister, in turn, holds several radioactive fuel rod assemblies, together constituting dozens of fuel rods. This technology is considered, by Holtec, to be the safest method to store spent fuel rods in the world. Each canister, used only once, is transported to the site in very heavy duty, shock protected, steel shipping casks on either trucks or trains. Each canisters is lifted out of its cask and placed in an individual, prepared, shallow subsurface silo. The silos are covered but ventilated to allow passive air cooling, and designed to keep rain, overland flow, and ground water out as long as (a) the canisters and silo walls remain unbreached, (b) the ground is not flooded above the air intake vents, (c) the silos remain upright and undisturbed, and (d) the water table does not rise to the level of the silos (all of which may be unwarranted assumptions).

In this report, I will normally use the term "Holtec facility" to refer to refer to the HI-STORE CIS facility, "Holtec site" to refer to the area containing the CISF and the property around the CISF near the Eddy-Lea county line, and simply "nuclear waste" to refer to SNF/HLNW. The region currently has two other storage sites for (1) transuranic nuclear waste at the Waste Isolation Pilot Plant, (WIPP), about 15 miles SSW of the Holtec site, and (2) low level nuclear waste at Waste Control Specialists (WCS), a site about 35 miles ESE of the Holtec site, just over the New Mexico-Texas border in Andrews County, Texas. These sites were energetically and vociferously opposed by professional geologists for many of the same reasons discussed in this report, and the literature describing their reasons can also, for the most part, be used in the present case.

Despite the similar geologic problems and dangers, these two earlier sites (and the third one we are discussing now) were chosen for permanent storage for their much less radioactive—but still dangerous—nuclear waste primarily because of the assumed geographic isolation and low population density of the region, the citizens of the area's good nature and tolerance for free enterprise solutions to dirty problems regardless of the human risks and dangers involved, the area's large population of Mexicans and Latin-Americans, many people with low incomes and corresponding little political power, and most especially the weak political leadership in the counties and cities in the region who still hold to an outmoded laissez faire concept of capitalism (which, by the way, is not shared by the majority of the citizens of the region). The geological objections were not considered definitive by the NRC in their approval of WIPP and WCS. As it happened, despite frequent claims of "transparency," both the two earlier sites have accepted nuclear waste of much higher radioactive content than what they publicize, so citizens were correct to oppose the two existing permanent waste storage sites.

The author has visited and studied over a dozen superfund sites in the Houston area, taught a course in environmental law, and is currently a consulting scientist in the petroleum and environmental industries in the Permian Basin. He created the first environmental science course in Houston in 1978 and taught it and similar courses, such as environmental geology, for over twenty years. He has 24 years of experience working in the petroleum industry in the office, laboratory, and at well locations in the field. He has been inside the WIPP facility on a guided tour. He has several academic and industrial specialties, but for the purpose of this report his areas of expertise are sedimentary petrology, stratigraphy, and sedimentology. While not a specialist in the following disciplines, he has taught college students the basics of toxic and hazardous waste disposal and hydrogeology (ground water hydrology), and has taught high school chemistry and physics. He has 23 years of experience teaching many different Earth science courses for thousands of students in colleges and universities.

The purpose of Part I is to describe the geologic conditions and situation at the Holtec site that makes it extremely inadvisable to temporarily or permanently store nuclear waste at this site. The area is unsuitable because of abundant surface water in salinas (saline playa lakes, called *lagunas* in the region), ground water in several aquifers, porous and permeable rocks in the stratigraphic column beneath the site, a region filled with evaporite karst features including salt dissolution, surface collapse, surface subsidence, sinkholes, dolines, fissures, caves, solution lineaments, karst valleys, and cenotes. In particular, the author believes that the area around the Holtec site and proposed facility is similar in many ways, including origin, to Nash Draw, a well-studied karst valley—not a draw (usually dry ephemeral stream valley) in the usual sense—that demonstrates karst landforms, surface subsidence, and internal drainage, and it could possibly be extended a short distance to the NE where it would take in the Holtec site. It should be renamed the Nash Karst Valley rather than Draw. In addition, the petroleum industry has active wells immediately adjacent to the Holtec site and in the surrounding area and region. These and future wells are both vertical and horizontal and most will be fracked (hydraulically fractured). In addition, the area contains salt water disposal wells in which both fracking and production wastewater will be injected into the subsurface. Also, the Holtec property will be kept oil well free, thus removing potential petroleum leases from exploration and production during a time of the greatest activity in the history of this great oil- and gas-producing region (the Delaware Basin).

Holtec makes three unwarranted assumptions in its plan to store nuclear waste. (1) First, for many of these geologic problems to manifest themselves, the silos or canisters must corrode or crack sufficiently to let water in to be irradiated and then be able to escape into the environment, and Holtec assumes that this won't happen fast enough to be a problem. But this is exactly what has happened in the case of just about every superfund site I have seen (the only exceptions are when the toxic or hazardous waste is dumped directly onto the ground or poured directly into the ground, and this only speeds the pollution damage). The containment vessels and artificial barriers may be of the finest design and workmanship, but corrosion, cracking, and decomposition due to stresses and exposure to the elements will eventually cause these to happen over time. The time may well be more than 100 years, but the stored nuclear materials will be dangerously radioactive for far longer than that, so Holtec is planning to pass the dangers to succeeding generations (but to earn its profits now: see the section in Part II on privatizing benefits and socializing costs). Only if the storage site is placed in a nonporous and impermeable subterranean rock cavity—with the same artificial material safeguards—and will be inaccessible to people in the future, and the nuclear waste moved only once from the reactors to the storage site, will the proper conditions for longterm hazardous and toxic waste storage be met.

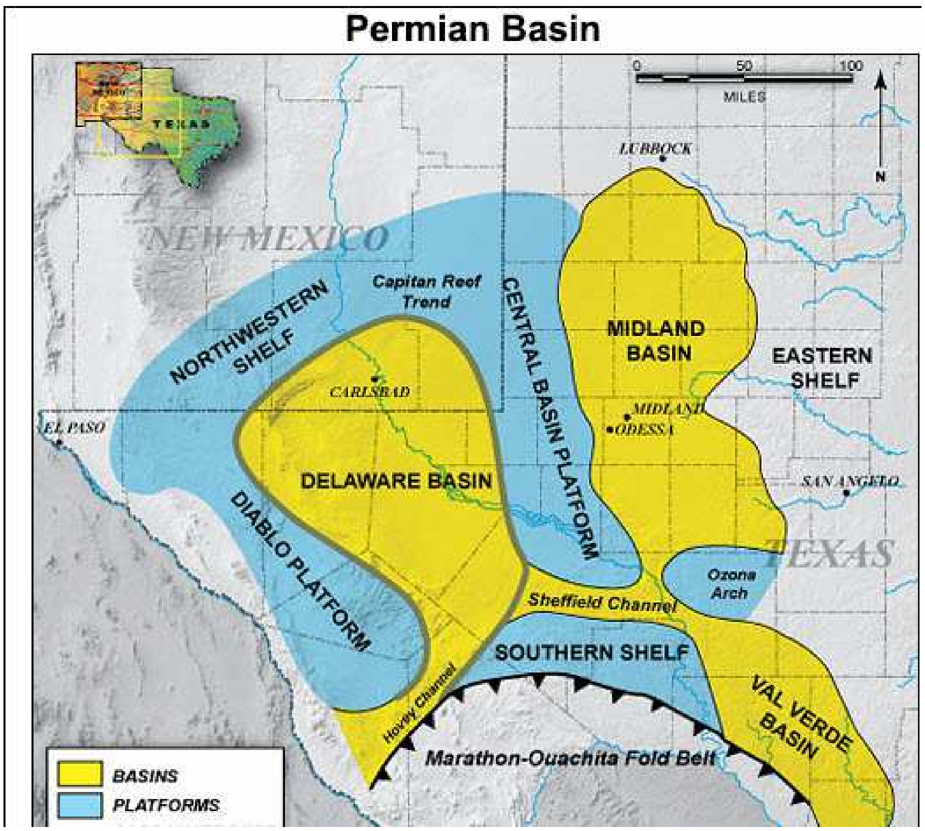
(2) Second, Holtec assumes that the nuclear waste will remain isolated in their shallow subsurface silos and canisters, safely out of the reach of human activity, while the waste is stored there. This unwarranted assumption is belied by (a) the great potential for the waste to never be moved again—a second time—to its hypothetical permanent storage location, and (b) the fact that the Holtec facility is *designed* to be accessible to humans for the presumed eventual removal of the waste to its permanent inaccessible storage location. In the meantime, the Holtec facility will be subject to proliferation, terrorist attack, bombing, and similar illegal activities. The idea that guards and a fence will keep out determined individuals, organizations, and states who mean to do harm is ludicrous. Once all or even some of the waste is stored, a large militia group can take over the facility, declare themselves an independent state, and threaten to destroy the silos and canisters with explosives if authorities try to remove them. The authorities will not be able to bomb, burn, or fire upon the militia domestic terrorists, so how will the threat be stopped?

(3) Third, Holtec assumes that—since most examples of karst collapse and sinkhole formation have been caused by human activity, such as subsurface dissolution of salt by leaking uncased, uncemented, and abandoned wells or out-of-control dissolution mining of evaporites—(a) human activity that might contribute to evaporite dissolution can be prevented in the region and (b) natural evaporite karst processes will not be a problem at the site due to their operation over long periods of geologic time. Both of these assumptions are wrong. Examples of anthropogenic karst dissolution, collapse, and subsidence are by definition unplanned accidents and cannot be prevented unless all human activity is banned, and this is not going to be the case. And natural evaporite karst processes are dynamic and occurring now in the area, albeit over long periods of time but well within the radioactive lifetimes of high level nuclear waste. Holtec plans to gamble that such long-term calamities will not take place while the nuclear waste is being stored "temporarily," but this is unrealistic, especially since there are better solutions (such as the novel idea of transporting and permanently storing the waste correctly and safely the first time).

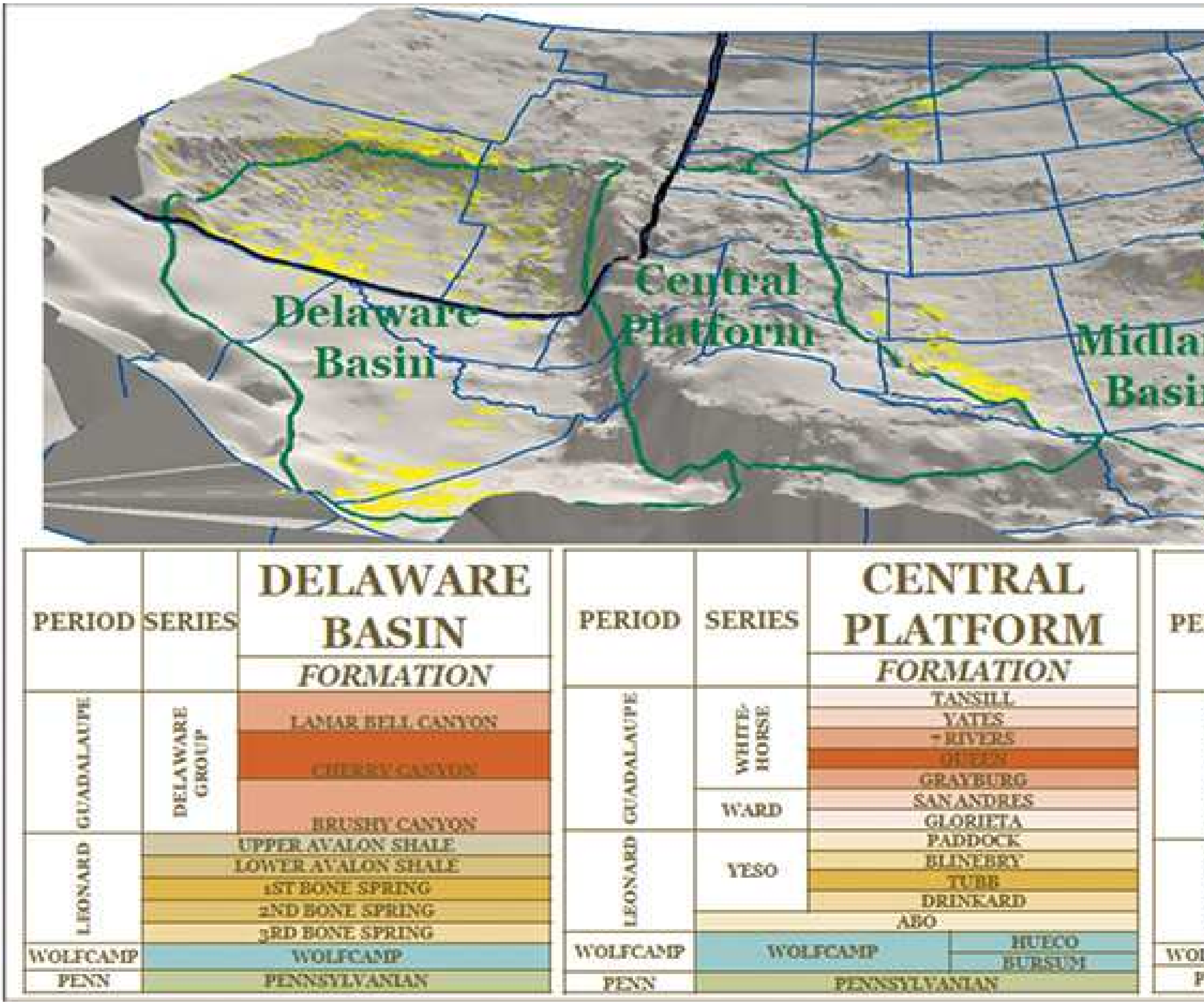
2. Geology of the Region.

The regional geology of the Holtec site makes it probably the worst place in New Mexico or Texas to store nuclear waste. Almost any spot in the two states chosen randomly, excepting urban areas, would provide better long-term protection. The location was chosen for political reasons, not geological or environmental ones. The region exhibits abundant nearby evaporite and carbonate karst features created by dissolution of subsurface rocks, permanent and ephemeral surface water (multiple lagunas and steams) and ground water (multiple aquifers), porous and permeable sedimentary rocks in the subsurface, and very active very nearby petroleum exploration and production and potash mining. The Holtec site appears to be sited on top of a karst valley, an extension of a well-studied nearby karst valley that has undergone subsidence. All of these attributes mitigate any rationale for choosing this region for nuclear waste storage. Since when did it become acceptable to site hazardous and toxic waste landfills in areas of surficial fresh water, above freshwater aquifers, above porous and permeable sedimentary rocks, and in regions of abundant karst features and processes?

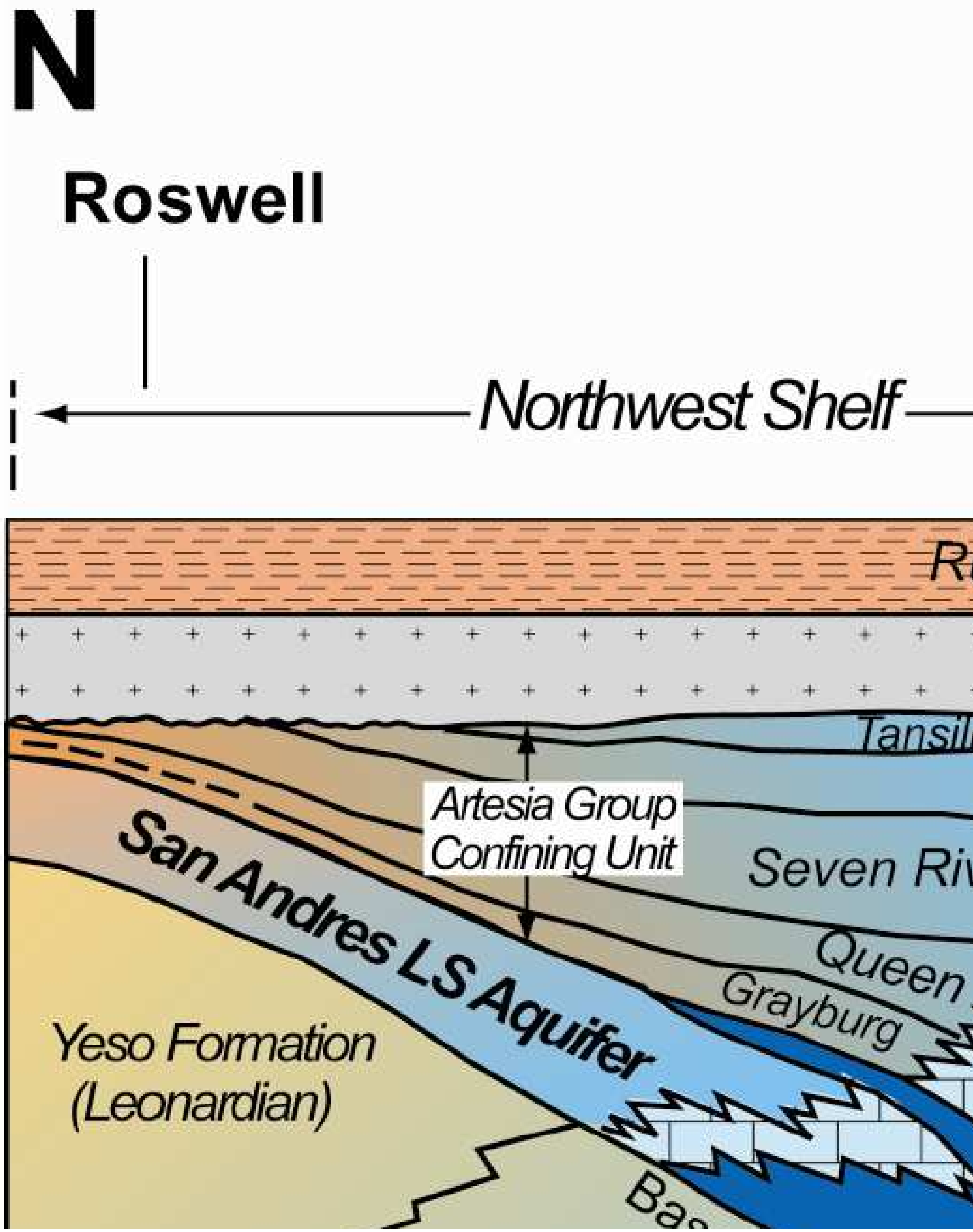
For the images and maps that follow, I have borrowed freely from scientific journal articles and Holtec scientific reports, all available on the Web.



Southeastern New Mexico and West Texas are geologically dominated by a great sedimentary basin, the Permian Basin. It consists of three sub-basins, two platforms, and three shelves. The Permian Basin has extremely thick sequences of source rocks (porous and weakly permeable mudrocks from which petroleum is generated by basin subsidence with higher temperatures and pressures over millions of years) and reservoir rocks (porous and permeable sandstones and carbonates—limestones and dolomites—into which the petroleum migrates). In addition, the stratigraphy and structural features of the basin provide thousands of petroleum traps that literally trap the oil and gas before it migrates to the surface and is lost to evaporation and degradation, as happens to about 50% of all the petroleum generated, so it can be discovered and produced. Tens of thousands of oil and gas wells have been drilled on the blue and yellow areas in the map above during the last century. The Permian Basin is one of the five largest and most productive petroleum-rich basins on the planet.



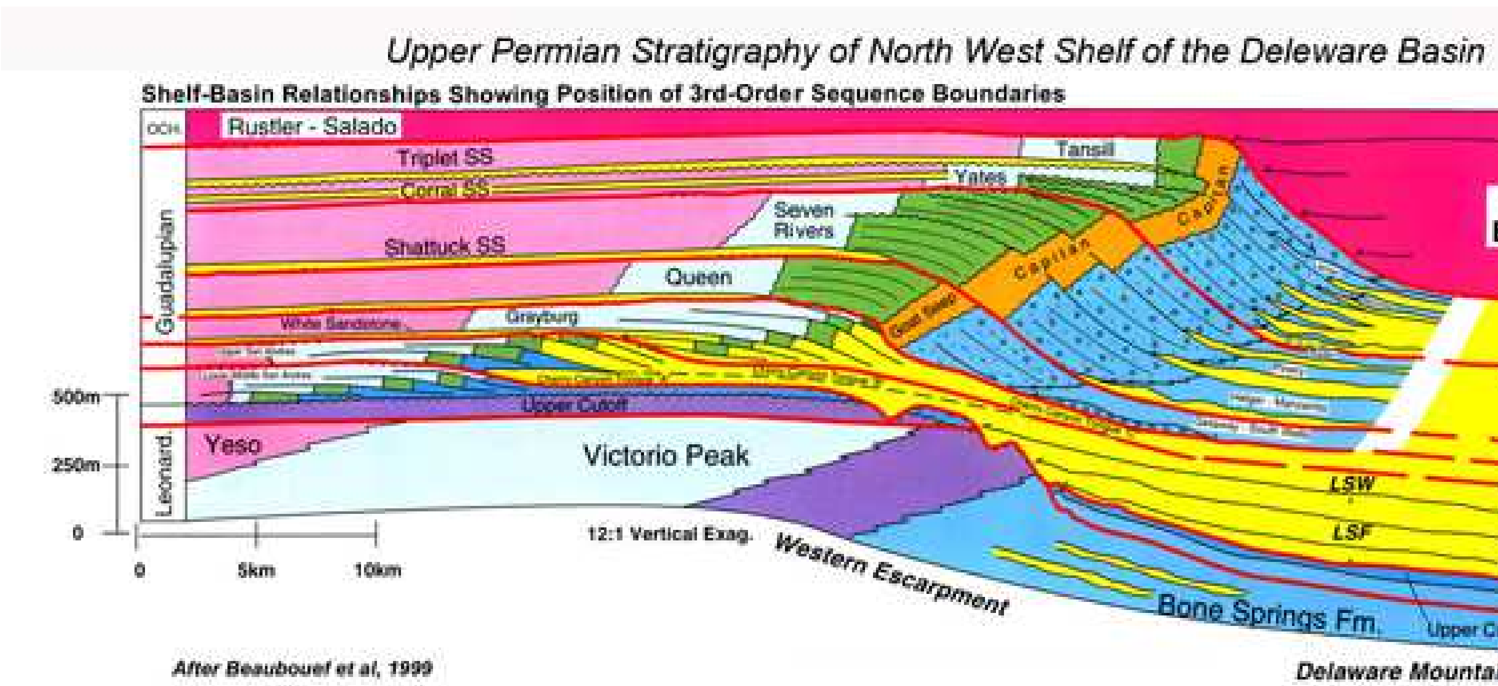
The Delaware Basin to the west and Midland Basin to the east are both highly productive. The two giant basins are separated by the Central Basin Platform. The stratigraphic sequences in the two basins are similar but not identical, and some formations have different names. The adjacent shelves have very similar sequences and share the formation names of the basin whose margin they rim.



N
Roswell
Northwest Shelf
Artesia Group
Confining Unit
Seven Riv
Queen
Grayburg
San Andres LS Aquifer
Yeso Formation
(Leonardian)

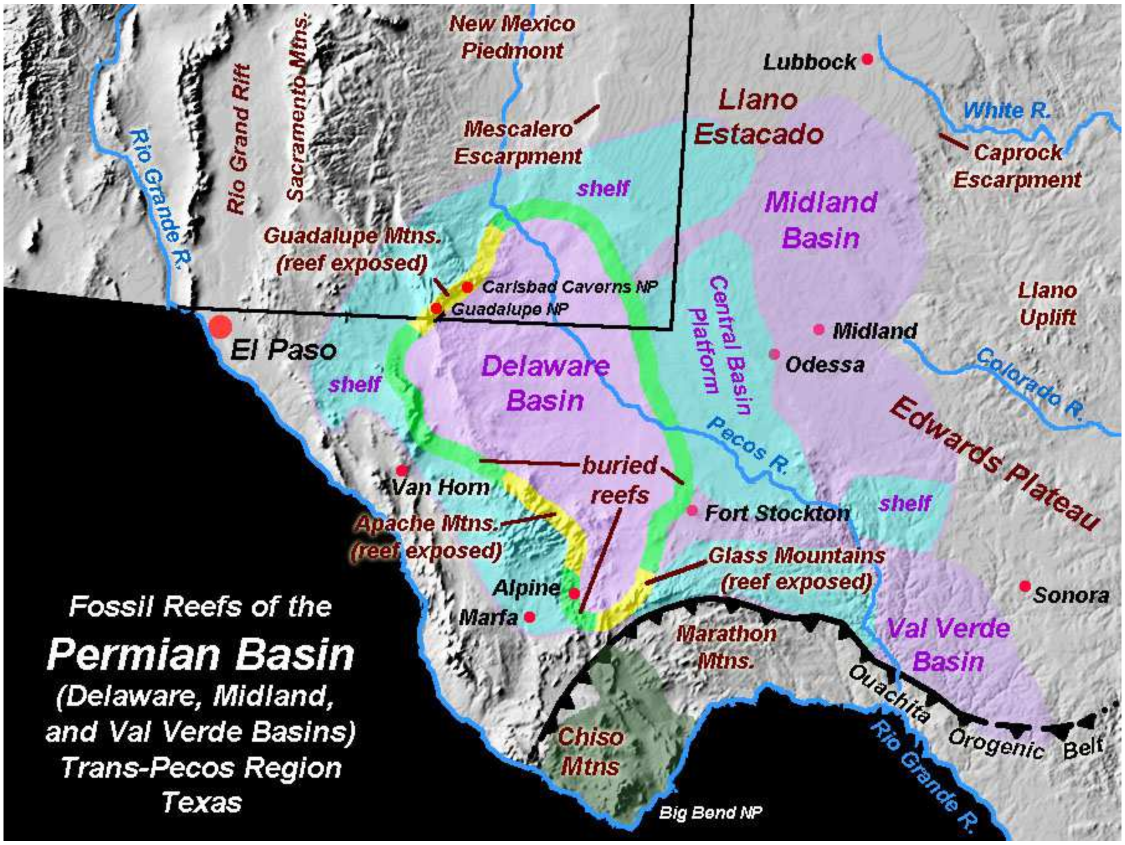
The Holtec site is right above rocks on the shelf margin of the Northwest Shelf just north of the Delaware Basin, approximately where Carlsbad is located on the diagram above. For this report we are interested only in the region of the Northwest Shelf of the Delaware Basin, right now perhaps the most active sedimentary basin in the world for oil exploration due to fracking of the basinal mudrocks and similar fine-grained rocks of the shelf margin and basin slope whose wells are also fracked. The Holtec site sits right in the middle of all this activity. We use the term “mudrocks” because the term shale is not correct for these rocks which contain as much or more carbonates, quartz silt, very fine grain quartz sand, and organic carbonaceous compounds than detrital and authigenic aluminosilicate clay minerals. These rocks, such as the Bone Spring in the Delaware Basin, the Sprayberry in the Midland Basin, and the Wolfcamp in both basins, also lack the characteristic fissility of shale, a rock made primarily of silicate clay minerals with very minor quartz silt.

A series of very fine grain sandstone formations—the Brushy Canyon Fm, Cherry Canyon Fm, and Bell Canyon Fm—were deposited onto the slope and basin floor when sea levels were low and silicate clastics could erode from terrestrial areas, through the shelf, and into the basin.

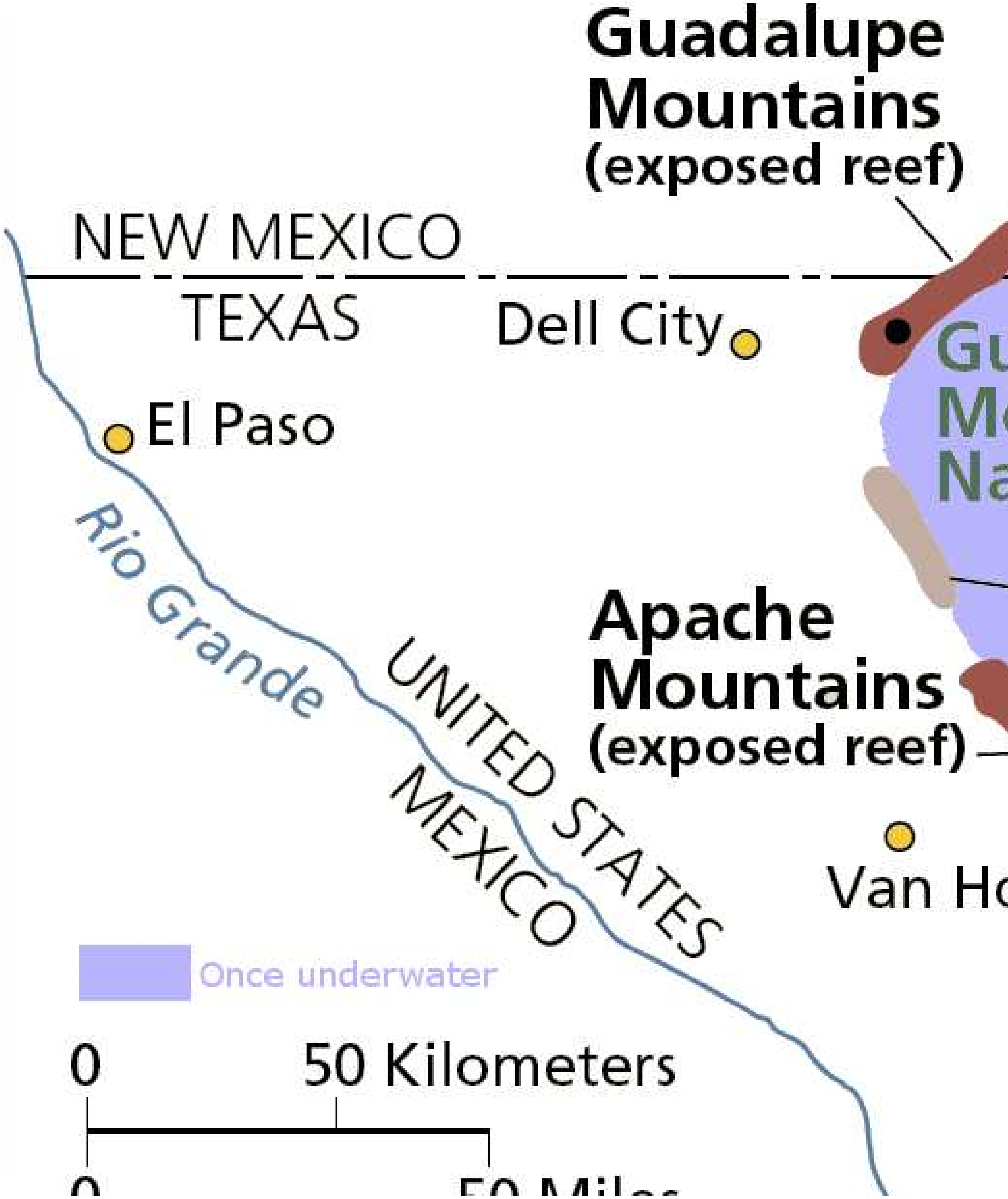


The mudrocks of the basin and shelf and the very fine, argillaceous sandstones of the slope and basin are the prime targets of oil exploration in the Delaware Basin, for they are porous, full of hydrocarbons, and can be fracked to improve their permeability to make them excellent producers.

Above the oil-rich sedimentary rocks are two very thick layers of evaporites, the gypsum Castile Fm over the basin and the halite (rock salt) Salado Fm over the entire basin, shelf, and back-reef lagoons. They formed when the marine water filling the giant basins evaporated. This happened repeatedly as sea level rose and fell in a long series of cycles caused by Gondwana glaciation.

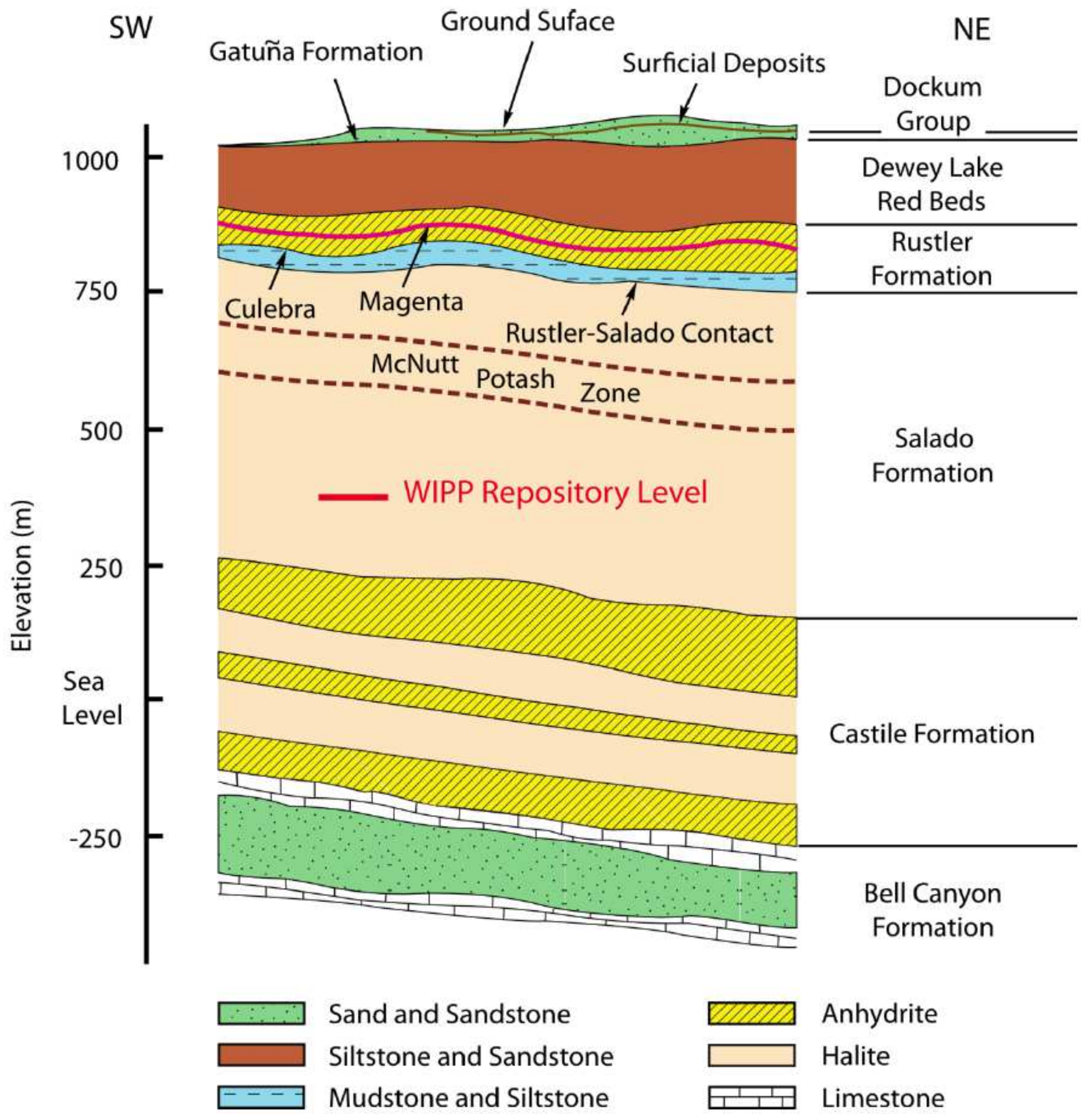


Of great importance is the presence of a giant organic buildup around the margin of the basin on the shelf edge named the Permian Reef and composed of Capitan Fm limestone. This organic buildup is usually called a reef in analogy to modern shelf margin reefs, since it was built by abundant calcareous marine algae and invertebrates, but it was not a rigid framework like modern coral reefs. Instead, calcareous algae, sponges, bryozoans, and brachiopods were the dominant reef builders. The original lithology of the buildup or reef was limestone but it has been frequently dolomitized, for example in the Apache Mountains, which has been totally dolomitized. The Guadalupe Mountains have been partially dolomitized in zones and strata. The Glass Mountains have largely escaped dolomitization and have the best unaltered fossils and thus the best biostratigraphic sections of all. The significance of this carbonate mineralogy is that the reef could develop excellent porosity and permeability due to ancient marine sedimentation and burial processes and thus could serve as a good reservoir rock. This is even more true of the carbonate rocks behind the reef. If oil is trapped in the rock, it fills up the pore space and remains to be discovered and produced. But the reef or shelf margin carbonate rock can also serve as an aquifer, the Capitan Reef Aquifer, if it remains underground at appropriate depths. This aquifer holds brackish water in the deeper subsurface as it is at the the Holtec site, but also fresher water when it has been faulted up to surface and above surface levels and can be recharged by precipitation (meteoric water). For example, potable water can be found in the Capitan Reef Aquifer near Carlsbad, NM.


Guadalupe Mountains (exposed reef)
NEW MEXICO
TEXAS
Dell City
El Paso
Rio Grande
Apache Mountains (exposed reef)
UNITED STATES
MEXICO
Van Ho
Once underwater
0
50 Kilometers

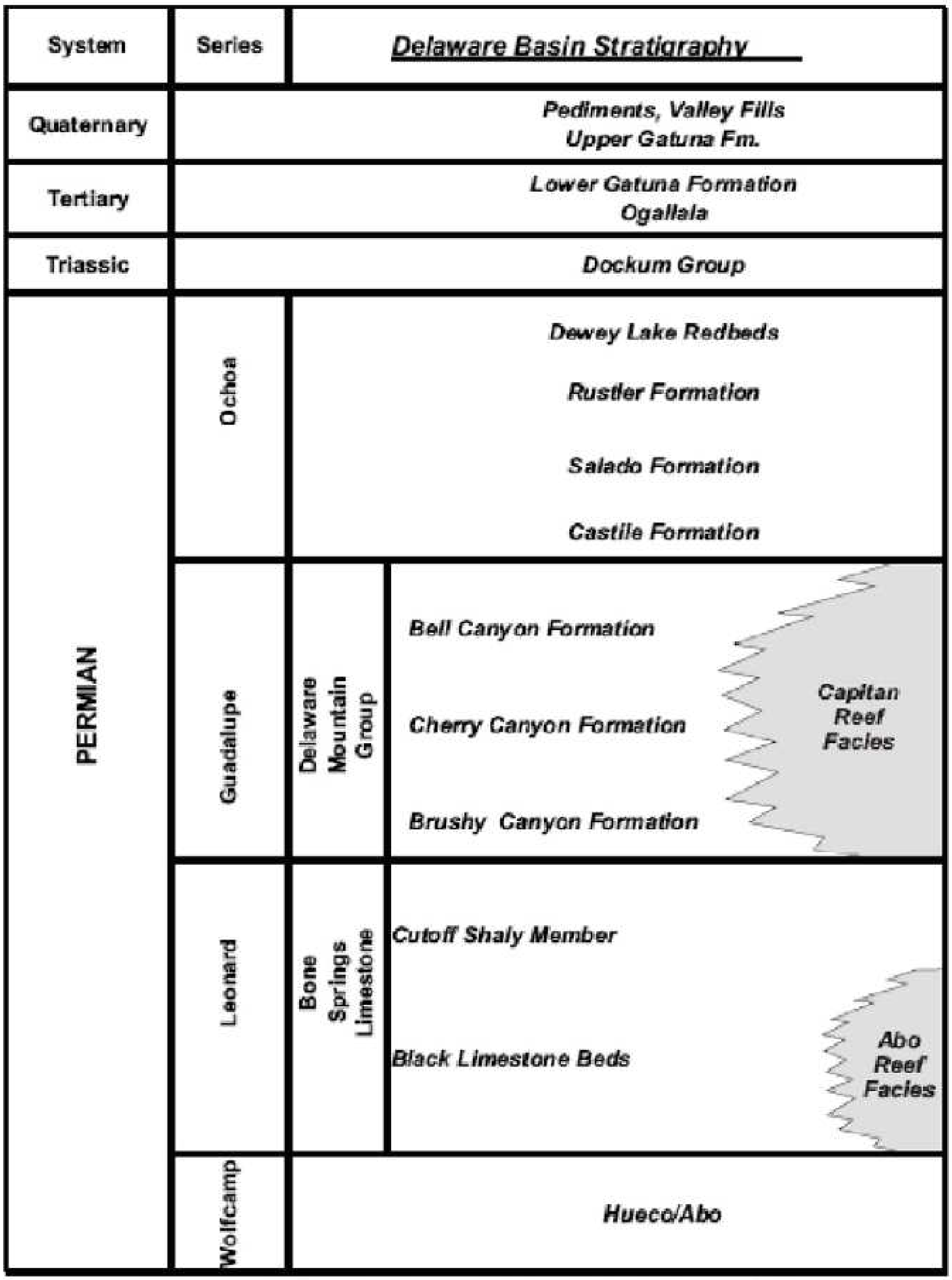
In this figure we see the Capitan Reef Limestone totally circling the margin or shelf edge of the Delaware Basin. Usually it can only be found in the subsurface, but in three places tectonic faulting raised the limestone to higher elevations. After erosion, three mountain ranges remain exposed: the Guadalupe, Apache, and Glass Mountains. You can visit these mountain ranges and actually see the reef-building organisms in the limestone or dolomitic Capitan Fm.

Since limestone and dolomite can be dissolved by subsurface waters, karst features such as caverns, sinkholes, karst towers, karst valleys, etc. can be formed. This is termed *carbonate karst*. The Guadalupe Mountain Range in particular is world famous for its outstanding carbonate karst features, especially caves. But there is a second type of karst, *evaporite karst,* which forms when surface and subsurface waters dissolve salt and gypsum and create similar karst features such as caverns, sinkholes, and subsidence basins. The Delaware Basin is also world famous for its gypsum caves and karst features that form by evaporite dissolution. In particular, the basin shelf edge along the Northwest Shelf and the Central Basin Platform have abundant evaporite karst features and topography, including a large number of sinkholes, karst valleys, and smaller areas of karst depression that have undergone subsidence. These processes continue today. There are several such features in the region around the Holtec site on the Northwest Shelf. Remarkably, Holtec is proposing to site its nuclear waste facility in a broad karst subsidence basin similar to Nash Draw, and which may be an extension of Nash Draw.


SW
Ground Suface
NE
Gatuña Formation
Surficial Deposits
Dockum Group
1000
Dewey Lake Red Beds
Rustler Formation
750
Culebra
Magenta
Rustler-Salado Contact
McNutt Potash Zone
500
Salado Formation
WIPP Repository Level
Elevation (m)
250
Sea Level
Castile Formation
-250
Bell Canyon Formation
Sand and Sandstone
Siltstone and Sandstone
Mudstone and Siltstone
Anhydrite
Halite
Limestone

Basic Geologic Data for CP-975

Table 1 Geology at Drillhole CP-975						
System/ Period/Epoch		**Group**	**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and pad fill			0 - 6 ft
	Pleistocene	Mescalero caliche			6 ft - 13 ft
	Miocene-Pleistocene	Gatuña			13 ft - 29 ft
Mesozoic	**Triassic**	**Dockum Group**[2]	Cooper Canyon		29 ft - 525 ft
			Trujillo		525 ft - 708 ft
			Tecovas		708 ft - 1090 ft
			Santa Rosa		1090 ft - 1380 ft
		Dewey Lake[3]			1380 ft - 1565 ft
Paleozoic	**Permian**	Rustler		Forty-niner *A-5* *M-4/H-4* *A-4*	1565 ft - 1600 ft *1565 ft - 1587 ft* *1587 ft - 1591 ft* *1591 ft - 1600 ft*
				Magenta Dolomite	1600 ft - 1610 ft
				Tamarisk *A-3* *M-3/H-3* *A-2*	1610 ft - 1761 ft *1610 ft - 1650 ft* *1650 ft - 1761 ft* *888 ft - 902 ft*
				Culebra Dolomite	not present as dolomite[4]
				Los Medaños[5]	1761 ft - 1805 ft
		Salado			1805 ft - 2020 ft (TD)
				MB103	*1902 ft - 1930 ft*
				MB109	*2015.5 ft - TD*[6]



Source: ELEA 2007, Section 2.3.2.2.

Figure 3.3.3: PERMIAN TO QUATERNARY-AGED STRATIGRAPHY OF THE DELAWARE BASIN

Above are three stratigraphic columns: the first for the Delaware Basin not far from the Holtec site and which is very similar to it, the second determined by drilling at the Holtec site, and the third a generalized column for the region. For the purposes of this report, the sedimentary rocks in the upper part of the Delaware Basin and Shelf stratigraphic column concern us the most, for while they are not the deep targets of oil exploration (which are all below the Salado Fm salt which acts like a trap seal), they contain aquifers that hold ground water and are closer to the surface. These younger sediments and rocks include Alluvial sands, silts, and clays, the Mescalero Caliche, the Gatuna Fm (not present), the Ogallala Fm (not present), the Dockum Group with Santa Rosa Fm, the Rustler Fm, the Salado and Castile Fm salts, and the Capitan Fm. Again, there are great thicknesses of subjacent rock formations, even on the shelf, but they are too deep to be relevant except in the case of oil exploration.

I have obtained the stratigraphic column of the Fasken Oil & Ranch Baetz Federal 23 #001 which is 1.5 miles WSW of the proposed Holtec facility.

Above-Rustler	0' - 1200'	(Alluvium, Gatuna, Ogallala, Dockum Fms.)
Rustler Fm	1200' - 1400'	
Salado and Castile	1400' - 2,950'	
Yates Fm (sometimes present)	2,950' - 3,200'	
Capitan Fm	3,200' - 4,600'	
Bell Canyon Fm	4,600 - 5,600'	
Cherry Canyon Fm	5,600' - 6,500'	
Brushy Canyon Fm	6,500' - 7,700'	
Bone Spring Fm	7,700' - 10,800'	
Wolfcamp Fm	10,800' - 11,700'	
Below-Wolfcamp	11,700' - 15,150'	(Pennsylvanian, Mississippian, Devonian, Silurian Fms.)

There is a 400' difference between the top of the Salado in the Holtec drillhole and this well.

Using the Fasken Baetz Federal 23 #001 well depths and very accurate depths know for the WIPP site, we calculate the Salado potash zone is about 1,650' beneath the surface at WIPP, above the repository depth of 2,150', while it is approximately at 1,640' depth at the Holtec site. The top of the Salado below the Holtec site is about 1,400', calculated by the depth indicated on Holtec's very small-scale cross-section Figure 3.3.2 and measurements from the Fasken Baetz 23 Federal #001 well 1.5 miles WSW of the Holtec Site. This is a moderate depth, not shallow and not deep, but close enough to the surface to be a problem if leaking oilfield waters from old brine injection wells or broken casing caused a dissolution cavity to develop in the Salado.

The giant Capitan Reef brackish water aquifer lies 3,000' - 3,200' feet below the Holtec site, probably too deep to cause a problem. This aquifer experiences limestone karst activity at shallow depths, not evaporite karst, but is too deep to affect the surface under the Holtec site.

Near the surface it produces many spectacular caves and other carbonate karst features.

3. Presence of Both Carbonate and Evaporite Karst Features in the Region and Immediate Area of the Holtec Site

presence of caves, alluvial sinkholes, collapse sinkholes, alluvial dolines (depression), karst valleys, springs, lineaments, cenotes, fissures

Wink Sinks, Jal Sink, JWS Sinkhole, Williams Sink, Loco Hills Sinkhole

Nash Draw—a karst depression, laguna clusters incl. Holtec site

4. Presence of Groundwater, Aquifers, Surface Water, Playa Lakes

A. Water Wells, Aquifers, Ground Water

- **Ground Water: Four Aquifers Below the Holtec Site; +with wells near Holtec site; *close nearby but absent at site)**

- **+Alluvial Aquifers** (Holocene and Pleistocene)

- ***Gatuna Aquifer** (Pliocene-Pleistocene) - eastern margin is 10 mi W of Holtec site)

- ***High Plains/Ogallala Aquifer** (Miocene-Pliocene) - western margin is 12 mi NE of Holtec site)

- **+Santa Rosa Aquifer** of the Dockum Group (Triassic)

- **+Culebra and Magenta Dolomite Aquifers** in the Rustler Formation (Ochoan Permian)

- ***Capitan Reef Aquifer** of the Delaware Mountain Group (Guadalupean Permian) - too deep at Holtec site but pumped nearby in Carlsbad, etc., where it is potable)

The proposed Holtec site and facility are directly above the Capitan Reef Aquifer in the subsurface. This is shown in three diagrams from Holtec reports below.

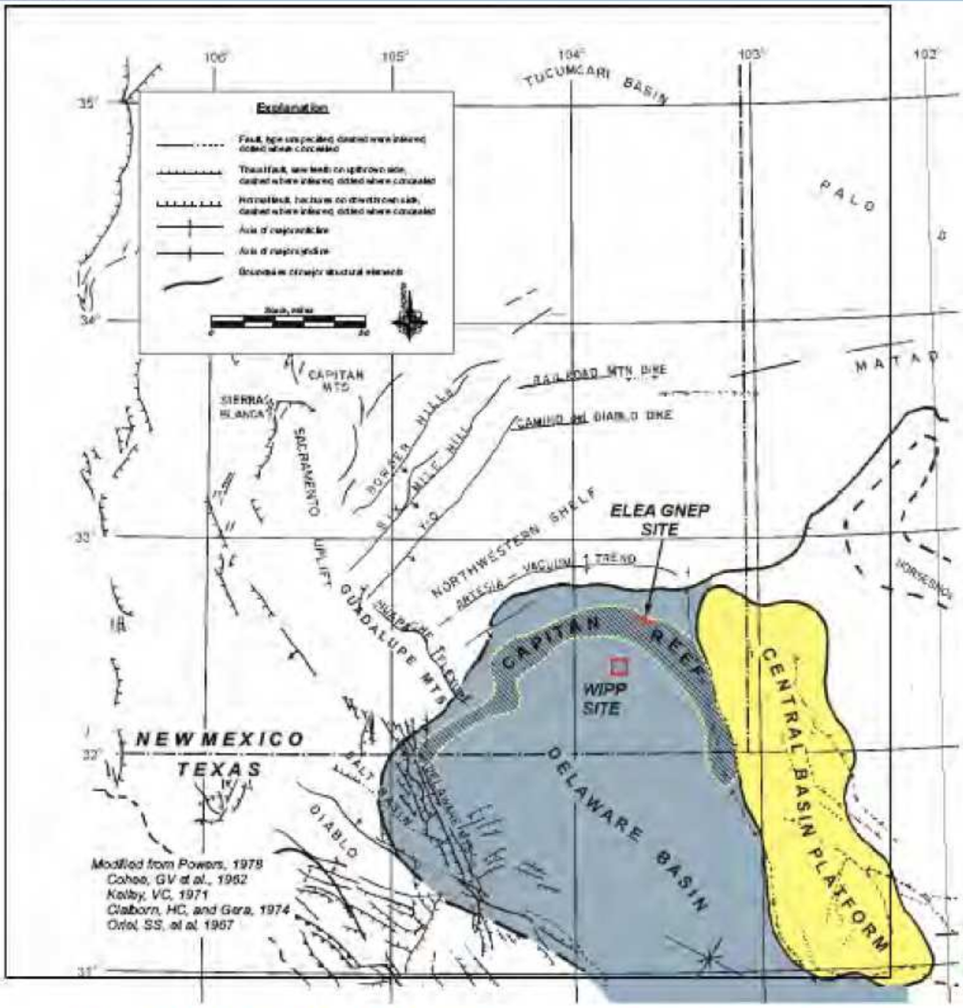
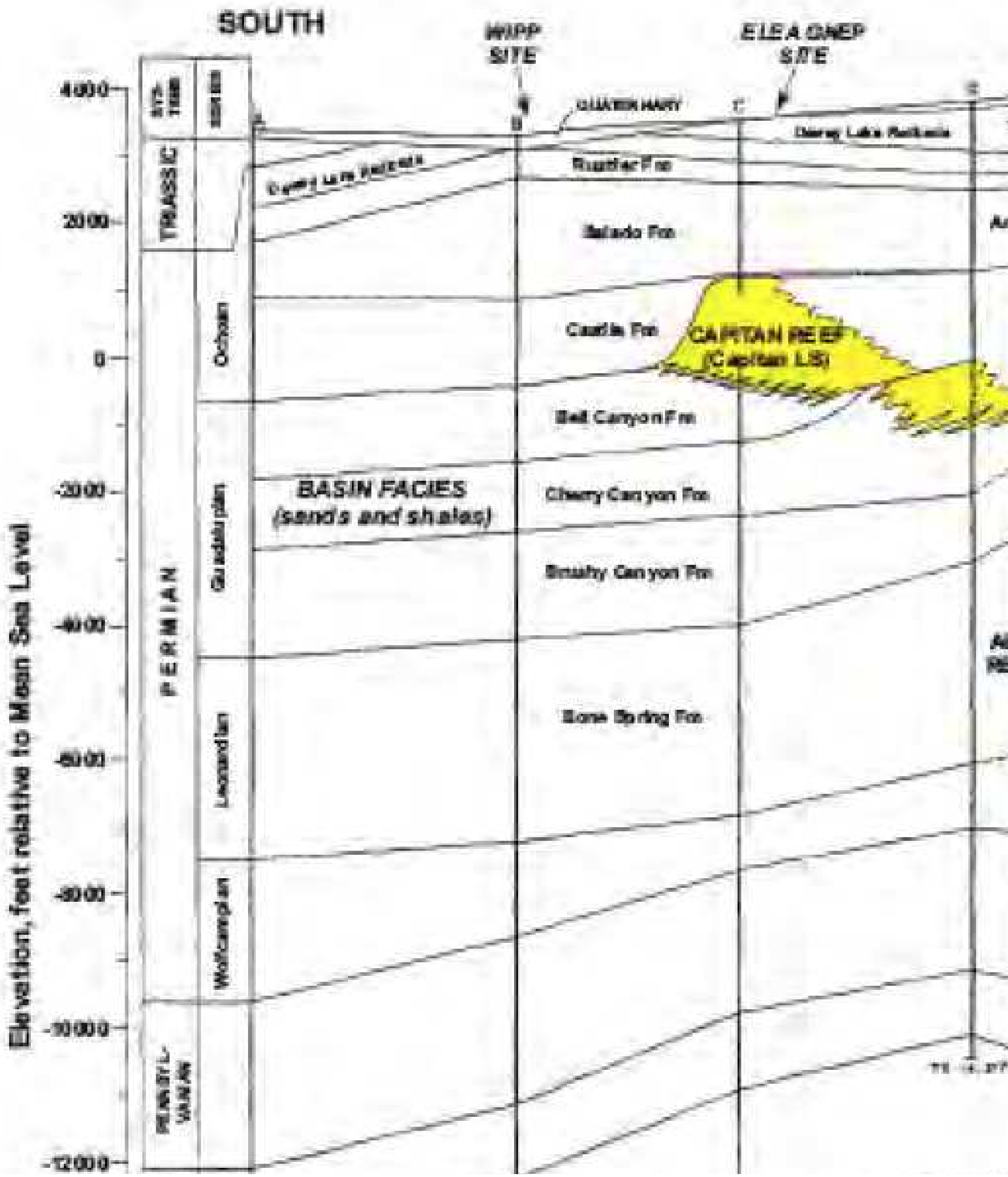


Figure 2.3.2.2-3 Major Regional Geological Structures near the Site (Powers et al., 1978)


SOUTH
WIPP SITE
ELEA GNEP SITE
QUATERNARY
Dewey Lake Redbeds
Rustler Fm
Salado Fm
Castile Fm
CAPITAN REEF (Capitan LS)
Bell Canyon Fm
BASIN FACIES (sands and shales)
Cherry Canyon Fm
Brushy Canyon Fm
Bone Spring Fm
TRIASSIC
PERMIAN
Ochoan
Guadalupian
Leonardian
Wolfcampian
Elevation, feet relative to Mean Sea Level
4000
2000
0
-2000
-4000
-6000
-8000
-10000
-12000


Loco Hills
Maljamar
Eddy
Lea
Laguna Plata
Laguna Gatuna
CISF SITE
Eddy
Lea

B. Lagunas/Salinas/Salt Water Playa Lakes

source of surface water, not suitable location for toxic, hazardous, nuclear waste disposal

5. Presence of Petroleum Exploration, Drilling, Fracking, and Wastewater Injection

well compilation, summary of interviews with oil companies, investigation of public well data

Part II.

Several Scientific, Economic, Political, and Anecdotal Reasons That Make It Inadvisable to Store High-Level Nuclear Wastes at the Proposed Holtec Temporary Storage Site in New Mexico

1. Nuclear Waste Surface Storage

The Holtec proposal will transport spent fuel rods, a form of high-level nuclear waste, from dozens of old and decommissioned nuclear reactors in the U.S. to a single site in New Mexico. The repository site is (1) on or near the surface, not buried deeply underground, (2) the individual storage silos are just under the surface with the tops above ground to permit human access, (3) the soil and subsurface rock is composed of porous and permeable sedimentary rock, not nonporous and impermeable igneous rock, and (4) the site relies solely on constructed barriers of concrete and other man-made materials to contain any leakage of radioactive isotopes or contamination with rain or flood waters. This proposed location and its migration barriers are inadequate to deal with high-level radioactive waster containment and potential leakage and violate the most elementary standards for construction of hazardous waste landfills, which at minimum should include natural barriers to fluid migration in addition to artificial ones. The proposed site isn’t even adequate to contain heavy metals, chlorinated hydrocarbons, pesticides, and other toxic and hazardous wastes, much less nuclear wastes.

In addition to being stored in a subsurface nonporous and impermeable igneous rock, nuclear waste must be located deep underground where it is inaccessible to humans for millions of years. It is not realistic to believe that the waste in surface and shallow subsurface storage will be guarded and protected for 120 years from proliferation, malfeasance, and terrorism. Holtec may not even exist as a company in 50 years. It is possible and indeed likely the nuclear waste will be left to the sole care of the federal government long before the termination of the permit. Holtec plans to make millions of dollars in profit from the permit and contract and then leave total responsibility and liability for the waste to the U.S. federal government as quickly as possible after all the waste has been transported and contained. Of course, surface storage in silos and caskets is being used because (1) presumably the SNF/HLNW will be removed within decades and transported and stored in a much more secure location, and (2) the technology already exists for surface storage.

2. The Nuclear Waste Will Not Be Moved a Second Time

The Holtec site is intended to be temporary storage until the permanent nuclear waste repository is designed, permitted, and built, so its inadequate design is not supposed to be an issue. However, it will be permitted for 120 years, much longer than the lifetime of the artificial materials (thin steel canister housing, concrete barriers, etc.). But even worse, it is very likely that, when the high-level nuclear waste is buried in its storage canisters, the waste will never be moved a second time as claimed and reach a final and safe storage site deep underground in a remote mountain composed of igneous rock. This is because right now--due to the increasing collection of spent fuel rods at nuclear plants--there exist both (1) the tremendous motivation to remove the waste from the reactors that produced it before their old storage containers corrode any further, and (2) plenty of money is available today from the nuclear storage trust fund to pay for transportation and storage of the nuclear waste.

The waste is currently licensed to the nuclear power plants and their parent electrical energy companies and is their proximate responsibility, but before removal and transport the title for the waste will transferred to the U.S. federal government, who has ultimate responsibility (no transport, storage, and disposal company in its right mind would accept licensing and title for waste with this much liability, but all the companies involved expect the federal government to do this, since it promised to do so). Once the waste is licensed to the DOE, transported to and stored at tremendous cost in another state, and the $50 billion trust fund has been depleted, the political motivation of the electrical energy companies and their state governments to transport the waste a second time will disappear. Next, because of having no multiple-state political motivation, the enormous sums of money needed to safely move and store the waste a second time as planned—to a final secure repository that meets proper disposal standards—will no longer be available, and the political will to appropriate more money to do this will not be successful. Ultimately, if Holtec is granted its permit, it is highly likely the waste will remain stored in its inadequate and accessible surface location in New Mexico permanently and be available as a terrorist target, a perpetual money sink for security and maintenance, a continuously deteriorating hazardous waste dump for centuries, and a future superfund site.

3. Externality Benefit and Cost Analysis

Our poorly-regulated American free enterprise system—our vaunted "mixed economy" or "regulated capitalism"—allows corporation to *privatize gains and socialize losses* due to weak regulation based on ignoring sound economic theory. Two other ways to state this aphorism—fully supported by modern economic theory—is that powerful and wealthy entities (corporations, companies, businesses, industries) have been able to *privatize benefits and socialize costs* or *privatize profits and socialize risks*. For example, in one of his many critiques of American capitalism, Noam Chomsky wrote in 2006, "As in the past, the costs and risks of the coming phases of the industrial economy were to be socialized, with eventual profits privatized …" (Failed States: The Abuse of Power and the Assault on Democracy). Many of our country's largest corporations depend on this publicly-obscure economic malfeasance—one that has been described as a reverse corporate tax, corporate socialism, or a massive scam on taxpaying citizens—to a greater or lesser extent to survive past their rational usefulness to society and even to make exorbitant profits at the expense of the public good. This scam is hardly noticed because our economic system has been structured to minimize the obvious problems and public costs which are rarely paid up front. Most examples of socializing losses, costs, and risks involves disposal of harmful wastes into the natural environment including the air, fresh surface water, ground water, ocean water, soils, and rocks.

Well-known (to economists and environmentalists) examples of this phenomenon deal with environmental damage, degradation, and even local destruction, such as air and water pollution by profitable chemical companies and fossil fuel combustion with resultant global warming/climate change by profitable fossil fuel energy companies. These industries (1) create enormous amounts of pollution that harm human health, quality of life, and productivity and (2) damage the natural environment and degrade biodiversity at tremendous costs that are never incurred by the industries themselves but are passed onto present society and future generations. Simply put, our modern regulated free-enterprise system cannot keep up with regulating and enforcing existing regulations that protect nature and society from polluting corporations. New rules are perpetually needed to keep up with advancing technology, and existing regulations cannot be properly enforced due to a myriad of reasons. If the corporations were to actually deal ethically with the obscure or hidden environmental losses and costs that result from their activities they would (1) pay to decrease their pollution to manageable and harmless levels and (2) raise their prices to pay for pollution control which oblige their customers to pay for the social costs. Pollution mitigation payments affect the bottom line. Consumers might very well prefer to keep prices low, such as gasoline prices, and pass the negative external costs onto their descendants. To counteract this, governments might tax gasoline prices to make them better reflect their true cost to society and invest the tax proceeds into air pollution mitigation.

If company A operates ethically by internalizing pollution and company B does not by socializing pollution, A goes out of business and B makes a greater profit. Governments can keep all companies ethical, clean, and profitable by regulating them.

The modern economic theory that deals with this phenomenon is known as *externality theory*. Externality theory is a *scientific theory*, one that has evidence and factual reliable knowledge supported by repeated testing to justify it, not the popular concept of a theory, which is an idea, guess, or speculation. In this theory, an *externality* is the cost or benefit that affects a party who did *not choose* to incur that cost or benefit, while an *internality* is the cost or benefit that affects a party who *chooses* that cost or benefit. Companies, of course, always choose to internalize benefits, gains, and profits, but typically do not want to choose the often enormous external social or environmental losses, costs, or risks that are inherent in much industrial activity. Typically, therefore, companies shun *externality costs* while the benefits, gains, or profits privately accrued are termed *internal benefits*. There are also internal losses or costs (which companies choose to accept because they are inevitable or inconsequential) and external gains or benefits (which companies choose not to accept because they can only benefit others or are small enough to ignore), but we will ignore them in this brief analysis.

Economists often urge governments to adopt regulation policies that "internalize" externalities, that is, oblige companies to choose to internalize environmental or social costs so that costs and benefits will equally affect all parties who choose to incur them and a sustainable balance is achieved. Corporations will not often willingly choose to internalize external costs to achieve internal benefits but *will* choose to do so *if* they are obliged to by government regulators so they engage in their business enterprise (an offer—or choice—they can't refuse). Too often, however, government regulation fails to do this. The classic example of such failure these days is increasing climate disruption (including climate change and global warming), with increasing regional periods of temperature over 100° F, droughts, wildfires, melting glaciers, rising sea levels, more powerful hurricanes, calamitous precipitation, localized flooding, etc. Such enormous societal costs or losses—too often hidden or obscure to the public—are, in many cases, ignored by modern corporations which allowed to do so by venal and ignorant elected public officials, but are nevertheless repaid by living and future citizens over human generations (since costs and benefits will eventually have to even out).

Voluntary exchange of internal and external costs is by definition mutually beneficial for business parties involved, because the parties would not agree to undertake it if either thought it detrimental to their interests. However, a transaction can cause effects on third parties without their knowledge or consent. From the perspective of those affected, these effects may be negative or positive. We will only consider negative effects here which are, in fact, the most common examples. A *negative externality* is any difference between the private cost of an action or decision to an economic agent and the social cost which a company does not choose to accept. In simple terms, a negative externality is anything that causes an indirect cost to individuals. Air and water pollution from industry, vehicles, etc. are the common examples of negative externalities (i.e., external costs or losses).

Frequently, corporations are allowed to ignore external costs and they are passed onto society and future generations. The best example of this is the fossil fuel industry and climate change: pollution is defined as the accumulation of waste and byproducts in amounts harmful to living organisms. At first, the waste and byproducts (carbon dioxide and methane) were small and thus not pollution, but gradually they became so large that life on Earth was being harmed, but by this time we found our civilization trapped in an energy system from which it was and is still difficult to escape. The best opportunity to escape this system passed four decades ago, when scientists' warnings were taken seriously by public officials, but because of political lobbying by the fossil fuel industries and government complacency the opportunity passed. This history was recently described in a recent interactive New York Times article (https://www.nytimes.com/interactive/2018/08/01/magazine/climate-change-losing-earth.html).

Holtec and our representative national government plan to emulate this sorry story if Holtec is allowed to "temporarily" transport and store SNF/HLNW in New Mexico and ignore external costs and future problems by, for example, forgoing future financial responsibility, not posting a bond, or failing to collect additional fees. (The obvious problem here, needless to say, is that when we learn the potential practical and geologic dangers of storing the waste at their proposed site, the size of an adequate bond would be equal to or greater than the potential profit that Holtec hopes to make.) If the nuclear wastes were to be moved permanently by a contractor to a legitimately secure and ultimate repository, no bond from the contractor would be required (in other words, the ultimate "bond" would be the full faith and credit of the federal government dependent on the best scientific data). We acknowledge that the U.S. federal government has the ultimate responsibility for the wastes, so *it must be responsible to make sure all the intermediate steps are planned and conducted responsibly and are consistent with reliable scientific information and sound economic theory*. There is still time to ensure this happens.

4. Risk Analysis

In analogy to Benefit and Cost Analysis involving externalities, we must briefly assess the risks involved with transporting and storing the nuclear wastes to a temporary or permanent surface storage repository. *Risk analysis* is the science of risks and their probability and evaluation. Risks are often coupled with Benefits or Opportunities, so the formal assessment is termed a Risk-Benefit or Risk-Opportunity Analysis. It is likely another person with greater expertise in risk analysis than I have will deal with this important aspect in more detail (the Holtec license proposal contains a brief risk-benefit analysis, but it is woefully misleading because it omits the obvious and significant risks I present below). Let me, however, just make a few pertinent and, I think, fatal observations.

Under the Holtec proposal, the inevitable risks are unacceptable and the stated benefits are unachievable. The primary reason the risks are unacceptable is because either (1) the nuclear wastes will be moved twice, thus unavoidably more than doubling the risks of transportation and the costs of a second transport and storage, or (2) the transported waste will ultimately be stored at the surface site in New Mexico permanently, becoming the de facto final repository for the SNF/HLNW. The stated benefit of safely storing SNF/HLNW in a surface landfill in New Mexico is unachievable for several reasons. Let's examine each of these in turn. I will very briefly discuss two aspects of these in the next two sections, but right now let's look at the forest rather than the trees.

(1) At his own recent district town hall meeting in Odessa, Texas, I spoke with Representative Michael Conaway, my own U.S. Congressman from Midland (I live less than a mile from his house and have met him about eight times, usually when he votes because I am often the election judge in his district), who co-sponsored the original bill with Darryl Issa that allowed companies such as Holtec and WCS to seek an NRC/DOE permit to transport and store the nation's SNF/HLNW temporarily in surface/shallow-subsurface silos. This bill only recently was attached to a giant agriculture bill (Conaway is the U.S. House Agriculture Committee Chairman) and passed the House. Its Senate companion recently passed the Senate, and the bills will have to be reconciled in a House-Senate conference committee (which probably won't happen until 2019 under different political circumstances). I explained to Rep. Conaway that while the risks for one transport were small, transporting the waste twice would more than double the risk and make it unacceptable. He couldn't understand this. He explicitly told me that "if the waste had a small transport risk the first time, it would have the same risk the second time." I tried to explain that—unlike flipping a coin which has no risk and therefore each flip has the same odds—performing a risky task twice at least doubles the overall risk. And the second time here will be even riskier than double, because the canisters will have deteriorated over the decades and be weaker and more prone to cracking and breaking. I also tried to explain that multiple risks are calculated multiplicatively, not arithmetically. This explanation was beyond his numerate powers to comprehend. I also asked him why he agreed to join Rep. Darrell Issa in sponsoring the bill. Issa's reason, of course, is that the decommissioned San Onofre nuclear power plant is in his San Diego district and its stored fuel rods are in a very dangerous location on an eroding cliff overlooking the Pacific Ocean. Conaway replied that he had also been asked to sponsor the bill by WCS in Andrews, TX, and he thought it was a legitimate business opportunity for them. When I pointed out how dangerous it was, he replied, "I just wanted to approve the business opportunity, which I thought was legitimate. I expect that the experts in the NRC will justify it or not with their hearings and expert scientific and public testimony, and

that's not my responsibility."

I also attempted to explain the problem financially, since Rep. Conaway's original profession, prior to being a politician, was a CPA. I said the costs of moving all the country's waste to a "temporary" site in New Mexico or Andrews County, Texas, will probably exhaust the $50 billion trust fund. Raising that amount again by fees is impossible, so an equal amount to pay for moving the wastes a second time will have to be provided by legislative appropriation, and this would certainly never happen. He wasn't concerned about this problem, either.

(2) Many, including me for reasons discussed in detail above, believe that the SNF/HLNW, if moved to the Holtec Site in New Mexico, will never be transported a second time to a secure repository for political and financial reasons. This would leave our country's entire "stockpile" of spent nuclear fuel rods in shallow-subsurface silos whose tops are above ground in a single location exposed and accessible to terrorists and the elements—forever. This would be such an alarming, calamitous, and demented outcome that the risks must be enormous, almost beyond calculation. The nuclear wastes should be moved only once to a final, secure, subterranean igneous rock site—only then will the risks be acceptable. To be explicit, all the transportation risks would be acceptable if the fuel rods in their casks would be moved only once to their ultimate secure destination. If Holtec bids on such a contract and wins it, I would have no complaint. This is the true "legitimate" business opportunity.

In its own brief risk-benefit analysis, Holtec does correctly mention that all the nuclear power plants whose SNF/HLNW will be removed and transported to New Mexico will be benefitted. It fails, however, to acknowledge the severe transportation and storage risks due to human activities and natural causes. It mentions these risks but attempts to minimize them, and while the admitted risks may be small, over time—and especially over decades and possibly centuries—the risks will manifest themselves. Even one failure or disaster will be a major calamity to the humans involved, and this is unacceptable and should not ever be allowed to happen. The only way to ensure this is to not permit the nuclear waste to be transported and stored in New Mexico in the first place. Holtec fails to mention that despite the benefits to the various states and nuclear power plants who are able to rid themselves of their spent nuclear fuel rods, the corresponding risks will be accrued by the U.S. federal government, not by Holtec. Instead, Holtec perversely and falsely claims that the federal government itself will benefit by implementing the Holtec license plan. But this is false because the federal government will gain the benefits only when the wastes are interred in their final resting place. While they are in-route or in a "temporary" storage area, the federal government has simply assumed the risks previously held by the states and nuclear power plants, not gained the benefits. Finally, Holtec fails to mention the one entity gaining the greatest benefit, Holtec itself, by making huge profits within a program that is so-far designed to privatize the internal gains (to Holtec and the places where nuclear power plants exist) and socialize the external risks and potential losses, which by now must be considered an unethical business practice, especially after it has been pointed out, as I have here.

5. Transportation Risks

Several types and intensities of transportation risks dealing with the transport caskets, industrial-scale equipment, trucks and trains, etc. have been pointed out by opponents of the “temporary” transport and storage plan. These will be discussed by individuals with more expertise than I have on these subjects. However, I am a resident of the area, the Permian Basin, where much of the transportation will occur and where the SNF/HLNW is proposed to be stored, and I wish to present a few personal observations about the dangers of transporting the wastes in this region. I acknowledge that the transport caskets that hold the fuel rod containers during transport are engineered to be as safe as possible, even during falls, but they cannot be expected to be 100% safe. There is some small risk at least (some informed critics claim that the risk is large, not small). The northern shelf edge of the Delaware Basin (one of the three sub-basins within the Permian Basin), where the waste is proposed to be buried in shallow-subsurface silos, is a relatively remote area, but it is not isolated from human activities for it contains a large number of oil and gas producing wells, tank batteries, separators, gas processing plants, wastewater injection tanks and wells, giant potash mining plants, nuclear waste storage sites (WIPP, WCS), water wells, highways, and railroad tracks. The entire Delaware Basin has seen enormous growth in the last five years due to the fracking boom and it will continue to grow even more. In particular, tremendous stress is being placed on the local highway and railroad infrastructure and construction and safety upgrades cannot keep up.

(1) Truck Traffic Risks. I will discuss the proximity of petroleum industry construction next to the Holtec site in a later section. Let me mention now that the number of traffic accidents and deaths has been increasing rapidly over the last 5-10 years. Holtec plans to transport the SNF/HLNW to the site using both trucks and trains. When I hear the designation “Highway of Death,” I don’t know if the speaker is referring to Hwy 285 north out of Pecos, the major east-west transport route, Interstate 20, or some other route. The two I named are dangerous to drive now and I can testify to this personally. Every highway in the two major oil basins, Midland and Delaware, is dangerous to drive because of the constant heavy oilfield truck traffic. The newspaper in my city, Midland, routinely reports new highway deaths in the county and always mentions how the number has increased every year. We have had six or seven new accident deaths in just the last few weeks. The same is true for bicyclists and motorcyclists. It is literally not safe to ride a bicycle or motorcycle right now on any highway; I used to do both but have given them up. Today even driving cars is unsafe; one has to be extra careful.

(2) Train Traffic Risks. Trains provide the same story. Train accidents and derailments in our region are now common. When I testified on 2018 April 30 in Roswell and May 1 in Hobbs before the NRC panel, I and others mentioned this. I specifically mentioned the April 18 train accident in Monahans, Ward Co., that derailed more than a dozen train cars carrying heavy fracking sand (https://www.oaoa.com/news/traffic_transportation/vehicle_accidents/article_f7e3395e-435a-11e8-bbe5-5b37334a3c03.html). Little did I know that on the evening of May 1 when I testified before the NRC, or I would have brought it up, two new major accidents had occurred earlier that very day. First, seven cars had derailed and overturned and three had derailed at 10:00 a.m. in Odessa (https://www.mrt.com/news/article/Union-Pacific-train-derails-along-Highway-80-12879319.php). This train also had very heavily-laden cars carrying fracking sand, suggesting that heavier cars than normal—which would be the case for top-heavy nuclear waste transport canister—are especially tip-over prone. Next, four locomotives and 30 train cars had derailed in Ward County east of Barstow at 6:00 p.m. (http://www.cbs7.com/content/news/Train-derailment-in-Ward-County-officials-responding--481440711.html). In this case, the train had struck a "water truck" (a truck carrying oil field wastewater to a disposal station). I want to emphasize this: *On the very day I testified before the NRC about the dangers of the Holtec nuclear waste transportation and storage plan there were two major train accidents with multiple derailments*. These two, plus the April 18 one, plus several others were all associated with oil field traffic and materials. This activity is only going to increase and derailments will become even more common than they are now. From just this anecdotal evidence from one individual, I believe it is simply not safe to transport nuclear wastes by truck or train within the Permian Basin, and yet that is a central part of the Holtec plan. I realize that accident risks due to truck and train accidents has been calculated by the NRC and contractors, and they are low, but the risk assumptions must be seriously re-examined in light of the immense new transportation activity due to the petroleum industry in the Permian Basin and new calculations performed. A much higher calculated risk is warranted.

6. Storage Canister Failure

The risk of transport cask and storage canister failure during transport and accidents with resulting leakage and contamination is very small but not infinitesimal. It will be discussed in more detail in another section of this report by someone with more expertise than I possess. Instead, I refer readers to this quite readable critique, https://sanonofresafety.org/holtec-hi-storm-umax-nuclear-waste-dry-storage-system/, which begins with these claims:

> Holtec HI-STORM UMAX canister storage systems and all other thin-wall nuclear waste canister storage systems are vulnerable to short-term cracking, radioactive leaks and potential explosions and criticalities. Each canister has roughly as much highly radioactive Cesium-137 as was released from the 1986 Chernobyl nuclear disaster.
>
> These thin-wall "Chernobyl" cans have the following design flaws:

- Vulnerable to short-term cracking and major radioactive leaks
- Cannot be inspected inside or out
- Cannot be repaired
- Cannot be monitored or maintained to **PREVENT** radioactive leaks
- No plan for failing canisters.

Following this opening, the webpage goes into great and convincing detail about the problems these storage canisters face. In answer to a question from a reader, San Onofre Safety administrator Donna Gilmore says this: "I have documents from Holtec and NRC that confirm the fuel will go critical in dry storage if unborated water enters canisters through cracks. The NRC approves them based on the assumption there will never be through-wall cracks."

Holtec in a statement explicitly and arrogantly excoriated opponents criticizing their license plan for the potential for leakage when the fuel pellets are in solid form and thus cannot leak. Do they really expect opponents and regulators to ignore the fact that the containment vessels can become stressed and cracked during transport, and they and artificial barriers will corrode over centuries, undergo cracking, allow rainwater to enter and become irradiated, and then leak onto the surface and into subsurface aquifers? As is so often the case, Holtec is thinking in terms of proximate internal benefits over a few decades, not long-term external risks and costs over centuries.

An older publication, *Ground Water at Yucca Mountain: How High Can It Rise?,* 1992, National Academies Press, http://nap.edu/2013, makes these points:

> "Because radioactivity from spent nuclear fuel rods could most likely be released from an MGDS [mined geologic disposal system] to the outside environment through water entering the repository and transporting the radionuclides into the ground-water system, it was considered that a repository located a considerable distance above the water table in an area with extremely low rainfall would limit that mode of release."
>
> "If [flooding occurred], and if engineered containments failed, the water could carry still-active radioactive isotopes into the biosphere, a possibility that would lead to serious questions concerning the acceptability of the site."

That publication, by the way, concluded that the Yucca Mountain repository was safely above any potential or historic rise of the water table. I documented the presence of several aquifers at the proposed Holtec site, although only one is shallow. During my recent visit to the site, I witnessed an intense rainstorm. Although situated in a relatively dry environment, heavy rain does occur periodically with surface runoff and overland flow. Rainwater also infiltrates into the subsurface in this region, for example, around the margins of the salinas (salt playas, named lagunas here). Furthermore, the area possess many water wells that tap these aquifers, both fresh and brackish, so the water table is near the surface at typical water well depths.