CHAPTER 7

EXPANSIVE SOIL

Expansive soils are soils that expand when water is added, and shrink when they dry out. This continuous change in soil volume can cause homes built on this soil to move unevenly and crack. Each year in the United States, expansive soils cause $2.3 billion in damage to houses, other buildings, roads, pipelines, and other structures. This is more than twice the damage from floods, hurricanes, tornadoes, and earthquakes combined. (Kerrane) U.S. Housing and Urban Development (HUD) estimated $9 billion damages in 1981 resulting from expansive soils. It indicated that shrink-swell problems were the second most likely problem a homeowner would encounter, after insects.

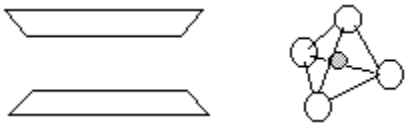
Damage to sidewalk and street resulting from expansive soils

http://wwweng.uwyo.edu/classes/sp2011/ce4630/reports/wes/expansive/expansive.htm Accessed 5/26/2011

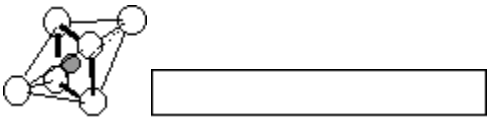
Expansive Soils Formation

As Igneous rock (primarily volcanic ash) breaks down through chemical weathering, it creates the clays.

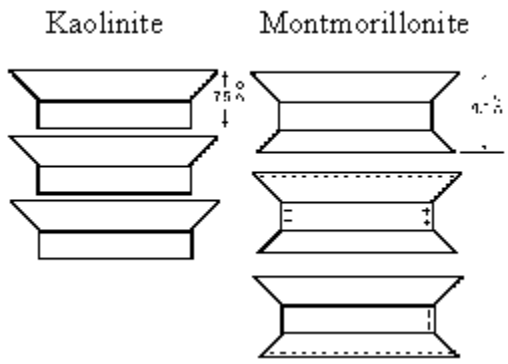
- Weathering breaks the parent rock apart and allows the atoms to recrystalize. These form Silicon Tetrahedron Sheets



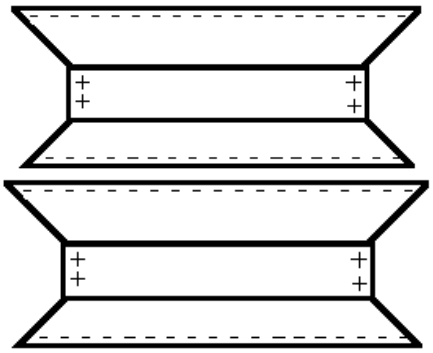
- and Aluminum Octahedral Sheets.



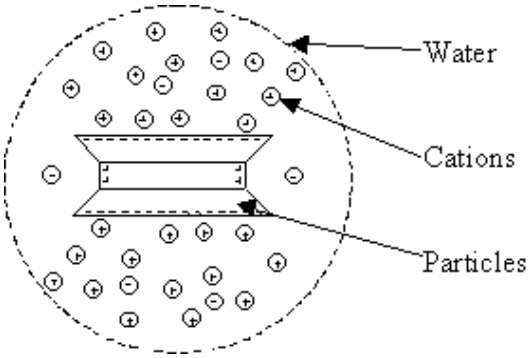
- Kaolinites are formed in well drained soils, with an abundance of Oxygen, Silicon and Aluminum. Since the constituents are "pure", these form very regular shapes which bind together in regular structures. These are held together in large stacks by strong Hydrogen Bonds.



- Montmorillonites are formed in poorly draining soils so that a wide variety of atomic species are available for recrystalization. When the aluminum octahedtrals are trying to form, sometimes "isomorphic substitution" occurs in which a magnesium atom substitutes for an aluminum atom. This creates irregular shapes and unbalanced charges with weak "van der Waals" forces between them.

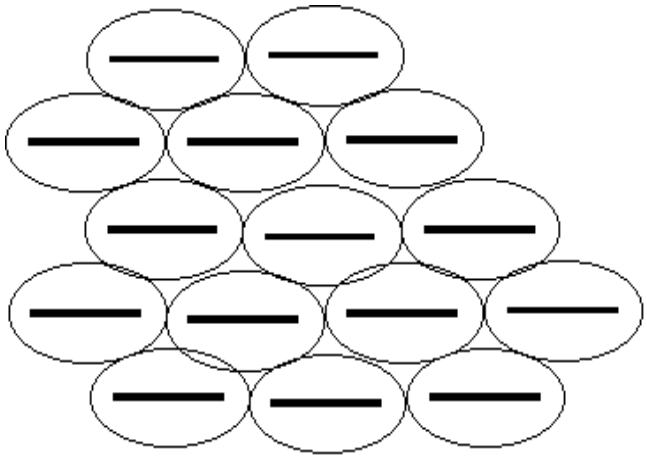


- To be electrically balanced, montmorillonites develop micelles with water and cations.

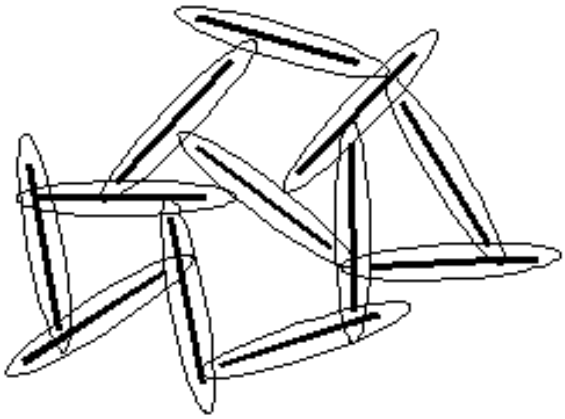


- Depending on the environment in which the clays form, they may be dispersed or flocculated.

- This is the condition most "soils" (like the black soils) are in.



Dispersed Structure



Flocculated Structure

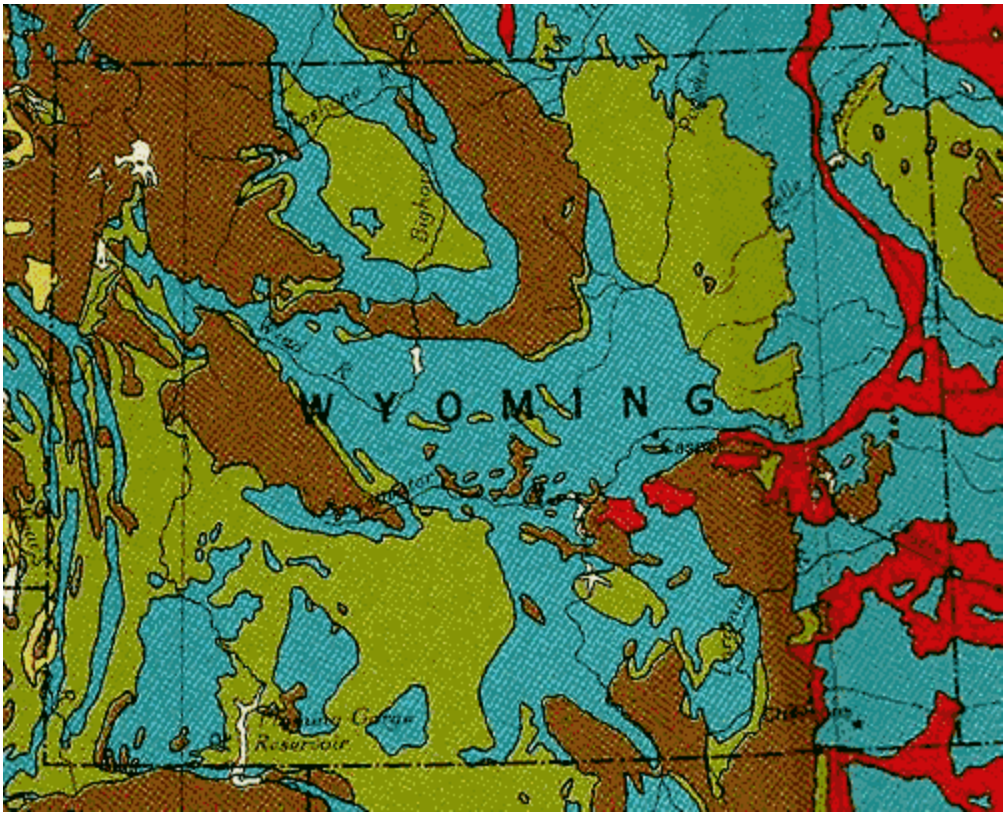
- ✓ Over geologic time, these may be compressed and form clay to claystone to shale to schist.

- ✓ Hence, the mineral has the potential, the environment has the cause. (Edgar)

Some Wyoming clays have the potential to shrink and swell when they become wetted or dried. These clays are primarily montmorillonites. There is one type of montmorillonite, sodium montmorillonite (commonly known as bentonite), that is especially prone to shrinking and swelling. Another montmorillonite, calcium montmorillonite, also shows some shrink-swell capabilities. Areas where these clays are known to be present are shown in **Figure 7.1**. All of the areas shown on the map are geological formations that contain bentonite, except for the Casper Mountain area in Natrona County where calcium montmorillonite is present. There are other areas in Wyoming with soils that have a shrink-swell component due to montmorillonites that are included in the soils. Those soils have not been completely mapped.

Image A, initial view; Image B, after a small amount of water has been introduced; Image C, 48 hour time lapse.
http://www.home-inspections-radon-testing.com/expansive_soils Accessed 5/26/2011

The hazard these expansive soils create can be significant although they have, for the most part, been recognized and mitigated in urbanized areas. Many of the expansive soils do not create large areas of destruction; however, they can disrupt supply lines (i.e. roads, power lines, railways, and bridges) and damage structures. Expansive soils do not change size quickly. **(See Images, Page 7.3)** Observing damage in real-time can sometimes be difficult. Although damage may not occur in a matter of minutes, it still has potential to severely damage structures and roads over time if not sufficiently mitigated.

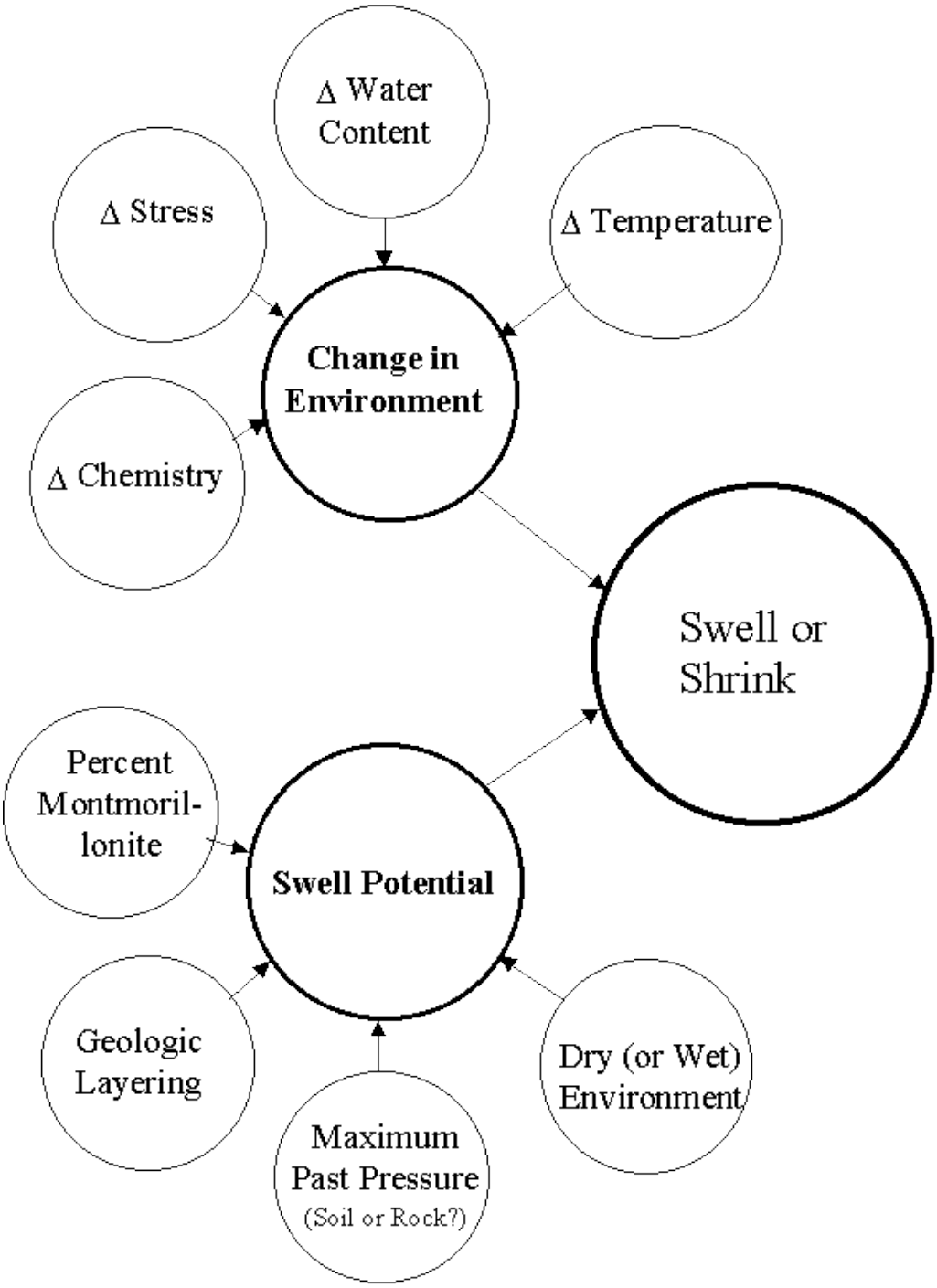


Red	High Potential for High Swell
Blue	Likely Potential for Mod. To High Swell
Green	Moderate Potential for Some to Low Swell
Brown	Low Potential for Swell

(Edgar, 2002)

Potential vs. Realized Swell

Many soils and rocks have the potential to swell. That is a function of its minerology. The actual swelling will be caused by a change in the environment in which the material exists.



History

Very little work has been done to study the extent of expansive soils in Wyoming. Although there have been instances in the Casper area where foundations and other concrete work have fractured and been displaced, historical accounts of actual damaging events caused by expansive soils have been difficult to locate. Even less is known about expansive soil locations outside of the Casper area.

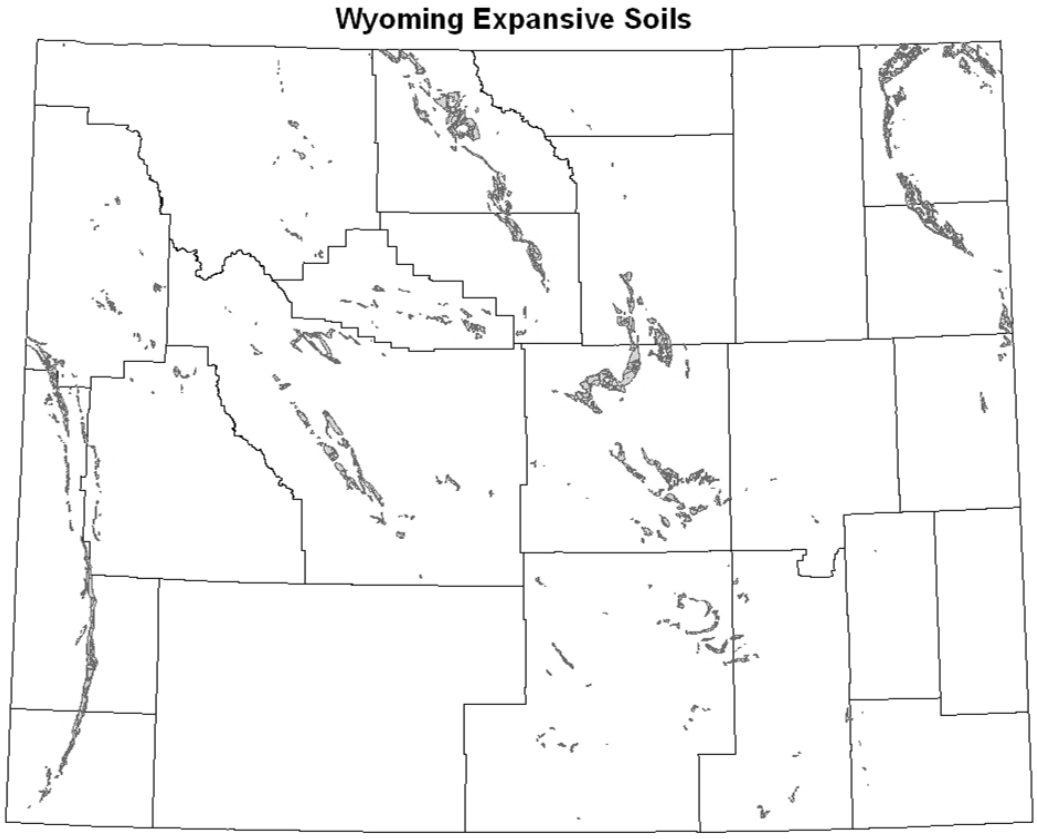


Figure 7.1—Possible Expansive Soils in Wyoming

As seen on **Figure 7.1** and the map presented in Thomas Edgar's technical paper **(See map, Page 7.4)** there are other areas in the state where expansive soils are present. This includes the eastern slope of the Wind River Mountains, the eastern side of the Bighorn Basin, the flanks of the Black Hills, and along the eastern edge of the Overthrust belt in north central Lincoln and Uinta counties. Very few reports regarding expansive soils have been described from these areas.

Impacts

As previously mentioned, damage from known expansive soil areas (namely the Casper area) has been very poorly documented. Collecting a dollar estimate of damage caused by expansive soils has proven difficult, if not impossible. It is estimated that there has been

less than $5 million of actual expansive soil related damage in the Casper area and the rest of the state.

Photograph of expansive soils under very dry conditions. Severe soil shrinkage has resulted in desiccation cracks.
http://www.home-inspections-radon-testing.com/expansive_soils Accessed 5/26/2011

Future Impacts

There are two measurements used for calculating future impacts, historic dollar damages, and building exposure values. There are not enough current data to accurately estimate historic damages.

For the 2008 update to the State Plan, the Wyoming State Geological Survey (WSGS) calculated the building exposure value for buildings that may occur within the areas of expansive soils. All expansive soils mapped have been digitized and the expansive soils layer was then digitally crossed with Census block building values. In the event of an expansive soil boundary dissecting a census block, the proportional value of the buildings in the census block will be assigned to the expansive soil. In a case where a census block is within an expansive soil, the combined values of all the buildings in the census block are assigned. The values derived by county are shown in **Figure 7.2**. The rank of counties based upon expansive soil building exposure values is shown in **Table 7.3**. These damage estimates assume an instantaneous event, which would damage all of the property on suspected expansive areas at one time. The information was not updated due to both the lack of historically-documented damage and a lack of further, additional expansive soil inundation information.

The loss scenario pictured and outlined in the map and table below is extremely unlikely, meaning the exposed damage estimates are most likely vastly overstated. It is far more likely damage from expansive soils will be individual events, which will cause damage to a small number of buildings or road segments over time.

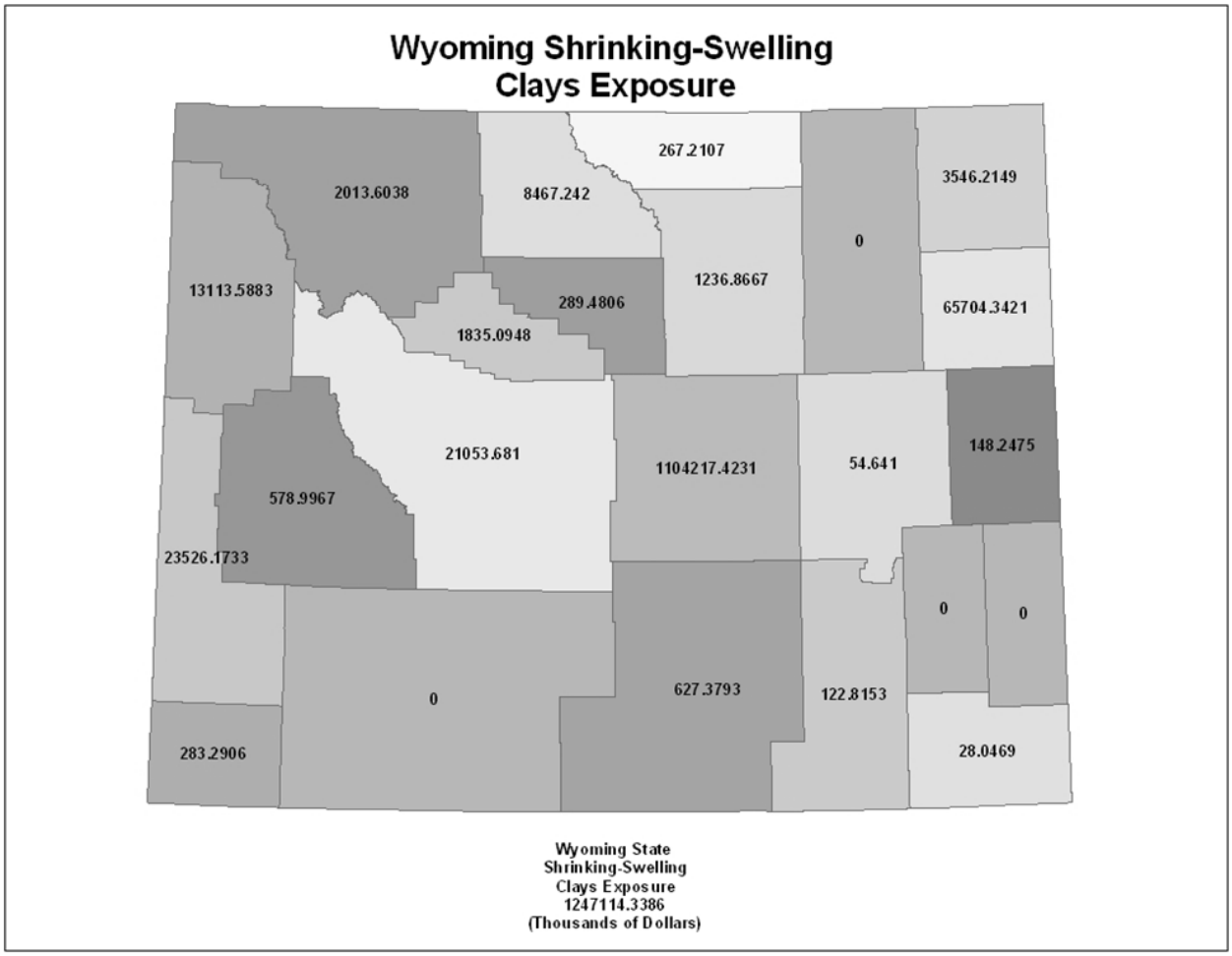


Figure 7.2—Building Exposure for Expansive Soils in Wyoming.

Table 7.3—Building Exposure by County for Expansive Soils In Wyoming.	
County	**Exposure value (USD)**
Natrona	1,104,217,423
Weston	65,704,342
Lincoln	23,526,173
Fremont	21,053,681
Teton	13,113,588
Bighorn	8,467,242
Crook	3,546,215
Park	2,013,604
Hot Springs	1,835,095
Johnson	1,236,867
Carbon	627,379
Sublette	578,997
Washakie	289,481
Uinta	283,291
Sheridan	267,211
Niobrara	148,248
Albany	122,815
Converse	54,641
Laramie	28,047
Campbell	0
Goshen	0
Sweetwater	0
Platte	0
TOTAL	**$1,247,114,339**

Given the risk associated with expansive soils is most likely to be to a small number of individual structures and short road segments over time, loss of life is not associated with expansive soils, and the risk to structures and infrastructure appears to be vastly overstated, it was determined not to further address population vulnerability as associated with the hazard of expansive soils within the state. Should this hazard be determined to be of greater significance in the future, more attention will be given in the State's Multi-Hazard Mitigation Plan to the vulnerability of Wyoming's population as it relates to expansive soils.

In the unlikely event expansive soils are determined to be a significant hazard in Wyoming, the risk may most greatly impact areas where development is occurring and the potential for damage is increased as a result of construction completed without mitigation efforts addressing expansive soils. According to the 2010 census, current areas where the greatest percentage population increase is occurring within Wyoming are Sublette (>50%) and Campbell Counties (25% - 49.9%). The counties experiencing the greatest numerical increase in population are Laramie and Campbell Counties increasing by 10,000 - 20,000 people over the past 10 years, equating to an additional 1-2 thousand persons per year. According to the maps depicting areas where expansive soils are most prevalent, Sublette County is the least likely of the three to experience damage resulting from expansive soil **(Map, page 7.7)** with limited-to-no exposure to expansive soil likely in the other two counties **(Figure 7.2, Page 7.12)**.

Local Mitigation Plan Risk Assessments

A review of Wyoming's local plans reflects little recognition of the hazard expansive soil. This would appear to be indicative of either a lack of information or the absence of this hazard in the majority of Wyoming's counties. Those who address the hazard within their plan have utilized data researched and available to them through the State Multi-Hazard Mitigation Plan. You will note the lack of documented instances of damage. Therefore it stands to reason this hazard would not be addressed locally. Those who addressed expansive soils within their local plan have ranked the risk of expansive soil within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Given the lack of local recognition to expansive soil as a hazard, a potential research project for future updates to the state plan may be to further map the extent expansive soils within the state, with the possibility of removing this hazard from the plan.

Below is a table outlining information mined from the local plans' expansive soil hazard sections. The table shows little documentation available of historical incidents of damage caused by expansive soil within each county's borders as outlined in their plans. Further, the table extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to expansive soil hazards.

Expansive Soil
Information Mined from Local Plans

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low	Potential Loss Potential	Previous Incident(s)
ALBANY	Y	2010	N			
BIG HORN	Approvable	2010	N			
CAMPBELL	Expired	2005	Y		$0 quoted from State Plan	Undocumented
CARBON	Y	2008	N			
CONVERSE	N/Draft	2005			Incomplete Information	
CROOK	N/Draft	2003	Y		State-level Info from State Plan	
FREMONT	Expired	2005	N			
GOSHEN	Y	2007	N			
HOT SPRINGS	N					
JOHNSON	Y	2008	Y	Medium	$1.2 million	Limited Info
LARAMIE	Expired	2005	N			
LINCOLN	Y	2006	N			
NATRONA	Approvable	2010	Y	Low	Low	Rare
NIOBRARA	Y	2009	N			
PARK	Y	2006	N			
PLATTE	Expired	2004	N			
SHERIDAN	Y	2009	N			
SUBLETTE	Y	2008	N			
SWEETWATER	N					
TETON	Y	2009	N			
UINTA	N/Draft	2011	N			
WASHAKIE	Expired	2005	N			
WESTON	N					
NORTHERN ARAPAHO TRIBE	N					
EASTERN SHOSHONE TRIBE	N					

Proposed State Mitigation Projects

The following mitigation projects have been proposed by state, federal, and local entities in the process of generating the Wyoming Multi-Hazard Mitigation Plan. Chapter 22 has all proposed mitigation projects.

- Conduct mapping studies to determine extent of expansive soils.
- Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.
- Provide hazards information to shelters, emergency facilities in public buildings, campgrounds, and phone books.
- Provide emergency phones at strategic locations with direct lines to emergency dispatch services.
- Develop reseeding plans for losses due to all hazard events.
- GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.
- Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.
- Education programs encompassing multi-hazard insurance for business, resident and government application.
- Education programs encompassing multi-hazard mitigation for business, resident and government application.
- Planning studies regarding transportation of essential and/or key personnel during all hazard events.
- Continue outreach to counties on identifying cost effective and feasible mitigation projects.
- Promote Continuity of Operations and Continuity of Government, statewide.
- Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.
- Identify, document, and advertise all volunteer agency's locations and contact information.

Sources Cited:

Edgar, Thomas V., P.E., Ph.D., 'Foundations on Expansive Soils', February 7, 2002. http://wwweng.uwyo.edu/classes/sp2011/ce4630/reports/wes/expansive/expansive.htm

Kerrane, Jeffrey P. Esq., http://www.bensonpc.com/downloads/public/What_Are_Expansive_Soils.pdf, Accessed 5/26/2011