

Subgrade Challenges in a Railroad Environment

BCR2A Workshop

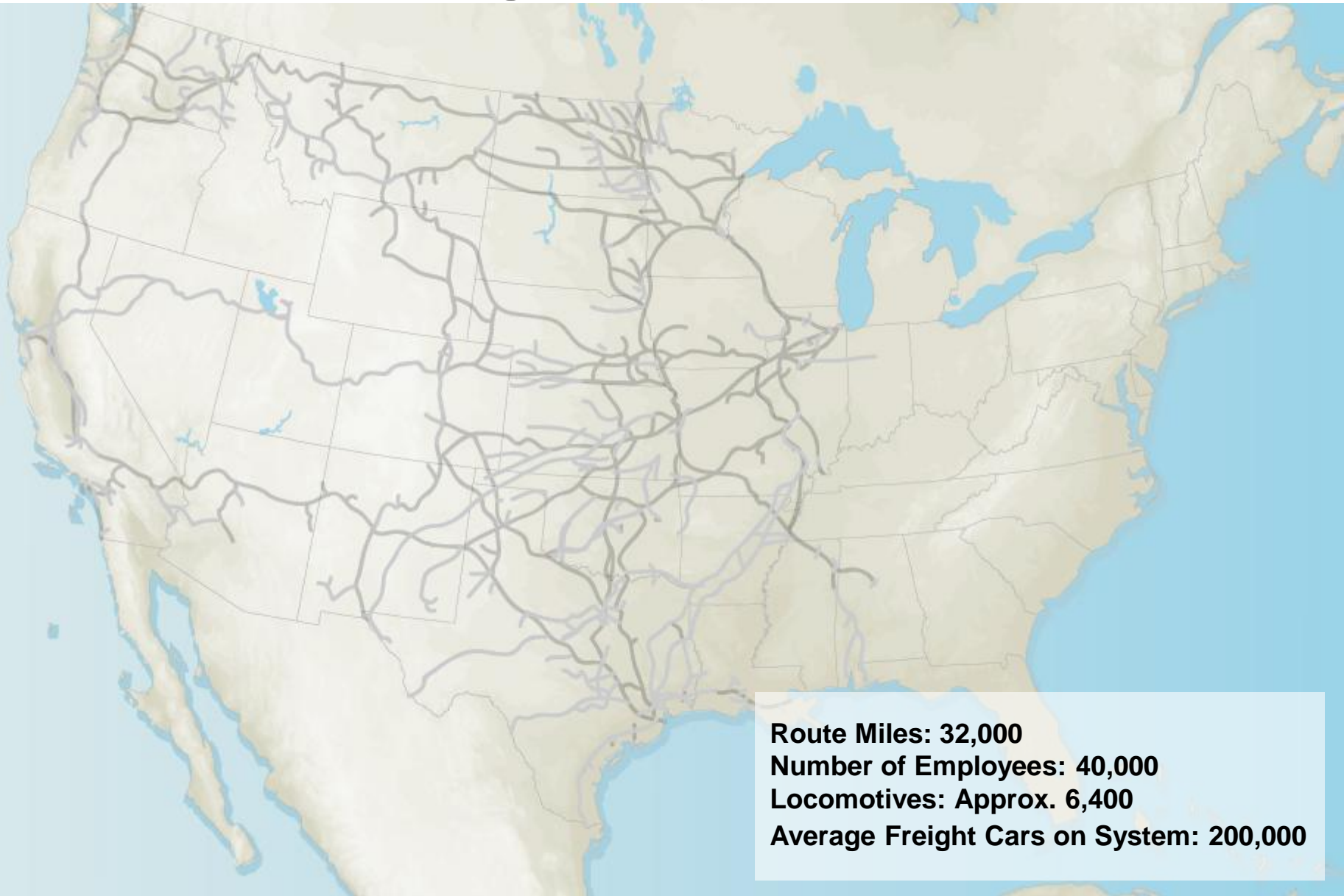
June 29, 2009

Thomas Schmidt P.E.



BNSF
RAILWAY

BNSF Network



Route Miles: 32,000
Number of Employees: 40,000
Locomotives: Approx. 6,400
Average Freight Cars on System: 200,000

About BNSF



- BNSF is a privately owned and publicly traded freight railroad
- Unlike other forms of freight transportation, our trains operate on an infrastructure built and financed almost entirely by the railroad
- Every day, we deliver trainloads of consumer goods, agricultural products, industrial products, and coal to customers across our 32,000-mile rail network

BNSF: Size and Scope

- **32,000 route miles in 28 states and two provinces**
- **Approximately 6,400 locomotives and 200,000 freight cars**
- **Employs approximately 40,000 people**
- **Operates an average of 1,400 freight trains per day**
- **Moves one fourth of the nation's rail freight**
- **Serves all major ports on the West Coast and Gulf of Mexico**
- **If stacked end-to-end, all the intermodal loads shipped with BNSF in one year would reach from Los Angeles to Shanghai 6 times.**
- **Leads rail industry in technological innovation**
- **Has one of the largest computer systems in the world to manage our network operations 24 hours a day**

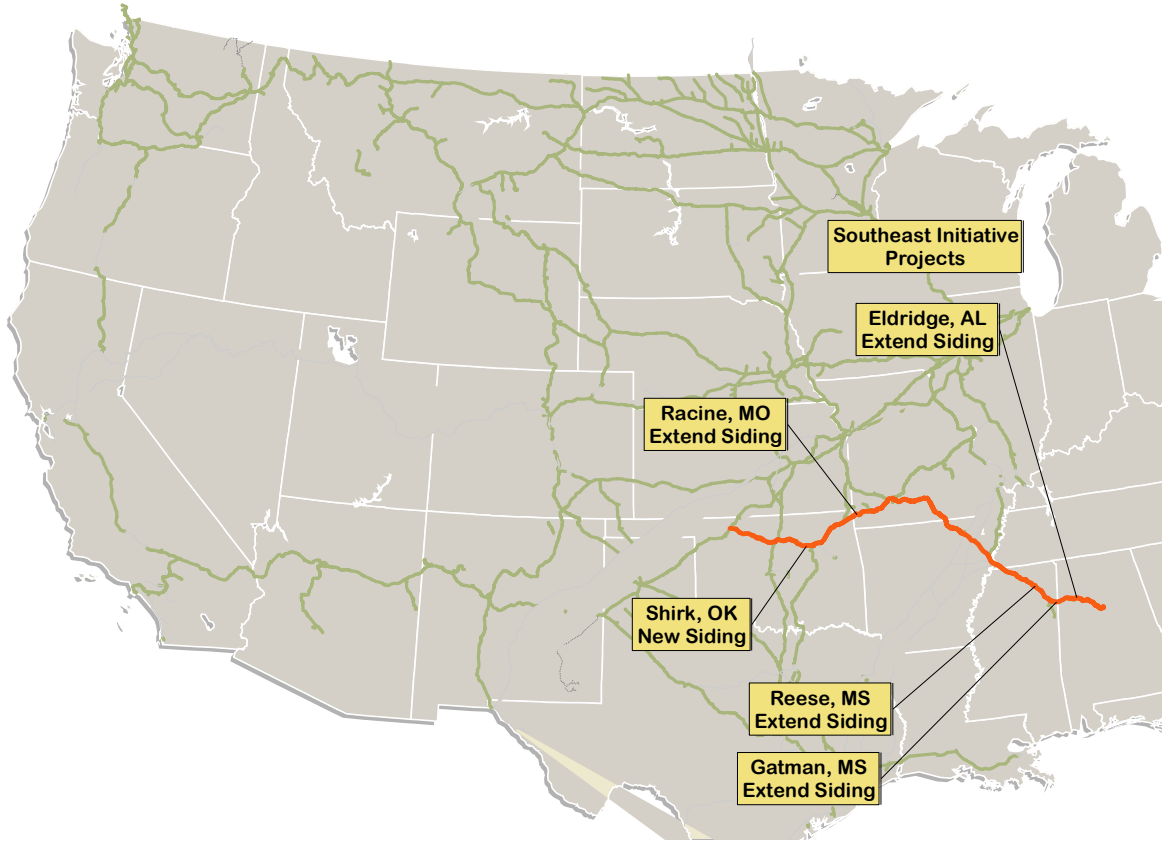




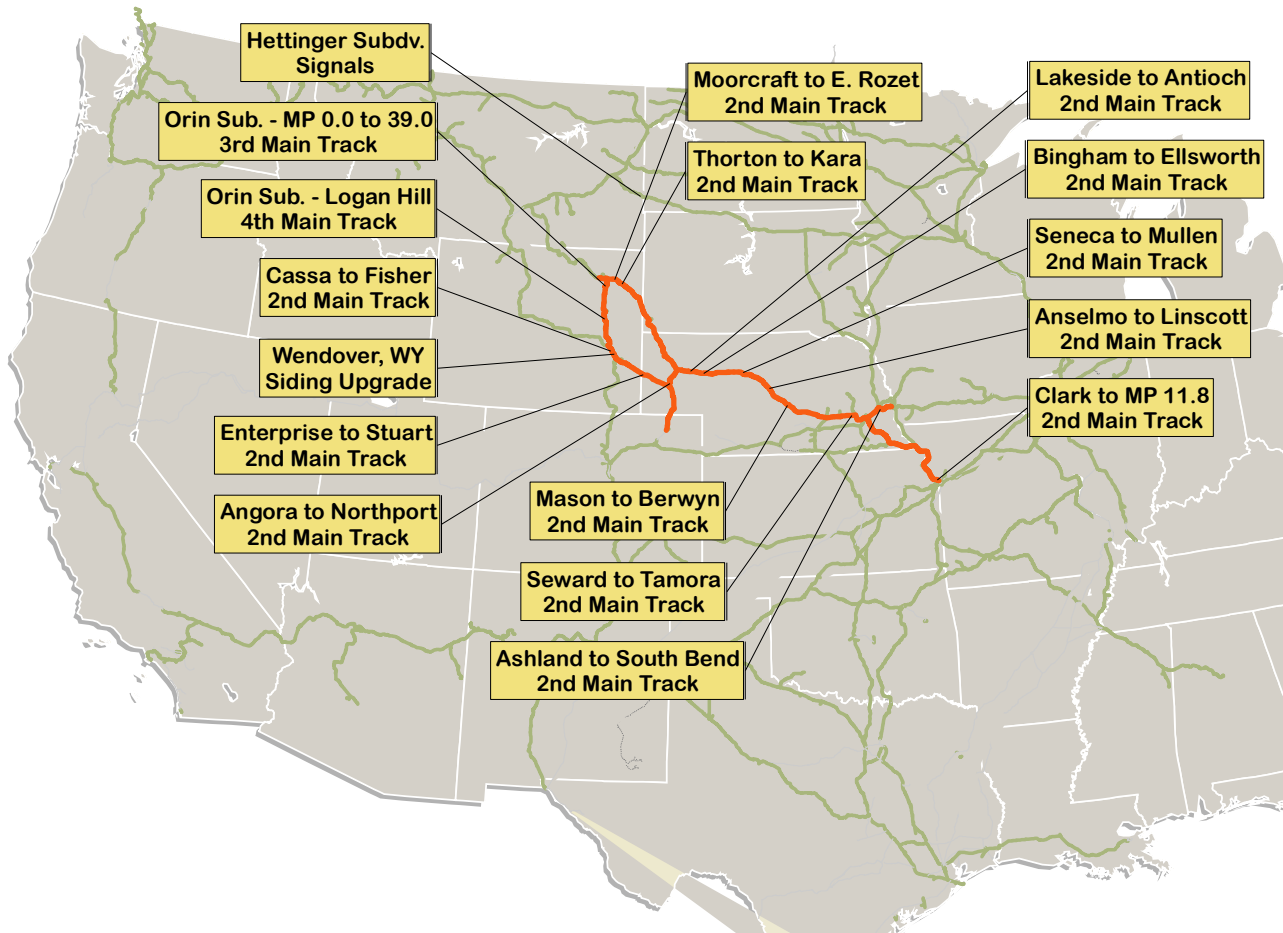
Transcon Capital Expansion– 2007



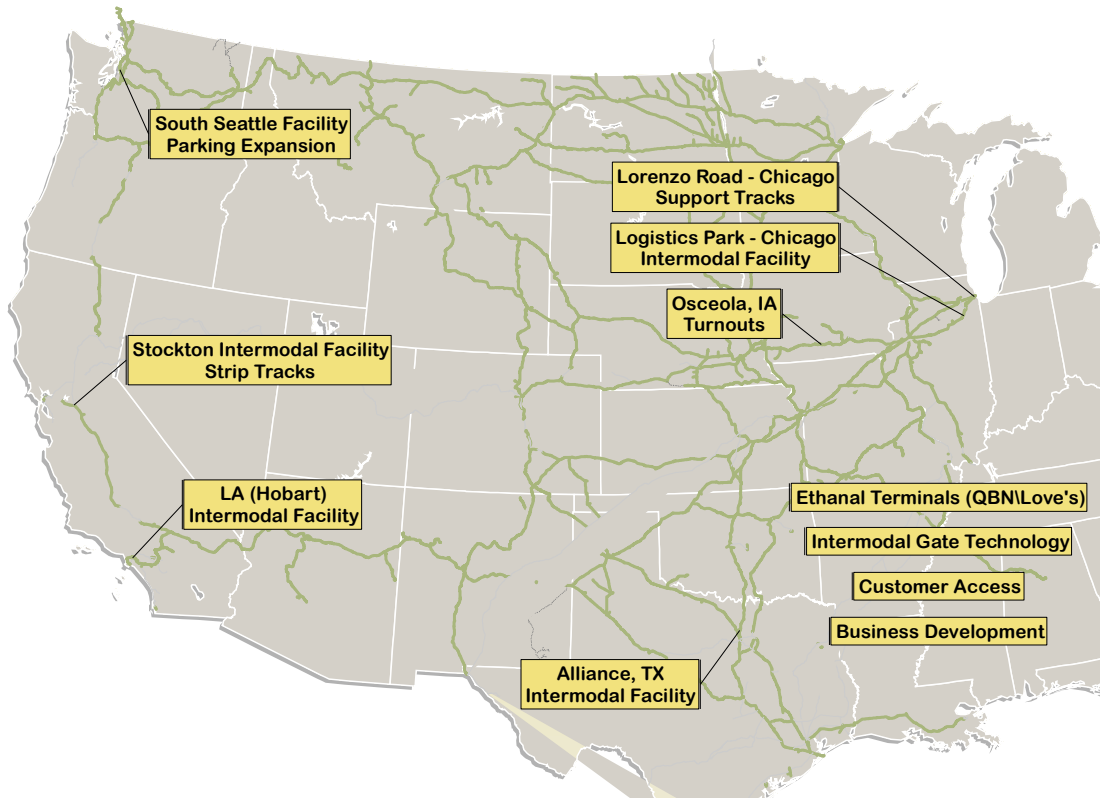
Southeast Initiative Capital – 2007



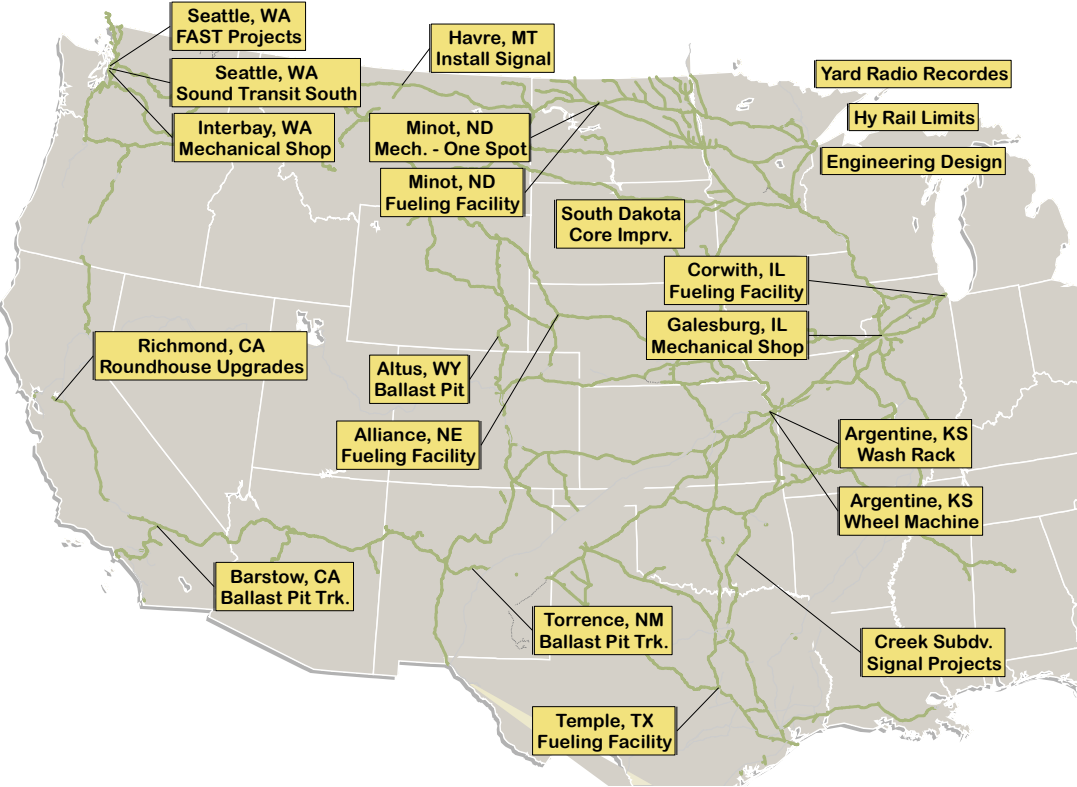
Coal Capital Expansion – 2007



Marketing Facility Capital – 2007



Other Projects Capital – 2007



System Map



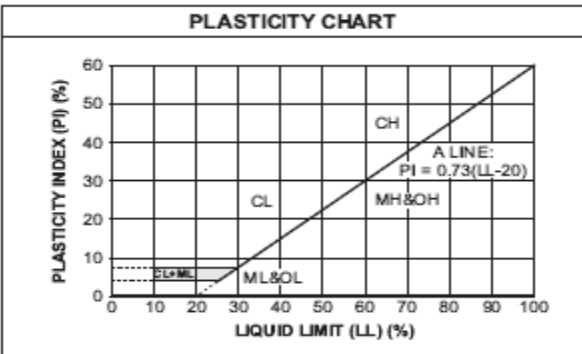


UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART		
COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)		
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	
	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-day mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	
	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-day mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

LABORATORY CLASSIFICATION CRITERIA		
GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:
 Less than 5 percent GW, GP, SW, SP
 More than 12 percent GM, GC, SM, SC
 5 to 12 percent Borderline cases requiring dual symbols



200 sieve

Silts and Clays Liquid limit 50 or more	inorganic	Liquid Limit - not dried	> 0.75	Organic silt ^{K,L,M,O}
		PI plots on or above "A" line	CH	Fat clay ^{K,L,M}
	organic	PI plots below "A" line	MH	Elastic silt ^{K,L,M}
		Liquid Limit - oven dried	< 0.75	OH
		Liquid Limit - not dried		Organic silt ^{K,L,M,O}
HIGHLY ORGANIC SOILS		Primarily organic matter, dark in color, and organic odor	PT	Peat

^A Based on the material passing the 3-in. (75-mm) sieve.

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols:

GW-GM well-graded gravel with silt

GW-GC well-graded gravel with clay

GP-GM poorly graded gravel with silt

GP-GC poorly graded gravel with clay

^D Sands with 5 to 12% fines require dual symbols:

SW-SM well-graded sand with silt

SW-SC well-graded sand with clay

SP-SM poorly graded sand with silt

SP-SC poorly graded sand with clay

$$^E C_u = D_{60}/D_{10} \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel, "whichever is predominant.

^L If soil contains $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name.

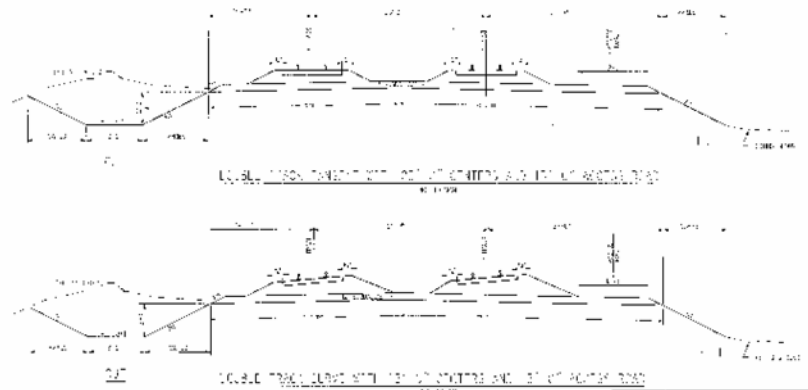
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.



SCALE: 1:1000
 ALL DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED

PROJECT NO. 1000/1000		DATE: 10/10/2020
NO. 1000/1000	NO. 1000/1000	NO. 1000/1000
NO. 1000/1000	NO. 1000/1000	NO. 1000/1000





06/20/2007



06/27/2006



DO NOT
HUMP

ETSX100145

NCT 003

LD 147
LE 178



10.12.2006 10:41















D-8

D-3

D-4

15/04/2007 08:29



San Bernardino













Seattle















Thanks for your attention.

