July 21, 2016
Project No.: 8040.040

Mr. Juan Esparza, PE
Principal Engineer
Truckee Meadows Water Authority
1355 Capital Boulevard
Reno, Nevada 89502

RE: Geotechnical Constructability Report
TMWA Chalk Bluff
Proposed Solids Drying Ponds

REF: Cut/Fill Report, Grading Corridor Pond 2, 6/20/16

Dear Mr. Esparza:

Wood Rodgers, Inc. is pleased to present this geotechnical constructability report for the proposed solids drying pond expansion at the Chalk Bluff facility in Reno, Nevada. The purpose of this investigation was to document the characteristics of exploratory excavations and to discuss the potential rippability conditions for the project as currently proposed. Our understanding of the project is based on our conversations with you and your staff and the referenced Cut/Fill Report and drawing.

PROJECT DESCRIPTION

The proposed solid drying pond(s) will be located in the northeast portion of the Chalk Bluff facility, just east of the existing solids drying pond and north of the main facility entrance off of South McCarran Boulevard. The proposed Pond 2 has been planned for a flat bottom area of 125,000 square feet at a flat bottom elevation of 4677.0 feet. Based on the referenced drawing, site topography will encompass an existing slope ranging from elevation 4702.0 feet to about 4664.0 feet, and will require maximum cuts and fills on the order of 25 feet to finish grades. The pond will incorporate 2H:1V cut slopes and 3H:1V fill slopes.

SITE DESCRIPTION

The pond site is generally undeveloped and surrounded by other facility ponds to the west and south, empty land, and a utility easement to the eastern limits of the property. A portion of the southern and western limits of proposed Pond 2 appear to have been used as staging and stockpile grounds. Existing ground coverage consists of bare soil and dry desert grass about two feet tall. The project area generally includes a uniform slope that exhibits an approximate surface gradient of about 8% toward the south. The site was accessed via a gravel turn off from the main paved access road.

FIELD EXPLORATION & LABORATORY TESTING

The project site was explored on July 6, 2016 by excavating a series of six exploratory test pits using a Hitachi 330LC track-mounted excavator equipped with a 24-inch wide bucket. The approximate locations of the test pits are shown on Plate A-1 – Approximate Exploration Locations. The maximum depth of test pit advance was 20 feet below the existing ground surface; the targeted depths were attained with relative ease with the equipment used. Backfill was loosely placed and the areas re-graded to the extent possible.

Wood Rodgers personnel examined and classified all soils in the field in general accordance with ASTM D2488 (Description and Identification of Soils, Manual-Visual method). Additional soil classifications, as well as verification of the field classifications, were subsequently performed in accordance with ASTM 2487 (Unified Soil Classification System [USCS]) upon completion of laboratory testing. Laboratory testing included moisture content (ASTM D2216), sieve analysis (ASTM D6913), and Atterberg limits (ASTM D4318) on representative bulk samples. Table 1 presents a results summary of Laboratory Test Data.

Table 1 - Summary of Test Data

Test Hole	Depth (Ft.)	Moisture (%)	%Gravel (+ #4)*	% Sand (#4-#200)	%Fines (-#200)	Liquid Limit	Plastic Index	USCS
ASTM Standard		D2216	D6913			D4318		D2487
TP-1	2 - 20	8.5	4	70	26	NP	NP	SM
TP-2	2 - 8	9.8	13	71	16	NP	NP	GM
TP-2	8 - 20	31.0	1	54	45	37	11	SC
* Since ASTM D2487 is limited by a maximum particle size of 3", the gradation test data presented is based on a maximum particle size of 3". Larger particles (i.e. 8 to 12" in diameter) were observed in our test holes and should be anticipated as part of grading.								

The field exploration was supplemented with two geophysical surveys of shear-wave and seismic P-wave velocity measurements using the Refraction Microtremor (ReMi®) method in accordance with ASTM D5777. Two linear arrays were completed in an area representative of deeper cut sections of Pond 2, as shown on Plate A-1. An east-west (ReMi E-W) array was completed along the contour elevation 4695 feet± and a north-south (ReMi N-S) was aligned down the slope near the center of the pond beginning from approximate elevation 4695 feet and ending near elevation 4680 feet. The resulting geophysical models are presented on Plate A-5 and Plate A-6.

GEOLOGIC AND SOIL CONDITIONS

Based on the Preliminary Revised Geologic Maps of the Verdi, Reno, and Vista 7.5' Quadrangles (Ramelli and Henry 2010, USGS) the major mapped unit in the site area is Quaternary alluvium (Qrd); this is an unconsolidated sedimentary deposit that includes fans, valley fill and stream deposits. Previous geologic mapping has also described the area as Donner Lake Outwash deposits containing boulder to cobble gravel. The grain size generally ranges from gravels to silt. This alluvium material approximately makes up 80% of the site material as mapped in Plate A-1b. The minor mapped unit in the site area is a sedimentary unit that is made up of diatomite and lacustrine (Tnd). Diatomite is a very fine-grained, siliceous sedimentary rock that is chalk-like, soft, friable, very finely porous, very low in density and usually light in color. The boundary between the two units is dashed along the Highland Ditch, showing that the contact between the two units is undefined; therefore, Tnd could likely extend further south into the proposed pond area. Based on the exploratory test pits and material test results, it is likely both units were encountered within the site area.

Based on Caterpillar's Handbook of Ripping (which is attached for your ease of reference) Prediction Charts for a D8R Ripper performance for sedimentary rock such as siltstone indicate rippable conditions for seismic P-wave velocity up to 6,500 feet per second (ft/s). Marginal ripping conditions extend to a velocity near 8,500 ft/s where non-rippable conditions are expected. Based on the two-dimensional seismic P-wave measurements on-site, rippable velocities are present from the surface to approximately 35 feet below the surface whereas marginal rippability velocities are indicated at a depth of approximately 35 feet below grade. Please note this prediction is based off a D8 ripper operating with single or double shank, and that larger equipment would be expected to rip higher velocity materials as noted on the specific charts for D9 and D10 machines.

GROUNDWATER LEVELS
Subsurface water was not encountered during the exploration, and is anticipated to lie at a depth that would not adversely impact construction or operation of the pond.

CONCLUSIONS
The following list summarizes our findings:

- The targeted exploration depths were reached without encountering excavation refusal conditions.
- Geophysical models of P-wave velocity indicate rippable conditions to approximately 35 feet below existing grade, and are consistent with the observations made from the test pit excavations.
- The planned grading and filling appears achievable based on the soil types and planned slope configurations. Fill compaction should be specified as a minimum of 90% (ASTM D1557). An estimated shrinkage factor of 30% is reasonable for the in-situ consolidation and moisture levels observed in the test pits.

We appreciate the opportunity to provide our geotechnical services. Please contact us if you have any related questions or comments.

Sincerely,

WOOD RODGERS, INC.

PROFESSIONAL ENGINEER - STATE OF NEVADA
BLAKE DOUGLAS CARTER
Exp. 12-31-16
CIVIL
No. 22331

7/21/16

Blake D. Carter, PE
Associate
RE Number: 22331
Expires: 12/31/16

James G. Smith, PE
Principal

Attachments:

Plate A-1:	Approximate Exploration Locations
Plate A-2:	Log of Test Pits
Plate A-3:	Unified Soil Classification System Chart
Plate A-4:	Laboratory Test Results
Plate A-5a:	ReMi® E-W 1-D Shear Wave Velocity Profile
Plate A-5b:	ReMi® E-W 2-D (Seismic) P-Wave Velocity Profile
Plate A-6:	ReMi® N-S 2-D (Seismic) P-Wave Velocity Profile

Plate B-1 thru B-6: Test Pit Photos

Caterpillar Hand Book of Ripping (12th Edition)

APPROXIMATE EXPLORATION LOCATIONS

TMWA CHALK BLUFF
RENO, NV
JULY, 2016

NOTES:
Job # 8040.040

WOOD RODGERS

J:\Jobs\8040_TMWA_OA\8040.040 Chalk Bluff Drying Ponds - TMWA\GIS\Tasks\TestPits_20160707_V1.mxd 7/13/2016 4:06:32 PM eford

Figure 1. The red perimeter is the undeveloped land on the site and the green is the proposed area for the ponds

WOOD RODGERS 5440 Reno Corporate Drive, Reno, NV 89511 Phone 775.823.4068 Fax 775.823.4066	**GEOLOGIC MAP OF PROJECT AREA**	***Geotechnical Investigation*** ***Proposed Solids Drying Ponds*** ***TMWA Chalk Bluff*** ***Reno, Nevada*** Project No.: 8040.040 Date: 07/20/16 **PLATE A-1b**

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

TEST PIT NUMBER TP-1

CLIENT Truckee Meadows Water Authority
PROJECT NAME Chalk Bluff Drying Pond
PROJECT NUMBER 8040.040
PROJECT LOCATION Reno, NV
DATE STARTED 7/6/16 **COMPLETED** 7/6/16
GROUND ELEVATION 4700 ft **TEST PIT SIZE** 24 inches
EXCAVATION CONTRACTOR Stampede Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Hitachi 330 LC
AT TIME OF EXCAVATION --- NFWE
LOGGED BY OJ Juneau **CHECKED BY** B. Carter
AT END OF EXCAVATION --- NFWE
NOTES: 39.517100262/-119.86307844
AFTER EXCAVATION --- NFWE

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	R-VALUE	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0		SANDY CLAY, (CH) stiff, dry, brown, angular cobbles less than 8-inch diameter encountered at surface										
		BEDROCK, (Sandstone of HunterCreek, Th), very thick-bedded, intensely fractured, moderately soft, friable, deeply weathered; excavates as a Silty Sandstone and mechnically breaks down to a Silty Sand (SM) with extimated <5% gravel, 70% sand and 25% fines content. Very sparse, one 12-inch diameter boulder encountered.										
5												
10			GB 1A					8.5	NP	NP	NP	26.4
15												
20												

Bottom of Test Pit at 20.0 Feet.

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

TEST PIT NUMBER TP-2

CLIENT Truckee Meadows Water Authority
PROJECT NAME Chalk Bluff Drying Pond
PROJECT NUMBER 8040.040
PROJECT LOCATION Reno, NV
DATE STARTED 7/6/16 **COMPLETED** 7/6/16
GROUND ELEVATION 4698 ft **TEST PIT SIZE** 24 inches
EXCAVATION CONTRACTOR Stampede Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Hitachi 330 LC
AT TIME OF EXCAVATION --- NFWE
LOGGED BY OJ Juneau **CHECKED BY** B. Carter
AT END OF EXCAVATION --- NFWE
NOTES: 39.5171389810001/-119.862493507
AFTER EXCAVATION --- NFWE

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	R-VALUE	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0		CLAYEY GRAVELS, (GC) 20 % gravel, 20 % sand, 60 % fines, stiff, dry, brown, Max nominal 18 inch										
5		POORLY GRADED GRAVELS TO SILTY GRAVELS, (GP-GM) 30 % gravel, 40 % sand, 30 % fines, dense, slightly moist, brown, Max nominal 18-inch	GB 2A					9.8	NP	NP	NP	15.9
10–15		BEDROCK, (Sandstone of HunterCreek, Th), very thick-bedded, intensely fractured, moderately soft, friable, deeply weathered; excavates as a Silty Clay (CL) with extimated 5% gravel, 45% sand and 50% fines content. Maximum particle size 12-inch diameter	GB 2B					31.0	38	26	12	44.7
20												

Bottom of Test Pit at 20.0 Feet.

GEOTECH BH COLUMNS PLATE - GINT STD US LAB.GDT - 7/22/16 10:58 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS\TMWA\CHALK BLUFF.GPJ

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

TEST PIT NUMBER TP-3

CLIENT Truckee Meadows Water Authority
PROJECT NAME Chalk Bluff Drying Pond
PROJECT NUMBER 8040.040
PROJECT LOCATION Reno, NV
DATE STARTED 7/6/16 **COMPLETED** 7/6/16
GROUND ELEVATION 4698 ft **TEST PIT SIZE** 24 inches
EXCAVATION CONTRACTOR Stampede Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Hitachi 330 LC
AT TIME OF EXCAVATION --- NFWE
LOGGED BY OJ Juneau **CHECKED BY** B. Carter
AT END OF EXCAVATION --- NFWE
NOTES: 39.517340818/-119.861900832
AFTER EXCAVATION --- NFWE

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	R-VALUE	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0		SANDY CLAY, (CH) stiff, dry, brown, angular cobbles less than 8-inch diameter encountered at surface										
		CLAYEY SANDS, (SC) 30 % gravel, 40 % sand, 30 % fines, dense, dry, gray, Max particle size 12 inch										
5												
		BEDROCK, (Sandstone of HunterCreek, Th), very thick-bedded, intensely fractured, moderately soft, friable, deeply weathered; excavates as a Silty Clay (CL) with extimated 5% gravel, 45% sand and 50% fines content. Maximum particle size 12-inch diameter										
10												
15												
20												

Bottom of Test Pit at 20.0 Feet.

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

TEST PIT NUMBER TP-4

CLIENT Truckee Meadows Water Authority
PROJECT NAME Chalk Bluff Drying Pond
PROJECT NUMBER 8040.040
PROJECT LOCATION Reno, NV
DATE STARTED 7/6/16 **COMPLETED** 7/6/16
GROUND ELEVATION 4678 ft **TEST PIT SIZE** 24 inches
EXCAVATION CONTRACTOR Stampede Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Hitachi 330 LC
AT TIME OF EXCAVATION --- NFWE
LOGGED BY OJ Juneau **CHECKED BY** B. Carter
AT END OF EXCAVATION --- NFWE
NOTES: 39.5192357990001/-119.861002886
AFTER EXCAVATION --- NFWE

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	R-VALUE	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0		SANDY CLAY, (CH) stiff, dry, brown, angular cobbles less than 8-inch diameter encountered at surface										
		SILTY SANDS, (SM) 15 % gravel, 65 % sand, 20 % fines, medium dense, slightly moist, gray										
5												
		BEDROCK, (Sandstone of HunterCreek, Th), very thick-bedded, intensely fractured, moderately soft, friable, deeply weathered; excavates as a Silty Sandstone and mechnically breaks down to a Silty Sand (SM) with extimated <5% gravel, 70% sand and 25% fines content. Very sparse, one 12-inch diameter boulder encountered.										
10												
15												
20												

Bottom of Test Pit at 20.0 Feet.

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

TEST PIT NUMBER TP-5

CLIENT Truckee Meadows Water Authority

PROJECT NAME Chalk Bluff Drying Pond

PROJECT NUMBER 8040.040

PROJECT LOCATION Reno, NV

DATE STARTED 7/6/16 **COMPLETED** 7/6/16

GROUND ELEVATION 4668 ft **TEST PIT SIZE** 24 inches

EXCAVATION CONTRACTOR Stampede Construction

GROUND WATER LEVELS:

EXCAVATION METHOD Hitachi 330 LC

AT TIME OF EXCAVATION --- NFWE

LOGGED BY OJ Juneau **CHECKED BY** B. Carter

AT END OF EXCAVATION --- NFWE

NOTES: 39.5189644960001/-119.862879212

AFTER EXCAVATION --- NFWE

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	R-VALUE	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0		SANDY CLAY, (CH) stiff, dry, black, angular cobbles less than 8-inch diameter encountered at surface										
		SILTY SANDS, (SM) 20 % gravel, 65 % sand, 15 % fines, medium dense, slightly moist, brown										
5		Donner Outwash Deposits (Qdo), Boulder to cobble gravel, rounded, maximum particle size 18-inch diameter, excavates as a Poorly-Graded Gravel to Well-Graded Gravel (GP-GW)										
10												
15												

Bottom of Test Pit at 15.0 Feet.

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

TEST PIT NUMBER TP-6

CLIENT Truckee Meadows Water Authority
PROJECT NAME Chalk Bluff Drying Pond
PROJECT NUMBER 8040.040
PROJECT LOCATION Reno, NV
DATE STARTED 7/6/16 **COMPLETED** 7/6/16
GROUND ELEVATION 4662 ft **TEST PIT SIZE** 24 inches
EXCAVATION CONTRACTOR Stampede Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Hitachi 330 LC
AT TIME OF EXCAVATION --- NFWE
LOGGED BY OJ Juneau **CHECKED BY** B. Carter
AT END OF EXCAVATION --- NFWE
NOTES: 39.517015622/-119.862206759
AFTER EXCAVATION --- NFWE

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	R-VALUE	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0		SILTY SANDS, (SM) 20 % gravel, 60 % sand, 20 % fines, medium dense, slightly moist, brown, Top soil										
		Donner Outwash Deposits (Qdo), Boulder to cobble gravel, rounded, maximum particle size 36inch diameter, excavates as a Poorly-Graded Gravel to Well-Graded Gravel (GP-GW)										
5												
10												
15												

Bottom of Test Pit at 15.0 Feet.

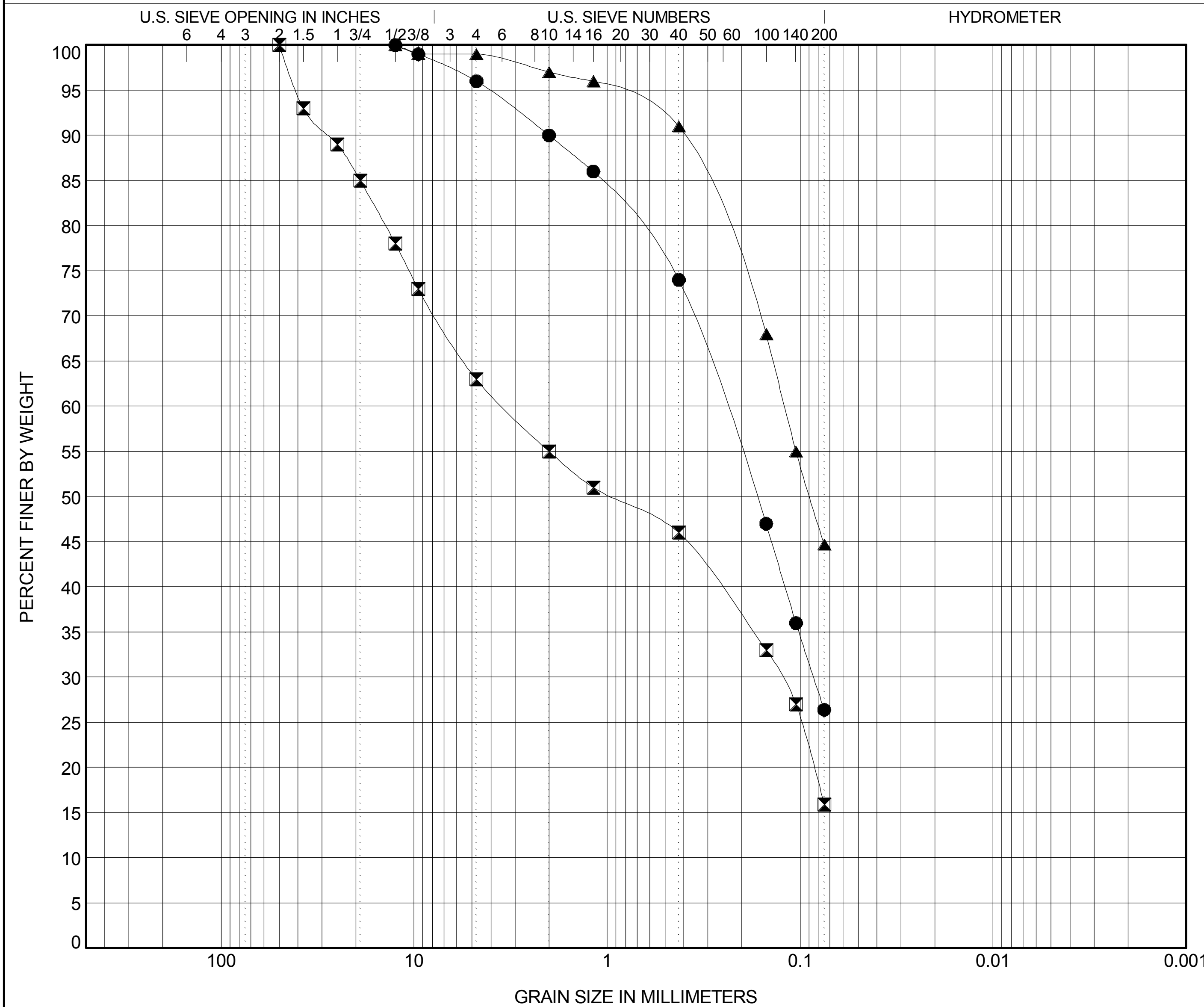
GEOTECH BH COLUMNS PLATE - GINT STD US LAB.GDT - 7/22/16 10:58 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS\TMWA\CHALK BLUFF.GPJ

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

GRAIN SIZE DISTRIBUTION

CLIENT Truckee Meadows Water Authority **PROJECT NAME** Chalk Bluff Drying Pond

PROJECT NUMBER 8040.040 **PROJECT LOCATION** Reno, NV



	TEST PIT	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**TP-1**	**2.0**	**SILTY SAND(SM)**	**NP**	**NP**	**NP**		
⧗	**TP-2**	**2.0**	**SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**		
▲	**TP-2**	**8.0**	**SILTY SAND(SM)**	**38**	**26**	**12**		

	TEST PIT	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP-1**	**2.0**	**12.5**	**0.248**	**0.085**		**4.0**	**69.6**	**26.4**	
⧗	**TP-2**	**2.0**	**50**	**3.434**	**0.125**		**37.0**	**47.1**	**15.9**	
▲	**TP-2**	**8.0**	**12.5**	**0.12**			**1.0**	**54.3**	**44.7**	

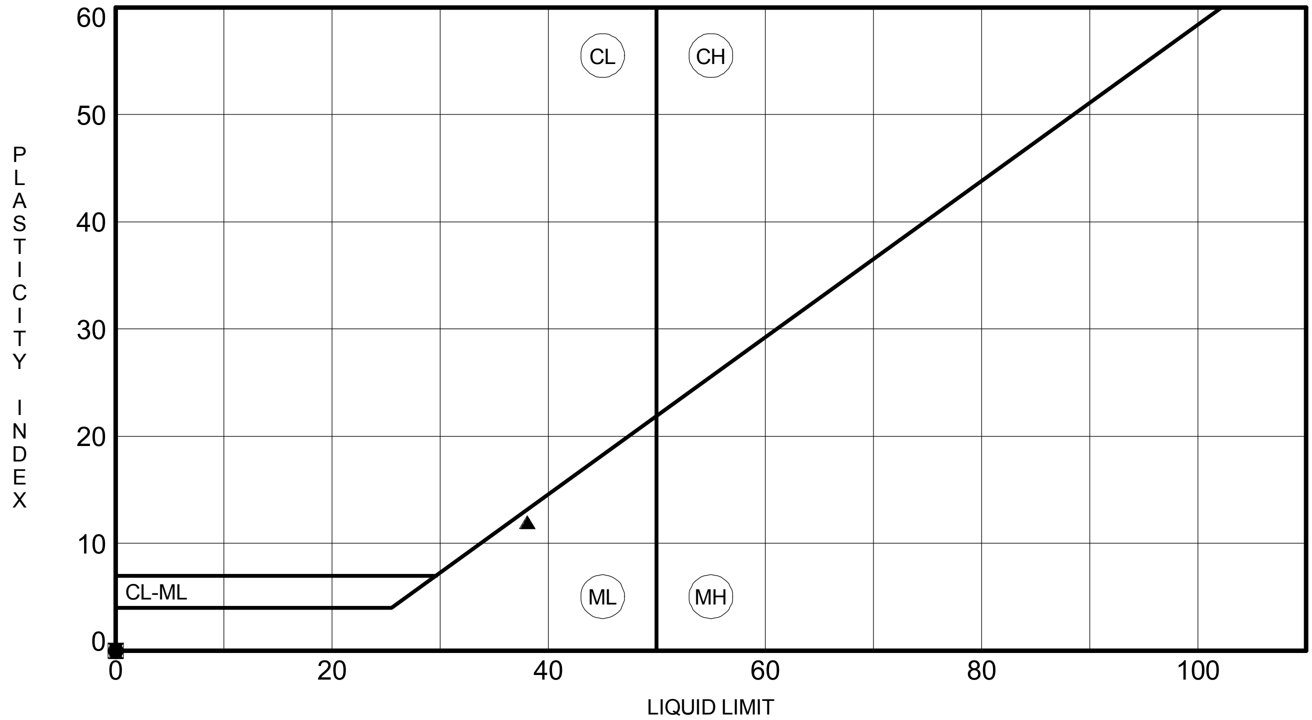
GRAIN SIZE - GINT STD US LAB.GDT - 7/22/16 10:59 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS\TMWA\CHALK BLUFF.GPJ

Wood Rodgers, Inc.
5440 Reno Corporate Drive
Reno, NV 89511
Telephone: 775-823-4068
Fax: 775-823-4066

ATTERBERG LIMITS' RESULTS

CLIENT Truckee Meadows Water Authority **PROJECT NAME** Chalk Bluff Drying Pond

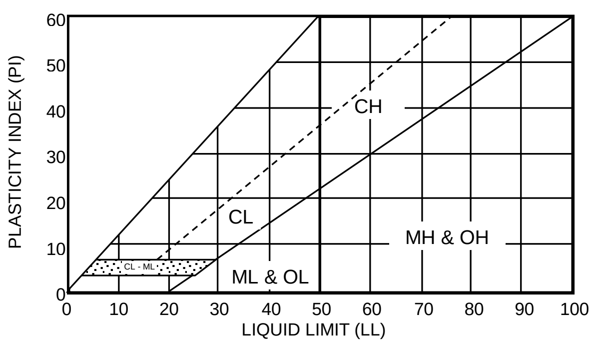
PROJECT NUMBER 8040.040 **PROJECT LOCATION** Reno, NV



	TEST PIT	DEPTH	LL	PL	PI	Fines	Classification
●	**TP-1**	**2.0**	**NP**	**NP**	**NP**	**26**	**SILTY SAND(SM)**
⧗	**TP-2**	**2.0**	**NP**	**NP**	**NP**	**16**	**SILTY SAND with GRAVEL(SM)**
▲	**TP-2**	**8.0**	**38**	**26**	**12**	**45**	**SILTY SAND(SM)**

ATTERBERG LIMITS - GINT STD US LAB.GDT - 7/22/16 10:59 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS\TMWA\CHALK BLUFF.GPJ

MAJOR DIVISION				TYPICAL NAMES
COARSED-GRAINED SOILS MORE THAN HALF IS COARSER THAN NO. 200 SIEVE	**GRAVEL** MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN SANDS WITH LITTLE OR NO FINES	GW	WELL GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, SILTY GRAVELS WITH SAND
			GC	CLAYEY GRAVELS, CLAYEY GRAVELS WITH SAND
	SAND MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
			SP	POORLY GRADED SAND WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS WITH OR WITHOUT GRAVEL
			SC	CLAYEY SANDS WITH OR WITHOUT GRAVEL
FINE-GRAINED SOILS MORE THAN HALF IS FINER THAN NO. 200 SIEVE	**SILT AND CLAY** LIQUID LIMIT 50% OR LESS		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTS WITH SANDS AND GRAVELS
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY CLAYS WITH SANDS AND GRAVELS, LEAN CLAYS
			OL	ORGANIC SILTS OR CLAYS OF LOW PLASTICITY
	SILT AND CLAY LIQUID LIMIT GREATER THAN 50%		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOLID, ELASTIC SILTS
			CH	INORGANIC CLAYS OR HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC SILTS OR CLAYS MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS



CONSISTENCY		RELATIVE DENSITY	
SILTS & CLAYS	SPT BLOW* COUNTS (N)	SANDS & GRAVELS	SPT BLOW* COUNTS (N)
VERY SOFT	0 - 2	VERY LOOSE	0 - 4
SOFT	3 - 4	LOOSE	5 - 10
MEDIUM STIFF	5 - 8	MEDIUM DENSE	11 - 30
STIFF	9 - 15	DENSE	31 - 50
VERY STIFF	16 - 30	VERY DENSE	50 +
HARD	30 +		

* The Standard Penetration Resistance (N) In blows per foot is obtained by the ASTM D1585 procedure using 2" O.D., 1 3/8" I.D. samplers.

DEFINITIONS OF SOIL FRACTIONS	
SOIL COMPONENT	PARTICLE SIZE RANGE
COBBLES	ABOVE 3 INCHES
GRAVEL	3 IN. TO NO. 4 SIEVE
COARSE GRAVEL	3 IN. TO 3/4 IN.
FINE GRAVEL	3/4 IN. TO NO. 4 SIEVE
SAND	NO. 4 TO NO. 200
COARSE SAND	NO. 4 TO NO. 10
MEDIUM SAND	NO. 10 TO NO. 40
FINE SAND	NO. 40 TO NO. 200
FINES (SILT OR CLAY)	MINUS NO. 200 SIEVE

DESCRIPTION OF ESTIMATED PERCENTAGES OF GRAVEL, SAND, AND FINES	
TRACE	Particles are present but est. < 5%
FEW	5% - 10%
LITTLE	15% - 20%
SOME	30% - 45%
MOSTLY	50% - 100%

NOTE: Percentages are presented within soil description for soil horizon with laboratory tested soil samples.

WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

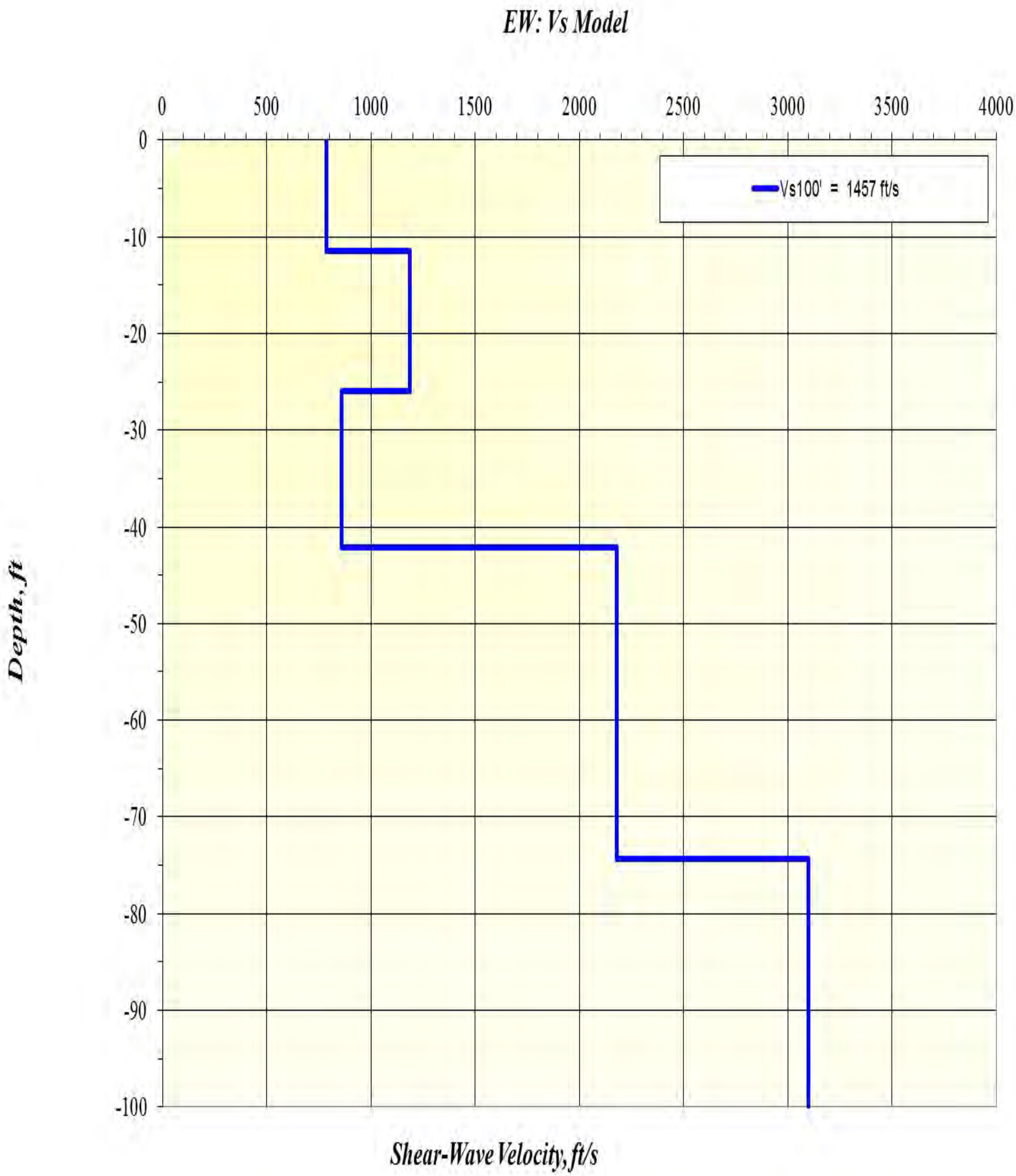
UNIFIED SOIL CLASSIFICATION AND KEY TO SOIL DESCRIPTIONS

Geotechnical Investigation

Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE A-3



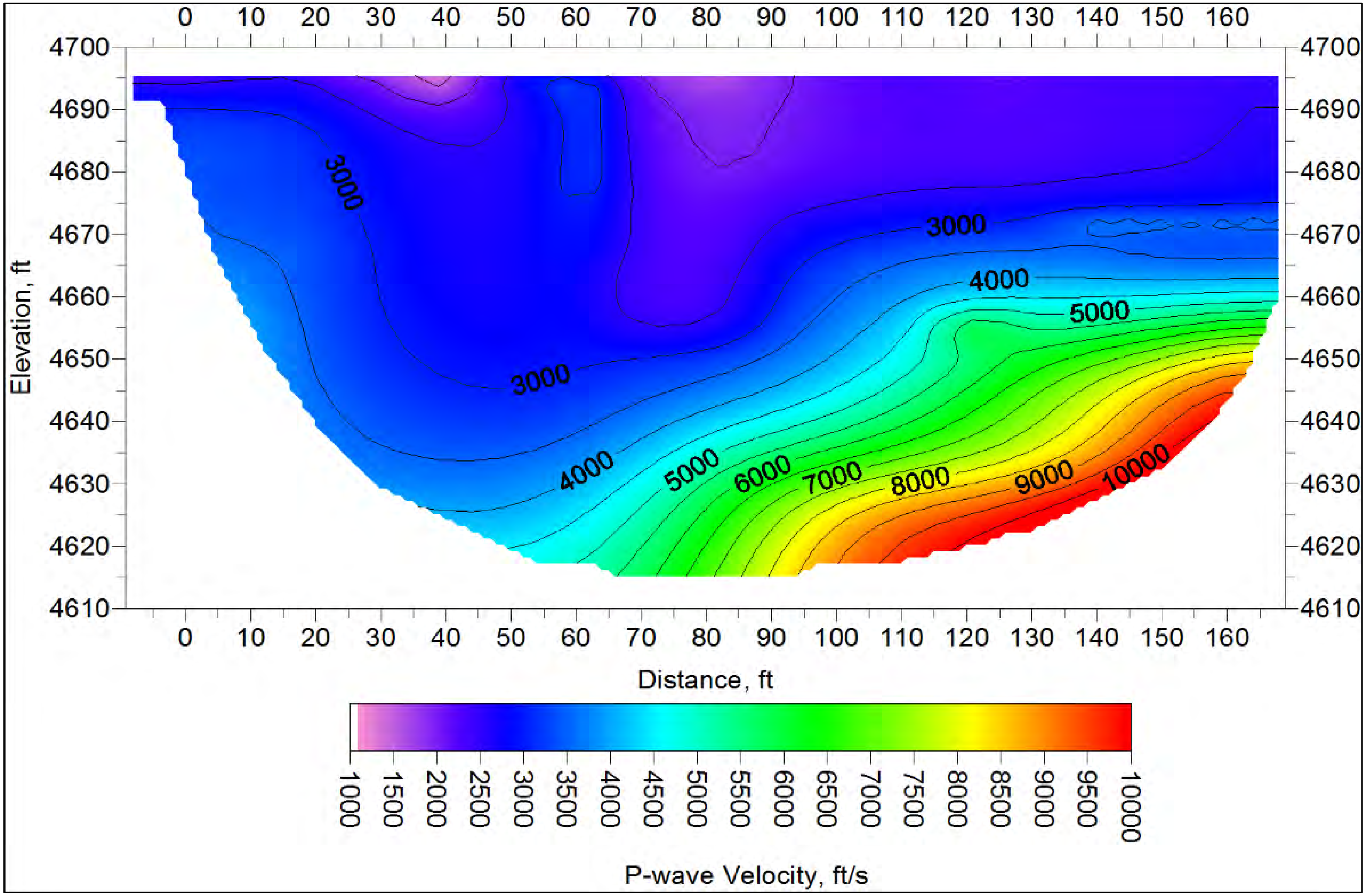
WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

REMI® E-W ONE-DIMENSIONAL SHEAR WAVE VELOCITY PROFILE

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.04
Date: 07/20/16

PLATE A-5a



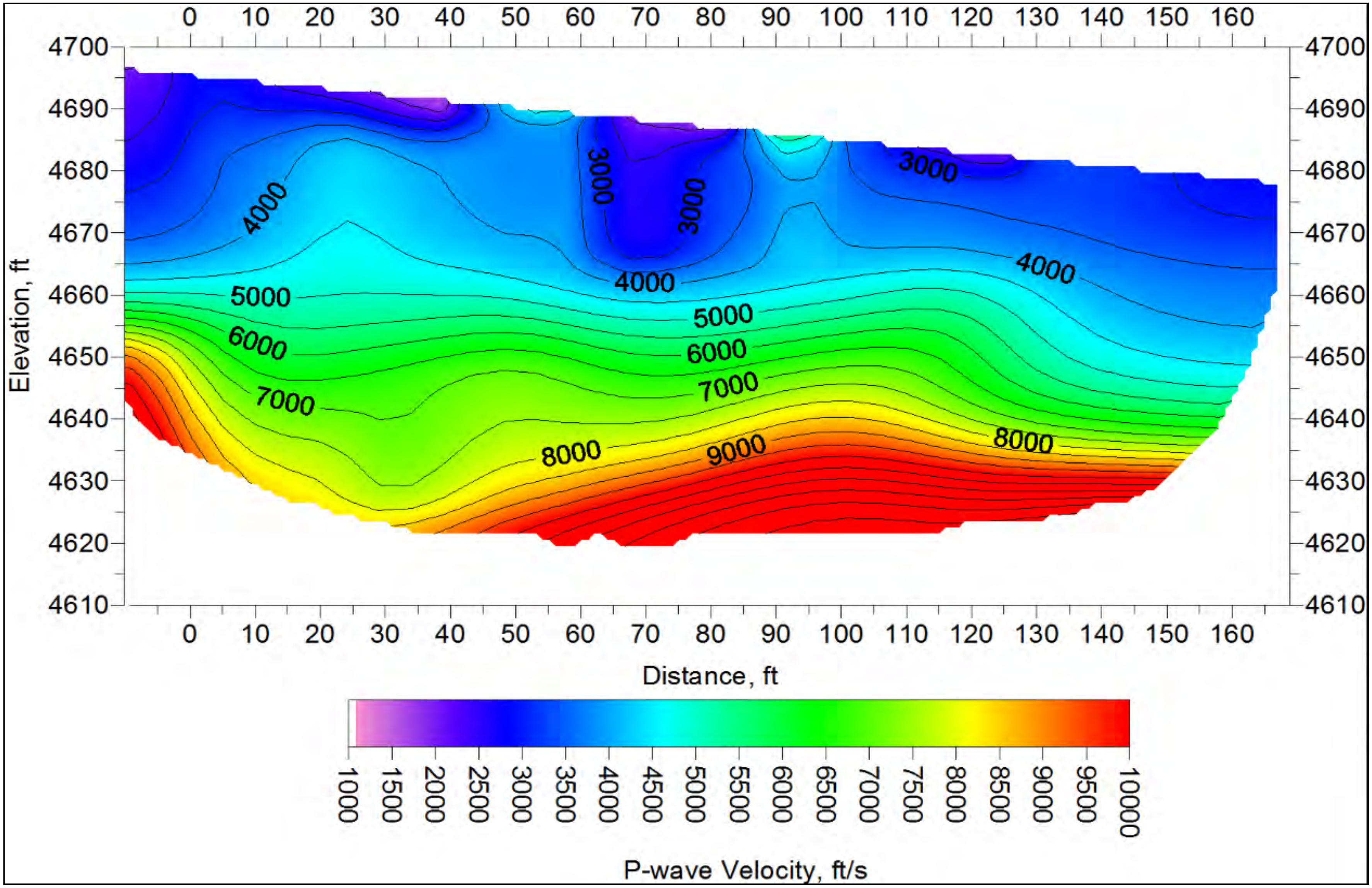
WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

REMI® E-W
TWO-DIMENSIONAL P-WAVE (SEISMIC) VELOCITY PROFILE

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE A-5b



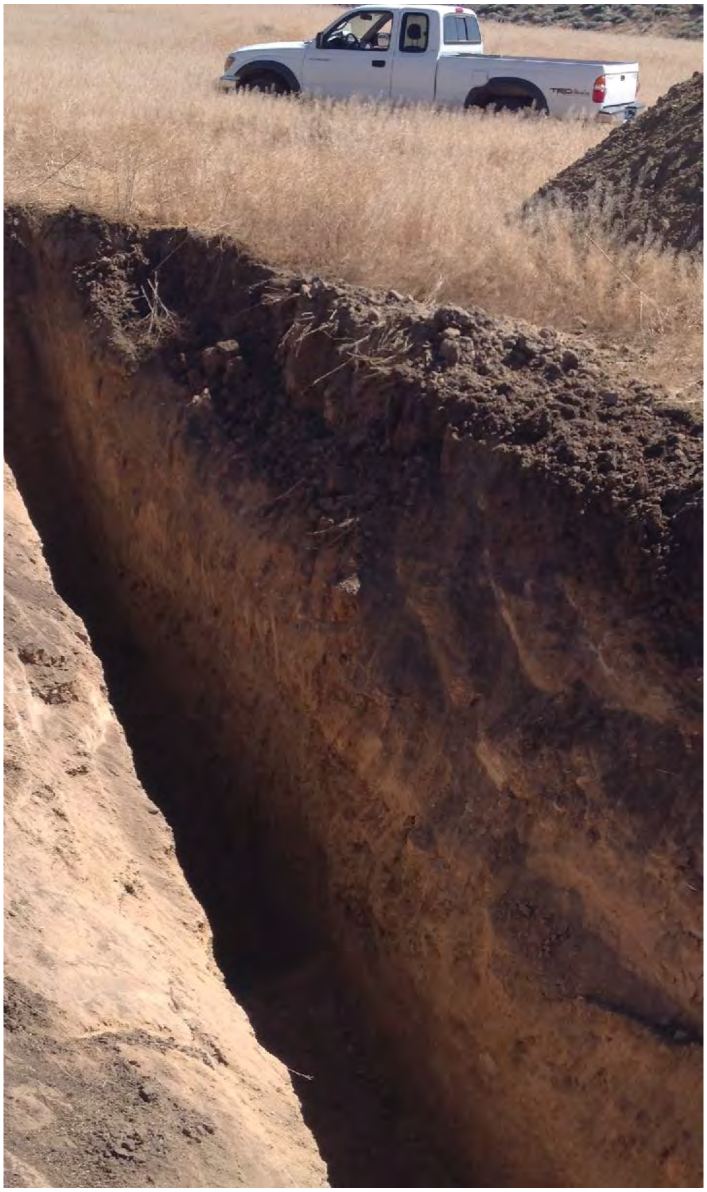
WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

REMI® N-S
TWO-DIMENSIONAL P-WAVE (SEISMIC) VELOCITY PROFILE

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE A-6



WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

TP-1 PHOTOS

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE B-1

WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

TP-2 PHOTOS

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040

Date: 07/20/16

PLATE B-2

WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

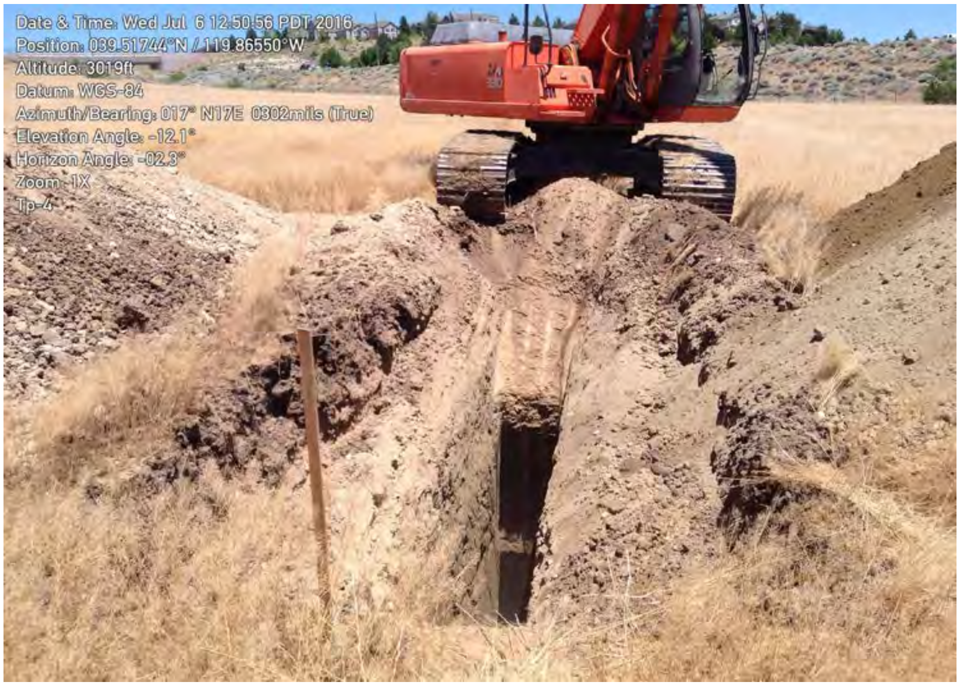
TP-3 PHOTOS

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040

Date: 07/20/16

PLATE B-3



WOOD RODGERS
5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

TP-4 PHOTOS

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE B-4

WOOD RODGERS

5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

TP-5 PHOTOS

Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE B-5

WOOD RODGERS

5440 Reno Corporate Drive, Reno, NV 89511
Phone 775.823.4068 Fax 775.823.4066

TP-6 PHOTOS

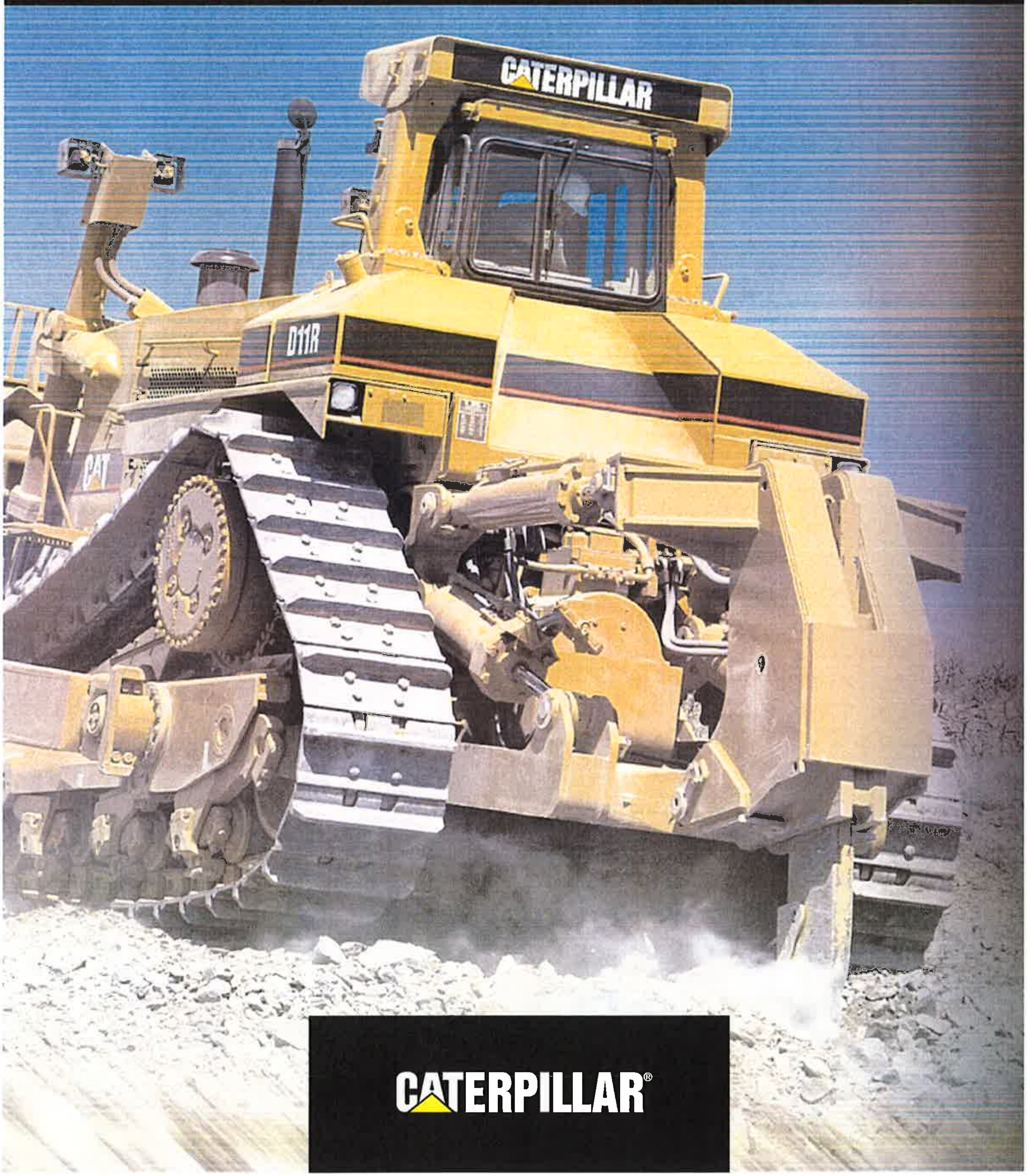
Geotechnical Investigation
Proposed Solids Drying Ponds
TMWA Chalk Bluff
Reno, Nevada

Project No.: 8040.040
Date: 07/20/16

PLATE B-6

Twelfth Edition

HANDBOOK OF RIPPING



CATERPILLAR®

HANDBOOK OF RIPPING

Table of Contents

HANDBOOK OF RIPPING • TWELFTH EDITION

FEBRUARY 2000 • CATERPILLAR INC. • PEORIA, ILLINOIS

www.CAT.com

Production ripping is being used more and more today as an alternative to drilling and blasting with explosives. Actually, ripping has a long history dating back to the Roman Empire. There is evidence the Romans used a ripper mounted on wheels and pulled by oxen when they were building the Appian Way. Rippers were also used in the United States during railroad construction from 1860 to 1880.

History of the Ripper

The ripper as we know it today did not appear until approximately 1930. Rippers drawn by tractors were developed by R.G. LeTourneau in 1931 and used on the Hoover Dam project. At that time, they weighed about 7,500 pounds and were pulled by tractors with about 75 flywheel horsepower (equivalent to today's Caterpillar D4C track-type tractor). Their chief shortcomings were their clumsiness and poor penetration ability. If enough weight was added to obtain adequate penetration, the tractors weren't powerful enough to pull them. Extra tractors were often added until as many as three tractors were pushing or pulling a single ripper. These units achieved only limited success, usually in shale, clay, limestone, hardpan, cemented gravel, and frozen ground.

Modern Rippers

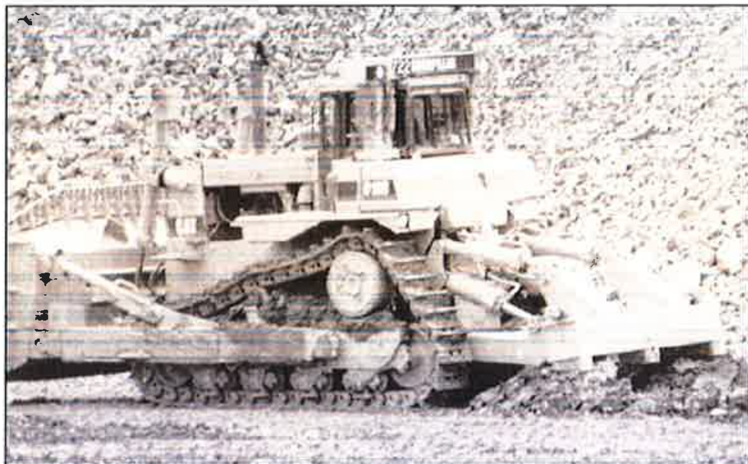
Modern tractors of the '50s and '60s advanced ripping capabilities by mounting the ripper to the rear of the machine. This design, coupled with advanced hydraulic systems, more machine weight, and greater horsepower, greatly improved ripping performance and efficiency.

These advances in performance were welcomed as environmental factors began to limit or restrict conventional blasting techniques. Urban encroachment, safety, and pollution concerns all have placed much

greater demands on customers' ability to use drill and blasting as a way to remove material. In the mining world, concern for mixing materials, process improvements (leach pads), and similar safety and environmental considerations likewise increased interest in ripping.

Current tractors have become so successful in ripping applications that 75% of the D8R – D11R are shipped from the factory with rippers.

	% of tractors equipped with rippers	% single shank	% multishank
D11	83%	82%	18%
D10	86%	75%	25%
D9	75%	72%	28%
D8	59%	57%	43%



Summary

Environmental and safety concerns have made production ripping a popular alternative to drilling and blasting. Design advances, including hydraulic enhancements, increased horsepower, and better traction, continue to improve ripping performance and efficiency.

The Current Cat Ripper

The current line of large Caterpillar elevated sprocket tractors made further advancements with the suspended undercarriage. The bogie system improved operator ride for increased comfort.

The bogie system also increased the tractive capability of the tractor by keeping more track in contact with the surface. This increased traction allows the machine to put more usable horsepower into the job, less track spin for less wear, and overall improvement in cost per hour.

Material Hardness and Rippability

Not all materials or formations can be ripped. Others cannot be ripped economically. Determining whether or not a rock formation can be ripped is not a simple process, but today's technology and experience can help develop a reasonable prediction for each customer site.

Obviously, the ideal test for determining rippability is to put a ripping tractor on the job and see if it can rip the material – test by trial. But this may not be practical due to the time and expense involved. Therefore, in order to determine if ripping is feasible, a basic knowledge of geology and rock characteristics affecting ripping is necessary. This knowledge is gained through on-the-job experience ripping in various formations.

When classified by origin, rocks fall into one of three categories, with similar rippability characteristics existing within each type. Knowing the correct classification can often help answer the question: "Can it be ripped?"

Igneous Rock

Igneous Rocks are formed by the cooling of molten masses originating within the earth. Igneous rocks never contain fossils, are identified by their mineral content and texture, and almost never have the stratified, banded, or foliated characteristics of other rocks. They usually possess high compressive and tensile strength. Granites, basalts, pegmatites, pitchstone, and pumice are igneous rocks commonly encountered on earthmoving jobs. Formations of these rocks are usually the most difficult to rip because they typically lack the stratification and cleavage planes essential to the successful ripping of hard rock. Igneous rocks are usually rippable only where they are deeply weathered and/or very highly fractured. These conditions can readily be detected via field seismic surveys.

Metamorphic Rock

Metamorphic Rocks result from the transformation of pre-existing rocks which have been changed in mineral composition, texture, or both. The agents causing metamorphism in rocks are shearing stresses, intense pressure, chemical action from liquids and gases, and high temperatures. Common metamorphic rocks are gneiss, slate, marble, quartzite, and schist. These rocks vary in rippability depending on their degree of stratification or foliation. All are found on or near the earth's surface and usually occur as homogeneous masses.

Summary

While some materials still cannot be ripped or ripped economically, heavier machines, improvements in horsepower, and advancements in tractor design are making ripping possible in more applications.

The physical characteristics which favor ripping may be summarized by:

1. Frequent planes of weaknesses such as fractures, faults, and laminations
2. Weathering
3. Moisture-permeated formations
4. High degree of stratification
5. Brittleness
6. Low strengths
7. Low field seismic velocity

The list of conditions which make ripping difficult is not nearly as long as it used to be. Ripping tends to be more difficult if the rock formation is:

1. Massive
2. Without planes of weakness
3. Crystalline rock
4. Non-brittle, energy-absorbing rock fabrics
5. High strengths
6. High field seismic velocity

Sedimentary Rock

Sedimentary Rocks consist of material derived from destruction of previously existing rocks. Water action is responsible for the largest percentage of sedimentary rocks, although some result from wind or glacial pressure. Their most prominent feature is stratification, i.e., they are built of layers differing in texture, material, thickness, color, or a combination of these properties. This layering is referred to as bedding, and individual layers, which are often uniform in texture, color, and composition, are referred to as beds. A single bed may vary in thickness from paper thin to several hundred feet. Examples of common sedimentary rocks are sandstone, limestone, shale, conglomerate, and caliche. This family of rocks is generally the most easily ripped.

The material condition of rock affects its rippability. Although sedimentary formations generally offer the best opportunity for ripping, and igneous and metamorphic the least, decomposed granites and other weathered igneous and metamorphic rocks often can be ripped economically.

Little or no trouble is encountered with hardpan, clays, shales, or sandstones. Likewise, any highly stratified or laminated rocks and formations with extensive fracturing offer good possibilities for ripping. Solid, thickly bedded rock formations may require drilling and blasting. A discussion of ripping vs. blasting, and when each may be considered appropriate, is included later in this handbook.

Rippability Investigation & Prediction Service

Although visible laminations, faults, and fractures may indicate rippability and are usually helpful, conditions which are not visible are also important. That's because surface features give only a clue as to what lies underneath. To determine rippability when a field trial is not feasible, a method of estimating underlying characteristics is required.

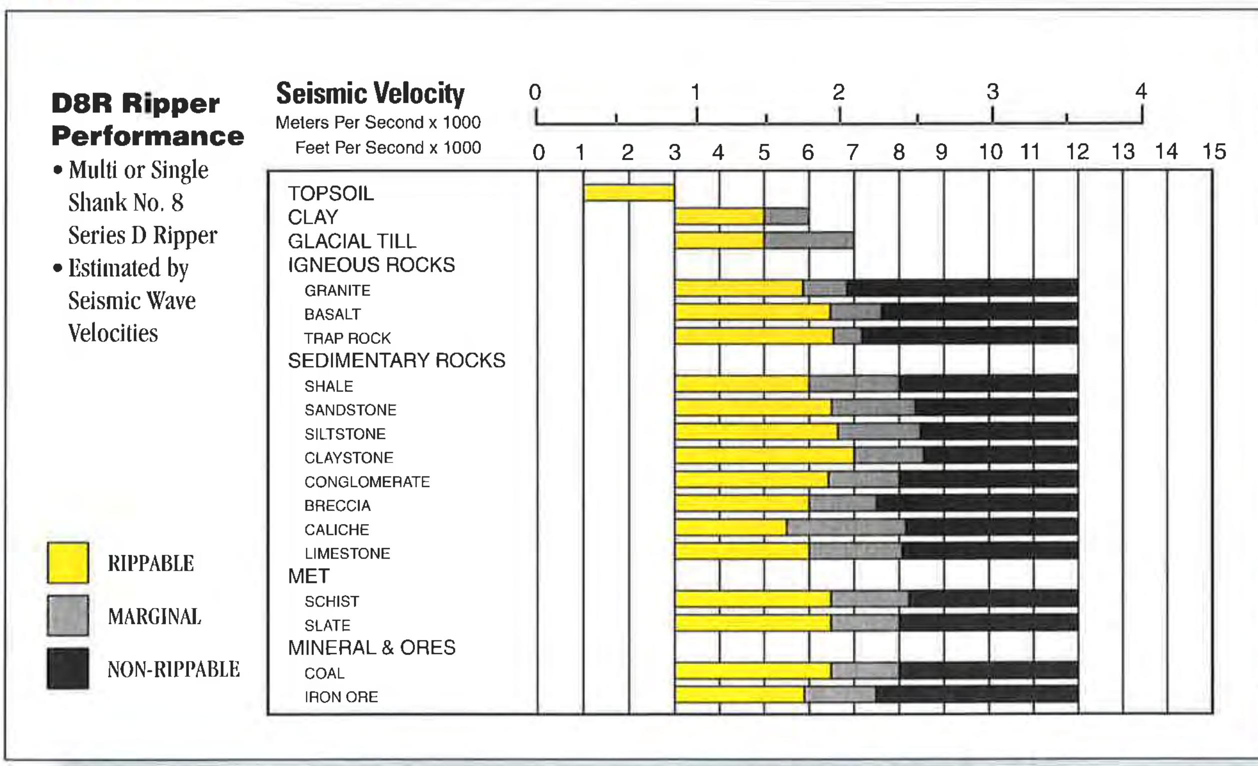
Caterpillar has developed a systematic analysis procedure to predict the rippability of a rock formation which combines new technology with geological and ripping experience. Our process for gathering the information necessary to make a prediction is called the Rippability Investigation and Prediction (RIP) service and is available through Caterpillar research. (Contact your district office.) The service consists of three steps:

1. Rock analysis
2. Site inspection
3. Seismic analysis

Rock Mechanics Analysis

A rock mechanics analysis is the first phase of the RIP service and requires that a fresh rock sample be submitted to our lab for analysis along with other pertinent information about the site. (Minimum sample size should be 10" x 10" x 10".)

Rippers



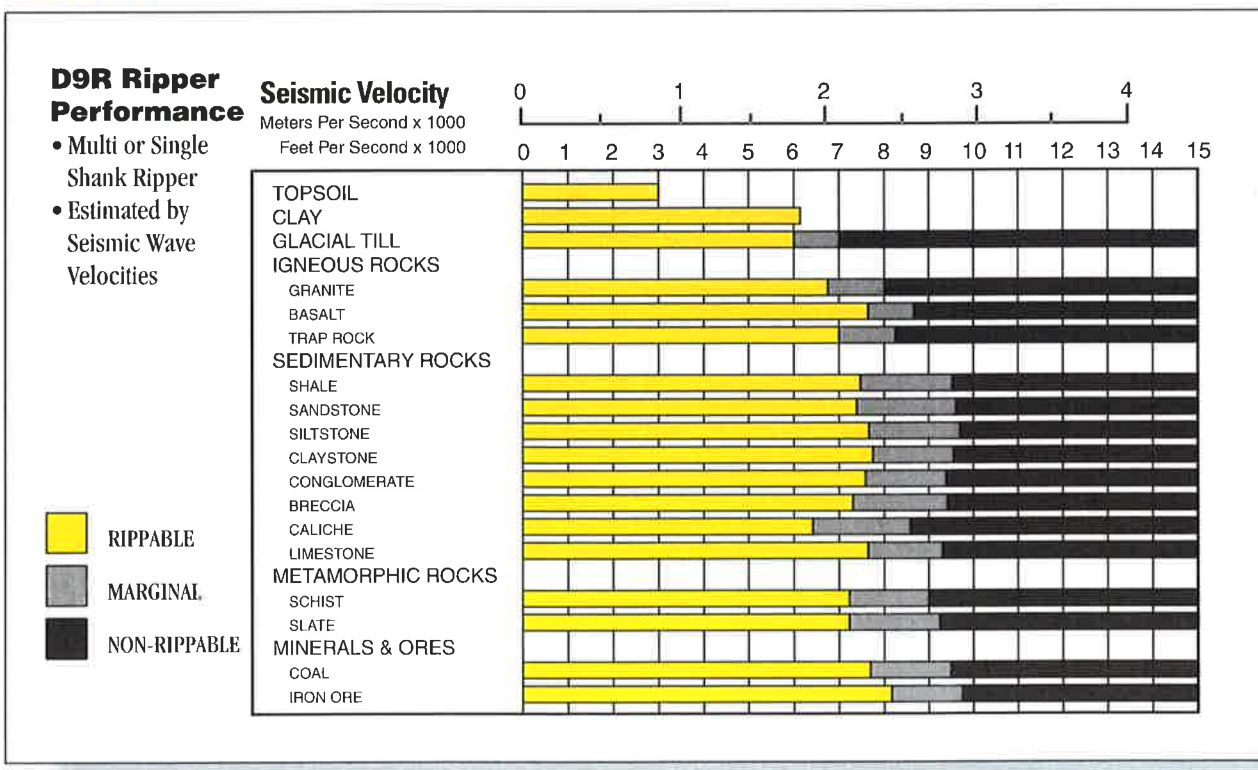
Geological Site Inspection

The second phase of the RIP service consists of a site visit by Caterpillar personnel which includes a geological inspection. During the site inspection, the rock formation in question is examined for in-place rock mass characteristics that may affect a ripping tractor's performance. These may include rock type, degree of weathering, bedding features, joint characteristics, and many other pertinent geological features.

Seismic Evaluation

The third phase of the RIP service includes a seismic evaluation. Caterpillar introduced the use of the refraction seismograph in 1958 as an aid to determine rippability of materials. The instrument functions by measuring seismic velocity, an indicator of the degree of consolidation of rock formations. Caterpillar continues to offer this service, along with many independent firms.

Rippers



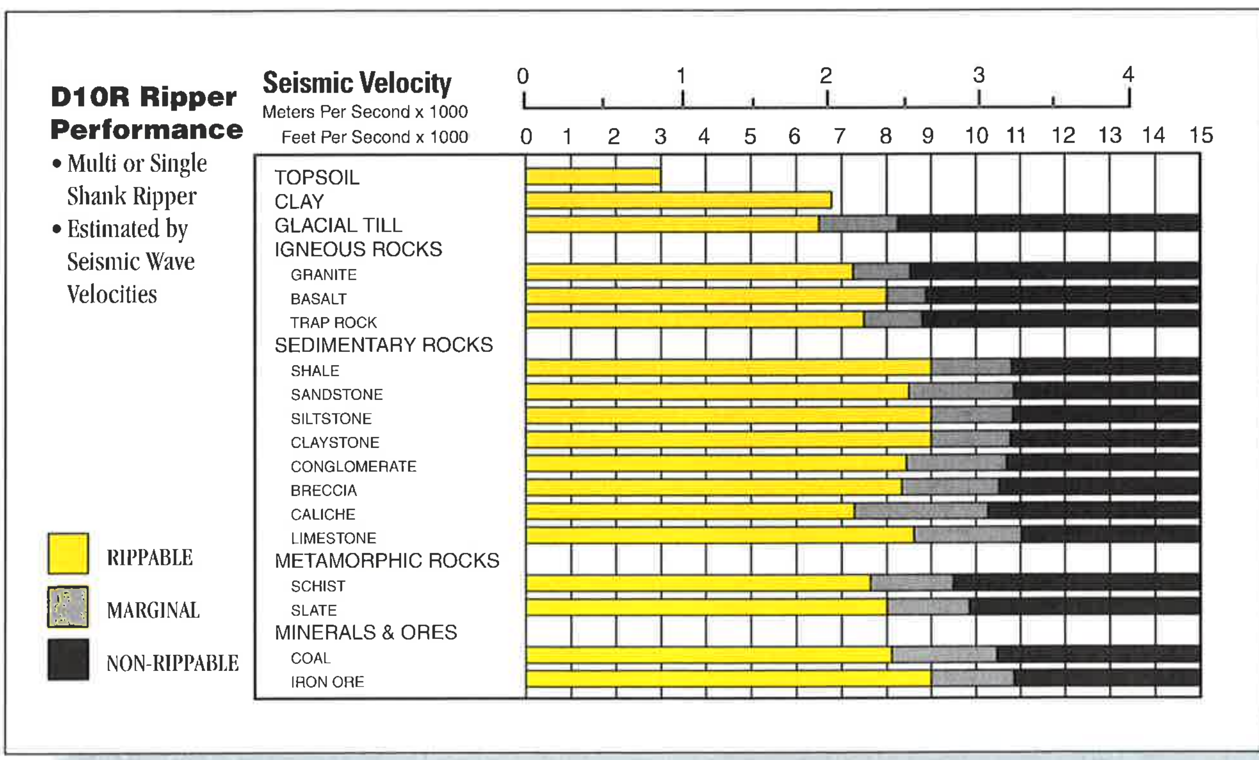
Rippability Investigation & Prediction Service

Caterpillar Systematic Analysis

Not all material conditions are visible from the surface. To determine the rippability of below-the-surface material and formations, Caterpillar Inc. developed a systematic analysis procedure based on technology and field experience. The service consists of three steps:

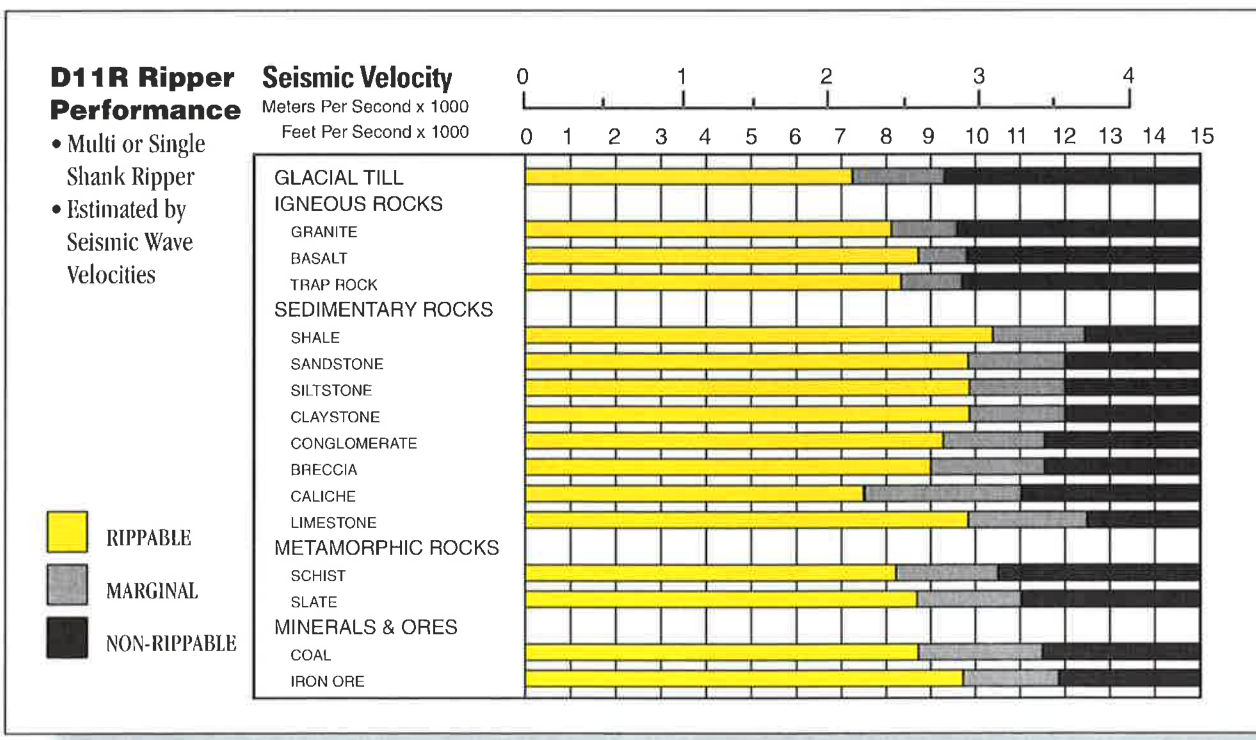
1. Rock analysis
2. Site inspection
3. Seismic evaluation

Rippers




CATERPILLAR

Rippers


D11R Ripper Performance
• Multi or Single Shank Ripper
• Estimated by Seismic Wave Velocities
Seismic Velocity
Meters Per Second x 1000
Feet Per Second x 1000
0 1 2 3 4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
GLACIAL TILL
IGNEOUS ROCKS
GRANITE
BASALT
TRAP ROCK
SEDIMENTARY ROCKS
SHALE
SANDSTONE
SILTSTONE
CLAYSTONE
CONGLOMERATE
BRECCIA
CALICHE
LIMESTONE
METAMORPHIC ROCKS
SCHIST
SLATE
MINERALS & ORES
COAL
IRON ORE
RIPPABLE
MARGINAL
NON-RIPPABLE

Ripping Equipment Selection

Proper equipment selection and sound ripping techniques are critical to effective and economic ripping. Following sections will focus on these two important areas.

Selecting the proper ripping tools can make the difference between just being able to rip a material, and being able to reach optimum efficiency and maximum production (lowest cost/yd^3).

For any ripping job, choosing the right ripping tractor for conditions depends on:

1. Tractor flywheel horsepower
2. Tractor gross weight
3. Downpressure available at the tip

The elevated-sprocket design tractor with modern resilient undercarriage has proven to be an excellent ripping tractor because of its superior tractive ability. These large tractors are able to rip many previously unrippable materials and have greatly increased ripping production in existing ripping applications.

Ripper Selections

The first step in ripper selection is to determine the application. Will the job call for production ripping or will the tractor be used as a multipurpose tool? The more production ripping required, the greater the effectiveness of the single shank ripper. If the tractor spends more than 20 percent of its time ripping, it is considered a production ripping application. Material also has an effect on ripper selection. The harder or tighter a material, the more the application calls for the single shank ripper.

The multishank design becomes more effective in multiple site/multiple use applications where versatility is an asset. In these applications, material may not be as hard and ripping depth not as important. The more varied the job conditions, the greater the need for the multishank ripper. The multishank is especially useful in pre-ripping for scrapers or other loading tools, covering a wider area, or ripping close to a high wall or obstruction.

In a ***Hinge***-type ripper, the linkage carrying the beam and shank pivots about a fixed point at the rear of the tractor. As the shank enters the ground and penetrates to maximum depth, the tooth angle is constantly changing.

Hinge-type rippers offer the advantage of an aggressive entry angle, but cannot be adjusted to compensate for varying conditions.

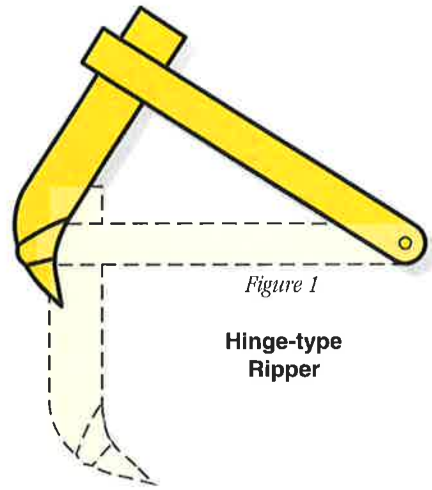


Figure 1

Hinge-type Ripper

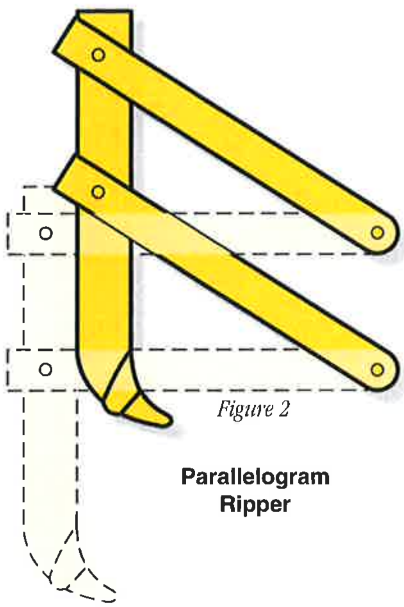


Figure 2

Parallelogram Ripper

A ***Parallelogram***-type ripper allows the linkage carrying the beam and shank to maintain an essentially constant tip-ground angle regardless of tooth depth. This type of ripper has advantages over the hinge-type when ripping above maximum depth, but does not provide the aggressive tooth angle necessary for hard-to-penetrate materials.

The ***Adjustable Parallelogram*** ripper combines the features of both the hinge-type and parallelogram rippers. It can vary the tip angle beyond vertical for improved penetration and can be hydraulically adjusted while ripping to provide the optimum ripping angle in most materials.

All Caterpillar large tractors use *adjustable* parallelogram rippers, available in single shank and multishank arrangements. The single shank models are built for the toughest ripping work, where maximum penetration and depth is required. The multishank arrangement will accept three shanks for use in less dense materials.

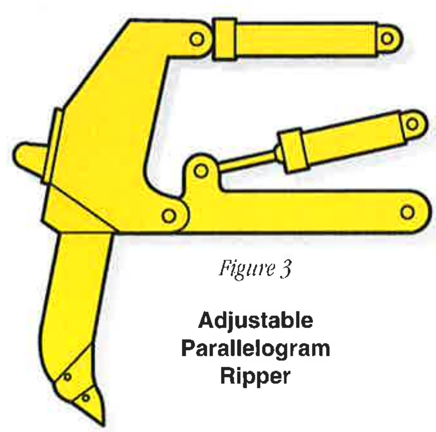


Figure 3

Adjustable Parallelogram Ripper

Ripping Equipment Selection

Ripper Shanks

Only straight ripper shanks are available for the large track-type tractors. These provide the lifting action needed in tight, laminated materials, plus the ripping ability required in blocky or slabby ripping material. All of the shanks for the large tractors are of the one-piece design, eliminating the weld joint. This increases strength at a critical area and allows for improved heel clearance. The rolled stock from which a ripper is made is now cut to length, bent, then fully machined at the tip end.

Shank protectors are standard for D8 and larger Caterpillar shanks. The replaceable protectors are pinned to the leading edge of the shank (see figure 4), protecting it from wear and greatly extending shank life.

Ripper tips (see Figure 4) are available in several shapes and sizes designed to meet specific application requirements. Three questions should be considered when determining the best ripper tip for a particular job:

1. How difficult is the material to penetrate?
2. What are the fracture characteristics?
3. How abrasive is the material?

Tooth penetration can be the key to ripping success in many situations, especially in homogeneous materials such as mudstone or fine-grained caliche, or in tightly cemented conglomerate. These materials are not difficult to rip if they can be penetrated. Caterpillar manufactures short, intermediate, and long penetration tips recommended for use in compacted, dense materials where initial penetration is difficult. These alloy steel tips resist tempering (loss of hardness) at higher operating temperatures for long wear life. They are also self-sharpening and provide excellent penetration capability.

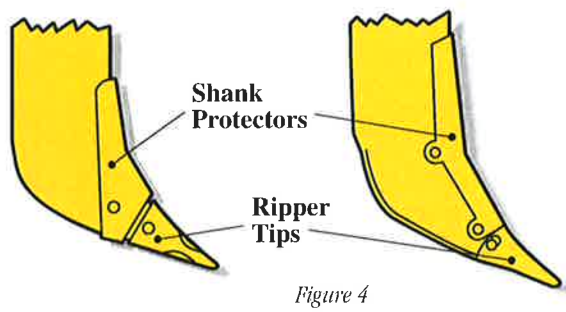


Figure 4

Track Shoe Width

Working on rock requires narrow shoes to reduce bending or breakage. However, most ripping tractors work in several different kinds of materials. This variety of work environments requires a track width that does the best all-around job, therefore a standard width track shoe is usually the best choice. A good rule of thumb is to use the narrowest shoe that provides adequate flotation and traction, without excessive track slippage. Shoes of the correct width give maximum performance and the lowest operating costs. Because ripping is often an abrasive, high impact application, heavy-duty Caterpillar extreme service shoes are usually recommended. These are single-grouser shoes heat-treated to a higher tensile strength, and provide more wear material than conventional shoes.

A standard width track shoe performs a multitude of jobs.

Summary

To achieve optimum efficiency and maximum production (lowest cost/yd^3), selection of the proper ripping equipment is crucial. Application-specific choices must be made between single shank or multishank rippers. Proper selection of shank protectors and tips can affect ripping productivity and efficiency.

Cat Ripping Tip Options

Tip Selection

Tip selection is also affected by the abrasiveness of the material. Centerline ripper tips are designed for abrasive applications where increased wear life is a consideration. Centerline tips are made of steel, are self-sharpening, and provide reversibility due to the centerline design. Although there are three centerline tip lengths available (short, intermediate, and long), each is recommended for a specific application.

Ripper Tip Designs:

- The short tip (see Figures 5 and 6) should be used in extreme impact conditions only, as *it does sacrifice some wear material compared to intermediate and long tips.*

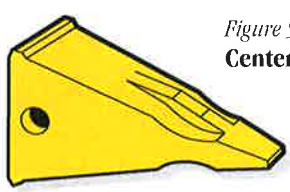


Figure 5 - **Short Centerline Tip**

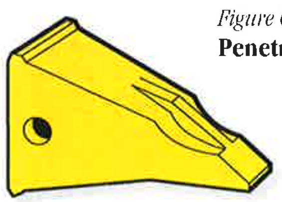


Figure 6 - **Short Penetration Tip**

- The intermediate tip (see Figures 7 and 8) is used for moderate impact and abrasion conditions.

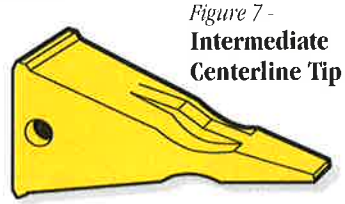


Figure 7 - **Intermediate Centerline Tip**

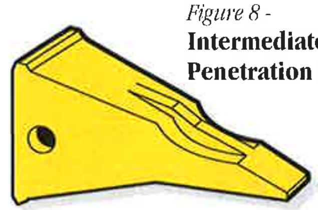


Figure 8 - **Intermediate Penetration Tip**

- The long tip (see figures 9 and 10) is designed for low impact, highly abrasive conditions where breakage is not a problem. This tip has the greatest amount of potential wear material.

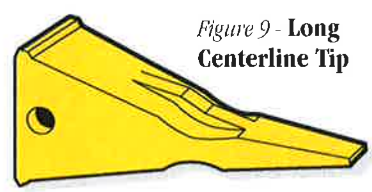


Figure 9 - **Long Centerline Tip**

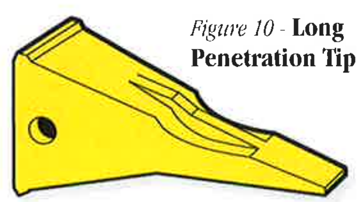


Figure 10 - **Long Penetration Tip**

Models	Penetration			Centerline		
	Long	Inter.	Short	Long	Inter.	Short
D11R Single Shank		○			○	○
D11R Multishank D10R	○	○	○	○	○	○
D9G, D9H, D9R D8H thru D8R		○	○	○	○	○

For both penetration and centerline ripper tips, *always use the longest tip that will rip without excessive breakage.* This will provide increased wear life, simply because the longer the tip, the more wear material available. Using the correct tip is critical to low-cost ripping, so you may want to try different tips before making your final selection. Since longer tips offer more wear material, it's usually recommended to try a longer tip first and switch to a shorter one if excessive breakage occurs.

Summary

Caterpillar manufactures short, intermediate, and long tempering-resistant steel alloy **penetration tips** for use in compacted, dense materials where initial penetration is difficult; and short, intermediate, and long steel **centerline tips** for increased wear life in abrasive applications. *Always use the longest tip that will rip without excessive breakage.*

Ripping Equipment Troubleshooting Guide

Use the following chart to aid in solving problems involving ripping equipment.

Problem	Causes	Action
Excessive tip breakage	Tip may be too long for conditions	Change to shorter tip
	Shank protector missing	Check and replace if needed
	Shank or adapter nose broken, bent, or worn	Check and replace if needed
	Wrong shank angle	Adjust shank angle
	Too many shanks being used	Decrease number of shanks
	Operator backing up or turning with tip in ground	Raise tip before turning or backing up
Shank or adapter breakage	Badly worn shank	Repair or replace shank
	Operator side loading shank	Rip only in straight line in forward direction
	Operator turning while ripping	
	Operator backing up with tip in ground	
Difficult tip installation	Material buildup on shank nose	Remove material
	Shank nose bent or damaged	Repair or replace shank
Lack of penetration	Wrong tip in use	Try different tip or penetration tip
	Material too dense	Use larger tractor, if possible Make series of very shallow passes to provide improved traction Pre-blast
	Improper operator technique	Change operators or instruct as to proper technique (see following section on ripping techniques)
	Penetration tip installed the wrong way	Look for word "bottom" engraved on tip and install accordingly
Damage to track shoes	Track shoes too wide	Use narrower extreme service shoes
	Track shoes not extreme service	

Ripping Basics

The best ripping procedure depends on a job's actual conditions. Likewise, as conditions vary from job to job, what is appropriate for one situation may not work in the next. Experience is the best teacher when it comes to maximizing ripping efficiency. But a review of the following 11 points can help identify the necessary procedures.

1. How many shanks should be used?

The multishank ripper is intended as a high production ripper in hard-packed soils and for loosened embedded rock. It is intended to be used in material that can be ripped with at least two shanks. It is intended for applications where ripping with a single center shank is required less than 20 percent of the time. It is not intended for high production ripping in rock with a single center shank. One shank should be used in material which breaks out in large slabs – so the slabs either fracture or pass around the single shank. When two or more shanks are used in this situation, the shank can act as a rake and wedge the larger slabs under the ripper beam. Or, as often happens when using two shanks in difficult materials, one of the shanks may become stalled by a hard spot. This causes off-center loads to be placed upon the ripper beam and mounting, and thus the tractor.

A single shank can be used in the center pocket of a multishank ripper in order to gain penetration in more difficult material. The multishank frame provides the flexibility to achieve the greatest ripping production in various strengths of materials.

The use of only one shank centers the load in the beam and mounting assembly and allows full force to be exerted at a single point. Even if the material can be handled by two shanks, production can often be increased by using a single shank for smoother operation and less slippage and stalling.

Two shanks can be most effective in softer, easily fractured materials which are going to be scraper loaded. In some cases, two shanks may be required by job conditions such as ripping along a high wall or the toe of a slope. Three shanks should be used only in very easy-to-rip material such as clay hardpan or soft shales.

2. When should a deep rip shank be used?

A deep rip shank should be used where laminations or other places of weakness exist that cannot be reached with the standard length shank. These longer shanks also have the potential to produce greater volume per ripping pass in many materials compared to a standard single shank. Common applications include relatively easily ripped material such as clay hardpans, coal, and some sandstones and shales. Caution must be applied when using deep shanks in harder material, because the extra shank length reduces their ability to handle ripping loads when compared to conventional shanks.

These shanks are designed for light to moderate duty and therefore can break when used in the extended positions in hard material.

3. Should tandem ripping ever be considered?

Improvements in tractor design, including elevated sprocket, bogie suspension, and increased weight and horsepower, have made tandem ripping obsolete.

4. Should material ever be blasted before ripping?

Rock that is extremely difficult to penetrate and rip can often be lightly blasted (called "preblasting" or "pop" blasting) and then ripped successfully. In many applications preblasting can provide cost and environmental benefits over complete blasting.

The procedure simply involves light charges on wide centers to improve initial ripper penetration. Ripping normally then has the advantage of fracturing the material into smaller pieces than blasting. This method has produced cost savings in some applications, but must undergo careful cost evaluation.

It is also cost effective in many operations to rip as much material productively as possible and then blast the unrippable material. This allows the operation to move as much material as possible at the lowest possible cost.

5. What is cross-ripping and when is it used?

Cross-ripping involves ripping an area with a series of longitudinal passes (east to west, for example) and then covering the same area while ripping in a transverse direction (north-south).

In general, cross-ripping makes the pit rougher, increases scraper tire wear, and requires twice as many passes; however, it does help break up "hard spots" or material which comes out in large slabs, and will loosen vertically laminated material in which single-pass ripping produces only deep channels. When material is extremely hard to penetrate, cross-ripping will often separate fracture planes set up by the first pass and allow ripper use where blasting would otherwise be required.

Cross-ripping is often done to reduce material size to better facilitate scraper loading of the material, or in order to meet crusher throat limitations. When considering cross-ripping, careful analysis should determine if material removal efficiency is increased enough to offset the increased time and expense.

6. Which direction is best?

Generally, ripping direction is dictated by the job layout. However, there are certain conditions under which ripping direction will greatly affect results.

When ripping in a scraper cut, it is always best to rip in the same direction that the scrapers will load. If the rock formation lies in such a manner that cross-ripping is required, the final pass should always be in the direction of scraper loading. This procedure yields several advantages. It greatly aids scraper loading, reduces the chances of damaging or springing the scraper bowl, allows the ripping tractor to double as a pusher in certain situations, and it permits traffic to flow in the same direction.

Occasionally, a rock formation will be found containing vertical laminations or fractures that run parallel to the cut, in which case, ripping in the direction of the cut may result only in deep channels. When this occurs, it may be necessary to rip the material across the cut first to obtain proper fracturing, then make the final pass in the direction of the cut.

Material such as caliche tends to break out differently than most materials. This "buttercutting" effect lowers productivity and demands additional ripping passes.

When applied to ripping, buttercutting is a term used to describe material breakout similar to the slicing of a knife through butter. There is minimal fracturing of the ripped material except in the vicinity of the shank. This can occur in soft or non-brittle materials that display discontinuous breakout. Discontinuous breakout occurs in rock because there are no preferred planes of weakness for a fracture to propagate along. Examples of materials which can exhibit this type of breakout are cemented gravels, caliches, and breccias.

It's also advantageous to rip downhill whenever possible. Gravity helps the tractor take maximum advantage of its weight and horsepower. However, uphill ripping is occasionally used to get more rear-end down pressure or to get under and lift slabby material.

If the material is laminated and the plane of the laminations is inclined upward toward the surface, it's best to rip from the shallow end (where the laminations reach the surface) toward the deep end. This helps keep the ripper tip in the ground. When ripping is done in the opposite direction, the tip tends to "ride over" the laminations and be forced out of the ground.

7. What gear is best for ripping?

Proper gear and speed selection is critical to obtaining maximum ripper production and efficient tractor operation. Generally speaking, first gear is used in most ripping situations because a speed of 1 to 1-1/2 mph, at about 2/3 throttle, gives the most economical production.

Just a small increase in speed above the optimum can result in ripper tip wear, excessive track slip, and ultimately in lower production and higher costs. Excessive speed generates excessive heat at the ripper tip and greatly shortens tip life. Therefore, when ripping in easy-to-rip materials, it is better to rip deeper at regular speed or use two or three shanks than to use one shank and increase ripping speed.

8. What is the best ripping depth?

Ripping depth is normally determined by job requirements, material hardness, bedding thickness and degree of fracturing. Ideally, ripping with standard shanks should be done at the maximum depth that penetration and traction allow. This results in maximum production per unit of fuel and tip wear material used.

Sometimes, however, it may not be practical to rip at maximum depth. When opening a cut on a very hard or smooth surface where grouser penetration is limited, making a series of shallow cuts significantly improves traction and penetration by providing a "bed" of loose material for the track grousers to grip. Or where considerable stratification is encountered, it is usually best to rip and remove the material in its natural layers rather than try to make a full-depth pass. An initial pass at less than full-depth will often break the material loose so that the second pass can be made at the optimum depth and achieve more complete fragmentation.

Ripping depth and the number of shanks to be used should be considered together. While deep ripping with a single shank usually yields maximum production, many soft or thinly laminated materials can often be better handled by multiple shanks at a more shallow ripping depth.

9. Is a difficult first pass normally encountered?

Usually the first pass is the most difficult because in consolidated material there are no "voids" for the loosened material to move into. Thus, initial penetration can be difficult, and proper technique and penetration angle is a must. On subsequent passes, material can move into voids created by the previous pass. For this reason, a decision to blast should not be made based on seemingly poor performance during the first ripping pass.

10. What pass spacing should be used?

Pass spacing helps determine the production rate, because obviously the fewer number of passes, the shorter the amount of time required to cover the area. Optimum spacing then is necessary to maximize production and hold down costs. Using the maximum recommended spacing is not always advisable because material end-use and removal methods must also be considered. The closer the spacing, the smaller the ripped fragments of material will be. Thus, crusher requirements and loading methods can determine the correct spacing.

When full penetration can be obtained, pass spacing of one half the tractor width is usually recommended. This allows one track to ride over the material just ripped, thus increasing traction and further crushing the material. Using this as a base, pass spacing can either be increased or decreased depending upon the fracturing characteristics of the material and end-use requirements.

11. What about removing the ripped material?

First of all, for best results, never remove all the ripped material covering an area if deeper ripping must be done. Dozers and scrapers should always have one or two inches of crushed material resting on top of the solid formation for increased traction and to help cushion the tractor. The coefficient of traction is much greater for a tractor working on crushed rock than for one working on a smooth, solid bed of rock.

Where scrapers are to be used to remove and haul the material, it's important to consistently rip to a uniform depth. This eliminates protruding knobs of hard rock and shallow spots which could force the scraper cutting edge out of the ground. This is damaging to cutting edges and to the scrapers themselves, possibly reducing the useful life of the unit and certainly increasing its maintenance costs. A good rule of thumb is to rip no deeper than can be ripped on the most difficult part of the cut area, and thus no deeper than the scrapers can readily load.

Summary

With today's advancements in tractor design – elevated sprocket, bogie suspension, increased weight and horsepower – the need for second tractor tandem ripping has been eliminated.

Ripping depth and the number of shanks should be considered together. Deep ripping with a single shank usually yields maximum production; but many soft or thinly laminated materials can often be better handled by multiple shanks at a shallower ripping depth.

Ripping Techniques

Until now, this handbook has dealt with the kinds of information necessary before ripping begins – material rippability, ripping basics, ripping equipment selection, etc. This section will introduce perhaps the most important variable of all in maximizing ripper production – *effective operator technique*. This section provides important techniques which can make the difference between success or failure. Again, each ripping situation is different; these techniques are recommended to increase production, maximize ripper tip life, reduce track wear, and prevent tractor and ripper damage in the majority of ripping applications.

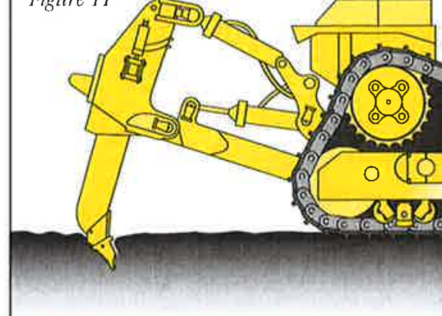
The Decelerator as a Key to Ripping

The decelerator is one of the most important controls on the tractor, and proper use of it is a must for efficient ripper operation. Located to the right of the brake, it should be used to match drawbar pull to available traction and ground conditions, and to prevent track spin. Too much power while ripping can result in excessive track spin, reduced undercarriage and ripper tip life, and potential tractor damage. A constant, steady pull when ripping maximizes production and minimizes wear and tear on the operator and the machine.

Proper use of the decelerator enables the operator to apply just enough power to be on the verge of track spin, taking advantage of all usable horsepower. This technique is especially important when making initial cuts on a smooth or hard surface. Use the decelerator to start out slowly, reduce the aggressiveness of the tracks, and make a series of light cuts to break up surface material and form a "work pad" for the next series of deeper cuts.

Positioning the Ripper Shank at the Start of the Pass

Figure 11



Achieving initial penetration is critical and may be the determining factor for whether a material is rippable or not. Adjustable rippers have the advantage of allowing the operator to experiment and find the best angle for penetration.

In most cases, initial penetration for each pass begins with the ripper shank angled well back beyond the vertical position (see Figure 11), depending on tip selection. If the rock is extremely hard, angling the shank back near the maximum angle may enable penetration and thus permit ripping the material. When ripping more easily penetrated material such as soft shale, the shank angle may be only slightly back beyond vertical for initial penetration.

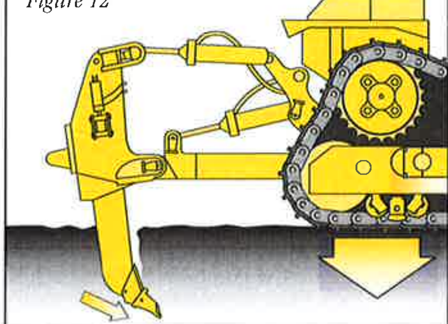
In hard material, the rear of the tractor may be forced up slightly as the ripper tip contacts the surface and penetration begins. This effect is normal, but if the ripper tip fails to penetrate, and the rear of the tractor stays up, raise the shank enough to set the tracks down flat again. Then try different shank angles until the best angle for penetration is found, while looking for faults, weak spots, fractures, and weathering to aid initial penetration.

Positioning the Ripper Shank During the Pass

Using the correct shank angle during the pass is *very critical* to ripper production. For best results in most situations, follow these guidelines.

Adjust the shank angle forward until the tractor feels "pulled into" or pinned to the ground. Due to shank design, a shank angle that may appear to be too far forward can actually be in the best position for ripping. The ripper tip should be slightly below the heel of the shank, as shown in Figure 12.

Figure 12

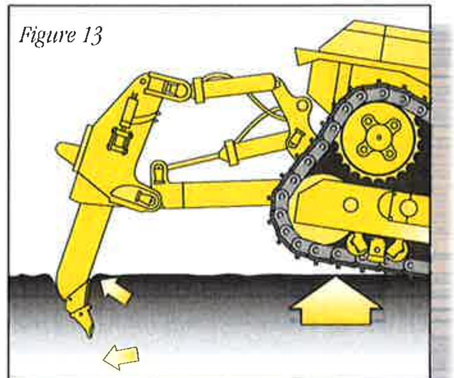


This angle is best for ripping because the force exerted on the small area of the tip initially fractures and weakens the material. Then as the shank passes through, the material is shattered from the bottom to the tip. If the shank pitch angle is too far back (not moved forward enough after penetration), it causes the tip to drag *across* the rock and puts the face of the tip and shank in contact with the material being ripped. This results in excessive wear and increased resistance, lifting the rear of the tractor, so that traction is lost and ripping effectiveness reduced. Operating with the shank angle too far back is the most common error made by ripping tractor operators.

This condition – shank too far back – raises the rear of the tractor (See Figure 13`)and results in: 1. high undercarriage wear rate (track spin); 2. poor shank life (shank impacts rock first); 3. poor tip life (tip is dragged across rock and cannot self-sharpen); 4. reduced production.

For parallelogram rippers, the operator can estimate when the shank is in the best ripping position by observing the tilt cylinder rods. After finding the best ripping angle for the material you are working in, see how much of the cylinder rod is extended and use this as a guide for future reference.

Figure 13



At the proper shank angle, the tip will penetrate and split the rock much as a wedge is used to split a log. At the same time, this will help keep the tip short by wearing more on the bottom surface than on the top.

It's also very important to avoid moving the shank too far forward. This permits the tip to rise above the shank heel, resulting in rapid heel wear and loss of penetration.

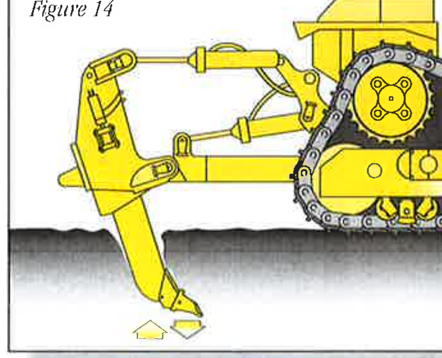
Proper Shank Length Selection

The length of shank extended from the ripper frame pocket is determined by two general rules. First, use a length at which the tractor can efficiently pull the shank through the material; secondly, maintain sufficient clearance under the lower ripper frame to avoid interference from large chunks or slabs brought to the surface.

When the material is very hard and penetration is difficult, the shank should be in the shortest position. The objective is to operate the lower ripper frame as parallel to the material as possible, for even stress distribution. Occasionally though, the shank may bring up chunks or slabs that lodge under the lower ripper frame. This situation may lift the rear of the tractor. If this occurs repeatedly, increase the clearance under the lower frame by extending the shank. This may cause the lower frame to operate inclined upward, rather than parallel to the ground. Although not the ideal frame position, it does prevent plugging the ripper frame. Avoid dropping the ripper frame so that it inclines downward from the tractor.

This traps ripped material under the frame and makes forward travel difficult, while causing excessive wear and potential damage to the underside of the ripper beam.

Figure 14



Ripping Techniques

Using Hydraulic Force to Help Fracture Rock

An effective technique for ripping hard rock seams or pockets is to combine tractor drawbar power and hydraulic force. When the ripper has contacted the hard rock, follow this procedure:

1. Use the decelerator to control track slip.
2. Use the ripper shank control to adjust shank angle back slightly.
3. Maintain engine speed high enough to allow the tractor to continue moving forward as the ripper shank angles back.
4. While the tractor moves forward, return the ripper shank to its original position (forward), combining ripper hydraulic force with tractor drawbar pull.

This technique can be very effective in tough material as well as when attacking hard rock pockets or seams.

Dozer Position While Ripping

A dozer carried too high during ripping can allow the tractor to straddle and hang up on large objects if it fails to push them out of the way. There is also danger that a track may ride up on an object, tilting the tractor and risking damage to the shank or ripper frame.

These problems can be overcome by carrying the blade low enough to remove obstructions, but high enough to allow smaller fragments to pass under. Remember, it's not practical to try to rip and doze at the same time.

In most cases, ripping downgrade is the most productive.

Ripping Downgrade

Ripping downgrade can increase production. If the job layout permits, the downgrade approach can be helpful when working a hard spot or seam.

There are several situations to be avoided when ripping downgrade.

1. Remember that traction on rock is less than on dirt.
2. Avoid ripping on or creating slopes the tractor cannot climb.
3. Avoid sideslopes.

Even in conditions that appear ideal, downgrade ripping may not always be practical. For instance, when the material lies in heavy, longer, level laminations, ripping will be difficult and production will be reduced. If this situation is encountered, the best solution would be to rip upgrade. The degree of the slope and available traction may limit ripping depth and handling methods.

Ripping Coal

All methods for ripping rock can be applied to ripping coal. Even so, ripping coal requires additional consideration.

If the shank is not angled forward enough after penetration, the tip will blunt rapidly and may cause the tip to mushroom.

Since ripping characteristics of coal can be widely varied, the ripper tip should be checked often for evidence of blunting, or color change caused by heat buildup.

Should either of these conditions be observed, increase the shank angle forward. It may also be advisable to use less down pressure, or rip at a slower speed.

Correct dozer position during ripping process.

Occasional Deposits of Hard Rock or Boulders

Pockets or seams of hard rock or boulders are common in many ripping operations. Sometimes they may be too hard to be easily broken. There are several ways to rip hard spots and boulders. If it is a seam of extra hard material, try to determine the direction the seam runs. It may lie diagonally, perpendicular, or parallel to the direction of ripping. By observing where the hard spots are found, a pattern will emerge. This pattern will reveal the direction of the hard material.

When the direction of the hard deposit has been determined, rip directly across the hard material. Often the grain will lie crosswise to the deposit.

In some cases hard deposits are found in the form of pockets or knots, or they may be boulders. It may be possible to work the ripper tip under them and lift them out.

NOTE: When a deposit of hard material cannot be removed, it may be necessary to work around it until it is exposed enough to doze out.

Pockets or seams of hard rock can be removed more easily if the pattern of the material is understood.

Summary

There are many variables to ripping. Utilization of the proper operator techniques will increase production, maximize ripper tip life, reduce track wear, and prevent tractor and ripper damage.

Special Ripping Applications

Most of the discussion in the preceding sections has concerned the ripping of well-consolidated rocks and minerals. Ripping is also used in other materials and applications in order to save the user money, do the job faster or more effectively, or even as a method to convert unusable land into a productive asset at a lower bottom line cost.

One such application is the use of large track-type tractors for deep ripping in agricultural areas. In many cases, breaking up hardpan under the surface permits formerly non-productive land to be economically planted.

California's San Joaquin Valley, for example, holds a virtually impermeable layer of clay and iron oxide hardpan up to six feet below the surface. Ranging from an inch to two feet in thickness, this layer prevents deep root penetration and traps water at the surface. By deep ripping, sometimes to a depth of seven feet, this hardpan layer is effectively shattered.

Diversity of Materials That Can Be Ripped

As demand for tillable land increases, deep ripping may prove a solution to dwindling supplies in many areas.

Three of the more common materials often ripped besides rock are coal or lignite, concrete, and asphalt or blacktop paving. These materials are somewhat easily ripped, but special considerations are involved in order to maintain maximum production. In any case, wherever such materials can be ripped, it is usually cheaper to rip them than to loosen and break them up by other means.

Old concrete, usually six to eight inches thick, can usually be effectively broken with a single shank ripper. A ripper in this case is especially effective in severing steel reinforcing rods or wire which can pose loading and removal problems.

Most asphalt surfacing and other types of blacktop paving are easily torn up with a ripper, usually a multishank. Although the nature of the materials varies, at times these surfaces can be ripped with multishank rippers mounted on track-type loaders or motor graders.

Although procedures and methods for ripping rock can also be applied to ripping coal, additional attention is required due to its unusual properties.

Some people use very long shanks in coal or lignite ripping and make repetitive passes each about two feet (0.6m)deeper than the preceding one. Leach pads have also become an important ripping tractor opportunity. Deep ripping of the pads loosens material which in turn improves the leaching process. Custom deep rip multishank ripping packages are available on D9 – D11 for maximum production and efficiency.

Frozen Ground Ripping

Another application seen increasingly more often is the ripping of frozen ground. Frozen ground used to bring wintertime jobs to a standstill, especially in the northern U.S., Canada, and Alaska. With current ripping tractor technology, however, few frozen soils or subsoils exist which cannot be ripped. Generally, if the material can be ripped in warm weather it can be ripped when frozen, although at lower production rates.

Leach pads have become an important ripping tractor opportunity.

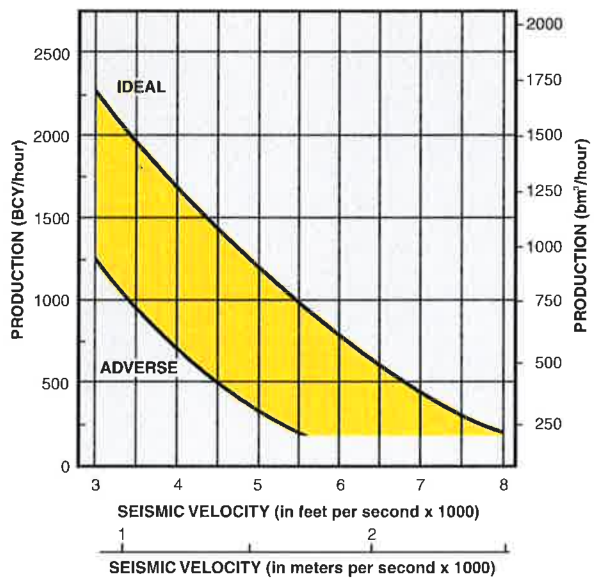
Summary

Ripping is often used in materials and applications other than rock to save cost and time, and increase efficiency. Contact Custom Products or your local dealer for special ripping applications.

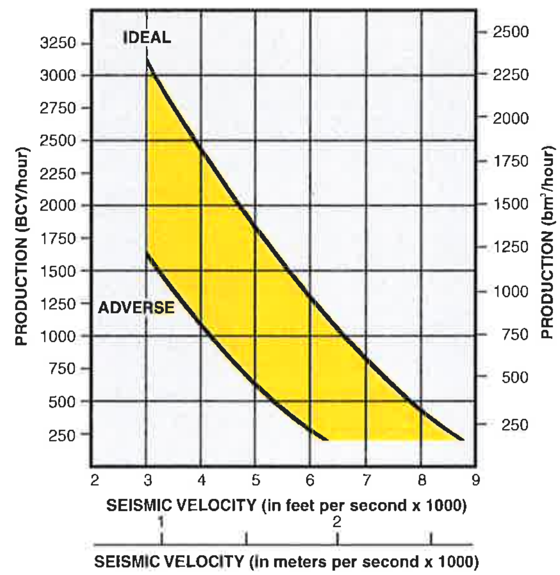
Estimating Ripper Production

Ripping costs must be compared to other methods of loosening material – usually drilling and blasting – on a cost per ton or bank cubic yard (BCY) or bank cubic meter (BCM) basis. (See *density chart* on page 26 to transfer between bank cubic yards and tons.) Thus, an accurate estimate of ripping production is needed to determine unit ripping costs.

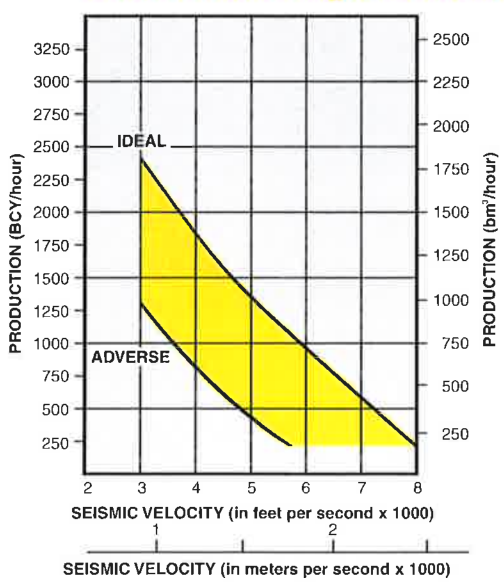
D8R with Single Shank



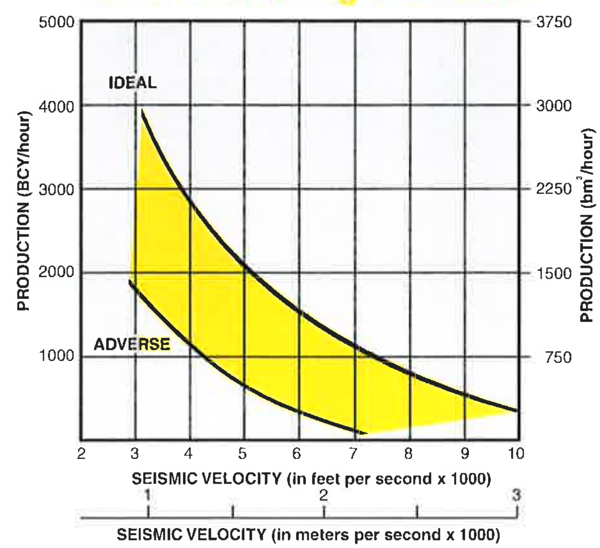
D10R with Single Shank



D9R with Single Shank



D11R with Single Shank



Estimating Ripper Production

There are three general methods of estimating ripping production:

1. The most widely used and accepted method is to survey and cross-section the area and then record the time spent ripping. After the material has been removed, cross-section the area again to determine the volume of rock removed. The volume divided by the time spent ripping gives the ripping rate in terms of bank cubic yards or bank cubic meters per hour.

2. Another method is to record the time spent by scrapers or trucks. Total quantity and time required can be converted to production in tons, bank cubic yards, or bank cubic meters per hour.

3. The third method (if a study is unavailable) is using a production ripping formula for quick estimating on the job. By knowing the ripping distance, rip spacing, and depth of penetration, volume per cycle can be calculated. From this, production in BCY (BCM) can be determined. Experience has shown results obtained from this method are about 10 to 20 percent higher than the more accurate methods of weighing or cross-sectioning. See the latest edition of the Caterpillar Performance Handbook for more detailed information.

Considerations for using production estimating graphs

- Machine rips full-time – no dozing
- Power shift tractors with single shank rippers
- 100% efficiency (60 min/hour)
- Charts are for all classes of material
- In igneous rock with seismic velocity of 8000 fps or higher for the D10, and 6000 fps or higher for the D9 and D8, the production figures shown should be reduced by 25%.
- Upper limit of charts reflect ripping under ideal conditions only. If conditions such as thick lamination, vertical lamination or any factor which would adversely affect production are present, the lower limit should be used.

Ripping Costs

The required production rate and cost per bank cubic yard (BCY) or bank cubic meter (BCM) are the determining factors as to what method should be used to get solid materials into movable form. The advantage of the large ripping tractor over drilling and blasting is its ability to loosen many materials faster and at slower cost per yard (meter). To more precisely evaluate this advantage, it's necessary to know the methods used to figure ripping costs on a per unit basis. (See *Density Chart* to transfer between bank cubic yards and tons.)

The method of determining owning and operating costs for a ripping tractor is substantially the same as for any other tractor. There is the purchase price of the tractor and attachments, plus delivery costs to the jobsite. Ripping tractors usually are equipped with extreme service track shoes and additional guarding. Also include taxes, insurance, depreciation and other fixed owning costs.

The principal difference when considering a ripping tractor versus a dozing tractor is the amount charged for repairs and the replacement of ground engaging tools such as ripper tips, shank protectors, cutting edges, etc.

Ripping and dozing hard rock is unquestionably one of the most difficult and demanding jobs a track-type tractor can do. Consequently, higher repair costs must be expected. See Performance Handbook for general cost estimating techniques.

Density Chart

Approximate Densities	TON/YD³	TONNES/YD³
Limestone	2.0 – 2.2	2.37 – 2.60
Dolomite & marble	2.3 – 2.35	2.72 – 2.78
Chalky lime	1.8 – 2.0	2.13 – 2.60
Coquina (corals)	1.5 – 1.8	1.77 – 2.13
Sandstone (strong)	1.8 – 2.2	2.13 – 2.60
Weak sandstone	1.7 – 1.8	2.01 – 2.13
Tar sands	2.4 – 2.8	2.84 – 3.31
Quartzites	2.2 – 2.3	2.60 – 2.72
Conglomerates	2.1 – 2.2	2.48 – 2.60
Shales	2.2 – 2.3	2.60 – 2.72
Slates	2.3	2.72
Gypsum	1.9 – 1.95	2.25 – 2.30
Anhydrite	2.4 – 2.5	2.84 – 2.95
Gneiss	2.3 – 2.8	2.72 – 3.31
Granite	2.2 – 2.4	2.60 – 2.84
Basalt	2.2 – 2.4	2.60 – 2.84
Dark igneous	2.6 – 2.8	3.07 – 3.31
Coal	1.2	1.42

Conversions:
One U.S. Ton = .9 Metric Ton   One Yd³ = .765 Meters³

Summary

An accurate estimate of ripping production is needed to determine unit ripping costs. The most accurate cost estimates are obtained by conducting on-site ripping job studies.

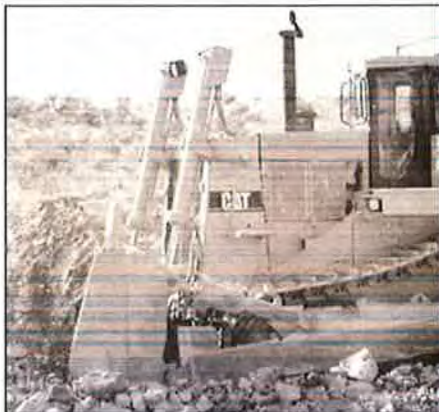
Ripping vs. Drilling and Blasting

Because of the improvements in ripping tractor capabilities, a viable alternative to blasting exists. As mentioned before, environmental factors will undoubtedly play an important role in reaching this decision.

For example, in an urban area there may be restrictions prohibiting the use of explosives, making ripping a necessity. Political factors or the threat of terrorism severely restrict the use of explosives in some countries. But in most situations, where there is equal opportunity for the use of either method, the first consideration is probably one of cost – will it be cheaper to rip or blast? This initial-cost consideration must then be weighed with other influencing factors: the economics of fully utilizing equipment; the end use of the material; and transporting and loading methods.

Full utilization of the equipment available or already on the job can help determine the best method of loosening the material. This is because many earthmoving jobs already involve track-type tractors and scrapers for a sizable portion of the total yardage. If this equipment can be used to finish the job – rather than bring in a rock crew with drills, explosives, loaders and hauling units – it's not difficult to appreciate the savings involved. It's soon apparent that considerable effort can be expended to rip the material in order to keep scrapers on the job.

End-use of the material also influences the ripping vs. blasting decision. There are few size limitations when the rock is simply moved by a bulldozer and "wasted." If the material is used to form an embankment, however, very definite limitations are usually placed upon the size



End-use of the material is an important factor in determining whether to rip or blast.

of the rocks to be accepted. Optimum compaction cannot be obtained if there are large rocks in the fill.

Variations in ripping depth, spacing, and direction of passes usually can produce the desired material size. Blasting is at times unpredictable, as the desired rock fragmentation may be difficult to obtain and even require expensive secondary blasting (in effect, reblasting). Appreciable increases in crusher production have been realized by cement plants and aggregate quarries after switching from a blasting to a ripping operation.

The final comparison of ripping vs. blasting can be made in terms of *how the material is to be moved.* As we stated, dozed material presents few problems. Material top loaded into hauling units cannot be larger than the loading bucket.

Scrapers can inexpensively haul materials which are well broken up and loosened. Elevating loaders and conveyors are high capacity systems. Their greatest advantage – high production – can be achieved only if the material is in small pieces and easy to handle. Generally, ripping is the most cost-effective method to achieve these requirements.

A cost analysis will indicate the economics of ripping over drilling blasting. This ample comparison indicates how ripper tip life is an important factor in deciphering the production needed for ripping to be cost effective. Ripper tips are the most expensive variable in the operating costs of ripping tractors, accounting for approximately 30 to 40 percent of total operating costs on the largest tractors.

In the final analysis, a ripping vs. blasting decision will depend on the total volume of material to be loosened and moved, on the production capabilities and costs of the ripping tractor(s) used, and on the size and relative efficiency of drilling and blasting techniques.

Summary

The initial-cost consideration between ripping or blasting must be weighted with other factors: the economics of fully utilizing equipment; the end use of the material; and transportation and loading methods.

Ripper Compatibility Guidelines

The topic of ripper compatibility between various tractors generates questions and concerns. The following information serves as a basic reference for ripper compatibility.

- The D11R (Serial Number 7PZ) Single Shank and Multishank Ripper Arrangements are interchangeable with the D11R (Serial Number 9TR).
- The D11R Carrydozer (Serial Number AAF) Single Shank and Multishank Ripper Arrangements are interchangeable with the D11R Carrydozer (Serial Number 9XR).
- The D11R (Serial Number 9TR) Single Shank and Multishank Ripper Arrangements are not recommended for use on the D11R (Serial Number 8ZR) or the D11N (Serial Number 4HK). The pitch cylinders are different in length and stroke and are pinned to the tractor rather than using trunnion ball mountings.
- The D11R (Serial Number 8ZR) Single Shank and Multishank Ripper Arrangements are interchangeable with the D11N (Serial Number 4HK).
- The D11N Single Shank Ripper Shank does not fit on the D10 Ripper. The size of the D11N shank is 110 by 450 mm (43.0" by 177.2"), while the D10 shank is 100 by 400 mm (39.4" by 157.5").
- The D11N Multishank Ripper Shank will fit on the D10 Ripper. Both use the same shank size.
- The D11N Multishank Ripper Shank Beam Assembly will fit on a D11N Tractor equipped with an impact ripper. A single shank beam assembly will not fit.
- The D10 Single Shank and Multishank Ripper is not compatible to the D11N Tractor. The mounts are different. The D10N Pushblock will fit on the D9N Ripper if excess material is burned off.
- The D10R Single Shank and Multishank Ripper Arrangements will fit and can be used on the D10N.
- The D10N Single Shank and Multishank Ripper Arrangements are not recommended for use on the D10R. Mounting groups are different, transmission guards are different, and the single shank ripper is a different size cross section. Also the transmission cannot be serviced or removed without removing the ripper frame.
- The D10N Multishank Beam Assembly will fit on a D10N Tractor equipped with an impact ripper. A single shank beam assembly will not fit.
- The D9L Multishank Ripper is not recommended for use on the D10N Tractor. In the carry position, the ripper tip can contact the track on the D10N Tractor.
- The D9L Single Shank Ripper is not recommended for use on the D10N Tractor. Extensive rework is required.
- The D9R Single Shank and Multishank Ripper Arrangements are not recommended for use on the D9N or vice versa. Pitch and lift cylinders are different, as well as hydraulic pressures, transmission guard, and lines group. If conversion is a necessity, contact your local dealer.
- The D9L Single Shank Ripper Frame is not compatible with the multishank ripper beam due to different frame requirements.
- The D9L conversion from standard to deep ripping requires one 3G8567 Tooth Group, one 9W3353 Hydraulic Pin Puller, and one 7T4408 Pin Puller Control. The conversion does not work on a D9L Multishank Ripper.
- The D9L Impact Ripper Beam Assembly is not interchangeable with the D10N Tractor Impact Ripper Beam Assembly and vice versa.
- The D9L Multishank Beam Assembly will fit on a D9L Tractor equipped with an impact ripper. A single shank beam assembly will not fit.
- The D9H Ripper is not compatible with any Series N Tractor.
- The D9H Ripper is not recommended for use on the D8L Tractor. Extensive rework is required.
- The D8R Single Shank and Multishank Ripper Arrangements are interchangeable with the D8N with slight modifications to the lines group.
- The D8K Ripper will fit the D9N Tractor if 4Z0511 Adapter Arrangement (Custom Product) is used.
- The D8K Ripper is not recommended for use on the D8N Tractor. The ripper mounts are different.
- The D8K Single Shank Ripper fits the D8L Tractor with use of 4Z0511 Adapter Arrangement (Custom Product) and 4Z0519 Pin Puller Modification.

- The D8K Ripper is not recommended for use on the D7H Tractor. The fuel tank on the D7H Tractor is too low.

- The shank block holders for the D8K, D8L, D8N, and D9N Tractors are the same.

- The single shank and multishank D8L Radial Rippers fit directly on the D9N Tractor. The ripper teeth are approximately 305 mm (12") closer to the track, possibly trapping more material. Digging depth increases by 25 mm (1") with the multishank ripper. Digging depth decreases 25 mm (1") with the single shank ripper.

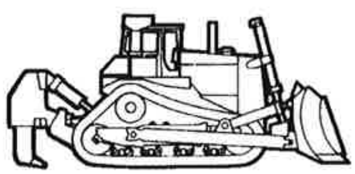
Caterpillar® Track-Type Tractor Specifications

Model	Ripper	Standard Tip	Shank Length		Penetration (Depth)*	
D11R & D11R CD						
	S/S	Short center line	8.9 ft.	2707mm	63.5 in.	1612 mm
	M/S	Short penetration	6.4 ft.	1958 mm	42.1 in.	1070 mm
	D/R	Short center line	10.7 ft.	3267 mm	85.7 in.	2178 mm
D10R						
	S/S	Short center line	8.2 ft.	2490 mm	53.9 in.	1370 mm
	M/S	Intermediate penetration	5.9 ft.	1799 mm	37.0 in.	941 mm
	D/R	Intermediate penetration	9.8 ft.	2977 mm	73.1 in.	1857 mm
D9R						
	S/S	Short center line	7.6 ft.	2322 mm	48.6 in.	1231 mm
	M/S	Intermediate center line	5.2 ft.	1600 mm	31.6 in.	798 mm
	D/R	Short center line	9.0 ft.	2750 mm	65.3 in.	1658 mm
D8R						
	S/S	Short center line	6.6 ft.	2010 mm	44.5 in.	1130 mm
	M/S	Intermediate center line	5.2 ft.	1600 mm	30.7 in.	780 mm
	D/R	Short center line	8.0 ft.	2449 mm	62.0 in.	1574 mm

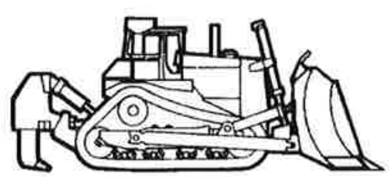
***S/S** = Single shank* ***M/S** = Multishank* ***D/R** = Deep ripping shank*

** Ripper penetration measured at maximum depth with standard tip and shank pinned in top hole.*

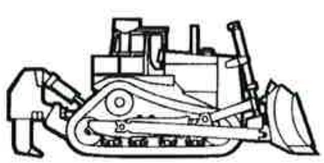
Note: *This chart does not represent all of the possible configurations. Contact your Cat dealer.*



D11R
850 fwhp/634 kW
230,100 lb/104 590 kg

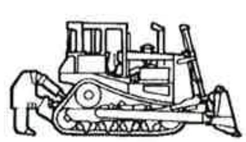


D11R Carrydozer
850 fwhp/634 kW
248,600 lb/113 000 kg



D10R
570 fwhp/425 kW
144,986 lb/65 764 kg

D9R
405 fwhp/302 kW
104,538 lb/47 418 kg



D8R
305 fwhp/228 kW
82,880 lb/37 594 kg

CATERPILLAR®

AEDK0752-02 (2/00)

Printed in U.S.A.