Minnesota Road Research Project

2004 Cell 26 Reconstruction

Low Volume Road Cell 26

Ronald Mulvaney, P.E.
Ronald.Mulvaney@dot.state.mn.us
(651) 779-5499 Fax (651) 779-5616

Benjamin Worel, P.E.
Benjamin.Worel@dot.state.mn.us
(651) 779-5522 Fax (651) 779-5616

William J. Zerfas, P.E.
william.zerfas@dot.state.mn.us
(651) 779-5289 Fax: (651) 779-5616

Minnesota Department of Transportation
Office of Materials and Road Research
1400 Gervais Avenue
St. Paul, Minnesota 55109

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ABSTRACT

The purpose of this report is to document the reconstruction process and to provide background information about the historical performance and subsequent deterioration of Cell 26 that lead up to the reconstruction.

Cell 26 extends from Station 170 + 75 to Station 174 + 65 on the LVR. The cell, one of eleven LVR HMA test cells, was originally designed to be a 6" full depth hot mix asphalt cell. The HMA had a Marshall Hammer design of 50 blows and uses an AC 120/150 penetration grade asphalt binder. Laboratory testing has shown that the 120/150 asphalt binder used at MnROAD has a Performance Grade (PG) of 58-28.

On September 6, 2000 cell 26 was reconstructed by reclaiming the entire 6" full depth asphalt surface including approximately 1"-2" of the in place clay loam subgrade. The 1"-2" of subgrade material was used as a cooling mechanism for the teeth on the reclaimer. The material resulted in about a total of 8"of material that was compacted and left in place to serve as a base for the new 2" oil gravel asphalt surface.

"Failure" of the rehabilitated cell 26 began to occur within hours of opening the roadway to the MnROAD 18-wheel, 5-axle, semi tractor/trailer. The oil gravel surface started to show signs of shoving immediately after 38 laps of the MnROAD truck. By the spring thaw of 2001 the oil gravel surface and reclaimed base had deteriorated to such a degree that the pavement had to be regraded and compacted to provide a drivable surface.

Following the failure, resilient modulus tests and shear tests were performed on the reclaimed base. The results showed that the resilient modulus values were not unusually low, but the results of shear tests showed that the shear strength of the reclaimed base material was lower then other MnROAD base materials and much too low to allow the use of a 2" oil gravel surface.

In June of 2004 cell 26 was again reconstructed using MnROAD staff, the City of Ostego personnel and equipment, and the MnDOT metro area paving crew. The 2" oil gravel surface along with 14" of reclaimed base and subgrade were removed. It was decided that cell 26 would be used to field verify the current Superpave criteria related to low temperature cracking (thermal and/or transverse cracking). The cell was replaced with 4" HMA Superpave mix over 12" Class 6-Special aggregate base. The design is based on 20-year ESAL's of 110,000, according to the MnPAVE design software. Commercial Asphalt Company, Maple Grove, MN performed the mix design for a Mn/DOT designation SPWEB240R.

Introduction
MnROAD Facility
The Minnesota Department of Transportation (Mn/DOT) constructed the Minnesota Road Research Project (MnROAD) between 1990 and 1994. MnROAD is located 40 miles northwest of Minneapolis/St.Paul and is an extensive pavement research facility consisting of two separate roadway segments containing 51 distinct test cells. Each MnROAD test cell is approximately 500 feet long. Subgrade, aggregate base, and surface materials, as well as, roadbed structure and drainage methods vary from cell to cell. All data presented herein, as well as historical sampling, testing, and construction information, can be found in the MnROAD database and in various publications. Layout and designs used for the Mainline and Low Volume Road are shown in figures 2 and 3. Additional information on MnROAD can also be found on its web site at http://mnroad.dot.state.mn.us/research/mnresearch.asp .

Mainline Test Road
The 3 ½-mile Mainline Test Road (Mainline) is part of westbound Interstate 94. The two-lane facility contains 31 test cells. The Mainline consists of both 5-year and 10-year pavement designs. The 5-year cells were completed in 1992 and the 10-year cells were completed in 1993. Originally, a total of 23 cells were constructed consisting of fourteen hot mix asphalt (HMA) test cells and nine Portland Cement Concrete (PCC) test cells. In 1997, two Superpave HMA test cells and six ultra-thin whitetopping concrete cells were added.

Traffic on the Mainline comes from the traveling public on westbound I-94. Typically the Mainline is closed once a month and the traffic is rerouted to the original interstate highway to allow MnROAD researchers the ability to collect data and record test cell performance. The traffic volume has increased 40% since the test facility first opened in 1994 and 2003. The Mainline equivalent single axel loads (ESALs) are determined from two weigh-in-motion (WIM) devices located at MnROAD. This data is collected, shared and used to calculate the Mainline ESALs, which are stored in the MnROAD database. An IRD Inc. hydraulic load scale was installed in 1989, east of the mainline test cells. In 2000, a Kistler quartz WIM was installed between PCC cells 10 and 11.

Low Volume Road
Parallel and adjacent to the Mainline is the Low Volume Road (LVR). The LVR is a 2-lane, 2 ½-mile closed loop that contains 20 test cells. Traffic on the LVR is restricted to an MnROAD operated vehicle, which is an 18-wheel, 5-axle, tractor/trailer with two different loading configurations. The "heavy" load configuration results in a gross vehicle weight of 102 kips (102K configuration). The “legal” load configuration has a gross vehicle weight of 80 kips (80K configuration). On Wednesdays, the tractor/trailer operates in the 102K configuration and travels in the outside lane of the LVR loop. The tractor/trailer travels on the inside lane of the LVR loop in the 80K configuration on all other weekdays. This results in a similar number of ESALs being delivered to both lanes. ESALs on the LVR are determined by the number of laps (80 per day) for each day and are entered into the MnROAD database.

Cell 26 History

Materials

Cell 26 extends from Station 170 + 75 to Station 174 + 65 on the LVR. The cell, one of eleven LVR HMA test cells, was originally designed to be a 6" full depth hot mix asphalt cell. The HMA has a Marshall Hammer design of 50 blows and uses an AC 120/150 penetration grade asphalt binder. Laboratory testing has shown that the 120/150 asphalt binder used at MnROAD has a Performance Grade (PG) of 58-28.

On September 6, 2000 cell 26 was reconstructed by reclaiming the entire 6" full depth asphalt surface including approximately 1"-2" of the in place clay loam subgrade. The 1"-2" of subgrade material was used as a cooling mechanism for the teeth on the reclaimer. The material resulted in about a total of 8"of material that was compacted and left in place to serve as a base for the new asphalt surface.

A nonwoven geotextile was used on the eastern half of cell 26 from station 172+75 to174+65. The geotextile was not used to provide structural strength but rather used to separate the clay loam subgrade from infiltrating into the reclaimed base layer. The geotextile was placed on only half of the cell in order to determine the benefits, if any, of using the geotextile.

The new asphalt surface was a modified version of an emulsified oil-gravel system that was developed in Sweden in the early 1950's. The oil gravel process uses softer asphalt, with a lower viscosity and higher penetration than conventional hot mix asphalt (HMA). HMA paved surfaces are typically designed to distribute and carry much of the load of the traffic loading while oil-gravel surfaced roads are dependant on the bearing capacity of the base for its strength. The benefit of using a softer asphalt binder is prolonging the natural aging process of the paved surface. By slowing the aging process the pavement keeps from becoming brittle which helps decrease the amount of cracking that is produced. In the warmer months, the softer asphalt is flexible and allows for movement of the mat and has the potential for the asphalt to repair itself through the kneading action of the traffic.

Traffic Loading

In June of 1994, the MnROAD truck began traveling on the LVR. At the time of the initial reconstruction in September 2000, the original full depth asphalt had received 111,068 Equivalent Single Axle Loads (ESALs) in the 80K lane and 107,332 ESALs in the 102K lane. This corresponds to approximately 47,639 passes of the MnROAD truck in the "legal" (80K) load configuration and 14,555 passes of the MnROAD truck in the "overload" (102K) configuration seen in Figure 1.1. By May 3, 2001 at the time of the oil gravel failure the 80K lane had received an additional 14,800 ESALs and the 102K lane had received an additional 15,682 ESALs, which corresponds to 6,558 and 2,039 laps respectively. Detailed traffic information can be found in the MnROAD database.

Pavement Condition

Condition surveys have been conducted on all of the cells at MnROAD from the time of initial construction using the Strategic Highway Research Program (SHRP) distress identification manual as a guide. The MnROAD database contains additional information pertaining to performance data collected with the Pavetech van and the details of individual condition surveys. The database also contains various reports and memorandums that contain visual observations and measurements made by MnROAD research staff. The pavement condition information that describes the most important events relating to Cell 26 is summarized below.

Full Depth Asphalt Investigation

From the time of the initial construction in 1994 until April of 1996 no cracking was present in cell 26. By April of 1996, 3 thermal cracks had formed for a total of 35 feet in the 102K lane. The cracking did not increase until April 1999 when one additional crack formed for a total of 40 feet. All the cracking was rated as low severity (mean crack width < 0.25 inches) using the SHRP definition of thermal cracking.

A 60 square foot distressed area developed in April of 1998 around a group of sensors in the outside wheel path of the 102K lane around station 172+00. This area was patched on several occasions, but the continued loading and the inability to compact the base around the sensors lead to its continual deterioration.

In April of 1999, 12 ft^2 of low severity fatigue cracking was recorded in the 80K lane and 34 ft^2 was recorded in the 102K lane. In the spring of 2000 cell 26 developed dramatic debonding of the top lift near the centerline cold joint of the HMA after receiving approximately 109,000 ESALs from the MnROAD truck. The debonding occurred between stations 173+00 and 174+00.

An evaluation of rut data beginning in 1994, reveals that rutting began almost immediately after the cell was opened to traffic. Cell 26 had 0.2 inches of rutting as early as May of 1995. Rut depths increased gradually then experienced a sharp increase in September of 1995. By mid-August of 1996, ruts in Cell 26 were as deep as 1/2 inch.

Oil Gravel Investigation

Following the reconstruction in the fall of 2000 the new oil gravel began to show signs of shoving in 4 areas of the 80K lane immediately after 38 laps of the MnROAD truck as can be seen in Figure 1.4. These 4 areas of shoving developed into fatigue cracking that was cut out and replaced with extra oil gravel that was left over from the initial oil gravel paving operation. These repairs along with the colder fall temperatures seemed to stabilize the pavement until it froze that winter. During the spring thaw of 2001 the cell was completely destroyed and had to be graded with a motor grader to provide a drivable surface for the remainder of the year as can be seen in figure 1.1. Because of the rapid deterioration of cell 26 accurate distress surveys were not taken, but conservative estimates show fatigue cracking covering 80% of the pavement surface and ruts greater than four inches.

Figure 1.4- Oil Gravel after 38 Laps of the MnROAD Truck

CELL 26 CONSTRUCTION

In June of 2004 cell 26 was again reconstructed using MnROAD staff, the City of Ostego personnel and equipment, and the MnDOT metro area paving crew. The 2” oil gravel surface along with 14” of reclaimed base and subgrade were removed. It was decided that cell 26 would be used to field verify the current Superpave criteria related to low temperature cracking (thermal and/or transverse cracking). The cell was replaced with 4” HMA Superpave mix over 12” Class 6-Special aggregate base. The design is based on 20-year ESAL’s of 110,000, according to the MnPAVE design software. Commercial Asphalt

Company, Maple Grove, MN performed the mix design for a Mn/DOT designation SPWEB240R.

Construction Field Notes
Table 1 is a summary of Mn/DOT's filed notes taken during construction.

TABLE 1 Reconstruction Field Notes

Date	Notes
May 6th	Removed 2 inches of the remaining oil gravel surface along with 14 inches of the reclaimed base and subgrade. The excavated material was hauled to the MnROAD stockpile site. MnROAD staff completed the surveying. DCP and FWD testing were complete on the Subgrade.
May8th	The subgrade was graded and compacted to within ½ inch. 4 inches of class 6 base material was placed with a higher crown at the center to protect the base of impending rain forecasted for the weekend. GPR plates were also placed, but will have to be uncovered and surveyed in next week.
May 10th	Rolled the existing class 6 material. Shot elevations on first lift of the base and GPR plates. Completed DCP testing on Base.
May 11th	MnDOT drill crew completed thinwalls on subgrade.
May 18th	MnDOT drill crew return to complete Split spoon samples to determine why they may be losing 12-15 inches of material in thinwalls.
May 19th	Finish placing final lifts of Class 6 base with Otsego's trucks and grader. St. Cloud survey crew placed Blue tops every 50 feet.
May 20th	Otsego Complete final grading to blue tops. Three sandcones were completed.
May 21st	Completed DCP and FWD testing on Class 6 base.
May 23rd	MnDOT researchers placed sensors and the wire leads into the base. The trenches for the wire leads were dug and recompacted by hand.
May25th	MnDOT metro area paving crew completed the paving. The first lift was put down at 2 inches and ended up about 1½ inches after compaction. The northwest end was about ½ inch after compaction. The Second lift was increased to about 3 inches before compaction to meet the 4inch overall thickness required. The northwest end ended up about 1½ inches thick because the paver followed the dip in the first pass.

Sensors Installed
Listed below is the sensors in test cell 26.

TABLE 2 Sensors Installed

Cell	Sensor Type	# of Sensors	# of Locations
26	TC	12	1
	GPR	2	2

Sensor Type Codes / (Use)
TC Thermal Couple
(measures the temp of the soil & pavement)
GPR Ground Penetrating Radar plates
(plates installed at bottom of HMA mat)

Construction Samples Taken

The following samples were taken for testing during construction and are shown in Table 3.

TABLE 3 Samples Taken During Construction

Sample Material	Sample #	Type Samples	Storage location
HMA (Binder)	2604AC001- 2604AC006	5 Gallon Buckets	MnROAD Pole Barn
HMA (Mix)	2604BM003 - 2604BM005 2604BM008 - 2604BM010	5 Gallon Buckets	Trial Mix Lab
HMA (Mix)	2604BM011 - 2604BM030	5 Gallon Buckets	MnROAD Pole Barn
HMA (Mix)	2604BM001 - 2604BM002 2604BM006 - 2604BM007	Cylinder molds	Metro Inspection
HMA (3/4" Barton Elk River)	2604BA001	Pile	MnROAD Stock Pile
HMA (9/16" Limestone Chips)	2604BA002	55-Gallon Drum	MnROAD Stock Pile
HMA (Plant Millings)	2604BA003	55-Gallon Drum	MnROAD Stock Pile
HMA (Class-2 Limestone)	2604BA004 - 2604BA005	5-Gallon Buckets	MnROAD Pole Barn
HMA (Cores)	2604BC001 - 2604BC010	6" Cores	Maplewood Lab
Subgrade (Surface Moisture)	2604MS001 - 2604MS005	Quart Buckets	Maplewood Lab
Base (Surface Moisture)	2604MS006 - 2604MS011	Quart Buckets	Maplewood Lab
Subgrade (Sub-surface Moisture)	04TW00 - 04TW0	Thinwalls	Maplewood Lab
Subgrade (Sub-surface Moisture /Resilient Modulus)	04TW0 - 04TW0	Thinwalls	Maplewood Lab

Thin wall Sampling

(See Ruth Robertson)

GPR Testing

(See Marc Loken)

DCP Testing

Dynamic Cone Penetrometer (DCP) on the subgrade generally appears reasonably uniform with a couple of soft spots on the west end and one on the east end.

DCP testing on the base material produced values in the range of 7 to 15 mm/blow range.Testing occurred after final grading, but before final compaction. The moisture content at the time of the DCP testing ranged from about 4 to 5 ½ percent. Generally, the middle of the Class 6 (100 to 200 mm depth) is better then the top or bottom. A vibratory smooth steel wheel roller was used to create more uniformity and to tie the surface together as much as possible just before paving.

Results of the testing can be found in the appendix to this report.

Construction Testing Results
The following tables show the results of the construction testing performed during this project.

TABLE 4 Subgrade Moisture

Sample	Station	Offset	% Water
2604MS001	174+50	5	13.1
2604MS002	173+50	5	12.3
2604MS003	172+50	5	38.4
2604MS004	171+50	5	12.2
2604MS005	170+50	5	12.6

Samples taken at the time of FWD and DCP Testing

TABLE 5 Aggregate Base Moisture

Sample	Station	Lane	Offset	% Water
2604MS006	170+90	Westbound	9	4.0
2604MS007	170+90	Westbound	9	4.2
2604MS008	172+90	Westbound	9	4.5
2604MS009	174+40	Westbound	9	3.9
2604MS010	174+40	Westbound	9	4.3
2604MS011	174+40	Westbound	9	5.2

Class-6 special was used from the MnROAD stockpile area for the 12” base material.

TABLE 6 Aggregate Base Sandcone Testing

Sample	Station	Offset	% Water	Density
2604SC001	173+50	-8	2.5	97.3
2604SC002	172+18	13’-6”	2.3	103.6
2604SC003	170+88	-5	2.3	100.6

TABLE 7 Aggregate Base Gradations

Sieve	Requirements		Field Result	
	Min	Max	2601GR001	2601GR002
1"	100	100	100	100
¾"	85	100	95.2	98.2
3/8"	50	70	68.9	74.5
# 4	30	50	44.6	48.5
# 10	15	30	29.8	34.9
# 40	5	15	15.5	17.4
# 200	0	5	6.5	7.0
Opt. Moisture			7.5	6.5
Max Density			129.2	129.2

Class 6 Special was used for the base material consisted of Class A aggregate (Original class-6 from the stockpile area)

TABLE 8 HMA Aggregate Gradations

Sieve	Requirements		MT-BM04-0128	MT-BM04-0127	MT-BM04-0126
	Min	Max			
¾"	100	100	100	100	100
½"	85	96	95.0	98	95
3/8"	70	84	84.0	90.0	88
# 4	51	65	65.0	70	71
# 8	43	55	55.0	57	60
# 200	2.0	5.6	5.7	5.6	5.8

TABLE 9 HMA Core Testing

Sample	Station	Lane	Offset	Lift	Thickness	Specific Gravity
2604BC001	171+00	Inside	-6	1	1.75	2.352
2604BC002	175+00	Inside	-6	1	2.25	2.348
2604BC003	175+00	Centerline	0	1	2.25	2.338
2604BC004	171+00	Centerline	0	1	1.5	2.368
2604BC005	171+00	Inside	-6	1	1.75	2.318
2604BC006	175+00	Outside	6	1	2.00	2.376
2604BC007	170+50	Inside	-6	Full	3.5	2.320
2604BC008	175+00	Inside	-6	Full	4.375	2.361
2604BC009	170+50	Outside	6	Full	3.75	2.352
2604BC010	175+00	Outside	6	Full	3.5	2.263

TABLE 10 LVR HMA Superpave Mix Testing Results

Material	Test	Results	Sample/Test Type
MT-BM04-0126	Relative Density	96.3	Mix from Truck Box
MT-BM04-0127		96.9	
MT-BM04-0128		97.9	
MT-BM04-0126	%AC (Field Cores)	6.4	Incinerator & Extraction
MT-BM04-0127		5.8	
MT-BM04-0128		5.8	
MT-BM04-0126	Bulk Specific Gravity	2.385	Mix from Truck Box
MT-BM04-0127		2.396	
MT-BM04-0128		2.418	
MT-BM04-0126	Max. Specific Gravity	2.477	Mix from Truck Box
MT-BM04-0127		2.472	
MT-BM04-0128		2.470	
MT-BM04-0126	% One Faced Crushed	92.1	Mix from Truck Box
MT-BM04-0127		97.9	
MT-BM04-0128		94.5	
MT-BM04-0126	% Two faced Crushed	92.1	Mix from Truck Box
MT-BM04-0127		97.9	
MT-BM04-0128		94.5	
MT-BM04-0126	Fine Aggregate Angularity	39.8	Mix from Truck Box
MT-BM04-0127		40.8	
MT-BM04-0128		40.4	
MT-BM04-0126	Production Air Voids	3.7	Mix from Truck Box
MT-BM04-0127		3.1	
MT-BM04-0128		2.1	
MT-BM04-0126	Voids in Mineral Aggregate	16.0	Mix from Truck Box
MT-BM04-0127		15.1	
MT-BM04-0128		14.3	
MT-BM04-0126	Voids in Fine Aggregate	76.9	Mix from Truck Box
MT-BM04-0127		79.5	
MT-BM04-0128		85.3	

Construction Summary
Final construction comments are shown in table 11.

TABLE 11 Construction Comments

Category	Comments on LVR Cell 26
Challenges	Due to the lack of funding the construction was completed internally within MnDOT with help from the City of Otsego. This proved to be difficult because of the lack of adequate equipment, timing of when equipment was available, and lack of personnel.
	Completing a subsurface investigation to determine if any soil correction is required after final plans have been completed and construction has started is not the correct process to follow.
	Compaction of the base was completed using a pull behind pneumatic tire roller. The lack of a vibratory steel wheel roller made it very difficult to achieve compaction of the class 6 base.
	The MnDOT metro paving crew completed the paving and the paver they used did not have grade controls. They were also not experienced paving directly on top of the base. Because of these facts the paving resulted in a very noticeable bump at the northwest end of cell 26. According to GPR data the pavement thickness at the bottom of the bump was around 1" thick.
	The first lift of paving was laid down at 2" which ended up with a compacted lift thickness of about 1 ½" instead of 2" as required. In order to meet the required 4" mat thickness the second lift was increased to almost 3".
Successes	The paving was completed on time, which allowed Nissan to complete their testing as scheduled.
	Removing the deteriorated oil gravel surface along with the recycled base and replacing it with 12" of class 6 base should provide a sufficient base structure should cell 26 need to be repaved.
Future Construction Practices	Make sure the proper funding is available before committing to a reconstruction project.
	Make sure the paving contractors have grade controls on their pavers.
	Complete all subsurface testing before construction begins.

List of Figures

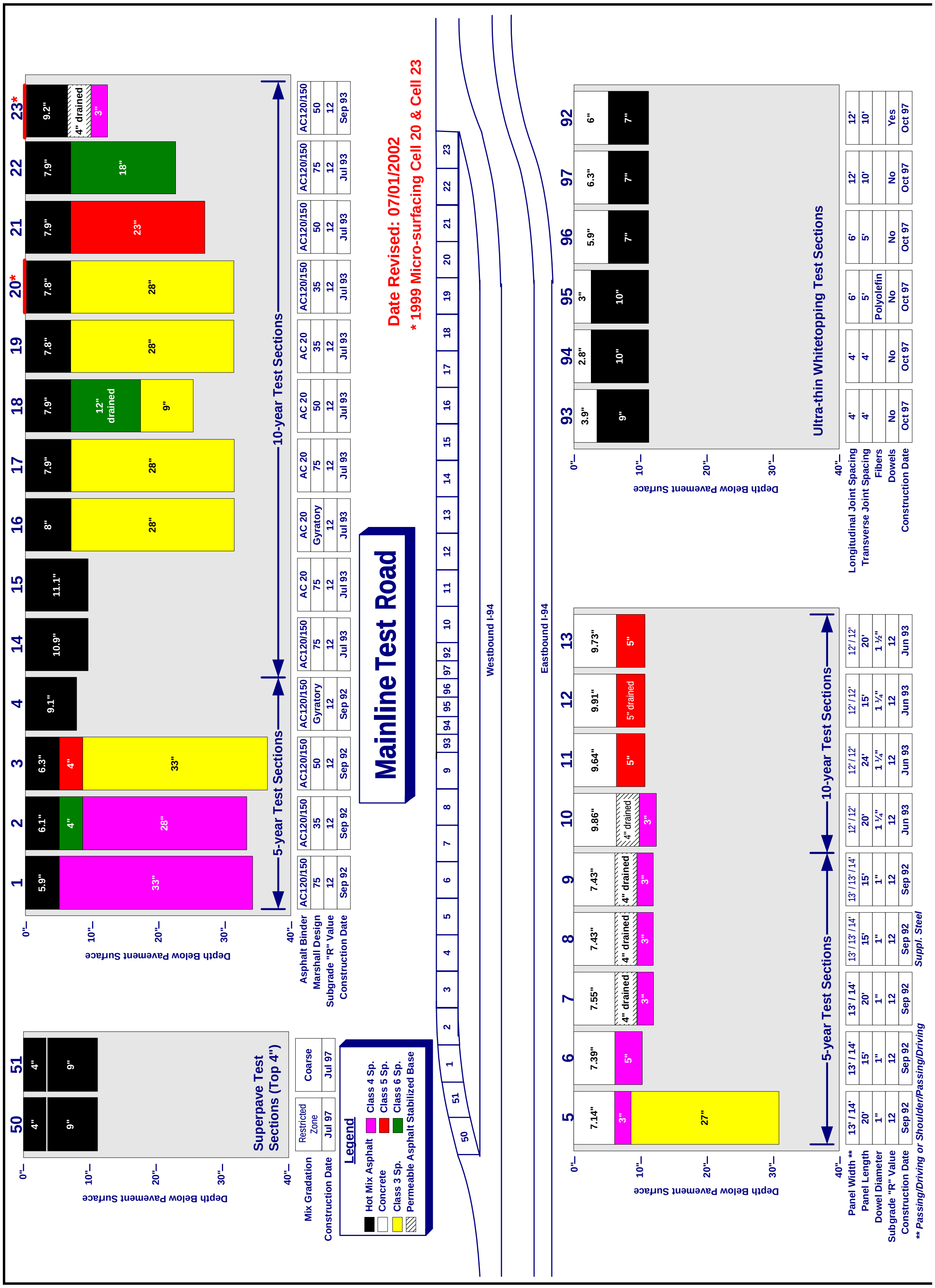

FIGURE 1 MnROAD TEST CELL LAYOUT (Mainline)

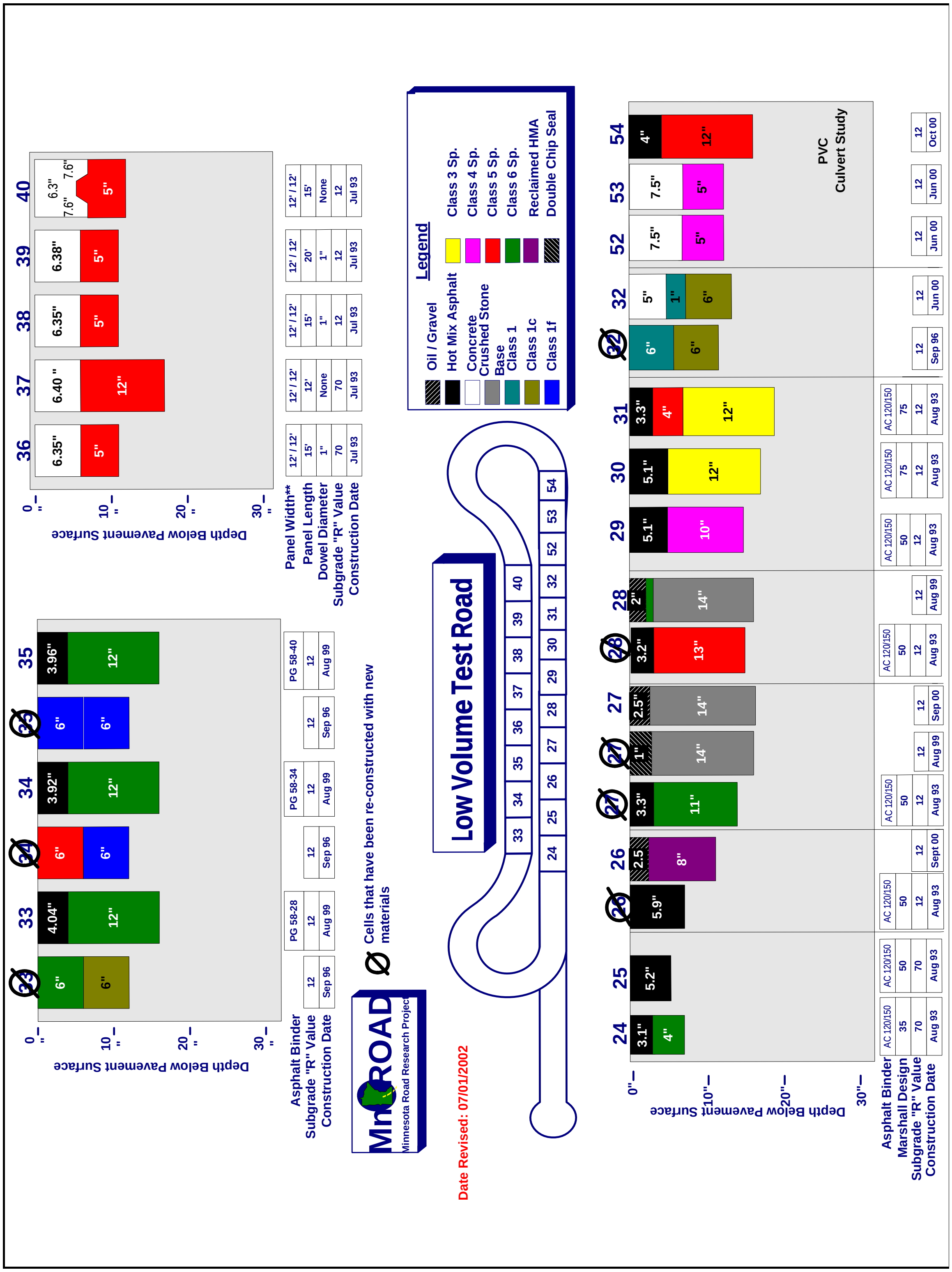

FIGURE 2 MnROAD TEST CELL LAYOUT (Low Volume Road)

BITUMINOUS PLANT MIX DESIGN REPORT
Mn/DOT - Office Of Materials and Road Research
1400 Gervais Avenue Maplewood, MN 55109
Phone: (651) 779-5614 FAX: (651) 779-5580

#0- 2004-042

THIS MIX DESIGN REPORT IS NOT VALID UNTIL PLANT NO. INDICATED BELOW IS CERTIFIED.

TO BE FILLED IN BY CONTRACTOR		Date:	4/13/2004
ENGINEER	FOR	SPEC	2360
PROJECT NUMBER		SPEC YEAR	2004
CONTRACTOR SIGN.		MIX TYPE	SPWEB240 (R)
FOR ALL STATE, COUNTY, AND CITY PROJECTS, CONTRACTORS MUST FAX A COPY TO MN/DOT TWO WORKING DAYS PRIOR TO PRODUCTION AT (651) 779-5580.		AC GRADE	PER PROPOSAL

THIS MIXTURE HAS BEEN REVIEWED FOR VOLUMETRIC PROPERTIES ONLY, IT DOES NOT ASSURE THAT FIELD PLACEMENT AND COMPACTION REQUIREMENTS WILL BE MET.

PLANT NO. 9 0 1 2 0 4 - 2 0 0 4 A JOB MIX FORMULA

Begin With Test Number: - - N W - - -

S P W E 2 0 1

Sieve Size (mm)	(in.)	Composite Formula	JMF LIMITS		For Information Only Virgin Formula
37.5	(1 ½)				
25.0	(1)				
19.0	(3/4)	100	100	100	100
12.5	(1/2)	89	85	96	88
9.5	(3/8)	77	70	84	73
4.75	(#4)	58	51	65	55
2.36	(#8)	49	43	55	47
0.075	(#200)	3.6	2.0	5.6	2.7
Spec. Voids		4.0	3.0	5.0	
Spec. VMA		14.0	13.7		

PERCENT PASSING — %AC (NEW): 4.9

%AC 5.7 (TOTAL) 5.3

TM# 0- 2004-001 Indicates a Gyratory density of 2375.5(148.3) kg/m³ (lbs/ft³) at 40 Design Gyrations.

Use of anti-strip agent required NO

Proportions		Source of Material		Sp.G
65	%	BARTON ELK RIVER #2	PIT# 71059	2.644
15	%	KRAEMER BURNSVILLE 9/16 CHIP (LIMESTONE)	PIT # 19106	2.678
5	%	KRAEMER CLASS 2 (LIMESTONE)	PIT# 19106	2.705
15	%	PLANT MILLINGS		2.680
0	%	BARTON ELK RIVER #2 SCREENED SAND	PIT #71059	2.650
	%			
	%			

Mix Aggregate Specific Gravity at the Listed Percentages = 2.657
Remarks: MINUS #4 AGGREGATE SPECIFIC GRAVITY AT THE LISTED PERCENTAGES = 2.645.
LAB MIXING TEMP. RANGE = 288-296 °F LAB COMPACTION TEMP. RANGE = 266-274 °F
NOTE: TEMPERATURES ARE FOR **PG 58-28 KOCH (2003) AC**. CONSULT SUPPLIER DATA IF OTHER PG GRADES ARE U[illegible]D.

Mix Design Reviewed by:
Mix Design Specialist

cc:
Dist. Mat'ls Eng. (Metro East & West) (2)
Metro Inspection
Contractor – COMMERCIAL ASPHALT #4

FIGURE 3 Cell 26 (PG 58-28) Mix Design

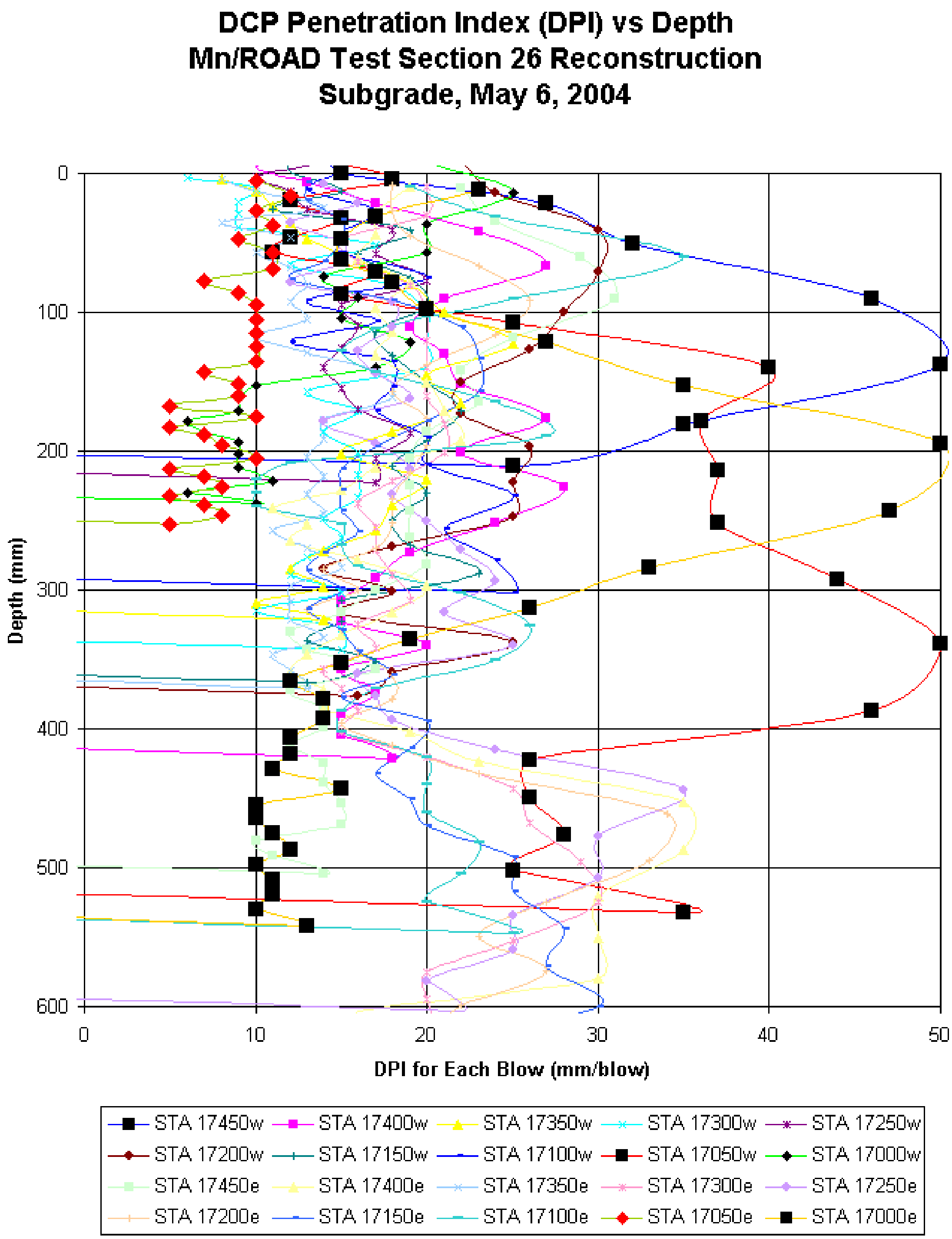

FIGURE 4 DCP Subgrade Testing

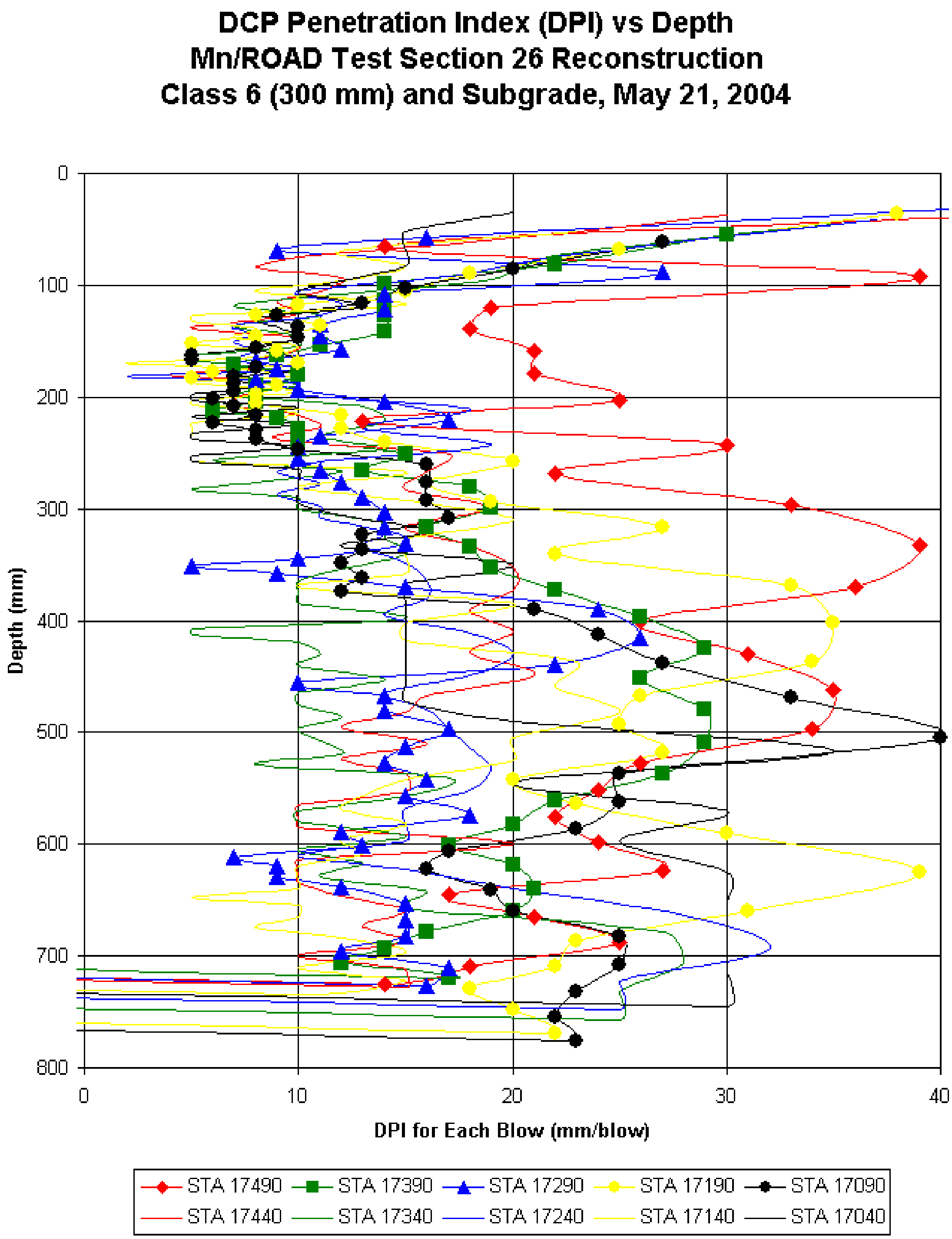

FIGURE 5 DCP Base Testing